A Review of Software Cost Estimation in Agile Software Development Using Soft Computing Techniques

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***Abstract*— For a successful software project, accurate prediction of its overall effort and cost estimation is a very much essential task. Software projects have evolved through a number of development models over the last few decades. Hence, to cover an accurate measurement of the effort and cost for different software projects based on different development models having new and innovative phases of software development, is a crucial task to be done. An accurate prediction always leads to a successful software project within the budget with no delay, but any percentage of misconduct in the overall effort and cost estimate may lead to a project failure in terms of delivery time, budget or features. Software industries have adopted various development models based on the project requirements and organization's capabilities. Due to adaptability to changes in a software project, agile software development model has become a much successful and popular framework for development over the last decade. The customer is involved as an active participant in the development using an agile framework. Hence, changes can occur at any phase of development and they can be dynamic in nature. That is why an accurate prediction of effort and cost of such projects is a crucial task to be done as the complexity of overall development structure is increased with the time. Soft computing techniques have proven that they are one of the best problem solving techniques in such scenarios. Such techniques are more flexible and presence of bio-intelligence increases their accuracy. Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Neural Network (ANN), Fuzzy Inference Systems (FIS), etc. are applied successfully for estimation of cost and effort of agile based software projects. This paper deals with such soft computing techniques and provides a detailed and analytical overview of such methods. It also provides the future scope and possibilities to explore such techniques on the basis of survey provided by this paper.**

Keywords- Agile software development; neural network; cost estimation; effort estimation; soft computing; software project management (SPM).

I. INTRODUCTION

In the early 60's when software development was not a serious industrial point of focus, the software developers used to develop software using adhoc processes. The projects were tiny in terms of functionality. Hence, developers didn't feel about a standardized and systematic process of development. But after some years software development started becoming commercial as more and more software projects were started to be ordered by different type of customers (Specially for defense purposes). Size of projects started becoming big with the increase in functionalities of the project. Therefore the adhoc process of development was not enough to lead a successful software project. For solving this problem, Software Project Management (SPM) is introduced between 60's and 70's. At the same time in the 70's Royce came with the Software Life Cycle (SLC) which assisted the SPM [1, 2]. SPM's domain began from the very first stage where a customer put a project order to the successful deployment of the product with the maintenance to upgrade the product. SPM included a series of interrelated processes which were to be carried out in a specific manner with the development process. SPM became a serious issue while developing a software project. It was understood that a high-quality SPM might lead to quality product while a misconduct in SPM might cause a failure. Project scheduling is one the important part of SPM which includes estimation of effort and cost [3, 4, 5].

Recent research and practical outcomes of different software developments have proved that prediction of cost and effort estimation with a high rate of accuracy increases the chance of successful quality product. Significant research in software cost and effort estimation began around 1965 where 104 attributes of 169 projects were studied [Nelson 1966] [5, 6]. This research focused to some estimation models in that era of time. Many researchers started working in this field and all of them faced few common problems, i.e. with the increase in functionalities, the corresponding increase in project size of software was not linear. Hence prediction of actual estimate became complex. Then researchers concluded that the process of estimation is a full time process and should be carried out throughout the Software Development Life Cycle (SDLC) for getting tuned with changes. Since then several cost estimation approaches like ANN, Mamdani FIS, Expert Systems, Estimation by Analogy, Use Case Point, etc. have been applied successfully for different kinds of development projects [7, 8, 9].

Origin of agile software development methodologies around 2000 has a strong background history in software development. Agile software development has been believed

2375-5822/16 $31.00 © 2016 IEEE
DOI 10.1109/CINE.2016.27

worldwide by different software development organizations [10]. An agile method allows for responding to changes put by the customer at any point of development. This enables continuous testing and maintenance. Hence a highly flexible and quality product is produced [11, 12]. Short development cycle and early working product prototype increase its productivity. Also active customer involvement makes adoption easy for any change which leads to integrity [13, 14]. Due to continuous change within the agile development methods, it is hard to get an accurate estimate. Besides traditional methods of estimation have already failed to give accurate and precise solution to estimates [15].

Recent researches have shown that soft computing methods are becoming quite suitable for handling problems like cost estimation, optimization, machine learning, forecasting, etc. Many soft computing techniques like Mamdani FIS, ANNs (i.e. Regression Neural Networks, Radial Basis Functions (RBF), Counter Propagation Neural Network (CPNN), etc.), Bio-Inspired Techniques (i.e. PSO, GA, etc.) are being applied successfully for estimating cost and effort in agile software development environment [11, 16, 17].

