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A STUDY ON RATIONALIZATION OF FUZZY LOGIC TECHNIQUES IN SOFTWARE ENGINEERING MEASUREMENTS

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ABSTRACT: The measurement of software is recognized as a fundamental topic in software engineering research and practice and is challenging to both researchers and practitioners, due to non-availability of exact data. Software testing cost has become an important filed due to pervasive role of software in today's world. Uncertainties are best handled by using fuzzy logic; the emphasis is on estimation of software testing costs using fuzzy technique.

INTRODUCTION

Software cost estimation is the process of predicting the effort required to develop a software system. In the early days of computing, software costs constituted a small percentage of the overall computer-based system cost. An order of magnitude error in estimates of software cost had relatively little impact. Today, software is the most expensive element of virtually all computer- based systems. A large cost estimation error can make the difference between profit and loss. Cost overruns can be disastrous for the developer. Of the three principal components of software cost i.e. hardware, travel and training, and effort costs, the effort cost is dominant. Software cost estimation starts at the proposal state and continues throughout the life of a project.

CHARACTERSISTICS OF SOFTWARE COST ESTIMATION

The following are four important characteristics of software cost estimation:

1) **Budgeting:** provides accuracy of the overall estimate of spending throughout the project is the most desired capability.
2) **Trade off and risk analysis:** illuminates the cost and schedule sensitivities of software project decisions like staffing, tools, code reuse, etc.
3) **Project planning and control:** provides cost and schedule breakdowns by component, stage and activity.
4) **Software improvement investment analysis:** is important additional capability is to estimate the costs as well as the benefits of such strategies as tools reuse and process maturity.

A major factor contributing to software failure is the ineffective performance of software and system verification, validation and testing throughout the life cycle. The overall life cycle cost of software associated with its failures exceeds 10% of annual corporations turnover. The major problem associated with such cost estimates is that input elements like costs, risk levels and VVT performance levels are imprecise in nature. Therefore, a fuzzy logic technique is utilized to deal with such problems.

In an effort to assess the economic impact of inadequate testing, thirty Swedish companies were surveyed over a period of three years. The findings indicated average losses of 9-16% of the company's annual turnover due to poor-quality software. The study also revealed that the economic impact of inadequate infrastructure for software testing was small relative to the overall impact of the costs associated with inadequate VVT.

Measuring the VVT process is becoming a central issue for many software intensive organizations. More and more software studies attempt to develop theoretical models for measuring and quantifying the testing process to the software arena. The life cycle of software development may be divided into ten phases , each of which has its own VVT activities.

1. Definition
2. Design
3. Prototypes
4. Integration
5. Testing
6. Production
7. Usage
8. Maintenance
9. Upgrade
10. Disposal

As a total VVT process covering all aspects of system behavior is not attainable due to cost and time considerations, there is need to quantify costs and risks of alternative VVT strategies and to develop an approach for minimizing the system's life cycle cost.

A model instead of using a single number for the estimated VVT cost, the VVT cost is considered as a triangular fuzzy number, which yields satisfying results.

VVT COSTS AND RISK ASSESSMENT

The vast majority of industrial organizations spend considerable funds to promote product quality using sub-optimal VVT processes. However, a total VVT process covering all aspects of systems behavior is not attainable due to cost and time considerations. There is a need to quantify costs and risks of alternative VVT strategies and to develop an appropriate approach for minimizing the systems lifecycle cost. VVT is a branch of software and systems engineering which focuses on ensuring that systems are delivered as error-free as possible, are functionally sound and meet the users needs. Verification is “confirmation by stakeholders that specific intended use of a product is fulfilled”. Testing is “executing a program under specified conditions and observing the results.

The methodology for estimating VVT cost and risk may be described through four concepts viz. ideal cost, activity cost, appraisal risk cost, impacts risk cost

1. ***Ideal cost:*** Ideal cost of a phase is the aggregate of costs of all the activities of the phase, when each activity is fully performed. Ideal cost of a system is the sum of ideal costs of all the phases.

2. ***Activity cost:*** When VVT activities are performed under some strategy then some VVT activities are performed partially, some are performed fully and some are not performed at all. Level of performance is decided by the strategy formed, which is selected in accordance with the combined business objectives vision of the system's stakeholders.

