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تقديم

عزيزي الباحث

يسعدنا في دار النشر **رؤية للبحوث العلمية والنشر** أن نقدم لكم المجلة الدولية للحاسبات والمعلوماتية IJCI وهي مجلة علمية دولية محكمة متخصصة، تهدف إلى أن تكون عوناً للباحثين العرب لتساعدهم على نشر إنتاجهم العلمي من الأبحاث، والدراسات العلمية. وتهتم المجلة بنشر الأبحاث العلمية التي يتوافر فيها الأصالة والحداثة والمنهجية العلمية والتي تشكل إضافة علمية في جميع التخصصات والعلوم باللغتين العربية والإنجليزية. وتخضع البحوث المنشورة في المجلة للتحكيم على يد نخبة من الأساتذة الأكاديميين المتخصصين من العديد من دول العالم.

تنشر المجلة الدولية للحاسبات والمعلوماتية IJCI الإنتاج العلمي في العديد من المجالات والتخصصات العلمية لإتاحة الفرصة أمام الباحثين وطلاب الدراسات العليا لنشر بحوثهم وأوراقهم العلمية. ومن أهم هذه التخصصات على سبيل المثال (وليس الحصر):

- الذكاء الاصطناعي Artificial Intelligence
- نظم التشغيل Operating Systems
- مترجمات لغات البرمجة Programming Languages Compilers
- النظم الضبابية (الفازية) Fuzzy Systems
- الشبكات العصبية Neural Network
- منهجيات هندسة البرمجيات Methodologies of Software Engineering
- هندسة المتطلبات Requirements Engineering
- المنهجيات الرشيقة لتطوير البرمجيات Agile Methodologies for Software Development

- Object-Oriented Programming البرمجة الشيئية
- Software Testing اختبار البرمجيات
- Software Quality Assurance توكيد جودة البرمجيات
- Software Project Management إدارة مشروعات البرمجيات
- Systems Analysis and Design تحليل وتصميم النظم
- Methodologies of Systems Development منهجيات تطوير النظم
- Information System Projects مشروعات نظم المعلومات
- Database قواعد البيانات
- Information Security أمن المعلومات
- Cyber Security الأمن السيبراني
- Data Mining تنقيب البيانات
- Computer Network شبكات الحاسب
- Image Processing معالجة الصور
- Network Security أمن الشبكات
- Pattern Recognition التعرف على الأشكال
- الرياضيات والإحصاء في مجال علوم البيانات

  Mathematics and Statistics of Data Science
- طرق البرمجة في مجال علوم البيانات
- Programming Methods for Data Science
- Machine Learning تعلم الآلة
- Deep Learning التعلم العميق
- Application Domains of Data Science مجالات تطبيق علوم البيانات
- Management Information Systems نظم المعلومات الإدارية
- Decision Support Systems نظم دعم اتخاذ القرار

- نظم تخطيط موارد المؤسسة ERP
- التجارة الإلكترونية E-commerce
- التسويق الإلكتروني E-Marketing
- الحكومة الإلكترونية E-government
- التحول الرقمي Digital Transformation
- ذكاء الأعمال Business Intelligence

كما تشجع المجلة الدولية للحاسبات والمعلوماتية IJCI نشر الإنتاج العلمي في العلوم والموضوعات المتداخلة ذات الفائدة العلمية أو التطبيقية الواضحة. وهذه النوعية من الأبحاث تشمل موضوعين أو أكثر من الموضوعات المذكورة سابقاً.

نظراً لأهمية الوقت لجميع الباحثين، تتعاون المجلة الدولية للحاسبات والمعلوماتية IJCI مع مجموعة من المحررين المتميزين والمراجعين النظراء الذين لديهم الخبرة الكافية والمهارات الفنية والأدوات لتسريع عملية المراجعة والنشر قدر الإمكان. وغالباً ما تستغرق هذه العملية فترة زمنية من أسبوع إلى 3 أسابيع على الأكثر.

رئيس التحرير

قائمة الأبحاث المنشورة بالعدد

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المجلة الدولية للحاسبات والمعلوماتية

الإصدار (2)، العدد (1)

"Applying Quality Assurance Practices to Information Systems Project Management"

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Abstract:

This paper focuses on proposing a quality assurance model for Information Systems Projects Management (IS-PM). This paper presents some important concepts related to this field. It presents the phases and activities of IS-PM. This paper presents a set of proposed steps for achieving each activity of planning ISs projects. Depending on the proposed steps and a combination of statistical techniques, this paper introduces a proposed quality assurance model for IS-PM activities. This proposed model can be used to build an automated software tool. This paper presents a proposed database schema for building such tool.

Keywords:

Information Systems Projects Management; Quality Assurance Tool; Quality Assurance Model; Information Systems Projects

1- Introduction and Problem Definition

IS-PM is the on-going activities for planning, organizing, directing, and controlling progress to develop an acceptable system, i.e., conform to the quality standards within the allocated time and budget. Process management is the on-going activities that establish standards for activities, methods, tools, and deliverables of the life cycle. In other words, process management aims to manage the process of IS development but IS-PM aims to manage the project.

Project management is very important for the success of IS projects. The mismanaged projects may lead to unfulfilled or unidentified requirements, uncontrolled change of project scope, uncontrolled change of technology, uncontrolled risk of the project, uncontrolled subcontracting and integration, cost overruns, and late delivery [5]. ISs projects frequently fail. The rate of failure in large IS projects is larger than the rate of success. The failure rate of large projects is reported as being between 50%-80% [7]. An IS project is considered a failed project if it does not achieve the requirements or specifications. In other words, it is executed less or more than the planned scope. Also, it is considered a failed project if it is executed out of the budget or schedule.

The problem is that there is a considerable number of failed IS projects. Also, there is no integrated standards that can be used for increasing the success chance of IS projects. Most international quality standards or frameworks such as ISO, IEEE, CMM, CMMI, and TICKIT don't focus on IS-PM. There is much literature on the quality of software and IS development but there is no sufficient literature on the quality of IS-PM activities. For previous reasons, the quality of IS-PM is the main concern of this paper.

2- IS-PM Phases and Domains

IS-PM activities can be organized as life cycle phases that include initiating the project, planning the project, executing the project, and closing the project [18]. Also, IS-PM activities can be organized in IS-PM domains that include project scope management, project schedule management, project costs management, project integration management, etc.

