AN IMPLEMENTATION OF SOFTWARE EFFORT DURATION AND COST ESTIMATION WITH STATISTICAL AND MACHINE LEARNING APPROACHES

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ABSTRACT

In software industry estimation of effort, cost (EDC) and duration is a troublesome procedure. The exertion itself is in charge of experiencing trouble in evaluating EDC. In any software estimation process, the preeminent advance is to characterize and comprehends the framework to be assessed. Software cost estimation algorithmic methods are estimating by analogy, expert judgment method, price to win method, top-down method, bottom-up method are developed by researchers in the field of software engineering. Any methods are not superior to the other methods. In fact, the qualities and shortcomings of those strategies are differentiating to one another. Presently there are two types of software EDC models to estimate the software those are statistical approaches and machine learning approaches. Many of the software cost estimation methods follows statistical approaches, which are not having the capability to present causes and strong or accurate results. Machine learning techniques are suitable in software engineering because it produces accurate results, which estimates by training rules and iterations. Machine learning techniques resolve the challenges like developing programs in a computer and to give the effective outputs by using the experience

Keywords: SPSS, Project code meter, EDC, Machine learning.

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1. INTRODUCTION

Software Engineering is a discipline which is majorly concerned about the development of well-organized large software applications that are used in digital computers. This includes various theories and methodologies in planning which includes not only scientific issues like tools and technologies for trained software development but also administration aspects like scheduling, staffing, organizing, planning, controlling and budgeting. Software Engineering is a difficult process which solves the problem by creating it as an abstract model or also related to as an iconic model. When compared with science SE is closely associated with good clients in business. This well-perceived scientific method [8] of software development takes user specification as input of a software produce is released as an output.

This methodical and prearranged advance in software expansion was completed with a sequence of phases referred to as Software Development Life Cycle [5]. Most of popular and generally used SDLC models are agile construction, waterfall model, V model, feature-driven development model, several hybrid models, object-oriented models, and various prototyping models. The structured set of tasks that are incorporated to expand software scheme is called as a procedure. Every phase in SDLC is a development requiring resources, constraints and other tasks. They also impose agreement and help the programmers to improve the exercises that are related to this.

The degrees incorporate social event important from a customer, a point by point practical spec about what the strategy does and whether all the client prerequisites are satisfied. At the point when the customer acknowledges the useful detail according to the example determination the product is being created and tried. The created software is additionally conveyed and introduced in the acquirer end.

The important activities of a software process include software requirement gathering, Software design, Software construction, Software testing, Software maintenance, Software configuration management, Software engineering management, Software engineering process, Software engineering tools and methods, Software Quality Assurance and Risk management.

2. SOFTWARE ESTIMATION MODELS

So as to estimate effort, cost of software growth, many types of researchers proposed different approaches and these approaches are categorized into in subsequent ways [7].

3. SOFTWARE COST ESTIMATION TOOLS

There are 21 commercial-off-the-shelf (COTS) cost estimation tools [9]. This set reflects a wide range of methodologies, levels of aptness or mellowness, features, and cost. Most of the tools are parametric models. Some tools address hardware as well as software, but most do not. A few tools offer a stochastic model. Developers of parametric models derive Cost Estimating Relationships (CERs) by regression analysis on historical data on project attributes (cost drivers) and cost. Cost estimation models use these relationships as scale factors in an exponential equation to calculate the effort and schedule required for the software development effort. The following 1 shows software cost estimation tools.

Figure 1 shows software cost estimation tools.

3.1. Machine Learning Models

For estimation of software Effort, duration and cost many algorithmic and non-algorithmic approaches are implemented but among this machine learning models are very accurate, these are machine learning models to predict software EDC.

3.2. Fuzzy method

The systems using this Fuzzy logic can simulate human behavior and reasoning. Fuzzy system tools efficiently solve the challenges in the situations like decision making is hard and huge number of constraints. These systems always takes the facts that ignored by other approaches. A fuzzy system consists of four steps:

Step 1: Fuzzification: It provides trapezoidal numbers for the linguistic terms.

Step 2: New linguistic term can be produced to determine complexity matrix.

Step 3: find out productivity rates and deduce linguistic terms.

Step 4: Defuzzification: estimate effort needed to complete the product and compare the previous techniques.

4. CASE BASED REASONING

Case based reasoning is a technique to collect and store the results of inspections on past products such as effort, language used, and cost so on. When we inspect the proposed product, if it identifies any new feature, then it is possible to recollect the store feature.

4.1. Assessment of CBR Systems

CBR systems results are very interesting in terms of performance. CBR systems shows high performance compared to algorithmic approaches and close performance level to the expert. CBR systems used the stored database and have huge knowledge base to compare the new feature to stored one. Accurate estimates can be obtained by the CBR systems than experts. Experts don't have any capability to match their experience to the new observations.

