List of Research Papers per Teachers in the journals notified on UGC website during the year 2018

Sl.NO	NAME OF THE FACULTY AUTHOR	TITLE OF PAPER	NAME OF JOURNAL	VOLUME	NAME OF THE DEPART MENT	PAGE NO.
1.	Dr.B.Kalaavathi	High Performance Feature Selection Algorithms Using Filter Method for Cloud-Based Recommendation System	Cluster Computing The Journal of Networks, Software Tools and Applications	Volume 14, Issue 11	CSE	2-14
2	Dr.B.Kalaavathi	Intrusion Detection and Prevention System in MANET Using Hierarchical Task Network Planning	Perspectives in Information Science	Volume 22, Issue 4	CSE	15-27
3	Dr.B.Kalaavathi	Honeypot TB-IDS: Trace Back Model Based Intrusion Detection System Using Knowledge Based Honeypot Construction Model	Cluster Computing The Journal of Networks, Software Tools and Applications	Volume 22, Issue 10	CSE	28-35
4	Mr.M. Jaganathan	An Heuristic Cloud Based Segmentation Technique Using Edge and Texture Based Two Dimensional Entropy	Cluster Computing	Volume 22, Issue 5	CSE	36-45
5	Mr.Santhakumar	A Self Balancing Space Vector PWM For Z Source T Multilevel Inverter	Journal of Electrical Engineering	Volume 18, Issue 3	EEE	46-55
6	Mr.S Velmurugan	A Multimodal Authentication for Biometric Recognition System Using Hybrid Fusion Techniques	Cluster Computing	Volume 43, Issue 8	EEE	56-63
7	Dr. P.Meenakshi Devi	An Analysis of Energy Efficiency Improvement Through Wireless Energy Transfer In Wireless Sensor Network	Wireless personal communication Springer	Volume 98, Issue 4	IT	64-78
8	M.Dhurgadevi	An Analysis of Energy Efficiency Improvement Through Wireless Energy Transfer In Wireless Sensor Network	Wireless personal communication Springer	Volume 98, Issue 4	IT	79-93

Cluster Computing (2019) 22:S311–S322
https://doi.org/10.1007/s10586-018-1901-0

CrossMark

High performance feature selection algorithms using filter method for cloud-based recommendation system

D. Muthusankar[1] · B. Kalaavathi[2] · P. Kaladevi[1]

Received: 23 November 2017 / Revised: 14 January 2018 / Accepted: 18 January 2018 / Published online: 20 February 2018

Abstract
In cloud-based recommendation system, the feature selection is implemented to reduce the large dimension of the cloud data. The feature selection increases the performance of the recommendation system without affecting the accuracy of the system. In this paper two filter model based algorithms SFS and MSFS are proposed to extract the necessary features for the recommendation system. The state of the art Naive bayes classification algorithm is used to evaluate the performance of the feature selection algorithm. The bench mark datasets Newsgroups, WebKB and Book Crossing are used for performance evaluation. The experimental results show that the proposed algorithm is superior to the existing feature selection algorithms T-Score, Information Gain and Chi squared.

Keywords Feature selection · Filter method · Selective feature selection

1 Introduction

The amount of data increases rapidly in the cloud every day. It is impossible to analyse the data manually. To get the usual information from the data, automated processing systems are used which uses the machine learning algorithms. The number of information collected from the cloud data is huge and large number of characteristics of the data is collected for the information [37, 40]. The increased feature in the web log will decrease the performance of the mining algorithms implemented in cloud. The feature reduction is an essential pre-processing technique for most of the mining algorithms which includes classification, clustering, pattern mining.

Normally a feature selection algorithm employs a combination of operations including a searching function to identify new feature subsets [24, 27, 29, 34] and a measuring function to score the identified feature subsets. To the simplest form a feature extraction algorithm works by examining every possible feature subsets and identifies the feature subset that yields very less error rate comparatively to other feature subsets. Though it may be simpler but tends to be more costly in terms of computational resources, as it need exhaustive searching of the entire feature space for all training documents and computationally difficult for large feature sets [22]. Based on the evaluation metric used the feature selection algorithms can be grouped under (i) wrappers, (ii) filters and (iii) embedded methods. The main objective of any feature subset selection algorithm is to identify more relevant feature subset that could match the exact target perception through (i) reducing dimensionality, (ii) eliminating unrelated information, (iii) increasing the precision learning and (iv) developing the clarity of the result [2, 4–6, 10]. All the works contributed towards feature selection is based on one of the following approaches: (1) embedded, (2) wrapper, (3) filter and (4) hybrid.

✉ D. Muthusankar
muthudms@hotmail.com

B. Kalaavathi
kalabhuvanesh@yahoo.com

P. Kaladevi
kala_cse@yahoo.co.in

1 Department of Computer Science and Engineering, K.S. Rangasamy College of Technology, KSR Kalvi Nagar, Tiruchengode, Namakkal, Tamil Nadu 637215, India

2 Department of Computer Science and Engineering, K.S.R. Institute for Engineering and Technology, KSR Kalvi Nagar, Tiruchengode, Namakkal, Tamil Nadu 637215, India

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

1.1 Embedded method

The algorithms based on embedded model try to select the features by integrating it as a step in training process. Generally the algorithms of this type have more specific feature selection process depending upon the learning algorithm. Due to this fact embedded method based algorithms are usually efficient than the other models [11, 36, 38]. Machine learning algorithms including decision tree algorithms and artificial neural network algorithms are all one kind of the embedded method [16, 20, 23].

1.2 Wrapper method

By identifying the interactions between the subset of variables, the wrapper method predicts the accuracy of the selected feature subsets [14, 30]. It employs a predetermined learning algorithm to identify the subset's accuracy which is higher than other models. The wrapper based methods are computationally complex due to the following reasons: (a) when the available training set is limited the approach tends to suffer from overfitting risk and (b) when the subset of variables increases the time to compute also increases [18].

1.3 Filter method

Discard of learning model, the filter model based algorithms select the subsets based on generality features. By containing the less relevant features, the filter based model includes the interesting features for further processing. Moreover filter models does not take the interaction between subset variables into account. The computational complexity of filter based models is considerably low as compared to other models, but it lacks in accuracy [3, 5, 17, 25, 28].

1.4 Hybrid method

The hybrid method based algorithms are a mix of wrapper and filter based models [9, 22, 28, 33, 35], the main objective of this model is to bring the accuracy of wrapper model together with computational complexity of filter model into one single model.

The wrapper models are highly accurate but suffers from overfitting risk for limited training sets [5, 7]. The choice of model in this paper is filter based, because it based on generality features and performs well against large datasets.

To have better efficiency of mining algorithms it is crucial to reduce the number of features in the database without affecting the accuracy of the results. There are two methods to shrink the features in the database, feature extraction and feature selection. The feature extraction combines or transforms to generate a new feature set may be of different type. The feature selection drops out some of the unwanted features and generates the subset of the existing features of the database. The feature selection can be done in three ways, first is that the feature selection is a part of the mining algorithm known as embedded approach, the next is wrapper approach, the feature selection algorithm in wrapped according to the mining algorithm. The last is the filter approach, this approach is a pre-processing approach, the feature selection is independent of the mining algorithm. In this paper the filter approach is used to select the feature, the advantage of this approach is that it is simple and gives better efficiency compared to the other types of feature selection algorithm. In this proposed algorithm the feature selection is done on the basis of the filter method. A huge number of feature selection algorithms are proposed earlier, such as T-Square, Chi Square statistics, Information gain, Improved Gini index, Ambiguity measure feature selection etc.

The feature selection process can be considered a problem of global combinatorial optimization in machine learning, which reduces the number of features, removes irrelevant, noisy and redundant data, and results in acceptable accuracy [13]. Therefore, a good feature selection method based on the number of features investigated for sample data mining algorithm is needed in order to speed up the processing rate, predictive accuracy, and to avoid incomprehensibility.

2 Literature survey

There had been a lot of research works going on towards feature selection methods for web-recommendation systems [21]. The most prominent methods of feature selections include Information gain (IG) and Chi square statistic (CHI), though both the methods are effective they are quite computationally expensive too, to alternate these two methods document frequency (DF) can be employed as it is computationally inexpensive and is similar to that of GI and CHI [32]. Shang et al. [26] proposed a new Gini index based feature selection model called improved Gini index, the new approach proved to be computationally less complex and more faster compared to earlier feature extraction approaches. The Greedy properties of both IG and CHI

PRINCIPAL,
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

models were addressed [32] by proposing a novel feature selection algorithm named *Orthogonal Centroid Feature Selection* (OCFS) based on the Orthogonal Centroid algorithm. The OCFS algorithm is considered to be more effective in sparse dataset as it had optimized the objective function of original orthogonal algorithm and the approach is comparatively more efficient and simpler than IG and CHI. IG,CHI and DF suffered a lot from the problem of unbalanced datasets, in which few categories contain more number of training documents than the rest of the categories which results in abnormal term frequency among the categories, to address the issue Mengle and Goharian [19] proposed a feature-selection method called ambiguity measure (AM). The approach follows a principle of adding significance to those terms that appears only in one category, and influences in single-labeled classification decision. The AM feature selection performs well against unbalanced datasets. Fuhr et al. [9] proposed a rule based multistage indexing for large data fields., based on the Darmstadt Indexing approach the proposed algorithm indexes the terms in two steps i) description step and ii) decision step. Fragoudis et al. [8] also employed a similar multistep process in feature extraction in their proposed approach named Best terms (BT), the complexity of the proposed model is linear and the performance is comparatively better against many algorithms. The following subsections present a brief discussion about each of the methods discussed above.

Yang et al. [32], in their work compared various feature selection models including term selection based on document frequency (DF), information gain(IG) and χ^2 test (CHI), his findings are as follows:

2.1 Document frequency (DF)

In simple words the document frequency measures the count of documents that contain the specified term. Yang et al. [32] tried to filter the infrequent terms by measuring the document frequency for every unique terms in the training dataset, it then eliminates the infrequent terms based on a predefined threshold. It works based on the intuition that the infrequent terms are less influential or less informative for category predictions. The main advantage of DF is its simplicity that it can be used for vocabulary reduction, it is highly scalable and its computational complexity grows linearly against the number of training documents.

2.2 Information gain (IG)

Information gain is used extensively in machine learning as a term-goodness measure [34], by having the knowledge of the term's presence in a document it identifies the information needed for category prediction. For the set of categories 't' in the training space 's', the information gain of the given term '*m*' is represented as:

$$\begin{aligned} IG(m) = &-\sum\nolimits_{j=1}^{s} Pb(t_i) log Pb(t_i) \\ &+ Pb(m)\sum\nolimits_{j=1}^{s} Pb(t_i|m) log Pb(t_i|m) \\ &+ Pb(\bar{m})\sum\nolimits_{j=1}^{s} Pb(t_i|\bar{m}) log Pb(t_i|\bar{m}) \end{aligned} \quad (1)$$

By computing the information gain (IG) for every unique term in the training space using the conditional probabilities of the given term, Yang et al. [34] eliminated the terms which had fallen under the specified threshold. The approach achieved a time complexity of O(N) and space complexity of O(VN), where V represents vocabulary volume and N represents the number of training documents.

2.3 χ^2 Statistics (Chi)

The χ^2 statistic measures the level of independency between the term 'm' and the category 't', the measure is compared against χ^2 distribution with independency metric set at one degree of freedom. The Chi metric for the term 'm' and category 't' is expressed as:

$$\chi^2(m,t) = \frac{D \times (IL - KJ)^2}{(I+K) \times (J+L) \times (I+J) \times (K+L)} \quad (2)$$

where I represents the value of number of times the term 'm' and category 't' co-occur, J represents the count of time the term 'm' occur without the category 't', the value K denotes the number of times the category 't' occurs without the term 'm' and the value L denotes the number times when both the category 't' and term 'm' does not occur. The value D denotes the number of training documents.

In their comparative study Yang et al. [32], concluded that though both the IG and CHI methods are effective they are quite computationally expensive too, to alternate these two methods Document Frequency (DF) can be employed as it is computationally inexpensive and is more similar to that of GI and CHI.

2.4 Improved Gini index

The improved Gini index model is based on classical Gini index method which is considered to be a non-purity split method. Proposed by Breiman et al. [1] the classical Gini index has been widely incorporated in many decision tree based mining algorithms. The Classical Gini index (CG) for a set of samples 'N' with 'k different 'S' classes is represented as:

$$CG(N) = 1 - \sum\nolimits_{j=1}^{k} Pb_j^2 \tag{3}$$

Shang et al. [26] based their work over classical Gini index model and devised an approach to implement the classical model directly for text feature selection, their approach 'Improved Gini Index' measured the purity of text feature F toward a class S_i. It computes with an intuition that the larger the value of purity is, the better the quality of attribute, which is reflected in the improved gini index formula (IG) for the text feature F:

$$IG(F) = \sum Pb(F|S_j)^2 Pb(S_j|F)^2 \tag{4}$$

where $Pb(F|S_j)$ denotes the probability that the feature F co-occurs with category S_j and $Pb(S_j|F)$ denotes that the feature F belongs to category S_i for each occurrence of F.

2.5 Orthogonal centroid feature selection

Yan et al. [31] proposed a supervised feature extraction algorithm for text classification problems, the algorithm capitalizes the orthogonal transformation on centroid [2, 12, 31]. The approach initially measures the Centroid of each class and training samples based on the optimization algorithm [32]. It then calculates the feature score for all the feature space using the formula:

$$f_s(f) = \sum\nolimits_{t=1}^{t} \frac{d_i}{d} \left(v_i^n - v^n\right)^2 \tag{5}$$

where d_i and d denotes the document count in the category t, and the training set respectively, v_i^n and v^n represents the nth element of Centroid v_i of the category t_i and the nth element of the Centroid vector v of the entire training set respectively.

2.6 Ambiguity measure

Mengle and Goharian [19] proposed Ambiguity measure algorithm which works based on the intuition of human perception over a document. Human perception over a document falls on certain unambiguous content that the eye sees and does not require the entire content of the document, moreover based on certain words identified from the document, the person can group the document under certain category. With this understanding the ambiguity measure (AM) can be expressed as:

$$AbM(m_j, t_i) = \left(\frac{mf(m_j, t_i)}{mf(m_j)}\right) \tag{6}$$

where $mf(m_j, t_i)$ denotes the frequency of the term m_j in the category t_i and $mf(m_j)$ is the value denoting the frequency of the term m_j in the whole document space.

Due to the key advantage of filter based feature selection models that identifies the feature subset based on the inherent quality of the data, it can be used in any form of data with high dimensionality. Moreover its generality and high computation efficiency has attracted many works towards designing feature extraction algorithm based on filter model [15, 18, 27, 30, 39]. Kira et al. [15] proposed one of the earlier works in filter based feature selection model Relief, it selects relevant features using statistical method, and the proposed model was noise tolerant and does not depend on heuristics. It was scalable linearly in bound with number of given features and training instances and it suffered from a main drawback that it cannot eliminate redundant features. Mark et al. [30] demonstrated a Correlation-based Feature Selection method that measures the value of feature subset selected the model employs Symmetric Uncertainty for measuring Feature-Class and Feature–Feature correlation, the model works better well in smaller datasets and avoids redundant features.

Zhao and Liu [39] designed INTERACT a filter model based feature selection algorithm that employs symmetric uncertainty and backward elimination approach for more accurate feature selection but the performance degrades when the data dimensionality increases. Song et al. [27] in their work proposed FAST, a fast clustering-based feature selection algorithm that selects the features in two step process involving graph-theoretic clustering methods and efficient minimum-spanning tree clustering method, the method reduces the dimensionality to great extent and performs well for microarray data. Liping [18] proposed condition dynamic mutual information feature selection model that tried to overcome the issue of mutual information selection process dynamic correlation problem, the filter based approach uses mutual information for selecting the features and displays considerable performance but suffers from noise related issues.

3 Proposed methodology

3.1 Successive feature selection

The successive feature selection (SFS) procedure, tries to identify the small set of attributes for further classification

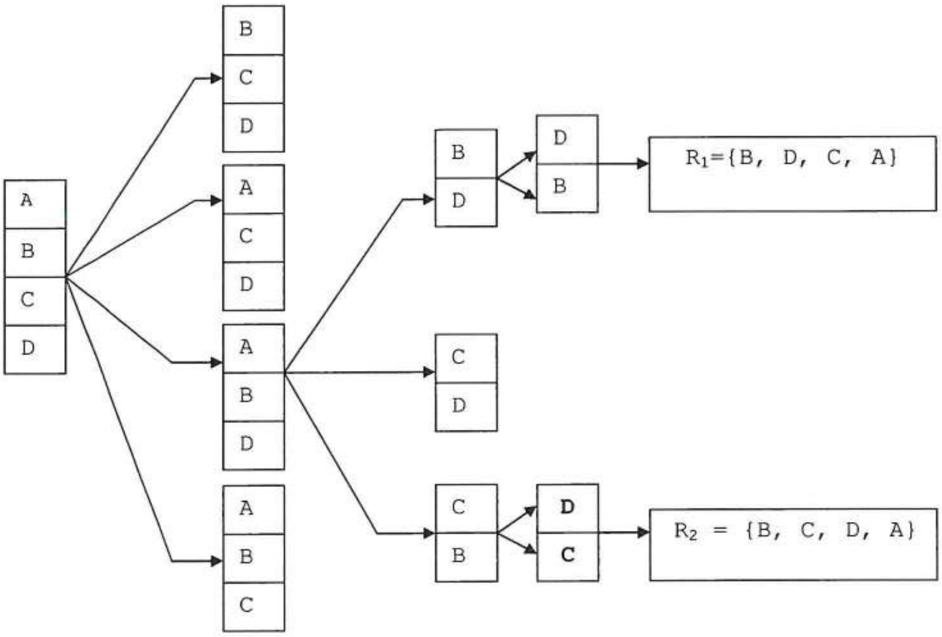


Fig. 1 Successive feature selection

and rule extraction mining algorithms. Usually the dataset comes with enormous set of attributes. If all these attributes are used in mining algorithms the result accuracy will drop. Successive feature selection algorithm identifies the attributes so that the mining can be performed with cost and time effectiveness.

In successive feature selection, first the features are divided into a set of blocks. The block size is fixed depending upon the space constraints of the system. Let the block size of feature is S. Within each block of features the Naive bayes classification algorithm is used to find the best features based on the accuracy of the classification. In each block of size S, N numbers of features where $N < S$, are extracted based on classification accuracy. From the result of the classification algorithm N number of feature are selected which have the top accuracy rate. The remaining features N–S are dropped when moving forward for the next iteration. From each block N numbers of features are extracted. These N features from each block are combined and the N best features from the combined features of the previous set are selected. The elimination processes are continued until all the features are ranked in selected subset. The removal of the features based on the Naive bayes classifier results in the minimal information loss. Accuracy is estimated using classifiers and the best features in each subset are processed.

For example, let the block size of the feature S is set at 4. Consider the features are A, B, C, D. During the first level of the feature selection one of the features is dropped. By dropping one feature out of four features results in four subsets. Then the Naive bayes classifier is used to select the best feature from the level 1. The best feature, from the level 1 is selected to the next level, level 2 as shown in Fig. 1. Three subsets with two features are selected for the next level. If more than one attribute have the same classification accuracy, and if it is in the top accuracy, then all the subset with the same accuracy are selected for the next level. For the given example B,D feature is selected for the next level.

In the next level features are selected by dropping one feature in each level. The process continues till all the features are ranked. In this example, two rank subsets have been obtained. The R_1 and R_2 are the two ranks obtained by SFS. From the example it is known that the B is the highest rank feature and A is the lowest rank. The features are selected based on the rank of the feature.

3.1.1 Algorithm: successive feature selection

Input	:	Set of Features
Output	:	Selected set of features
Step 1	:	Set the value for S and N.
Step 2	:	Partition the feature into S size blocks.
Step 3	:	In the next level of feature selection, drop one of the feature and obtain the subset which will be equal to number of features.
Step 4	:	The feature subset is divided into four subset features each consists of three features. $A, B, C, D: \{B, C, D\}, \{A.C.D\}, \{A, B, D\}$, {A,B,C}
Step 5	:	For the next level from the previous subset one more feature is dropped to find the 2 feature subsets. {B,D}, {C,D},{C,B}
Step 6	:	The single feature is ranked according to the previous accuracy value of classification in the 2-feature subset. The feature selected to the last level are D,B and D,C respectively from the 2 subsets
Step 7	:	From the two subsets two ranks are obtained in the level {B,D,C,A} and {B,C,D,A}. From the ranks it can be noted that B has the highest rank feature and A is the lowest rank feature.
Step 8	:	Select three top ranked feature F_1= {B,C,D} F_1= {B,D.C}
Step 9	:	Select a set of common top three ranked features $F_k = F_1 \cup F_2 = \{B.C.D\}$

3.2 Modified successive feature selection

In the SFS more than one rank subsets are obtained, the order of the features based on rank varies in SFS. For the mining algorithm that processes these features does not considers about the ordering of the features and so the SFS is sufficient to select the features.

$$Fk = F1 \cup F2 = \{A, B, C\} \tag{7}$$

For the example shown in Fig. 1 the features (A, B, C} are selected and returned by the SFS. If the order of the feature is important in the mining algorithm, then the SFS is not sufficient. In the above example shown in Fig. 1, A is the highest rank feature but the next rank feature varies in the two functions. The modified successive feature selection (MSFS) is proposed to give the ordering the feature selected.

Now, the ranking can be found by using the normalization of the different subsets. First the mean of the two subsets M_1 and M_2 are calculated. Then the normalization of the rank is done to extract the features in the order of the rank. The Modified Successive Feature Selection (MSFS) Algorithm is given in the following Sect. 3.2.1

3.2.1 Algorithm: modified successive feature selection

Input	:	Two set of ranked features
Output	:	Rank of features in order
Step 1	:	Set of features are F1= {B,C,D} and F1= {B,D,C}
Step 2	:	Apply the union operation on the two set of features given as the input.
Step 3	:	Find the set of common features present in the different sets $F_k = F_1 \cup F_2 = \{B, C, D\}$
Step 4	:	Then the value of mean M_1 and M_2 is found out for the two subsets.
Step 5	:	There are k classes, maximum of k is{1… k}, and here k is the maximum of F_k
Step 6	:	The rank of feature i, in two subset is calculated by $Ranking = \frac{R_{1i} + R_{2i}}{\lvert M_1 - M_2 \rvert}$
Step 7	:	Finally feature ranking is calculated as Ranking = Max{Rank from first subset, Rank from second subset}

4 Experimental results

4.1 Dataset

Three web mining data sets namely, Newsgroups, WebKB and book crossing shown in Table 1 are used for experimentation purpose. The Newsgroups dataset contains compilation of 20,000 news postings portioned in form of 20 different newsgroups. The WebKB dataset contains the collections of web pages of seven classes that belong to computer science departments which include the details of student, faculty, course, project, department, staff and other. The book crossing (Book) data set [41] contains the ratings given by the users about their likeness over a book. Here for experimental purpose only the 500 most frequently rated book are considered.

4.2 Performance metrics

The output of the proposed method for each classification provides insight into the efficiency of the feature selection

Table 1 Datasets

Data set	Training set	Test set
Newsgroups	31	31
WebKB	38	34
Book crossing	63	20

and classification technique. The results must be analyzed in terms of the degree of precision, recall, accuracy, error rate and execution time attained of the chosen features in the given instances.

True Positive (TP)	These instances are correctly identified. The instance which are predicted is correct and belongs to the predicted class is true positive
True Negative (TN)	These instances are correctly identified. The instance which does not belong to the class is predicted and is not selected in the feature selection. **False Positive (FP):** these instances are incorrectly selected/ predicted as an instance of the class. The instance which does not belong to the class is predicted as the member of the class
False Positive (FP)	these instances are incorrectly selected/ predicted as an instance of the class. The instance which does not belong to the class is predicted as the member of the class
False Negative (FN)	these instances are incorrectly selected/ predicted as an instance of the class. The instance which belongs to the class is not predicted/selected as the member of the class

4.3 Precision

The precision gives the positive predictive value. Precision gives the number of correctly identified members all among those which have been predicted/selected for the class. It is defined as the correctly identified members proportional to the total members selected for the class and it given in the Eq. (8)

$$Precision = \frac{TP}{(TP + FP)} \tag{8}$$

4.3.1 Recall

Recall is defined as the sensitivity and it is 1-type II error. The sensitivity is calculated as the proportion of the true positive to the sum of the true positive and false negative and it is given in Eq. (9). Recall gives proportion of number of the instance of the classes identified correctly to those which satisfies the condition.

$$Recall = \frac{TP}{(TP + FN)} \tag{9}$$

4.3.2 Accuracy

Accuracy is a measure which gives result accuracy of the correctly selected features. It is found by dividing the number of correctly selected instances divided by the total number of instances which are both identified correctly and wrongly as in Eq. (10). Accuracy measure gives the selection performance done on the dataset. It gives the percentage of the inputs in the dataset which have rightly selected.

$$Accuracy = \frac{(TP + TN)}{(FP + FN + TP + TN)} \tag{10}$$

4.3.3 F-Measure

$$\text{F - Measure} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}} \tag{11}$$

F-measure is statistical value calculated based on the above Eq. (11).

4.3.4 Accuracy percentage

$$\text{Accuracy Percentage} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \times 100 \tag{12}$$

Accuracy percentage is calculated from true positive, true negative, false positive and false negative and given in Eq. (12). The value gives the percentage how much percentage of the class instance is identified correctly. The last two metrics F-Measure and accuracy percentage is not used to measure the performance since precision, recall and accuracy is used, since the F-Measure and accuracy percentage is calculated by the performance metrics precision, recall and accuracy.

4.3.5 Execution time

The algorithm takes the takes the dataset and selects the features. The time elapsed between reading the input and producing the output features is termed as execution time in this SFS and MSFS algorithm. The execution time is measured in seconds.

4.4 Testing accuracy and execution time

Tables 2 and 3 summarizes the features used by SFS, MSFS technique and the accuracy achieved. It is compared with the standard T-Score, information gain (IG) and Chi squared (χ^2) Chai and Domeniconi [2]. This comparison clearly points out that MSFS method can significantly

Table 2 Comparison of MSFS with TS, IG, χ^2, SFS for testing accuracy

Data set	No. of features					Accuracy (%)				
	TS	IG	χ^2 test	SFS	MSFS	TS	IG	χ^2 test	SFS	MSFS
Newsgroups	30	3	3	3	2	51	57	64	73	84
WebKB	30	3	3	3	2	47	59	62	76	82
Book crossing	30	3	3	3	2	56	62	67	74	94

Table 3 Execution time of MSFS with TS, IG, χ^2, SFS

Data set	No. of features					Execution time (s)				
	TS	IG	χ^2 test	SFS	MSFS	TS	IG	χ^2 test	SFS	MSFS
News groups	30	3	3	3	2	55	57	51	42	44
WebKB	30	3	3	3	2	59	56	56	43	49
Book crossing	30	3	3	3	2	67	65	66	52	59

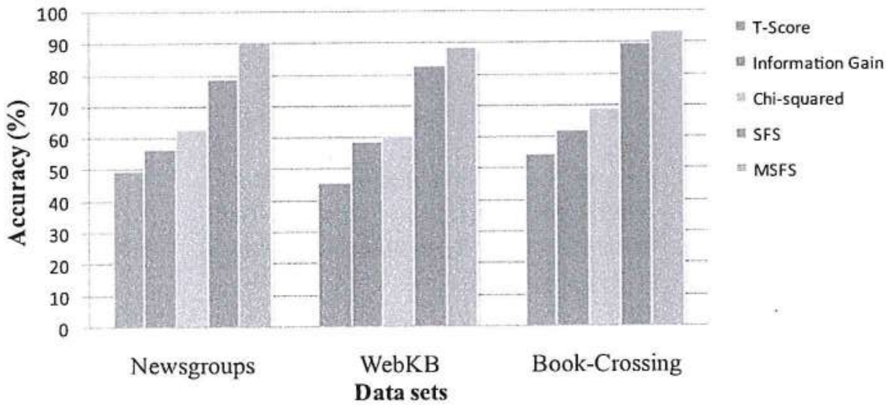


Fig. 2 Accuracy for T-score, information gain, Chi squared, SFS and MSFS

reduce the number of features required for accurate classification. However, it is noted that these results represent only the best performing subsets, TS has 30 features, IG gain has three features, Chi squared has three features, SFS has three feature combinations and MSFS has two features. The general performance should be estimated by the testing accuracy. The experiments were conducted in Corei3 processor with 4 GB RAM.

For all the three datasets the number of features extracted is less and the execution time is less for SFS and MSFS than the TS, IG, Chi squared and the values are shown in the above Tables 2 and 3. The execution time MSFS is higher since the input of MSFS depends upon the SFS. The MSFS orders the features selected by SFS depending upon the rankFor Newsgroups data set, MSFS claims a good the accuracy of 91% and it uses two features in 44 s while SFS acquires only 79% using three features in 42 s. The Chi squared gets an accuracy percentage 63% with three feature and the execution time taken is 51 s, IG obtains 57% of accuracy rate using three features is obtained 57 s for the IG and 50% of accuracy percentage with 30 features in 55 s b TS. For WebKB data set, MSFS acquires the accuracy of 89% using two features in 49 s comparing with SFS, SFS obtains accuracy percentage of 86% using three features and it takes 43 s, while the Chi squared test reaches about the accuracy percentage of 61 using three features and selects the features in 56 s, the IG reaches an accuracy percentage of 59 with three features and it runs in 56 s and 46 percentage of accuracy with 30 feature combination is claimed by TS running in 59 s. For Book Crossing data set, MSFS acquires the accuracy of 94% using 2 features and the MSFS executes in 59 s while SFS reaches about accuracy of 90% with 3 features and it completes in 52 s, Chi squared reaches an accuracy percent of 69 using 3 features and it runs in 66 s, IG reaches an accuracy percentage of 62 using 3featuresand executes in 65 s and TS reaches an accuracy percent of 55 with 30 features in 67 s.

Fig 2 represents the feature accuracy for the dataset shown in the Table 1. Here, all of the features are labelled according to their TS ranks. From the Fig. 2 it can be noted that the SFS and MSFS outperforms the TS, IG, and Chi

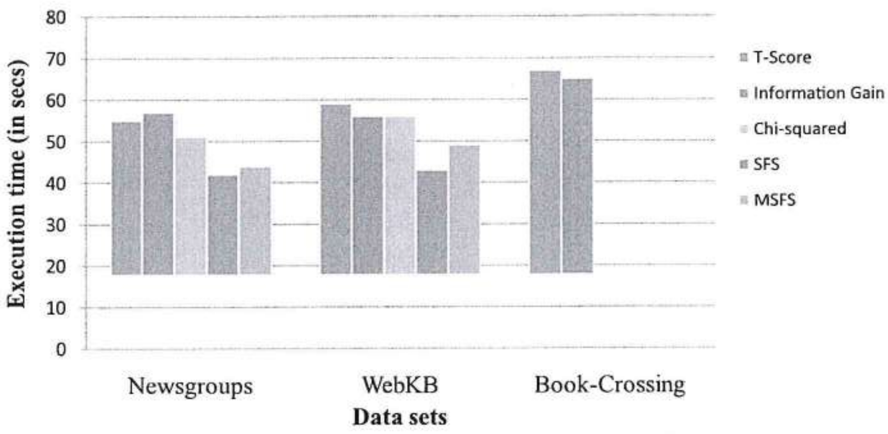


Fig. 3 Execution time of T-Score, information gain, Chi squared, SFS and MSFS

Table 4 Comparison of T-Score, information gain, Chi squared, SFS and MSFS for precision and recall

Data set	Precision (%)					Recall (%)				
	TS	IG	χ^2 test	SFS	MSFS	TS	IG	χ^2 test	SFS	MSFS
News groups	59	67	51	75	92	93	82	73	60	56
WebKB	63	61	58	82	91	90	75	71	65	54
Book crossing	61	69	59	88	94	87	72	71	62	52

squared. The MSFS gives better accuracy than the SFS and it can be clearly seen in Fig. 2.

Figure 3 represents the execution time for SFS and MSFS for web data. Here, the features are labelled according to their TS ranks. Two feature subsets are found by the MSFS, which achieved less execution time in the training and testing process with high accuracy.

4.4.1 Precision, recall and error rate

Recall is the fraction of the relevant feature to the number of features in the list (s). Precision is the fraction of differential expressed features in the list of length to the number of differential features. The error rate is a proportion of the number called features.

From the Tables 4 and 5, it is proved that the MSFS uses less features and have got a higher precision, with less recall and error rate when compared to the TS, IG and Chi squared. For Newsgroups data set, MSFS reaches the precision percentage of 92 with recall rate of 56% and error rate of 0.035 while reaches the precision percentage of 75 with 60% of recall and 0.037% of error rate, Chi squared reaches the precision percentage of 51 with 73% of recall and 0.054 of error rate, IG obtains only 67% of precesion with 82% of recall and 0.062 of error rate and TS reaches the precision percentage of 59 with 93 percent of recall and 0.075 of error rate. For WebKB data set, MSFS reaches the precision percentage of 91 with recall rate of 54% and error rate of 0.021 while SFS reaches the precision percentage of only 82 with recall percent of 65 and 0.024 of error rate, Chi squared reaches the precision percentage of only 58 with recall percent of 71 and 0.052 of error rate, IG reaches the precision percentage of only 61 with recall percent of 75 and 0.064 of error rate and TS reaches the precision percentage of only 63 with 90% of recall and 0.064 of error rate. For book crossing data set, MSFS reaches the precision percentage of 94 with recall rate of 52% and error rate of 0.022 while SFS reaches the precision percentage of only 88 with recall percent of 62 and 0.029 of error rate, Chi squared reaches the precision percentage of only 59 with 71% of recall and 0.042 of error rate, IG reaches the precision percentage of only 69 with 72 percent of recall and 0.046 of error rate and TS reaches the precision percentage of only 61 with 87% of recall and 0.057 of error rate.

Table 5 Comparison of T-Score, information gain, Chi squared, SFS and MSFS for error rate

Data set	Error rate (%)				
	TS	IG	χ^2 test	SFS	MSFS
Newsgroups	0.075	0.062	0.054	0.037	0.035
WebKB	0.064	0.064	0.052	0.024	0.021
Book crossing	0.057	0.046	0.042	0.029	0.022

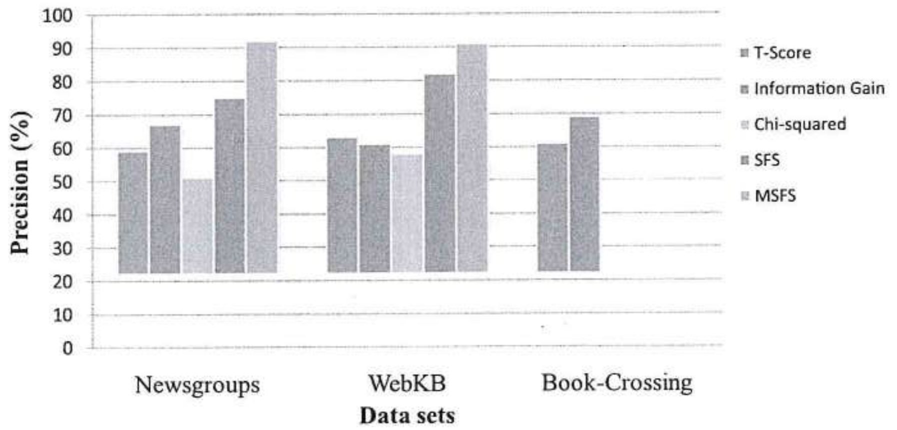


Fig. 4 Precision for T-Score, information gain, Chi squared, SFS and MSFS

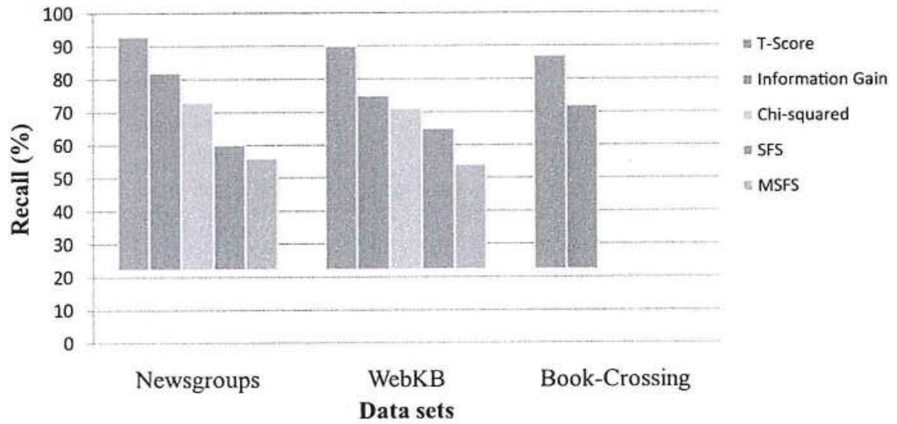


Fig. 5 Recall for T-Score, information gain, Chi squared, SFS and MSFS

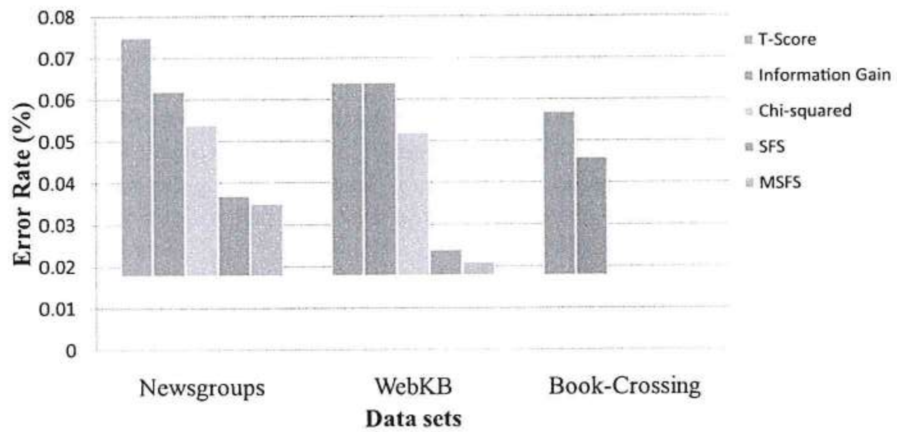


Fig. 6 Error rate for T-Score, information gain, Chi squared, SFS and MSFS

4.4.2 Precision for T-Score, information gain, Chi squared, SFS and MSFS

Figure 4, shows precision for TS, IG, Chi squared, SFS and MSFS. We compared the results of our experiments with the both precision values obtained by all three standard data set i.e., News groups, WebKB and book crossing. Figure 5 shows recall for TS, IG, Chi squared, SFS and MSFS. The proposed method, MSFS has high precision and less recall when compared with other TS, IG and Chi squared approaches.

