An Empirical Study of Software Cost Estimation in Saudi Arabia Software Industry

Abdu Gumaei, Bandar Almaslukh, Nejmeddine Tagoug

Abstract*— Cost estimation of software projects is a very important activity in software process development for shaping how much effort and time software projects required. Successful software projects depends mainly on an accurate cost estimation which is one of the most critical factors of good management decisions. Accurate cost estimation of software projects is not easy to do because it needs more experience and more knowledge about the nature and key features of projects. Especially as there are many cost estimation models available including algorithmic models, expert judgment model, estimating by analogy, and machine learning models. Saudi Arabia is one of the most outsourced country which has employed some methods for cost estimation. Incorrect cost estimations of projects in software development houses of this country prompted us research about the reasons for this problem. In this study, we concentrated on Saudi Arabia software companies and prepared a questionnaire to collect data with goal of exploring the software cost estimation models and analyzing the reasons which effect on the selection of software cost estimation models or methods in Saudi Arabia software industry.

***Index Terms*— Software Projects, Cost Estimation, Expert Judgment Model, Algorithmic Models, Estimating by Analogy**

I. INTRODUCTION

In recent years, software industries have introduced a significant contribution in many fields in the world, but at the same time they also suffer from some problems due to the high failure level in software projects development [1]. One of the most important things of this failure is the inaccurate software cost estimation. Software cost estimation is the process of estimating the effort required to build software projects. In the development phase of each software project, managing the time, the effort, and other resources based on the correct cost estimation are key factors to software project success. Based on our experience in software development processes, effort estimation is one the most important events of software management and one of the most significant reason of software project failures [2,3,4,5,6]. Thus, effort estimation of software processes affects anything in the project from analysis to deployment in order to achieve a high level of customer satisfaction and success in the market. There are many statistics of software project failures show that inaccurate estimation is the main factor of their failures. Also, these statistics and studies indicate the importance of accurate estimation of software [2,3,5,6,7,8,9,10,11].

Manuscript Received on December 2014.

Mr. Abdu Gumaei, Department of Computer Science, King Saud University, Riyadh, KSA, Saudi Arabia.

Bandar Almaslukh, Department of Computer Science, King Saud University, Riyadh, KSA, Saudi Arabia.

Dr. Nejmeddine Tagoug, Department of Information Systems, King Saud University, Riyadh, KSA, Saudi Arabia.

At the same time, there are several different techniques of software cost estimation but the most common seven types of these techniques are; Algorithmic Model, Estimation by Analogy, Expert Judgment, Price To Win, Top-Down Estimation, Bottom-Up Estimation, and Machine Learning. Algorithmic Model provides mathematical algorithms which generate a software cost estimation as a major cost driver. Cost driver is a factor that effect the cost of software projects. Most famous algorithmic models are Boehm's COCOMO, COCOMO II, and Albrecht's Function Points. Traditional cost estimation model COCOMO has incorporated with the concept of fuzziness of some measurements such as size, mode of development and the cost drivers in an attempt to improve the accuracy of the overall development effort [12]. Also, another method for software cost estimation based on Radial Basis Function Networks has designed to enhance the accuracy of the produced estimates measured [13]. Kingdom of Saudi Arabia (KSA) is one of the most consuming countries for projects and software products in the world as well as that the government has allocated thousands of millions to software production and information technology [14]. The statistics related to Saudi software industry indicate that IT spending was $3.4 billion in 2008 and expected to increase by 9% annually [15]. In contrast, the demand for software products such as banking and others in different sectors in the country becomes more and more. On the other hand, software development industry in KSA is dominated by an extremely large of small and medium size companies. However, it is not clear what the software cost estimation methods are used and whether the accurate methods and knowledge are achieved. To improve the software industry in KSA, we need to identify the current state of use to software cost estimation methods and its impact on the accuracy of software projects pricing which in turn affect the success or failure of software projects. To accomplish that objective, we have built a survey on software cost estimation methods in KSA that measures the extent of the use and adopting of various cost estimation methods. In this paper we will analyze and discuss the results of our survey and the main findings learnt from this survey. Many studies about software cost estimation methods have been done in several countries [16,17,18]. However, the related works to evaluate the software cost estimation in developing countries is very little and almost non-existent. Also, from the literature review, there is no study has been conducted to measure the effect of software cost estimation on success or failure of projects in software industry. Moreover, this study is characterized by giving some guidance to enhance the accuracy of software cost estimation in an attempt to improve the effectiveness of project management and software development process. The rest of

