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Enactment of Firefly Algorithm and Fuzzy C-Means Clustering For Consumer Request and Demand Prediction

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Abstract: Day by day massive information is being added up over the World Wide Web. Utilizing and predicting related web pages as per user's interest from exponentially growing web information is becoming crucial and very critical. Web users expect relevant web pages of their interest to be retrieved at a faster pace in short time duration. So, this paper aims to present a novel methodology in finding consumer's upcoming demand and predicting future request in web page recommendation system. The baseline of the proposed methodology is, it uses a hybrid Levenberg-Marquardt firefly neural network algorithm to classify data as potential and non-potential consumers, then collects and clusters data of potential consumers using improved fuzzy C-means clustering algorithm and finally envisages the upcoming demand for the subsequent consumer. The proposed model is implemented in the operational platform of Java in Cloud Sim and can applicable for quantum computing also. The results are recorded, tabulated and analysed for various metrics like execution time, memory occupied, clustering time, clustering accuracy and recommendation accuracy. On comparative analysis with existing K-means technique, the proposed system proves to be more efficient.

Keywords: Web page recommendation, K-means clustering, Levenberg-Marquardt, firefly, neural network, classification, prediction, Quantum Computing.

1. Introduction

The usage of World Wide Web has become integral part of our life. Massive amounts of information are being added up every day leading to exponential growth of data. Due to the massive expansion of the internet and IT technology, electronic commerce is suitable, inexpensive and with no restriction in the area of space and time, it turns out to be the mainstream of populace utilization model [3]. From the voluminous amount of information, web mining techniques help to discover and analyse useful information. Such discovered knowledge is very useful for decision makers to bring relevant changes in the industry like in e-commerce to increase the productivity.

Data mining involves extracting meaningful information as per user's interests from voluminous dataset. In data mining procedure, web mining is a process which is used to extract and determine knowledge automatically from data obtainable on the web in the form of web documents, images, audios, videos etc. The foremost ideology of data mining process is to recognize possessions, picking suitable information, simplification, examining and analysing information [2]. Web mining comprises three kinds of information such as - data from internet data, log of internet access servers and web structure data [1].Depending on the type of data, web mining is categorised into

- Web content mining
- Web usage mining
- Web structure mining

Web usage mining uses web logs to extract usage patterns of users. Whereas web content mining and web structure mining uses web data content and configuration of web like hyperlinks information respectively. Knowingly or unknowingly, users provide some useful data that is recorded in the web log. Discovering user pattern from weblog will help to scale up the performance of web services. Ideally, web usage mining goes through three stages- pre-processing, pattern discovery and analysis [19].

Many times, customers are given multiple choices or overloaded with irrelevant information. Due to the enormous quantity of hosted documents on the web, progressively and consequently removing information competently and wisely is a demanding mission in online web system [10]. Depending on their entity inclination, interests and requirements, web personalization systems have materialized to get through this difficulty by supplying a personalized knowledge to consumer [11]. Web-page recommendation is a significant process in intelligent web systems. Recommender systems

pertain to variety of procedure and forecast algorithm to envisage user significance on information, substance and services from the remarkable quantity of existing data on the internet. To handle this issue, personalised recommendation systems suggest web pages or products that might interest the customers. Broadly, recommendation system is classified into Content based system and Collaborative filtering system [20]. Content based system uses rating information given by the users. This system doesn't take into consideration of other user profiles. Whereas, collaborative filtering works on the fact that the choice made by an active user will be same as the other similar user. It forms a user-item rating matrix to understand the characteristics of the users [14].

Motivation: The existing web page recommendation systems have some fundamental restrictions like adaptability, flexibility, and inadequate access. Handling pages that are lately included or infrequently appointed but significant to a consumer is not illustrated by many existing systems. One of the challenging tasks in many online web sites is identifying accurate results, handling and arranging several options to the consumer at an instant of time. The arithmetic group only offers hard clustering which doesn't consider all the real time scenarios. In obtainable web page suggestion system, the consumer measures only the chronological feature of a web client conference by means of chronological mining algorithms which offer only the model that subsist in the progression. In our investigation we have projected system which engenders the suggestion to the consumer, allowing for the chronological information that subsists in their convention model of web pages. Estimating the efficiency and presentation of great dataset is complicated and consumes more time. Additional restrictions are cold-start difficulty, data sparseness difficulty, and recommender reliability difficulty [22].These foremost disadvantages of diverse obtainable works prompted us to perform a study on web page suggestion systems.

