ABSTRACT
To develop a project successfully, it is important for any organization that the project should be completed within budget, on time and the project should have requisite quality. This paper presents an Adaptive Neuro-Fuzzy Approach for Software Development Time Estimation. This proposed technique is aimed at building and evaluating a Neuro-fuzzy model using three (3) membership functions (MFs) for software project development time. The forty one modules were used as a data set. Our proposed approach for Neuro fuzzy using 3 membership functions i.e. Gaussian MF (GMF), Triangular MF (Tri MF) and Trapezoidal MF (Trap MF) is compared with neural network models and the results show that values of various relative error parameters for Neuro-fuzzy is lower than the values of parameters applying neural network.

General Terms
Neuro Fuzzy, Software Time Estimation.

Keywords
Adaptive Neuro Fuzzy Inference System (ANFIS), Neural Network, Fuzzy Logic, Prediction, MRE, MMRE, BRE, Development Time (DT), Membership Function (MF).

1. INTRODUCTION
Software industries are one of the largely growing industries in recent years. Success of these growing industries plays a key role to the world balanced economy. For the success of the software industries, management of the industries has to plan a software development project. The neural network research started in the 1940s, and the fuzzy logic research started in the 1960s, but the Neuro-fuzzy research area is relatively new [32]. The objective of this paper is to present a possible way of combining fuzzy logic and neural networks for achieving higher accuracy. Once the concept of fuzzy logic is incorporated into neural network, the result is a Neuro-fuzzy system that combines the advantages of both techniques.

A software tool (MATLAB 7.10) was used to process the Neuro-fuzzy systems. Accurate time estimation is a crucial skill in project management. Without it, you won’t know how long your project will take, and you won’t be able to get commitment from the people who need to sign it off. Even more importantly for your career, sponsors often judge whether a project has succeeded or failed depending on whether it has been delivered on time and on budget. To have a chance of being successful as a project manager, you need to be able to negotiate sensible budgets and achievable deadlines. Once you’ve estimated the time needed for each task, you can prepare your project schedule. Add your estimates to the draft activity list that you produced in the second step, above. You can then create a Gantt chart to schedule activities and assign resources to your project; and to finalize milestones and deadlines. There are different approaches that you can use to estimate time. Bottom-Up estimating, Top-Down estimating, comparative estimating, parametric estimating and three Point estimating. There are various steps to estimate time accurately. Integration of neural networks, fuzzy logic and algorithmic models into one scheme has resulted in providing robustness to imprecise and uncertain inputs. In this paper, we present an adaptive Neuro fuzzy inference system (ANFIS) for software development time estimation. In the proposed method accurate estimation of software development time will be done and the results of Neuro Fuzzy approach will be compared with different types of neural network models based upon various parameters such as Magnitude of Relative Error (MRE), Mean Magnitude of Relative Error (MMRE), Balanced Relative Error (BRE) and Prediction (Pred).

2. RELATED WORK
Lopez Martin et al. [14] proposed a fuzzy logic model for development time estimation. Ting su et al. [33] described an enhanced fuzzy logic model for the estimation of software development effort which had the similar capabilities as the previous fuzzy logic model in addition to enhancements in empirical accuracy in terms of MMRE. Abbas Heiat [34] used artificial neural network techniques like RBF (Radial Basis Function) and MLP (Multi Layer Perceptron) for software development effort. The main goal of this paper is to evaluate software development time using an adaptive Neuro fuzzy approach.

3. METHODOLOGY
The main goal of this paper is to evaluate software development time using an adaptive Neuro fuzzy approach. In this paper an Adaptive Neuro Fuzzy Inference System (ANFIS) tool is used. The network is trained by using learning algorithm i.e. Hybrid Approach (combination of back propagation and least mean square algorithm). This methodology consists of four steps: 1) Loading of Training Data and 2) Generating Fuzzy Inference System 3) Training of ANFIS 4) Development Time Estimation.

Design and Implementation of Neuro Fuzzy model for Software Development Time Estimation

Shina Dhingra
Student
DAV Institute of Engineering & Technology
Kabir Nagar, Jalandhar
PUNJAB

Palvinder Singh Mann
Assistant Professor
DAV Institute of Engineering & Technology
Kabir Nagar, Jalandhar
PUNJAB
No. of MF
Type of MF
Training Data

Initialize the Fuzzy Inference System
Use genfis1 command

Training of ANFIS
Use anfis

Testing of ANFIS

Fig 1: Proposed Model

Pseudo – Code of Methodology

Begin:

Step I; Determine the inputs of the model;
Collect a data set; Divide the data into two sets: Train data set, and the other one for evaluating the validity of the estimated model, called the test data set.