the paper is organized as follows. In the next section an investigation of software practices in Saudi Arabia software companies is presented. Research methodology with analysis and results are then shown and discussed in section 3. Our recommendations from this study are discussed in section 4, and a final conclusion is presented in section 5.

II. Investigating Of Software Practices In Saudi Arabia Software Industry

In 2012, a study was done on Saudi Arabia software companies concentrating on investigating the state of software engineering practice for software development [19]. This study showed that most of the software companies in Saudi Arabia were private, and few of them were public companies because of the fact that software projects industry is controlled by small companies in this country. According to this study, the percentage of public companies was 36% and private companies was 64% as shown in Figure 1 below.

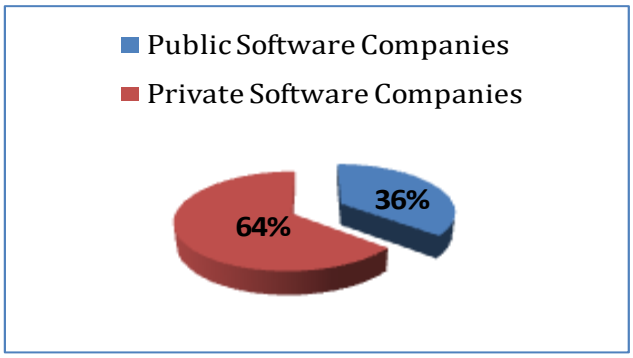


Fig. 1. The percentage of software companies in Saudi Arabia country based on [19]

Also, this study showed that most of Saudi Arabia software companies have small teams. This smallness comes from that companies frequently develop projects with small size which do not require large employees, and also the management of small employees is more simple and less expensive [19]. Figure 2 shows that the large companies have more than 200 employees with distribution ratio is 13%, intermediate companies have employees between 50 to less than 200 with distribution ratio is 38%, and small companies have less than 50 employees with distribution ratio is 49%.

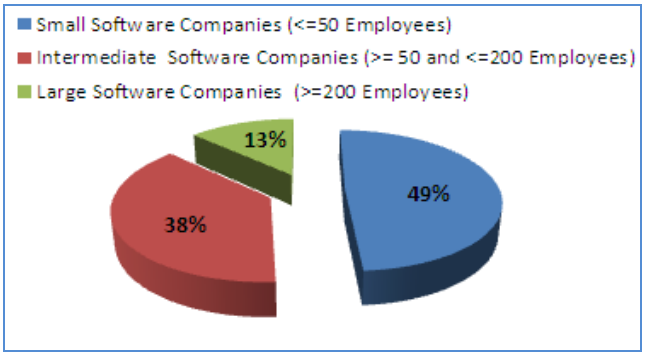
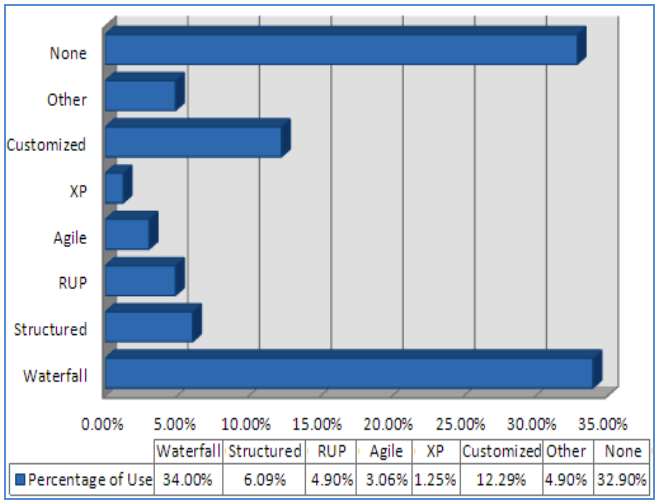