Contribution: The main intention of the proposed model to overcome the above-mentioned challenges is to envisage upcoming consumer request in shorter time using clustering and categorization techniques. Clustering techniques helps to cluster the customers of similar interest. This knowledge discovery will help to extract relevant web pages specific to different kinds of customers. Thus, this paper aims at predicting the upcoming consumer demand and as well as recommending web pages with the novel methodology proposed. The projected method uses Levenberg-Marquardt calculation in Fire-fly based neural network algorithm for classification and improved fuzzy C-means clustering for clustering the potential data.

Organisation: The rest of the paper is organized as follows. Section 2 provides a review on related works. Section 3 explains the architecture, algorithm and working of proposed methodology. Results and Discussions, Comparative Analysis is given in Section 4 and Section 5 respectively. And finally, conclusion of this research work is given in Section 6.

2. Related Works

In intellect web system, web-page recommendation is a significant process. Lots of literature work is being carried out in this area to enhance the efficiency of the web-page recommendation system and provide user friendly web experience to the consumers.

Web usage mining term was defined by Cooley and et.al [7]. Mehrdad Jalali*et al* [16] projected an innovative method to categorize consumer navigation model for online forecast of consumer upcoming target using mining of Web server logs. The model exploits the advantages of properties in undirected graph for division algorithm to form consumer navigation model by assigning weights. To categorize existing consumer behaviour the highest general subsequence algorithm is used to envisage consumer upcoming movement. They utilized various assessment process to estimate the eminence of group establish and eminence of suggestion. The investigational consequences have exposed that the method enhanced the eminence of group for consumer navigation model and the eminence of suggestion for mutual CTI and MSNBC datasets.

R. Suguna and D. Sharmila [17] used web usage mining as the foremost basis for web suggestion in organization among Collaborative filtering method, association rule mining and Markov representation to suggest the web pages to the consumer. Thereafter, FP-Tree algorithm with additional enhancement is used in utilizing the least support value to discover the associative model for achieving extra exactness.

Er. Romil V Patel and Dheeraj Kumar Singh [18] offered a complete indication of using the procedure - Naive Bayesian Classification among supervise learning procedure. Foremost intention is to categorize consumer practice precisely among session base,from data dividing subsequent to data cleaning for employing additional active web site and web pages to attract potential users for business development, advertising, and government society. To develop web site or build active web pages, they utilize large data sets for precise categorization.

Maryam Jafari *et al* [19] offered a comprehensive prologue to Web usage mining and concentrated on process that could be utilized for the mission of model removal from Web log files to enhance web function. Following the process of determining model, the outcome is utilized for model study segment. Investigation of the Web consumer navigational model assists in recognizing the consumer activities for creating Web recommender systems.

The quick development and expanding reputation of Ecommerce has enforced the obtainable suggestion system to hold great quantity of clients and to supply them through elevated eminence of suggestion. The work of Prajyoti Lopes and Bidisha Roy [21] have concentrated on problems in suggestion system and projected a method that implies on constructing web convention mining to diminish it. The study work provides effective suggestion not only to registered consumer but to unregistered consumers as well. The magnificence of the projected system was it aid in maintaining the obtainable clients and attracts innovative clients.

3. Proposed Methodology

The foremost intention of the projected system is to envisage consumer upcoming request in short time by means of clustering and categorization procedure. The classification procedure is used to classify the consumer into potential and non-potential consumer and the clustering procedure is used to cluster the consumers by comparing significance of mutual consumer interests.