2-1 IS-PM Phases

IS-PM can be viewed as life cycle phases that include initiating the project, planning the project, executing the project, and closing the project [4]. Each phase includes a set of activities. IS-PM activities are achieved throughout developing IS project. Figure (1) illustrates the life cycle of IS-PM. A common life cycle of IS-PM includes four phases [4]:

1. Initiating the project.
2. Planning the project.
3. Executing the project.
4. Closing the project.

Initiating the IS project aims to understand the project environment, background, stakeholders, and management [6]. Planning the project is the process of defining clear, discrete activities and the work needed to complete each activity within a single project. The product of the planning process is the project plan, a document that describes the project and how the project manager intends to execute it [4]. Executing the project includes a set of on-going activities that are achieved throughout the project development. It includes all activities that must be continuously carried out until the project is finished [6]. Closing the project aims to bring the project to an end. Projects can conclude with a natural or an unnatural termination. A natural termination occurs when the requirements of the project have been met – the project is successful. An unnatural termination occurs when the project is stopped before completion [4]. This paper focuses on planning the project.

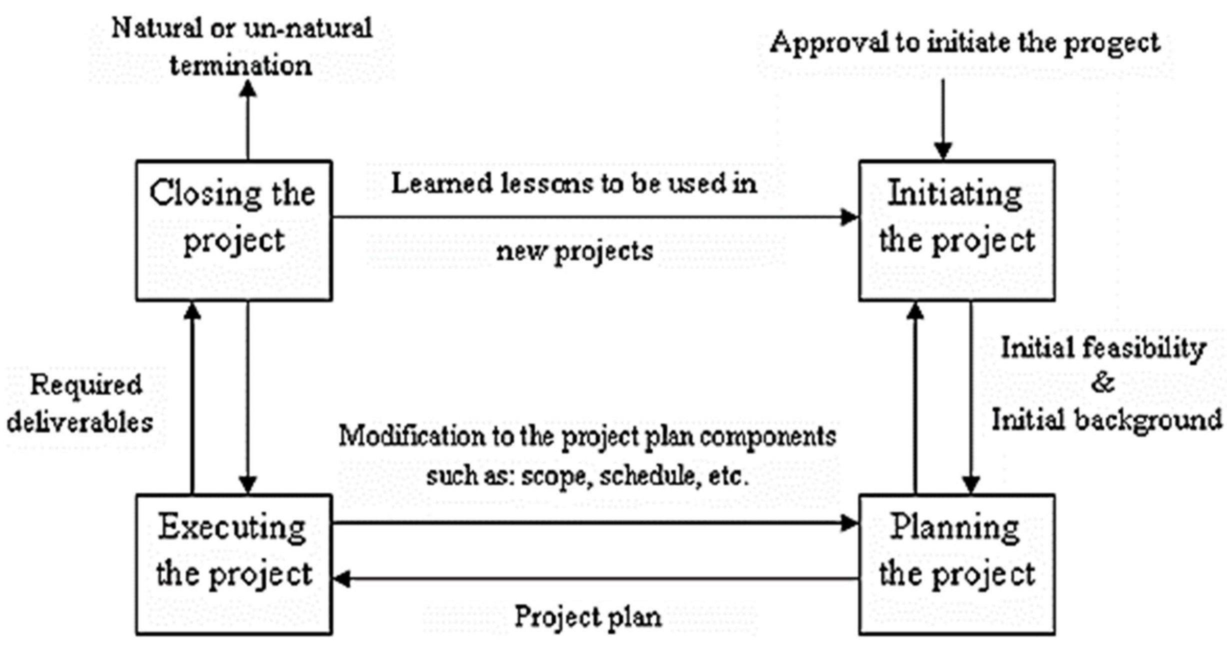

Figure 1. IS-PM life cycle.

2-2 IS-PM Domains

Another common approach for viewing IS-PM activities is IS-PM domains that include:

- Project Scope Management: involves activities to define and control what is included in the project and what is out of its scope. Project scope is the base of the subsequent phases and activities in the project.
- Project Schedule Management: is the administration and control of the finite resource of time. The project manager must manage the schedule carefully for preventing or correcting any slippages.
- Project Costs Management: is the planning and control required to ensure that a project is completed within the approved budget. The three conventional measures of project success are budget, schedule, and functionality.
- Project Integration Management: includes the processes required to ensure that the various elements of the project are properly coordinated.
- Project Quality Management: quality of IS projects means that these projects conform to the requirements or specifications and have minimized errors. The quality of IS projects must be achieved within the planned time and cost for these projects.
- Project Human Resources Management: involves those processes required to make the most effective use of the people involved in a project [2].
- Project Communication Management: involves the timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information. It provides critical links among people, ideas and information that are necessary for success within the project team and out to the business.
- Project Risk Management: includes the processes concerned with identifying, analyzing and responding to project risks, maximizing the results of positive events and minimizing the consequences of adverse events.
- Project Subcontracting Management: has a great importance because if one of the subcontractors late, this may lead to project slippage. So, the project manager

must ensure that everything is clear to subcontractors. Also, the project manager must know the legal and financial issues of subcontracting.

- Project Documentation Management: there are two types of project documents: those that the project manager needs in order to manage the project, and the vastly more voluminous technical data. The documents of technical data must be kept and accessible to all project staff.
- Users Participation Management: the project manager and his team must make time for users, insist on their participation, and seek agreement from them on all decisions that may affect them. Involving the system users facilitates the definition of the new system requirements.
- Review and Approval Process Management: include the procedures by which project deliverables will be reviewed and accepted. The review process produces comments that should be documented and analyzed to be considered in making changes to the reviewed deliverables. The review and approval procedures may be iterated till reach to an approved deliverable.
- Systems Development Management: The project manager must select an appropriate development methodology and manage it effectively.
- Feasibility Study Management: The project manager must make attention to the project's feasibility throughout the project phases to decide whether to continue, redirect, or abandon the project. A feasibility study may include the following categories: financial, technical, operational, legal, political, and schedule.

3- Proposed List of Quality Steps for IS-PM Activities

IS-PM phases are achieved throughout a set of steps. Appendix (A) includes a set of proposed quality steps for achieving the activities of the planning project (as an example). These steps were supported with opinions and vision of many textbooks, papers, websites, international standards, CMM and CMMI, consultants, World Bank projects, experience, and technical reports. Figure (2) illustrates sources that were used to support the proposed quality steps.