Figure 6, reports the error rates for BPN classifier based TS, IG, Chi squared, SFS and MSFS technique. The MSFS approach using two features combination and BPN classifier achieved the better error rate. Notice that BPN classifiers based on different number of features, and choosing the one that achieves the lowest error rate is not an entirely unbiased procedure, since the "test set" is used multiple times. It can be noted form Fig. 6 that the proposed MSFS has less error rate is when compared with the other TS, IG, Chi squared, SFS approaches.

5 Conclusion and future work

This paper discusses about two feature selection algorithms based on filter model. The first algorithm SFS selects the features by dropping the bottom ranked feature in each level. The SFS model shows less computational complexity with higher accuracy against existing models. The second feature extraction model using MSFS algorithm selects the best features for web recommendations. The MSFS algorithm showed improved results obtained in a short time when compared to the TS, IG and Chi squared. The error rate in the proposed MSFS algorithm is decreased by 50% compared to the TS, and performs better than the IG, and Chi squared. For recall the proposed MSFS algorithm improves performance 40% compared to the TS, and performs better than the IG, and Chi squared. This technique is a powerful method for ranking the feature and works for both single and multiple feature data. The experimental results have shown that MSFS outperforms SFS and other models both computationally and in accuracy. For future work, it is planned to implement Genetic algorithm in feature selection using criminal dataset.

References

1. Breiman, L., Friedman, J., Stone, C.J., Olshen, R.A.: Classification and regression trees. CRC Press, Baco Raton (1984)
2. Chai, H., Domeniconi, C.: An evaluation of gene selection methods for multi-class microarray data classification. In: Proceedings of the Second European Workshop on Data Mining and Text Mining in Bioinformatics, pp. 7–14, (2004)
3. Chuang, L.Y., Chang, H.W., Tu, C.J., Yang, C.H.: Improved binary PSO for feature selection using gene expression data. Comput. Biol. Chem. **32**(1), 29–38 (2008)
4. Chuang, L.-Y., Yang, C.H., Li, J.C., Yang, C.H.: A hybrid BPSO-CGA approach for gene selection and classification of microarray data. J. Comput. Biol. **19**(1), 68–82 (2012)
5. Das, S.: Filters, wrappers and a boosting-based hybrid for feature selection. In: Proceedings of the International Conference on ICML vol. 1, pp. 74–81 (2001)
6. Dash, M., Liu, H.: Feature selection for classification. Intell. Data Anal. **1**(1–4), 131–156 (1997)
7. Dash, M., Liu, H.: Consistency-based search in feature selection. Artif. Intell. **151**(1–2), 155–176 (2003)
8. Fragoudis, D., Meretakis, D., Likothanassis, S.: Best terms: an efficient feature-selection algorithm for text categorization. Knowl. Inf. Syst. **8**(1), 16–33 (2005)
9. Fuhr, N., Hartmann, S., Lustig, G., Schwantner, M., Tzeras, K., Knorz, G.: AIR/X-a rule based multistage indexing system for large subject fields. In: Proceedings of the RIAO, vol. 91, pp. 606–623, (1991)
10. Guyon, I., Elisseeff, A.: An introduction to variable and feature selection. J. Mach. Learning Res. **3**, 1157–1182 (2003)
11. Howland, P., Park, H.: Generalizing discriminant analysis using the generalized singular value decomposition. IEEE Trans. Pattern Anal. Mach. Intell. **26**(8), 995–1006 (2004)
12. Jeon, M., Park, H., Rosen, J.B.: Dimension reduction based on centroids and least squares for efficient processing of text data. In: Proceedings of the 2001 SIAM International Conference on Data Mining, Society for Industrial and Applied Mathematics, pp. 1–13, (2001)
13. Karaboga, D., Ozturk, C.: A novel clustering approach: artificial bee colony (ABC) algorithm. Appl. Soft Comput. **11**(1), 652–657 (2011)
14. Kim, Y., Street, W., Menczer, F.: Feature selection for unsupervised learning via evolutionary search. In: Proceedings of the Sixth ACM SIGKDD International Conference, on Knowledge Discovery and Data Mining, pp 365–369, (2000)
15. Kira, K., Rendell, L.A.: The feature selection problem: traditional methods and a new algorithm. In: Proceedings of the 10th National Conference Artificial Intelligence, pp. 129–134, (1992)
16. Krishna, B.B., Mouli, K.C.: A novel subset selection clustering-based algorithm for high dimensional data. IJSEAT **3**(7), 246–251 (2015)
17. Langley, P.: Selection of relevant features in machine learning. In: Proceedings of the AAAI Fall symposium on relevance, vol. 184, pp. 245–271, (1994)
18. Liping, W.: Feature selection algorithm based on conditional dynamic mutual information. Int. J. Smart Sensing Intell. Syst. **8**(1), 316–337 (2015)
19. Mengle, S.S., Goharian, N.: Ambiguity measure feature-selection algorithm. J. Assoc. Inf. Science Technol. **60**(5), 1037–1050 (2009)
20. Mohamad, M.S., Omatu, S., Deris, S., Yoshioka, M.: A modified binary particle swarm optimization for selecting the small subset of informative genes from gene expression data. IEEE Trans. Inf Technol. Biomed. **15**(6), 813–822 (2011)
21. Ng, A.Y.: On feature selection: learning with exponentially many irrevelant features as training examples. Doctoral dissertation, Massachusetts Institute of Technology. (1998)
22. Nguyen, T.T.S., Lu, H.Y., Lu, J.: Web-page recommendation based on web usage and domain knowledge. IEEE Trans. Knowl. Data Eng. **26**(10), 2574–2587 (2014)
23. Ozturk, C., Hancer, E., Karaboga, D.: Dynamic clustering with improved binary artificial bee colony algorithm. Appl. Soft Comput. **28**, 69–80 (2015)
24. Rogati, M., Yang, Y.: High-performing feature selection for text classification. In: Proceedings of the International Conference on Information and Knowledge Management, pp. 659–661, (2003)
25. Seo, M., Oh, S.: CBFS: High performance feature selection algorithm based on feature clearness. PLoS ONE **7**(7), e40419 (2012)
26. Shang, W., Huang, H., Zhu, H., Lin, Y., Qu, Y., Wang, Z.: A novel feature selection algorithm for text categorization. Expert Syst. Appl. **33**(1), 1–5 (2007)
27. Song, Q., Ni, J., Wang, G.: A fast clustering-based feature subset selection algorithm for high-dimensional data. IEEE Trans. Knowl. Data Eng. **25**(1), 1–14 (2013)

28. Souza, J., Japkowicz, N., Matwin, S.: Feature selection with a general hybrid algorithm. In: Proceedings of the SIAM International Conference on Data Mining, p. 45, (2005)
29. Xing, E.P., Jordan, M.I., Karp, R.M.: Feature selection for high-dimensional genomic microarray data. In: Proceedings of the International Conference on ICML, vol. 1, pp. 601–608, (2001)
30. Hall, M.A., Smith, L.A.: Feature selection for machine learning: comparing a correlation-based filter approach to the wrapper. In: Proceedings of the Twelfth International FLAIRS Conference
31. Yan, J., Liu, N., Zhang, B., Yan, S., Chen, Z., Cheng, Q., Fan, W., Ma, W.Y.: OCFS: optimal orthogonal centroid feature selection for text categorization. In: Proceedings of the 28th annual international ACM SIGIR conference on Research and development in information retrieval, pp. 122–129, (2005)
32. Yang, Y., Pedersen, J.O.: A comparative study on feature selection in text categorization. In: Proceedings of the International Conference on ICML vol. 97, pp. 412–420, (1997)
33. Yang, J., Liu, Y., Zhu, X., Liu, Z., Zhang, X.: A new feature selection based on comprehensive measurement both in inter-category and intra-category for text categorization. Inf. Process. Manag[**48**(4), 741–754 (2012)
34. Yang, J., Qu, Z., Liu, Z.: Improved feature-selection method considering the imbalance problem in text categorization. Sci. World J. (2014). https://doi.org/10.1155/2014/625342
35. Yu, J., Abidi, S.S.R., Artes, P.H.: A hybrid feature selection strategy for image defining features: towards interpretation of optic nerve images. In: Proceedings of the 2005 International Conference on Machine Learning and Cybernetics (2005)
36. Zhang, C., Ouyang, D., Ning, J.: An artificial bee colony approach for clustering. Expert Syst. Appl. **37**(7), 4761–4767 (2010)
37. Zhang, D., Hsu, C.H., Chen, M., Chen, Q., Xiong, N., Lloret, J.: Cold-start recommendation using bi-clustering and fusion for large-scale social recommender systems. IEEE Trans. on Emerg. Topics Comput. **2**(2), 239–250 (2014)
38. Zhang, Y., Wang, S., Phillips, P., Ji, G.: Binary PSO with mutation operator for feature selection using decision tree applied to spam detection. Knowl.-Based Syst. **64**, 22–31 (2014)
39. Zhao, Z, Liu, H.: Searching for interacting features. In: Proceedings of the IJCAI'07 20th International Joint Conference on Artifical intelligence pp. 1156–1161 (2007)
40. Zhu X., Dong, F., Luo, J., Wang, J., Shen, J.: A personalized hybrid recommendation system oriented to e-commerce mass data in the cloud. In: Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, pp. 1020–1025, (2013)
41. Ziegler, C., McNee, S., Konstan, J., Lausen, G.: Improving recommendation lists through topic diversification. In: Proceedings of the 14th International Conference on World Wide Web, ACM, pp. 22–32, (2005)

D. Muthusankar completed the B. Tech degree in Information Technology in 2005 from K. S. R College of Engineering, Tamilnadu, India. He did his Master of Engineering in K. S. Rangasamy College of Technology, Tamilnadu, India. His areas of interest include Data Mining, Web Mining, Network Security, Computer Networks and Cloud Computing. Currently he is working as an Associate Professor in K. S. Rangasamy College of Technology, Namakkal, Tamil Nadu, India.

B. Kalaavathi received the B.E. (Computer Science and Engineering) degree in 1993 from Bharathiyar University, Chennai, M.Tech from Pondicherry University in 2000 and Ph.D. from Periyar University in 2010. She is currently working as a Professor/Head in Computer Science and Engineering, K. S. R. Institute for Engineering and Technology, Namakkal. She is a member of CSI & ISTE INDIA. She has published more than 50 papers in various international journals and conferences. Her current areas of interest include Cloud Computing, Data Mining, Image Processing, Mobile Computing and Data Structures and Algorithms Analysis.

P. Kaladevi completed the B.E. degree in Computer Science and Engineering in 2004 from Kongu Engineering College, Erode. She completed his M.E. (CSE) in 2010 at K. S. Rangasamy College of Technology, Namakkal. Currently, she is pursuing his Ph.D. in Information and Communication Engineering under Anna University, Chennai and working as an Associate Professor in K. S. Rangasamy College of Technology, Namakkal, Tamil Nadu,India. Her current areas of interest include Cloud Computing, Data Mining and Big Data Analytics.

Intrusion detection and prevention system in MANET using hierarchical task network

Article · December 2018

Kalaavathi Bhuvaneshwaran
KSR Institute for Engineering and Technology

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

Intrusion detection and prevention system in MANET using hierarchical task network planning

Umamaheswari, A

AP, Department of CSE,Mahendra Engineering College,Namakkal
umamaheswariphd321@yahoo.com

Dr.Kalaavathi, B

Professor, Department of CSE,
K.S.R Institute for Engineering and Technology, Namakkal.

Abstract: Nowadays Mobile Adhoc Network is a boon of network technology. It is anefficient network to share Hypermedia documents. Even though it is popular, it has certain problems due to lack of security. Intruder has done the malicious activities in the network. The field of artificial intelligence is used to identify the intruder without affecting the network flow in MANET.Artificialintelligence is a part of computer science which concern in designing computer systems with intelligence of human behavior.Hierarchical Task Network Planning prevent and reduce the malfunctions in the MANET.

Keywords:Mobile Adhoc Network, Mobile Agent, Intrusion Detection and Hierarchical Task Network Planning.

1 Introduction

MANET has successfully performed in many applications. It covers the area of rescue operations,tactical operations, environmental monitoring and diagnosis.But the Security in MANET is a risky issue because of lack of central monitoring points and connected with many number of nodes. MANET is more vulnerable than wired network. The open broadcast medium and cooperativeness of the mobile devices introduced new risky situations.Mobility, federation and lack of infrastructure are ad hoc network features relevant to IDS.

Issues of Intrusion Detection System in MANETs are lack of central Points, Mobility,Wireless Links, limited resources, lack of a clear line of defence andcooperativeness and securecommunication.

Conventional intrusion detection systems examining audit logs of anomaly based intrusion detection which is more frequently monitoring interactions between system components at a suitable interface. Conventional IDSs are not easily applied to all the situations in the mobile ad hoc network. New approaches need to be introduced or else existing approaches need to be applied in artificial intelligence for MANETS.

2 Overview of Attacks

Network Layer Attack

Many attacks can be disrupted in the network layer. They are classifies as:

Wormhole Attack

An attacker gets packets at one location in the network and tunnels them to some other location in the network, where the packets are resent into the network.

Blackhole Attack

A malicious node wrongly advertises good paths to the destination node during the path finding process or in the route update messages. The main role of the malicious node can hinder the path finding or intercept all data packets sent to the destination node [20].

Byzantine Attack

Set of compromised intermediate node makes collusion and carry out attackslike creating routing loops, routing packets on non-optimal paths and selectively dropping packets. This attack is very difficult to detect.

Information Disclosure

A compromised node may disclose confidential or important information to unauthorized nodes in the network. The network topology, geographic location of nodes or optimal routes to authorized nodes may be the important information in the network.

Resource Consumption Attack

A malicious node tries to waste or consume the resources of other nodes present in the network. The targeted resources are battery power, bandwidth and computational power. Unnecessary requests for routes, very frequent generation of beacon packets, or forwarding of stale packets to nodes can be made an attack in the network.

Sleep Deprivation Attack

The node is always busy for pumping packets to other nodes. It can be consumed battery power for other node.

Routing Attacks

Various attacks are mounted on the routing protocol. They are

Routing Table Overflow

An adversary node declares the route to non-existent nodes in the network due to the overflow of the routing tables.

Routing Table Positioning

Compromised nodes in the network send fake routing updates or modify genuine route update packets sent to other uncompromised nodes. It makes the problem of congestion in portions of the network; some parts of the network cannot be accessed.

Packet Replication

The deputed node replicates stale packets. It consumes additional bandwidth and battery power. It leads to unnecessary confusions in the routing process.

Route Cache Poisoning

Each node maintains a route cache which holds the information regards route in the recent past. Sometimes it makes a problem of congestion and inaccessible of the network.

Transport Layer Attacks

Session Hijacking

An adversary node takes control over a session between the two nodes. Authentication processes are carried out only at the start of the session, once the session between two nodes gets established, adversary node hijacks the session.

Application Layer Attacks

Repudiation

Repudiation refers to the denial or attempted denial by anode involved in a communication of participated in all or part of the communication.

Multilayer Attacks

Denial of service and impersonation are multilayer attacks.

Denial of Service

In physical and MAC layers, the malicious node leads to jamming signals which disrupt the on-going transmissions on the wireless channel. In network layer an adversary can take part in the routing process and exploit the routing protocol to disrupt the normal functioning of the network[20].

Impersonation

The malicious node assumes the identity and privileges of an authorized node, either to make use of network resources may not be available under normal situations or to disrupt the normal functioning of the network by injecting the false routing information into the network.

3 Intrusion and Prevention Systems

The intruder can be classified as passive intruder and active intruder. The passive intruder obtains the information from the network without disturbing the operation of the network. The active intruder disturbs the operation in the network. The active intruder may be internal intruder and external intruder. The active intruder are monitored and executed by the nodes which are in outside of the network are called external intruder. The active intruder who is belonging to the same network, attacks the network is called internal intruder. Integrity, confidentiality and availability of a network are monitored and prevent to compromise by the intruder.The concept is classified into two categories .One is hypothesis and another is made practically.Mathematical notations are used to explain the concept of planning methods in Artificial intelligence.

ISSN: 1413-9936

System calls logging on the local node, recording of traffic received on a network interface and reputation scores (multi trust data or recommendations) are taken as data collection.

Data collection, detection and response are the three components in IDS. Data collection has collected the details of transferring data to a common format, data storage and sending data to detection module. In the detection, data is analyzed to detect intruder attempts and indications of detected intruders are sent to the response agent. The response component determines the set of actions after detecting the intrusion.

Three IDS techniques are used. They are anomaly-based intrusion detection, Misuse-based intrusion detection and specification-based intrusion detection.

In anomaly-based intrusion detection system, profileand symptomsof normal behaviors of the system such as commands frequently used,CPU usage for programs.Statistical methods and artificial intelligence techniques are used. It is capable of detecting previously unknown attacks.More false positive occurs.

In misuse-based intrusion detection, signatures with current system activities monitored. It has given low falsepositive rate. But it cannot detect new attacks. It is used only as strong as its signature database. It needs frequently updating for new attack.

In Specification based intrusion detection, set of constraints on a program or a protocol are specified. But it cannot detect some kind of attacks such as (DOS).It does not violate program specification directly. Intrusion is detected; response is triggered according to their response policy. Response is passive or active. Passive raise alarms and notify the proper authority. Active responses mitigatethe effects of intrusion.

It is divided into two groups.One group is to thecontrol over the attacked system. It is used to restore damaged by killing processes, terminating network connections. Another group is to control over the attacking system.IDS traffic should be considered for high secure networks.

The IDS find the intruder after attacking the network and ruin the details of the network. But the intrusion detection and prevention system [IDPS] is prevented the system before the attacker attack the system.

4 Artificial Intelligence

Artificial intelligence is the study of how to make computers do things at which, at the moment, people are better.

An agent can be viewed as perceiving its environment and acting upon that environment.

A rational agent is to act and achieve the best outcome or, when there is uncertainty, the best expected outcome.

The rational agent depends on four things. They are

1. The performance measure defines the criterion of success.
2. Agent's- prior knowledge of the environment.
3. The actions that the agent can perform.
4. The agent's percept sequence to date.

The performance measure represents the criterion for success of an agent's behavior. The agents generate the sequence of actions according to the percepts it receives. The sequence of actions causes the environment to go through a sequence of states. If the sequence is desirable then the performance of the agent is good.

The Structure of Agent

The action is performed after any sequence of describing behavior.

Agent=Architecture + Program

There are four basic kinds of agent program used in intelligent systems. They are

- Simple reflex agents, Utility-based agents, Goal -based agents , Model-based reflex agents

Simple Reflex Agent

It selects actions on the environment basis of the current percept and ignoring the rest of the percept history.

Model-Based Reflex Agents

The agent should maintain the some sort of internal state that depends on the percept history and reflects at least some of the unobserved aspects of the current state.

Goal-Based Agents

The agent needs some sort of goal information that describes situation about the current state description as required.

Utility-Based Agents

Utility function maps a state which describes the associated degree of utility. In the mobile adhoc network, Model based reflex agent has used as agent program for intrusion detection and prevention systems.

Model Based Reflex Agents

The agent is to keep track of the part of the network it can't see now. Some sort of internal state are maintained and it depends on the percept history and reflects at least some of the unobserved aspects if current state of the network. Updating the internal state information of the mobile ad hoc network as time goes. It requires two kind of knowledge encoded in the agent program. First the agent needs to collects some information about the network works independently of the agent. Second, the agent need some information about how the agent's own actions affect the world.

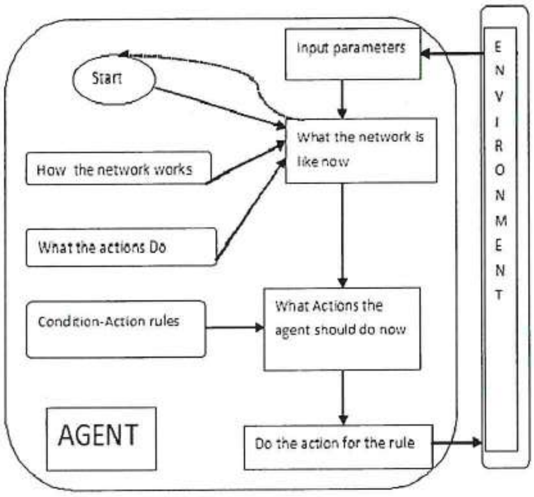


Figure 1 A Model –based reflex Agent

In Figure 1, The Agent monitor mobile adhoc network with the parameter of inputs such as number of nodes, protocol, sending id, destination id, number of packets, time duration when message transferred. There is any conflict occurs in the message passing time or some other deviations in the network, the agent take the decision by using condition action rule in the plan library. The agent gets ready to solve the problem like indicate the intruder or redirect the path for message transfer.In the mobile ad hoc network, the agent has the following characteristics:

- Autonomous: An agent takes an initiative step depends upon the network behaviour.
- Interactive: Mobile agent communicates and interacts with other agents with their environment.
- Coordinative: Data can be exchanged between agents in their environment.
- Proxy: Mobile agents can be acted as some other agent with authentication and it maintains the degree of autonomy.
- Ragged: Mobile agents should have the ability to deal with errors when ever occurred.
- Proactive: They should be goal oriented depend upon the action rule based approach.
- Cooperative: multiple agent Coordinate with other agents to achieve a common goal. Mobile
- Intelligent: Mobile agent should be smart in order to act efficiently.

5 Existing Intrusion Prevention

The partial ordered planning [POP] is used in low level actions. Each plan has the following components. They are actions, ordering constraints, casual links, and open conditions.

Actions

The "empty plan" contains the start and finish actions. Start has no preconditions and has all the input parameters in the initial state of the planning problem. Finish has no effects. It has its preconditions the goal literals of the planning problem.

Input parameters in the MANET is

- Duration(length of the connection)
- Protocol type
- Service(Network service on the destination)
- Source bytes(Number of data bytes from source to destination)
- Dest_bytes(Number of data bytes from Destination to source)
- Flag (Normal or Error status of the Connection)

Ordering Constraints

Each ordering constraints is of the form $A \prec B$ which is read as "A before B". It means action A must be executed sometime before action B but not necessarily immediately before.

In MANET, the above input parameters are noted in the source node and checked the parameters in the destination node.

Casual Links

A set of casual links between two actions A and B in the plan is written as $A \xrightarrow{p} B$ and it read as "A achieves p for B.

Open Preconditions

A precondition is open,where there is no action achieved in the plan. Planners have to work to reduce the set of open preconditions to the empty set without inconsistency.If there is any mistake or uninterruptedoccurred, thecasual link is broken.

Solution

A consistent plan in which there are no cycles in the ordering constraints and noconflicts with the casual links. A consistent plan with no open precondition is a solution. In MANET, the Data can be transferred from source to destination in the proper channel. The Agent monitored the parts of the partial order planning. There is no connection to the destination from source due to denial of service.

Pitfalls of Partial Ordered Planning

It is failure with backtracking if the current plan contains an irresolvable conflict. Sometimes open condition leads to a problem in the action which cannot be achieved to next step.

Action in the open condition gets unavoidable decision and it provides additional constraints on other choices to be made, eventhough the computation on this open condition is expensive.

6 Proposed System

The paper proposed hierarchical task network planning [HTN] in artificial intelligence. It deals about the nodes of the network by using planning of multiple observations to avoid intrusions.

- In HTN planning, the initial plan which describes in high level description. Plans are refined by applying action decomposition. Each action is decomposed to reduce a high level action into a partially ordered set of lower-level actions. Hierarchical Task Networks (HTN)[21]
  - Tasks: primitive (action) / non-primitive (compound tasks)
  - Methods (task reduction schemas): expand or reduce non-primitive tasks
  - Operators (no preconditions, only effects): reduce methods
  - Critics: remove conflicts to reduce backtracking

Hierarchical task network planning [HTN]

1 A planning problem P is the input.

2 If input P contains only primitive tasks,then solve the problem conflict in P and return the result. If the problem conflict cannot be resolved,return failure.

3 Select a non-primitive task t in P.

4 Expand t for selection.

5 Replace t with the expansion

6 To find the interactions among the tasks in P by using critics and give solution to handle them.

7 Apply one of the ways (actions) suggested in step6

8 Goto step 2.

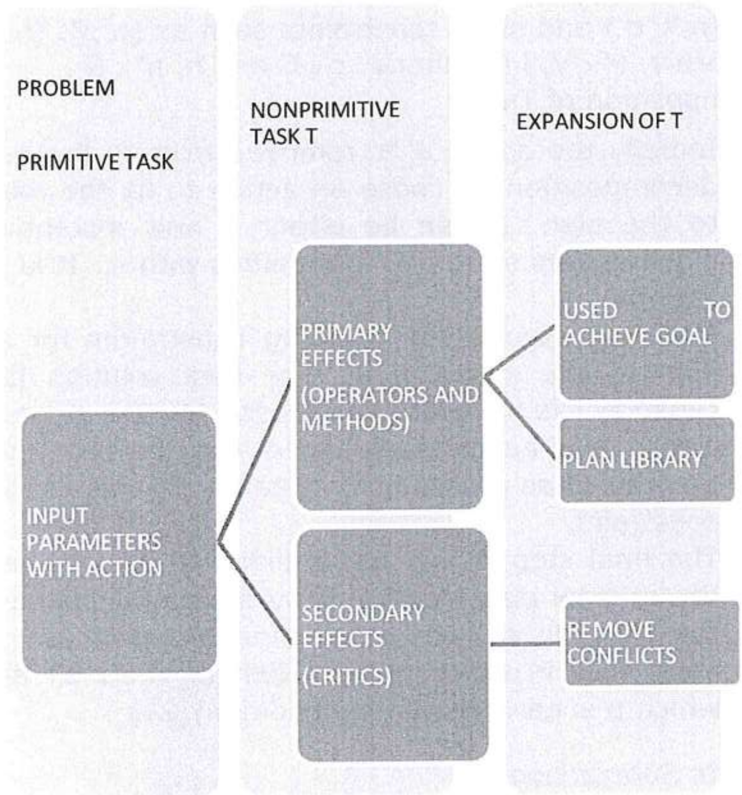


Figure 2 Proposed System

In the above figure, input parameters havegiven to the node.This is the primitive task. There are two effects in the HTN.

- Primary effects–to achieve the destination without intruder. Plan library contain several decomposition (that is used to prevent the intruder by using the anomaly based intrusion or Misuse based intrusion or specification based Intrusion or combination of three)
- Secondary effects –to remove the conflicts (that is not reach the destination which means intruder present in the network.)

A primitive task is a syntactic construct of the form do $[f(x_1.....x_k)]$, where $f \epsilon F$ and $x_1 .....x_k$ are terms. A syntactic construct of the form achieve[l] is a goal task, where l is a literal. A compound task is a syntactic construct of the form $[t(x_1 .....x_k)]$,where $t \epsilon$ T and $x_1 .....x_k$ are terms. Sometimes goal tasks and compound tasks are non-primitivetasks.[21]

A plan is a sequence σof ground primitive tasks.A task network is a syntactic construct of the form $[(n_1{:}\alpha 1)...(n_m : \alpha_m),\phi]$,where

- Each α_i is a task;
- $n_i \epsilon$ N is a label for α_i (to distinguish it from any other occurrences of α_i in thenetwork);
- Φ is a Boolean formula constructed from variable binding constraints such as (v=v′) and (v =c). The ordering constraints such

as (n ∃ n′) and state constraints such as (n ,l), (l, n) and (n, l, n′), where v, v′ ϵ V, l is a literal, c ϵ C and n, n′ ϵ N

Decomposition of Tasks

1. Initially the action a′ is removed from P. For each step s in the decomposition d′, chose an action to fill the role of s and add it to the plan. It can be either a new instantiation of s or an existing step s′ from P that unifies with s. It is called as subtask sharing.
2. The next step is the ordering constraints for a′ in the original plan to the step's in d′. The best solution for each ordering constraint is to record the reason for the constraint, then, when a high level action is expanded, the new ordering constraints can be relaxed as possible, consistent with the reason for the original constraint.
3. The final step is the casual links. If B→ a′ was a casual link in the original plan, replace it by a set of casual links from B to all the steps in d′ with preconditions p that are supplied by the start step in the decomposition d.(i.e., all the steps in d′ in which p is an external precondition)[21]

Constraints Satisfaction

A model M satisfies an operator if M interprets the primitive task associated with the operator. The primitive task is executable under the conditions specified in the preconditions of the operator and the effects specified in the post conditions of the operator.

For a nonhierarchical,the cost is O (b^n)in forward state-space planner with b allowable actions at each state. For a hierarchical task network planning, each non primitive action has d possible decompositions,each into k actions at the next lower level. If there are n actions at the primitive level, then the number of levels below the root is $\log_k n$, the number of internal decomposition nodes is $1+k+k^2+...+k^{\log_k n - 1}$ =(n-1)/(k-1). Each internal node has d possible decompositions, there are $d^{(n-1)/(k-1)}$ possible regular decompositions trees that can be constructed.[21]

If the k^{th} root of the nonhierarchical cost, if band d are comparable, keep d is small and k is large. It saves the comparisons of cost, when the library has a small number of long decompositions.

If the hierarchical task network planning has implemented in the mobile ad hoc network, long macros or functions are usable across a wide range of problems. The construction of a plan library containing known methods for implementing complex, high level of actions .One method is constructed the library is to learn the methods from previous problem-solving experience. After the experience of constructing a plan from scratch, the agent can save the plan in the library as a method for implementing the high level action defined by the task. The agent has become more and more competent over time as new methods are built on top of old methods. The important of the learning process is the ability to generalize the methods that are constructed, eliminating detail that is specific to the problem instance and keeping the key elements of the plan.

7 Conclusion

The proposed system is to implement theplanning for an agent to prevent the intruder attack in the network. Hierarchical task network planning [HTN] consists of two tasks in every cluster for planning the task to monitor and prevent the intruder to attack the system. It prevents the network to attack and recover the whole network. In future it can be implemented by using technology with hardware and software adopting, mobile agents.

References

More, S., Matthews, M., Joshi, A., & Finin, T. 2012. AKnowledge-Based Approach To Intrusion Detection Modeling. Security and Privacy Workshops IEEE Symposium on (pp. 75 -81), 2012.DOI: 10.1109/SPW.2012.26

Garcia, K.A., Monroy, R., Trejo, L. A., Mex-Perera, C., & Aguirre, E. 2012. Analyzing log files for postmortem intrusion detection. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 42(6) (2012), 1690-1704.DOI: 10.1109/TSMCC.2012.2217325

Shakshuki, E. M., Kang, N., &Sheltami, T. R. 2013. EAACK-A Secure Intrusion-for Manets. IEEE Transactions on Industrial Electronics, 60(3) (2013), 1089- 1098.DOI: 10.1109/TIE.2012.2196010

Namita Singh,& Uday Singh. 2013. Intrusion Detection and Self-Recovery System. International Journal ofComputer Science & Communication Networks, 4(3) (2013), 111-118.

Askrov, A., &Chong, S. 2012. Learning is change in Knowledge : Knowledge Based Security for Dynamic Policies. IEEE CS Security Foundation Symposium, 2012. DOI: 10.1109/CSF.2012.31

Anifowose, F. A., &Eludiora, S. I. 2012. Applications of AI in Network Intrusion Detection. World applied Programming, 2(3) (2012), 158-166.

Ponomarchuk, Y., & Seo, D. W. 2010. Intrusion detection based on traffic analysis in wireless sensor networks. In Wireless and Optical Communications Conference (WOCC), 2010 19th Annual (pp. 1-7), 2010.DOI: 10.1109/WOCC.2010.5510642

Picco, G.P. 2001. mobile agents: an introduction. microprocessors and Microsystems, 25(2) (2001), 65-74.https://doi.org/10.1016/S0141-9331(01)00099-0

Radhika, A., Kavitha, D., &Haritha, D. 2011. Mobile agent based routing in MANETS-attacks & defences. Network Protocols and Algorithms, 3(4) (2011), 108–121. DOI: https://doi.org/10.5296/npa.v3i4.1351

Sahadevaiah, K., &PrasadReddy, P. V. G. D. 2011. Impactof security attacks on a new security protocol for mobile ad hoc networks. Network Protocols and Algorithms, 3(4) (2011), 122–140. DOI: https://doi.org/10.5296/npa.v3i4.1364

Pfleeger, S. L., Predd, J. B., Hunker, J., &Bulford, C. 2010. Insiders Behaving Badly : AddressingBad Actors and their Actions. IEEE Transactions on Information Forensics and Security, 5(1) (2010), 169-179.DOI: 10.1109/TIFS.2009.2039591

Selker, T. 1994. COACH:A teaching agent that learns. Communications of the ACM, 37(7) (1994), 92-99. Doi: 10.1145/176789.176799

Network Simulator- ns-2. http://www.isi.edu/ nsnam /ns/.

Wikipedia, The Free Encyclopedia, Intrusion Detection System,http://en.wikipedia.org/wiki/intrusiondetection_system, 2011.

Yang, H., Luo, H., Ye, F., Lu, S., & Zhang, L. 2004. Security in mobile ad hoc networks: Challenges and solutions. IEEE Wireless Communications, 11(1) (2004), 38-47. DOI:10.1109/MWC.2004.1269716

Sevil Sen,John A, Clark. 2015. Intrusion detection in mobile adhoc networks using machine level approach

Erol, K., Hendler, J., & Nau, D. S. 1994. Semantics for hierarchical Task–Network Planning. Technical report Cs-TR-3239, 1994.

Cardoso, R. C., &bordini, R. H. 2010. A multiagent extension of hierarchical task network. workshop-escolo de sistemas de agents,seus ambientes e aplicacoes, 2010.

Nithiyanantham, P., & Shabreen, S. 2016. Detection and Neutralizing Multiple Spoofing Attackers using Packet Reception Rate and Inter Arrival Time. International Journal of Scientific Engineering and Technology Research, 05 (16) (2016), 3202-3207.

Stuart Russell, & peter Norvig. Artificial Intelligence, A modern approach. second edition, pearson educations.

Cluster Computing (2019) 22:S14027–S14034
https://doi.org/10.1007/s10586-018-2173-4

CrossMark

Honeypot TB-IDS: trace back model based intrusion detection system using knowledge based honeypot construction model

A. Umamaheswari[1] · B. Kalaavathi[1]

Received: 8 November 2017 / Revised: 8 February 2018 / Accepted: 13 February 2018 / Published online: 8 March 2018

Abstract

In current years, the use of mobile ad hoc networks (MANETs) has been extensive in many applications, counting some mission dangerous applications, and as such safety has become one of the foremost concerns in MANETs. Due to particular unique appearances of MANETs, prevention approaches alone are not satisfactory to make them protected; therefore, detection should be auxiliary as detection to attack that can break the system to hold packets. In general, the intrusion detection methods for traditional wireless networks are not well suited for MANETs. We propose a new Honey pot Deception trace back model, which is a honeypot TB-IDS. The system is positioned on the point of (server) network intrusion deceptions are nodes are carried out network weightage analyses model, from where it can monitors all the received traffic with continues weighing routes the data. It works as construct to reviews the transmission path and packet analyze to which the IP processed IDS for all the clients that are connected to the server. This TB-IDS detects both types of attacks like Anomaly based Intrusion Detection and Rule based Intrusion Detection system. First of all the System captures the packets from incoming traffic analyzes it and collects the information about the packet agent monitoring system. Once the Intruder is detected it is sent to honey pot to construct as mitigation point. Honey pot blocks the attacker from the network with knowing the information analysis to block the intruder.

Keywords NBIDS · Mobile ad hoc · Honeypot · Trace back model

1 Introduction

A mobile ad hoc network (MANET) is a self-configuring network that is formed automatically by a collection of mobile nodes without the help of a fixed infrastructure or centralized management [1]. Each node is equipped with a wireless transmitter and receiver, which allow it to communicate with other nodes in its radio communication range [2]. In order for a node to forward a packet to a node that is out of its radio range, the cooperation of other nodes in the network is needed; this is known as multi-hop communication [3]. Therefore, each node must act as both a host and a router at the same time. The network topology frequently changes due to the mobility of mobile nodes as they move within, move into, or move out of the network [4]. A MANET with the characteristics described above was originally developed for military purposes, as nodes are scattered across a battlefield and there is no infrastructure to help them form a network [5]. In recent years, MANETs have been developing rapidly and are increasingly being used in many applications, ranging from military to civilian and commercial uses, since setting up such networks can be done without the help of any infrastructure or interaction with a human [6]. Some examples are: search-and-rescue missions, data collection, and virtual classrooms and conferences where lap- tops, PDA or other mobile devices share wireless medium and communicate to each other [7]. As MANETs become widely used, the security issue has become one of the primary concerns. For example, most of the routing protocols proposed for MANETs assume that every node in the network is cooperative and not malicious [8]. Therefore, only one compromised node can cause the failure of the entire network.

✉ A. Umamaheswari
umamaheswariphd321@rediffmail.com

1 Mahendra Engineering College, K.S.R Institute for Engineering and Namakkal Technology, Thiruchengode, Tamil Nadu, India

Network Based Intrusion Detection System (NBIDS) is an independent platform that identifies intrusions by examining network traffic and monitors multiple hosts [9]. NIDS gain access to network traffic by connecting to a network hub. Host-based intrusion detection system (HIDS) consists of an agent on a host that identifies intrusions by analyzing system calls, application logs, file-system modifications (binaries, password files, capability databases, Access control lists, etc.) and other host activities [10]. Stack-based intrusion detection system (SIDS) consists of an evolution to the HIDS systems. The packets are examined as they go through the TCP/IP stack and, therefore, it is not necessary for them to work with the network interface in promiscuous mode [11]. This fact makes its implementation to be dependent on the Operating System that is being used. Anomaly Based IDS detects computer intrusions and its misuse by monitoring system activity and classifies it as either normal or anomalous, based on heuristics or rules, rather than patterns or signatures. This will detect any type of misuse that falls out of normal system operation [12]. This is as opposed to signature based systems which can only detect attacks for which a signature has previously been created. The Artificial Neural Networks can efficiently and effectively used to recognize what attack traffic is and normal system activity. Also another method known as strict anomaly detection is used to define the normal usage of the system, by using a strict mathematical model, and the flag to indicate any deviation. Rule Based IDS detects intrusions on a network by storing signature profiles and identifying patterns associated with network intrusions in a signature database and then generating classification rules based on the signature profiles [13]. Data packets transmitted on the network and having corresponding classification rules are classified according to generated classification rules. Classified packets are forwarded to a signature engine for comparison with signature profiles. Signature based IDS monitors' packets in the Network and compares with pre-configured and pre-determined attack patterns known as signatures [14]. The issue is that there will be lag between the new threat discovered and Signature being applied in IDS for detecting the threat. During this lag time your IDS will be unable to identify the threat.