The projected process encompasses following four steps;

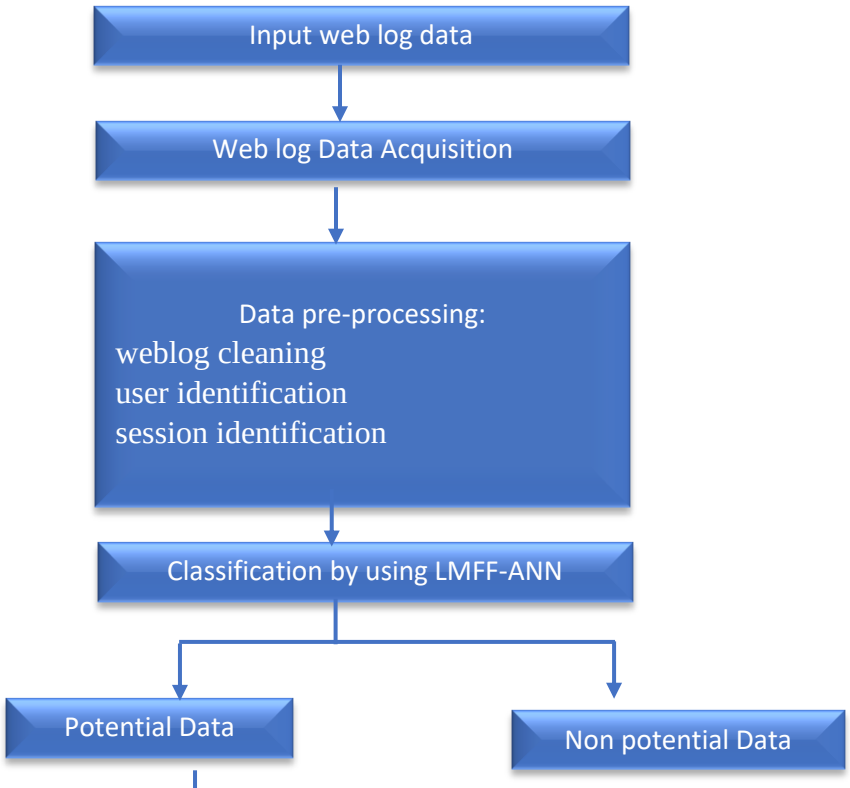
Step 1: Initially choose the input web log data and pre-process the input web log file.

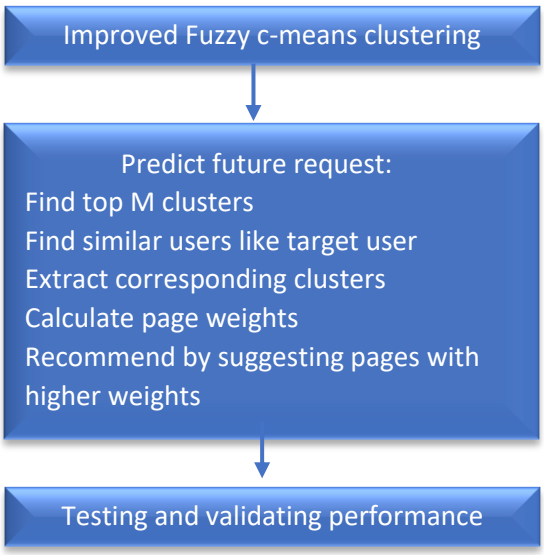
Step2: Consumers are classified into potential and non-potential consumer using Firefly based Artificial Neural Network (FANN). In this paper, feed forward neural system will be practically equipped by the hybrid algorithm that uses Levenberg Marquardt calculation in firefly algorithm.

Step 3: Clustering the potential data by the aid of Improved Fuzzy C Means (IFCM) clustering algorithm.

Step 4: The final step of our projected process is envisaging the upcoming demand for the equivalent consumer by pattern analysis. And the results are compared with K-means algorithm to analyse the efficiency of the proposed system.

The workflow of the proposed system is depicted in the flowchart below:





3.1 Data Acquisition and Pre-processing

Web log data contains important information like customer name and address, server name and IP, date and time, status code, etc. [23]. Web log data from individual server is collected and converted into a common file format. This raw web log data is the input to next stage of pre-processing.

The input web log file is estimated, and the essential characteristics from the web access log is extracted during the pre-processing phase. The main tasks during this phase are weblog cleaning, user identification, session identification [2].