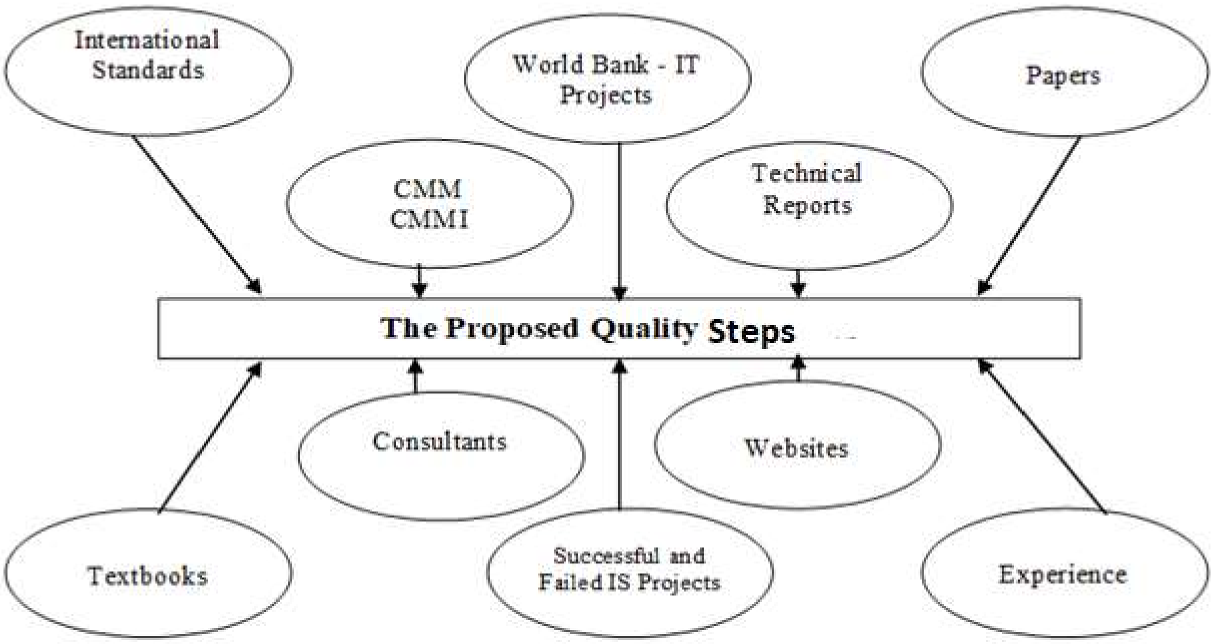

Figure 2. Sources that support the proposed quality Steps

4- Proposed Quality Assurance Model

Based on the proposed steps, the researcher can build a proposed quality assurance model for evaluating the quality of achieving an IS-PM activity.

1. Select an IS-PM activity.
2. Input the actual data of the selected activity.
3. Calculate the quality of the selected activity.
4. Interpret the quality of the selected activity.

4-1 Select an IS-PM Activity

The IS-PM phases, activities, and steps should be identified and described prior to any work in the project. So, the first procedure in the proposed model is identifying the activity to be evaluated and defining its steps. The proposed model enables the project manager and quality reviewers to use any IS-PM life cycle on one condition: the selected IS-PM life cycle must consist of phases, each phase must consist of activities, and each activity can be achieved through a set of tasks or steps. The quality reviewers may use local or international steps. Also, they may define their own steps. Sometimes, quality steps of achieving IS-PM activities may be imposed by higher level of management. Then, the quality reviewers inform and clarify these steps to the project manager. The project manager should use these steps as a guide for achieving the selected activity. The project manager should understand the proposed steps to apply them effectively for achieving the selected activity. The algorithm of this procedure includes the following steps:

1. Select an IS-PM phase.
2. Select an IS-PM activity related to the selected phase.
3. Recall the steps of the selected activity.
4. Inform and clarify the steps to the project manager.
5. Achieve the selected activity.

4-2 Input the Actual Data of the Selected Activity

The second procedure in the proposed model is entering the actual data of achieving the selected activity that can be used for calculating the quality. This step is reached after executing the identified activity by the project manager. The quality reviewers collect the actual data of achieving the activity and input them into the model for computing the activity quality. For achieving the purpose of the proposed model, the proposed steps are organized in a table as in Table (1). Table (1) presents a sample for this organization. We propose a rating scale for measuring the implementation of the steps of each activity. The proposed scale based on that each step has a five-point rating scale. The midpoint of the scale is an average (AV) implementation of the step. The lower end of the scale is a poor (P) implementation of the steps, with the bottom of the scale being very poor (VP). The ratings on the upper end of the scale are good (G) and very good (VG). During computing the quality, the values 1,2,3,4, and 5 are corresponding to the ratings VP, P, AV, G, and VG respectively. The steps for achieving each activity are not having the same level of importance. So, each step must have a weight of 1, 2, or 3. The weight is a measure of the importance of each step. A weight 3 is used to show the step of the most importance or it is called a required step. A weight 1 is used to show the steps of the lowest importance or it is called an optional step. A weight 2 is used to show the step of the average importance or it is called a recommended step. Before evaluating any activity, the quality reviewers determine the weights of the steps. These weights are placed in the column titled “Importance Type”. Also, some steps may be not applicable in some specific cases. So, there is a column titled “NA” in the table. During computing the quality, the not applicable steps are eliminated. The quality reviewers input the actual data for each step related to the selected activity. Table (1) presents a sample of the actual data for achieving the activity “Defining the project scope and deliverables” in the initiation phase.

The proposed algorithm for entering the data of the activity includes the following steps:

1. Identify the list of steps related to the selected activity.
2. Check the list of steps.
3. If it is not empty, continue, else end.
4. Select a step to be entered.
5. Identify the importance type of the selected step.
6. Identify the implementation value of the selected step (NA, VP, P, AV, G, or VG)
7. Go to step 2.

Phases and Activities	Importance Type	NA	VP	P	AV	G	VG
Phase - Planning the Project							
Activity (1): Defining Project Scope and Deliverables							
1. Involve users in the process of defining project scope and deliverables.	2					√	
2. Define the project scope. The project scope should include functionality, business rules, procedures, interfaces to other systems, and the project deliverables.	3					√	
3. Define project deliverables. The project deliverables should be documented in a list, with brief description, of everything tangible that the project will produce.	3						√
4. Develop a written scope statement.	3				√		

Table 1. A sample of the actual data of achieving an IS-PM activity.