Fig. 2. Employees Scale with distribution ratio of software companies in Saudi Arabia country based on [19]

As well as, this study clarified that most of the companies that use no software development methodology are of small size companies and the rest of these small size companies use the traditional waterfall methodology as the development approach while new developing methodologies such as Structured, RUP, Agile, XP, Customized, and other methodologies were used much more in medium and large companies as shown in Figure 3. In small size companies that do not use any methodology, developers start programming on the fly without any development methodologies. The reasons of do not use any methodology in their opinion are that applying a software development methodology is a difficult task and time consuming. Other reasons were related to increasing the cost, losing the guidance, and lack to experts. Finally, this study stated that the use of software engineering tools categorized by software company size and that the medium and large companies were making good use of these tools. However, this study did not address the methods used to estimate the cost of software projects in Saudi Arabia companies and the relationship between the software cost estimation and project's failure in these companies



	Waterfall	Structured	RUP	Agile	XP	Customized	Other	None
Percentage of Use	34.00%	6.09%	4.90%	3.06%	1.25%	12.29%	4.90%	32.90%

Fig. 3. The percentage of development methodologies usage in Saudi Arabia software companies based on [19]

III. Research Methodology

Our research methodology follows the steps of software engineering institute guidelines for building the design of the survey [20]. The steps of this methodology are shown in Figure 4 and given below.

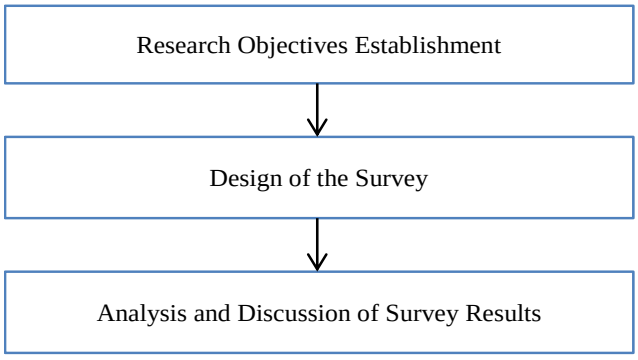


Fig. 4. Flowchart of research methodology steps

A. *Research Objectives Establishment*

In this step, we established the research objectives represented in identify the current state of use to software cost estimation methods and its impact on the accuracy of software projects pricing which

in turn affect the success or failure of software projects and does these estimation methods have improvement capabilities of software production in Saudi Arabia software industry.

B. Design of the Survey

We have conducted the questionnaire to collect data about the current software cost estimations methods in Saudi software industry. We used the collected data to assess the accuracy of these methods. However, the survey consists of 18 questions that were selected mainly from [18]. The number of questions was short and; most of the question was close ended in order to get better number of respondents. In this survey we will investigate the following points:

- The accuracy of current cost estimation methods.
- Software cost estimation techniques being used.
- At which software development phases the organizations make cost estimations.
- Reasons of inaccuracy in cost estimation methods being used.

The survey was conducted at the beginning of year 2014. Most of the questionnaires was filled up by project managers or a high skilled software developers. We distributed more than 70 questionnaires. The total of 45 completed responses were acquired and analyzed.

C. Analysis and Discussion of Survey Results

Here, we present the results and findings of the survey. We will start to analyze the current accuracy of cost estimation methods in practice. Then, we will check and discuss software cost estimation methods being used in the involved companies. After that, we will investigate when do organizations usually make cost estimations. Finally, we will analyze and discuss the reasons of inaccuracy in cost estimation methods being used.

