Comparative study of Institute based ERP based on ANFIS, ANN and MLRA

Dr. Rajeev Gupta, Sarita Chouhan, Neha Bhuria

***Abstract*— Now a days, there is an essential need for efficient ways of continuous assessment, identifying shortcomings and improving system performance. On one hand, the quality of ERP systems is related to the user satisfaction. On the other hand, measuring humans satisfaction is intermingled by uncertainty and vagueness. The main objective of this study is to identify the antecedents of end-user satisfaction with an Enterprise Resource Planning (ERP) system, in the context of a educational institute. That is why ordinary statistical analysis is not necessarily efficient in this context. This motivated us to use fuzzy logic methods in assessing the effectiveness of ERP. The results establish that ANFIS is able to predict outcome well with an error (RMSE) of 0.2945 and outperforms ANN and MLRA with errors of 0.85 and 0.86 respectively. This study is expected to provide guidelines academia to predict ERP outcomes and thereby enable corrective actions to redirect ailing projects.**

***Index Terms*— ANFIS, ERP Implementation Outcome, Antecedents, Prediction.**

I. Introduction

The track record of successful IT projects of which Enterprise Resource Planning (ERP) is a subset projects remains poor. The latest CHAOS study of the Standish Group reports a marked decrease in IT project success rates, with only 32% succeeding in "on time" and "on budget" delivery with required features and functions.

44% were delivered late or over budget, and/or with less than the required features and functions. 24% were can-celled prior to completion or delivered and never used. This is worse than the figures of about decade back as observed by Robey in 2002: "About half of ERP projects fail to achieve anticipated benefits".

Information systems (IS) project failures often encounter project "escalation" defined as a continued commitment to a failing course of action despite "uncertainty surrounding the likelihood of goal attainment". Escalation research lists issues that cause escalation and suggests strategies for de-escalation which includes abandoning or "redirecting" the project. While these are acceptable as reactive steps a proactive approach of predicting impending failures, would be invaluable as one could then attempt to forestall or at least redirect the project far better.

The essence of proactive control is having predictive capabilities. The challenge is to move from the diagnosis of the source of past problems to the prediction and forecasting of potential problems in new projects. Can a robust, easy to use and reliable predictor be developed that would "red flag" impending failures in ERP implementations? This is the research question we seek to answer in this paper. This research has developed a method of predicting User Satisfaction, a key measure of ERP project success using ex ante causal factors as predictors.

Manuscript received May 16, 2014.

This study consolidates and extends an earlier study which gathered data from a cross section of business organizations that had implemented ERP systems in the last three years and developed and tested a measurement model for causal factors for success. Data was collected, using a structured questionnaire, on Cri
-tical Success Factors (CSFs), identi-
fied in literature as being causal for the success of an ERP impleme-ntation and overall User Satisfaction , a key indicator of the success. Respondents to our questionnaire represented different user cohorts: Strategic Users, Technical Users and Operational Users. The validity and reliability of the measurement model and its innate value as a predictor of ERP success was established using Structural Equation Modeling (SEM) with LISREL 8.7.

In the present study the data from the earlier study was used to develop predictive models for ERP implementation outcomes measured in terms of User Satisfaction.

Three prediction techniques, Multiple Linear Regression Analysis (MLRA), Artificial Neural Networks (ANN) and Adaptive Neuro Fuzzy Inference System (ANFIS) were tested. Of the three ANFIS was found to be significantly better in predicting User Satisfaction of an ERP project.

This paper is organized as follows: Section 2 presents the literature review and establishes the need and relevance of this research work. Section 3 outlines the method used in the research. This section also explains different prediction techniques with specific emphasis on ANFIS. Section 4 presents the results of the modeling and compares the results of the various techniques used. Section 5 concludes the paper with the direction for continuing research.

II. Methodology

The conceptual model underlying the present study is given in **Figure 1**.

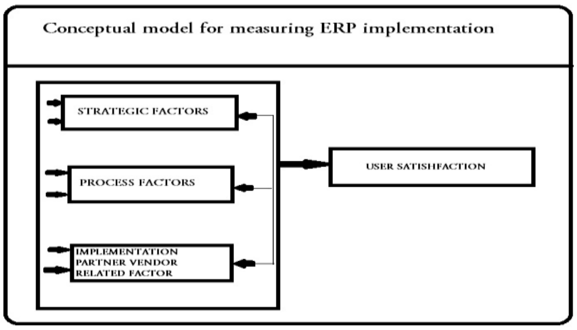


Figure 1. Conceptual model.