4-3 Calculate the Quality of the Selected Activity

The third procedure in the proposed model is calculating the quality of the selected activity. The not applicable steps and their weights are eliminated from the calculations. We mentioned before that the steps don't have the same level of importance. So, the weighted mean is an appropriate statistical technique to measure the quality for the activity because it takes into consideration the impact of the weights of the steps. The weighted mean can be calculated using the formula:
Weighted Mean= $(\sum Xi.Wi)/ \sum Wi$

Where: Xi is the implementation value of each step i, Xi may take the value 1,2,3,4, or 5 that are correspondence to the ratings VP, P, AV, G, and VG respectively. Wi is the weight of each step i

Figure (3) illustrates a flowchart that presents the algorithm of this procedure. The algorithm includes the following steps:

1. Identify the list of entered steps related to the selected activity.
2. Initialize the required variables. We will use four variables for calculating the quality. So, we initialize them by zero. Product=0, Sum-of-products=0, Sum-of-weights=0, Quality-value=0
3. Check the list of steps related to the selected activity.
4. If it is not empty, go to step 4,
   Else, compute Quality-value= Sum-of-products/Sum-of-weights,
   End.
5. Select a step.
6. Check the selected step. Is it a NA step?
   If it is not, go to step 6,
   Else, go to step 3.
7. Compute Product=Implementation value*Importance type.

8. Compute Sum-of-products= Sum-of-products + Product.
9. Compute Sum-of-weights=Sum-of-weights +Importance type.
10. Go to step 3.

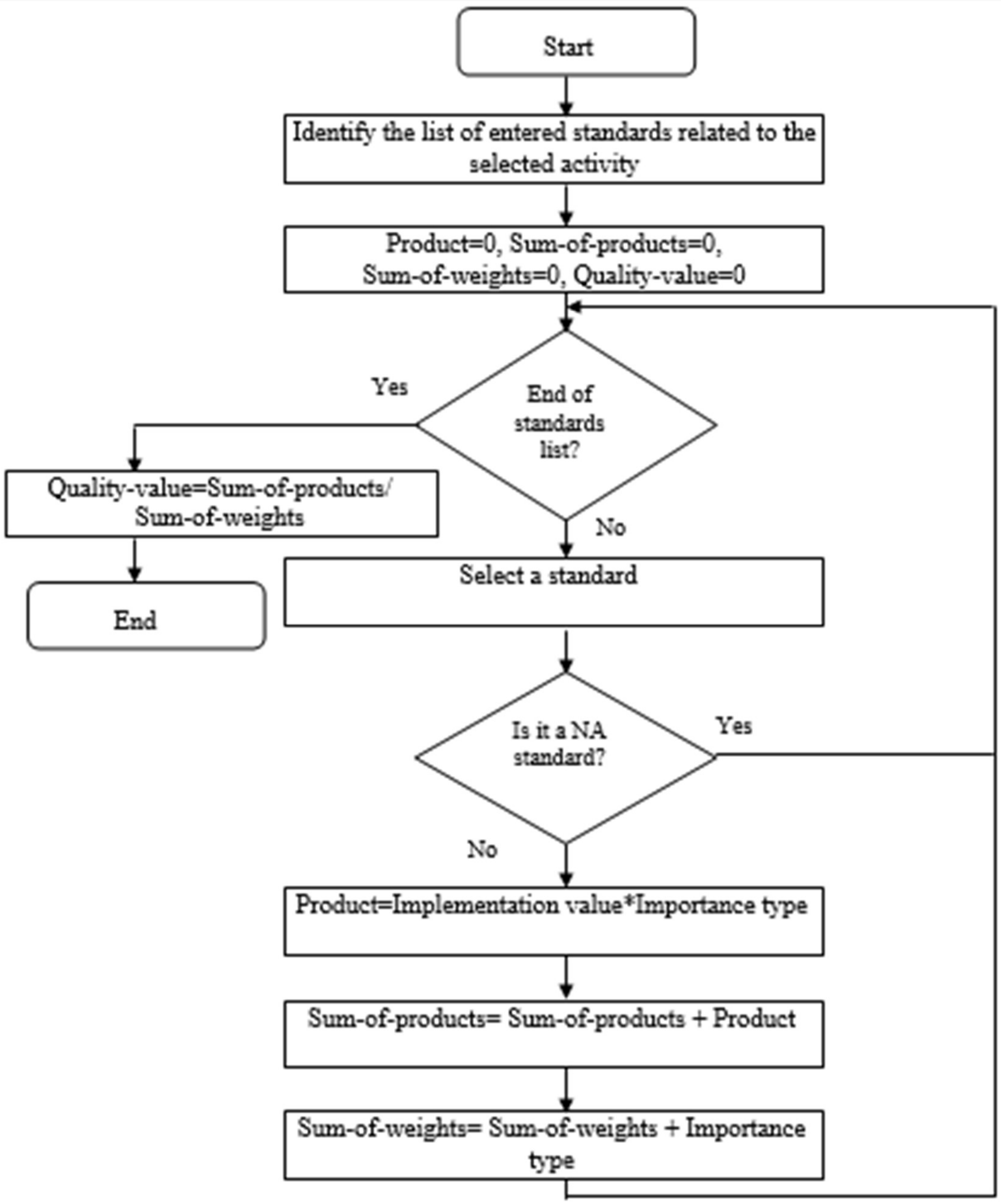

Figure 3. The algorithm of calculating the quality of the selected activity.

To test this algorithm, we can compute the quality value for the selected activity "Defining the project scope and deliverables" according to the actual data presented in Table (1).

Quality value= (4x2 + 4x3 + 5x3 + 3x3)/(2 + 3 + 3 + 3) = 4/5

According to the actual data and calculations, the quality of the selected activity is 4. Based on the used statistical technique and rating scale, the quality value will range from 1 to 5.

4-4 Interpret the Quality of the Selected Activity

The final procedure in the proposed model is interpreting the quality value of the selected activity. The quality reviewers should report their interpretation to their top management. Also, they may inform the project manager to increase the maturity of the implementation of this activity. If the quality value is not accepted, top management may take corrective actions or inform the project manager to take corrective actions. The acceptable level of quality is different from one company to another or from one project type to another. The quality reviewers can determine a specific value in the range from 1 to 5 for judging and interpreting the quality value. The algorithm of this procedure includes the following steps:

1. Identify the interpretation table.
2. Input the quality value of the selected activity.
3. Compare the quality value with the values of the interpretation ranges.
4. Check the quality value.
   If it is accepted, go to step 6,
   Else continue.
5. Produce a report.
6. End.

5- Proposed database schema for building an automated software tool

There are many facts that can be used as business rules for building proposed automated software tool for evaluating the quality of an IS-PM activity. These business rules include:

1. The tool must be easy to use. It must include instructions for completing the forms.
2. The tool must have the ability to run as an online website or as an offline application.
3. The tool must check the data of signing in or up for the user.
4. IS-PM life cycle must include phases.
5. The tool must enable the user to use an existing IS-PM life cycle or to define his IS-PM cycle.
6. The tool user inputs the data of his project. The other users cannot modify or read these data.
7. The tool must enable to evaluate the quality of a specific activity, phase, or project.
8. The tool must enable the user to use an existing interpretation table or to input his interpretation table.