II. REVIEW STRATAGEM

This paper represents a methodical literature review on cost and effort estimation in agile software development using soft computing techniques. The review is presented by collecting data from several sources.

A. Research Concerns

The paper deals with following research issues recognized by the authors, which are discussed broadly in the later part of the paper.

RC1. Which soft computing methods have been applied to agile development based products for getting the cost and effort estimation?

RC2. Which agile development models are popular?

RC3. What are the accuracy and the error rate of different methods?

B. Inclusion & Exclusion Concerns

The study includes the papers which have applied the different soft computing techniques for estimation in ASD. Papers are included from various online sources, journals, conferences, workshops, etc. published till date. Some papers which are not specifically based on agile software development are also included due to some important information. Papers and information which are not relevant to the research topic are excluded from the study.

C. Description of Data Sources

The authors have gone through several online databases of Springer, Elsevier, ACM, IEEE Digital Library, etc. Papers are searched through different search strings related to research topics as given below in the table. The following Table I. includes the various papers found in various conferences, workshops and journals through the respective search strings.

Table I. Available Relevant Research Articles to Review

S. No.	Search Strings	Papers from journals	Papers from conferences
1	Software cost and effort estimation	[6-9, 15, 16, 18-34]	[13, 17, 35-41]
3	Agile software development	[12, 14, 42-48]	[11, 13, 35, 49-52]
4	Cost estimation in agile development using soft computing	[16, 20, 53, 54, 56-58]	[11, 55]

D. Study Selection Process

Title and Abstract Level selection:

The review process carried through several research papers where some of them were selected by looking on to their titles and abstracts. As the abstract of a research article clearly state about its goals and objectives, so this level of refinement and data collection are selected from some of the research papers.

Complete Article level selection:

A number of articles were reviewed and analyzed in detail. Results, objectives, applied methods, conclusion were deeply observed. For a broad level review, this type of screening is selected.

III. EXPLORATION OF RESEARCH CONCERNS

RC1. Which soft computing methods have been applied to agile development based products for getting the cost and effort estimation?

Following Table II. represents an analytical view of the available soft computing methods applied for predicting cost and effort in ASD projects.

Technical description in Table II. contains a short description about special features of proposed techniques while output features represents an overall view of performance among some existing techniques.

Table II. Description of Effort & Cost Estimation Techniques in Agile Software Development (Soft Computing Approaches)

S. No.	Name of applied method	Authors	Technical description	Performance parameters	Output features
1.	An intelligent expert system for determining efforts in different types of software including agile development	Ziauddin, et al. [59]	The expert system is used where knowledge is represented in terms of If-then rules. A rule is associated with each weight for dealing with uncertain knowledge. The system contains 394 rules and 101 actions. The knowledge base is able to learn and enhance its database.	MRE, MMRE	The experiment is performed on 10 projects and the development effort has been calculated by tool COCOMO II. Results outperforms the COCOMO II and Function Point Analysis (FPA) in terms of MMRE.
2.	An agile cost estimation technique for aerospace procurement operations by means of genetic casual cost centering	R. Curran, et al. [60]	The proposed technique is integrated with a generic methodology which helps to absorb the available past information and knowledge. This can further utilize it into agile estimation capability.	R^2	The results of the proposed technique shows a reactive cost estimation which leads to a reduction of procured aerospace parts.
3.	Cost estimation model for estimating cost and effort in agile software projects	Sungjoo Kang, et al. [61]	The proposed model focuses on calculating cost for desired features of the software while tracing the project progress dynamically. For dynamic project tracking Kalman filter algorithm is used and function points are also considered as an additional cost driver. Variation of function points is used as input to the Kalman algorithm for getting strong velocity and estimate.	MSE, MMSE	Results are compared with traditional techniques through a case study [62]. The comparison was carried out between Kalman filter algorithm and linear extrapolation based model. Results show that proposed model directly tracks the variance because it uses daily based velocity by observation while the other method does not reflect the change until the end of iteration on nearly the 31st day.
4.	Incremental vs. global prediction models for predicting efforts in iterative software development	Pekka Abrahamasson, et al. [63]	The proposed model includes the ANN and regression from the domain of soft computing.	RMSE, LOOV-RMSE, MRE	The experiment includes two semi industrial projects based on Extreme Programming (XP). Results show that the incremental model outperforms the traditional estimation techniques in early phases of development.
5.	Learning Dynamic Bayesian Network model for predicting project velocity in XP development projects	Peter Hearty, et al. [64]	A Bayesian Network is used because it can include prior assumptions and spare data with expert judgment in a single casual network. Hence, it is successfully used for prediction models. To build a dynamic Bayesian Network (BN), authors have extended the BN's by including a temporal dimension to the network model. The authors have used AgenaRisk [65] tool set to build the model.	MRE	The model is applied on a Motorola industrial project where the model learns from initial data entered by the parameter learning. Results show that when the model is applied to the real industrial projects, including data from initial part or project, it leads to update its parameters. When this setup combines with the knowledge, the model can make extremely accurate predictions for XP based projects.
6.	Story point based agile software estimation using different SVR kernel methods	Shashank Mouli Satapathy, et al. [66]	The proposed method uses different SVR kernel for getting better accuracy in prediction. The experiment is performed on data sets as given in [66].	MMRE, PRED	The output obtained from experiment is optimized by means of 4 different SVR methods. Results show that RBF kernel based methods outperforms the other 3 methods.
7.	Neural network based story point technique for estimating agile software effort	Aditi Panda, et al. [11]	The authors have experimented with different NN (i.e. Group Method of Data Handling (GMDH), General Regression NN (GRNN), Cascade Correlation NN & Polynomial NN). The experiment is performed on data sets as given in [67].	MMRE, PRED, MSE, R^2	Results show that Cascade Correlation Neural Network outperforms other neural networks.
8.	A cost estimation framework (based on PSO) for estimating agile software effort	Manga I, et al. [16]	The proposed framework improves the time and effort estimation accuracy by minimizing them.	MRE, MMRE, PRED, TMRE, EMRE	The results obtained show that the output is close to the actual value.