5. RULE-BASED SYSTEMS

Rule based systems are very useful in estimating the effort of software in few cases. Rule based system stores some set of rules in its knowledge database, which have been used to compare the features of proposed project. When there is any identical rule is found, that rule will fire, which can be used to generate a new rule to form chaining effect. The chaining effect continues until there are no rules to fire and the result is displayed to user.

6. REGRESSION TREES

Regression trees are widely used to estimate the cost of the software in software engineering. A regression tree is constructed by investigating the attributes, and considers the most informative attributes. Use an algorithm on these informative attributes to construct the tree and split the attribute values where it is appropriate. Tree only ever splits into two leaf nodes. Checking can be done for any logical errors, by using this probable format.

6.1. Artificial Neural Networks (ANNs)

ANNs [6] are constructed based on the architecture of biological neural networks and these are also known as parallel systems. Artificial neuron is a collection networks that are interconnected. The neuron uses stepped function to determine the weighted sum of the inputs. The derived output might be a positive or negative given as input to other neurons in the parallel network. Feed-forward multilayer perception is one of the widely used models in ANN. Neurons are initialized with random weights. The network learns the associations between the inputs by altering the weights when the training set is obtainable from both the inputs and outputs. ANNs estimates development effort and it compares the accuracy to the algorithmic approaches rather than the suitability of this approach to estimation process. So many numbers of trials were required to found the number of concealed nodes. Other factors values are considered from experience and practical exercises.

6.2. Genetic Programming

Software estimation issue can be modeled as a symbolic regression equation. In regression model a set of values associated with the set of input factors, which generates an equation by considering these input factors as inputs to equation and it accurately estimates only one output factor. For example, a nearest neighbor system considers some of the factors to adjust the weights of variables and it discovers closeness of neighbors to get accurate result. The control parameters list used in genetic programming is being 20 and in neural networks its count is 10, but it is difficult to count control factors. However, sensitivity and accuracy does not depend on the count of the control factors. Granularity search is used to find probable values for control factors which will depend on their range also. To determine the ease of configuration for a genetic procedure, we can test the values of parameters.

6.3. Support Vector Machine (SVM)

Support vector machines are used to perform classification and regression analysis by constructing hyper plane or various hyper planes in a high dimensional data space. The major goal of SVM is it discriminates two class labels, and it also reduces the error rate for the largest interval. The advantage of SVM is its assessment, by choosing acceptable parameters 'C' to construct optimal hyper plane. SVM constructs numerous hyper planes and chooses one of the hyper planes is optimal based on that it avoids local solution problem occurred in neural networks. SVM identifies the vectors which are intimately closed to known classes. This step is known as feature selection or feature extraction. These features accurately distinguish the classes or predict future samples. Learning process is very simple in SVM. There is no local optimal challenge like in neural networks. It scales well on a high dimensional space and there is proportional change of classifier complexity and error rate. Explicitly error rate will be controlled. Every data point can be viewed in dimensional space like a p-dimensional point or vector with (p-1) dimensional hyper plane.

6.4. K-Nearest Neighbors (KNN)

K-nearest neighbor algorithm is classification method based on the training data set in the feature space. It is also known as instance based learning, or lazy learning. It uses function and it imprecisely estimates locally and all the calculations are delayed until to get the classifier. KNN algorithm is very simple among all other classification algorithms. In KNN an object is classified based on the majority votes of its neighbors, then the object being labeled the most frequent class name among its nearest neighbors where k is a positive integer. If $k=1$ then that object is labeled by the neighbor class name because it has only one neighbor. Regression technique also uses same approach, but it labels the average value of the K nearest neighbors to the object. It is advantageous to assign the weights to each neighbor. A weight $1/d$ is assigned to each neighbor, where d is the distance from neighbor. This technique is known as linear interpolation. Neighbors should be considered from the set of objects, where the class labels must be known exactly.

6.5. Bayesian Belief Networks (BBN)

Bayesian Belief Networks based on graphical model and it shows the relationships between attributes. BBNs allow reasoning under uncertainty and take the benefits from both of the graphical representation and mathematical expressions in Bayesian probability. In BBNs, it is likely to eloquent beliefs of experts regarding variable dependencies and it proliferate the effect of facts on the uncertain outcomes, known as 'future system reliability'. BBNs also permit the insertion of technical rigidity when the probabilities of independent nodes are 'expert opinions'. BBN determines the inferences of the beliefs that are given as input factors. Some of the factors can be verified by using the previous project experimental results and experts experience. There are many benefits of using BBNs, one of the essential benefits is the facility to show and alter difficult models that are not developed by any other classical models. BBNs have meticulous mathematical derivations and the software tools are used to understand to do computations of their use. BBNs provide a better way to predict software flaws. BBN shows the join probability distribution among the factors.