1) Accuracy of cost estimation methods in practice

Figure 5 exhibit the cost estimation accuracy of our survey that had conducted in Saudi software industry. We found that the majority (approximately 73%) of the organizations had estimation accuracy between 70-90%, and a small rate (15%) organizations had estimation accuracy less than 70%. Finally, there was very few (almost 11%) organizations got estimation accuracy more than 90%. In the following parts, we will explain why there is a fluctuation in the cost estimation accuracy in Saudi software industry.

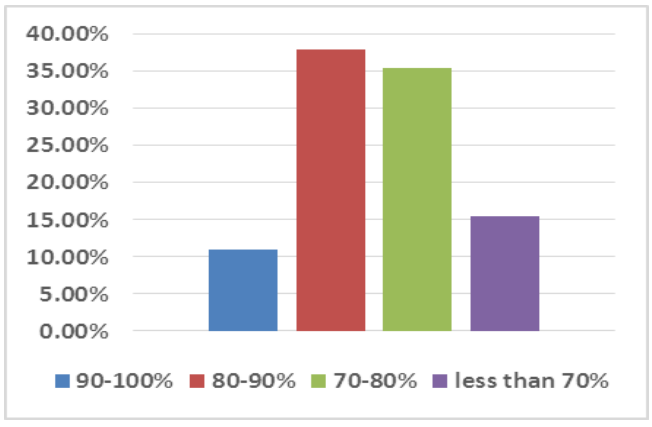


Fig. 5. Accuracy percentage of estimation methods used

2) Software cost estimation methods being used in involved companies

Regarding to our survey result, we can classify the estimation methods into four classes: expert judgment, price-to-win, estimation by analogy and algorithmic model. During the survey, we notify that the majority of the organizations use a combination of two or more methods in single estimation. In Figure 6, usage percentage of each estimation methods have been depicted. According to Figure 6, Expert judgment and price-to-win were most popular methods used in Saudi software industry, with 49% and 40% respectively. In contrast, the least two usage methods were algorithmic model and estimation by analogy, with 6.6% and 4.4% respectively. Based on survey result, we found that using expert judgment or estimation by analogy in combination with algorithmic model such as COCOMO in order to enhance cost estimation accuracy significantly. In contrast, price-to-win method usually lead to very bad estimation. However, organizations use price-to-win methods frequently because there is many competitors. Thus, they use price-to-win in order to create good relationship with customer in hope of getting repeat business.

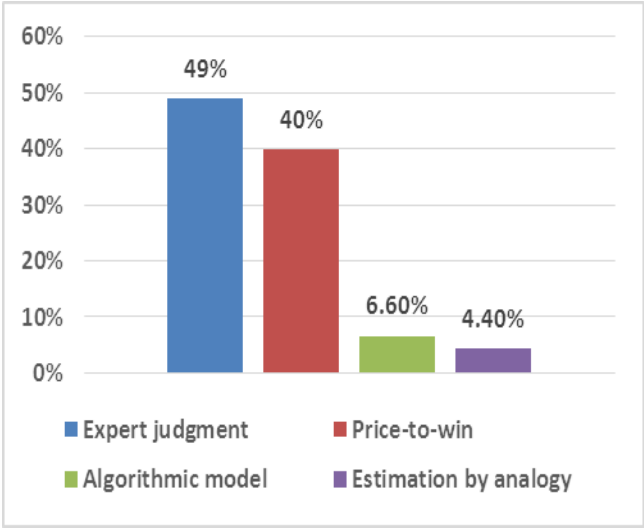


Fig. 6. Usage percentage of estimation methods

3) In practice, when do organizations usually make cost estimations?