The goal of this paper is to develop a user friendly, cost effective system with features such as to detect intrusions in the system using specified rules and some anomalies, it should run continuously with minimal human supervision, it also should impose a minimal overhead on the network where it is running to distinguish the difference between normal and abnormal traffic [15]. The Use of honeypot deception is considered so that attacker should not know he is being traced and his attack has failed.

2 Survey on exiting Intrusion detection system

Spitzner [16] host based intrusion detection system presented an intrusion detection system which informs system administrator about potential intrusion incidence in a system. The designed architecture employs statistical method of data evaluation that allows detection based on the knowledge of user activity deviation in the computer system from learned profile representing standard user be heavier.

Karthik et al. [17] network intrusion detection system NID is designed as a data mining framework to automatically detect attacks against computer networks and systems [18]. An unsupervised anomaly detection technique assigns a score to each network connection that reflects how anomalous the connection is proposed with association pattern analysis module to summarize those network connections that are ranked highly anomalous by the anomaly detection module.

Tambunan et al. [19] network intrusion detection system is proposed which embedded a NIDS in a smart-sensor-inspired device under a service-oriented architecture (SOA) approach [20]. Using this embedded NIDS can operate independently as an anomaly-based NIDS, or integrated transparently in a Distributed Intrusion Detection System (DIDS). It combines the advantages of the smart sensor approach and the subsequent offering of the NIDS functionality as a service with the SOA use to achieve their integration with other DIDS components [21]. It also addresses the construction of a physical sensor prototype. This prototype was used to carry out the tests that have demonstrated the proposal's validity, providing detection.

An Activity Pattern Based Wireless Intrusion Detection System was designed for wireless network [22]. It exploits pattern recognition techniques to model the usage patterns of authenticated users and uses it to detect intrusions in wireless networks. User activity is monitored and their discriminative features are extracted to identify intrusions in wireless networks. The PCA technique, used for accumulating interested statistical variables and compares them with the thresholds derived from users' activities data, has been employed in detection module. When the parameters exceed the estimated thresholds, an alarm is raised to alert about a possible intrusion in the network. The Activity Pattern Based Wireless Intrusion Detection System has the novel feature viz., light-weight design which requires less processing and memory resources and it can be used in real-time environment.

EAACK proposed and implemented a new intrusion-detection system named Enhanced Adaptive

Acknowledgment (EAACK) specially designed for MANETs. EAACK consists of three major parts, namely, ACK, secure ACK (S-ACK), and misbehavior report authentication (MRA). In order to distinguish different packet types in different schemes included a 2-b packet header in EAACK.

Moore and Al-Nemrat [23] Security and cooperation in wireless network is discussed in by considering the fact that most routing protocols in MANETs assume that every node in the network behaves cooperatively with other nodes and presumably not malicious, attackers can easily compromise MANETs by inserting malicious or non-cooperative nodes into the network.

Bhanu et al. [24] an artificial immune system based on holland's classifier as network intrusion detection proposed as a new method for network intrusion detection which is not aimed to provide a comparative study but to give more understanding on the feasibility of combining Artificial Immune System and Hollandâs Classifier to detect network intrusion [25]. This new Artificial Immune System, named AIS-CS, can attain higher than 90% intrusion detection with a false negative percentage below 10% and a fairly low false positive rate on a network composed of 50 regular nodes and 50 intruders.

Fern´andez et al. [26] having explored some intrusion detection methods, none of them is discussed for reactive intrusion detection and we propose a novel network Immune system which uses Heterogeneous activity pattern to perform mitigation of attacks which is based on reactive one.

2.1 Problematic mitigations in IDS

MANET network present additional security problems

- Mobile nodes are more vulnerable to capture or compromise.
- Proper routing operation of MANET depends on cooperation of all nodes—compromised nodes may disrupt entire network.
- No fixed infrastructure to support security, eg, authentication server—nodes must handle security by themselves.
- Any behavior outside of a "normal profile" is considered suspicious nodes.
- Typically statistical nodes are considered to detect Ids anal.

3 Implementation of proposed system

To provide security against cyber devices, proposed a new system as dynamic honeypot with deceptive virtual hosts and intrusion detection system. Proposed system consist of the following tasks

3.1 Main focusing of objective theme

- The primary purpose of performing intrusion detection is to help prevent the consequences caused by undetected intrusions. Implementing a programmer of effective security controls is an effective starting point for establishing the supporting security infrastructure.
- Real-time detection depends upon having a watchdog system that sits in the background and monitors all activities involving the connected devices.
- The monitoring system must be able to interpret various incidents and diagnose actual attacks.
- They have nearly real-time detection and response.
- Many current host-based systems can receive an interrupt from the operating system when there is a new log file entry.

3.2 Architecture for TB-IDS in honeypot MANET

Due to centralization of collected data the server is connected to multiple clients and is set to receive all incoming messages which are stored in knowledge database.

Anomaly detection systems The normal profiles (or normal behaviors) of users are kept in the system. The system compares the captured data with these profiles, and then treats any activity that deviates from the baseline as a possible intrusion by informing system administrators or initializing a proper response.

Misuse detection systems The system keeps patterns (or signatures) of known attacks and uses them to compare with the captured data. Any matched pattern is treated as an intrusion. Like a virus detection system, it cannot detect new kinds of attacks.

Specification-based detection The system defines a set of constraints that describe the correct operation of a program or protocol. Then, it monitors the execution of the program with respect to the defined constraints.

The presented TB-IIDS uses Rule-based and Anomaly-based intrusion detection technique (Fig. 1). The honeypot deception technique is implemented in this ID, so as to

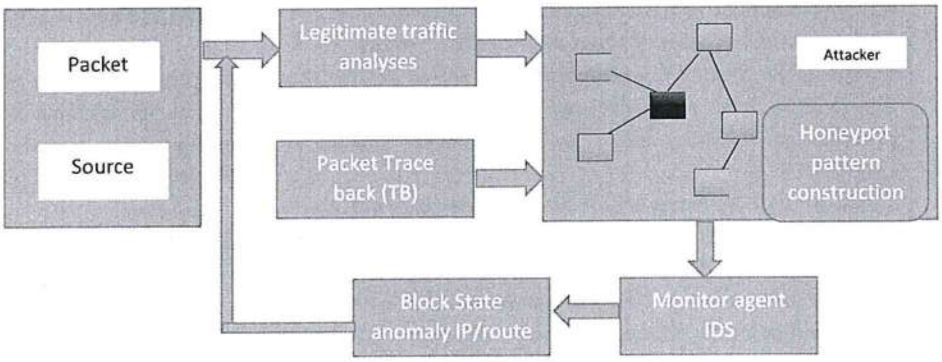


Fig. 1 Architecture: honeypot based intrusion detection system

detect the intrusion, without the knowledge of the attacker who will still keep on attacking thinking that his attack is successful but actually he will not be able to penetrate into actual system. In this way enough time is available to detect the attacker and his activities. The system is designed in this presented work is such that it is very fast because of the less access time, it is cost effective and user friendly.

3.3 Weightage analyses in honey pot IDS

From the extracted feature and the activity pattern of the packet arrived, the intrusion detection system reads the service history from the data base. The service history has logs about previous malicious packets and their patterns, the proposed method compares with each of the pattern from the log.

3.3.1 Routing knowledge analysis in home agent

Routing from home agent is present in each system and it gathers information about its system from application layer to routing layer. Our proposed system provides solution in three techniques. (1) It monitors its own system and its environment dynamically. It uses honeypot construction to find out the local anomaly. (2) Whenever the node want to transfer the information from the node F to B. It broadcast the message to E and A. Before it transmits data, it gathers the neighboring nodes (E &B) information using mobile agent route the valid path to. It calls the rule to find out the attacks with help of test train data. (3) It provides same type of solution throughout the global networks. It has been explained in the following section.

(1) *Monitoring current node* home agent is present in the system and it monitors its own system continuously. If an attacker sends any packet to gather information or broadcast through this system, it calls the classifier construction to find out the attacks. If an attack has been made, it will filter the respective system from the global networks.
(2) *Neighboring node honeypot point* any system in the network transfer any information to some other system, it broadcast through intermediate system. Before it transfer the message, it send mobile agent to the neighboring node and gather all the information and it return back to the system and it calls classifier rule to find out the attacks. If there is no suspicious activity, then it will forward the message to neighboring node.
(3) *Data collection* data collection module is included for each anomaly detection subsystem to collect the values of features for corresponding layer in a system. Normal profile is created using the data collected during the normal scenario. Attack data is collected during the attack scenario.
(4) *Data preprocess* the audit data is collected in a file and it is smoothed so that it can be used for anomaly detection. Data preprocess is a technique to process the information with the test train data. In the entire layer anomaly detection systems, the above mentioned preprocessing technique is used.

3.3.2 Cross feature analysis for honeypot construction

Each feature or character vector f in the training data set, calculate honey pot construction C, for each feature fi using {f1, f2…fi -I, fi+.-f k} - Ci is learned from the training data using honeypot construction model. The probability P. (filfl, f2 …,I fi- i, f+1,…,fk) is learned. Compute the average probability for each feature vector f, and save in a probability distribution matrix M. A decision threshold 0 is learned from the training data set. Normal profile is created using the threshold value. If the probability is greater than threshold value it is labeled as normal, otherwise it is labeled as abnormal anomaly detection

Algorithm: 3.1

Input: Packet Feature PV, Activity pattern Ap, Access History (HA) from network.

Output: Legitimate weight and access packet from honey point.

Step1: start

Step2: read the extracted feature Pv, Activity pattern Ap, Access History Ah.

Step3: read the access history Ah from data base and retrieve the feature set AF.

step4: for each time window Twi from Tw

Compute average connections Ac = Compute average stream AStream= Tc-total number of connections at time window Twi.

End.

step5: if Ac>μ and Astream > ß then

retrieve subset of access records related to the source ip and port of the received packet dp.

Ha=ϕ(AF(Dp(sip),Dp(sp))).

for each record in Ha

Compute hp =hp+(Ha(hp)).

Compute Pl = pl+(Ha(pl)).

Compute TTL = ttl(Ha(ttl)).

End.

Compute average values of hp,pl,ttl

Ahp = (hp/tah) – tah is the total number of records in HA.

Analyze malicious node

Read malicious history details and extract the same related to source ip and port of dp.

MAh=ϕ(MAF(Dp(sip),Dp(sp))).

Compute malicious access history MAF.

Trace back malicious access raised from the source ip and port.

Compute legitimate weight

Lwp =((hp(Pv)/Ahp) ×(pl(Pv)/Apl) × (ttl(Pv)/Attl))

If(Lwp>= Lth)

Forward packet to service handling

Else

Reject the packet and add the packet feature to the malicious history.

End.

Step6. Stop.

Packets that have been processed by the honeypot server are considered as a suspicious activity and are then collected. Once processed by the honeypot, the packet will be incorporated into the data honeypot. Packs of honeypot data are processed into a set of data that has been processed from the honeypot-honeypot server, synchronized and the data considered as an assault.

3.4 Honeypot monitor pattern

Once the intrusion is detected the intruders IP is blocked and turned into the Honeypot then honeypot collects the information about Intruder If the content of packet is matched with the attack patterns then packet coming from this host are blocked and forwarded to honeypot. The honeypot actually blocks the packets. At the same time the

IP address and attack type are added to database called Intruder List.

Algorithm 3.2

Input: raw packet- dp

Output: Packet trace back Pv, Access History Ah.

Step1: start

Step2: read input packet **dp**.

Step3: convert raw packet into IP Packet Pip.

Step4: read source Ip address of packet IP.

Pip = IP(Sip).

Step5: read source port sp of IP.

Sp = IP(sp).

Step6: extract TTL from IP

TTL = IP(ttl).

step7: compute Payload details Pl.

Pl = data_size(Np).

Step10: construct packet tarceback PV.

Pv = {Pip, Sp, NC, Pl, TTL}.

step11: stop.

If packets are sent by a legitimate user then they are forwarded to clients attached in network through real server. Therefore, Snort will check both the IP header information and the payload data of the captured packet against this signature. When more than one rule exists, we can use the priority field to set the priority level for every rule and the sid field to set the alert ordering.

4 Result and discussion

The proposed TB-IDS activity pattern based network immune system has produced good results. Unlike other immune system, the proposed system addresses both connection and packet based attacks using activity pattern. Simulations are carried out Microsoft frame work sniffer tool. We compute the legitimate traffic analyses model weight based on the connection to construct the honeypot. Based on the estimation of routing valid to the packet is allowed to pass into the network to get service. So the proposed approach has good frequency in finding malicious packets and reducing the attacking rate.

Graph 1 shows the result of the proposed system in finding malicious packet and if there are 100 packets which are malicious arrived on time, then the graph shows the frequency of detection of malicious packet. It is very clear that the proposed system identifies the more malicious packet compared to other host based and activity pattern based intrusion detection systems

Graph 2 shows the time complexity of the proposed system compared to other methodologies. It shows clearly that the proposed system takes only a little time compared to other methods for different number of packets. The other methods take more time compare to the proposed system to analyses and detect the intrusion for number of packets.

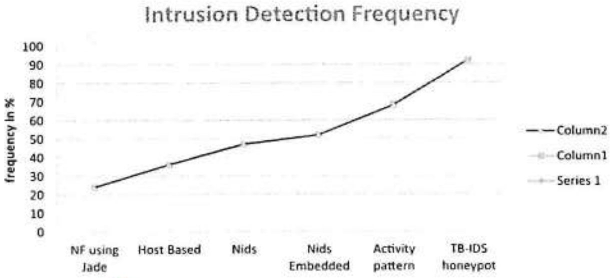
The frequency is analyzed through repeated concurrent monitoring detection rate of packet flow by honey pot construction deception rate.

Graph 3 shows the performance analysis of the proposed system compared to other methodologies. It shows clearly that the proposed system high performance compared to other methods for detecting IDS. The other methods take more time compare to the proposed system to analyses and detect the intrusion for number of packets.

Graph 4 shows the intrusion detection rate of the proposed system compared to other methodologies. It shows clearly that the proposed system had higher detection accuracy compared to other methods for detecting IDS.

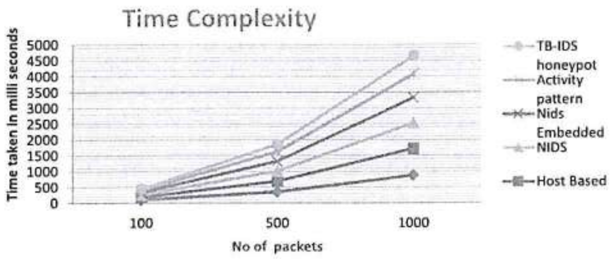
5 Conclusion

They efficient time independent observation is to conclude the Trace back honeypot deception based network immune system is to find the malicious packet and mitigation attacks to get optimized resultant. Unlike other methodologies, the new system uses various parameters to find the malicious packets. The proposed TB-IDS honeypot method finds the malicious nodes in an efficient way and increases the frequency of intrusion detection and reduces the threat. The proposed method increases the overall throughput of the network. The proposed method can be further improved by adapting various other features at different layers.

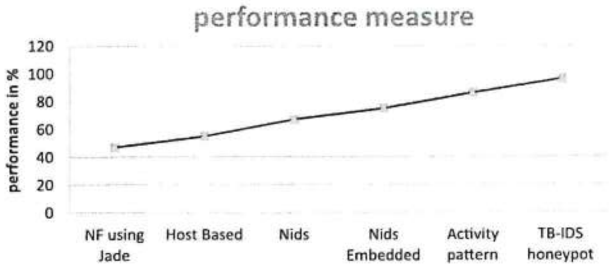


Graph 1 The frequency detection of malicious packet

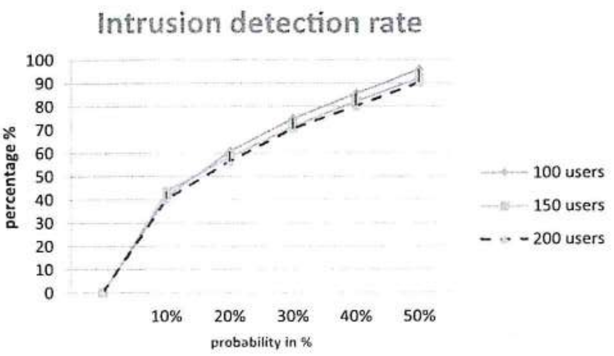
PRINCIPAL,
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.



Graph 2 The time complexity of the proposed system



Graph 3 The performance analysis of proposed system



Graph 4 The intrusion detection rate of proposed system

References

1. R. Akbani, Korkmaz, T., Raju, G. V. S: Mobile ad hoc network security. In: Lecture Notes in Electrical Engineering, Springer, vol. 127 (2012)
2. T. Anantvalee and Wu, J.: A survey on intrusion detection in mobile ad hoc networks. In: Wireless/Mobile Security. New York: Springer (2008)
3. Elhadi, M., Shakshuki, EAACK.: A secure intrusion-detection system for MANETs. In: IEEE Transactions on Industrial Electronics, vol. 60(3) (2013)
4. Gungor, V.C., Hancke, G.P.: Industrial wireless sensor networks: challenges, design principles, and technical approach. IEEE Trans. Ind. Electron. **56**(10), 4258–4265 (2009)
5. Haldar, N.A.H.: An activity pattern based wireless intrusion detection system. In: Information Technology: pp. 846–847 (2012)
6. Shen, J.: Network intrusion detection by artificial immune system, IECON, pp. 716–720 (2011)
7. Khattab, S., Gobriel, S., Melhem, R., Mosse, D.: Live baiting for service-level DoS attackers. Proceeding of the IEEE INFOCOM (2008)
8. Maciá-Pérez, F.: Network intrusion detection system embedded on a smart sensor, industrial electronics. IEEE Trans. **58**(3), 722–732 (2012)
9. Randiranosolo, A.S.: An Artificial immune system based on Holland's classifier as network intrusion detection. Mach. Learn. Approaches **1**, 504–507 (2012)
10. Sridevi, R.: Genetic algorithm and artificial immune systems: a combinational approach for network intrusion detection. In: Advances in Engineering sciences and Management, pp. 494–498 (2012)
11. Thai, M.T., Xuan, Y., Shin, I., Znati, T.: On detection of malicious users using group testing techniques. In: Proceeding of the International Conference Distributed Computing Systems (ICDCS) (2008)
12. Vokorokos, L.: Host based intrusion detection system In: Intelligent Engineering Systems (INES), pp. 43–47 (2010)
13. Sumner, K.: Honeypots security on offense, security architecture vol. 774(716) (2012)
14. Kheirkhah, E., Amin, S.M.P.: Experimental study of SSH attacks by using honeypot decoys. Indian J. Sci. Technol. **6**(12), 5567–5578 (2013)
15. Spitzner, L.: Honeypots: Tracking Hackers. Addison-Weasley, Boston (2013)
16. Spitzner, L.: The value of honeypots, part one: definitions and value of honeypots. Security Focus (2001)
17. Karthik, S., Samudrala, B., Yang, A.T.: Design of network security projects using honeypots. J. Comput. Sci. Coll. **20**(4), 282–293 (2014)
18. Dankova, E et al.: An anomaly-based intrusion detection system, In: Electrical Engineering and Informatics 2, Kosice, ISBN 978-80-553-0611-7 (2011)
19. Tambunan, B., Raharjo, W.S., Purwadi, J.: Implementation of honeypot detection and intrusion prevention system. ULTIMA Comput. **5**, 1–7 (2013)
20. Joshi, R.C., Sardana, A.: Honeypots: A New Paradigm to Information Security. Science Publishers, Rawalpindi (2011)
21. Joseph, S.G.: Advanced honeypot architecture for network threats quantification. Int. J. Sci. Eng. Appl. Sci. **15**, 2395–3470 (2015)
22. Wafi, H., Fiade, A.: Implementation of a modern security systems honeypot honey network on wireless networks . EEE (2017)
23. Moore, C., Al-Nemrat, A.: Analysis of Honeypot Programs and the Attack Data Collected. Springer International Publishing Switzerland, Cham (2015)
24. Bhanu, S., Khilari, G., Kumar, V.: Analysis of SSH Attacks Darknet using Honeypot. Int. J. Eng. Dev. Res. (IJEDR) **3**(1), 348–350 (2014)
25. Narote, S., Khanna, S.: dvance honeypot system for analysing network security. Depart. Comput. Eng. **19**, 65–70 (2014)
26. Fern´andez, D., Ruiz, F.J., Bellido, L., Pastor, E., Omar, W., Mateos, V.: Enhancing learning experience in computer networking through a virtualization-based laboratory model. Int. J. Eng. Educ. **32**(6), 2569–2584 (2016)

A. Umamaheswari received a Bachelor's degree in Computer Science and Engineering from Madras University in the year 1997. Then received Master's degree in Computer Science and Engineering from Anna University in the year 2002. She is working as a Assistant Professor in the Department of Computer Science and Engineering at Mahendra Engineering college. Her research interests include Mobile Ad Hoc Network, Artificial Intelligence and Machine Learning.

B. Kalaavathi received a Bachelor's degree in Computer Science and Engineering from Bharathiyar University in the year 1993. Then received Master's degree in Computer Science and Engineering from Pondichery University in the year 2000 and she has completed her Ph.D from Periyar University in the year 2010. She is working as a Professor and Head in the Department of Computer Science and Engineering at K.S.R Institute for Engineering and Technology. Her research interests include Distributed Computing, Mobile Ad Hoc Network and Machine Learning.

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

Cluster Computing (2019) 22:S12767–S12776
https://doi.org/10.1007/s10586-018-1757-3

CrossMark

An heuristic cloud based segmentation technique using edge and texture based two dimensional entropy

M. Jaganathan[1] · A. Sabari[2]

Received: 9 October 2017 / Revised: 3 January 2018 / Accepted: 6 January 2018 / Published online: 15 January 2018

Abstract

The Edge detection will localize the objects and their boundaries within an image which is a basis for various image analysis and the applications of machine vision. There are conventional approaches to edge detection which are expensive in terms of computation as each set of such operations are conducted for every pixel. In case of approaches that are conventional the time taken for computation will increase with that of the image size. The edge detection is used extensively in case of image segmentation of the medical images. An Ant Colony Optimization algorithm consists of many advantages such as parallelism, robustness and easy computation.The Glowworm Swarm Optimization (GSO) is that probabilistic technique which is used for finding the optimal paths that are connected completely in the guided search by means of using the information on brightness. The technique is also used for solving problems in computation that are reduced in finding. In case of the GSO algorithm where the insects move in a search space that is dictated probabilistically by using transition probabilities. In this work, a heuristic cloud based segmentation is performed using edge method and texture based 2-Dimensional entropy. The results have shown that this method proposed has achieved better performance.

Keywords Image segmentation · Edge detection · Texture · Parallel processing · Ant Colony Optimization (ACO) and Glowworm Swarm Optimization (GSO)

1 Introduction

The image segmentation is the challenging mechanism in digital image process which is used to segment an image into many parts with similar properties. The aim of such a segmentation is simplification that represents an image in an analysable way. The goal of such an image segmentation will be the division of the image into many parts or segments that has similar attributes [1]. The very basis applications in image segmentation will be the content based retrieval of images, the medical imaging, the object detection and tasks of recognition, along with that of the automatic traffic control systems as well as a video surveillance. Image segmentation can further be classified into two different types which are the local segmentation (connected to a certain region or part of the image) and also the global segmentation (connected to segmenting of the entire image that can contain large pixels). The techniques of Image segmentation are edge detection, region based, fuzzy theory based and artificial neural network based image segmentation.

The edge detection techniques [2] is defined as the transform of images to the edge images by means of benefiting from the changes made of the grey tones. The edge detection will divide images by observing the change in the pixels of their intensity. These edges will be the sign of the lack of ending and also the continuity. Resulting from this type of transformation, the edge image will also be obtained without having to encounter any such changes in the physical qualities of the main image. The edge of image includes a significant local change in the intensity that is associated normally with the discontinuity of the image intensity or the first imitative of any of the image intensity. The edge will be that set of connected pixels that lie within the boundary among two different regions differing in their grey value and so these pixels in the edge will be known as the edge points. The edges are distinguished by means of estimating the gra-

✉ M. Jaganathan
jaganbecs@gmail.com

A. Sabari
asabari@gmail.com

1 KSR Institute for Engineering and Technology, Tiruchengode, India

2 K. S. Rangasamy College of Technology, Tiruchengode, India

dient and its intensity. The edge is that local concept and will not form any closed path. There are three steps in edge detection such as the filtering (for reduction of noise), the enhancement (for computing a gradient magnitude) and the detection (for determining edge points).

In Segmentation based on Thresholding theimage segmentation using thresholding will be a powerful technique that is used for segmenting the foreground or even an object from that of a specific background [3]. This technique dependson the image qualities. The foreground is also lighter than that of the background for such detection. Separating of such objects from a background will be done by using a value T called the thresholding value in accordance to the algorithm. Considering pixel (x, y) having a value that is greater or equal to the value of threshold which is $f(x, y) \geq T$ then object will be taken as a foreground and in case $f(x, y) \leq T$ then this will be considered as a background. Based on this value there are two different techniques that are described which are the global (single) thresholding and the local thresholding.

Region-based segmentation method is based on the region and this can further divide the entire image as sub regions that completely depend on certain rules like the pixels in a region that has a similar grey level [4]. The techniques that are region based will depend on the patterns that are common based on that of the intensity values inside a cluster of such neighbouring pixels. This cluster is known as the regions and the goal of this type of segmentation algorithm will be to group the regions in accordance to their anatomical or also their functional roles. When they are compared to the method of edge detection, these segmentation algorithms that have been based on the region that will be taken as a relatively simple and also an immune one to any noise. The methods that are Edge based will have to partition the images that are based on the changes that are rapidly made to that of the near intensity which are all regions based. Such types of segmentations algorithms will be based on the region and will also include methods of the region growing, the merging or the region splitting.

In the Fuzzy theory based image segmentation, the Fuzzy set theory will be used for the analysis of images and will also provide information that is accurate for any image. The function of fuzzification may be used for removal of noise and the grey scale image may also be transformed within a fuzzy image using the function of fuzzification. There are various morphological operations that are combined using a fuzzy method for getting better results. The fuzzy k-means and also the Fuzzy C-means (FCM) are used widely in case of image processing [5].

In artificial neural network (ANN) based image segmentation, each neuron will correspond to the image pixel. The image will be mapped to that of the neural network and the image as neural network will be used as training samples and the connection that exists between neurons which are the pixels that are found. These new images will also be segmented from the trained images. Some of such commonly used neural network for their segmentation of images will be the Hopfield, the Back Propagation Neural Network (BPNN) and the Feed Forward Neural Network (FFNN). These types of image segmentation uses the neural network using the pixel classification and the edge detection.

The choice of this type of a threshold value that is suited in the very challenging task and their images. The thresholding value will further depend on the randomness of such distribution of intensity of images. The Entropy is a parameter used for measuring the randomness of these distribution of images. The Shannon-entropy based and also the Non-Shannon (the Renyi, the Collision and the Min) in which the approaches that are entropy-based will be used for the selection of threshold values. For the main purpose of such evaluation the Peak Signal to Noise Ratio (PSNR) and the Uniformity (U) that are parameters used [6].

To understand and clarification of the Synthetic Aperture Radar (SAR) images, the image segmentation acts a main role. This is because whenever the SAR image segmentation is disturbed, the global threshold estimation can be observed as a search procedure for suitable integer in a continuous integer interval.

The image texture that is perceived by humans will be a visualization of the patterns that are complex and that have a spatially organised and repeated sub-patterns that have a uniform appearance [7]. This can demonstrate a certain size, colour, brightness, randomness, smoothness, roughness and granulation. In case of medical images the internal structure of the organs or human tissues are described. As a consequence, the analysis of text image will play a critical role in interpreting the images of capsule endoscopy. Detecting abnormal changes will include the investigation of the properties of texture that includes a healthy small intestine that has intestine mucosa creating a particular pattern inside the image. The humans assess the texture will qualitatively using a quantitative analysis of texture is needed. There are several algorithms that are used for performing computations.

Cloud computing is a new model of computing that provides a large resource for computing in a pay per use method. This has several promising traits that help in the healthcare industry. The Service Oriented Architecture (SOA) for the building of any cloud service is used by the general public and the medical personnel for image processing that is reliable. Resource integration for could and the "ImageJ", will be the processing of software in a could service. This has resulted in worldwide applications that will gain access to that of the cloud service. A medical imaging system for the ultra sound image using cloud is developed. There were encouraging results that are feasible in the help of cloud for helping in the ultrasound imaging [8].

A Parallel computing is a simultaneous usage of the many computing resources for solving problems in computation and for maximizing the parallel computing benefits will contain many independent subtasks. For removing the noise new pixels that are independent are calculated and a parallel computing is implemented in the Central Processor (CPU), and also the Graphical Processor (GPU). This article will describe the noise removal algorithm my using parallel computing in GPU. Even though the removal of digital noise among images are investigated an initial reference will be given in the article. Researchers are not focused on the performance of the algorithm and the results are considered important [9].

In image compression, the wavelet transform has enlarged acceptance. In Discrete Wavelet Transform (DWT), signal energy focuses to a detailed wavelet coefficients which is useful for compressing images.

A Nature-inspired computation will now have an attention in the recent decades and most of such popular algorithms in this are the Evolutionary Algorithms (EAs) and the Swarm Intelligence (SI). The EAs, like the Genetic Algorithm (GA), have been inspired with the natural selection and also the survival of the fittest [10]. The SI, like that of other algorithms like the Artificial Fish Swarm (AFS) algorithm and the Particle Swarm Optimization (PSO) algorithm, that are enlightened by using the behaviour of animal foraging. These methods being simple are covered all related fields that have also included image enhancement, de-noising of image, image fusion, edge detection, image retrieval, image registration, image compression, image retrieval, image segmentation and finally texture classification. Like in the case of inspired algorithms, some researchers have also proposed the behaviour of the honey bees in the recent years. The popular ACO or the GSO algorithm may be proved to be better than the Differential Evolution (DE), the EA, the GA and the PSO algorithm.

Here in this work the ACO, the GSO, the Parallel ACO (PACO) and the parallel GSO of the image segmentation are used and the rest of the investigation has been organised as: the related work in literature are described in Sect. 2. Section 3 describes methods used, Sect. 4 the experimental results and the conclusion is shown in Sect. 5.

2 Related works

Pont-Tuset et al. [11] proposeda unified approach for the image segmentation of the bottom-up hierarchy and object generation that is known as the Multiscale Combinatorial Grouping (MCG). An algorithm was developed with the fast normalized cuts and then a high performance one for using multiscale information. A grouping strategy was proposed that combines the various multi-scale regions in the object by exploring their combinatorial space and presented the Single-scale Combinatorial Grouping (SCG), which is a Multi-scale Combinatorial Grouping (MCG) producing competitive proposals within about just five seconds for each image.

Wen et al. [12] proposed an image segmentation model that are obtained from the reaction–diffusion equations and with their level set mechanism. Diffusion was used to regularize a level set function and reaction consists of all the desired signs of property for forcing a level set function. This may also be initialized to bounded functions (like a constant function). This proposed model will be applied to a very wide range of images that have results that are promising for the real images and the work will give a new method for investigation of the diffusion of the equations directly for segmenting.

Zhou et al. [13] proposed anew region-based active contour model for segmenting the medical image in a level set construction. A unified fitting energy framework that has been based on the distributions of Gaussian probability for obtaining a Maximum a Posteriori probability (MAP) and its estimation. An energy term that contains a global term of energy for characterizing a fitting of the Gaussian distribution in accordance to that of the intensities both inside and outside this evolving curve. In this, the contour evolution minimising the associated energy, this global energy term will accelerate the evolution of such evolving curves as well as the local energy term will guide all the evolving curves that are near to the objects for stopping boundaries.

Niu et al. [14] also made a proposal of another novel region based model for the object segmentation or image structures that introduced a local similarity factor that depends on the distance of local spatial located inside a local window and a difference in local window for improving the results of segmentation. By means of using this type of a similarity factor this method that has been proposed will be able to extract accurately the object boundary at the same time guaranteeing some robustness of noise. Also, this system that has been proposed will avoid completely the pre-processing steps that are typical to that of a segmentation of the region based contour model and also the experiments that are performed on these synthetic images and also all the real world images have demonstrated that this proposed algorithm which is compared with the other state of the art algorithms is found to be even much more robust to the manifestations of a higher noise level in images.

Sarkar et al. [15] had made a proposal for unsupervised classification of the land cover investigation of the hyper spectral satellite images for improving the separation among that of the objects and their background with a multi-level thresholding that is based on Maximum Rényi Entropy (MRE). These multi-level thresholding that divides another grey level image as homogeneous regions is a popular tool in segmentation. There is one more hyper spectral image analysis called the DE that is an evolutionary algorithm which is in the current interest. The DE's performance has been extensively investigated by means of using a comparison of a well-known nature that is inspired by the global techniques of optimization.

Lahmiri and Boukadoum [16] made one more of a sequential system for de-noising and segmenting an image that had been contaminated with the Gaussian noise. Fourth-order Partial Differential Equation (PDE) filter cancelled the noise and the PSO was used for the segmentation. Experimental test based on a chest X-ray in various levels of Gaussian noise was performed in a better way. Test based on the Jaccard and the Dice statistics for proposed method outperforms in a better way than other method.

Bose and Mali [17] further made another proposal of an image segmentation algorithm that combined Artificial Bee Colony optimization (ABC) and Fuzzy C Means (FCM) calling it the Fuzzy-based ABC (FABC) where fuzzy membership function for the purpose of searching optimum cluster centres that used the ABC. This FABC is found to be much more efficient than the other techniques like the Genetic Algorithm (GA), the PSO along with the Expectation Maximization (EM) algorithms. The FABC will be able to overcome the drawbacks of the FCM and does not depend on choosing initial cluster centres and is better in convergence, robustness and accuracy of segmentation. This becomes even more efficient as it takes advantage of the characteristics of this ABC for initializing the cluster centres.

Zhao et al. [18] further presented one more segmentation algorithm that was based on the two-dimensional (2D) Kullback–Leibler (K–L) divergence and also the Modified PSO (MPSO). This approach makes another combination of the 2D K–L divergence among images and their segmented results by means of adopting the 2D histogram and also employs the divergences of these regions as the MPSO fitness function tends to improve the aaccuracy of image segmentation. This proposed 2D K–L divergence has improved the accuracy of such image segmentation and the MPSO will be able to overcome the premature convergence and its drawbacks.

Rajinikanth et al. [19] also made a proposal of a colour image segmentation by means of using the Cuckoo Search (CS) algorithm. This proposed technique performed based on the validation of all these Bacterial Forage Optimization (BFO) and also the PSO. CPU time is the parameter used to evaluate in quantitative and qualitative way. Other parameters presented are Mean Structural Similarity Index Matrix (MSSIM), Normalized Absolute Error (NAE), Structural Content (SC) and PSNR. This segmentation procedure that was implemented will be verified by means of using the image dataset that has been smeared with the Gaussian Noise (GN) and Speckle Noise (SN). According to investigation, the CS algorithm and also its multi-level segmentation has offered the best of results compared to that of the BFO and the PSO.

Singla and Patra [20] made one more presentation of a threshold that was fast and context sensitive for solving problems of segmentation. In connection with the histogram this technique will employ these problems of images segmentation. The initial thresholds will also be chosen in the middle of two such consecutive peaks on that of the energy curve. After which a measure of cluster validity being the optimal number of each threshold can be determined. Lastly, the GA can detect this optimal value for this threshold from their bounds. This technique that is proposed will incorporate all these spatial contextual information of images in this threshold section in their process of selection with no loss to the benefits of the techniques based on histogram and this is very efficient in terms of computation.

3 Methodology

This section discusses the ACO, the GSO, the PACO and the parallel GSO methods.

3.1 Problem formulation

If there are L intensity levels in every component, like that of the three colour components for the images of the RGB in a given image [21], the levels will be in the range {0, 1, 2, . . ., L - 1}. Then, it is defined as in (1):

$$p_i^C = \frac{h_i^C}{N} \sum_{i=0}^{L-1} p_i^C = 1 \tag{1}$$

In which i represents a particular level of intensity which is, $0 \leq i \leq L - 1$; C denotes the image components that are C = {R, G, B} for the RGB images; N indicates the total pixel number and h_i^C denotes the actual number of pixels for an intensity that corresponds the level of intensity i in a component C. The h_i^C will represent image histograms for component C normalized as a probability distribution p_i^C. The actual total mean (or the combined mean) of every component images may be calculated easily as (2):

$$\mu_T^C = \sum_{i=0}^{L-1} i p_i^C = 1 \tag{2}$$

Here the n-level thresholding presents the $n-1$ threshold levels t_j^c, $j = 1, ..., n-1$, and this operation will be performed as (3):

$$F^C(x, y) = \begin{cases} 0, & f^C(x, y) \leq t_1^C \\ \frac{1}{2}\left(t_1^C + t_2^C\right), & t_1^C < f^C(x, y) \leq t_2^C \\ \vdots & \\ \frac{1}{2}\left(t_{n-2}^C + t_{n-1}^C\right), & t_{n-2}^C < f^C(x, y) \leq t_{n-1}^C \\ L-1, & f^C(x, y) > t_{n-1}^C \end{cases} \tag{3}$$

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

In which x and y denote the width (W) and the height (H) of pixels of image of a size H × W that is denoted by $f^c(x, y)$ along with the L intensity levels for each such component. Here, all pixels in a given image is divided as n classes $D_1^c, ..., D_n^c$, that represent many objects and some specific features for them like the topological features and the chances of the w_j^c of classes $D_1^c, ..., D_n^c$ are by (4):

$$w_j^C = \begin{cases} \sum_{i=0}^{t_j^C} p_i^C, & j = 1 \\ \sum_{i=t_{j-1}^C+1}^{t_j^C} p_i^C, & 1 < j < n \\ \sum_{i=t_{j-1}^C+1}^{L-1} p_i^C, & j = n \end{cases} \tag{4}$$

Here the mean for each class μ_j^c is calculated as (5):

$$\mu_j^C = \begin{cases} \sum_{i=0}^{t_j^C} \frac{p_i^C}{w_i^C q}, & j = 1 \\ \sum_{i=t_{j-1}^C+1}^{t_j^C} \frac{p_i^C}{w_i^C}, & 1 < j < n \\ \sum_{i=t_{j-1}^C+1}^{L-1} \frac{p_i^C}{w_i^C}, & j = n \end{cases} \tag{5}$$

One of the simplest and most efficient methods in obtaining threshold will be to maximize the between class variance of the components defined by (6):

$$\sigma_B^{c^2} = \sum_{j=1}^{n} w_j^C (\mu_j^C - \mu_T^C)^2 \tag{6}$$

In which j is a specific class where w_j^c and μ_j^c will be the probability of occurrence and mean of class j. It can also mean that the problem in n-level has been reduced to the problem of search for thresholds in optimization of these thresholds t_j^c which will maximize objective functions (which are fitness functions) of every image component C, that is generally defined as per (7):

$$\varphi^C = \max_{1 < t_1^C < ... < L-1} \sigma_B^{c^2}(t_j^C) \tag{7}$$

The Computing of the aforementioned problems of optimization include a high level of computational complexity as its number of such threshold levels and this increases the image components. Several optimization method have been proposed in literature and only recently the methods that are biologically inspired like the ACO and the GSO are used as alternatives that are computationally efficient are used in place of the analytical methods for solving the problems of optimization.

