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Monitoring and Controlling System's Behaviour to Achieve Optimal Reliability using Fuzzy Cognitive Maps

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Abstract— ***Decision support is a boon to IT Industries. The importance of decision support can be well understood by the developers who undergo the building process of software. The increased efficiency & accuracy are considered well in advance by developers when planning to build software. The decision-making strategy is required to make an estimate of the resources so that a prediction can be made beforehand for the consequences involved in making software. Though today, industries make several decisions yet some of them come out to be a success. To improve the current scenario, the paper proposed a tool, based on Fuzzy Cognitive Maps to represent a dependency graph, showing the impact of the factors and an output to gives the improved reliability. The matrix is a list of factors in terms of Reliability, Cost and Time plotted against each other which directly or indirectly affect the reliability of software. Various experts are involved to review the matrix and give dependency factors of respective objects on each other based on various project experiences they have. In addition to it, the proposed model processes and analyses the outcomes and outputs the dependency matrix with an improved reliability factor to enhance the performance and reliability of software with presented objects dependency parameters.***

Keywords— Fuzzy Cognitive Maps, dependency graph, IT industries

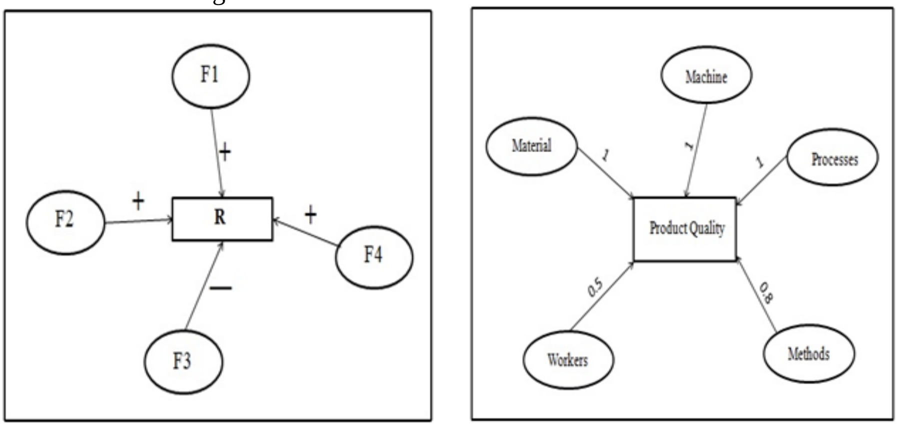
I. Introduction

With the increase demand of technology and globalization of products, the software industry is facing a number of challenges in order to keep up with the current world. The increasing demand for a software has made the need for the industries in getting a more dynamic, sustainable and reliable system every time. The time where efficiency and productivity goes hand in hand requires also that the software that they are designing is reliable and also coming with a badge of a better and improved face when compare to the earlier versions. Many new products that were originally welcomed for addressing the customer requirements turned out to be a severe consequence because the developers were unaware of the far reaching effects of the product design and the diversity in the requirements. To address these challenges, decision making becomes a company's obligation. Decision making was never easy as the process is ascertain and fuzzy. Good decision can be a challenging task which a firm faces every hour today. These decision makers and the information system (IS) [1] can get advantage of a model which can assess the impact of the decisions. Assessing the impacts doesn't claim for a guaranteed success but the companies that relied on, did better in their fields. Decision making can be further improved if the decisions are in multiple perspectives. There is no assurance that all aspects will be covered but, steps were taken to ensure that it is done. The aim is to reduce or even eliminate negative environmental and social impacts by changing product features, materials, and processes associated with production, distribution, and disposal. This will be achieved through incremental improvements of existing products (e.g. a car with a higher power output and maintaining the higher fuel efficiency too) which can lead to a better reliable product.

