

EARLY STAGE SOFTWARE DEVELOPMENT EFFORT ESTIMATIONS – MAMDANI FIS VS NEURAL NETWORK MODELS

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ABSTRACT

Accurately estimating the software size, cost, effort and schedule is probably the biggest challenge facing software developers today. It has major implications for the management of software development because both the overestimates and underestimates have direct impact for causing damage to software companies. Lot of models have been proposed over the years by various researchers for carrying out effort estimations. Also some of the studies for early stage effort estimations suggest the importance of early estimations. New paradigms offer alternatives to estimate the software development effort, in particular the Computational Intelligence (CI) that exploits mechanisms of interaction between humans and processes domain knowledge with the intention of building intelligent systems (IS). Among IS, Artificial Neural Network and Fuzzy Logic are the two most popular soft computing techniques for software development effort estimation. In this paper neural network models and Mamdani FIS model have been used to predict the early stage effort estimations using the student dataset. It has been found that Mamdani FIS was able to predict the early stage efforts more efficiently in comparison to the neural network models based models.

KEYWORDS

Effort estimation, early estimations, artificial neural network, fuzzy logic, Mamdani FIS

1. INTRODUCTION

Accurate estimation of software size, cost, effort and schedule is probably the biggest challenge facing software developers today. A typical estimation process involves generating a work breakdown structure (WBS), making assumptions, identifying dependencies, examining historical data, estimating each task and documenting the results [1]. Independent surveys carried out by Lederer [2] and Moløkken et al. [3] to evaluate the importance of effort estimation in software development, reported that 70-85% of the respondents agreed to the importance of effort estimation.. As software development has become an essential investment for many organizations, accurate software cost estimation models are needed to effectively predict, monitor, control and assess software development [4]. It has major implications for the management of software development because both the overestimates and underestimates have

direct impact for causing damage to software companies. Since estimation accuracy is largely affected by modeling accuracy, finding good models for software estimation are now one of the most important objectives of the software engineering community [5]. New paradigms offer alternatives to estimate the software development effort, in particular the Computational Intelligence (CI) that exploits mechanisms of interaction between humans and processes domain knowledge with the intention of building intelligent systems (IS) [6]. Among IS, Artificial Neural Network and Fuzzy Logic are the two most popular soft computing techniques for software development effort estimation.

Since the last two decades, Artificial Neural Network (ANN) are being used extensively for predictions in diverse applications and the neural networks are recognized for their ability to produce reasonably accurate predictions in situations where complex relationships between inputs and outputs exist and where the input data is distorted by high noise levels [7]. Hughes [8], Wittig and Finnie [9][10] and Idri et al. [11] have employed neural network to predict the development effort on different data sets.

Many researchers have worked and proposed SCE models based on the Fuzzy Logic Techniques. Fei and Liu, [12] introduced the f-COCOMO model which applied Fuzzy Logic to the COCOMO model for software effort estimation. Kumar et al, [13] had applied fuzzy logic in Putnam's manpower buildup index (MBI) estimation model. Ryder [14] researched on the application of fuzzy logic to COCOMO and Function Points models. His result showed Fuzzy Logic is good at making effort estimations.

1.1. Early Stage Software Development

Early stage effort estimations can be defined as making software development effort estimations at the initial stages more precisely the Design stage of SDLC. Carrying out effort estimations at the early stages is beneficial because the design stage prediction implies fewer overheads at the later stages of software development. Figure 1 below signifies that the total project effort comprises of the efforts (given in percentage) which goes into surpassing each of the individual phases. It is evident from the Figure 1 that most of the efforts (nearly 60 per cent) are spread over two initial phases of Analysis and Design. Hence if the accurate effort requirements can be predicted from the initial or early phases of the SDLC, then an efficient project development schedule can easily be prepared so as to complete the project well within the targeted time and budget constraints.

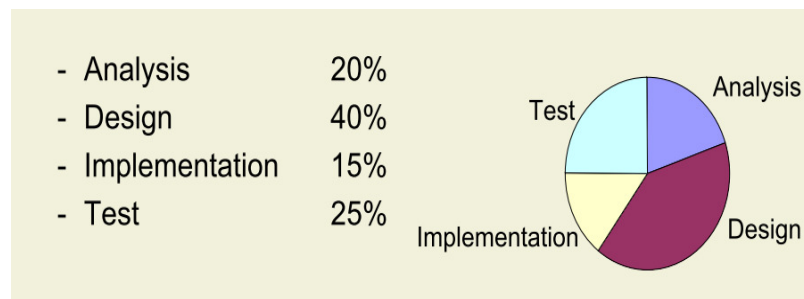


Figure 1: Effort distribution in the individual phases of SDLC
(Source: Peter Müller – Software Engineering, SS 2006)

The state of the art literature has revealed that not much work on estimating the effort required for software project development at the early stages in the Software Development Life Cycle (SDLC)

has been done. Thus, this area still remains open to attract researchers to develop and propose new models for early stage effort estimation.