Weblog cleaning is the process of segregating status code 400that corresponds to failure, removing pages or images and noisy data that are not relevant to the user from log entries. The second step is manipulating count of distinct users with the help of information on IP address, operating system and browser which is recorded in the log entry. And the final step, session identification is identifying entries requested by the user. The pre-processed data are specified in to the classification segment.

3.2 Classification using Levenberg Marquardt-Firefly-ANN

Artificial neural networks are known for its robustness and capability to solve real time problems that are difficult by normal methods. It learns by instances and have the capability to solve complexities in solving pattern classification, matching and optimization, associative memories, etc. [26].

The proficiency of Feed Forward Neural network with back propagation is better compared to other well-known neural networks. Back propagation method is one of the most commonly used techniques to train artificial neural network by adjusting weights and biases. Unfortunately, the frequently used error back propagation algorithm doesn't yield results at a faster pace. For patterns of medium and small size, Levenberg Marquardt (LM) proves to be an efficient algorithm. And the convergence rate of Firefly algorithm, a meta-heuristic algorithm is fast and improved one when it is fed into back propagation algorithm while training a feed forward neural network. So, to enhance the efficiency and effectiveness, a combination of LM calculation in Firefly algorithm to train feed forward neural network with propagation for data classification is used in this paper.

3.2.3 Proposed LMFF-ANN

Firefly based Artificial Neural Network (FANN) is used for the classification to classify the consumer into potential and non-potential. In this document, feed forward neural system will be practically equipped by the hybrid algorithm, described as LM+firefly which are the organization of Levenberg Marquardt calculation among firefly algorithm.

There are different types of neural networks. One of the effective categories is the Feed Forward Back Propagation Neural Network classifier (FFBNN) which is successfully subjugated for the principle of categorization.

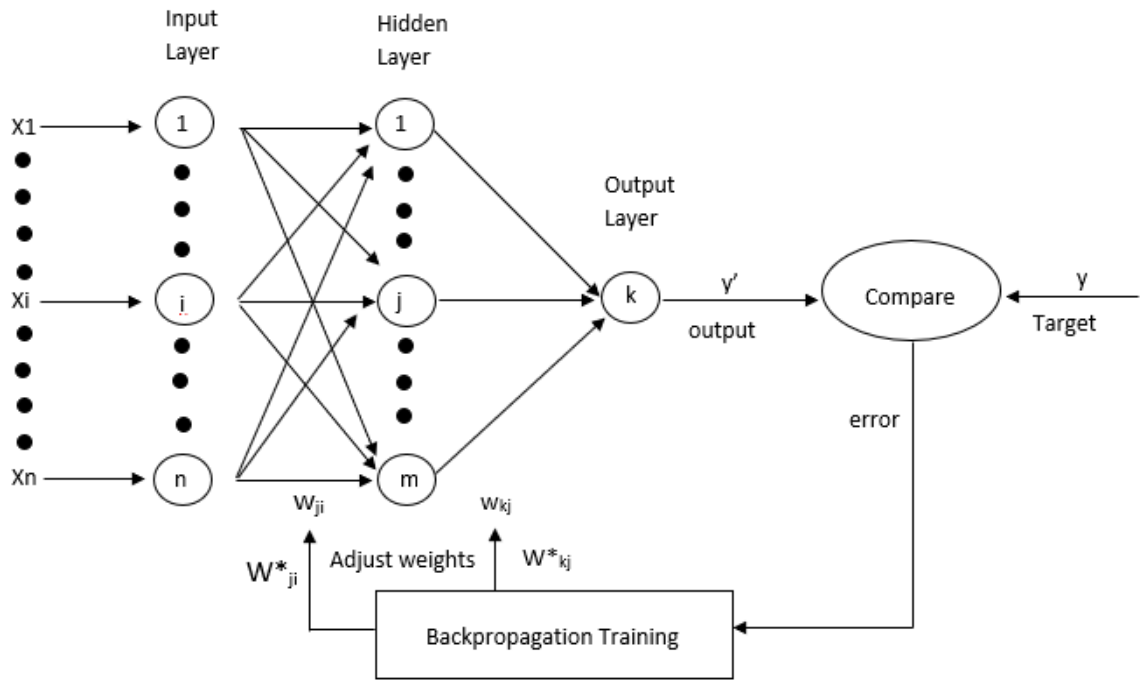


Figure 1. Feed Forward back propagation neural network

The Neural network is usually a three-layered typical classifier formed using n input nodes, m hidden nodes and k output nodes. There are two phases involved in Feed Forward Back propagation neural network –

- Forward phase
- Backward phase.