This paper aims to deepen product planners understanding of the current industries and their dynamics, but also provides a systematic way to integrate the knowledge into the product development process, which can discuss the changes originate when the factors affect the software reliability. The method uses Fuzzy Cognitive Maps (FCM) [2] to capture, integrate and analyse the impact and needs of the software product. The resulting models provide a planning tool for product development teams that enables them to understand how reliability will be affected by alternative concepts in various scenarios. The estimation of reliability of software on the basis of the domain experts was not sufficient to address the requirements for the current software industries so applying an algorithm to iterate the input matrix with the help of which the impact on the factors can be seen, needed to address the complete reliability for software. The factors can be numerous which can affect the reliability of software, but considering the current scenario, most particular factors, which were frequently used, were assembled in a matrix in order to realize that these can be the most suitable factors for achieving the reliability for software. An example close to this proposal is in the case of a today's softwares in which the software is updated regularly and still is able to get the correct and dependable results with a much more improved accuracy and efficiency and that's what it's known as the improvement in the software.

II. FUZZY COGNITIVE MAPS

Fuzzy Cognitive Maps are known to be associated with the results showing the dependency [3] of the factors and the relation exists between them, but its origin was taken from the concept of Cognitive Maps [4] which were introduced by Axelroid [5], for applying to fields which were ill structured or not well defined. The application areas are very broad for CM and FCM. However, CMs are not easy to use as the magnitude is difficult to express in numbers. The causal maps as depicted in Figure 1(a). Concepts are linked through arrows that represent causality. The arrows are denoted with "+" or "-" depending on what type of causality exists. The requirement of the proposed model is to make use of the magnitude and the dependency and for that, it will be better to use Fuzzy Cognitive Maps. Fuzzy Cognitive Maps as shown in Figure 1(b) was introduced by Kosko [6] in 1986 and were used in analysing the inference patterns and the causal relationship that exists between them.FCM is used in a variety of applications like in controlling related themes, to Failure Models, Effect analysis for a system, etc. FCM is greatly used to represent the impacts created by concepts [7]. For example, if concept C1 directly impacts on C2 then there will be a directed edge E12, and if concept C2 directly impact on concept C1 then there will be a directed edge E21, otherwise there won't be any edge between the corresponding nodes. The degree as discussed earlier normally lies between [0, 1] or [-1, 1] will represent the impact as Low, Med, High etc on the directed edges.



(a) (b)

Figure 1 An illustration of (a) Cognitive Map and (b) Fuzzy Cognitive Map

III. PROPOSED MODEL

The proposed model will be used for providing a systematic way to estimate the reliability of a system built using Fuzzy Cognitive maps. After going through a number of researches, we landed up with a list of factors based on Reliability [8], Time [9] and Cost [10] which can make a turning point in estimating the reliability of software. A panel of experts from different IT industries are made to include diversity in suggestions so that different aspects of reliability estimation can be covered. The factor matrices are analysed with the help of expert's domain who provide us with the suggestion on the basis of previous experiences made on similar projects. The matrix obtained after the experts interventions, is a fuzzified data matrix which with the help of the rules made using FIS in MATLAB will be later defuzzified to be used in the model for analysing the reliability of software.

Although the impact of factors may vary for different organizations [11], as different software's have different origins and capabilities performing various roles for various purposes, still lot of aspects were considered while selecting the factors. The matrices is build with a combination of 42 factors which can have direct or indirect impact for reliability estimation [12].The weights of the dependent factors are calculated using Fuzzy Inference System [13]. Figure 2 and Figure 4 represents factors for Reliability, Cost and Time. Figure 3 and Figure 5 have some cells marked black. This is done to ensure that no values should be filled in these cells avoiding comparison of same factors.

FACTORS AFFECTING TESTING		Reliability												Time									
		Reliability	Architect	Sponsor /client	% of reused	Testing straterg	Documeatation	Expenditure on	implemeatation	Spec justifica	Quality assuran	Quality of	Time	Project complex	Length of pre-	Training	Requirement	Frequency of	% of reused	Accuracy of	Overall schedul	Deadline
Cost	Cost																					
	Product																					
	Skills of technical																					
	Skills of																					
	Place/enviorment																					
	Risk classificatio																					
	Overall																					
	Training																					
	Cost of																					
	Method of																					
	Budget																					
	Development platform																					
	Development team size																					
	Overall testing plan																					
	Overall testing																					
	Testing enviornment																					
	Integration testing																					
	Expenditure on external																					
	Liable for																					
	Accuracy of cost																					
	Documentati																					

Figure 2 Showing the factors of Reliability, Cost and Time.