2. EXPERIMENTAL METHODOLOGY

For carrying out the effort prediction in the early stages of software development, precisely in the design phase of SDLC, a student dataset was prepared based on the Entity Relationship Diagrams (ERDs) generated by the final year B.Tech. degree students of Computer Science & Engineering Department of Sikkim Manipal Institute of Technology, India, as part of their Major Project work spanning 16 weeks duration. Total Count of Entities (TCOE), Total Count of Attributes (TCOA), Total Count of Relationships (TCOR), Cumulative Grade Point Aggregate (CGPA) and Major Project final marks have been considered as explanatory variables in the dataset. The relevant data of students of different batches have been gathered. The final marks obtained by students in the Major Project are used to obtain the Recalculated Development Effort (RDE) in number of weeks (effort) of software development.

In a previous work [15] carried out by the authors of this paper, a comparison of different neural networks was carried out to predict the effort estimation at the early stages of software development. In the work the Development Time (DT) was obtained by applying various methods such as the Feed Forward Back Propagation Neural Network model, Cascaded Feed Forward Back Propagation Neural Network (CFFBPNN) model, Elman Back Propagation Neural Network (EBPNN) model, Layer Recurrent Neural Network (LRNN) model and Generalized Regression Neural Network (GRNN) model with the help of Neural Network toolbox of MATLAB R2007b software. The performances were then compared in terms of MMRE, Pred (0.25), BRE% etc. All these models were trained with first 31 inputs from the dataset and later the models were tested with 10 inputs from the same dataset.

In another work [16], Mamdani FIS from the Fuzzy logic toolbox of Matlab 7.0 was applied on the student dataset as given in Annexure II, Table 3, to evaluate the efficiency of the FIS in estimating the efforts in the early stages of SDLC. For experimentation from the dataset, the Total count of Entities (TCOE), Cumulative Grade Point Aggregate (CGPA) have been taken as two input variables and Redistributed Development Effort (RDE) as the output variable for preparing Mamdani FIS.

In the present paper a comparison of the performance of different neural network models with Mamdani FIS is done. For the experiments the same student dataset was used and models were applied on to the dataset. A comparison of the MMRE values obtained from calculating the Redistributed Effort Estimations (RDE's) after employing the neural networks and fuzzy logic on the dataset was carried out to evaluate the efficiency of the better of the two in estimating effort estimation at the early stage of effort estimation.

2.1. Evaluation Criteria

There are many evaluation criteria to evaluate the accuracy of the software development effort in literature. The Mean Magnitude Relative error (MMRE) is a widely-accepted criterion in the literature and is based on the calculation of the magnitude relative error (MRE). Eq. (1) as below shows an equation for computing the MRE value that is used to assess the accuracies of the effort estimates.

$$MRE_i = \frac{|ActualEffort_i - PredictedEffort_i|}{ActualEffort_i} \quad \text{Eq. (1)}$$

The MRE calculates each project in a dataset while the MMRE aggregates the multiple projects. The model with the lowest MMRE is considered the best [4].

3. RESULTS AND DISCUSSIONS

The values of MMRE are calculated for each of the neural networks and fuzzy logic are as shown in Annexure I, Table 2 and Annexure III, Table 4 respectively. The results obtained after comparing the RDE values are graphically shown in Figure 2 and their values are listed in Table 1.

Table 1 Comparison of different neural networks and Mamdani FIS based on MMRE values

Models	MMRE(%)
FFBPNN	12.96
Cascaded FFBPNN	13.59
LRNN	11.45
Mamdani FIS	3.89

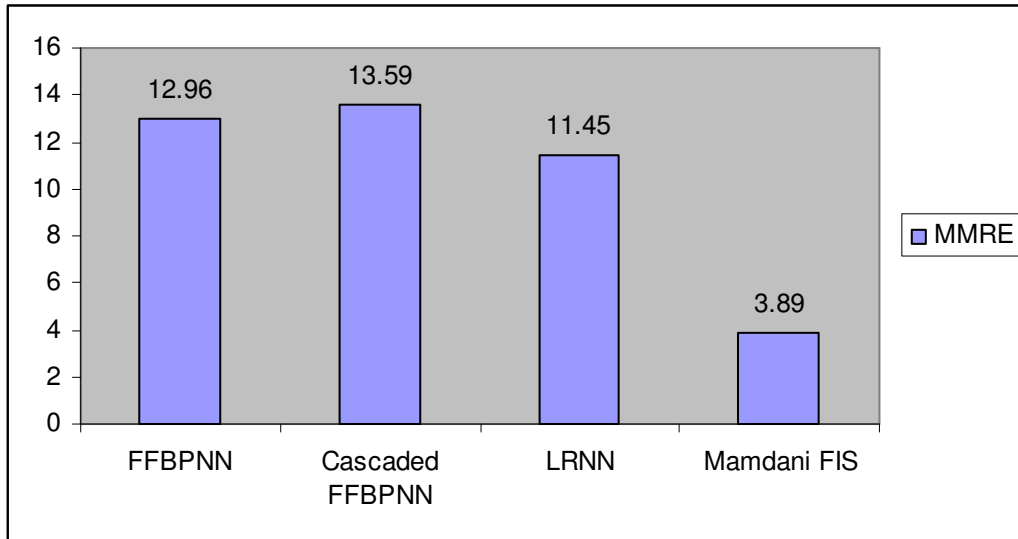


Figure 2: Comparison of MMRE values of neural network and fuzzy logic

4. CONCLUSION

It is evident from the Figure 2 that the Linear Regression Neural network (LRNN) has the lowest value for MMRE among the other neural network models but when it is compared with fuzzy

logic, it is observed that fuzzy logic outperforms neural network models as it has the lowest MMRE value. Thus, fuzzy logic is the best model for predicting early stage effort estimation.