6.6. Instance-Based Learning (IBL)

The major challenge in software project management is the cost estimation. Most of the techniques used to estimate the cost and effort are based on the algorithmic models. Another technique to estimate the effort which is not based on the algorithmic model is known as instance-based learning. IBL approach gives high quality performance where the algorithmic model prediction is not possible.

6.7. Decision Tree

To make any decision it is very difficult with uncertain details because a) the significance outcome from choosing various specified decision choices cannot be estimated with certainty 2) So many different parameters should be considered to make a decision 3) It may be advantageous to think about the alternatives to reduce the uncertainty in the decision by adding some more values. 4) A decision maker's attitude headed to taking risk can affect the interest of various choices. A decision tree is a classification technique; it partitions the instance space iteratively.

6.8. Statistical Approach for software EDC Estimation

For estimation [11] of software EDC statistical SPSS Tool used by using this tool can find Mean, Mode, Standard Deviation and also can use T-Test, ANNOVA, Regression and Correlation testing.

6.9. Data Source

Kaggle.com [2] and PROMISE is an open source software Engineering repository where public datasets are available, using this can predict software models. For this experiment downloaded public data set from PROMISE and this data set contains following information like project id, project, Team experience, Manager Experience and Effort.

In SPSS tool [7] there are two types of views data view and variable view where in data view it shows data like in below figure 3, which contain data mostly numeric.

Project	TeamExp	ManagerExp	YearExp	Length	Effort	Transactions	Entities	PartitionAdjust	Adjustment	PointsAdjust	Language
1	1	4	85	12	5152	253	52	305	34	302	1
2	0	0	86	4	5636	197	128	321	33	316	1
3	4	4	85	1	805	40	60	100	18	83	1
4	0	0	86	5	3829	250	119	319	30	303	1
5	0	0	86	4	2149	540	54	234	24	208	1
6	0	0	86	4	2821	97	89	186	38	192	1
7	2	1	85	9	2589	119	42	181	25	145	2
8	1	2	83	13	3913	186	52	238	25	214	1
9	3	1	86	12	7854	172	88	260	30	247	1
10	3	4	83	4	2422	78	38	116	24	103	1
11	4	1	84	21	4067	167	39	288	24	237	1
12	2	1	84	17	9061	146	112	258	40	271	1
13	1	1	84	3	2282	33	72	185	19	88	1
14	3	4	85	8	4172	162	61	223	32	218	1
15	4	4	85	9	4977	223	571	344	28	320	1
16	3	2	85	8	1617	119	48	167	26	162	2
17	4	3	85	8	3192	57	43	190	43	198	1
18	4	4	86	14	3437	68	316	384	20	326	2
19	3	4	87	14	4494	9	386	395	21	340	2
20	4	3	86	5	840	58	34	92	29	86	1
21	4	4	86	12	14973	318	269	567	34	561	2
22	2	4	85	18	5190	88	170	258	34	255	1
23	2	4	86	6	5776	396	132	438	27	447	1

Figure 3 SPSS data view

Name	Type	Width	Decimals
id	Numeric	12	0
Project	Numeric	12	0
TeamExp	Numeric	12	0
ManagerExp	Numeric	12	0
YearEnd	Numeric	12	0
Length	Numeric	12	0
Effort	Numeric	12	0
Transactions	Numeric	12	0
Entities	Numeric	12	0
PointsNonA...	Numeric	12	0
Adjustment	Numeric	12	0
PointsAjust	Numeric	12	0
Language	Numeric	12	0

Figure 4 SPSS variable view

In variable view it describes all variables with data type and width.

TeamExp								
		Frequency	Percent	Valid Percent	Cumulative Percent	Bootstrap for Percent ^a		
						Bias	Std. Error	95% Confidence Interval
								Lower Upper
Valid	-1	2	2.5	2.5	2.5	.0	1.7	.0 6.2
	0	7	8.6	8.6	11.1	-.1	3.3	2.5 16.0
	1	20	24.7	24.7	35.8	.0	5.0	14.8 34.6
	2	18	22.2	22.2	58.0	.0	4.6	13.6 30.9
	3	13	16.0	16.0	74.1	-.1	4.0	8.6 24.7
	4	21	25.9	25.9	100.0	.1	4.8	17.3 35.8
Total		81	100.0	100.0		.0	.0	100.0 100.0

Figure 5 Descriptive Statistics of Software

Fig 5 Shows Descriptive statics of software project and it shows cumulative percent, Bootstrap percents for given dataset.