1. Forward phase:

The restructured values of firefly algorithm are provided as input. The neural network is premeditated by the removed attribute $\{A_1, A_2, A_3, A_4, A_5\}$ as the input component, HU_a Hidden component and age f as the output component.

The assessment of the projected Bias task for the input layer is distinguished through Equation 4 which is specified below.

$$X = \beta + \sum_{n'=0}^{H_{NH}-1} w_{(n')} A_1(n') + w_{(n')} A_2(n') + w_{(n')} A_3(n') + ... + w_{(n')} A_5(n') \quad (4)$$

The activation function for the output layer is evaluated by Equation 12 shown below.

$$Active\ (X) = \frac{1}{1+e^{-X}} \quad (5)$$

The learning error is represented as follows.

$$LE = \frac{1}{H_{NH}} \sum_{n'=0}^{N_{NH}-1} Y_{n'} - Z_{n'} \quad (6)$$

where, LE - learning rate of FFBNN.

$Y_{n'}$ - Desired outputs.

$Z_{n'}$ - Actual outputs.

2. Backward phase:

To minimise the error, error signal is propagated in backward direction in the neural network. Accordingly, weights are updated in the neural network and this process repeats till optimisation is reached.

The Back-Propagation fault is estimate for each one node and subsequently the weights are restructured as per the subsequent Equation 14.

$$w_{(n')} = w_{(n')} + \Delta w_{(n')} \quad (7)$$

The weight $\Delta w_{(n')}$ is adapted as per Equation 8 shown below.

$$\Delta w_{(n')} = \delta . X_{(n')} . E^{(BP)} \quad (8)$$

Where, δ - Learning Rate, which is habitually in the range of 0.2 to 0.5.

$E^{(BP)}$ - BP Error.

The process repeats and each time activation and learning values are calculated using Equations (5) and (6), till the BP fault is condensed to the least i.e. $E^{(BP)} < 0.1.$

On accomplishing the least value, the FFBNN become known suitably appropriate for the transmission segment.

The proposed firefly-based feed forward back propagation neural network is initiated with preliminary populace of size Y which is distinct.

$$Y = A_d \qquad (d = 1,2,\ldots, n) \quad (9)$$

Where, n is the quantity of fireflies The initialized constant location values are produced through the subsequent Equation 11.

$$u_k^* = u_{\min} + (u_{\max} - u_{\min})^* r \quad (10)$$

Where, $x_{\min} = 0$, $x_{\max} = 1$ and r represents a uniform arbitrary number between 0 and 1.

The optimization formula acquired in equation (9),is derived from the reduction of the intention task as follows.

$$W(y) = \min \sum_{i=1}^{m} w(y_i) H_x(y_i) \quad (11)$$

Where,

$H_x(y_i)$ →The entropy

$w(y_i)$ →The weight of the entropy of each attribute

The association of the firefly (FF) p , when concerned to an additional striking (brighter) firefly q , is estimated through Equation 12 specified beneath.

$$u_p^{'} = u_p + \gamma(r) * (u_p - u_q) + \varphi\ (rand - \tfrac{1}{2}) \qquad (12)$$

In equation (12), the second expression is an explanation of magnetism, the third expression establishes randomization through $'\varphi'$ the randomization limitation and "rand" is a random quantity formed consistently distributed among 0 and 1.

Attractiveness, $\gamma(r) = \gamma_0 e^{-\theta r^m}$, $m \geq 1$ (13)

Where, r signify the detachment among two fireflies γ_0 signify the preliminary magnetism of firefly and θ expose the incorporation coefficient.