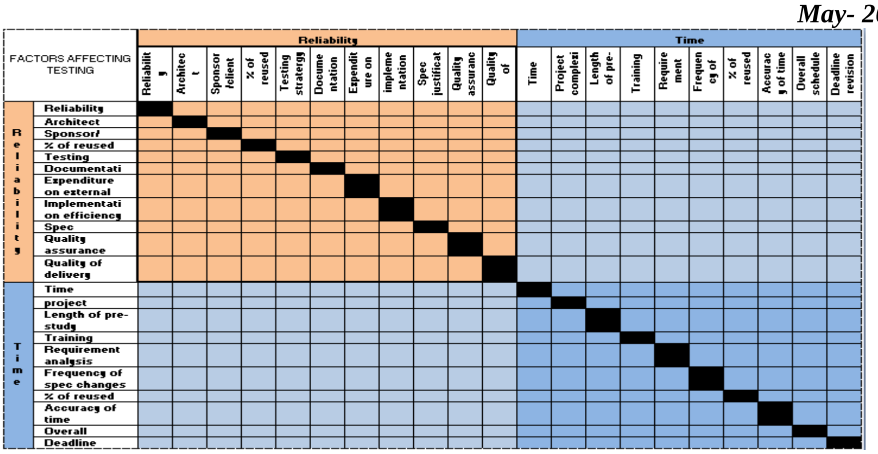


Figure 3 Matrix with Reliability and Time factors

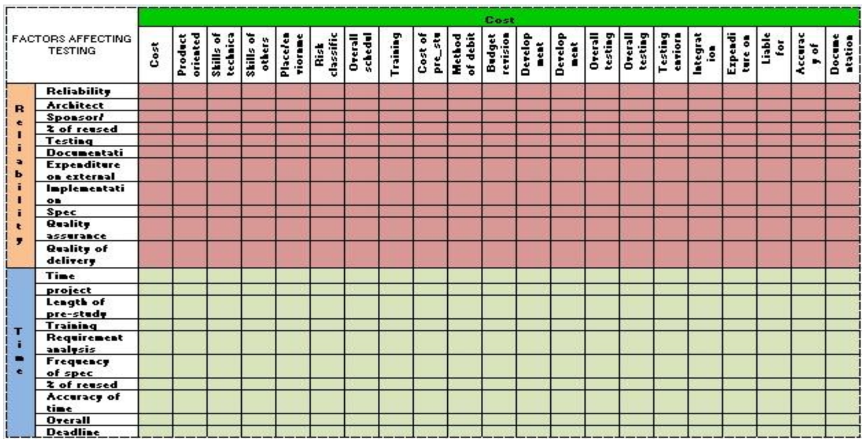


Figure 4 Matrix with Reliability, Time and Cost factors

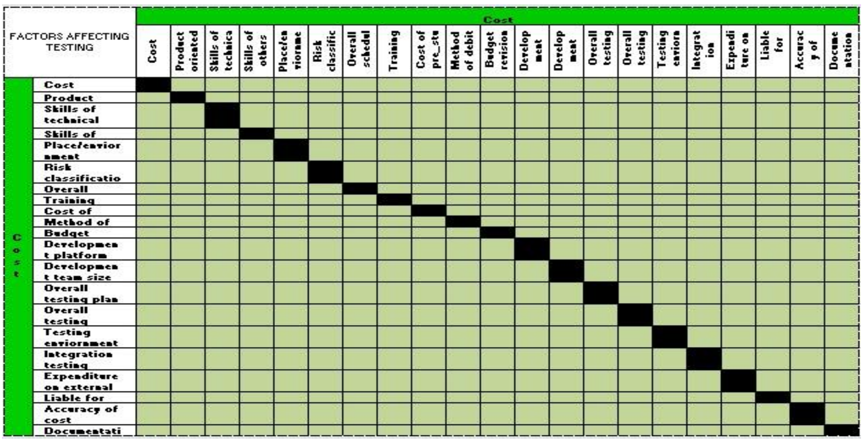


Figure 5 Matrix with Reliability and Time factors

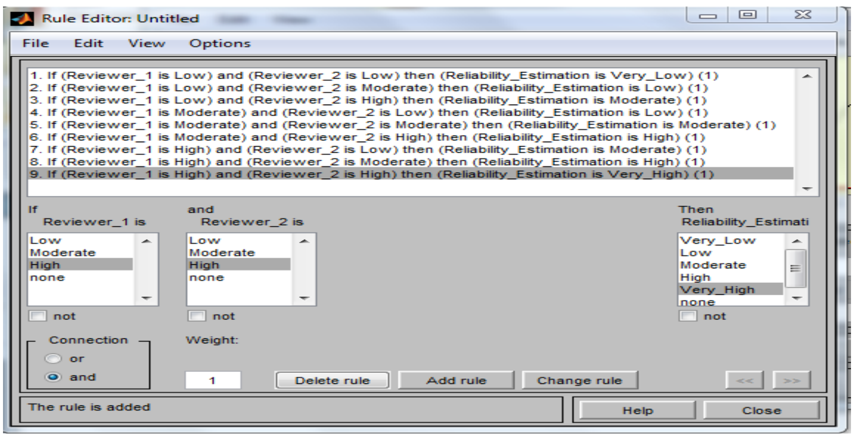


Figure 6 Representing Rules created for defuzzification of the matrices

The rules are constructed with the help of FIS rule editor as stated earlier to realize the exact impact made by one factor on to the other by giving out crisp values in to the matrices creating a relation between them shown in Table I.

Table I Qualitative terms and their corresponding estimates

Qualitative Term/Polarity	Corresponding Estimates
Very low(VH)	0.00-0.25
Low(L)	0.25-0.50
Medium(M)	0.50-0.75
High(H)	0.75-0.90
Very High(VH)	0.90-1.00
No Value	0.00

The rules are (Very Low, Low, Moderate, High, and Very High, No Value).These rules are assigned a weight or a numeric value which can help to defuzzify the data in the matrix. The defuzzified matrix will then be used by the model to process and produce a stabilized matrix. The algorithms proposed for the model are such, that the matrix values are iterated every time