Through an earlier empirical study data was collected from a cross section of around 12 students and 120 respondents representing three user cohorts: Strategic, Technical & Operational responded to a pre-tested and validated (for content validity) structured questionnaire. Respondents rated the CSFs present in their organizations during ERP implementation. The CSFs list used for this research was drawn from prior research, and confirmed by an expert panel as relevant for the current context. The CSFs were also validated as relevant as per Structuration, Expectations-Confirmation, Lewins Change and Agency theories. Responses were captured on a Likert scale with end values of 5 = Completely Agree and 1 = Completely Disagree. From the same set of respondents their overall satisfaction, a measure of Success of the ERP project was also captured on a seven point Likert Scale with end values of 7 = Completely Satisfied and 1 = Completely Dissatisfied.

III. Algorithm Requirement

Three different prediction techniques were used:-

1) Multiple Linear Regression Analysis (MLRA)
2) Artificial Neural Network (ANN)
3) Adaptive Neuro-Fuzzy Interference System (ANFIS)

In all cases about 70% data was used to build/train the model. The balance 30% of data was used for testing the model. Each of these is discussed in the following paragraphs.

A. *Multiple Linear Regression Analysis (MLRA)*

Linear least squares regression analysis is still the most common technique used, as observed in the literature. Being a pure statistical technique MLRA has a few important underlying assumptions. These are 1) "linearity"-the assumption that the predictor variable is linearly related to the dependent variable, 2) no "multicolloinearity"—the individual predictors are not correlated to each other, 3) no "heteroscadacity''-the error variances of the predictor variable are constant across the range of data. These conditions make the use of MLRA restrictive especially when modeling issues related to human judgment where multicollinearity and heteroscadacity are sometimes unavoidable. However, despite its limitations MLRA is an established technique and this study compares the results of MLRA with results obtained from other prediction techniques.

B. *Artificial Neural Networks (ANN)*

The most common model-building technique identified in the literature as an alternative to MLRA is back- propagation trained feed-forward neural networks often referred to simply as back-propagation networks. ANNs are complex and flexible nonlinear systems with the ability to deal with noisy or incomplete input patterns, high fault tolerance, and the ability to generalize from the input data. Neural networks excel at applications where pattern recognigation is important and precise computational answers are not required. ANN works on the principle of an adaptive learning algorithm and use an information processing system composed of a large number of interconnected processing elements (neurons) working in tandem. Neural networks are made of basic units arranged in layers. A unit collects information provided by other units (or by the external world) to which it is connected with weighted connections called synapses. These weights, called synaptic weight multiply (i.e.amplify or attenuate) the input information. A positive weight is considered excitatory, a negative weight inhibitory. One of the most popular architectures in neural networks is the multi-layer perceptron which is illustrated in **Figure 2**. Learning happens through a methodology of continuously altering the weights to achieve closer and closer values to desired output. One algorithm that performs this is known as the back propogation algorithm. The back propagation algorithm is a generalization of the least mean squre algorithm . The network weights are modified to minimize the mean squred error between the desired and the actual output of the network.The network is trained using a training data set where the inputs and output Value are Known. After the tranning is completed, the weights are frozen and the models can be used be prediction or outputs for new set of inputs Values.

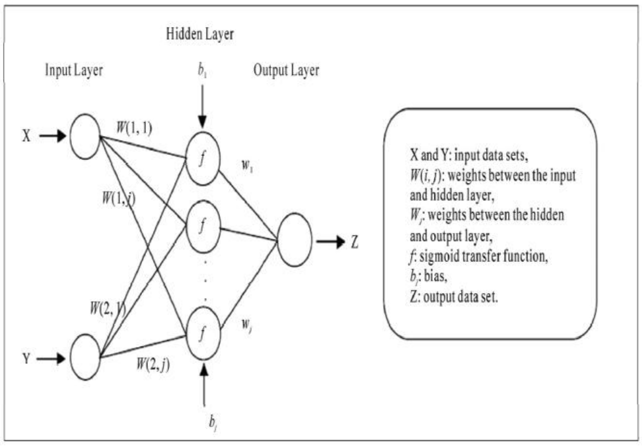


Figure 2. ANN-multilayered perceptron.