3.2 Ant Colony Optimization (ACO)

The ACO is that paradigm for the designing of metaheuristic algorithms in the problems of optimization that are combinatorial. The first algorithm had been proposed by Colorni, Dorigo and Maniezzo in the year 1991, known as the Ant System (AS). From that time there have been several variants of the basic principles that have been reported like the Ant Colony System (ACS) and the Max– Min Ant System (MMAS).

The idea behind the ACO has been inspired by the behaviour of ants and it was found that they can identify the optimal path from a nest to that of the source of food in surroundings that are complicated. If the path is broken the ants can find the optimal paths by bypassing obstacles [22]. At the time of foraging the ants can transfer mutually the release of pheromone to guide its own direction. The ants also will move to the trails of the high intensity of Pheromone and if many ants choose the same path the pheromone in the path will be increased and the ants will subsequently choose the path and this is called the process of positive feedback. The main purpose of the ants that are foraging have realised by the exchanging of the individual information. Image segmentation includes the ACS principles is mentioned as shown:

Every pixel X_j, $j = 1, 2, ..., N$ of image X will be considered as one ant that is an eigenvector of a grey value. The process of the ants identifying the source of food will be considered as the segmentation of image. The Euclid distance d_{ij} from that of the random pixel X_i to the pixel X_j has been calculated by (8):

$$d_{ij} = \sqrt{\sum p(X_i - X_j)^2} \tag{8}$$

In which p denotes a weighting factor.

The probability of choosing p_{ij} from the X_i to X_j is being computed by (9):

$$p_{ij} = \left\{ \begin{array}{l} \frac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{i \in S} \tau_{is}^{\alpha}(t)\eta_{is}^{\beta}(t)\ j \in S} \\ otherwise \end{array} \right\} \tag{9}$$

In which τ_{ij} is a pheromone; $\eta_{ij}(t)$ being heuristic leading function; α and β the influence factors; here S will be the aggregate of these passed paths [23]. ....With the ants moving, the pheromone in each path will be adjusted by using (10) after a single circulation.

$$\tau_{ij}(t+1) = \rho\tau_{ij}(t) + \Delta\tau_{ij} \tag{10}$$

In which the ρ denotes the factor of attenuation of pheromones and $\Delta\tau_{ij}$ denotes the pheromone increment for every path in the present circulation in (11).

$$\Delta\tau_{ij} = \sum_{k=1}^{N} \Delta\tau_{ij}^k \tag{11}$$

In which $\Delta\tau_{ij}^k$ denotes the rest of the kth ant pheromone in this circulation.

3.3 Glowworm Swarm Optimization (GSO) algorithm

The GSO algorithm has been inspired from biological behaviour of the glow work for attracting mates and their prey by using a natural emission of light. This was like the brighter the light the more the attraction and the pattern of the glow worm's movement will depend on the luciferin intensity and this will change every time owing to the neighbours. Additionally, the local range of decision will also be affected by the various glow worms among neighbours. This may be described in case the glow worm being very small and this will enable an increase in the range of local decision for identifying glow worms. As a result of this they gather a range for a better positon and normally the GSO algorithm has been divided into four different phases [24]:

Phase 1—the initialization at the time of initialization a solution space for the 'population size' will be randomly generated inside the limits of the feed rate, the cutting speed and the cut's depth. Here both the parameters of the size of population of the glow worms (n) and their maximum iteration ($t_{\max}$) will be set to 27. The other setting of parameters will include the luciferin value (l_0) = 5, the luciferin decay constant (ρ) = 0.4, the luciferin enhancement constant (γ) = 0.6, beta (β) = 0.08, the step size (s) = 0.03, the range of neighbourhood ($r_d^i(t)$ = 3 and also the parameter that is used for controlling the neighbours (n_t) = 5.

Phase 2—luciferin update this Iteration contains a luciferin update phase, and the glow worms' movement phase along with the local decision range and its update phase. This luciferin update phase had been influenced by means of the function value at the location of the glow worm [25]. The actual value of this function will be duly altered because of the function value in the current position even though the glow worm will have a similar value of the luciferin initially and the rule of luciferin update is shown in (12):

$$l_i(t) = (1-\rho)l_i(t-1) + \gamma J_i(t+1) \tag{12}$$

In which $l_i(t)$ = luciferin level for the glow worm i at a time t, ρ being the luciferin decay constant (0 < ρ < 1), γ the luciferin enhancement constant and $J_i(t)$denoting the objective function at the agent i's location and at time t.

Phase 3—the movement phase at the time of the movement phase, every glow worm will make use of a probabilistic mechanism for moving to neighbours which will have a higher intensity of the luciferin and also its own. The actual set of neighbours of a glow worm i at a time t has been computed in (13):

$$N_i(t) = \{j : ||x_j(t) - x_i(t)|| < r_d^i; l_i(t) < l_j(t)\} \tag{13}$$

In which $x_j(t) - x_i(t)$ denotes a the Euclidean norm of both the x and $r_d^i(t)$ which is the variable neighborhood range for any glowworm i at a time t that is bounded by means of a circular sensor range $r_s^i(0 < r_d^i < r_s^i)$. For every glowworm i, the movement to neighbors and their probability $j \in N_i(t)$ has been given by (14):

$$p_{ij}(t) = \frac{l_j(t) - l_i(t)}{\sum_{k \in N_i(t)} l_k(t) - l_i(t)} \tag{14}$$

The discrete-time model of glowworm movement may be shown as (15):

$$x_i(t+1) = x_i(t) + s\left(\frac{x_j(t) - x_i(t)}{||x_j(t) - x_i(t)||}\right) \tag{15}$$

In which s is the step size, || || the Euclidean norm operator and $x_i(t) \in R^m$ the location of the glow worm i at a time t in m-dimensional real space R^{m}.

Phase 4—the neighborhood update the range of Neighbourhood update phase has been used for detecting multiple peaks within a multimodal function landscape [26]. If r_0 is the initial neighbourhood range value for every glow worm $i(r_d^i(0) = r_0)$. A rule will be given as (16):

$$r_d^i(t+1) = \min\{r_s, \max\{0, r_d^i(t) + \beta(n_t - |N_i(t)|)\}\} \tag{16}$$

In which β will be a constant parameter and n_t the parameter that is used to control the actual number of neighbors.

3.4 Proposed parallel Ant Colony Optimization (PACO)

Here in this work there is found to be a single image segmentation that is used through the PACO which has been proposed for the purpose of overcoming the bilateral registration segmentation and its drawbacks. This is a parallel implementation of the ACO in which the ants do their investigation in a simultaneous manner. Here in this work there is one more single image segmentation using the PACO that has been proposed for the purpose of overcoming the drawback of such bilateral segmentation and its registration. The PACO is that kind of a parallel implementation of the ACO in which the ants perform their investigation on various processing units. This will make a provision an improved performance and will further speed up the process of search. In this PACO that is proposed a master slave and information exchange approaches have been combined for improving these image segmentation [27].

This PACO will also execute independently the sequential algorithm which will be on the M-1 parallel sub colonies and this runs do not have any communication overheads. They tend to be made use of in the randomized algorithms and the best solution for the M runs will be taken as their final solution. For increasing the speed of the process of search, a master slave approach is used. And this in turn helps in sending solutions to the other sub colonies that improve them by means of a local search. The master will not be able to collect all such locally optimal solutions and if a sufficient number are arrived at, this will update a trail matrix even before the construction of many more solutions.

The master will also be responsible for the spawning of such slaves and if the slave turns optimal for all of this processing a local search and also the pheromone matrix update will be completed by the slaves. They further exchange solutions in one more independent manner to identify the best of such solutions and send them back to their masters. At the time of such an operation, every slave will have to exchange information periodically with the neighbor and also determine the best solution with the length of the tour. Every sub colony will also make a choice of a tour with a minimal length as the best and will report it to master programs in the end of search. This master program will also find an ideal solution and will receive them from the slaves and will present this as their current solution.

Here for this approach every one of these colonis will be given some valid IDs and they choose partners to ensure the slaves that have IDs will exchange local optimal along with their predecessors and so every colony will exchange information using the same colony for every time interval. These slaves exchange three different parameters which are their pheromone matrices, their length of iteration and also their best iteration that has been obtained until now. For every colony the best ant will now represent the sub-colony and also its best iteration that has been obtained until now. When the master gets one more optimal solution this will multicast it to all the salves and the slaves will as a consequence prune them. This will further reduce the time that is wasted in the other slaves that will not know if one more slave would have been able to identify another optimal solution.

In PACO, K ants are divided into M subset colony. This make sure that the ant number for each colony is the ratio of the total number divided by the actual number of sub colonies. In the action of designing of the algorithm a colony will search for its best solution in an independent manner. To avoid local optimization in colonies, the exchange of colony information is performed with particular time interval by ensuring the reduced execution time interval.

3.5 Proposed parallel Glowworm Swarm Optimization (GSO)

The GSO belongs to the swarm intelligence where the natural swarm will be taken into consideration. Any of these glow worm that tends to emit more light which is of a high luciferin level will mean that it has been closer to that of their actual position and also a high objective value. The glowworm is attracted by the others that have a luciferin level that is within the same range and a glow work will move towards them as they will continue to be gathered at multiple peak locations within its search space.

Pseudo-code for GSO

(1) The original image is decomposed with a DWT that is of three levels and the coefficients at its third level that reflect the information of approximation that is reconstructed in an approximation image as the high frequency parts in the third level that possess information based on the edge and the texture will be reconstructed as gradient images.
(2) Employing one low-pass filter (which is a circular averaging filter) for dealing with the image approximation and further obtain filtered images.
(3) Normalize gradient image I with filtered image G to [0, 255] by using formulas $I(m,n) = round\left(abs\left(\frac{I(m,n)}{\max\limits_{\forall m,n}(I(m,n))} \times (L-1)\right)\right)$ and $G(m,n) = round\left(abs\left(\frac{G(m,n)}{\max\limits_{\forall m,n}(G(m,n))} \times (L'-1)\right)\right)$ once that is complete, construct a 256 × 256 filtered-gradient with a co-occurrence matrix C in order to get an improved two-dimensional grey entropy.
(4) An n-level thresholding will present n - 1 threshold levels, and will further set control parameters for the GSO algorithm, that includes population size, limit times for such abandonment, and maximum number of iterations.
(5) The GSO algorithm will iterate and finds values of optimal thresholding.
(6) Filtered image I is segmented with optimal thresholds to get a final segmented image.
(7) An image split of an image into four for a parallel GSO processing.
(8) Configuring the numbers of parallel glow.
(9) Every glow will estimate the fitness function among the number of map against the job size and time, number of reduce against job size and time.
(10) For every iteration of the glow worm a best fitness function will be taken and all the worms will try optimizing the fitness function which is:

$$Lf = (1\text{-}p)*Lf + g*Objective.$$

(11) This process will be repeated until max the number of iteration is got.

4 Results and discussion

In this section, the ACO, GSO, parallel ACO and parallel GSO methods are used. The average segmentation time, fit-

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

Table 1 Average segmentation time

Average segmentation time	Time (second)
ACO	71
Parallel ACO	19
GSO	48
Parallel GSO	16

Table 2 Fitness

Number of iteration	ACO	GSO	Parallel ACO	Parallel GSO
1	7.6	8.25	7.42	8.08
5	8.42	8.76	8.25	8.54
10	8.5	8.96	8.25	8.75
15	8.11	8.76	7.92	8.52
20	8	8.53	7.8	8.78
25	8.68	8.75	8.47	8.56
30	8.21	9.05	8.47	8.83
35	8.11	9.29	7.92	9.06
40	8.85	9.41	8.61	9.18
45	8.85	9.42	8.62	9.18
50	8.85	9.42	8.61	9.23

Table 3 Over segmented pixels

Over segmented pixels in %	ACO	GSO	Parallel ACO	Parallel GSO
Img1	1.18	1.18	1.23	1.35
Img2	1.16	1.23	1.28	1.24
Img3	1.14	1.27	1.16	1.14
Img4	1.3	1.23	1.3	1.34
Img5	1.36	1.17	1.19	1.24
Img6	1.43	1.17	1.27	1.31
Img7	1.26	1.2	1.12	1.32
Img8	1.31	1.23	1.4	1.28
Img9	1.38	1.32	1.32	1.16
Img10	1.15	1.21	1.37	1.22
Img11	1.35	1.11	1.16	1.33
Img12	1.46	1.29	1.36	1.29
Img13	1.36	1.14	1.3	1.2
Img14	1.29	1.29	1.33	1.11
Img15	1.21	1.23	1.24	1.31

Table 4 Not segmented pixels

Not segmented pixels in %	ACO	GSO	Parallel ACO	Parallel GSO
Img1	2.33	2.11	2.38	2.22
Img2	2.27	2.21	2.23	2.31
Img3	2.14	2.24	2.2	2.23
Img4	2.21	2.28	2.17	2.25
Img5	2.32	2.21	2.1	2.25
Img6	2.28	2.2	2.27	2.26
Img7	2.13	2.23	2.17	2.14
Img8	2.24	2.35	2.37	2.19
Img9	2.2	2.28	2.15	2.32
Img10	2.26	2.19	2.23	2.19
Img11	2.34	2.11	2.22	2.19
Img12	2.29	2.29	2.34	2.21
Img13	2.26	2.35	2.16	2.33
Img14	2.32	2.35	2.26	2.1
Img15	2.36	2.15	2.25	2.35

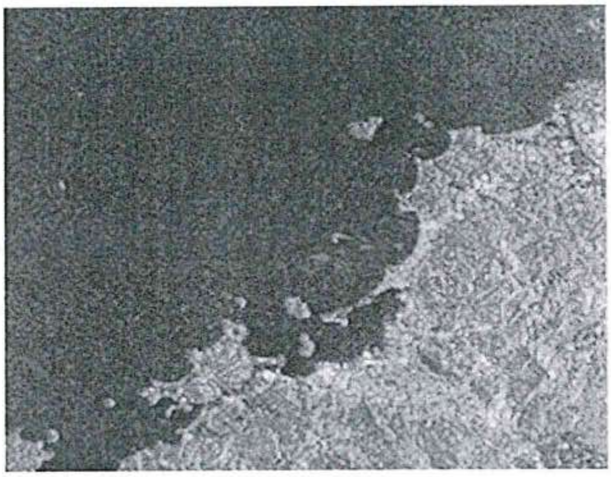


Fig. 1 Sample SAR image

ness, over segmented pixels and not segmented pixels as shown in Tables 1, 2, 3, and 4 and Figs. 2, 4, and 5. Figure 1 shows the sample SAR Image.

From the Fig. 2, it can be observed that the average segmentation time of parallel GSO is decreased by 126.43% than ACO, by 17.14% than GSO, and by 100% than parallel ACO. It is seen that image segmentation is carried out using cloud which significantly reduces the segmentation time for computation.

From the Fig. 3, it can be observed that the fitness of parallel GSO is increased by 4.79% than ACO, by 6.81% than parallel ACO and decreased by 1.93% than GSO.

From the Fig. 4, it can be observed that the over segmented pixels of parallel GSO is decreased by 2.61% than ACO, by 1% than parallel ACO and increased by 1.93% than GSO.

From the Fig. 5, it can be observed that the not segmented pixels of parallel GSO is decreased by 1.21% than ACO, by 0.02% than GSO and increased by 0.11% than parallel ACO.

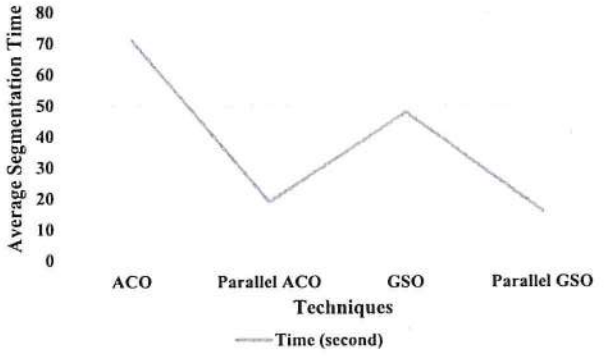


Fig. 2 Average segmentation time

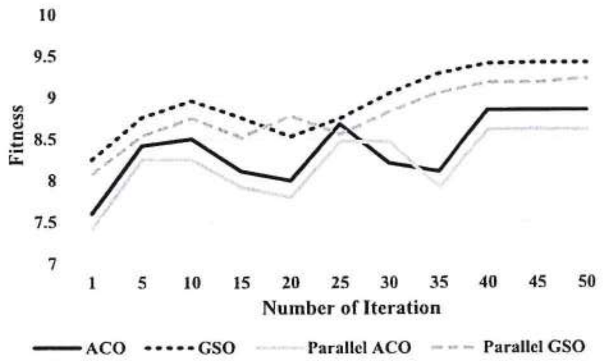


Fig. 3 Fitness

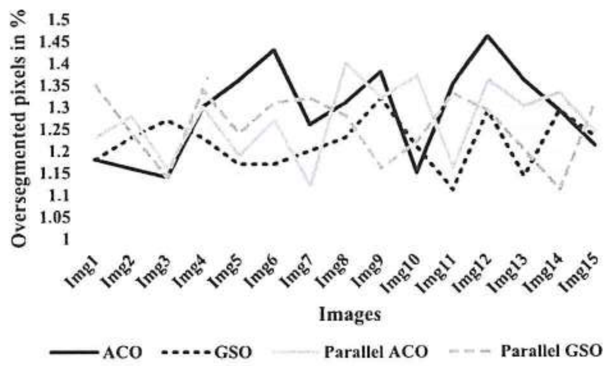


Fig. 4 Over segmented pixels

5 Conclusion

Normally, these segmentation of image will be included mainly in four methods which are based on segmentation and another parallel boundary, a serial boundary and also the parallel region. The traditional methods of such segmentation will be effective for certain images but may be limited in cases of other images that are applied to special fields and characteristics. The Swarm intelligence has been found to be a very new approach to the problem solving and has been inspired from the social behavior of the insects and other

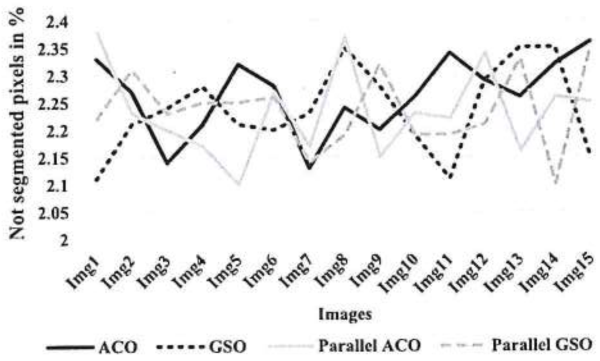


Fig. 5 Not segmented pixels

animals. Particularly, ants have inspired various methods and optimization techniques called the ACO and the GSO have been developed. In the former, real ants will find a short path from a source of food to the nest without any visual cues. A GSO algorithm is from the phenomenon that these glow worms will be attracted by another that has a higher luciferin value. The latter is also used in cases of noise test, simulation, clustering analysis, knapsack issues and numerical optimization calculation. The time required for experiments using the PACO and the parallel GSO are shorter than that of the ACO and GSO. Results have proved that the GSO and its fitness has been increased by about 4.79% than that of the ACO, by about 6.81% than that of the parallel ACO and has decreased by about 1.93% than that of the GSO.

References

1. Kaur, D., Kaur, Y.: Various image segmentation techniques: a review. Int. J. Comput. Sci. Mob. Comput. **3**(5), 809–814 (2014)
2. Sivakumar, P., Meenakshi, S.: A review on image segmentation techniques. Int. J. Adv. Res. Comput. Eng. Technol. **5**(3), 641–647 (2016)
3. Matta, S.: Various image segmentation techniques. Int. J. Comput. Sci. Inf. Technol. **5**(6), 7536–7539 (2014)
4. Saini, S., Arora, K.: A study analysis on the different image segmentation techniques. Int. J. Inf. Comput. Technol. **4**(14), 1445–1452 (2014)
5. Khan, W.: Image segmentation techniques: a survey. J. Image Graph. **1**(4), 166–170 (2013)
6. Khehra, B.S., Singh, A., Pharwaha, A.P.S., Kaur, P.: Image segmentation using two-dimensional Renyi entropy. In: Proceedings of the International Congress on Information and Communication Technology, pp. 521–530. Springer, Singapore (2016)
7. Szczypiński, P., Klepaczko, A., Pazurek, M., Daniel, P.: Texture and color based image segmentation and pathology detection in capsule endoscopy videos. Comput. Methods Progr. Biomed. **113**(1), 396–411 (2014)
8. Kumar, G.A., Nistala, V., Murthy, E.S.: Analysis of medical image processing and its applications in healthcare industry. Int. J. Comput. Technol. Appl. **5**(3), 851–860 (2014). ISSN, 2229-6093
9. Skirnevskiy, I.P., Pustovit, A.V., Abdrashitova, M.O.: Digital image processing using parallel computing based on CUDA technology. J. Phys. **803**(1), 012152 (2017). IOP Publishing

10. Ma, M., Liang, J., Guo, M., Fan, Y., Yin, Y.: SAR image segmentation based on Artificial Bee Colony algorithm. Appl. Soft Comput. **11**(8), 5205–5214 (2011)
11. Pont-Tuset, J., Arbelaez, P., Barron, J.T., Marques, F., Malik, J.: Multiscale combinatorial grouping for image segmentation and object proposal generation. IEEE Trans. Pattern Anal. Mach. Intell. **39**(1), 128–140 (2017)
12. Wen, W., He, C., Zhang, Y., Fang, Z.: A novel method for image segmentation using reaction-diffusion model. Multidimens. Syst. Signal Process. **28**(2), 657–677 (2017)
13. Zhou, S., Wang, J., Zhang, S., Liang, Y., Gong, Y.: Active contour model based on local and global intensity information for medical image segmentation. Neurocomputing **186**, 107–118 (2016)
14. Niu, S., Chen, Q., de Sisternes, L., Ji, Z., Zhou, Z., Rubin, D.L.: Robust noise region-based active contour model via local similarity factor for image segmentation. Pattern Recognit. **61**, 104–119 (2017)
15. Sarkar, S., Das, S., Chaudhuri, S.S.: Hyper-spectral image segmentation using Rényi entropy based multi-level thresholding aided with differential evolution. Expert Syst. Appl. **50**, 120–129 (2016)
16. Lahmiri, S., Boukadoum, M.: Combined partial differential equation filtering and particle swarm optimization for noisy biomedical image segmentation. In: Circuits & Systems (LASCAS), 2016 IEEE 7th Latin American Symposium on, pp. 363–366. IEEE, (2016)
17. Bose, A., Mali, K.: Fuzzy-based artificial bee colony optimization for gray image segmentation. Signal, Image Video Process. **10**(6), 1089–1096 (2016)
18. Zhao, X., Turk, M., Li, W., Lien, K.C., Wang, G.: A multilevel image thresholding segmentation algorithm based on two-dimensional K–L divergence and modified particle swarm optimization. Appl. Soft Comput. **48**, 151–159 (2016)
19. Rajinikanth, V., Raja, N.S.M., Satapathy, S.C.: Robust color image multi-thresholding using between-class variance and cuckoo search algorithm. In: Information Systems Design and Intelligent Applications, pp. 379–386. Springer, New Delhi (2016)
20. Singla, A., Patra, S.: A fast automatic optimal threshold selection technique for image segmentation. Signal, Image Video Process. **11**(2), 243–250 (2017)
21. Ghamisi, P., Couceiro, M.S., Martins, F.M., Benediktsson, J.A.: Multilevel image segmentation based on fractional-order Darwinian particle swarm optimization. IEEE Trans. Geosci. Remote Sens. **52**(5), 2382–2394 (2014)
22. Zhao, B., Zhu, Z., Mao, E., Song, Z.: Image segmentation based on Ant Colony Optimization and K-means clustering. In: Automation and Logistics, 2007 IEEE International Conference on, pp. 459–463. IEEE (2007)
23. Gupta, C., Gupta, S.: Edge detection of an image based on Ant Colony Optimization technique. Int. J. Sci. Res. (IJSR) **2**(6), 1256–1260 (2013)
24. Dogra, R., Gupta, N.: Glowworm Swarm Optimization technique for optimal power flow. Adv. Electron. Electr. Eng. **4**(2), 155–160 (2014)
25. Zainal, N., Zain, A.M., Radzi, N.H.M., Othman, M.R.: Glowworm Swarm Optimization (GSO) for optimization of machining parameters. J. Intell. Manuf. **27**(4), 797–804 (2016)
26. Manimozhi, J.: Optimizing and reconstruction of SAR images using Glowworm Swarm Optimization (GSO). Int. J. Comput. Sci. Mob. Comput. **3**(9), 219–230 (2014)
27. Jaya, J.: Implementation of computer aided diagnosis system based on parallel approach of ant based medical image segmentation. J. Comput. Sci. **7**(2), 291–297 (2011)

M. Jaganathan received his Bachelor degree in Engineering from K. S. Rangasamy college of Technology, Tiruchengode, Tamil Nadu and Master degree in Engineering from Anna University, Tiruchirappalli. He has 6.5 years of teaching experience from reputed Engineering College and currently, he is working as an Assistant Professor at KSR Institute for Engineering and Technology. His research interests includes image processing. He has published papers in reputed Conferences and Journals.

A. Sabari is having 15 years of teaching experience. He has received B.E. degree in Computer Science and Engineering from Madras University, Tamil Nadu, India in 2000 and the M.Tech degree in Computer Science and Engineering from Vishweshraiya Technological University, Karnataka, India in 2002. He has completed Ph.D. Degree in Anna University, Chennai, India in 2011. He is currently working as a Professor in the department of Information Technology at K. S. Rangasamy college of Technology, Tamil Nadu, India from 2002 to till date. He has published 38 papers in the reputed international journals and 14 papers in the national and international conferences. He has produced 4 research scholars and supervising 7 research scholars under Anna University, Chennai. His current research interest includes Ad Hoc networks, Wireless Sensor Networks, Network security and Data Mining. He is a life member of CSI and ISTE. He has arranged many seminars/hands on workshops for students and faculties in K. S. Rangasamy College of Technology. He constantly encourages students and faculty in various academic activities.

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

A Self Balancing Space Vector PWM for Z Source T Multilevel Inverter

C.Santhakumar*, R.Shiva kumar, C.Bharatiraja***,**
* Assistant Professor Department of Electrical and Electronics Engineering.K.S. R I.E.T, India.
**Professor Department of Electrical and Electronics Engineering, Sona College of Technology, India.
***Department of Electrical and Electronics Engineering, SRM Institute of Science and Technology, Chennai.

Abstract— **This paper presents a Z Source -T shape - Neurtal point Diode Clamped (NPC) - Multi Level Inverter (MLI) power conversion system (Z-T-NPC-MLI) with the aid of New Space Vector PWM (SVPWM) scheme. The proposed impedance source (Z-Source) MLI associations the advantages of boosting operations with DC to AC power conversions. There are many MLI Z-Source research papers for concentrating the desired voltage generations with minimal switching and conduction losses. Nevertheless, the reported research on Z-NPC-MLI SVPWM has dealt with reduction of Shoot through (ST) options and voltage boosting operations enhancement; those are does not address the neutral point fluctuation (NPF) problems on the DC-Link. This paper offers improved SVPWM strategies for Z-source NPC-MLI with minimal ST state options. The proposed SVPWM exploits the redundancy switching vector option for both ST and regular switching (non-ST), which offers self-control to NP (DC-link capacitor) balancing. With this benefit of this self- control DC-link capacitors balancing, the inverter able to maintain their output quarter symmetry waveform and henceforth the harmonic spectra for the voltage and current waveform is maintained lesser. The proposed SVPWM for Z-T-NPC-MLI is simulated in MATLAB/SIMULINK 2011.b software environment, and the results confirm the advantages of the proposed inverter and its simplified PWM scheme. The experimentation is also performed for 1kW three-phase Z-T-NPC-MLI system using sparten-6 FPGA processor. The experimental results are confirmed the simulation results.**

Keywords- Z Source MLI, T-MLI, Neutral point Diode Clamped,Capacitor balancin.

I. INTRODUCTION

Renewable energy sources (RESs) are taking the top position in the field of electrical generation. Almost all the countries in the world are encouraging the RESs (mostly PV and wind), due to various reasons like scarcity of the fossil fuels, to reduce the emissions caused via green power generation. Solar energy is the most promising source of energy among the RESs [1].

The inverters are the mandatory segment in the photovoltaic (PV) systems, as the output of any PV system will be DC. Due to this fact, research in the field of inverters has improved a lot in the recent ages. Apart from the PV system, most of the industrial applications require high power/ medium power inverters. The two-level inverters ware ran out after the arrival of multilevel inverters (MLIs). The first concept of MLI was proposed by R H Baker [2] in the year 1975. The MLIs enables to attain the high voltage and power ratings without the use of transformers. The advantages of MLIs are reduced voltage stress, low switching losses and low common mode voltage. The total harmonic distortion (THD) will be reduced with the increase of the number of levels of an MLI. However, the number of levels is limited by constraints like voltage unbalance and circuit complexity. The first three - level (3L) MLI was implemented by Nabae [3] in 1981. After 1990s, numerous MLIs topologies are reported in the literature. Nevertheless, these MLIs are grouped in majorly only three types: neutral-point clamped (NPC), flying - capacitor (FC) and cascaded H-bridge (CHB). The FC-MLI was invented by Fazel *et.al* in 1990. It uses a higher number of capacitors to make a level, hence it is requires more protection to ensure the uniform capacitors charging and discharging. The CHB-MLI involves extra isolated DC sources; which is practically impossible with the use of PV based power system. All these pros and cons, the NPC–MLI is a better choice for medium voltage and power applications. The NPC-MLI uses clamping diodes to achieve the levels, which have additional losses. With the elimination of clamping diodes in the NPC MLI L Ma *et.al* [4] proposed T-Type NPC-MLI in the year 2009, which can also be called as the diode-less NPC-MLI. Here, the switches in single leg of T Type NPC-MLI will be arranged in the form of the alphabet 'T'. The T Type NPC-MLI will have all the reward of the NPC-MLI. Apart from the elimination of the clamping diodes these T Type NPC-MLI have lower switching losses as the switches 2 and 3 will behalf the rating of switches 1 and 4. Due to the low conduction and switching losses T-Type NPC -MLI can achieve an efficiency of 99% [5,6]. Due to all these advantages T Type NPC-MLI will be the best option for the PV applications. However, the DC-link balancing is a considerable element on it.

The output voltage boosting for any MLI topology is not possible without adding DC to DC converter in their input side; this become a main drawback in case of PV applications. Normally, the conventional two stage system structure as DC to DC boosting conversion (through boost converter) and DC to AC (through inverter). This increases the control circuit design complexity and cost. After arrival of impedance source (Z-source) in 2003, the two-stage power conversion is replaced by single-stage power conversion (DC to boosted AC) is becomes popular and recommended for many applications [7]. The reduction in control methods and power switch, the power electronics researchers are started to use Z – source concepts in MLIs and used in many electrical notable application such as wind power generation, HVDC systems etc., In Z-source inverter, the boosting is achieved in front end 'X'- shape elements, formed two though inductors and two capacitors. The storing the energy in the inductors, it is needs to connect directly with input DC source. Therefore, the inductors need to short through MLI circuit switches. This proposes is called as shoot-through (ST). To organizing the regular switching and ST switching, the Z-source MLI PWM is fairly complex than that of a normal MLI PWM strategy. In carrier PWM methods, the maximum boosting and constant boosting carrier methods are the most acceptable for the Z-source MLI. Similar to MLIs, Z-source too absorbed mainly space vector PWM (SVPWM), since it has a great potential to deal the switching activation with direct control nature [12,13] The ST option for the Z-source NPC-MLIs precisely realized using by using SVPWM with redundant ST options [14]. The proposed method is offered a higher control degree of freedom to vary the output voltage boosting. The similar strategies with minimum ST switching actions are proposed in [15,8], which are mainly focusing to increasing the boosting function of the inverter. The methods are not solving the NP capacitors balancing; hence the output voltage of the inverter is ached with higher THD. The redundancy switching is allows the current flow in the NP in every phase and maintain the zero current at NP [16]. There some interesting paper is published in the literature to ensure the zero NP in every switching cycle interval, which are maintain the self- balancing he capacitors. Considering the NPC-MLI topology types, T-type topology have uses only main control power switches. The clamping diode is totally removed form T-type MLI, and hence it is offered a lesser loss than I-type NPC-MLI [6, 17]. Hence, the concentering the use T-type topology with Z-source is got a more interest in the power converter designer community.

Within this above discussed, the paper proposes a three-phase three- level Z-source T-type NPC-MLI and new SVPWM method for voltage-boosting improvement with DC-link NP capacitors balancing without comparing the voltage THD performances. The proposed SVPWM for Z-T-NPC-MLI is simulated in MATLAB/SIMULINK 2011.b software environment, and the results confirm the advantages of the proposed inverter and its simplified PWM scheme. The experimentation is also performed for 1kW three-phase Z-T-NPC-MLI system using sparten-6 FPGA processor. The experimental results are confirmed the simulation results.

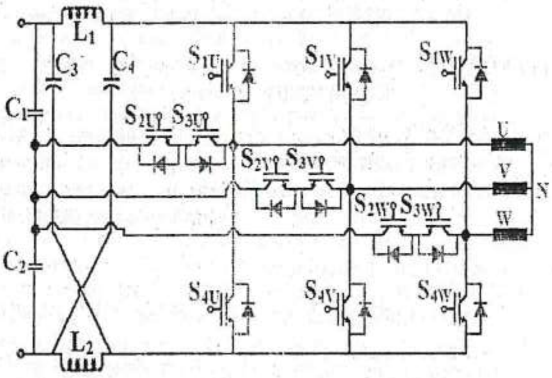


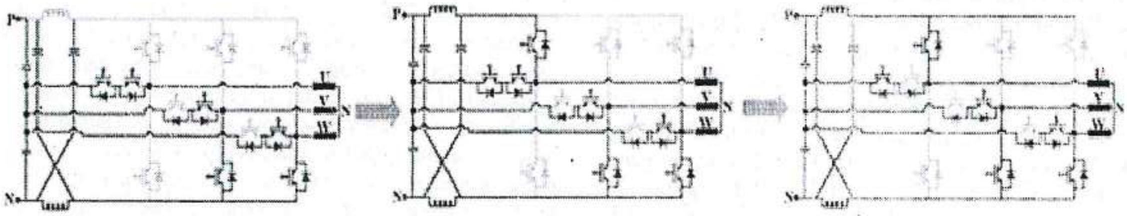
Figure.1 Topology circuit diagram of three-phase three-level Z- source T-NPC-MLI

II. CIRCUIT DIAGRAM OF THREE-PHASE THREE-LEVEL Z-SOURCE T-NPC-MLI

The three-phase three-level Z- source T-NPC-MLI is as presented in the Figure.1 and the working operation of the inverter can be elucidated with the aid of the single–leg switching shown in Table-1.

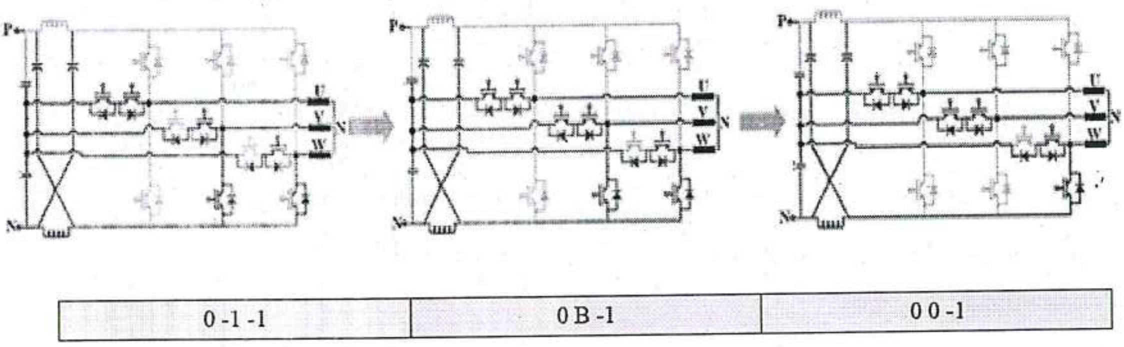
TABLE 1 Switching table of three-phase three-level Z- source T-NPC-MLI for leg-A

Mode	State	Switches Triggered	Diodes Forward biased	V_{OUT}
Non-ST Mode	+1	S_{1U} S_{3U}	D_{3U}	$(V_{DC}/2)+ L_1*(di/dt)$
	0	S_{2U}	-	0
	-1	S_{2U} S_{4U}	D_{2U}	$-(V_{DC}/2)- L_2*(di/dt)$
ST Mode	T	S_{1U} S_{2U} S_{3U}	-	0 (L_1 Charging)
	B	S_{2U} S_{3U} S_{4U}	-	0 (L_2 Charging)



0 -1 -1	T -1 -1	1 -1 -1

(a)



(b)
Figure.2 (a) Top Shoot through (b) Bottom Shoot through

From the Table-1, when the switch S_1 and S_3 are 'ON', the positive current flow from the source (V_{DC}) to the load. Similarly, the negative current flow form load to source is achieved, S_2 and S_4 is 'ON'. When S_2 is 'ON', the current fall to NP and it is should be zero in ideal operation conditions. However, due to the non-uniform switching action maintaining the zero current at NP is challenging [1].

A. Non shoot-through mode:

During the non-shoot through mode the input DC-link voltage (V_{DC}) and the inductor voltage together are fed to the MLI, which leads to the boosting operation. The Non-ST mode (regular MLI switching) is divided into three modes [19].

- Mode-1: During this mode, the positive output voltage and positive current is achieved by triggering S_1 and S_3. The switch S_1 is only connected between source and load, where the S_3 connecting the NP with the help of D_{2U}. This allow the next cycle switching from +1 to 0.
- Mode-2: During this mode, the negative output voltage and negative current is achieved by triggering S_2 and S_4. The switch S_4 is only connected between source and load, where the S_2 connecting the NP with the help of D_{3U}. This allow the next cycle switching from -1 to 0.
- Mode-3: During this mode, the zero output voltage is achieved by tuned 'ON' switch S_2. In this mode the current fall to NP and it is should be zero in ideal operation conditions.