Distance, $r_{pq} = \left\| u_p - u_q \right\| = \sqrt{\sum_{k=1}^{d} (u_{p,s} - u_{q,s})^2}$ (14)

Where, $u_{p,s}$ signify the s^{th} element of the spatial direct of the p^{th} firefly and d signify the entire quantity of dimensions. As well $q \in \{1,2,..., F_n\}$ distinguish the randomly preferred catalogue. Even though q is estimated randomly, it must be dissimilar from p . At this point F_n communicate to the quantity of fireflies.

Algorithm1: Firefly Algorithm Based Back-propagation Neural Network

Input: Restructured values of Firefly algorithm using Levenberg Marquardt calculation (F1,F2,F3..., Fn) and it corresponding destination (D1,D2,.....Dn), learning parameter , light absorption coefficient.

Output: Modified Weight and Bias matrix, learning error, Correct rate of Classification.

Begin:

Initialize input layer with function specified in Eqn. (4)

Initialize location values of fireflies using Eqn. (10)

Generate various weight using Eqn. (9)

Initialize activation function of output layer using Eqn. (5)

Calculate learning error for each generated weight using Eqn. (6). Here learning error is considered as a performance index

While True:

Assign minimum error calculated from learning error list to fj (brighter firefly)

while (m< SSE list length):

Assign any value to less bright firefly, fi other than the value of brighter firefly

If (fj<fi) :

Find distance between fj and fi using Eqn. (14).

Estimate attractiveness between fj and fi from Eqn. (13)

Move the Firefly Fi towards Fj using Eqn. (12).

Update respective weight and bias value calculated using Eqn.(7) and Eqn.(8)

else: Pass

End If

Now calculate the learning error with the updated list of weight and bias values.

Estimatedback propagation fault rate at the end of every iteration.

Increment m value by unit of one.

End While

If (back propagation fault>0.1):

Save the result and end the optimization procedure.

Else:

Repeat optimization process

End While

Back propagation fault determines the percentage of matches between input and output. The value is estimated at the end of every iteration which gives the correct classification rate. As the number of iterations increase, the randomness can be tuned to achieve convergence soon. Thus, the proposed system helps in solving classification of consumer data into potential consumer. This classified data using Levenberg Marquardt firefly neural network algorithm is fed into the next phase of clustering to predict consumer demand in web page recommendation systems.

3.3 Clustering using Improved Fuzzy C-means clustering (IFCM)

Clustering divides the data into different classes where objects within the cluster are similar and the characteristics of objects between the clusters are as diverse as possible. In this model, potential user's browsing history is used as criteria to form clusters. Depending on the clustered data, proposed system generates corresponding list of web pages to be recommended with good rankings. Fuzzy c-means clustering provides the advantage of considering interests of user that might belong to more than one cluster by setting membership levels.

Algorithm2: Improved Fuzzy C-means clustering

Input:

$C_1, C_2, C_3, ..., C_n$ are the collection of clusters

"M_{ij}" is the membership of j^{th}data in the i^{th}cluster a_j

"a" is the cluster centre

"d_i" is the input potential consumer data from FFBNN

"m" is the any real number greater than 1

"||*||" is the similarity between any measured data and the center

1. Initialize C, M, d, a
2. Cluster center calculation is done using equation

$$a_j = \frac{\sum_{i=1}^{n} M_{ij}^{m} d_i}{\sum_{i=1}^{N} M_{ij}}$$

3. Calculate the dissimilarity between data points and centroid using Euclidean distance.
4. Update the membership matrix using-

$$M_{ij} = \frac{1}{\sum_{k=1}^{a} \left(\frac{\|d_i - a_j\|}{\|d_i - a_k\|} \right)^{\frac{2}{m-1}}}$$

5. If $\left\| M^{(K+1)} - M^{(K)} \right\| < \in$ then stop,

Where,"$\in$" is a termination criterion between 0 and 1.

Else

Go back to step 2.

Output: collection of cluster centres and clustered data

The membership values used in the cluster centre calculation shows the strength of data and the corresponding clusters it belongs to. The average of cluster centre values from the output matrix gives the list of top N clusters.