Figure (4) illustrates the database schema of the proposed tool. It takes the impacts of web technology into consideration such sign in, sign up, sign out, and data security. The database schema includes the tables:

- Country: aims to handle codes of countries that will be used in sign up form.
- Occupation: aims to handle codes of occupations that will be used in sign up form.

- User_Sign: aims to handle the data of users. This data will be used in sign in and sign-up forms. It will determine the authority of the user for accessing the data of the project and steps.

- SDLC_Style: aims to handle the data of ISPM life cycle. It will be used in the form of quality steps.
- Phase: aims to handle the data of ISPM phases.
- Activity: aims to handle the data of ISPM activities.
- Standard: aims to handle the data of ISPM steps. This data will be used in the forms of entering or using the quality steps.
- Project: aims to handle the data of the project. This data will be used in the forms of evaluating the quality.
- Actual_step: aims to handle the actual data of evaluating the quality of project activities.
- Interpretation_Style: aims to handle the data of interpretation styles that may be used for interpreting the quality value.
- Interpretation_Range: aims to handle the data of interpretation ranges that may be used for interpreting the quality value.

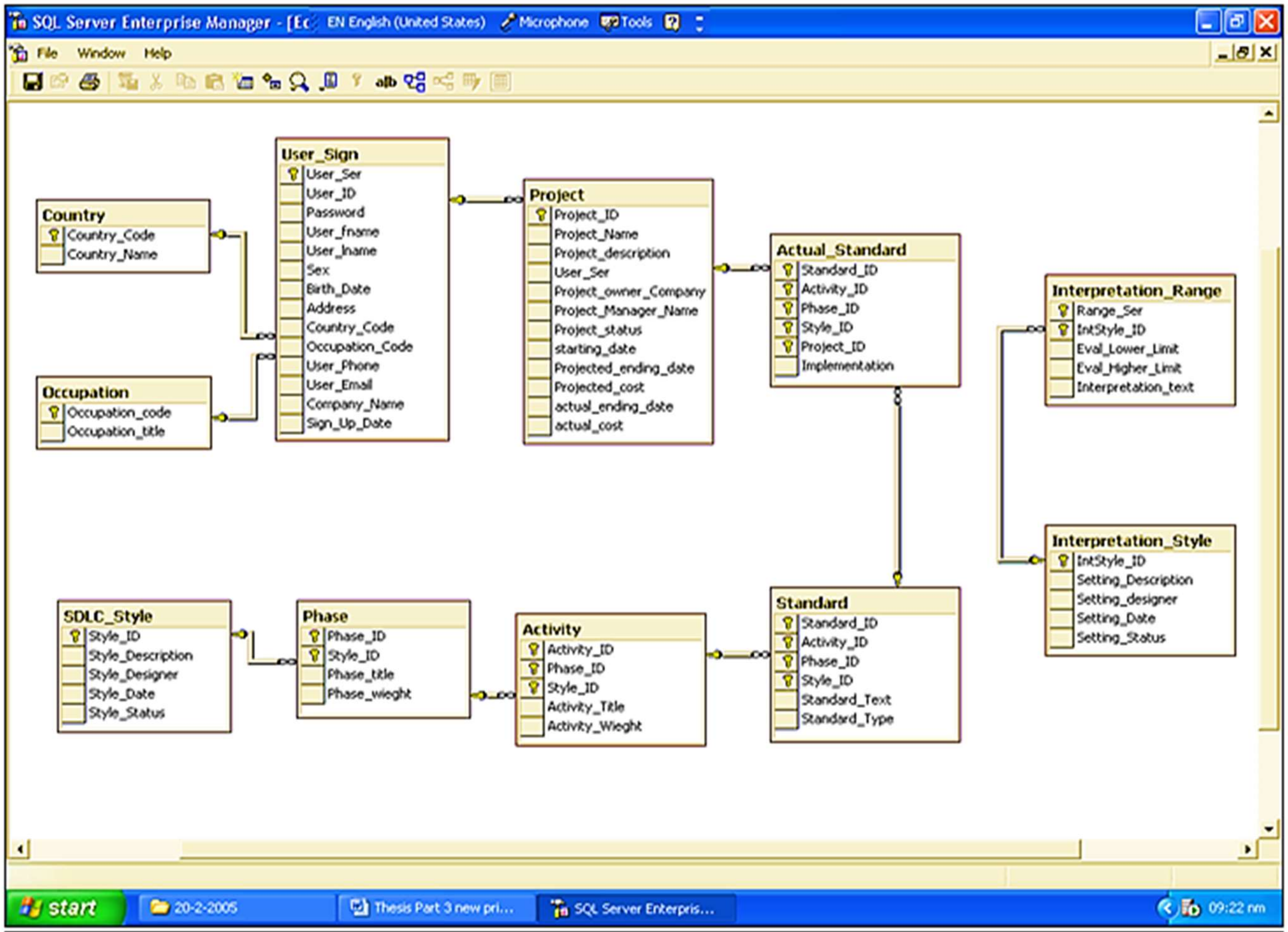

Figure 4. The database schema of the proposed automated tool.

6- Conclusion and Future Work

The objective of this paper was to propose a quality assurance model for IS-PM. So, we presented a set of proposed steps for achieving the activities of planning ISs projects as a sample of quality steps that can be elaborated for IS-PM activities. The

IS project manager and the quality reviewers can use these quality steps as a guide for achieving IS-PM activities. Based on the proposed steps and a combination of statistical techniques, we built a proposed model for evaluating the quality of IS-PM activities. The proposed model includes the main procedures: selecting an IS-PM activity, entering the actual data of the selected activity, calculating the quality of the selected activity, and interpreting the quality of the selected activity.

We conclude that quality reviewers are essential to be found within the IS-PM practices. Also, we found that special emphasis must be given to quality assurance for ISs projects in a trial to reduce the failure rate of ISs projects and increase the quality of achieving the IS-PM activities. Also, we found that it is important to build an automated software tool for evaluating the quality of the IS-PM activities. This paper presented a proposed database schema for building such tool.

For future work, the following points are expected to be focused:

- Expanding the work to build an automated tool for evaluating the quality of IS-PM activities.
- Searching in more detail in quality and performance metrics.
- Expanding the work to build a model for evaluating the performance indicators of IS-PM domains.
- Expanding the work to build an automated tool for evaluating the performance indicators of IS-PM domains.
- Searching in more detail some critical issues in IS-PM such as risk management, subcontracting management, scope management, and configuration management.
- Elaborating critical success factors of IS projects.