B. Shoot-through mode:

The Z-source MLI shoot-through options are considered to be in three categories, which are call it as, full-ST-state (FST), bottom- shoot-through (BST), top-through(TST) [16].

- FST: During this mode, all the four switches in the inverter leg is 'ON' and proving the direct path to short the inductor with input DC-supply (V_{DC}).
- TST: During this mode, the top three switches are turned 'ON' and proving the path to short the inductor. The TST is influenced by positive current on the V_{DC}.
- BST: During this mode, the bottom three switches are turned 'ON' and proving the path to short the inductor. The TST is influenced by positive current on the V_{DC}.

III. DESIGN OF Z SOURCE NETWORK:

In these sections, the paper takes an opportunity to analysis the Z-source inverter and to calculation of 'X' network elements (L and C) for find the boosting factor (B). Generally in buck-boost DC to DC converter uses the inductor and capacitor with power switch and blocking diode. The blocking diode is avoiding the reverse current flow form the load to source. Similar to buck-boost DC to DC converter, the Z-source inverter uses the L, C, blocking diodes in the positive and negative rail of the DC-bus [6].

As mentioned in Figure-1, the input side X-network (impedance network), and it's consist of two inductors (L_1 and L_2) and two capacitors (C_3 and C_4). The capacitor and inductor is used in the X-network is equal; therefore the voltage drop across them is related same.

$$V_{L1}=V_{L2}=V_L \quad (1)$$

$$V_{C1}=V_{C2}=V_C \quad (2)$$

Throughout the ST mode the voltage across the inductor (V_L) and capacitor (V_C) is same and the inductors are charging uniformly and maintain the voltage across the source X- network as $2V_C$.

$$V_L=V_C \quad (3)$$

During the ST;

$$V_i=2V_C \quad (4)$$

During the non-ST;

$$V_0=0 \quad (5)$$

Let consider, T = total switching time, T_T = TST switching time, T_B= BST switching time, T_0 = commutation time (zero switching) and T_{NST} = nearest vector switching used for regular MLI switching []. The switching time T a combination of the ST and non-ST time periods. The boosting factor (B) is given by

$$B=\frac{T}{T_{NST}-T_0}$$

Where $T=T_0+T_{NST}$, 20% of the ST time period is selected,

T_0 = 20% of the time period of one cycle

= 20% of 0.02

T_0 = 0.004 sec

$$B=\frac{1}{1-\left(\frac{2T_0}{T}\right)} \quad (6)$$

$$B=1.667$$

In the steady-state conditions, the voltage across the inductor (V_L) is zero, thus the V_L over one switching period is given by

$$\frac{(V_{DC}-V_C)T_{NST}+\left(\frac{V_{DC}}{2}\right)T_T+\left(\frac{V_{DC}}{2}\right)T_B}{T}=0$$

$$T=T_0+T_T+T \quad (7)$$

By solving equation (7), the voltage across the capacitor (V_C) is calculated as,

$$V_C=(V_{DC})\left(\frac{1-\frac{T_0}{2T}}{1-\frac{T_0}{T}}\right) \quad (8)$$

$$V_C=50V$$

The output voltage of the Z-source network both in ST and non-ST states are calculated as,

$$V_0 \text{ (Non-shoot through)} = \frac{2V_{DC}}{1-\frac{T_0}{T}} \quad (9)$$

$$=250V$$

$$V_0 \text{ (shoot through)} = \frac{V_{DC}}{1-\frac{T_0}{T}} \quad (10)$$

$$=125V$$

Since the voltage across the inductor(V_L) is the difference of the V_{DC}(V_i) and capacitor voltage(V_C).
Average inductor current is given by

$$I_L=\frac{\text{Total power}}{V_{DC}} \quad (11)$$

The inverter power and DC-link is considering for this proposed Z-T-MLI is 1kW and 100V respectively. Hence From equation (11) becomes,

$$I_L=10V \quad (12)$$

Maximum current ripple on the inductors is estimated as 30%; therefore the maximum current (I_{LMax}) and minimum (I_{LMax}) are calculated as,

$$I_{L\,MAX}=I_L+(30\%\text{ of }I_L) \qquad I_{L\,MIN}=I_L-(30\%\text{ of }I_L)$$

$$I_{L\,MAX}=13\text{ amp}, \qquad I_{L\,MIN}=7\text{ amp}$$

Let, the consider voltage variations from the maximum boosted and un-boosted voltages, the inductor value is calculated as,

$$L=\frac{V*T_0}{I_{L\,MAX}-I_{L\,MIN}} \quad (13)$$

$$L=10mH$$

Form the 1.2% voltage ripple is assumption; the capacitor value is calculated as,

$$C=\frac{I_L T_0}{\Delta V_C} \quad (14)$$

$$C=333.33\mu F$$

IV. PROPOSED SVPWM SCHEME FOR Z-T NPC MLI

The Z-source MLI SVPWM schemes differ from MLI, only by adding the ST-switching states. This is because, Z-Source NPC-MLI needs ST vectors to charge the inductors present in Z-network in Figure-.1In three-phase three-level Z-source MLI SVPWM uses 54 ST-states, which are connected with 27 regular switching event of MLI and providing the zero neutral-point current in every switching , which allow the DC-link capacitors balancing. However, due to the large switching ST, the inverter suffered with large switching losses which affect the inverter efficiency. In this section, explains the switching method and its self-control option to the capacitor balancing. The proposed method uses the TST and BST with regular MLI switching sequentially for considering the NP balancing.

A. Proposed ST option:

To achieve the minimal switches options between two adjacent states, the nearest three vector (NTV) switching sequence is adopted in SVPWM. The NTV is uses the nearest three switching choice and providing the three-phase current to the NP uniformly. For example; when the reference vector (V_{ref}) positioned in sub-triangle, 'Δ_{12}' in sector-1, the switching states are altered from (0-1-1) to (00-1). In this circumstances, the U phase switching state is transformed from {OFF, OFF, ON, ON} through {OFF, ON, ON, ON} to {OFF, ON, ON, OFF} to create BST to charge the inductor, L_2. Here, the four switches are taken for the lag-U (U-phase). During the switching states from (100) to (110) using the NTV method. In this situation the U-phase switching state is transformed from {OFF, ON, ON, OFF} through {ON, ON, ON, OFF} to {ON, ON, OFF, OFF} to create top-ST to charge the inductor L_1. After the end of STs, the inductor voltage (V_L) is added with input voltage (V_{DC}) and this boosted voltage ($2V_C \approx 2V_{DC}$) will appear at the inverter input terminals and MLI will convert the boosted-voltage into AC output voltage. Figure.3. illustrations the switching conversion for Δ_{12} in sector-1. Similar, in all six sectors TST and BST are used with NTV and boosting the input voltage V_{DC}.

PRINCIPAL,
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

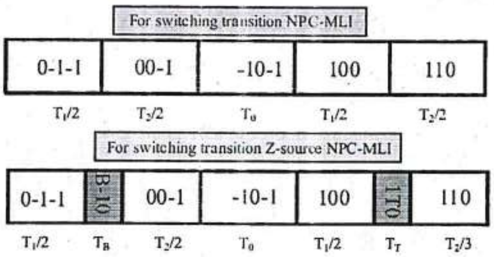


Figure.3 switching transition in linear modulation region for NPC-MLI and Z-source NPC-MLI

In the proposed SVPWM the ST operation is done only with the short vectors to achieve the TST and BST. Furthermore, the proposed SVPWM is fashioned based on the nearest three vector (NTV) switching approach [11], which ensures the circulation current flows in the capacitors. This will improve the quality of the shape of the output wave (quarter symmetry). In the simulation session the effect of capacitors balancing is discussed for both non-NTV and NTV schemes.

B. On-time calculation:

Generally the on-timings are calculated using the NTV scheme [13] in a triangle where the reference vector is located. In (15)-(18) are given the duty cycles for ST vectors and non-ST vectors.

The basic target vector with respect to volt-sec is

$$V_{ref} = T_1V_1 + T_2V_2 + T_0V_0 \quad (15)$$

Here, $T_1 = T_s(V^s_{\alpha o} - V^s_{\beta o}/\sqrt{3})$; $T_2 = T_s(V^s_{\beta o}/h$;
$T_0 = T_s - T_1 - T_2$.

In BST based triangle ST periods are created by splitting the on-timing of T_0.

$$T_0 = T_T + T_B + T_{0(active)} \quad (16)$$

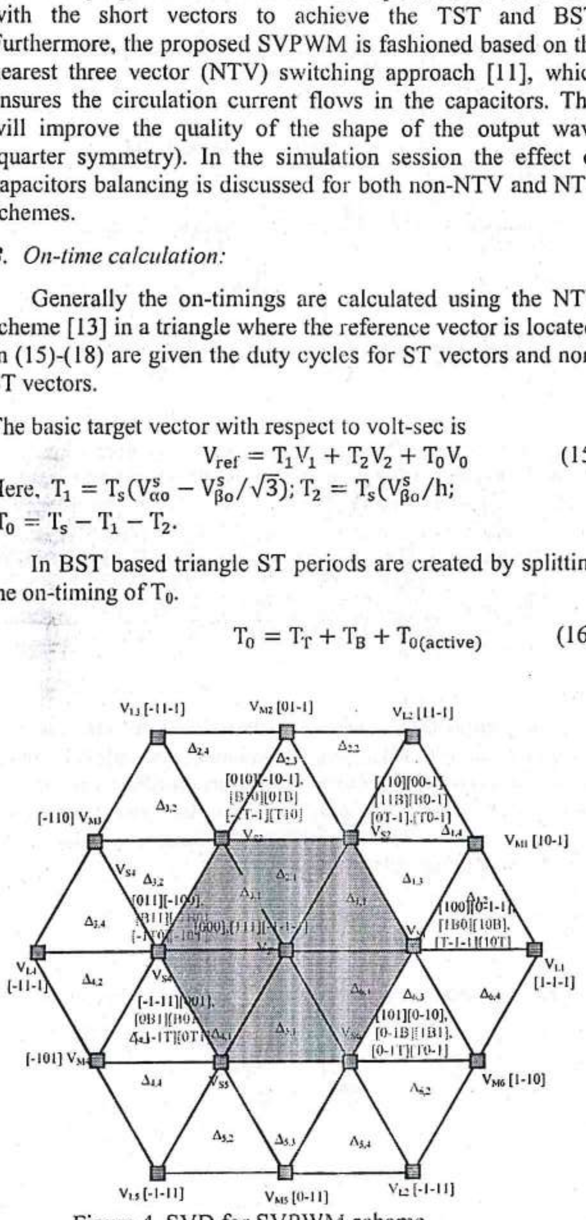


Figure.4. SVD for SVPWM scheme

In TST based triangle ST periods are created by splitting the timing of T_1 and T_2, since the ST creation in medium vector will disturb the inverter pole voltage.

$$T_1 = T_T + T_{1(active)} \quad (17)$$

$$T_2 = T_B + T_{2(active)} \quad (18)$$

C. SVPWM for the Z-MLI SVPWM:

Firstly, the three-phase voltage vectors are converted to two-phase using Park's transformation. The sector number S_i and angle in each sector γ is found by using the angle of the V_{ref} (θ). Each sector will be having four sub-triangles. If the V_{ref} lies in the sub-triangle 0 and 3 can be found easily by calculating rhombus calculations are to be performed using the slope of the reference vector. In the calculation of the sub-triangle, the Z-source SVPWM uses the published paper logic [13]. Once the sub-triangle number is identified, the ST vectors should be identified. Once the ST switching vectors are identified, the total on-time period should be split for ST and non-shoot-through operations.

Advantages of New SVPWM scheme

- Uses only 24 ST switching vectors, which reduces the complexity.
- The redundant technique on time calculation is easy and leads to easy timing calculation and hardware implementation.

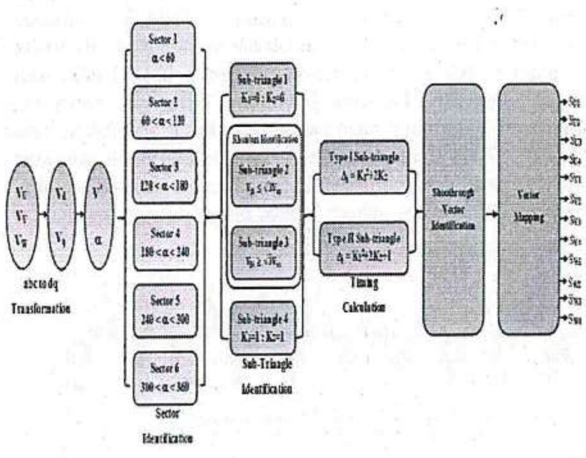
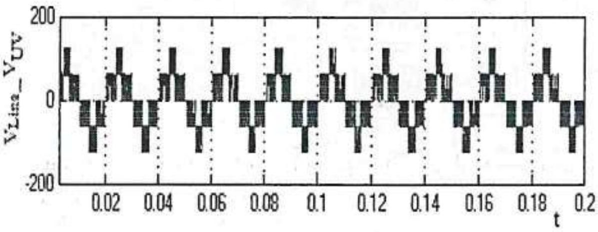


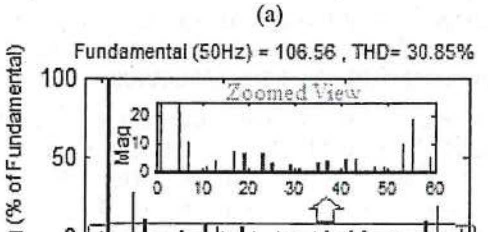
Figure.5. Proposed SVPWM switching pulse generation

V. SIMULATION RESULTS & ANALYSIS

The performance of the Z-source SVPWM for Three-phase three-level Z-T NPC-MLI with an RL load is studied through MATLAB/Simulink 2013.a simulation. The input DC-link voltage is sustained as 100V with the aid of DC. The values of capacitance and inductance in the Z-source network are 340μF and 10 mH. The IGBT with a parallel diode for commutation is used as the switch in the circuit, the internal resistance of IGBT is considered as 1mΩ and snubber resistance is 10μΩ [15]. Two equal capacitors are considered across the supply to split the supply voltage (V_{DC}) into two equal ($V_{DC}/2$) shares and to create a neutral-point voltage. The B is fixed to be 1.67. As a result for an input DC supply, V_{DC} =100V, theoretical output should be 142V in linear modulation range. The Figure.6. shows the line voltage (V_{Line}) and THD spectra at under modulation, M_a=0.6. Here, the V_{Line} and percentage of THD is observed to be 106.56V and 14.85%. The V_{Line} will be very low at the lower modulation indices because the on-time of the MLI will be less during this period, then the V_{Line} gradually increases with the increase of the M_a. Next, the proposed SVPWM is tested for extreme of linear modulation range (m_a=0.9) as shown in the Figure.7. At this M_a, the inverter delivered its maximum output link voltage as 164Vwith considered harmonics spectra of 31.38%. Based on the results it is evident that the proposed PWM, delivers the maximum output based on eq.(6). In addition, the proposed PWM output V_{line} and its respective % THDs are comparatively better when compared to the reported methods [6,11]. The main reason for the improvement of the V_{line} in Z-T NPC-MLI is due to employment of T-Type NPC-MLI rather than conventional NPC-MLI, which reduces the conduction losses to a better extent. The harmonics spectra and waveform quality improved by the selection of proper ST time periods by using the proposed SVPWM scheme. Figure.8 presents the different M_a performances for V_{line} and %THD of Z Source TMLI. Due to the redundancy and NTV switching logic, the -link capacitors (C_1 and C_2), whereas regular Z-SVPWM will not bother about the DC-link balancing. Figure.9. illustrates the capacitor balancing proposed–NTV based SVPWM and regular SVPWM. Based on the results, it could be deduced that the proposed scheme not only uses less ST States, but also balances the NP control, which makes better output quality.

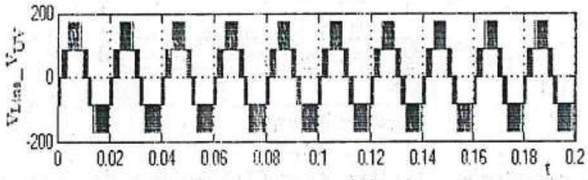


(a)

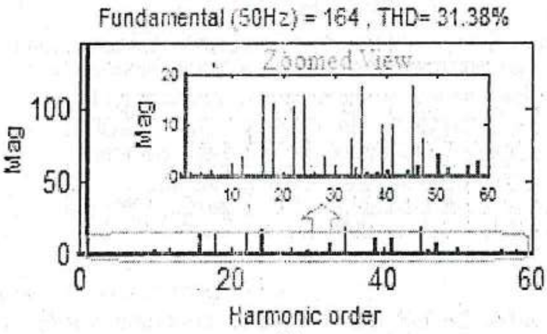


(b)

Figure.6 Simulation results for m_a=0.6; (a). line voltage(V_{LINE}), (b) m_a=0.5



(a)



(b)

Figure.7 Simulation results for m_a=0.8; (a). line voltage(V_{LINE}), (b) m_a=0.9

TABLE II- SIMULATION RESULT COMPERISION OF REGULAR SVPAM AND PROPOSED SVPWM FOR DIFFERENT M_a

M_a		0.2	0.4	0.6	0.8	0.907
Con SVPWM	V_{LINE}	40.7	69.5	102.1	136.7	156.9
	%THD	64.37	56.82	57.26	56.82	57.59
	%NPF	2.7	2.7	3.5	4.7	6.3
Proposed SVPWM	V_{LINE}	41.2	70.9	106.56	142.1	164
	%THD	34.37	36.82	30.85	31.82	31.38
	%NPF	2.7	2.7	2.8	2.9	2.9

Conduction Losses comparison

The Total conduction losses of the Z-T-NPC-MLI and conventional Z-NPC-MLI are calculated and plotted in Figure.9. for various M_a. These values are verified with the simulated tests. From the graph, it can be seen that the conduction losses are low throughout the operating value of M_a, which leads to better of Z-T-NPC-MLI.

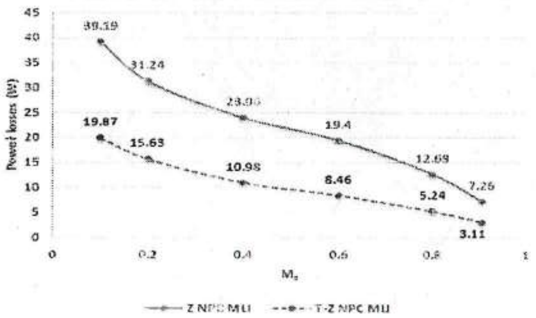
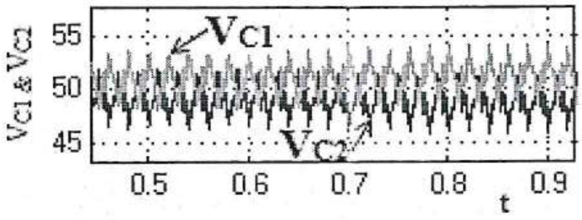
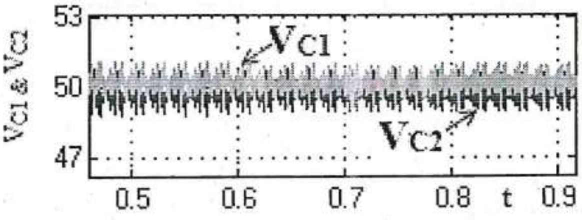


Figure.8 Conduction losses comparison of Z-T NPC-MLI and conventional Z Source NPC-MLI



(a)

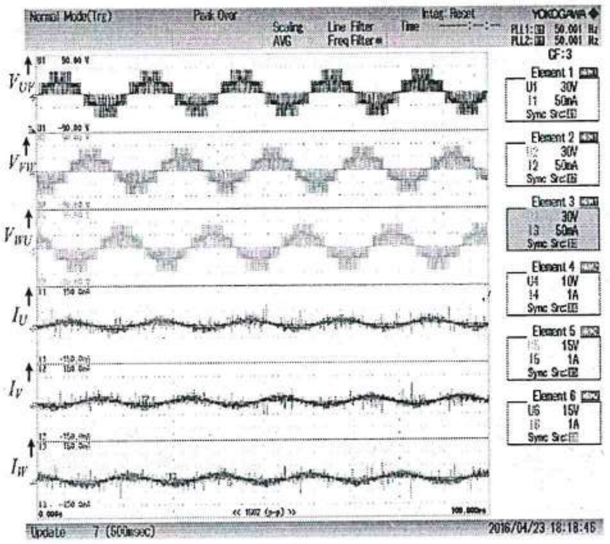


(b)

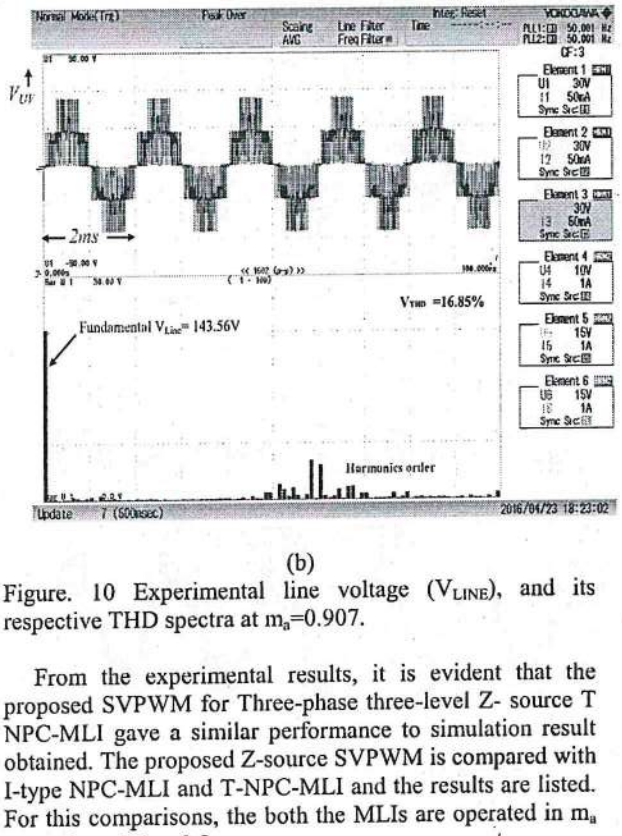
Figure. 9 Z-T NPC-MLI DC-link capacitors balancing simulation results; (a) Conventional ZSVPWM,(b) proposed ZSVPWM.I

VI. EXPERIMENTAL ANALYSIS

The simulation performance of the proposed SVPWM for Three phase - three level Z-T NPC MLI with an RL load is examined through FPGA based 1Kw Z-T NPC MLI simulation study was conducted. The input DC-Link voltage is maintained as 100V with the help of direct DC Source from 0 to 200 V RPS. The values of capacitance and inductance in the Z source network are 340μF and 10 mH respectively. The IGBT with a parallel diode for commutation is used as the switch in the circuit, the internal resistance of IGBT is considered as 1mΩ and snubber resistance is 10μΩ [22]. Two equal capacitors are considered across the supply to split the supply voltage into two equal halves and to create a neutral point. The boosting factor is considered to be 1.67. As a result, for an input DC supply voltage of 100V, theoretical output should be 142V in linear modulation. The Figure. 10, shows the line voltage (V_{Line}) and THD spectra at under modulation, M_a=0.9. Here, the V_{Line} and percentage of THD is observed to be 143.56V and 16.85%. Due to the redundancy ST switching logic, the DC-link capacitors (C_1 and C_2), is maintained their balancing and maintaining the NP. The Figure.11 (a) and (b) show the DC-link capacitors V_{C1} and V_{C2} voltages. Based on the results, it could see that the proposed SVPWM balancing the capacitors closely and ensuring the symmetry voltage waveform.



(a)



(b)

Figure. 10 Experimental line voltage (V_{LINE}), and its respective THD spectra at m_a=0.907.

From the experimental results, it is evident that the proposed SVPWM for Three-phase three-level Z- source T NPC-MLI gave a similar performance to simulation result obtained. The proposed Z-source SVPWM is compared with I-type NPC-MLI and T-NPC-MLI and the results are listed. For this comparisons, the both the MLIs are operated in m_a range from 0.4 to 0.8.

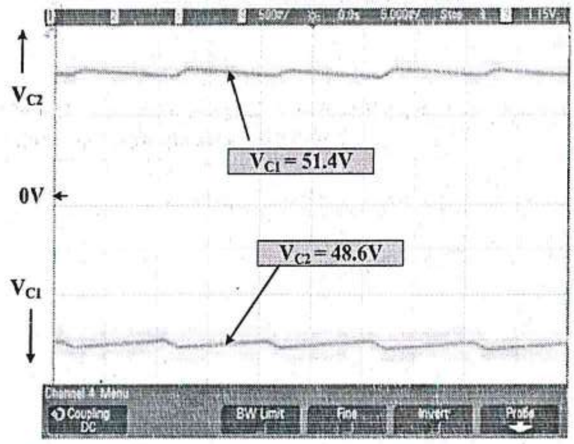
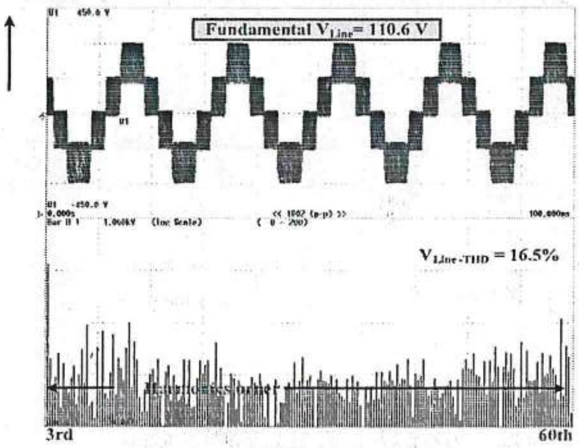
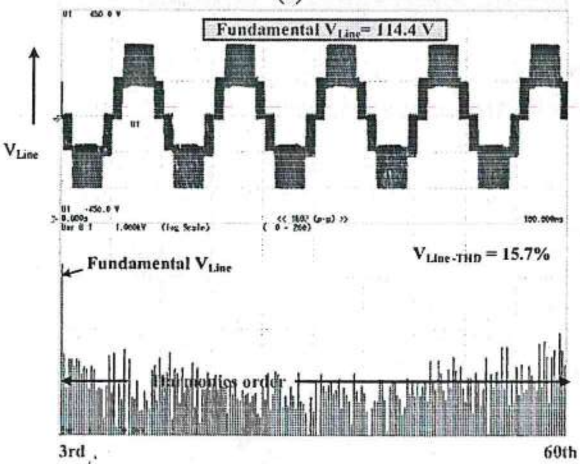


Figure. 11 Experimental Z-T NPC-MLI DC-link capacitors balancing for proposed ZSVPWM.I



(a)



(b)

Figure.12 Experimental line voltage (V_{LINE}), and its THD m_a=0.907;(a)Z-source I NPC-MLI,(b)Z-source T NPC-MLI.

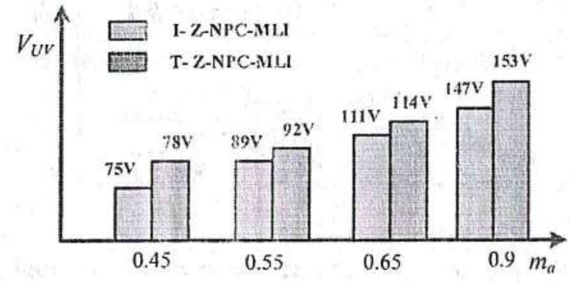


Figure.13 Experimental results; line voltage comparison between I-type and T type Z-source NPC-MLI

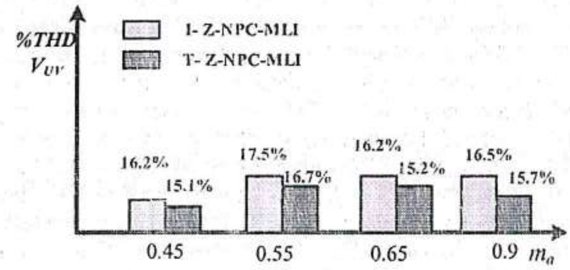


Figure.14 Experimental results; line voltage THD comparison between I-type and T type Z-source NPC-MLI

The inverters input voltages are fixed for 100V for this comparative study. Figure 12.(a) and 12.(b) are shows experimental results line voltage and its THD performance comparisons between I-type and T type Z-source NPC-MLI. From the results T-Z-source NPC-MLI show the better performance then I-type MLI. The fundamental line voltages are more in all the range of modulation Indies. The main reason for the improvement of the V_{line} in Z-T NPC-MLI is due to employment of T-Type NPC-MLI rather than conventional NPC-MLI, which reduces the conduction losses to a better extent. The efficiency of the inverter calculated for both I-type and T type Z-source NPC-MLI from the conduction losses. The T type Z-source NPC-MLI efficiency is estimated as 94.4% at m_a=0.9, whereas I-type has 91.3%. Based on the experimentation results and analysis, the T type Z-source NPC-MLI is provides a better with help of proposed Z-source SVPWM with minimal ST switching events.

V.CONCLUSION

A novel Z-T NPC MLI is implemented using the new SVPWM scheme and operated in the entire modulation region both in shoot through mode and non-shoot through mode. This proposed SVPWM scheme uses redundant technique, which provides the equal switching stress to all the phases which improves the performance of the inverter for long operations. Even though with the use of less number of shoot through vectors more boosting factor of 1.67 is achieved for the inverter which reduces the complexity in the switching of the inverter. The conduction losses calculation is done for Z-T NPC-MLI and conventional Z source NPC-MLI. The conduction losses of the Z-T NPC-MLI are much lower when compared to conventional Z source NPC-MLI; this indicates that the designed Z-T NPC-MLI is the most efficient Z source inverter. The simulation and experimental results of three-level Z-T NPC-MLI inverter fed RL load with various modulation indices are implemented through MATLAB/SIMULINK 13.a and hardware realization is done using improved FPGA implementation. The novel Z-T NPC MLI has better boosted line voltage and THD profile when compared to the conventional Z source NPC0MLI discussed by various authors in the literature.

- As redundant scheme is used in SVPWM scheme the switching stress will be uniform, thus reducing the complexity in timing calculations and can be implemented in hardware easily.
- Only 24 shoot through states out of 54 possible shoot through states are used, which reduces the complexity in the SVPWM scheme.
- Improved FPGA implementation enables the advantage of less device utilization. Therefore, the device memory saved by using improved FPGA implementation can be used for the other purposes like the developments in the scheme or closed loop operation.

REFERENCES

[1] C. Bharatiraja · S. Jeevananthan,and R. Latha, "FPGA based practical implementation of NPC-MLI with SVPWM for an autonomous operation PV system with capacitor balancing," International Journal of Electrical Power & Energy Systems., vol. 61, no. 1, pp. 489–509, Oct. 2014.

[2] Baker R. H., Bannister L. H. 'Electric power converter', U.S. patent 3867 643, 1975.

[3] Nabae A., Takahashi I. and Akagi H., "A New Neutral-Point-Clamped PWM Inverter," IEEE Transactions on Industry Applications, vol. 17, no. 5, pp.518-523, 1981.

[4] L. Ma, T. Kerekes, R. Teodorescu, X. Jin, D. Floricau, and M. Liserre, "The high efficiency transformer-less PV inverter topologies derived from NPC topology," in Proc. 13. *European Conf. Power Electronics and Applications*, 2009, pp. 1–10.

[5] Mario Schweizer, Johann W Kolar, "Design and Implementation of a Highly Efficient Three-Level T-Type Converter for Low-Voltage Applications,"IEEE Transactions on Power Electronics, vol. 28, no. 2, February 2013.

[6] Yong Wang, W. W. Shi, N. Xie, C.M.Wang, "Diode-Free T-Type Three-Level Neutral-Point-Clamped Inverter for Low-Voltage Renewable Energy System," IEEE Transactions on Industrial Electronics, vol. 61, no. 11, November 2014

[7] Fang Zheng Peng, "Z-Source Inverter," IEEE Transactions on Industry Applications, vol. 39, no. 2, March/April 2003.

[8] Francis BoafoEffah, Patrick Wheeler, Jon Clare, Alan Watson, "Space-Vector-Modulated Three-Level Inverters with a Single Z-Source Network," IEEE Transactions on Power Electronics, Vol. 28, No. 6, June 2013.

[9] P. C. Loh, D. M. Vilathgamuwa, Y. S. Lai, G. T. Chua, Y. W. Li, "Pulse width modulation of Z-source inverters", IEEE Trans. Power Electron., vol. 20, no. 6, pp. 1346–1355, Nov. 2005.

[10] P. C. Loh, F. Gao, F. Blaabjerg, "Topological and modulation design of three-level Z-source inverters," IEEE Transaction Power Electronics, Vol. 23, No. 5, pp. 2268–2277, Sep. 2008.

[11] B. Chokkalingam, S. Padmanaban, P. Siano, Z. Leonowicz, and A. Iqbal, "A hexagonal hysteresis space vector current controller for single Z-source network multilevel inverter with capacitor balancing," 2017 IEEE International Conference on Environment and Electrical Engineering and 2017 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), Jun. 2017.

[12] Gupta, A.K., Khambadkone, A.M.., "A Space Vector PWM Algorithm for Multilevel Inverters based on Two-level Space Vector PWM," IEEE Transactions on IEEE Transactions on Industrial Electronics, vol. 53, no. 5, pp. 163-171, 2006.

[13] C. Bharatiraja, S. Jeevananthan, and J. L. Munda, "A Timing Correction Algorithm-Based Extended SVM for Three-Level Neutral-Point-Clamped MLI in Over Modulation Zone," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 6, no. 1, pp. 233–245, Mar. 2018.

[14] Poh Chiang Loh, FredeBlaabjerg, Chow Pang Wong, "Comparative Evaluation of Pulsewidth Modulation Strategies for Z-Source Neutral-Point-Clamped Inverter" IEEE Transaction Power Electronics, vol. 22, no. 3, pp. 1005–1013, May 2007

[15] C. Bharatiraja · S. Jeevananthan, J.L. Mundaand R. Latha, "Improved SVPWM vector selection approaches in OVM region to reduce common-mode voltage for three-level neutral point clamped inverter," International Journal of Electrical Power & Energy Systems., vol. 79, no. 1, pp. 285–297, Oct. 2014.

[16] B. Chokkalingam and J. L. Munda, "Simplified SVPWM for Z Source T-NPC-MLI including neutral point balancing," 2016 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), May 2016.

[17] D. Leuenberger and J. Biela, "Comparison of a Soft Switched TCM T-Type Inverter to Hard Switched Inverters for a 3 Phase PV Grid Interface," 15th International Power Electronics and Motion Control Conference, EPE-PEMC 2012 ECCE Europe, Novi Sad, Serbia.

[18] Rodriguez, J.S., Lai, F.Z. Peng, "A survey on the neutral point clamped inverters," IEEE Transactions on Industrial Electronics, vol. 57, no. 7, July 2010, pp.2219– 2230.

[19] Ying-Yu, T., and Hau-Jean, H., "FPGA Realization of Space-Vector PWM Control IC for Three-Phase PWM Inverters," IEEE Transactions on Power Electronics, vol.12, no.6, pp.953-963, 1997.

[20] Hew, W.P., Ooi, C.P., and Rahim, N.A., "Realization of Space Vector Modulation Technique in a Single FPGA Chip for Induction Motor Drive," *Proceedings of IEEE Conference Electron Devices and Solid-State Circuits (EDSSC '05)*, pp.817-820, 2005.

Cluster Computing (2019) 22:S13429–S13436
https://doi.org/10.1007/s10586-018-1952-2

CrossMark

A multimodal authentication for biometric recognition system using hybrid fusion techniques

S. Velmurugan[1] · S. Selvarajan[2]

Received: 28 November 2017 / Revised: 21 January 2018 / Accepted: 31 January 2018 / Published online: 2 March 2018

Abstract

Biometric Recognition and authentication is used in every application for the secured identification of the persons. Several Researches has been carried out in the past decade that concerns only to enhance the accuracy of biometric algorithms for various kinds of features by ignoring the aspects of robustness and reliability. With this objective, new algorithm called effective linear scale authentication has been proposed which works on the principle of hybrid fusion of two feature inputs such as Hand geometry and iris of the users. The two different techniques have been adopted for the Feature Extraction. One is effective linear binary patterns and other is scale invariant fourier transform and it is stored in the databases for the further verification. This algorithm has been tested with the CASIA Image Datasets and the results had clearly proven that the novel idea of fusing the local features to address the scalar and angular inefficiencies of the existing methods.

Keywords ELSA · SIFT · CASIA · ELBP · Biometric recognition

1 Introduction

Biometric authentication and recognition has evolved as a new branch of exploration in adoption of newer techniques to offer more security, higher accuracy and speed [1]. The biometric recognition had become a smarter personal authentication systems in modern day banking, medical, and defence systems. Of the many proposed approaches, one of the most successful and widely reputed idea is the Fusion of the different Images [2]. The different modality images such as palm, finger print, hand geometry, iris, Finger knuckle could be taken as the inputs which are then fused in many ways so as to increase the high security mechanisms. In this paper, a novel idea of fusion of local multimodal features known as effective linear scale authentication (ELSA) that includes two distinct feature extraction techniques such as effective linear binary pattern (ELBP) and scalar invariant fourier transforms (SIFT) to minimize the system error rate. Unlike other algorithms, the proposed algorithm is Scale-invariant and Rotation-Invariant. Since only the local patterns and descriptors were used, it is far superior to other algorithms in terms of bad illumination and noisy inputs. The paper organized as follows as: (A) Related works (B) Proposed Systems with Block Diagram (C) Overall System Designs (D) Results and Comparison (E) Conclusion.