C. *Adaptive Neuro-Fuzzy Inference Systems (ANFIS)*

While ANN is a good technique that emulates the way a human brain makes a judgement, a limitation is the way t handles the input data. In the case of human reasoning input data need not always be crisp but could have linguistic labels like "small", "high" etc. Also, the response to data need not always follow a strict "Yes-No" rule but could have a range of responses across a continuum.

Such a pattern of responses is referred to as the membership function and such reasoning is called "fuzzy" reasoning. A fuzzy inference system using fuzzy rules can model qualitative aspects of human behavior. This was first explored by Takagi and Sugeno and has since been used in numerous applications involving pre-dictions. Fuzzy inference systems are composed of five functional blocks as given in **Figure 3**. These are 1) a rule base containing a number of if-then rules 2) a database which defines the membership function, 3) a decision making interface that operates the given rules 4) a fuzzification interface that converts the crisp inputs into "degree of match "with the linguistic values like high or low etc., and 5) a de fuzzification interface that reconverts to a crisp output.

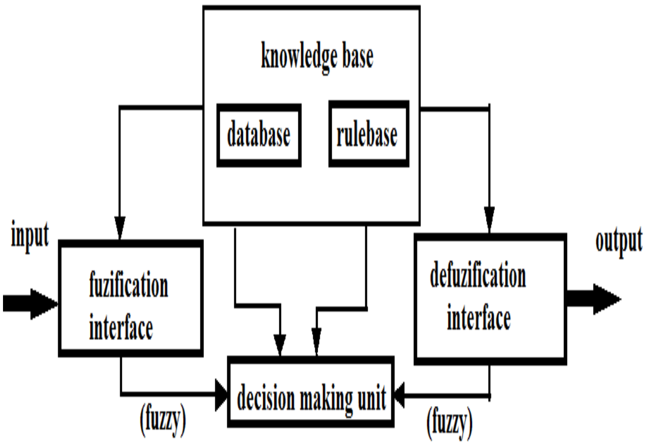


Figure 3. Fuzzy inference system

D. ANFIS Layer Description

A typical ANFIS consists of five layers, which perform different actions in the ANFIS are detailed below. For simplicity, we have illustrated a system that has two inputs x and y and one output Z. The rule base, for illustrative purposes consists of two if-then rules of the Ta-kagi-Sugeno type.

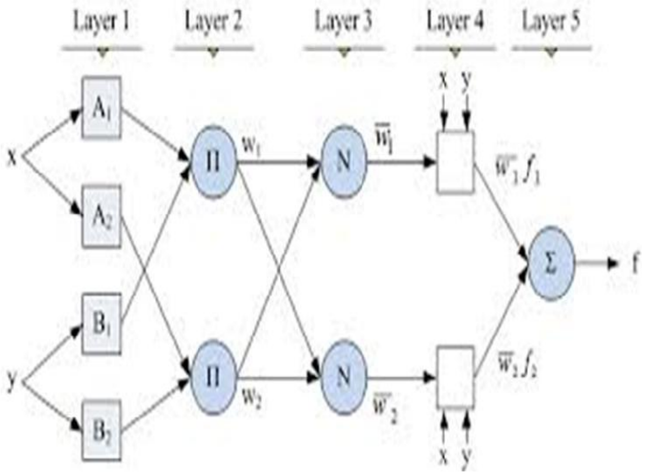


Figure 4: ANFIS Layer diagram

Layer 1: All the nodes in this layer are adaptive nodes. They generate membership grades of the inputs.
The node function is given by:
$O^1 A_i = \mu(x)$ $i = 1; 2$
$O^1 B_j = \mu(x)$ $j = 1; 2$
where x and y are inputs and A_i and B_j are appropriate membership: functions which can be triangular, trapezoidal, Gaussian functions or other shapes.
In our study, the Gaussian: MFs has been utilized and three input parameters are: Staff, Team Work and Technical.