In this part, we try to know at which software development phases the organizations make cost estimations. In Figure 7, most organizations made cost estimation at early phase of software development lifecycle such as project proposal phase, requirement analysis and feasibility study. For instance, the majority (40%) of organization made cost estimation at the project proposal phase (see Figure 7). Also, Figure 7 show that several organizations made cost estimation at requirement analysis phase, with almost 29%. We found that 22% organizations made cost estimation at feasibility study phase. Finally, it is clear that very few organizations made cost estimation in later phases such as implementation or testing phases, with 9%. We observed from the survey that organizations which do the estimation at early phases have poor accuracy whereas, a better accuracy for organizations that do cost estimations in later phases.

However, making cost estimation at early stages such as project proposal phase has a significant effect on accuracy of cost estimations, because there are many uncertainties and risks about customer requirements. Thus if it is necessary to make cost estimation at early phase, we recommend to take into account the uncertainties and risks.

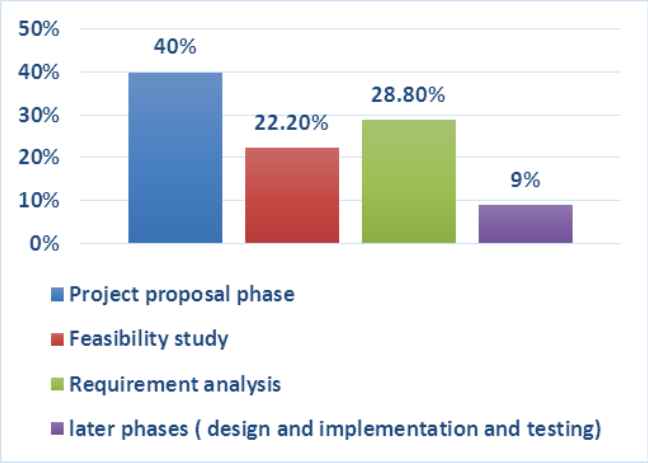


Fig. 7. Usage percentage of when they do estimation methods

4) Reasons of inaccuracy in cost estimation methods being used

According to our survey, we can recognize four reasons of inaccuracy in cost estimation methods are discussed as follow: Requirements are not clear, pressure from client or top management, lack of historical projects, and not using any cost estimation software. As we show in Figure 8 bellow, the most two reasons were unclear requirements and not utilizing any cost estimation tools, with high percentage 48% and 35% respectively. The third cause (with 13%) was pressure from client or tope management. Finally, lack of historical projects was the low rating cause with 4%. Even though most organizations use waterfall approach, they have unclear requirement as a cause on inaccuracy. The reason behind that they are usually make cost estimation at very early phase such as project proposal phase. The second reasons is using price-to-win method as a pressure from top management or customer. Despite the fact the survey result show only 4% score for "lack of historical projects" as a reason for inaccuracy, we believe that lack of historical projects will cause an observable effect on cost estimation accuracy.

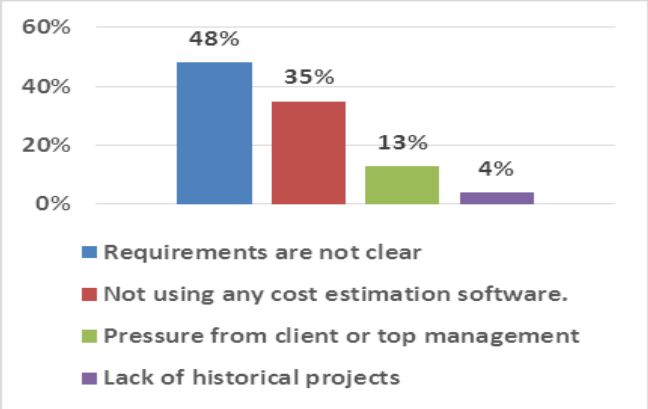


Fig. 8. Reasons of inaccuracy in software cost estimation

IV. Our Recommendations

It is clear that there are many issues that should be considered to improve the accuracy of cost estimation in Saudi software industry. According to our finding of the above survey, we give some recommendations in order to increase the accuracy of software cost estimation as follow:

- Using expert judgment or estimation by analogy in combination with algorithmic model such as COCOMO to improve cost estimation accuracy significantly.
- Reducing the use of price-to-win methods.
- Try to make cost estimation in the late phases in software development lifecycle as far as possible.
- If it is compulsory to make cost estimation at early phase, we recommend to take into account the uncertainties and risks.
- Store and use the cost estimation information of pervious projects.