3. ***Appraisal Risk Cos:*** Some products exhibits defects due to inherent imperfection in the development manufacturing or usage. The risk of detecting such deficiencies during the VVT process is labeled “Appraisal Risk”. In such a case, the product will be returned for a corrective procedure and then it will be retested. This process of evaluating the product and, if defective, rectifying it, will continue until the evaluation does not indicate a flawed artifact. The appraisal risk level of the various activities of phase 1 are given in the following Table

Appraisal risk level of various activities

Activity	1	2	3	4	5	6	7	8
Appraisal risk level	H	L		L	L		L	

4. ***Impact Risk cost***

Any partially performed VVT activity not performed at all constitutes an impact risk, these risks have stochastic effects on the system and of course, they constitute undesirable expenditures. A single such risk may generate multiple impacts, affecting the system at different lifecycle phases.

FUZZY LOGIC BASED VVT COSTS ESTIMATION

Cost of verification, validation and testing of software is approximately 30% of total life cycle cost. Full cost of VVT activities during the system definition phase is taken as 2.56% of total life cycle cost. Cost of appraisal VVT risks is taken as 1.32% of total life cycle cost. Cost of impact risk is 4.53% of total life cycle cost.

In addition, the following assumptions are taken for our model

a) Each VVT activity is completely independent from each other

b) VVT performance level corresponds to a linear cost of VVT activity.

Total VVT strategy cost of a phase = fuzzy VVT activity costs + fuzzy appraisal risk cost + fuzzy impact risk cost

LEVELS OF VVT PERFORMANCE

In order to model various types of VVT performance levels, we define seven linguistic variables viz. Very Low(VL), Low(L), Medium Low(ML), Medium (M), Medium High(MH), High(H) and Very High

FUZZY ACTIVITY COST

If the ideal cost of an activity j of phase I is m_{ij} , then the fuzzy ideal cost of the activity is taken as TFN $(\alpha_{ij,mij,}\beta_{ij})$, where i=1,2,3…….10 and j=1,2….11.

FUZZY APPRAISAL RISK COST

If the full cost of appraisal risk of any VVT activity j of phase I is $m_{aij,}$ then fuzzy full cost of appraisal risk is TFN $(\alpha_{aij,}m_{aij,}\beta_{aij})$, i=1,2,3 …..,10, j=1,2….11. Appraisal Risk Level of each VVT activity may accept any value from the linguistic terms { VL, L, ML, MH, H, VH}. TFN of appraisal risk level of activity j of phase I is taken as $(\alpha_{aij,}m_{aij,}\beta_{aij})$.

Appraisal risk cost of aVVT activity j of phase I is computed by multiplying the full cost of appraisal risk of the VVT activity, the appraisal risk level and the performance level of the corresponding activity.

FUZZY IMPACT RISK COSTS

If the full cost of impact risk of any VVT activity j of phase i is $m_{bij,}$ then fuzzy full

Full cost of impact risk is TFN $(\alpha_{bij,}m_{bij,}\beta_{bij})$, i=1,2,3…,10, j=1,2….11.

Impact risk level of each VVT activity may accept any value from the linguistic terms {VL, L, ML, MH, H, VH}. TFN of appraisal risk level of activity j of phase I is taken as $(\alpha_{aij,}m_{aij,}\beta_{aij})$.

As partially performed activity or not performed activity in any life cycle phase can cause impact risk in any subsequent phase. We calculate fuzzy impact risk cost by multiplying the full cost of impact risk of the VVT activity, the impact risk level and the reciprocal of the VVT performance level, given by $(\alpha_{bij*}\ \alpha_{ijn*}\ \alpha_{ijp,}\ m_{bij*}\ majn_{*}\ m_{ijp,}\ \beta_{bij*}\ \beta_{aijn*}\ \beta_{bij})$.

CONCLUSION

VVT is normally used as a vehicle for finding and removing errors. Most VVT cost data and relevant parameters are not available in precise form. Therefore, fuzzy modeling has the distinct advantage of deriving realistic information based on imprecise knowledge. Total VVT strategy cost is calculated as a sum of fuzzy VVT activity costs, fuzzy appraisal risk cost and fuzzy impact risk cost.

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