Step II; Generate ANFIS model;
[Define no of Membership functions] numMFs;
[define type of Membership functions] mfType;
[define no epoch] epoch_n;
[Generate Fuzzy Inference System structure from data using grid partition]
in_fis=genfis1 (trnData, numMFs, mfType);
[Training routine for Sugeno-type Fuzzy Inference System (uses a hybrid learning algorithm)]
out_fis= anfis (trnData,in_fis,epoch_n);

Step III; Evaluate the value of Development Time;
For each individual test data
For i=1 to total test data
[Evaluate the value of Development Time ]
dt(i)= evalfis(inpData,fis);
Next i ;

Step IV; Evaluate the Value of MRE from result obtained by step III;
For MRE of each individual test data
For i = 1:to total test data
mre(i)=abs((Actual dt(i)-dt(i))/Actual dt(i), dt(i));
Next i ;

Step V; Evaluate the Value of MMRE and PRED from result obtained by step IV;
For MMRE and PRED of each individual test data
Initialize mmre =0, pred =0;
For i = 1:to total test data
mmre=mmre+mre(i);
IF (mre (i)<=.25) pred =pred+1;
EndIf
Next i ;
MMRE=(mmre/(total test data))*100;
PRED=pred/(total test data);

Step VI; Evaluate the Value of BRE from result obtained by step III;
For BRE of each individual test data
For i = 1:to total test data
bre(1,i)=abs((Actual dt(i)-dt(i))/min(Actual dt(i), dt(i)));
Next i ;

END

3.1 ANFIS Method
The proposed method estimates the software development time accurately by proposed Adaptive Neuro Fuzzy Inference System (ANFIS) as it is a combination of Fuzzy Logic and Neural Network so ANFIS takes advantages from fuzzy logic and neural network. This ANFIS constructs a Fuzzy inference system by using given training data set whose membership function parameters are adjusted by back propagation algorithm or in combination with least square type of method. Fig 2 shows a high level diagram of the proposed ANFIS. Inputs and their membership functions appear to the left of the ANFIS structural characteristics, while outputs and their membership functions appear on the right.

Fig 2: Diagram of Proposed ANFIS for Gaussian MF
3.2 Performance Evaluation Metrics

The following evaluation metrics are adapted to assess and evaluate the performance of the time estimation models.

- **Magnitude of Relative Error (MRE)**
  \[ MRE = \frac{|Actual \ Time - Estimated \ Time|}{Actual \ Time} \times 100 \quad Eq.(1) \]

- **Mean Magnitude of Relative Error (MMRE)**
  \[ MMRE = \frac{1}{n} \sum_{i=1}^{n} \frac{|Actual \ Time - Predicted \ Time|}{Actual \ Time} \quad Eq.(2) \]

The MMRE calculates the mean for the sum of the MRE of n projects. Specifically, it is used to evaluate the prediction performance of an estimation model.

- **Prediction Level (PRED)**
  \[ PRED (l) = \frac{k}{n} \times 100 \quad Eq.(3) \]
  where \( l \) is the maximum MRE of a selected range, \( n \) is the total number of projects, and \( k \) is number of projects in a set of \( n \) projects whose MRE <= \( l \). PRED calculates the ratio of projects’ MREs that falls into the selected range \( l \) out of the total projects. (e.g. \( n = 100 \), \( k =80 \), where L= MRE <= 30%: PRED(30%)=80/100=80%).

- **Balanced Relative Error (BRE)**
  \[ BRE(\%) = \frac{|Estimated \ Time - Actual \ Time|}{\min(T,T')} \times 100 \quad Eq.(4) \]
  Where \( T = \) estimated time and \( T' = \) actual time

3.3 Training

The objective of Hybrid training algorithm is to minimize the approximation error. In order to overcome certain problems hybrid approach is used i.e. combination of back propagation algorithm and least mean square method. The 25 projects are used for training that is chosen randomly and 11 projects are used for testing. When fuzzy inference file is trained no. of epochs are used which are used to minimize the error. More the no. of epochs lesser will be the error. In ANFIS epochs are used to adjust the weights in order to minimize the error. To create a fuzzy inference system file genfis 1 command is used and for training of that file anfis command is used which takes certain inputs.

4. RESULTS AND DISCUSSION

Testing was carried out on a system with Intel ® core (i3), 2.93 GHz with 2GB RAM and implemented using MATLAB (7.10). We have divided the entire dataset into two sets, training set and testing set in the ratio of 100% and 20%. Training set consists of data from 25 projects selected randomly and testing set consists of 11 project samples that were used later on for testing.

Table 1 summarizes the development time estimates as obtained for Neuro fuzzy model using different membership functions.

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Actual DT</th>
<th>Estimated DT using Gaussian MF for Neuro fuzzy</th>
<th>Estimated DT using Triangular MF using Neuro fuzzy</th>
<th>Estimated DT using Trapezoidal MF using Neuro fuzzy</th>
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Table 2 below summarizes the comparison of estimated development time for Neuro fuzzy model with different neural network models [11].
Table 2. Comparison of different models

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</table>

Table 3 summarizes the comparison of various neural network models [11] with Neuro fuzzy models using parameters.

5. CONCLUSION

The paper suggests a new approach for estimating of software project development time. In this paper, Adaptive Neuro Fuzzy Inference model is considered and three membership functions i.e. Gaussian MF, Triangular MF and Trapezoidal MF are used to predict the future values. It is observed that Neuro Fuzzy model using Trapezoidal membership function gives better results than all other models. It is also observed that Trapezoidal MF gives better results for all the three parameters. In order to achieve more accurate estimation, the estimated values of several other techniques and combine their results may be useful.

6. ACKNOWLEDGEMENT

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7. REFERENCES