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الإصدار (2)، العدد (1)

Appendix (A) – Example of Quality steps of planning IS projects

Activities and steps
Activity (1) - Defining Project Scope and Deliverables
1. Involve users in the process of defining project scope and deliverables.
2. Define project scope. The project scope should include functionality, business rules, procedures, interfaces to other systems, and project deliverables.
3. Define project deliverables. Project deliverables should be documented and described in a list.
4. Develop a written scope statement.
Activity (2) - Listing Project Assumptions and Constraints
1. Define a list of project assumptions and constraints that must include assumptions and constraints of resources, delivery, environment, budget, and functionality.
2. Clarify the list of project assumptions and constraints to the client management, and the project team.
Activity (3) - Identifying, Analyzing, and Prioritizing Project Risks
1. Clarify the importance of project risk management to all team members.
2. Prepare and validate a list of project risks. It should include risks of staff, equipment, client, scope, technology, delivery, and physical risks.
3. Identify the consequence of project risks.
4. Identify the severity of impact for each risk.
5. Identify the probability of each risk.
6. Review and validate the data of the risk analysis with project team members.
7. Identify methods of prioritizing the project risks.
8. Determine and document the level of each project risk.
9. Communicate and clarify the level of each project risk to the project team.

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المجلة الدولية للحاسبات والمعلوماتية

الإصدار (2)، العدد (1)

"A Proposed Approach for Effort Estimation of Developing Mobile Applications"

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Abstract:

Effort estimation techniques play a key role in the planning process for the development of mobile phone applications. The development of mobile applications is different from the traditional applications of information systems because of their dissimilar characteristics and the rapid advancement of technology used in the development of the former. For this, existing traditional effort estimation techniques may not be suitable for use in predicting the development effort of mobile applications. The process of estimating and predicting the effort depends mainly on the characteristics of the applications. The aim of this study is to propose a methodology for the use of intelligent techniques to predict the effort to develop mobile applications, which are considered unconventional, and to cope with the rapid development of the mobile application development environment.

Keywords:

Effort Estimation, Mobile Application, Mobile Computing, Systematic Review.

1- Introduction

Nowadays, mobile devices are the fastest-growing computing platform. This rapid explosion of mobile devices over the last five years has dramatically altered the platform that is utilized for social, business, entertainment, gaming, and marketing using software applications. The development of mobile applications that provide rich content to users by using global positioning sensors (GPS), wireless connectivity, photo/video capabilities, built-in web browsers, and voice recognition, among other sensors became more complex and challenging. New features in mobile devices that did not exist previously in traditional software applications represent a challenge and novel requests for software engineers.

Another challenge added to the estimation of a mobile application is the different kinds of Mobile applications. It falls broadly into three categories: native, web-based, and hybrid Native applications run on a device's operating system and are required to be adapted for different devices. Web-based applications require a web browser on a mobile device. Hybrid applications are 'native-wrapped' web applications. Effort estimation is a vital project management activity needed for project planning[1]. The estimation process is expecting how much effort is needed to develop a software project and maintain based on vague customer requests[2].

For traditional software, several approaches have been defined to support the task that can be divided into two main categories, namely the non-model-based and model-based methods [2]. Broadly speaking, non-model-based methods involve the judgment of human experts, who provide an estimate based on their previous knowledge and practices [3]. Alternatively, model-based approaches rely on the definition of a set of cost drivers used as independent variables in prediction models aimed at estimating a numerical variable. One of the advantages of model-based approaches is that they are more applicable [4]. However, they critically depend on the identification and evaluation of cost drivers. Different approaches devised based on the employed cost drivers and each one can be applied in a different phase of the development process, once the information to evaluate the required cost drivers is available. New approaches specially design models to fit for mobile application effort estimation [5] or adapt existing one [6].

The main objective of this paper is to fetch different and critical factors that affect mobile application development using a systematic literature review (SLR), review previous work of other researchers, compare their work to point out the gaps, and propose an approach model to estimate the effort for mobile application development. to solve those problems.

The remaining part of this paper is organized as follows: Section 2 describes the review process. Section 4 reports the review results. Section 5 summarizes the main recommendations for future research on software estimation for mobile application.

2- Systematic Literature Review

A systematic literature review is conducted methodically by following a set of guidelines to collect and analyze all available evidence about a specific question in an unbiased and repeatable manner [7]. Firstly, following research questions were framed to guide the SLR:

RQ1: What are the characteristics of Mobile Applications?

RQ2: What are the techniques that have been used for effort or size estimation for mobile software development?

To find relevant studies to answer our research questions, the researchers conducted a search composed of two steps. The first step was to define a search string. The second step was to apply this search string to a set of selected digital libraries to extract all the relevant papers. These two steps are described in detail below.

2-1 Search terms

The complete set of search terms was formulated as follows: (mobile OR mob* OR "cell phone" OR telephone) AND (software OR system OR application OR app* OR development) AND (effort OR cost OR resource) AND (estimat* OR predict* OR assess*).

2-2 Literature resource

To answer the research questions, the researchers performed an automated search based on the pre-constructed search terms using the following electronic databases:

– IEEE Digital Library.

– ACM Digital library.

2-3 Search process

As part of the search strategy, search strings were applied on different databases to fetch the relevant studies since 2010 and then remove duplicate articles.

2-4 Study Selection Procedure

The aim of this step was to identify the relevant studies that addressed the research questions based on their title, abstract, and keywords.

To achieve this, the researchers evaluated each of the candidate papers identified in the initial search stage using the inclusion and exclusion criteria, to determine whether it should be retained or rejected. If this decision could not be made using its title and/or its' abstract alone, the full paper was reviewed.

Inclusion criteria:

- Relevant to the topic of our review
- Papers that have been published in the last eight years (2010 - 2017)
- Studies reported in a conference, journal, and thesis OR are reported in a technical report
- Studies wrote in English.

Exclusion criteria:

- Studies that do not present effort estimation models/methods/metrics for mobile application.
- Studies not written in English.

3- ASSESSMENT of Papers

The study quality assessment can be used to guide the interpretation of the synthesis findings and to determine the strength of the elaborated inferences. Nominated paper or articles quality assessed according to score given accord the answer three questions as shown in tabel1. Quesstion1 (Q1) assess if the authors of the study clearly state the aims and objectives of the carried-out research. This question could be answered positively for all the reviewed publications. Question two (Q2) ask if the study provides enough information (either directly or by reference to the relevant literature) to give the presented research the appropriate context and background. Question three (Q3) check if the validity of the model or metrics clearly discussed.