V. Conclusions

In this study, we have analyzed and discussed the results of a questionnaire that was conducted in the beginning of year 2014 to examine the use of software cost estimation methods and its impact on the accuracy of software projects pricing based on the data collected from 45 software companies of different cities in Saudi Arabia software industry. From the results, we found that most of the companies use Expert judgment and price-to-win methods in software cost estimation. We also found that algorithmic model and estimation by analogy were less commonly used in software cost estimation. During our study, we recommend if the companies use expert judgment or estimation by analogy with algorithmic model such as COCOMO together then they will achieve high accuracy in cost estimation results compared to the current accuracy. Finally, several reasons of inaccuracy in cost estimation methods with our recommendations have summarized and discussed in this research paper.

VI. Acknowledgements

This work was funded by a grant from the Deanship of Scientific Research at King Saud University, which is gratefully acknowledged.

References

[1] D. Sanjeev, "Software Metrics – A Tool for Measuring Complexity", *International Journal of Software and Web Sciences*, Vol. 1, No. 2, 2012, pp. 4-7.

[2] Daniel D. Galorath and Michael W. Evans, *Software Sizing, Estimation, and Risk Management*. Boca Raton, FL :Auerbach Publications, 2006, pp. 149-185. ISBN0849335930.

[3] D. Kashyap, A. Tripathi, A. K. Mishra, "Software Development Effort and Cost Estimation: Neuro-Fuzzy Model", *IOSR Journal of Computer Engineering* (IOSRJCE), Vol. 2, Issue 4, July-Aug. 2012, pp. 12-14.

[4] K. K. Rao, G. S. V. P Raju, T. V. M. Rao, "Effort Estimations Based on Lines of Code and Function Points in Software Project Management", *IJCSNS International Journal of Computer Science and Network Security*, Vol. 8, No. 6, 2008, pp. 358-356.

[5] I. Attarzadeh and S. Hockow,, "Improving the Accuracy of Software Cost Estimation Model Based on New Fuzzy Logic Model", *World Applied Science Journal*, Vol. 8, No. 2, 2010, pp. 177-184.

[6] V. BHATTACHERJEE, P. K. MAHANTI, S. KUMAR, "Complexity Metric for Analogy Based Effort Estimation", *Journal of Theoretical and Applied Information Technology*, Vol. 6, No. 1, 2009, pp. 001-008.