until the stability is reached. When the matrix is stabilized, an output will be generated giving the normalized values in the matrix along with the estimation of reliability made for the software. The estimation will be represented in terms of percentage to realize the improvement made by considering the above listed factors included for estimation. The model will represent the above results with the help of GUI based on MATLAB.

IV. RESULT

Using a set of 42 factors, matrices were designed for estimating the dependencies among the factors. With the help of MATLAB, GUI based tool is developed. The tool is used to input the defuzzified data to iterate the matrix and showing the normalized matrix. The normalized matrix obtained will be the final result as these would be the values which have to be the impact of the factors to achieve optimal reliability for software. The matrices are defuzzified by rules constructed with the help of FIS editor shown in Figure 6.

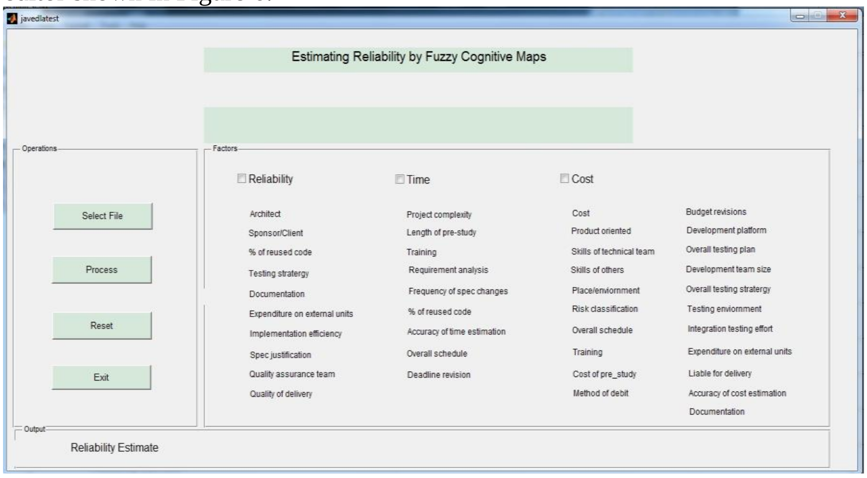


Figure 7 Home page of the model

The figure above (Figure 7) represents the Home page of the model. The three panels viz., Operations, Factors and Output are designed to help the user while interacting with the model.