Layer 2: The nodes in this layer are fixed nodes which multiply: the inputs and send the product out. The outputs of this layer are: represented as:

$W_i = \mu A_i(x) \mu B_j(y)$ $i,j=1,2$

Layer 3:The nodes in this layer are also fixed nodes. It calculates the ratio of a rule firing strength to sum of the firing strengths of all the rules.

Layer 4:Each node in this layer is an adaptive node, whose output is simply the product of the normalized firing strength and a first-order polynomial(for a first Order Sugeno model).
Thus, the outputs of this layer are given by:

$O^4_{ij} = \overline{W_{ij}} f_{ij} = \overline{W_{ij}}(p_{ij}x + q_{ij}y + r_{ij})$ $i,j = 1,2$
Parameters in this layer are re_ered to as consequent parameters.

Layer 5:The single node in this layer computes the overall output as the summation of all incoming signals

$Out = O^5 = \Sigma^2{}_{i=1} \Sigma^2{}_{j=1} \overline{W_{ij}} f_{ij}$

where the overall output Out is a linear combination of the consequent parameters when the values of the premise parameters are fixed. It uses sugeno type fuzzy interfernce systems and Gaussian membership function is used to train the given data set.

IV. WEBBASED ERP MODEL

Our Education ERP has been designed to cover the in depth functionalities of any Educational Institute/University/ Group of Institutions, from the perspective of various users carrying different roles and responsibilities such as Students, Teachers, Staff, Principal, Management, Parents, Alumni etc. All the data is managed in a time sensitive manner along with the rules and policies applicable at that time, so whenever required, the exact information can be re-produced as it is. The strength of our Education ERP increases many fold with the integration of our other ERP packages like HR, Payroll, Accounts Inventory, Library etc. However, the entire solution is designed based on a modular approach that gives flexibility to our clients to choose desired modules as per their requirements. We have developed an integrated solution for complete computerization for educational institutions, build on the most futuristic and highly sophisticated Java environment, denoted as MII - Educational Institutes Management System. The solution has been implemented in many prominent and reputed educational institutions of all levels from multi-branch Nursery Schools, Graded Schools to Colleges of the country. Since, this an Integrated, user configurable and dynamic software solution, it help institutions to get the wide range detailed and summarized information of Administrative and Academic nature, in different forms required at different level of the Organizational hierarchy and for other interested parties like Students, Parents and other Organizations. Educational Institute Management System (MII-ERP) is best software for schools, Colleges, Institutes, Engineering Colleges, management Colleges, medical Colleges, Nursery with SMS, IVRS, GPRS and web portal. A sample of the data set showing the independent variables as well as the dependent variable for the model is given in Table 1.