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Annexure I

Table 2: Development Effort as obtained by different neural network models

Serial No.	Actual RDE	RDE' using FFBPNN	RDE' using CascadeFBPNN	RDE' using LRNN
31	65	69.39	79.71	79.73
32	75	67.73	66.26	69.17
33	65	79.03	55.06	80.00
34	65	79.03	55.05	80.00
35	70	55.00	77.46	69.11
36	70	55.21	74.66	69.39
37	70	60.07	72.86	69.44
38	65	58.85	62.28	67.77
39	75	79.16	61.54	68.31
40	75	79.16	64.05	70.04
41	75	79.20	55.14	55.06

Annexure II

Table 3: ERD based Student Dataset: TCOE :: Total Count of Entities; TCOA :: Total Count of Attributes; TCOR:: Total Count of Relationships; CGPA:: Parameter for academic excellence; RDE:: Redistributed Effort (Recalculated effort)

Serial Number	TCOE	TCOA	TCOR	CGPA	RDE
1	24	70	29	6.219	75
2	24	70	29	8.012	75
3	24	70	29	7.733	75
4	10	56	9	7.564	70
5	5	44	5	5.519	55
6	19	47	11	7.507	70
7	8	33	9	6.171	75
8	8	33	9	6.705	75
9	17	53	7	7.629	75
10	9	37	7	8.130	70
11	10	36	8	8.083	65
12	10	36	8	8.126	65
13	10	36	8	7.202	65
14	5	17	5	8.417	65
15	5	16	7	7.757	70
16	4	26	4	7.431	70
17	4	26	4	7.121	70
18	4	26	4	7.660	70
19	7	34	6	8.017	75
20	7	34	6	9.076	75
21	7	27	5	7.550	70
22	6	37	5	6.583	65
23	6	27	12	7.276	65
24	6	27	12	8.124	65
25	5	26	4	6.530	75
26	5	26	4	6.685	70
27	6	28	6	7.843	65
28	7	38	9	9.160	70
29	7	38	9	8.617	75
30	6	18	3	8.719	80

31	4	22	3	8.860	65
32	5	18	5	7.664	75
33	16	85	15	6.795	65
34	16	85	15	6.757	65
35	9	36	9	6.207	70
36	9	36	9	6.636	70
37	9	36	9	6.790	70
38	8	24	7	8.095	65
39	20	115	22	7.990	75
40	20	115	22	8.095	75
41	15	60	9	6.340	75

Annexure III

Table 4: RDE using Mamdani FIS and corresponding MRE values

Serial Number	TCOE	CGPA	RDE	RDE using Mamdani FIS	MRE
1	24	6.219	75	75	0.000
2	24	8.012	75	75	0.000
3	24	7.733	75	75	0.000
4	10	7.564	70	75	0.071
5	5	5.519	55	64.3	0.169
6	19	7.507	70	75	0.071
7	8	6.171	75	65	0.133
8	8	6.705	75	65	0.133
9	17	7.629	75	75	0.000
10	9	8.13	70	75	0.071
11	10	8.083	65	75	0.154
12	10	8.126	65	75	0.154
13	10	7.202	65	75	0.154
14	5	8.417	65	71	0.092
15	5	7.757	70	71	0.014
16	4	7.431	70	70	0.000
17	4	7.121	70	70	0.000
18	4	7.66	70	70	0.000
19	7	8.017	75	73.4	0.021
20	7	9.076	75	72.8	0.029
21	7	7.55	70	73.2	0.046
22	6	6.583	65	64.4	0.009
23	6	7.276	65	71.3	0.097
24	6	8.124	65	72.1	0.109
25	5	6.53	75	64.4	0.141
26	5	6.685	70	64.5	0.079
27	6	7.843	65	72.1	0.109
28	7	9.16	70	72.7	0.039
29	7	8.617	75	73.3	0.023
30	6	8.719	80	71.9	0.101
31	4	8.86	65	70	0.077
32	5	7.664	75	71	0.053
33	16	6.795	65	70	0.077
34	16	6.757	65	70.4	0.083
35	9	6.207	70	67.1	0.041
36	9	6.636	70	68.6	0.020

37	9	6.79	70	70	0.000
38	8	8.095	65	75	0.154
39	20	7.99	75	75	0.000
40	20	8.095	75	75	0.000
41	15	6.34	75	71	0.053

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