3.4 Pattern Analysis

The clustered data is analysed, and exciting patterns and trends of potential users are extracted. When a new consumer arrives, the proposed system uses Fuzzy C-means algorithm logic and finds out similar cluster to that of the existing equivalent user. Once the clusters are found, the weights are assigned depending on the page category [25]. The weights are calculated depending on the frequency count of specific page opened by target users, count of specific page opened by similar users like target users and whether a page is opened or not by the target user. If the calculated weights are high, it will be recommended to the target user. Thus, the proposed system in this paper helps in finding consumer's upcoming demand and predicting future request in web page recommendation system.

4. Results and Discussion

The proposed system is implemented and executed in the operational platform of JAVA in Cloud Sim. To determine the efficiency and effectiveness, various metrics such as time, memory, clustering time, clustering accuracy and recommendation accuracy are calculated.

Accuracy is defined as the number of hits with respect to the number of page hits plus miss. And as per the confusion matrix, recommendation matrix is constructed to calculate the accuracy [21] and it is tabulated below:

	Predicted	
	Positive	Negative
Actual positive	True Positive (TP)	False Negative (FN)
Actual negative	False Positive (FP)	True Negative (TN)

$$\text{Accuracy} = \frac{\text{TruePositive} + \text{TrueNegative}}{(\text{TruePositive} + \text{TrueNegative} + \text{FalsePositive} + \text{FalseNegative})}$$

Observed values for different measures are recorded for various iterations and the results are tabulated as below:

Table 1: Clustering Accuracy for our proposed research

Iteration	Cluster Accuracy (%)	Clustering time (ms)	Recommendation accuracy (%)	Overall time (ms)
10	71.12	9658	78.12	18456
15	72.36	11256	79.36	22369
20	73.45	12369	80.11	24968
25	76.64	14569	82.36	29874

The values show that on an average the system performs clustering accuracy of approximately 73 percentage and recommendation accuracy of 80 percentage. The graphical representation of cluster accuracy and recommendation accuracy is shown in Figure 2.

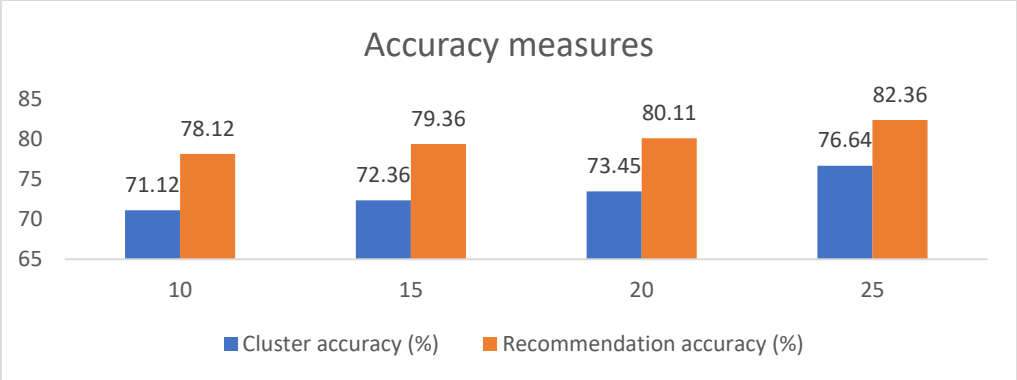


Figure 2. Clustering Accuracy Measures

6. Conclusion

The focus of this research work is enhancing web page recommendation system by finding the upcoming consumer demand and predicting web page using consumer comparable significance model. To facilitate that, one of the robust neural networks- Feed Forward Back propagation neural network has been deployed which uses Firefly algorithm output as input. The Firefly algorithm is calculated using Levenberg-Marquardt calculation. The advantage of this system is, it predicts user requests dynamically by using improved fuzzy C-means clustering. Results show that the clustering accuracy of the proposed system is approximately above 73 percent and recommendation accuracy is above 80 percent. And, the time taken by the proposed system when compared with existing K-means algorithm shows that the proposed system performs better. Thus, the proposed recommendation system will give user friendly experience and can be deployed in E-commerce websites to attract new consumers and enhance productivity.

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