2 Related work

Jobin et al. [3] presented a multimodal biometric system based on fusing iris, palm print, and finger-knuckle. The fusion process is performed using min–max normalization at matching score level. They used log-Gabor in order to extract both iris and palm print features. The features of finger knuckle are extracted using linear discriminant analysis (LDA). Androunikou et al. [4] presented a multi-modal biometric combination of voice, face, finger, and palm for 30 individuals entered to the system using BOLYBIO datasets. They used 5 data captured sessions for each biometrics; 4 for training, and 1 for testing. They combine the single traits at the output level using simple

✉ S. Velmurugan
velmurugans78@rediffmail.com

1 Department of Electrical and Electronics Engineering, KSR Institute for Engineering and Technology, Namakkal Dt, Tiruchengode, Tamilnadu, India

2 Muthayammal College of Engineering, Namakkal Dt, Rasipuram, Tamilnadu, India

voting scheme. The user is authenticated if the majority of individuals' modalities vote for authentication and rejected if the majority vote against. That idea is based on the weak classifier which led to powerful classifiers and achieving high performance in terms of both false acceptance rate (FAR) and false rejection rate (FRR) even in case of single modality verification is not tune for best performance. Jain et al. [5] presented three modalities face, palm print and gait. They use geometry preserving projections (GPP) algorithm for subspace selection, which is capable of discriminating different classes and preserving the intra-modal geometry of samples within an identical class. The training stage is carried out for each biometric trait in subspace learning using GPP and then the classification in low-dimensional space is performed. El-Alfy et al. [6] presented an approach where it can be able to freely acquire the image without ant restriction by putting users hand virtually in any position. The process extracted the left and right tip of each finger with thumb hence overall 10 features extracted for the classification purpose. The back propagation algorithm used as a classifier. It takes the training samples, multilayer feed forward network as an input and gives the trained classified samples as an output. Das and Meshram [7] proposed a hybrid method of face recognition by using the information from different regions of the face that is further extracted from detected face region. Pre-processing part based on Active shape model (ASM) and principal component analysis algorithm. Author implemented RBFNN classifier which consists of three functional modules with the help of fuzzy rules. Duraipandi et al. [8] proposed grey level co-occurrence matrix convolution neural network (GLCM-NN). The author used five different types of cattle data for research as compared with the earlier work. GLCM is a matrix that represents different combination distribution of pixel brightness values that occur in an image. GLCM provides feature related to texture of an image. The implementation has done on five different classes with best accuracy for 100 iterations so cattle identification done automatically [9].

In the above works, the ultimate idea is to fuse different modalities in order to address the FAR and FRR thereby improving accuracy. In the implementations, the accuracy do also heavily depends on various other factors like Scale and the angular orientation of the real-time test images when they are captured [10]. This paper focuses primarily on addressing these issues [11].

Another important aspect of the work is that all the features extracted and fused were local features and like many of the previous works matching score based idea is utilized to create novel matching score by implementing SIFT and LBP.

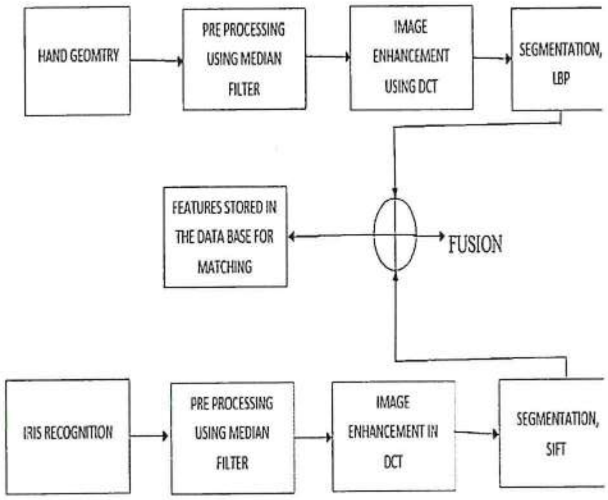


Fig. 1 Block diagram of the proposed system

3 Block diagram of proposed system

In Fig. 1 the Block diagram of the proposed ELSA algorithms has given as follows

4 ELSA working mechanism

ELSA works on the Bi-Modal Fusion techniques in which the hand geometry features has been taken as the LBP and other IRIS Images has been taken as the SIFT has the major techniques for the features. Step 1 Input Image: The Input Image of the Hand Geometry and IRIS has been taken from the CASIA databases version 4.0. the sample images [12]. Step 2 Preprocessing of the Images: As the next step for the both the images are preprocessed using the median filters for the removal of the noises and smoothening in the images collected from the databases. Step 3 Image Enhancement using DCT: The pre-processed images are fed to the Discrete Curvelet Transforms for better clarity of the Images for the efficient processing. Step 4 Effective LBP Method: ELSA follows the two important categories of the feature extraction which are given as follows as 1 [13]. Effective linear Binary Patterns (ELBP) 2 Scale Invariant Fourier Transforms (SIFT) Effective Linear Binary Pattern (ELBP): The tem LBP deals with the unique feature extractions based on the textures. Divide and conquer approach in which the examined window into cells (e.g. 16 × 16 pixels for each cell).As the next step, comparison of the pixel to each of its 8 neighbours (on its left-top, left-middle, left-bottom, right-top, etc.). Follow the pixels along a circle, i.e. clockwise or counter-clockwise. Where the center pixel's value is greater than the

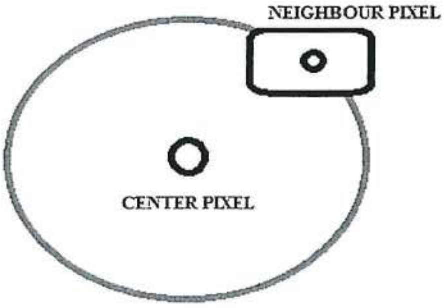


Fig. 2 Linear binary patterns-mechanism of taking the center pixels with respective to the neighbourhood pixels

neighbour's value, write "0". Otherwise, write "1". This gives an 8-digit binary number as shown in Fig. 2.

The histogram is computed over the cell, of the frequency of each "number" occurring (i.e., each combination of which pixels are smaller and which are greater than the centre). This histogram can be seen as a 32-dimensional feature vectors for the image size 256×256. Concatenate (normalized) histograms of all cells. This gives a feature vector for the entire window as the Single Value of Feature which has been extracted.

5 SIFT method

In this method, four stage method is adopted for the extraction of the feature from the image size of 256×256 which are given as follows (Fig. 3).

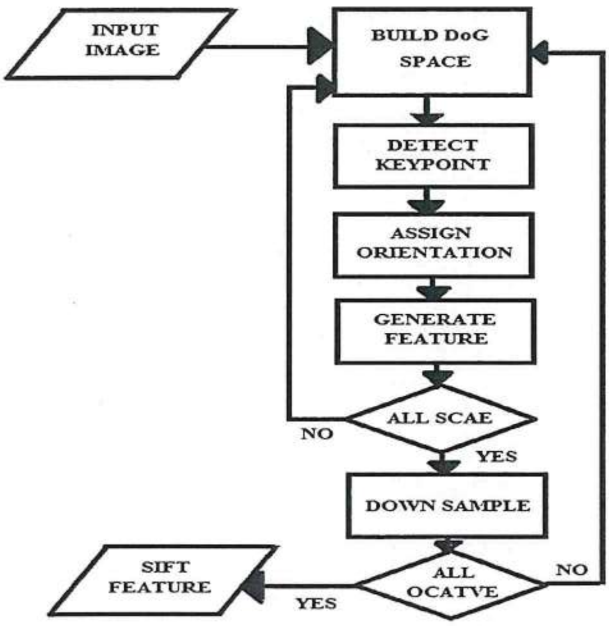


Fig. 3 Scale invariant fourier transforms-its working mechanism

5.1 Scale-space extrema detection

This stage of the filtering attempts to identify those locations and scales that is identifiable from different views of the same object. This can be efficiently achieved using a "scale space" function. Further it has been shown under reasonable assumptions it must be based on the Gaussian function. The scale space is defined by the function:

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

where * is the convolution operator, $G(x, y, \sigma)$ is a variable-scale Gaussian and $I(x, y)$ is the input image. Various techniques can then be used to detect stable key point locations in the scale-space. Difference of Gaussians is one such technique, locating scale-space extrema, $D(x, y, \sigma)$ by computing the difference between two images, one with scale k times the other. $D(x, y, \sigma)$ is then given by:

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma)$$

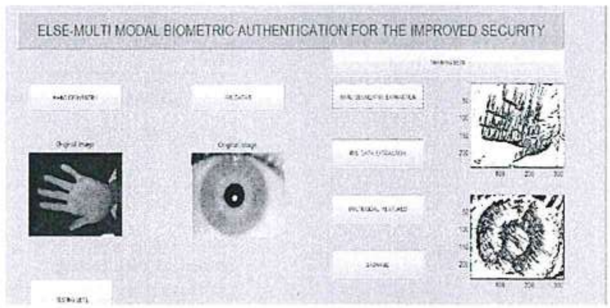


Fig. 4 The system GUI developed for the ELSA fusion of images

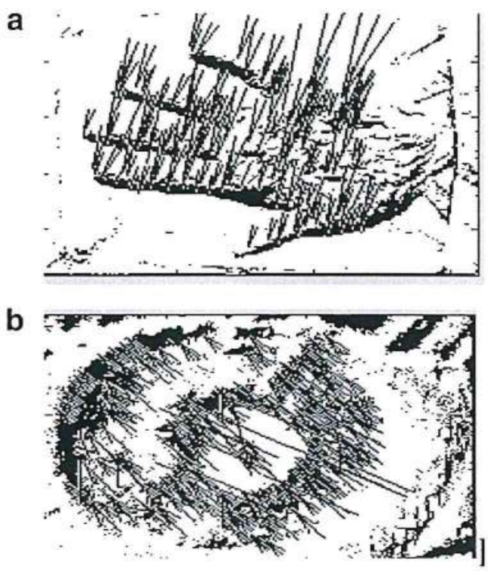


Fig. 5 **a** Output of fused image in Type A system. **b** Output of fused image in Type B system

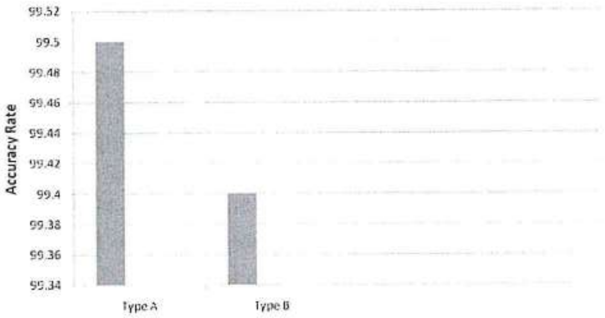


Fig. 6 Graphical representation of performance of the ELSA (Type-A) & Type-B

To detect the local maxima and minima of D(x, y, σ) each point is compared with its 8 neighbors at the same scale, and its 9 neighbors up and down one scale. If this value is the minimum or maximum of all these points then this point is an extrema.

5.2 Key point localization

This stage attempts to eliminate more points from the list of key points by finding those that have low contrast or are poorly localized on an edge. By taking the z-value. If the function value at **z** is below a threshold value then this point is excluded. This removes extrema with low contrast. To eliminate extrema based on poor localization it is noted that in these cases there is a large principle curvature across the edge but a small curvature in the perpendicular direction in the difference of Gaussian function. If this difference is below the ratio of largest to smallest eigenvector, from the 2 × 2 Hessian matrix at the location and scale of the key point, the key point is rejected.

5.3 Orientation assignment

This step aims to assign a consistent orientation to the key points based on local image properties. The key point

Table 1 Fusion value for SIFT-LBP Fusion method

Type	Image size	Elsa-type-A	Elsa-type-B
Hand geometry feature value	256 × 256	122	128
Iris feature value	256 × 256	126	110
Fusion		250	219

Table 2 ELSA type A output analysis

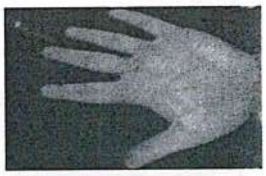
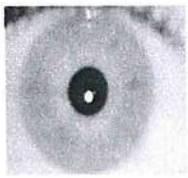
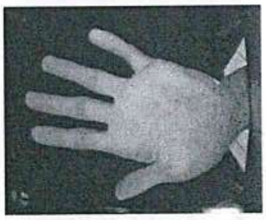
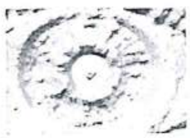
Stages of processing	Test image-hand geometry	Test image-iris images
1. Input image		
2. Image filtering process		
3. Image enhancement process		
4. Feature extraction process		

Table 3 ELSA type B output analysis

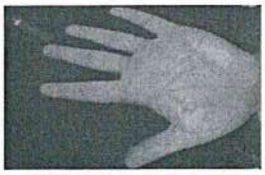
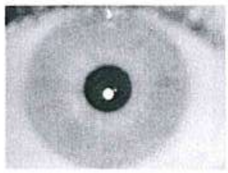
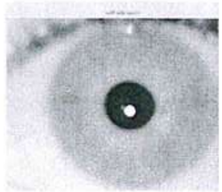
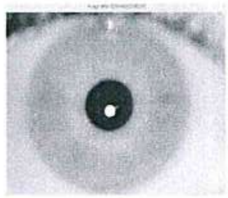
Stages of processing	Test image-hand geometry	Test image-iris images
1. input image		
2. Image filtering process		
3. Image enhancement process		
4. Feature extraction process		

Table 4 Accuracy rate measurement when ELSA is categorized into two types

SL. no	Algorithms	Test images	Hit ratio	Miss ratio	Accuracy rate (%)
01	ELSA (type A) hand geometry-SIFT IRIS-ELBP	700	695	006	99.5
02	ELSA (type B) hand geometry-ELBP IRIS-SIFT	700	693	007	99.42

Table 5 Response time of proposed algorithm with existing system

Sl. no.	Algorithms	Test images	Response time (training)	Difference in time (s)
01	ELSA (type A)	Hand geometry + IRIS	35.5 s	5.5
02	ELSA (type B)			
03	Existing system	Hand geometry + IRIS	40 s	

Table 6 Recognition time of proposed algorithm with existing system

Sl. no.	Algorithms	Test images	Recogntiontime (training)	Difference in time (s)
01	ELSA (type A)	Hand geometry + IRIS	47.8 s	2.2
02	ELSA (type B)			
03	Existing system	Hand geometry + IRIS	50 s	

descriptor, described below, can then be represented relative to this orientation, achieving invariance to rotation.

5.4 Key point descriptor

The local gradient data, used above, is also used to create key point descriptors. The gradient information is rotated to line up with the orientation of the key point and then weighted by a Gaussian with variance of 1.5 * key point scale. This data is then used to create a set of histograms over a window centered on the key point. Key point descriptors typically uses a set of 16 histograms, aligned in a 4 × 4 grid, each with 8 orientation bins, one for each of the main compass directions and one for each of the mid-points of these directions. These results in a feature vector containing 128 elements. Finally, all the feature vectors extracted and concatenated to form the Single dimensional features.

6 Fusion mechanism

In the final stage, ELSA takes into the two important types one is Type-A and the Type-B (Figs. 4, 5). In the Type-A Fusion take place when the hand geometry's features are extracted by SIFT and the IRIS Images as ELBP. In the type-B reverse operations are performed. These kinds of operations are used in the ELSA for the better accuracy in which the selection of the types will be done manually or automatically. In the both methods, fusion is taken as the number of the features added with the number of features taken from the one method which results in the less computational time (Tables 1, 2).

7 Overall system developed

The overall system developed using the MATLAB GUIDE tool for the testing and making the tools for the designs

8 Result and comparison

8.1 Biometric accuracy

The system incubates the two number of inputs such as the hand geometry and Iris images. The accuracy ratio is calculated by the formula given

$$\text{Accuracy ratio} = (\text{No of Hit Ratio}) / (\text{Total Number ofTrials}) * 100 \quad (1)$$

The proposed system is taken the input image from CASIA Iris Image database Version 4.0, CASIA hand geometry Image database, own data and trained up to 1000 images. Accuracy rate is calculated based on number of corrected (hit ratio) with respective to the total number of images t which is taken from standard databases. The performance of the proposed algorithm is been calculated depends on the two categories of shown in Tables 3 and 4 and shows the graphical representation of the performance of the systems dataset.

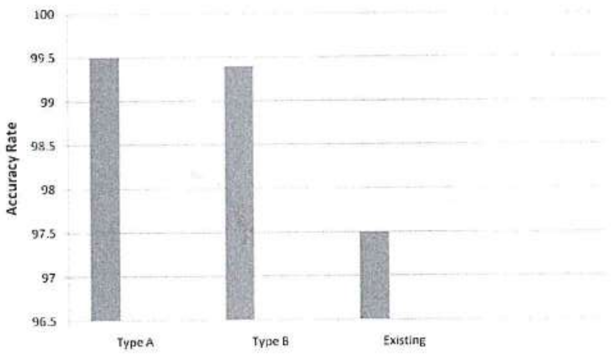


Fig. 7 Graphical representation of comparative performance of the ELSA (Type-A) & (Type-B) with the existing system

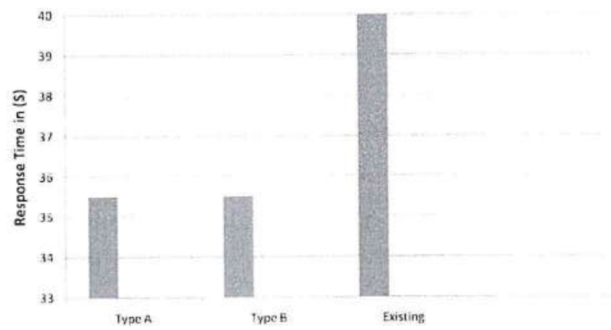


Fig. 8 Training response time for the Image Fusion using the ELSA (A&B) with that of existing systems

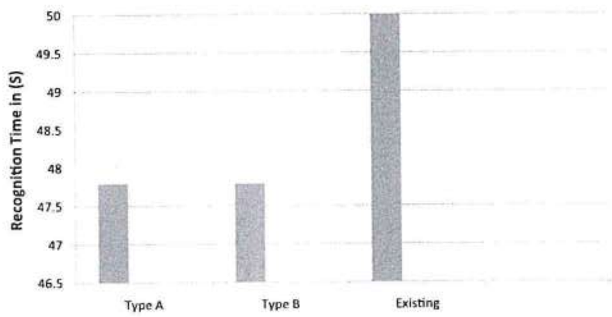


Fig. 9 The recognition time of proposed algorithm with existing system

In a similar multimodal biometric system using hand geometry and iris has been evaluated. In Table 5 the results were taken as existing results to which the proposed results have been compared.

9 Comparison

The obtained results has been compared with the existing systems which is shown in Fig. 6.

In the Fig. 7 the computation analysis such as training response time, recognition time has been calculated for the Input Image datasets and compared with the existing system.

The Response Time of Proposed Algorithm with Existing System.

Figures 8 and 9 shows the comparative chart of the recognition response time for the Image Fusion using the ELSA (A&B) with that of existing systems.

10 Conclusion

The proposed algorithm ELSA (Type-A) & Type-B has been designed and compared with the existing algorithms. It opens up a novel method of extracting and fusion of various kinds of features in biometric recognition that can be improved further. The biggest contribution of the work is fusing the features by using a cryptographic approach. The proposed algorithm has been tested with the CASIA datasets and the approach of combining the two different features extraction methods proves to be more efficient compared with the other algorithms. This kind of the algorithms finds its application in defence, medical, etc. Still the ELSA can be improved by adopting the new fusion techniques, different feature extractions for the large and dynamic datasets. It is also investigated to implement a reversible fusion so as to identify a person using any of the traits in near future.

References

1. Velmurugan, S., Selvarajan, S.: Linear binary pattern based biometric recognition using hand geometry and iris images. Int. J. Appl. Eng. Res. ISSN 0973-4562 **10**, 24 (2015) pp. 45675–45683 © Research India Publications. http://www.ripublication.com
2. Podio, F.L.: Personal authentication through biometric technologies. In: Proceedings 2002 IEEE 4th International Workshop on Networked appliances, 2002. Gaithersburg, pp. 57–66. IEEE (2002)
3. Jobin, J., Joseph, J., Sandhya, Y.A.: Multimodal biometric system using iris, Palmprint and Finger-Knuckle. Int. J. Comput. Appl. **57**(16), 0975 (2012)
4. Androunikou, V., Demetis, D., Theodosiou, Z., Bassiliades, N.: POLYBIO multibiometrics database: contents, description and interfacing platform. In: AIAI-2009 Workshops, vol. 475, pp. 150–157
5. Jain, A.K., Ross, A., Prabhakar, S.: An introduction to biometric recognition. IEEE Trans. Circuits Syst. Video Technol. **14**(1), 4–20 (2004)
6. El-Alfy, E.S., Bin Makhashen, G.M.: Evaluation of support vector machine with universal kernel for hand-geometry based identification. In: 2012 International Conference on Innovations in Information Technology (IIT), pp. 117–122. IEEE. (2012, March)
7. Das, P., Meshram, S.: An efficient handgeometry system for biometric identifications. IOSR J. Electron. Commun. Eng. **4**(4), 9–17 (2013)
8. Duraipandi, C., Pratap, A., Uthariaraj, R.: A grid based iris biometric watermarking using wavelet transform. In: 2014 International Conference on Recent Trends in Information Technology (ICRTIT), pp. 1–6. IEEE. (2014, April)
9. Golfarelli, M., Maio, D., Malton, D.: On the error-reject trade-off in biometric verification systems. IEEE Trans. Pattern Anal. Mach. Intell. **19**(7), 786–796 (1997)
10. Yano, V., Zimmer, A., Ling, L.L.: Multimodal biometric authentication based on iris pattern and pupil light reflex. In: 2012 21st International Conference on Pattern Recognition (ICPR), pp. 2857–2860. IEEE. (2012, November)
11. Rajasekar, V., Selvarajan, S.: Shape segmentation using learnable evolutionary model and object identification. Int. J. Appl. Eng. Res. **10**(16), 36987–36995 (2015)
12. Dhawale, M.A.D., Kale, K.V.: Fusion of iris and palmprint traits for human identification. Int. J. Comput. Techn. **2**(1), 42–47 (2015)
13. CASIA. http://biometrics.idealtest.org

S. Velmurugan received B.E. and M.E. degree from Muthayammal Engineering College affiliated to Anna University Chennai, Tamilnadu, India during 2005 and 2009. He is a life member of ISTE (Indian Society for Technical Education).At present he is Assistant Professor, Electrical and Electronics Engineering Department, KSR Institute for Engineering and Technology, Tiruchengode, Namakkal, Tamilnadu. His research interests include image processing, pattern recognition and biometrics.

S. Selvarajan received B.E. degree from Madurai Kamarajar University, Madurai, Tamilnadu, India in the year 1989. M.S. Degree from Birla University Pillani, Rajasthan, India and M.E. degree from Bharathiar University, Coimbatore, India 2002. He is a Graduate member of IEEE, IAENG, Senior member of IACSIT, CSI and life member of ISTE (Indian Society for Technical Education). He had completed his Ph.D. programme at Anna University, Chennai, India 2009. At present he is the Principal, Muthayammal college of Engineering, Namakkal, Tamilnadu from June 2011. He has published more than 30 papers in International Journals and Conferences. His research interests include image processing, pattern recognition, computer vision, biometrics, cryptography, and networking.

PRINCIPAL,
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

Wireless Pers Commun (2018) 98:3377–3391
https://doi.org/10.1007/s11277-017-5019-0

CrossMark

An Analysis of Energy Efficiency Improvement Through Wireless Energy Transfer in Wireless Sensor Network

M. Dhurgadevi[1] · P. Meenakshi Devi[2]

Published online: 29 November 2017

Abstract In a wireless sensor network, wireless Energy transfer is a demanding technology for the energy difficulties in recent times. The foremost disadvantage of presentation is limited duration because WSN contains only restricted battery energy at a node. Therefore, we anticipated cluster-related wireless energy transfer in this document. The foremost intention of the method is to augment the duration of the sensor network through charging by the help of this wireless power transfer technology. So that, mobile charging vehicle (MCV) is established to move within the network and charge the sensor node battery wireless. The sensor nodes in the network are collected as a cluster for energy efficiency. Here, the cluster head is chosen for each one cluster in the network which is based on the rank metric value. Suppose, if one node in the network is reducing its energy, then the CH will send charge request and route ID to the MCV. Afterward, the MCV recognize the node by means of the exacting route and establish to charge the node. The reproduction consequences illustrate that the network lifetime of our anticipated method is enhanced than obtainable method.

Keywords Wireless Energy transfer · Wireless sensor network · Mobile charging vehicle (MCV) · Rank metric · Cluster head

1 Introduction

Generally, the wireless sensor network contains several battery sensors. Sensors misplace its energy on sensing, conveying and receiving. The battery charge will also misplace in redundant condition. In wireless sensor network, the demanding procedure is to augment

✉ M. Dhurgadevi
dhurgadevi1183@gmail.com

1 KSR Institute for Engineering and Technology, Tiruchengode, Tamilnadu, India

2 Department of Information Technology, KSR Institute for Engineering and Technology, Tiruchengode, Tamilnadu, India

the energy efficiency of the node in recent times. When the nodes are motorized by means of a battery, then it contains only restricted duration. If the battery stage of sensor nodes is restricted, then the energy-effectiveness enhancement is a foremost confront. In the process of sending, the sensors misplace their energy. Recently, the sensor performs a foremost function in all areas particularly in health care observation [1]. Previously, several researchers put their attempt to extend the duration of sensor network [2–4].

Normally, the energy-harvesting procedure [5–7] is used to remove energy from the surroundings, but the procedure is not accomplished because the appropriate function of the procedure is greatly reliant on the surroundings. In an energy harvesting sensor network, the sensors are motorized by means of reusable energy like solar energy, wind energy, thermal energy etc. [8]. The foremost intention of innovative monitoring eminence maximization difficulty is used to exploit the eminence. Moreover, the dynamic rate weight task and lessening procedures are used to diminish the simultaneous flow difficulty.

Here, the wireless charging technology is permitting a mobile charger for conveying energy to sensor nodes wirelessly [9–11] not including the battery. A vehicle is required to transmit a charger to move in the network for to execute the Wireless power transfer [WPT] technology. In [14], wireless charging vehicle (WCV) is transferring the cellular arrangement in the network and transferred the sensors wirelessly. On the other hand, the energy effectiveness and duration of the network is so pitiable in this technology. So, we recommend the cluster-related wireless energy transfer for to resolve these difficulties. Here, we offered rank related weight metric computation for cluster head choice. Wireless/ Mobile charging vehicle is generally employed to charge the node in the network.

This document also contains: Some of the related works of wireless energy transfer technology is explained in Sect. 2. In Sect. 3, we depict our anticipated cluster-related wireless energy transfer. Consequences of our anticipated method are explained in Sect. 4. At last, this document is accomplished by Sect. 5.

2 Related Works

Madhja et al. [12] have examined the difficulty of competent wireless power transfer in wireless sensor networks. In their process, they offered particular mobile chargers for to charge the sensor nodes in the network. They have anticipated four innovative protocols. Here, two of them (CC, CCGK) are carried out as centralized, international network information management and charging. And, two of our protocols (DC, DCLK) are carrying out as disseminated, restricted network information coordination and charging.

Xu et al. [13] have explained a charging development, difficulty of discharging, several mobiles charging vehicles to charge sensors like the overall detachment of this observation occasion is diminished. Therefore, any one of the sensors will execute without energy among others. They have anticipated an estimation algorithm by the help of certain estimation proportion. They have invented a heuristic algorithm in the course of alteration to the estimation algorithm. They have diminished the service expenditure at 20% when contrast to the existing method.

Xie et al. [14] have offered a multi-node wireless energy transfer technology. It is verified by whether it is a scalable technology to tackle energy problem in a WSN or not. They have measured wireless charging vehicle (WCV) for to incriminate the sensors in the network. They have anticipated a cellular arrangement which divides the two-dimensional plane as adjacent hexagonal cells which are derived from the charging-series of the WCV.

They have depended on a recognized optimization arrangement through mutually optimizing flow routing, traveling course and charging time.

Shi et al. [15] have offered a dynamic routing algorithm for renewable wireless sensor networks among wireless power transfer. Their anticipated process encompasses the roaming course of WCV and charging program like the proportion of the WCV's holiday time in the sequence time. Moreover, they have established the perception of (N + 1) segment explanation with a competent dynamic routing process. Their most favorable wandering course is established by the direct Hamiltonian sequence.

Lin et al. [16] have anticipated a game hypothetical mutual charging format for wireless rechargeable sensor networks which is also recognized as GTCharge. They have transformed the charging progression as a collaborative game which obtained by wireless charging vehicles (WCVs). They have examined the quality of payment level, charging precedence and earnings. In this method, WCV has accomplished the greatest earnings.

3 Cluster-Based Wireless Energy Transfer in WSN

3.1 Overview

Here, we have offered wireless energy transfer with wireless charging vehicle or mobile charging vehicle for to develop the energy effectiveness and network duration. The sensor nodes in the network are collected as a cluster for energy efficiency. The cluster head will be elected for each one cluster in the network which is derived from the rank metric value. Rank metric value is premeditated by means of a amount of adjacent nodes, outstanding energy and the detachment among the node and its adjacent nodes in a cluster. In the node, the highest rank metric value is preferred as a CH. The CH is used to combine the entire information from the non-CH element in a cluster. Afterward, the basis node sends the data package to the target through choosing the least hop count as a subsequent hop node. Suppose, if the cluster head is reducing its energy, then it will be accused by means of mobile charging vehicle (MCV) which is previously charged at a service location. Suppose, if the non-CH element in the route is reducing its energy, then it will send charge request to the related CH. Afterward, the CH sends route ID and accusation demand to the MCV. In this process, the exacting non-CH component will be charged.

3.2 System Model

Here, Fig. 1 illustrates the system representation of our anticipated method. This process contains a combination of cluster and cluster head which is preferred by means of rank metric. In a cluster, every node is modernized by its adjacent table which contains outstanding energy and hop-count of adjacent nodes. The CH is used to combine the entire information from the non-CH component. Suppose, if the node is reducing its energy, then it will be accused by means of mobile charging vehicle (MCV) which is previously accused at a service location.

3.3 Cluster Formation

In group related process, the cluster head (CH) is the fundamental uncertainties for energy capable communication in remote sight and sound sensor system. In this document, we

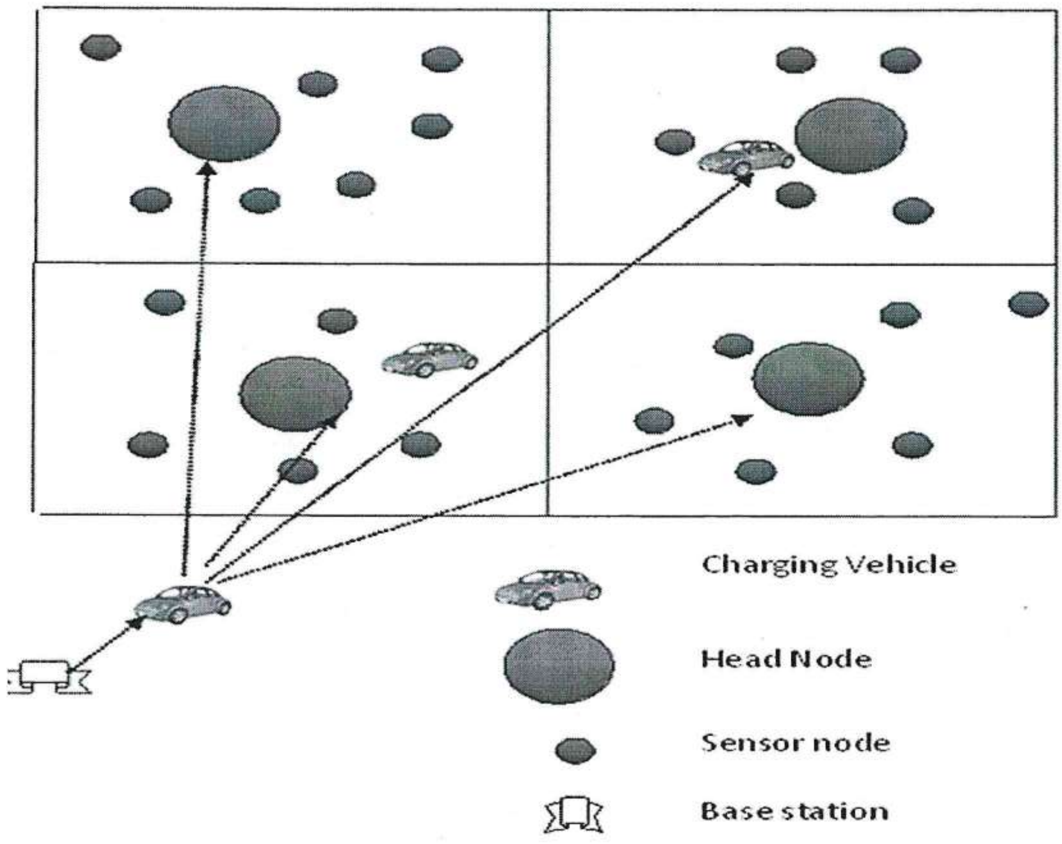


Fig. 1 System model

have established rank related cluster head determination procedure. Before picking a basic cluster head in a group, the conveying of HELLO message is used to combine video or audio data from each hub. In a cluster, each hub contains two tables such as a Neighbor table (NT) and Information Table (IT). The Information Table contains the type of each hub. Initially, the hub sends REQ message from basis to the adjacent hub. In this occasion, the basis hub obtains REP message from the adjacent hub and it improves the position of the adjacent hub in Neighbor Table. Normally, the association is removed from the path.

According to the previous conversation, a Rank Metrics process is combining every structure limitations by means of definite computing fundamentals which are selected through structure requirements. The flexibility of weight component is an aid to implement this computation to dissimilar systems. The cluster head selection progression is the collection of hubs which containing a superior evaluation of Rank metrics. The communication variety of hub is selected by CH, which means no two CHs are adjacent. There may be a situation if two CHs are produced the identical established assessment of the Rank metric. In this situation, a perfect array is used to select a hub with short misfortune value in the middle of hubs (Tables 1, 2).

Table 1 Information table of node

Node id	Residual energy	Distance between node and neighbor node	No of hub

Table 2 Neighbor table of nodes

Neighbor node ids	Residual energy	Distance between node and neighbor node	No of hub

According to the previous conversation, a Rank related Weight Metric method is premeditated to unite the system limitation among definite weighing.

Adjacent nodes are resolute by the transmission range (R_{tx}) of the nodes. Here, the values are standardized by utilizing the neighbor table (NT) of the node.

$$N_s = \sum_{s' \in s' \neq s} \{d(s, s') < R_{tx}\} \tag{1}$$

here s and s' are indicating the basis node and adjacent nodes in an identical way. N_s is explain about the overall quantity of adjacent nodes of the basis s. The detachment among basis and adjacent nodes i.e. $d(s, s')$ are premeditated through Euclidean detachment formula which is specified as

$$T_s = \sum_{s' \in N_s} \{d(s, s')\} \tag{2}$$

here the Eq. (2) is used to find out the overall failure in a routing path. The standard energy of each node is specified as,

$$E_{avg_s} = \frac{1}{N_s} \sum_{s \in N_s} E_{res_s} \tag{3}$$

here E_{res_s} is the outstanding energy of the entire adjacent nodes. In Eqs. (1), (2) and (3), Rank metric value of each one node is specified as,

$$Rank_s = \alpha \cdot N_s + \beta \cdot E_{avg_s} + \gamma \cdot \left(\frac{1}{T_s}\right) \tag{4}$$

here α, β *and* γ is representing the weighting feature for the corresponding group elements. The node among highest Rank metric is selected as the foremost cluster head (CH) (Figs. 2, 3, 4).

3.4 Wireless Energy Transfer

After that, the preferred CH sends the HELLO message to every non-CH element in the cluster. Figure 5 is illustrated in the arrangement of HELLO message which is sent by means of CH. This message also contains the cluster ID, CH–ID, outstanding energy detachment among node and an adjacent node, and a number of hops. Afterward, every non-CH member is modernizing their information in the message. Here, the CH is established to congregate the entire data package from the non-CH element and promote it to the target or base location. For routing, the node among least hop count is preferred as a next hop node from the adjacent table. A source node is conveying its data package to the CH and the CH conveys the composed data package to the target in the course of the next CHs in the network. The Route-ID of the cluster is gathered in the CH for every communication (Fig. 6).