Where, terms in the performance parameters are as follows in Table III:

Table III. Abbreviation for Performance Parameters

MRE	Magnitude of Relative Error
MMRE	Mean Magnitude of Relative Error
MSE	Mean Square Error
MMSE	Minimal Mean Square Error
PRED	Prediction
R^2	Squared Correlation coefficient
LOOV-RMSE	Avg. Mean Square Error for All Left Out Points
TMRE	Time Magnitude of Relative Error
EMRE	Effort Magnitude of Relative Error

RC2. Which agile development models are popular?
Table IV. Reprints the popularity of different ASD models:

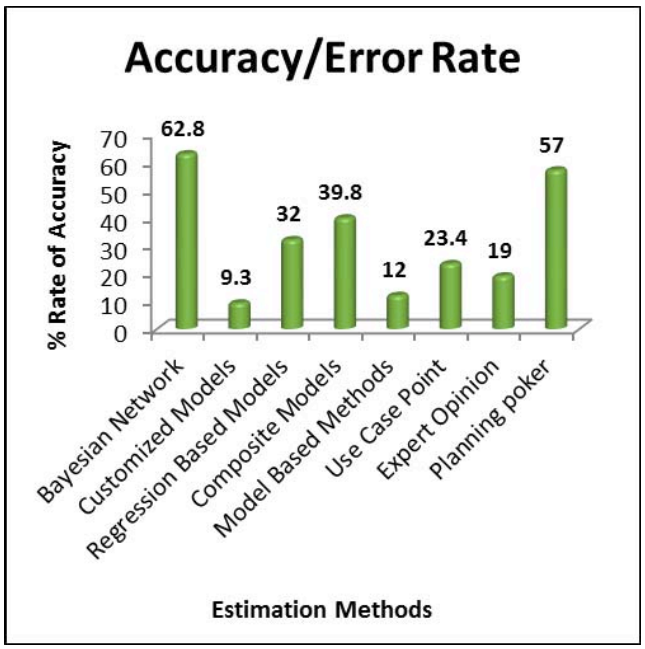
Table IV. List of popular ASD models [68]

Agile model	Popularity
Extreme Programming (XP)	28.13%
General agile model	25%
Iterative & Incremental development model	21.88%
RUP	9.38%
Scrum	9.38%
Plan driven methods	3.13%
Lean	3.13%

RC3. What are the accuracy and the error rate of different methods?

Fig. 1. is the graphical representation of error/accuracy rate for different estimation approaches on the basis of selected papers in the study:

Fig. 1. Accuracy/Error Rate of Different Estimation methods



IV. CONCLUSION & FUTURE WORK

This paper presents a systematic literature survey on effort and cost estimation techniques for agile software development by means of soft computing techniques. Various research articles are studied in details and an analytical representation is shown by the authors. The authors have found that very less work is done in the field of cost and effort estimation of ASD projects using soft computing techniques. There is a rapid increase in the percentage of software projects which are based on agile methodologies. So it is important to explore more methods for estimation of such models based projects. As far as the future work is concerned, the authors will study more related latest articles and will represent them as a detailed survey.

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