4- Related Work

Jošt et al [8] examine whether the traditional software metrics are appropriate for measuring the mobile applications' source code. the authors introduced eight metrics to be applied in the analysis of the mobile application. However، this method cannot be used in the early stage of development since it relies on the complete source code to get a proper measure. The authors also do not provide additional guidelines on how the proposed metric is applied to the mobile prototype and how they valued (high or low) the source code.

In order to find out which software effort estimation model is more accurate Arnuphaptrairong et al [9] empirically validate and compare the accuracy between Function Points Analysis method and a proposed technique especially design for mobile application effort estimation. The results show disappointed accuracy for both estimation models. The author explains the reason for this poor result to the productivity rates used in both models was very rigid.

Nitze [10] uses the COSMIC Function Points approach to measure the size of mobile application based on its functional user requirements and adapt it by introducing 19 elements for the mobile development. Although, the author concludes that COSMIC is an appropriate approach for mobile application size measurement.it still did not consider non-functional requirements.

Tunal [11] uses Functional Point Analysis (FPA) measurement to estimate the size of mobile tablet application developed by him. The estimate was compared to the actual size of the project after development. Results show high accuracy and low deviation between actual and estimated size. However, there are a variety of mobile applications such as mobile games, which has more complex features and characteristics. The FPA measurement might be not applicable for estimate it.

Shahwaiz et al [12] propose a parametric model to estimate effort needed to develop mobile application cations to help project managers. The authors identified 20 cost drivers initially، choose only 7 of them who has the most impact on the effort of development of mobile applications and then use step forward regression to derive the effort estimation model. The model tested and validated using data of more than 160 mobile projects developed by either freelancer or software houses. The authors claimed that their model outperformed the general-purpose COCOMO Ⅱ. However, they did not test the model for different mobile application types or sizes.

De Souza et al [13] present a proposal for an effort estimation model for mobile applications. They at first identifying specific characteristics of mobile systems and then adapt of an estimation method that exists Finnish Software Measurement Association (FiSMA). However, the authors did not discuss how the measurement is validated.

Abdullah et al [14] proposed UML-based functional measurement through COSMIC function point to be used to estimate the mobile game application. The authors used the angry birds game as a case study. The key idea in this study is to use UML representations for capturing the information needed for the measurement and estimation.

Ferrucci et al [15] analyze the use of COSMIC Function Points to measure the size of mobile applications and investigate whether the results correlate with code-based measurements. The authors claimed that the COSMIC functional size evaluated was well correlated to all the size measures considered. However, the prediction accuracy was not good compared to other methods.

5- Mobile Application Factors

Some aspects are differentiating mobile applications from the traditional application. These factors divided into three parts, hardware, software, and the communication.

5-1 Hardware Factors

- Limited power: Mobile applications have less processing power and relativity small by the LOC. In addition, mobile applications have less memory space than the traditional application [16].

- Screen size: Mobile phone screen size is small and varies from one device to others.

Table 1: Papers Quality Assessment

Paper ID	Title	References	Q1	Q2	Q3	Score
1	A parametric effort estimation model for mobile apps	(Shahwaiz, Malik, & Sabahat, 2017)	1	0.5	1	2.5
2	A Set of Metrics for the Effort Estimation of Mobile Apps	(Catolino, Salza, Gravino, & Ferrucci, 2017)	1	1	0.5	2.5
3	An analogy-based effort estimation approach for mobile application development projects	(Nitze et al., 2014)	1	1	0.5	2.5
4	An Empirical Validation of Mobile Application Effort Estimation Models	(Arnuphaptrairong & Suksawasd, 2017)	1	1	1	3
5	An Estimation Model for Test Execution Effort Motorola Industrial Ltda	(Aranha, Km, & Brazil, n.d.)	0.5	0.5	0	1
6	An investigation of the accuracy of code and process metrics for defect prediction of mobile applications	(Kaur, Kaur, & Kaur, 2015)	0.5	0.5	0.5	1.5
7	COSMIC functional measurement of mobile applications and code size estimation	(D'Avanzo, Ferrucci, Gravino, & Salza, 2015)	1	1	1	3
8	Estimating the Effort of Mobile Application Development	(De Souza & De Aquino Jr, 2014)	1	0.5	0	1.5
9	Investigating functional and code size measures for mobile applications	(Ferrucci, Gravino, Salza, & Sarro, 2015)	1	0.5	1	2.5
10	Mobile applications, function points and cost estimating	(Preuss, 2013)	0.5	0.5	0.5	1.5
11	Mobile Game Size Estimation	(Abdullah, Rusli, & Ibrahim, 2014)	1	1	1	3
12	On the Use of Requirements Measures to Predict Software Project and Product Measures in the Context of Android Mobile Apps: A Preliminary Study	(Francese, Gravino, Risi, Scanniello, & Tortora, 2015)	0.5	0.5	0.5	1.5

Table 1: Papers Quality Assessment (continue)

Paper ID	Title	References	Q1	Q2	Q3	Score
13	Reviews on functional size measurement in mobile application and UML model	(Atiqah, Abdullah, Ida, & Rusli, 2015)	1	1	0.5	2.5
14	Sizing android mobile applications	(Guruprasath, 2011)				
15	Measure the functional size of a mobile app: Using the cosmic functional size measurement method	(Heeringen & Gorp, 2014)	1	1	1	3
16	Software Size Estimation Using Function Point Analysis – A Case Study for a Mobile Application	(Tunalı, 2014)	1	1	0.5	2.5
17	A case study in COSMIC functional size measurement: Angry Bird Mobile Application	(Abdullah, Rusli, & Ibrahim, 2013)	1	1	1	3
18	Mobile applications, function points and cost estimating	(Preuss, 2013)	1	1	0	2

- Start-up time: Mobile device's user uses the mobile phone in short duration and mobile phone should have an ability to quickly start a mobile application.

5-2 Software Factors

- User-Interface: Mobile application designed to match the target mobile environment. The target environment standards are important to the user with the pleasant application.
- Interaction with the information sources: In the mobile application, data is transferred from one application to other application [17].

5-3 Communication Factors

- Network communication: Networks are a very important factor for communication from one device to another device. Mobile devices are connected to the internet, GPS system by the network communication [18].

6- Proposed Model

In this section, a proposed model steps based on best practices and up to date practical research findings for building effort models by use of machine learning algorithms presented. Figuer1 demonstrate those steps as follow:

Step 1: Identification of potential effort predictors was the very first step. A set of predictors can be considered from literature review, experts, or other general-purpose models [19].

Step 2: collect real-life mobile applications from trusted sites for open source application such as GitHub [20] or from software houses.