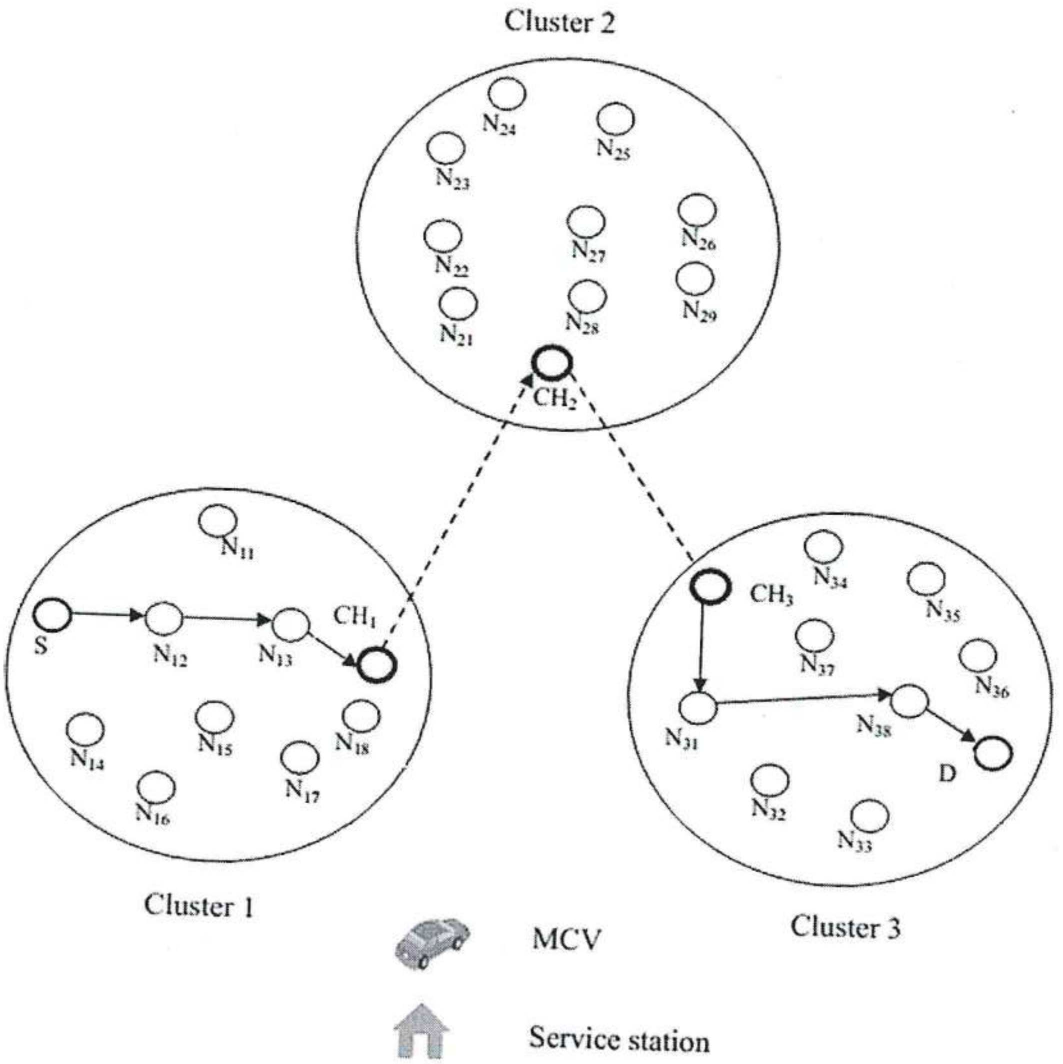


Fig. 2 Cluster-based routing

After this process, a node possibly will misplace its energy stage in the route. Therefore the CH confirms the energy stage of every node in the route and itself also. Suppose, if the energy stage of every node is obtained from the highest and the least threshold value, then the CH verifies the particular requirement to be revived.

$$T_{\max} > E_{res_i} > T_{\min} \tag{5}$$

Suppose, if the CH convinces that situation, then it sends Charge Request (C-REQ) to the mobile charging vehicle (MCV) at a service location.

$$CH \xrightarrow{C-REQ} MCV$$

In this network, MCV recognizes the position ID for the entire nodes. Here, the MCV progress to the CH and establish to charge after getting the demand from the CH. Suppose, if charging is completed, then MCV takings to the service location. Moreover, if a non-CH

Algorithm 1

1. *Initializes each and every one nodes in a cluster*
2. *Keep informed Information Table (IT) and Neighbor Table (NT) of each node in a cluster*
3. *Approximation degree of the node* s (N_s)*, sum of distance between* s *and* s' (T_s)*, average residual energy of the node* (E_{res_s})*.*
4. *In conclusion, compute the Rank metric* ($Rank_s$) *value of the node.*

$$Rank_s = \alpha \bullet N_s + \beta \bullet E_{avg_s} + \gamma \bullet \left(\frac{1}{T_s}\right)$$

5. ***If*** Rank $_m$ > Rank $_{m+1}$

   Rank $_m$ = CH

   Or else; go step 2

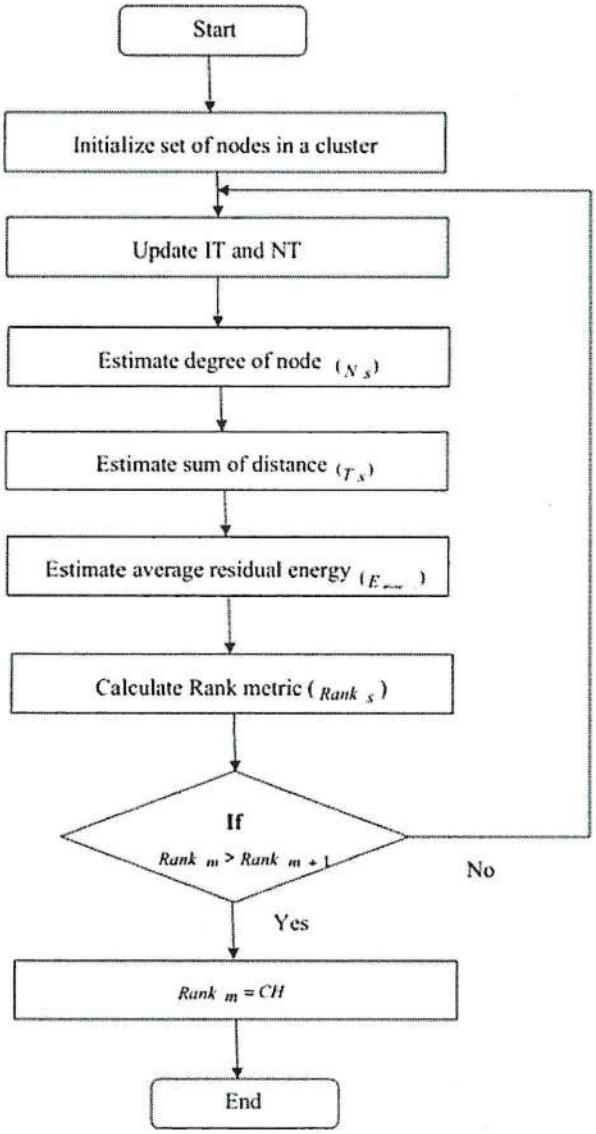


Fig. 3 Flowchart of Algorithm 1

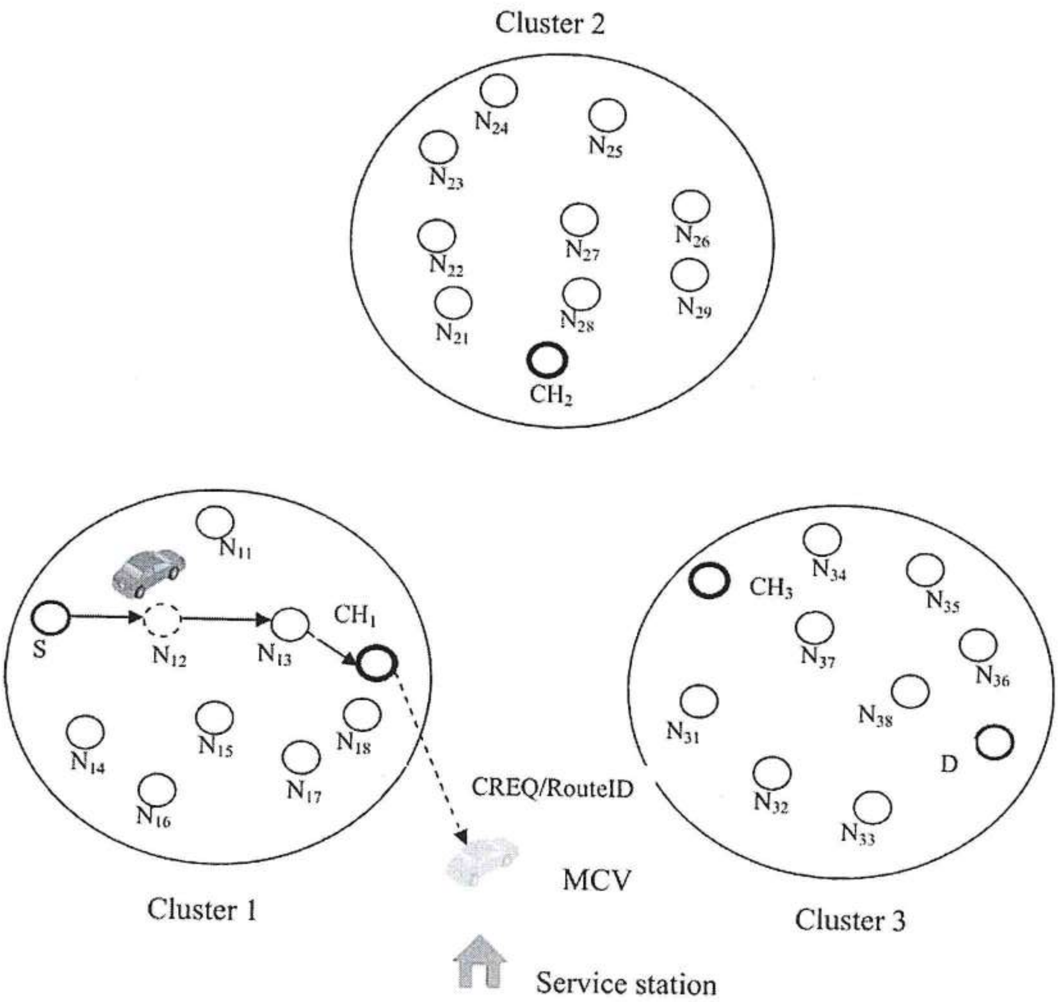


Fig. 4 Cluster-based wireless energy transfer (CWET)

Route ID	S	**N_{12}**	N_{13}	CH_1
		(C_REQ)	N_{25}	

Fig. 5 Route ID of cluster 1

component in the route gratifies the above situation, then it sends Charge Request (C-REQ) to the cluster head.

$$non - CH \overset{C-REQ}{\longrightarrow} CH$$

Afterward, the CH sends the Route-ID among C-REQ to the MCV. After getting the message from the CH, the MCV shift the route from the basis node and recognize the node which is to be accusing. Suppose, if charging is completed, then MCV takings to the service location.

Overall Algorithm

1. *Cluster formation and cluster head selection*
2. *CH gathers information about the non-CH members in the cluster*
3. *Updates neighbor table of each node*
4. *The node with minimum hop count is selected as a next hop node for routing*
5. *If* $T_{max} > E_{res,} > T_{min}$

    Node ^{i} *sends C-REQ to CH*

    CH sends Route-ID and C-REQ to MCV

    MCV charges the Node ^{i}

   Else

    Routing continued

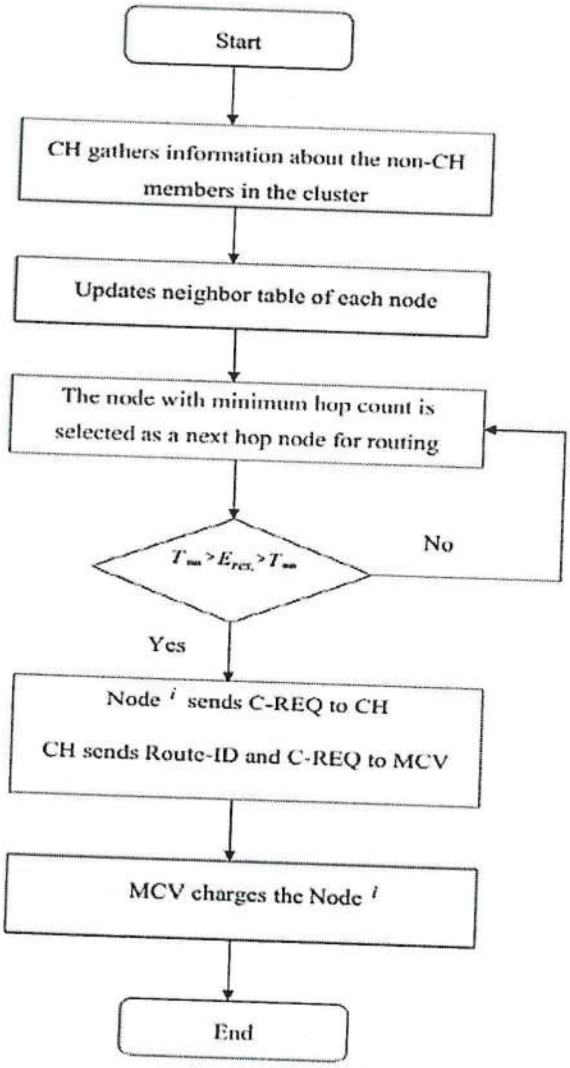


Fig. 6 Flowchart of overall algorithm

$$CH \xrightarrow{Route-ID/C-REQ} MCV$$

In Fig. 4, the node N_{12} is reducing its energy for conveying C_REQ to the CH_1. Afterward, the CH_1 sends the C_REQ among the Route ID to the mobile charging vehicle (MCV). After this process, the MCV shifts the route and recognize the node as to be accused. Here, Fig. 5 illustrates about the Route ID of cluster 1.

4 Results and Discussions

In this segment, the document is premeditated by NS2. To modernize their topology, every node is sending hello package to its adjacent node which is in its communication series. Here, the arrangement of topology has 40 nodes in surroundings system. The entire nodes are considered as dynamic nodes with identical energy stage at the establishment. The preliminary energy stage of every node is 100 Joules. The node among the highest quantity of adjacent node is chosen as a cluster head. The energy stage of cluster head is 200 Joules. The accusation rate of cluster head is 45 joules. Here, the two unsystematic produced WSNs are included 40 nodes. The sensor nodes are set up a square region as 1 km × 1 km. The least energy stage of the node is measured as 40 joules.The traveling speed of the WCV is considered as V and the value is 5 m/s. Figure 7 illustrates the topology arrangement of our anticipated method. Here, the 40 nodes are gathered as a cluster and the network encompasses one base location, WCV/MCV, and service location.

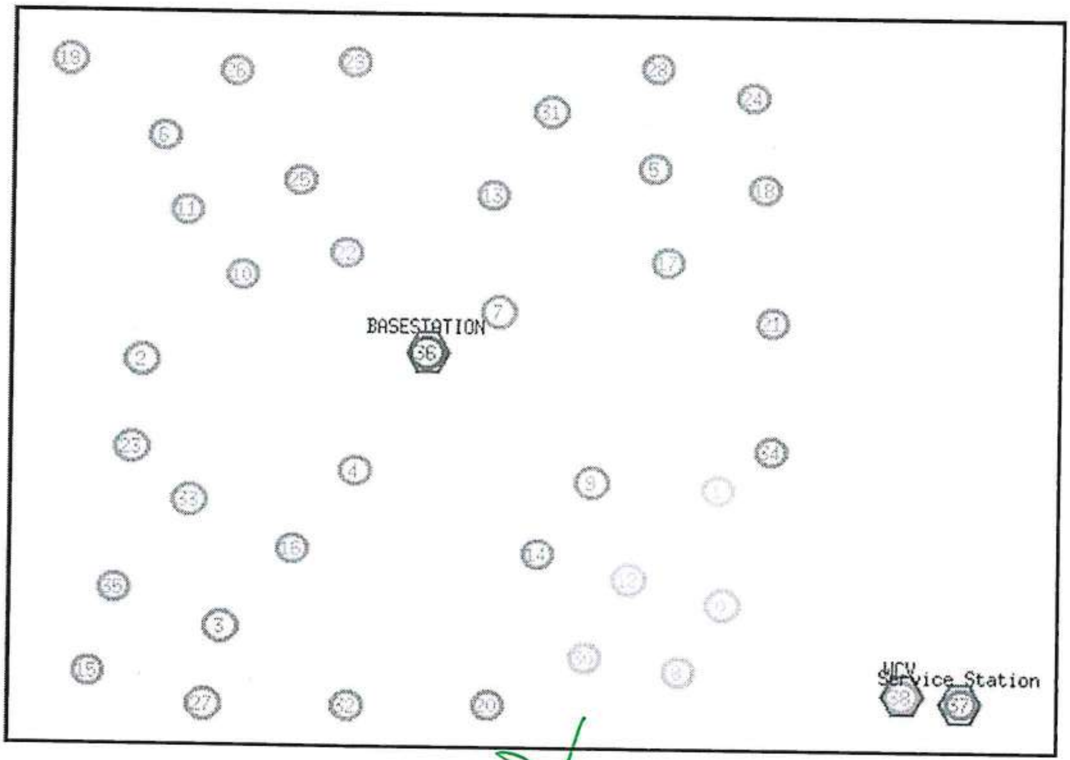


Fig. 7 Topology formation

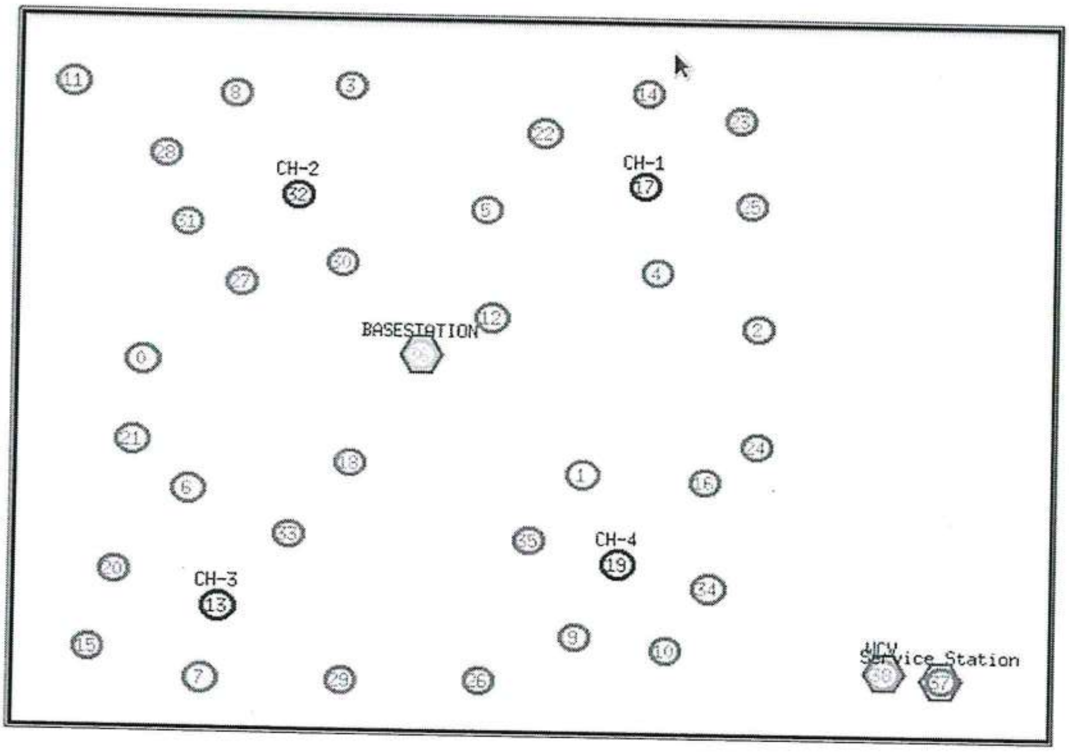


Fig. 8 Cluster head selection

Figure 8 illustrates about the computation of rank metric value for every node in a cluster. Here, the node among highest rank value is preferred as a cluster head (CH). So, we have preferred four cluster heads like CH-1, CH-2, CH-3, and CH-4.

In Fig. 9, the cluster heads CH-1, CH-2 and CH-3 are diminishing its energy. Therefore, they have sent C_REQ to the MCV. The MCV establish to accuse the cluster heads. Suppose, if one non-CH element is diminishing its energy, then it conveys the C_REQ to the related CH. Afterward, the CH sends the C_REQ and Route_ID to the MCV. The non-CH element is recognized and accused through choosing the exacting route.

4.1 Performance-Based on Nodes

In this segment, the presentation of the anticipated method is anticipated for diverse nodes 8, 16, 24, 32 and 40. The Figs. 10, 11, 12, 13, 14 and 15 is illustrated about the package delay, delivery ratio, package drop, energy utilization, network lifetime and throughput of our anticipated method. Here, the anticipated cluster-related wireless energy transfer (CWET) is contrast by means of the obtainable method MWEC [14]. Figure 10 is illustrated about the package delay of our anticipated method. Suppose, if the quantity of node is augmented, then the packet delay of the network also augmented. But, the packet delay of our anticipated method is diminished to 68% in the contrast to the obtainable method. According to the arrangement of energy competent cluster, the chance of delay is very small in our anticipated process. Figure 11 is illustrated about the delivery ratio of our anticipated method. According to the rank-related cluster head choice, the delivery ratio of our anticipated method is augmented to 40% than the obtainable method. The Figs. 12 and 13 illustrates about the package drop and energy utilization of our anticipated method correspondingly. The related CH sends charge request to the MCV in the cluster, at the

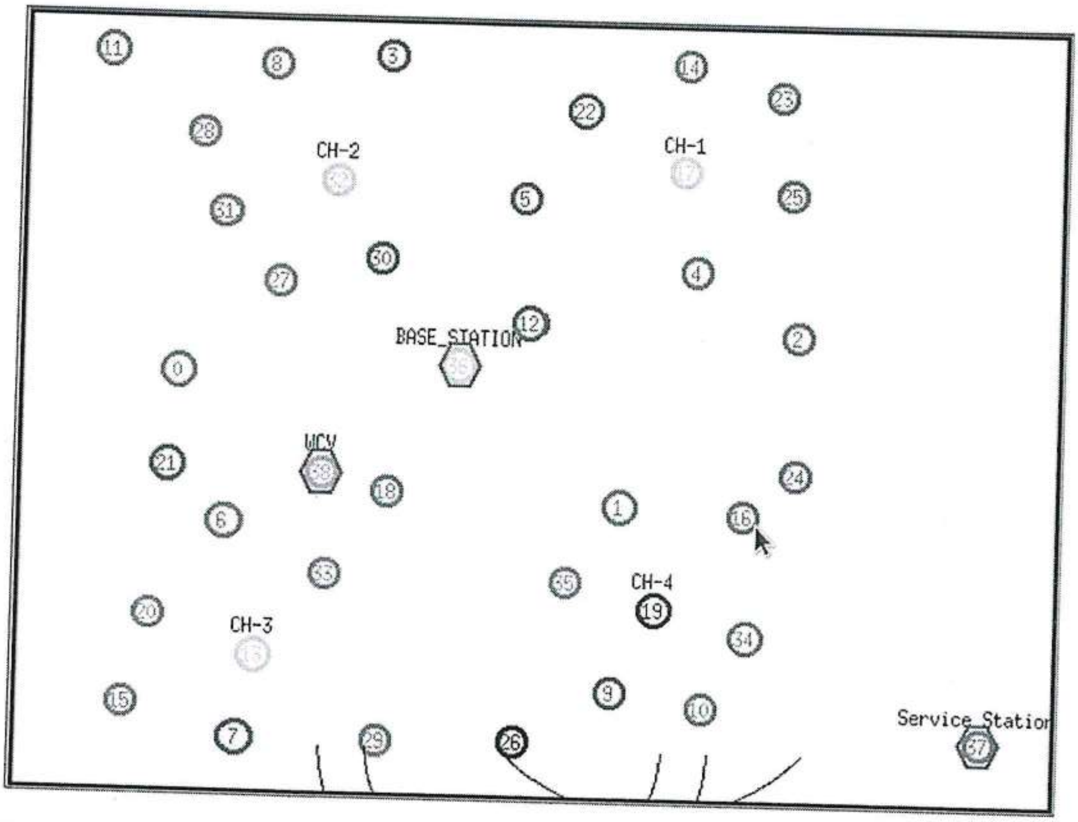


Fig. 9 Power transfer to nodes

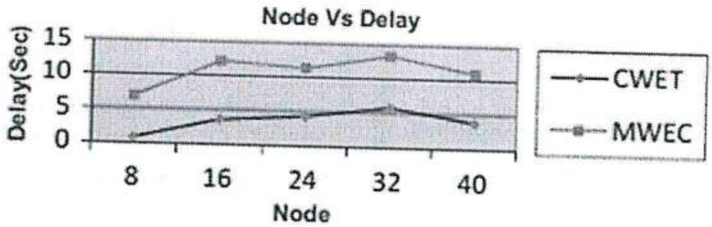


Fig. 10 Node versus delay

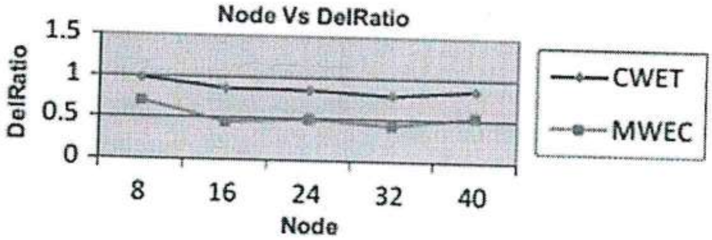


Fig. 11 Node versus delivery ratio

same time as a node in the route is diminishing its energy. Afterward, the MCV accuses the node earlier than it misplaces its energy. Therefore the package drop and energy utilization of our anticipated method are diminished to 95 and 96% correspondingly than the obtainable method. The Figs. 14 and 15 is illustrated about the network lifetime and

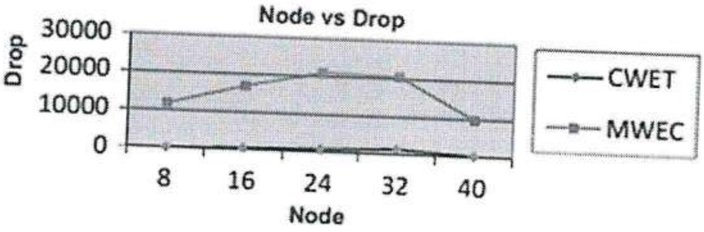


Fig. 12 Node versus drop

Fig. 13 Node versus energy consumption

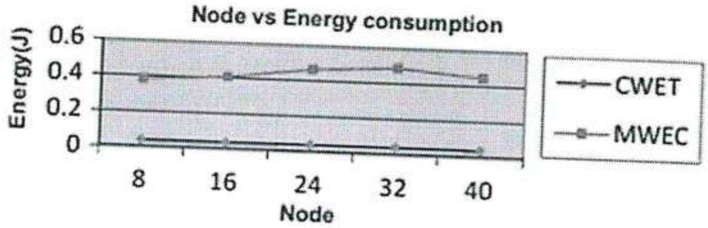


Fig. 14 Node versus network lifetime

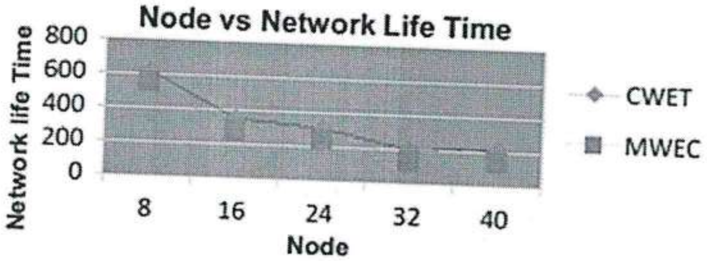
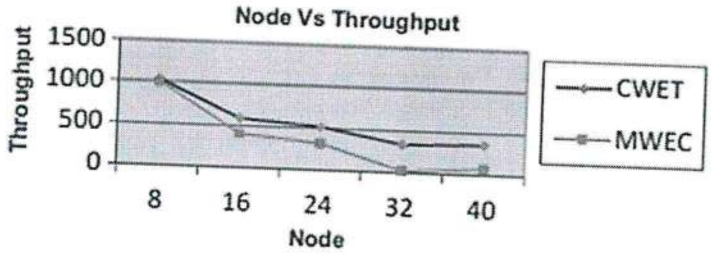


Fig. 15 Node versus throughput



throughput of our anticipated method. In this process, our anticipated method is augmented to 32 and 34% than the obtainable method.

5 Conclusion

In this document, we proposed cluster-related wireless energy transfer and our method are replicated by means of the network simulator NS2. Here, the sensors of the network are gathered as a cluster and the cluster head for every cluster is preferred by the help of rank-related weight metrics value. The choice of the node among a least hop count is used to take place the routing. Suppose, if a node in the cluster is exhausted its energy, then the cluster head sends the charge request to the MCV for to accuse the node. Our simulation consequences are illustrated about the network lifetime of our anticipated method.

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

References

1. Park, G., Rosing, T., Todd, M. D., Farrar, C. R., & Hodgkiss, W. (2008). Energy harvesting for structural health monitoring sensor networks. *Journal of Infrastructure Systems, 14*(1), 64–79.
2. Chang, J., & Tassiulas, L. (2004). Maximum lifetime routing in wireless sensor networks. *IEEE/ACM Transactions on Networking, 12*(4), 609–619.
3. Giridhar, A., & Kumar, P. R. (2005). Maximizing the functional lifetime of sensor networks. In *Proceedings of ACM/IEEE international symposium on information processing in sensor networks* (pp. 5–12). Los Angeles, CA.
4. Shi, Y., & Hou, Y. T. (2008). Theoretical results on base station movement problem for a sensor network. In *Proceedings of IEEE INFOCOM* (pp. 376–384). Phoenix, AZ.
5. Bulusu, N., & Jha, S. (Eds.). (2005). *Wireless sensor networks: A systems perspective, Chapter 9*. Norwood, MA: Artech House.
6. Jiang, X., Polastre, J., & Culler, D. (2005) Perpetual environmentally powered sensor networks. In *Proceedings of ACM/IEEE international symposium on sensor networks* (pp. 463–468). Los Angeles, CA.
7. Kansal, A., Hsu, J., Zahedi, S., & Srivastava, M. B. (2007). Power management in energy harvesting sensor networks. *ACM Transactions on Embedded Computing Systems, 6*(4), 32.
8. Liang, W., Ren, X., Jia, X., & Xu, X. (2013). Monitoring quality maximization through fair rate allocation in harvesting sensor networks. *IEEE Transactions on Parallel and Distributed Systems, 24*(09), 1827–1840.
9. Xie, L., Shi, Y., Hou, Y. T., Lou, W., & Sherali, H. D. (2013) On travelling path and related problems for a mobile station in a rechargeable sensor network. *ACM Transactions MobiHoc'13*, July 29–August 1, 2013.
10. Wang, C., Li, J., Ye, F., & Yang, Y. (2013). Multi-vehicle coordination for wireless energy replenishment in sensor networks. In *IEEE Proc.*
11. Peng, Y., Li, Z., Zhang, W., & Qiao, D. (2011). Prolonging sensor network lifetime through wireless charging. In *Proceedings of IEEE RTSS, 2010.*
12. Madhja, A., Nikoletseas, S., & Raptis, T. P. (2016). Hierarchical, collaborative wireless energy transfer in sensor networks with multiple mobile chargers. *Computer Networks, 97*, 98–112.
13. Xu, W., et al. (2016). Efficient scheduling of multiple mobile chargers for wireless sensor networks. *IEEE Transactions on Vehicular Technology, 659*, 7670–7683.
14. Xie, L., & Shi, Y. (2012). Multi-node wireless energy charging in sensor networks. *IEEE Transactions, 23*(2), 437–450.
15. Shi, L., et al. (2014). The dynamic routing algorithm for renewable wireless sensor networks with wireless power transfer. *Computer Networks, 74*, 34–52.
16. Lin, C., et al. (2016). Gtcharge: A game theoretical collaborative charging scheme for wireless rechargeable sensor networks. *Journal of Systems and Software, 121*, 88–104.

M. Dhurgadevi obtained her Bachelor's degree in Information technology from Anna University. Then she obtained her Master's degree in Computer Science and Engineering from Anna University. Currently she is working at K.S.R. Institute for Engineering and Technology, Tiruchengode, Tamilnadu, as Assistant Professor and working towards her Ph.D. in the area of Wireless Sensor networks. She is having 10 years of experience in teaching. She had published 8 papers in various national conferences and 10 papers in international conferences. She has published 7 books. Her research interests include data structures, Wireless networks, and Artificial intelligence. She is life member in ISTE.

PRINCIPAL,
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

Dr. P. Meenakshi Devi received her B.E. degree in Kongu Engineering College, Perundurai, in 1993 and M.E. degree in Thiagarajar College of Engineering, Madurai, in 2003, and the Ph.D. degree from the Anna University, Chennai, India. Currently, she is working as a Professor and Head in the department of Information Technology, in KSR Institute for Engineering and Technology. She is guiding 3 research scholars. She has published 30 papers in national and international journals. She has published 5 books. Her area of interests includes Information Security, Watermarking, Cryptography and Computer Networks. She is life member in ISTE.

PRINCIPAL,
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

Wireless Pers Commun (2018) 98:3377–3391
https://doi.org/10.1007/s11277-017-5019-0

CrossMark

An Analysis of Energy Efficiency Improvement Through Wireless Energy Transfer in Wireless Sensor Network

M. Dhurgadevi[1] · P. Meenakshi Devi[2]

Published online: 29 November 2017

Abstract In a wireless sensor network, wireless Energy transfer is a demanding technology for the energy difficulties in recent times. The foremost disadvantage of presentation is limited duration because WSN contains only restricted battery energy at a node. Therefore, we anticipated cluster-related wireless energy transfer in this document. The foremost intention of the method is to augment the duration of the sensor network through charging by the help of this wireless power transfer technology. So that, mobile charging vehicle (MCV) is established to move within the network and charge the sensor node battery wireless. The sensor nodes in the network are collected as a cluster for energy efficiency. Here, the cluster head is chosen for each one cluster in the network which is based on the rank metric value. Suppose, if one node in the network is reducing its energy, then the CH will send charge request and route ID to the MCV. Afterward, the MCV recognize the node by means of the exacting route and establish to charge the node. The reproduction consequences illustrate that the network lifetime of our anticipated method is enhanced than obtainable method.

Keywords Wireless Energy transfer · Wireless sensor network · Mobile charging vehicle (MCV) · Rank metric · Cluster head

1 Introduction

Generally, the wireless sensor network contains several battery sensors. Sensors misplace its energy on sensing, conveying and receiving. The battery charge will also misplace in redundant condition. In wireless sensor network, the demanding procedure is to augment

✉ M. Dhurgadevi
dhurgadevi1183@gmail.com

[1] KSR Institute for Engineering and Technology, Tiruchengode, Tamilnadu, India

[2] Department of Information Technology, KSR Institute for Engineering and Technology, Tiruchengode, Tamilnadu, India

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.

the energy efficiency of the node in recent times. When the nodes are motorized by means of a battery, then it contains only restricted duration. If the battery stage of sensor nodes is restricted, then the energy-effectiveness enhancement is a foremost confront. In the process of sending, the sensors misplace their energy. Recently, the sensor performs a foremost function in all areas particularly in health care observation [1]. Previously, several researchers put their attempt to extend the duration of sensor network [2–4].

Normally, the energy-harvesting procedure [5–7] is used to remove energy from the surroundings, but the procedure is not accomplished because the appropriate function of the procedure is greatly reliant on the surroundings. In an energy harvesting sensor network, the sensors are motorized by means of reusable energy like solar energy, wind energy, thermal energy etc. [8]. The foremost intention of innovative monitoring eminence maximization difficulty is used to exploit the eminence. Moreover, the dynamic rate weight task and lessening procedures are used to diminish the simultaneous flow difficulty.

Here, the wireless charging technology is permitting a mobile charger for conveying energy to sensor nodes wirelessly [9–11] not including the battery. A vehicle is required to transmit a charger to move in the network for to execute the Wireless power transfer [WPT] technology. In [14], wireless charging vehicle (WCV) is transferring the cellular arrangement in the network and transferred the sensors wirelessly. On the other hand, the energy effectiveness and duration of the network is so pitiable in this technology. So, we recommend the cluster-related wireless energy transfer for to resolve these difficulties. Here, we offered rank related weight metric computation for cluster head choice. Wireless/Mobile charging vehicle is generally employed to charge the node in the network.

This document also contains: Some of the related works of wireless energy transfer technology is explained in Sect. 2. In Sect. 3, we depict our anticipated cluster-related wireless energy transfer. Consequences of our anticipated method are explained in Sect. 4. At last, this document is accomplished by Sect. 5.

2 Related Works

Madhja et al. [12] have examined the difficulty of competent wireless power transfer in wireless sensor networks. In their process, they offered particular mobile chargers for to charge the sensor nodes in the network. They have anticipated four innovative protocols. Here, two of them (CC, CCGK) are carried out as centralized, international network information management and charging. And, two of our protocols (DC, DCLK) are carrying out as disseminated, restricted network information coordination and charging.

Xu et al. [13] have explained a charging development, difficulty of discharging, several mobiles charging vehicles to charge sensors like the overall detachment of this observation occasion is diminished. Therefore, any one of the sensors will execute without energy among others. They have anticipated an estimation algorithm by the help of certain estimation proportion. They have invented a heuristic algorithm in the course of alteration to the estimation algorithm. They have diminished the service expenditure at 20% when contrast to the existing method.

Xie et al. [14] have offered a multi-node wireless energy transfer technology. It is verified by whether it is a scalable technology to tackle energy problem in a WSN or not. They have measured wireless charging vehicles (WCV) for to incriminate the sensors in the network. They have anticipated a cellular arrangement which divides the two-dimensional plane as adjacent hexagonal cells which are derived from the charging-series of the WCV.

They have depended on a recognized optimization arrangement through mutually optimizing flow routing, traveling course and charging time.

Shi et al. [15] have offered a dynamic routing algorithm for renewable wireless sensor networks among wireless power transfer. Their anticipated process encompasses the roaming course of WCV and charging program like the proportion of the WCV's holiday time in the sequence time. Moreover, they have established the perception of (N + 1) segment explanation with a competent dynamic routing process. Their most favorable wandering course is established by the direct Hamiltonian sequence.

Lin et al. [16] have anticipated a game hypothetical mutual charging format for wireless rechargeable sensor networks which is also recognized as GTCharge. They have transformed the charging progression as a collaborative game which obtained by wireless charging vehicles (WCVs). They have examined the quality of payment level, charging precedence and earnings. In this method, WCV has accomplished the greatest earnings.

3 Cluster-Based Wireless Energy Transfer in WSN

3.1 Overview

Here, we have offered wireless energy transfer with wireless charging vehicle or mobile charging vehicle for to develop the energy effectiveness and network duration. The sensor nodes in the network are collected as a cluster for energy efficiency. The cluster head will be elected for each one cluster in the network which is derived from the rank metric value. Rank metric value is premeditated by means of a amount of adjacent nodes, outstanding energy and the detachment among the node and its adjacent nodes in a cluster. In the node, the highest rank metric value is preferred as a CH. The CH is used to combine the entire information from the non-CH element in a cluster. Afterward, the basis node sends the data package to the target through choosing the least hop count as a subsequent hop node. Suppose, if the cluster head is reducing its energy, then it will be accused by means of mobile charging vehicle (MCV) which is previously charged at a service location. Suppose, if the non-CH element in the route is reducing its energy, then it will send charge request to the related CH. Afterward, the CH sends route ID and accusation demand to the MCV. In this process, the exacting non-CH component will be charged.

3.2 System Model

Here, Fig. 1 illustrates the system representation of our anticipated method. This process contains a combination of cluster and cluster head which is preferred by means of rank metric. In a cluster, every node is modernized by its adjacent table which contains outstanding energy and hop-count of adjacent nodes. The CH is used to combine the entire information from the non-CH component. Suppose, if the node is reducing its energy, then it will be accused by means of mobile charging vehicle (MCV) which is previously accused at a service location.