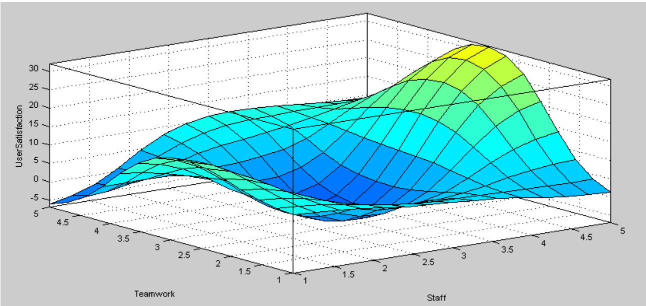
Data Input

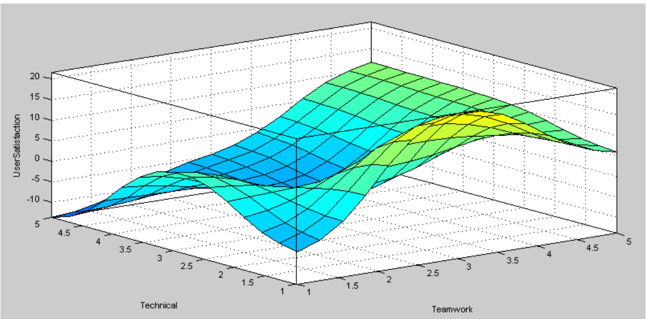
Table 1: Sample Dataset

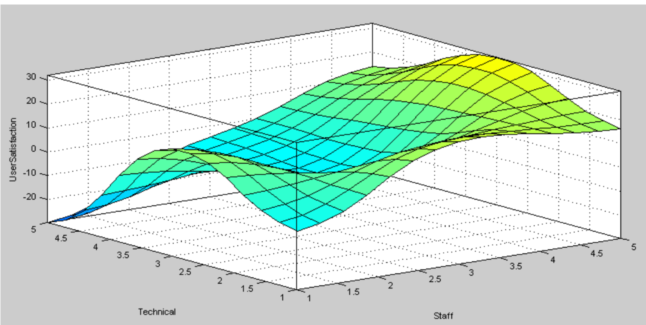
S. No.	Staff	Team Work	Technical	User Satisfaction
1	5	5	5	5
2	1	1	1	1
3	3	1.66	3	2
4	2.66	2.33	3.33	3
5	1.66	1.33	1.66	2
6	3.66	3.66	4.66	4
7	3.33	3.33	2.33	3
8	2.33	3	2.33	2
9	1.66	2.33	1.33	2
10	2	2	1.66	4
11	2	2.33	2.66	5

V. Result and Discussion

A. Prediction with ANFIS







B. Comparison between ANN, ANFIS and MLRA

Table 1: Comparison Table

S. No.	ERROR	MLRA	ANN	ANFIS
1	MAPE	8.944	31.38	2.12
2	RMSE	0.9812	1.3833	0.2945

VI. Conclusion and Future Aspects

This study has modeled the ERP Implementation process, using causal factors Staff, Team Work and Technical as predictor variables and User Satisfaction as the dependent Variable. These factors represent the relevant causal factor that impact the success or failure of an ERP implementation in term of User satisfaction. We developed/ trained Multiple Linear Regression
Analysis (MLRA), Artificial Neural Network(ANN) and Adaptive Neuro Fuzzy Interference System (ANFIS)
prediction models using part of the dataset(99 responses) prediction models using part of the balance (43 responses). Of the three techniques ANFIS outperformed ANN and MLRA in terms RMSE and MAPE. The study established the efficiency of ANFIS as a good predictor of project risk of ERP implementation measured to evaluate overall IS success.

References

[1] New Standish Research Report, "Roadmap to the Megap- les," 2009. http://www.standishgroup.com

[2] D. Robey, J. Ross and M. Boudreau, "Learning to Im- plement Enterprise Systems: An Exploratory Study of the Dialectics of Change," Journal of Management Informa- tion Systems, Vol. 19, No. 1, 2002, pp. 17-46.

[3] J. Brockner, "The Escalation of Commitment to a Failing Course of Action: Towards Theoretical Progress," Aca- demy of Management Review, Vol. 17, No. 1, 1992, pp.39-61.

[4] M. Keil, "Pulling the Plug: Software Project Management and the Problem of Project Escalation," MIS Quarterly, Vol. 19, No. 4, 1995, pp. 421-447.

[5] M. Keil, "Why Software Projects Escalate—an Empirical Study and Analysis of Four Theoretical Models," MIS Quarterly, Vol. 24, No. 4, 2000, pp. 631-664.

[6] A. J. Al-Shehab, R. T. Hughes and G. Winstanley, "Modelling Risks in IS/IT Projects through Causal and Cognitive Mapping," The Electronic Journal of Informa- tion Systems Evaluation, Vol. 8, No. 1, 2005, pp. 1-10.

[7] C. Venugopal and S. Rao, "Detecting Project Risks in ERP Projects Measurement Models for Critical Success Factors and Success of ERP Implementations," Procced- ings of International Conference on Advances in Indus- trial Engineering Applications, Chennai, India, 2010.

[8] T. M. Somers and K. Nelson, "The Impact of Critical Success Factors across the Stages of Enterprise Resource Planning Implementations," Proceedings of the 34th An- nual Hawaii International Conference on System Sci- ences, Hawaii, 2001, pp. 8016-8025.

[9] W. H. DeLone and E. R. McLean, "Information Systems Success: The Quest for the Dependent Variable," Infor- mation Systems Research, Vol. 3, No. 1, 1992, pp. 60-95.

[10] W. H. DeLone and E. R. McLean, "The Delone and Mclean Model of Information Systems Success—a Ten Year Update," Journal of Information Systems, Vol. 19, No. 4, 2003, pp. 9-30.

[11] T. H. Davenport, "Putting the Enterprise into the Enterprise System," Harvard Business Review, Vol. 76, No. 4, 1998, pp. 121-131.