Statistics							
			Statistic	Bootstrap ^b			
				Bias	Std. Error	95% Confidence Interval	
						Lower	Upper
N	Valid	Project	81	0	0	81	81
		TeamExp	81	0	0	81	81
		Effort	81	0	0	81	81
	Missing	Project	0	0	0	0	0
		TeamExp	0	0	0	0	0
		Effort	0	0	0	0	0
Mean	Project	41.00	.11	2.54	35.77	45.85	
	TeamExp	2.19	.00	.16	1.88	2.52	
	Effort	5046.31	10.80	509.16	4171.72	6208.23	
Median	Project	41.00	.18	4.45	32.00	49.00	
	TeamExp	2.00	.07	.27	2.00	3.00	
	Effort	3647.00	27.94	324.47	2989.00	4277.00	
Mode	Project	1 ^a					
	TeamExp	4					
	Effort	546 ^a					
Std. Deviation	Project	23.527	-.199	1.185	20.997	25.634	
	TeamExp	1.415	-.011	.079	1.245	1.560	
	Effort	4418.767	-60.068	642.377	3132.385	5628.299	

Figure 6 Statistics of given dataset

In Fig 6 shows statistical computation for software project in the way of number of projects, Team Exp and Effort required for project.

Graph 1 Software project statistical estimation

7. PROJECT CODE METER FOR SOFTWARE EDC ESTIMATION

It [1] is a software tool that allows project managers to measure and estimate the duration, cost, complexity, quality and maintainability of software projects and the productivity of the development team through their source code. Using a modern algorithm to determine the software, called Weighted Micro Function Points (WMFPs) [12], it follows strong ancestral

scientific methods such as COCOMO, COSYSMO, maintainability index, cyclomatic complexity and Halstead complexity and produces more accurate results than software tools .

8. FUNCTIONALITIES OF CODE METER

Below are functionalities which are supported by code meter: Outsourced work assessment, Remote employee monitoring, Software size comparison by development time (Effort), Budget Planning for software projects, Producing a Price Quote for source code, Predicting Development Schedule and Budget, Measuring past and ongoing Development Productivity, Evaluating the attractiveness of an Outsourcing offer (cost effectiveness), Assessing source code Quality and Obtaining source code Metrics.

Figure 7 projectcodemeter home page

This is the home page where can give input as project folder and estimated hours it calculate and gives following output.

Settings	
Analysis Type	Normal
Programmer price per hour	\$200
Quality Guarantee	First Release (v1.0) 3-Sigma
Platform Maturity	Popular Stable and Documented
Debugging Tools	Complete system Step Emulator / VM / ICE
Project Folder	F:\java\projects\Java_ IEEE\2017\Detecting Mobile Malicious Webpages in Real Time\code\Detecting Mobile Malicious Webpages in Real Time\js\

Project Labor Summary		
Total Time	591	Hours
Total Cost	\$118277	

Statistical Labor Distribution				
	Percent	Time in Hours	Time in Minutes	Cost in \$
Coding	43	256	15406	51353
Debugging	34	203	12191	40637
Testing	22	131	7885	26283
FC Flow Complexity	31	184	11095	36983
OV Object Vocabulary	16	96	5763	19210
OC Object Conjunction	30	179	10777	35923
AI Arithmetic Intricacy	4	25	1518	5060
DT Data Transfer	7	42	2536	8453
CM Comments	0	0	20	67
CS Code Structure	7	40	2418	8060
ID Inline Data	4	22	1354	4513
Project Total	100	591	35483	118277

Quality Measurements	
Code Quality Notes Count	7
Code to Comment Ratio (CCR)	0
Essential Comment Factor (ECF)	1
Code Structure Modularity (CSM)	108
Logic Density (LD)	37
Source Divergence Entropy (SDE)	27
Information Diversity Factor (IDF)	1190
Object Convolution Factor (OCF)	31

Quantitative Metrics	
Files	5
Logical Lines of Code LLOC	2573
Single Line Comments	10
Multi Line Comments	5
High Quality Comments	15
Strings	1859
Numeric Constants	1275

Figure 8 analysis of software estimation

9. CONCLUSION

In this paper first we studied Machine learning models, other estimation models and tools for software estimation and analyzed Software EDC with statistical tool (SPSS) and Software cost estimation tool (Project code Meter), in early literature most of the researcher's implemented human judgment and other approaches for EDC estimation but these are not accurate in practical, in the second stage many researchers focused on statistical approaches, these approaches need strong statistical knowledge and it produce semi accurate result. To this Project code meter is estimation tool where it shows complete EDC estimation with accurately.

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