3.3 Cluster Formation

In group related process, the cluster head (CH) is the fundamental uncertainties for energy capable communication in remote sight and sound sensor system. In this document, we

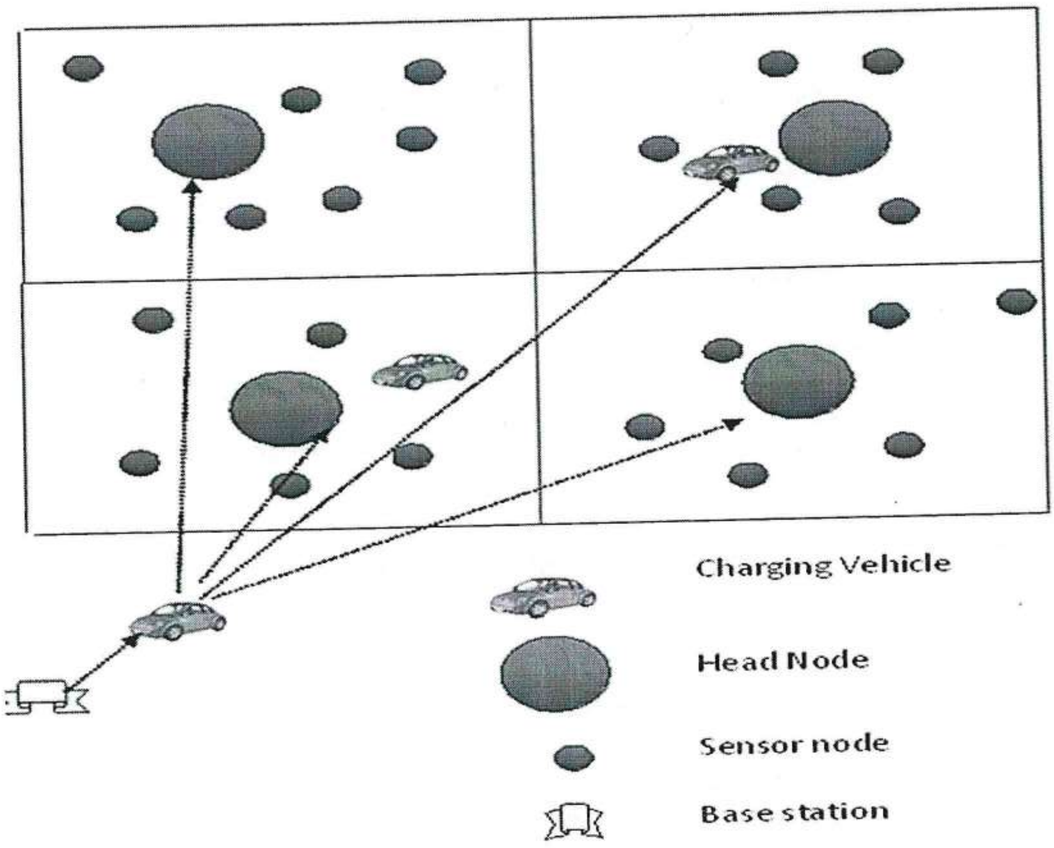


Fig. 1 System model

have established rank related cluster head determination procedure. Before picking a basic cluster head in a group, the conveying of HELLO message is used to combine video or audio data from each hub. In a cluster, each hub contains two tables such as a Neighbor table (NT) and Information Table (IT). The Information Table contains the type of each hub. Initially, the hub sends REQ message from basis to the adjacent hub. In this occasion, the basis hub obtains REP message from the adjacent hub and it improves the position of the adjacent hub in Neighbor Table. Normally, the association is removed from the path.

According to the previous conversation, a Rank Metrics process is combining every structure limitations by means of definite computing fundamentals which are selected through structure requirements. The flexibility of weight component is an aid to implement this computation to dissimilar systems. The cluster head selection progression is the collection of hubs which containing a superior evaluation of Rank metrics. The communication variety of hub is selected by CH, which means no two CHs are adjacent. There may be a situation if two CHs are produced the identical established assessment of the Rank metric. In this situation, a perfect array is used to select a hub with short misfortune value in the middle of hubs (Tables 1, 2).

Table 1 Information table of node

Node id	Residual energy	Distance between node and neighbor node	No of hub

Table 2 Neighbor table of nodes

Neighbor node ids	Residual energy	Distance between node and neighbor node	No of hub

According to the previous conversation, a Rank related Weight Metric method is premeditated to unite the system limitation among definite weighing.

Adjacent nodes are resolute by the transmission range (R_{tx}) of the nodes. Here, the values are standardized by utilizing the neighbor table (NT) of the node.

$$N_s = \sum_{s' \in s' \neq s} \{d(s, s') < R_{tx}\} \tag{1}$$

here s and s' are indicating the basis node and adjacent nodes in an identical way. N_s is explain about the overall quantity of adjacent nodes of the basis s. The detachment among basis and adjacent nodes i.e. $d(s, s')$ are premeditated through Euclidean detachment formula which is specified as

$$T_s = \sum_{s' \in N_s} \{d(s, s')\} \tag{2}$$

here the Eq. (2) is used to find out the overall failure in a routing path. The standard energy of each node is specified as,

$$E_{avg_s} = \frac{1}{N_s} \sum_{s \in N_s} E_{res_s} \tag{3}$$

here E_{res_s} is the outstanding energy of the entire adjacent nodes. In Eqs. (1), (2) and (3), Rank metric value of each one node is specified as,

$$Rank_s = \alpha \cdot N_s + \beta \cdot E_{avg_s} + \gamma \cdot \left(\frac{1}{T_s}\right) \tag{4}$$

here α, β *and* γ is representing the weighting feature for the corresponding group elements. The node among highest Rank metric is selected as the foremost cluster head (CH) (Figs. 2, 3, 4).

3.4 Wireless Energy Transfer

After that, the preferred CH sends the HELLO message to every non-CH element in the cluster. Figure 5 is illustrated in the arrangement of HELLO message which is sent by means of CH. This message also contains the cluster ID, CH–ID, outstanding energy detachment among node and an adjacent node, and a number of hops. Afterward, every non-CH member is modernizing their information in the message. Here, the CH is established to congregate the entire data package from the non-CH element and promote it to the target or base location. For routing, the node among least hop count is preferred as a next hop node from the adjacent table. A source node is conveying its data package to the CH and the CH conveys the composed data package to the target in the course of the next CHs in the network. The Route-ID of the cluster is gathered in the CH for every communication (Fig. 6).

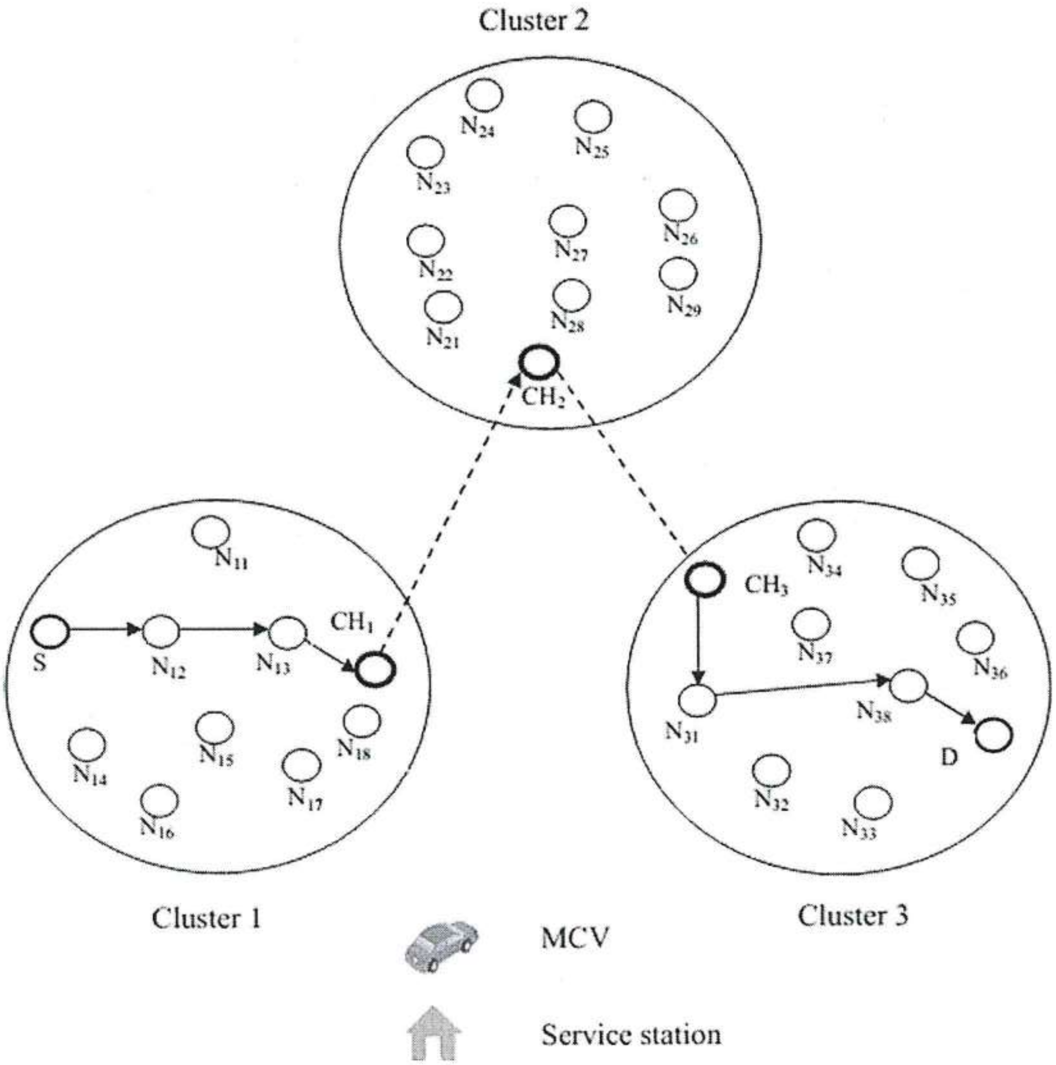


Fig. 2 Cluster-based routing

After this process, a node possibly will misplace its energy stage in the route. Therefore the CH confirms the energy stage of every node in the route and itself also. Suppose, if the energy stage of every node is obtained from the highest and the least threshold value, then the CH verifies the particular requirement to be revived.

$$T_{\max} > E_{res_i} > T_{\min} \tag{5}$$

Suppose, if the CH convinces that situation, then it sends Charge Request (C-REQ) to the mobile charging vehicle (MCV) at a service location.

$$CH \xrightarrow{C-REQ} MCV$$

In this network, MCV recognizes the position ID for the entire nodes. Here, the MCV progress to the CH and establish to charge after getting the demand from the CH. Suppose, if charging is completed, then MCV takings to the service location. Moreover, if a non-CH

Algorithm 1

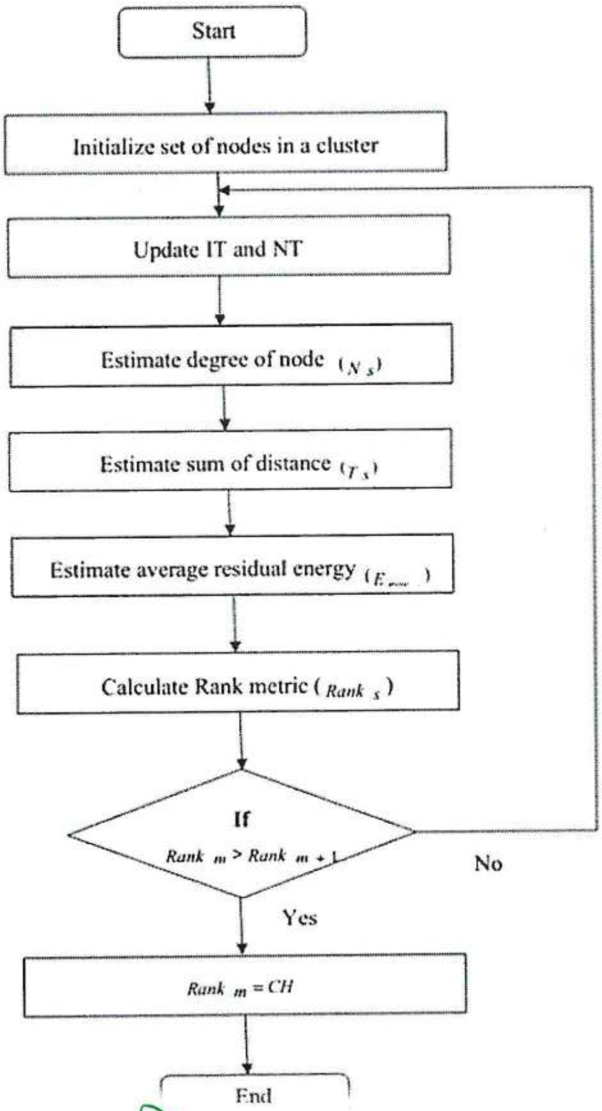
1. *Initializes each and every one nodes in a cluster*
2. *Keep informed Information Table (IT) and Neighbor Table (NT) of each node in a cluster*
3. *Approximation degree of the node* s *(* N_s *), sum of distance between* s *and* s' *(* T_s *), average residual energy of the node (* E_{res_s} *).*
4. *In conclusion, compute the Rank metric (* $Rank_s$ *) value of the node.*

$$Rank_s = \alpha \bullet N_s + \beta \bullet E\,avg_s + \gamma \bullet \left(\frac{1}{T_s}\right)$$

5. *If* $Rank_m > Rank_{m+1}$

   $Rank_m = CH$

   Or else; go step 2



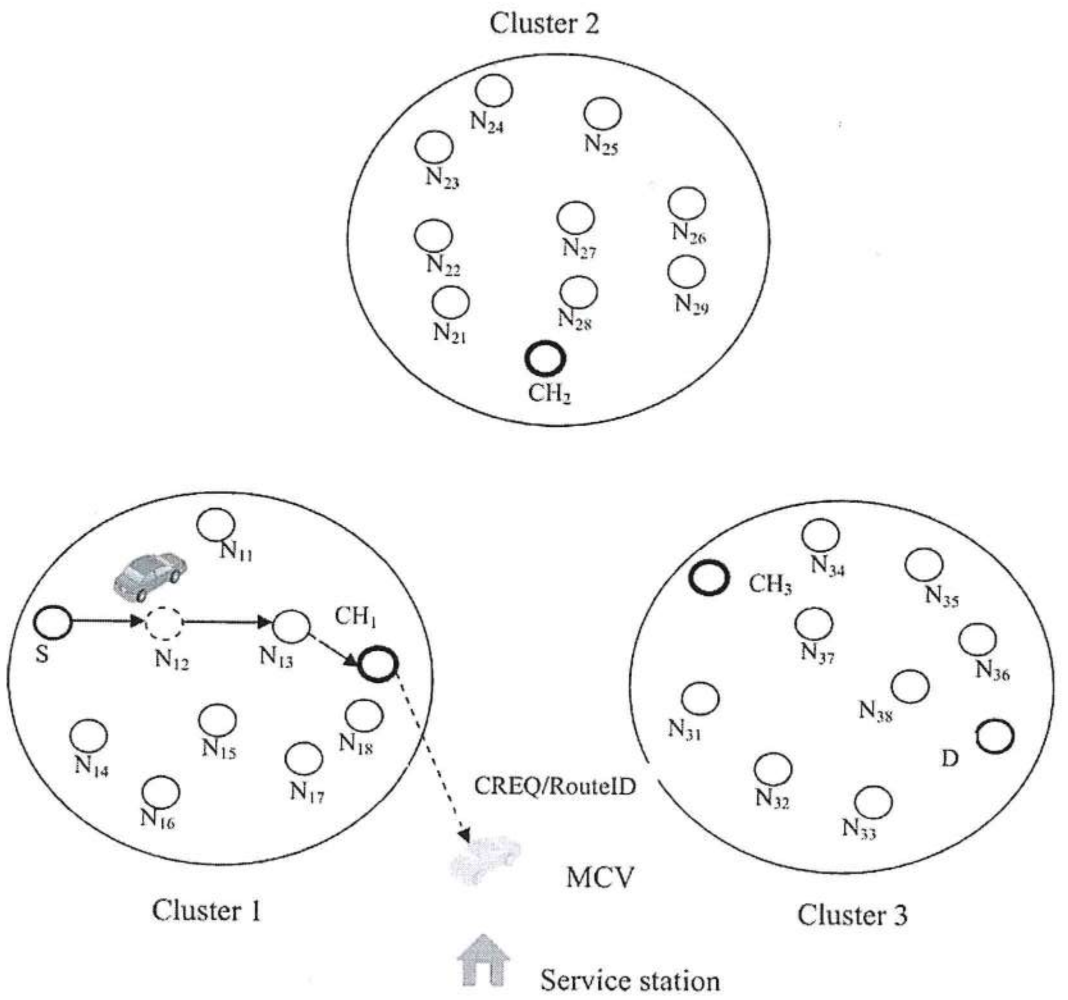


Fig. 4 Cluster-based wireless energy transfer (CWET)

Route ID	S	$\mathbf{N_{12}}$	N_{13}	CH_1
		(C_REQ)	N_{25}	

Fig. 5 Route ID of cluster 1

component in the route gratifies the above situation, then it sends Charge Request (C-REQ) to the cluster head.

$$non - CH \overset{C-REQ}{\longrightarrow} CH$$

Afterward, the CH sends the Route-ID among C-REQ to the MCV. After getting the message from the CH, the MCV shift the route from the basis node and recognize the node which is to be accusing. Suppose, if charging is completed, then MCV takings to the service location.

Overall Algorithm

1. *Cluster formation and cluster head selection*
2. *CH gathers information about the non-CH members in the cluster*
3. *Updates neighbor table of each node*
4. *The node with minimum hop count is selected as a next hop node for routing*
5. *If* $T_{max} > E_{res,} > T_{min}$

   Node ^{i} *sends C-REQ to CH*

   CH sends Route-ID and C-REQ to MCV

   MCV charges the Node ^{i}

   Else

   Routing continued

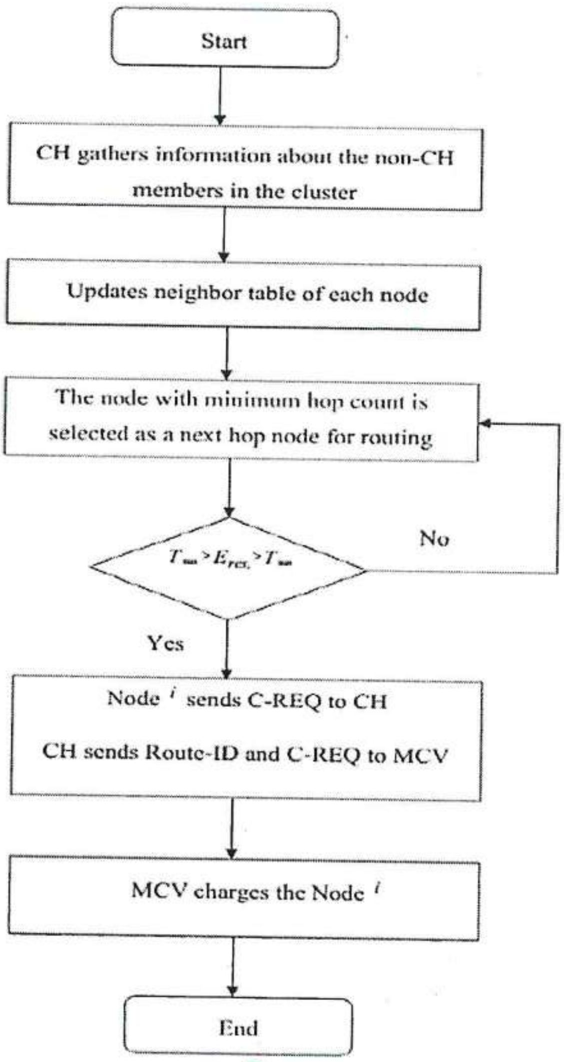


Fig. 6 Flowchart of overall algorithm

$$CH \xrightarrow{Route-ID/C-REQ} MCV$$

In Fig. 4, the node N_{12} is reducing its energy for conveying C_REQ to the CH_1. Afterward, the CH_1 sends the C_REQ among the Route ID to the mobile charging vehicle (MCV). After this process, the MCV shifts the route and recognize the node as to be accused. Here, Fig. 5 illustrates about the Route ID of cluster 1.

4 Results and Discussions

In this segment, the document is premeditated by NS2. To modernize their topology, every node is sending hello package to its adjacent node which is in its communication series. Here, the arrangement of topology has 40 nodes in surroundings system. The entire nodes are considered as dynamic nodes with identical energy stage at the establishment. The preliminary energy stage of every node is 100 Joules. The node among the highest quantity of adjacent node is chosen as a cluster head. The energy stage of cluster head is 200 Joules. The accusation rate of cluster head is 45 joules. Here, the two unsystematic produced WSNs are included 40 nodes. The sensor nodes are set up a square region as 1 km × 1 km. The least energy stage of the node is measured as 40 joules.The traveling speed of the WCV is considered as V and the value is 5 m/s. Figure 7 illustrates the topology arrangement of our anticipated method. Here, the 40 nodes are gathered as a cluster and the network encompasses one base location, WCV/MCV, and service location.

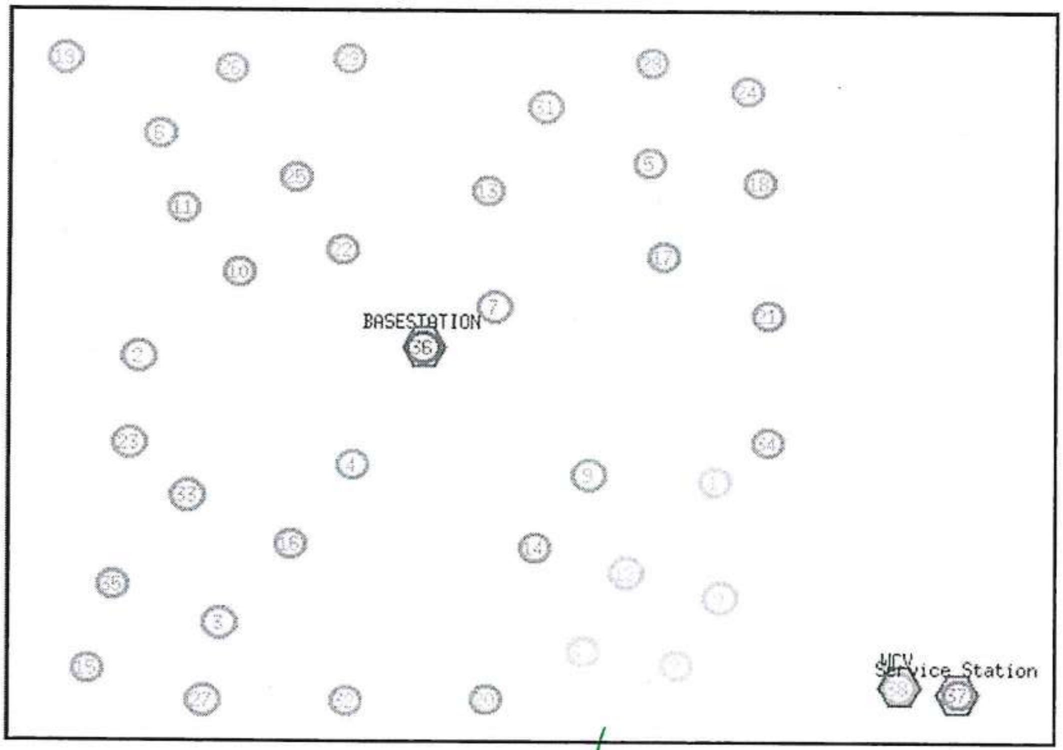


Fig. 7 Topology formation

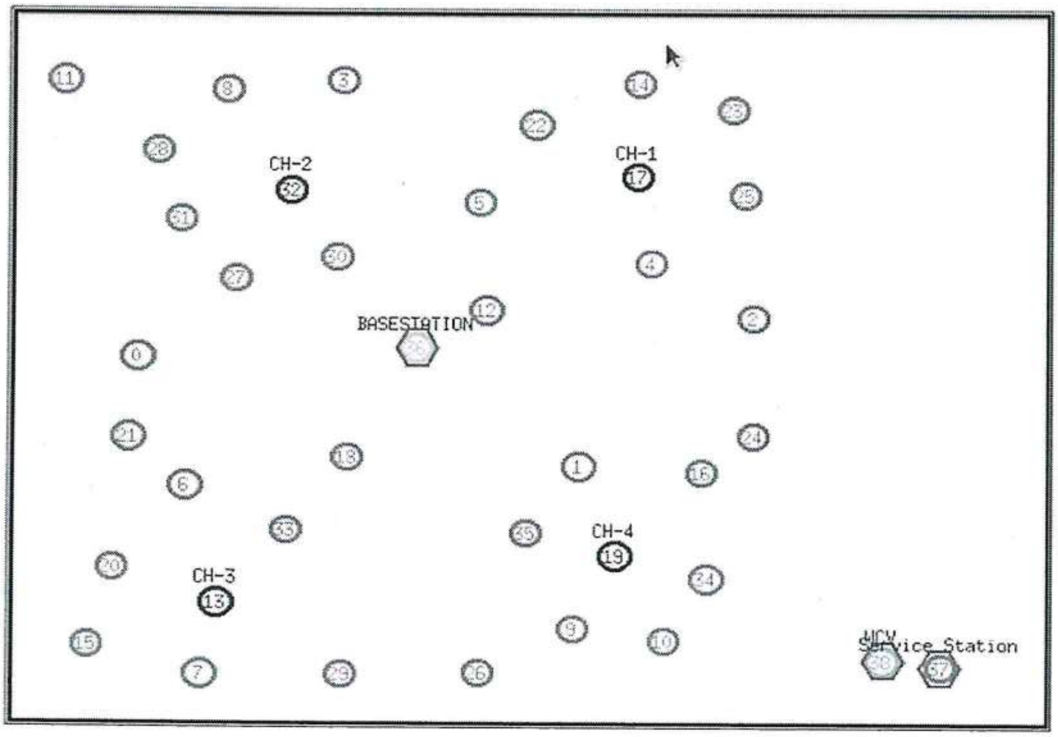


Fig. 8 Cluster head selection

Figure 8 illustrates about the computation of rank metric value for every node in a cluster. Here, the node among highest rank value is preferred as a cluster head (CH). So, we have preferred four cluster heads like CH-1, CH-2, CH-3, and CH-4.

In Fig. 9, the cluster heads CH-1, CH-2 and CH-3 are diminishing its energy. Therefore, they have sent C_REQ to the MCV. The MCV establish to accuse the cluster heads. Suppose, if one non-CH element is diminishing its energy, then it conveys the C_REQ to the related CH. Afterward, the CH sends the C_REQ and Route_ID to the MCV. The non-CH element is recognized and accused through choosing the exacting route.

4.1 Performance-Based on Nodes

In this segment, the presentation of the anticipated method is anticipated for diverse nodes 8, 16, 24, 32 and 40. The Figs. 10, 11, 12, 13, 14 and 15 is illustrated about the package delay, delivery ratio, package drop, energy utilization, network lifetime and throughput of our anticipated method. Here, the anticipated cluster-related wireless energy transfer (CWET) is contrast by means of the obtainable method MWEC [14]. Figure 10 is illustrated about the package delay of our anticipated method. Suppose, if the quantity of node is augmented, then the packet delay of the network also augmented. But, the packet delay of our anticipated method is diminished to 68% in the contrast to the obtainable method. According to the arrangement of energy competent cluster, the chance of delay is very small in our anticipated process. Figure 11 is illustrated about the delivery ratio of our anticipated method. According to the rank-related cluster head choice, the delivery ratio of our anticipated method is augmented to 40% than the obtainable method. The Figs. 12 and 13 illustrates about the package drop and energy utilization of our anticipated method correspondingly. The related CH sends charge request to the MCV in the cluster, at the

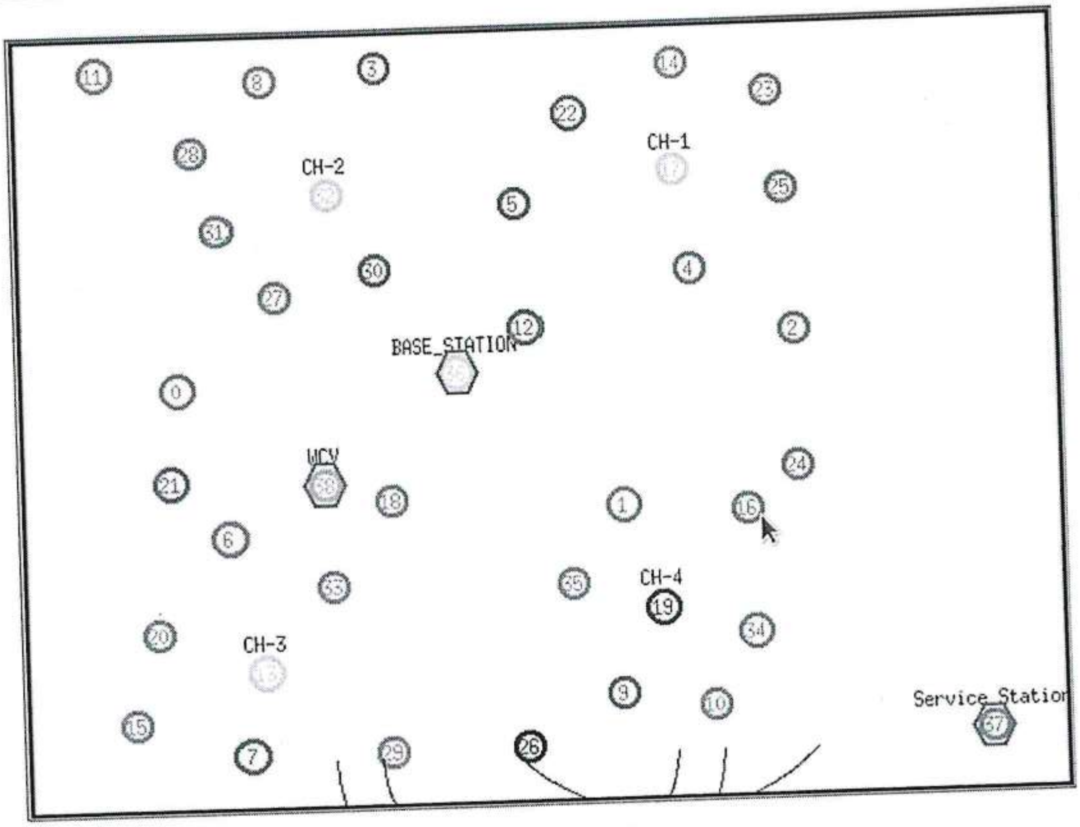


Fig. 9 Power transfer to nodes

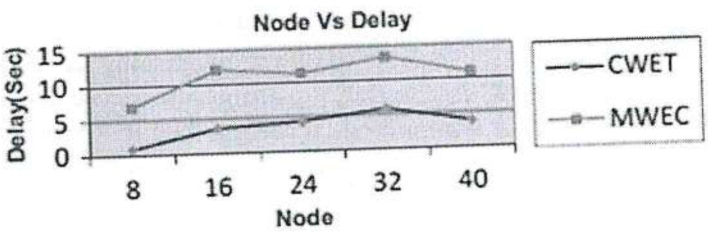


Fig. 10 Node versus delay

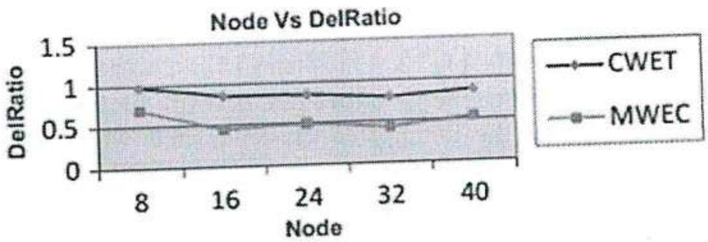


Fig. 11 Node versus delivery ratio

same time as a node in the route is diminishing its energy. Afterward, the MCV accuses the node earlier than it misplaces its energy. Therefore the package drop and energy utilization of our anticipated method are diminished to 95 and 96% correspondingly than the obtainable method. The Figs. 14 and 15 is illustrated about the network lifetime and

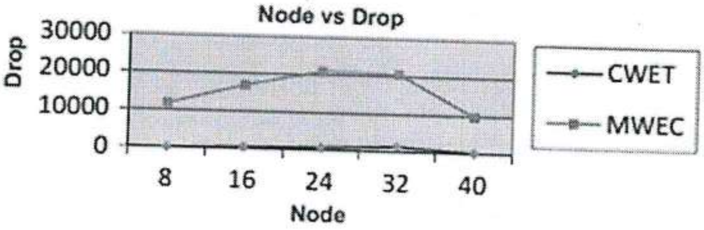


Fig. 12 Node versus drop

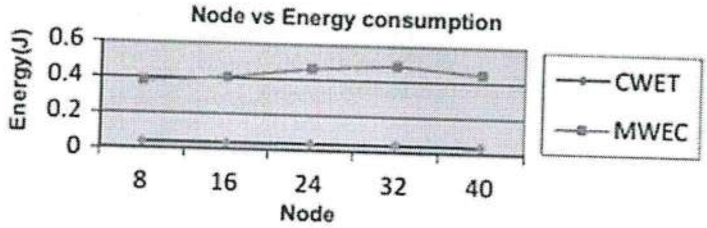


Fig. 13 Node versus energy consumption

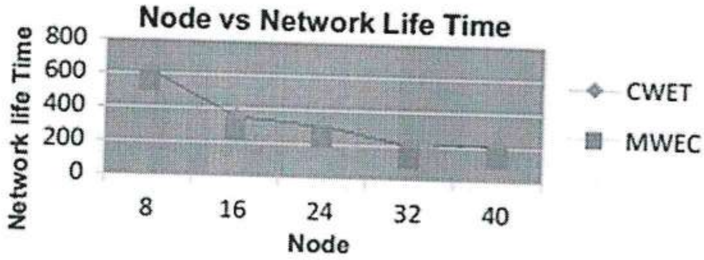


Fig. 14 Node versus network lifetime

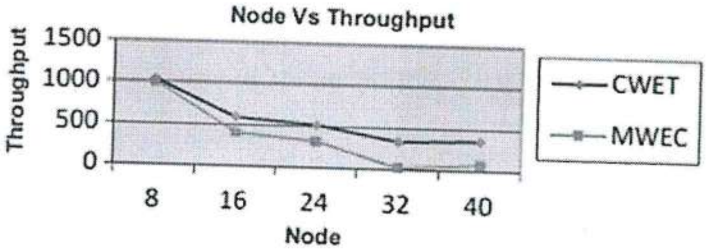


Fig. 15 Node versus throughput

throughput of our anticipated method. In this process, our anticipated method is augmented to 32 and 34% than the obtainable method.

5 Conclusion

In this document, we proposed cluster-related wireless energy transfer and our method are replicated by means of the network simulator NS2. Here, the sensors of the network are gathered as a cluster and the cluster head for every cluster is preferred by the help of rank-related weight metrics value. The choice of the node among a least hop count is used to take place the routing. Suppose, if a node in the cluster is exhausted its energy, then the cluster head sends the charge request to the MCV for to accuse the node. Our simulation consequences are illustrated about the network lifetime of our anticipated method.

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt. TAMIL NADU.

References

1. Park, G., Rosing, T., Todd, M. D., Farrar, C. R., & Hodgkiss, W. (2008). Energy harvesting for structural health monitoring sensor networks. *Journal of Infrastructure Systems, 14*(1), 64–79.
2. Chang, J., & Tassiulas, L. (2004). Maximum lifetime routing in wireless sensor networks. *IEEE/ACM Transactions on Networking, 12*(4), 609–619.
3. Giridhar, A., & Kumar, P. R. (2005). Maximizing the functional lifetime of sensor networks. In *Proceedings of ACM/IEEE international symposium on information processing in sensor networks* (pp. 5–12). Los Angeles, CA.
4. Shi, Y., & Hou, Y. T. (2008). Theoretical results on base station movement problem for a sensor network. In *Proceedings of IEEE INFOCOM* (pp. 376–384). Phoenix, AZ.
5. Bulusu, N., & Jha, S. (Eds.). (2005). *Wireless sensor networks: A systems perspective, Chapter 9*. Norwood, MA: Artech House.
6. Jiang, X., Polastre, J., & Culler, D. (2005) Perpetual environmentally powered sensor networks. In *Proceedings of ACM/IEEE international symposium on sensor networks* (pp. 463–468). Los Angeles, CA.
7. Kansal, A., Hsu, J., Zahedi, S., & Srivastava, M. B. (2007). Power management in energy harvesting sensor networks. *ACM Transactions on Embedded Computing Systems, 6*(4), 32.
8. Liang, W., Ren, X., Jia, X., & Xu, X. (2013). Monitoring quality maximization through fair rate allocation in harvesting sensor networks. *IEEE Transactions on Parallel and Distributed Systems, 24*(09), 1827–1840.
9. Xie, L., Shi, Y., Hou, Y. T., Lou, W., & Sherali, H. D. (2013) On travelling path and related problems for a mobile station in a rechargeable sensor network. *ACM Transactions MobiHoc'13*, July 29–August 1, 2013.
10. Wang, C., Li, J., Ye, F., & Yang, Y. (2013). Multi-vehicle coordination for wireless energy replenishment in sensor networks. In *IEEE Proc.*
11. Peng, Y., Li, Z., Zhang, W., & Qiao, D. (2011). Prolonging sensor network lifetime through wireless charging. In *Proceedings of IEEE RTSS, 2010*.
12. Madhja, A., Nikoletseas, S., & Raptis, T. P. (2016). Hierarchical, collaborative wireless energy transfer in sensor networks with multiple mobile chargers. *Computer Networks, 97*, 98–112.
13. Xu, W., et al. (2016). Efficient scheduling of multiple mobile chargers for wireless sensor networks. *IEEE Transactions on Vehicular Technology, 659*, 7670–7683.
14. Xie, L., & Shi, Y. (2012). Multi-node wireless energy charging in sensor networks. *IEEE Transactions, 23*(2), 437–450.
15. Shi, L., et al. (2014). The dynamic routing algorithm for renewable wireless sensor networks with wireless power transfer. *Computer Networks, 74*, 34–52.
16. Lin, C., et al. (2016). Gtcharge: A game theoretical collaborative charging scheme for wireless rechargeable sensor networks. *Journal of Systems and Software, 121*, 88–104.

M. Dhurgadevi obtained her Bachelor's degree in Information technology from Anna University. Then she obtained her Master's degree in Computer Science and Engineering from Anna University. Currently she is working at K.S.R. Institute for Engineering and Technology, Tiruchengode, Tamilnadu, as Assistant Professor and working towards her Ph.D. in the area of Wireless Sensor networks. She is having 10 years of experience in teaching. She had published 8 papers in various national conferences and 10 papers in international conferences. She has published 7 books. Her research interests include data structures, Wireless networks, and Artificial intelligence. She is life member in ISTE.

Dr. P. Meenakshi Devi received her B.E. degree in Kongu Engineering College, Perundurai, in 1993 and M.E. degree in Thiagarajar College of Engineering, Madurai, in 2003, and the Ph.D. degree from the Anna University, Chennai, India. Currently, she is working as a Professor and Head in the department of Information Technology, in KSR Institute for Engineering and Technology. She is guiding 3 research scholars. She has published 30 papers in national and international journals. She has published 5 books. Her area of interests includes Information Security, Watermarking, Cryptography and Computer Networks. She is life member in ISTE.

PRINCIPAL.
K. S. R. INSTITUTE FOR
ENGINEERING AND TECHNOLOGY,
K. S. R. KALVI NAGAR,
TIRUCHENGODE-637 215,
NAMAKKAL Dt, TAMIL NADU.