Step 3: data contain irrelevant and redundant features that might decrease the model performance that is a critical issue especially in software engineering data [21]. The third step is to select a subset of features that have significant or similar impacts on the evaluation target as using all features.

Step 4: Noisy and unreliable data may severely influence the predictive accuracy of machine learning models. Data processing is a critical task in the process of building ML models. Data processed through removing outliers cleaning, re- duction, transformation, and scaling features before building estimation model. Scaling transforms feature values according to a defined rule so that all scaled features have the same degree of influence.

Step 5: Partition of the dataset could perform using cross-validation schema. Cross-validation is a simple but effective way for the parameter tuning scheme [22]. The dataset is randomly split into three equally sized and mutually exclusive subsets: training subset, validating subset, and testing subset. The training subset is used to construct models with specified parameter settings. The validating subset is used for parameter tuning and to prevent the over-fitting problem of ML methods. The testing subset is used to evaluate the predictive abilities of training methods with optimal parameters.

Step 6: Machine Learning (ML) algorithms, the main advantage is adjusting to the changing environment. This is an important factor for software estimation because there are frequent technology advances, new tools, and programming languages available, and methodology improvements and changing skill sets of project teams that affect it [23]. Numerous ML algorithms available applied depending on the desired outcome. In this study, depending on labeled data so the supervised ML algorithm will be implemented. This step repeated and the next step to select the optimal values of tuning parameters that give the best accuracy or at least accepted one.

Step7: Evaluation of the effort estimation model inspected by using the following method.

a) Magnitude of relative error (MRE): MRE is a measure, which calculates the difference between values estimated by a suggesting model and the values estimated.
b) Mean magnitude of relative error (MMRE): MMRE is the mean measurement of the absolute values of the relative errors from the complete data set [24].

c) Root Mean Squared Error (RMSE): RMSE is the average variation between actual and predicted values predicted by the model [4]. RMSE can only be compared between models whose errors are measured in the same units.

The model that has the lower MRE and MMER considered as an acceptable model.

Figure 2 shows the basic black-box structure of our model. As shown in this figure, our model takes estimation predictors as inputs supplied by the user and generates an estimate of the source lines of code (SLOC) as output. The SLOC converted to the functional size by using a conversion function.

Conclusion and Future Work

The effort estimation techniques have a high strength in the planning of mobile application development. In this paper, the researchers used the steps of SLR to present and point out the gaps and future directions for research in effort estimation for mobile application by answering the questions that were given in this field by following the steps of SLR.

SLR steps such as search strategy, search terms, literature resource, search process, study selection, procedures, inclusion criteria, exclusion criteria, quality assessment, data extraction and synthesis finally presented the result of this work.

In this paper the researchers suggest an approach to predict the effort to develop mobile applications using machine-learning technique. The proposed approach consists of seven steps that start with data collection and ends with evaluation of models to select the best one to use.

The future work: the researchers will apply the proposed model in a case study.

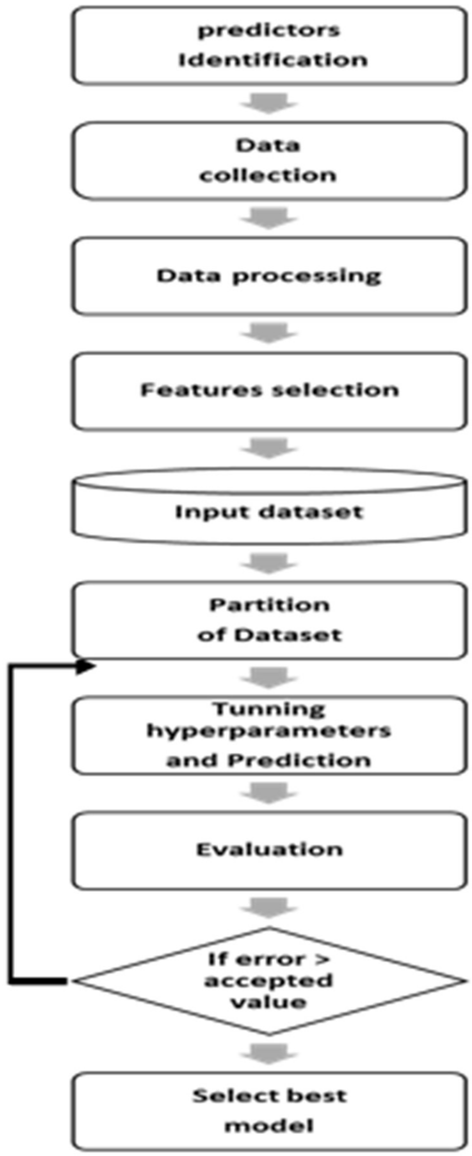

Fig. 1. Proposed Model Steps.

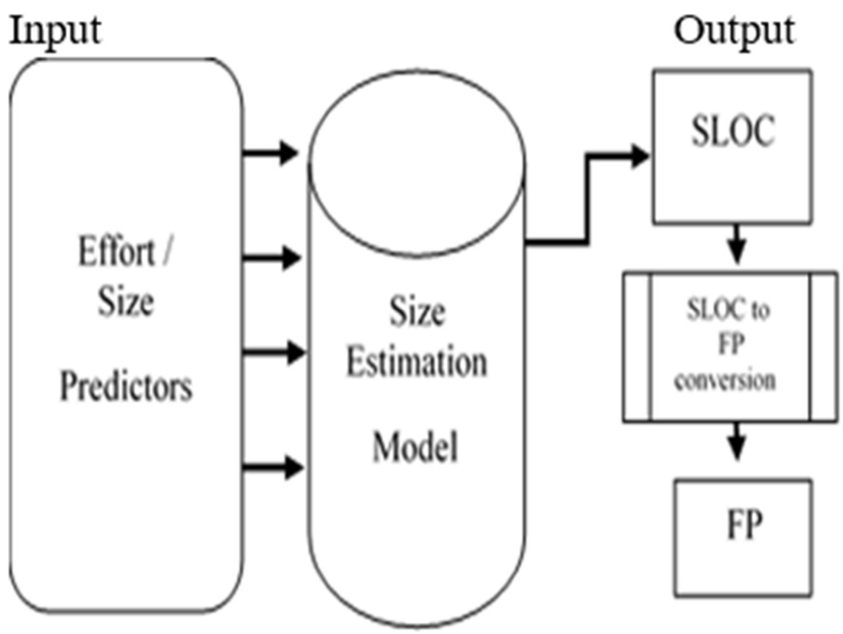

Fig. 2. Size Estimation Model (Black-Box)

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