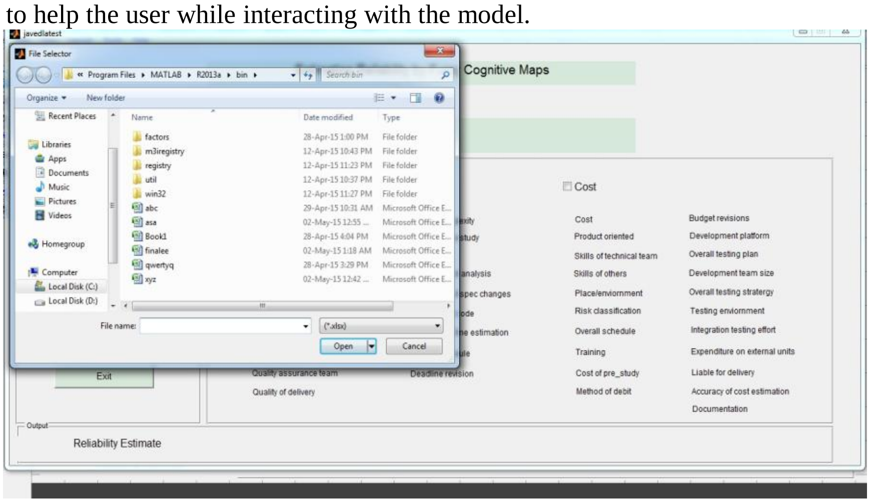


Figure 8 The file is being input by the model into the model

Figure 8 represents the model, proceeding with the task to estimate the reliability of software by making the matrix file input into the model. The input file containing the matrix can be made available from any location on the system. The model is designed in such a way to ensure that every time a new file can be input in to the model in order to provide different aspects of the reliability estimation. For every new file the output will vary according to the data presented in it.

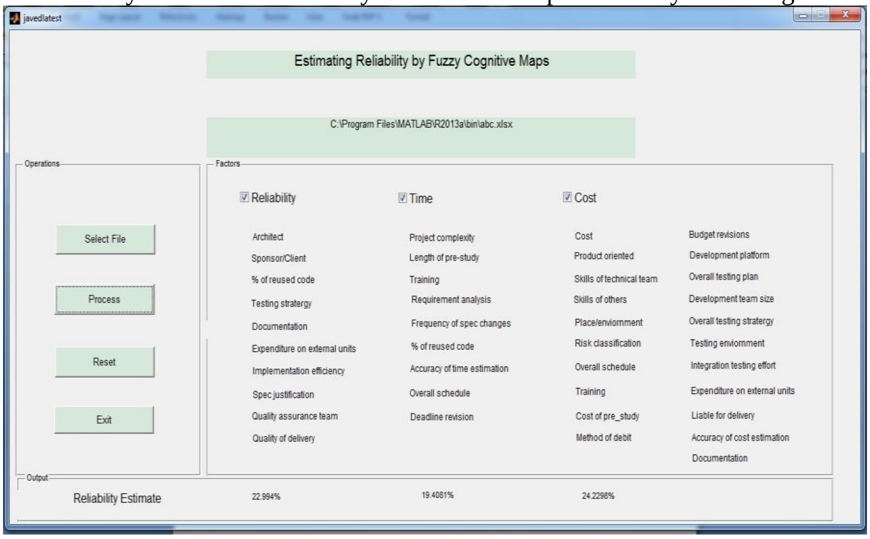


Figure 9 The figure representing the path of the file and final estimations.

The above figure (Figure 9) represents the file has been taken by the model as it represents the path from where the file has been taken. The model processes the file when 'Process' button is pressed and gives out the result by selecting the checkboxes provided as desired by the user. The model thus iterates the matrix until a stabilized matrix is obtained. The 'Output' panel gives the corresponding reliability estimations. The stabilized matrix shown in Figure 10 represents the normalized impacts that a factor should have to ensure optimal reliability of software.

V. CONCLUSION

The paper proposes a reliability estimation model for developers to predict the outcome for software that will be based on the factors discussed above. These factors were assembled to keep in consideration every aspect of software industries. The impact a factor makes on to the other clearly indicated the type of relation that exists between them. FCM was used to analyse the matrix filled with experts experiences to analyse and predict the results for the organizations point of view. Model was designed in order to change the values of the matrix for varying the output and re-run the process for achieving a better and a reliable output every time for software development industries.

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