[7] M. Jorgensen, S. Grimstad, "Software Development Effort Estimation — Demystifying and Expert Estimation", Berlin Heidelberg: Springer-Verlag, 2010, ch. 26, DOI 10.1007/978-3-642-01156-6_26.
[8] Ch. Satyananda Reddy and KVSVN Raju, "An Improved Fuzzy Approach for COCOMO's Effort Estimation using Gaussian Membership Function", *Journal Of Software*, Vol. 4, No. 5, 2009, pp. 452-459.
[9] P. Poscic, M. Pavlic, N. Vrcek, "Method for Estimating the Complexity of Designing Business Information Systems", *JIOS*, Vol. 32, No. 2, 2008, pp. 123-136.
[10] W. Humphrey, *Winning with Software: An Executive Strategy*, Addison Wesley, 2002.
[11] M. Cohn, *Agile Estimating and Planning*, Pearson Education Inc, 2006.
[12] V. Sharma, H. K. Verma, "Optimized Fuzzy Logic Based Framework for Effort Estimation in Software Development", *IJCSI International Journal of Computer Science Issues*, Vol. 7, Issue 2, No. 2, pp. 30-39, 2010.
[13] A. Idri, A. Zakrani, A. Zahi, "Design of radial basis function neural networks for software effort estimation", *IJCSI International Journal of Computer Science Issues*, Vol. 7, Issue 4, No. 3, July, pp.11-17, 2010.
[14] Information Technology Opportunities in the Kingdom of Saudi Arabia, An Executive Summary, 2002, Available: http://www.egovmonitor.com/reports/SA_ExecSumm.pdf.
[15] A. Talib and M. Malkawi, "Inward Strategy: An Optimal Solution to Build a Software Industry in Saudi Arabia", *IBIMA Business Review*, Vol. 2011 (2011), Article ID 126226, 17 pages.
[16] D. Yang, Q. Wang, M. Li, Y. Yang, K.Ye, J. Du, "A survey on software cost estimation in the Chinese software industry", In Proceedings of the Second ACM-IEEE international symposium on Empirical software engineering and measurement (ESEM), 2008, pp. 253-262.
[17] Z. Mansor, Z. M. Kasirun, S. Yahya, N. H. H. Arshad, "Current Practices of Software Cost Estimation Technique in Malaysia Context", In Proceedings of the Springer-Verlag Berlin Heidelberg , *ICIEIS* , Part I, *CCIS 251*, 2011, pp. 566–574.
[18] A. Ali, "A Survey on Software Cost Estimation in the Pakistani Software Industry", *IJCER International Journal of Computer and Electronics Research*, Vol. 3, Issue 1, 2014, pp. 13-19.
[19] A. Khalid, "An empirical investigation into the adoption of Software Engineering Practice in Saudi Arabia", *IJCSI International Journal of Computer Science Issue*s, Vol. 9, Issue 3, No. 3, 2012, pp. 328-332.
[20] Liming Wu, The Comparison of the Software Cost Estimating Methods, Available: 2014.http://www.compapp.dcu.ie/~renaat/ca421/LWu1.html.

Abdu Gumaei, has obtained his bachelor degree in Computer Science from Computer Science Department at AL-Mustansiriya University in Baghdad, Iraq; and his master degree in Computer Science from Computer Science Department at King Saud University, Riyadh, Saudi Arabia. Currently, he is a PhD candidate in Computer Science at King Saud University. His main areas of interest are software engineering, image processing, computer vision and machine learning. He has worked as a lecturer and taught many courses such as programming languages at computer science department, Taiz University. He has several research in the field of image processing. He has obtained a patent from the United States Patent and Trademark Office (uspto) in year 2013.

Bandar Almaslukh, is a PhD candidate in Computer Science at KSU University, Saudi Arabia. He holds a master degree in computer science from KSU University, Saudi Arabia. He is working as Lecturer at computer science department, Salman bin Abdul-Aziz University, Saudi Arabia. He has taught many courses such as programming language and data structure. He worked as Database Developer in Arriyadh Development Authority in Saudi Arabia for many years. Also, He worked as Network Administrator in Internet service provider (ISP) in Saudi Arabia. He got Bachelor Degree in computer science, college of computer and information sciences, King Saud University, Riyadh, Saudi Arabia.

Nejmeddine Tagoug, holds a PH.D in computer from the university of Montreal Canada. He is a researcher, and assistant professor in KSU University, Saudi Arabia, He has taught in many universities around the world: University of Montreal, UQAM in Canada, UAE University, Emirates, and IMAM University, King Saud University in Saudi Arabia. He worked as IT Director in the BNA Bank (Banque Nationale Agricole) in Tunisia for many years. He worked as senior consultant in computer with SCB Computer Technology, Jackson Mississippi in USA. He is the CEO of N & N Global Technology in Tunisia. He is specialist in software engineering and He has many publications in software engineering. He served as general chair in many conferences. He is editor in chief of NNGT Journals.