Kinect Based Electronic Assisting System to Facilitate People with Disabilities Using KXPRUM Agile Model

M. Rizwan Jameel Qureshi[1], Ahmed Barnawi[2]

[1-2.] Faculty of Computing and Information Technology, King Abdul-Aziz University, Jeddah, Saudi Arabia
rmuhammd@kau.edu.sa, ambarnawi@kau.edu.sa

Abstract: There is a need of electronic assisting system to facilitate people with disabilities to perform their daily life tasks. Microsoft Kinect technology was introduced with Xbox to allow the children to play games using motions instead of using joysticks. The success of Kinect technology came up heuristically to scientists to use this technology in other disciplines like medical field. This research is conducted to develop an electronic assisting system to facilitate patients to make them free of attendants to perform routine tasks like on coffee maker, on/off air conditioner/light and control wheelchair. A customized KXPRUM model is proposed to develop the electronic system. The results are reported on the first four releases of electronic assisting system. Five patients act as customer to conduct case study to validate the proposed KXPRUM model. 80% customer satisfaction is achieved to show the effectiveness of the proposed model.
[Qureshi MRJ, Barnawi A. **Kinect Based Electronic Assisting System to Facilitate People with Disabilities Using KXPRUM Agile Model**. *Life Sci J* 2014;11(10):57-62] (ISSN:1097-8135). http://www.lifesciencesite.com. 10

Keywords: automation; Kinect technology; XP; Scrum; patients with disabilities

1. Introduction

Artificial intelligence (AI) is a field of science that helps to develop smart machines having capabilities of human beings, such as reason a problem to take decision. AI software behaves rational means sensible and it performs actions and reactions with precision. Rationalism is a theory means logic. Logic is the foundation of correct knowledge. AI has several industrial and medical applications like expert systems and robotics. Robots are used in computer aided design (CAD), computer aided manufacturing (CAM) and clinical domains from many years. The new trend is to integrate Kinect technology and AI systems.

Kinect technology was first introduced by Microsoft in 2010 for Xbox 360 video game and it was a hit (Tolgyessy and Hubinsky, 2011). A new era of video games is started since Kinect was introduced. The children can play games with hands or feet without using joysticks. Kinect has the ability to recognize gestures through hands or feet. Kinect has four main parts. These parts are red blue green (RGB) camera, three dimensional depth sensing system, multi-array microphone and motorized tilt. The resolution of RGB camera is 1280x960 pixels to store three channel data to capture a color image. Kinect has the ability to recognize gestures and voice of user using depth sensing system and microphone. An infrared (IR) emitter emits infrared light beams and the depth sensor receives the IR beams returned back to the sensor and these IR beams are translated into depth information estimating the distance between an object and the sensor. A multi-array microphone consists of four microphones to capture sound. It is achievable to record audio and trace the location of the sound source and the direction of the audio wave due to the four microphones. The camera, depth sensing system and microphone are mounted on a motorized tilt unit that can rotate ±27 degree (Davaasambuu et al., 2012).

The accuracy of Kinect technology enforces scientists to use it for medical applications to facilitate the patients and elderly or physically disabled people. This paper is written to propose an electronic system using Kinect technology to assist patients and elderly/physically disabled people to perform their daily life tasks. The main functionalities are on/off: coffee maker, light, air conditioner, heater and control wheelchair. Figure 1 shows the main components of Kinect technology.

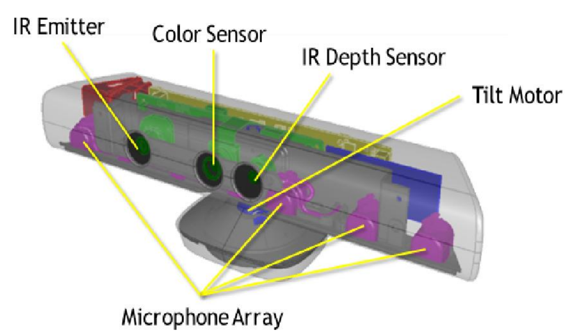

Figure 1. Main Components of Kinect Technology (Microsoft Corporation, 2014)

The paper is further organized as: section 2 covers the related work. The problem selected in this paper is covered in section 3. Section 4 describes the details of the proposed solution. The validation of the proposed solution is illustrated in section 5.

2. Related Work

The literature review is composed of two parts. First part is used to identify the details of existing applications of Kinect technology. Second part provides the details of existing agile methodologies to identify their drawbacks.

2.1 Existing Kinect based Systems

A monitoring system is proposed using Kinect sensors to assist people with disabilities (Ben Hadj Mohamed et al., 2013). The proposed system identifies movements/gestures of patients to interact with them using sensors. The proposed system needs to test in the hospitals/clinics to ensure its reliability and effectiveness.

Tolgyessy and Hubinsky (Tolgyessy and Hubinsky, 2011) are of the opinion that there is a need of more research to use the Kinect technology in robotic field especially in the educational domain. Fundamental concepts, technical knowledge and commonly used sensors are introduced to use the Kinect technology. Promising applications using Kinect sensors and robotics in the domain of education are also discussed.

Davaasambuu et al. (Davaasambuu et al., 2012) discuss virtual reality technology using Microsoft Kinect to rehabilitate patients. The objective is to identify main strengths and weaknesses of using Kinect technology in the area of electronic rehabilitation. Erdenetsogt et al. (Erdenetsogt et al., 2012) develop a prototype using six movements to test the idea. The results show that accuracy of electronic system to judge movements are between eighty eight to ninety two point five percent. The patients participated in the evaluation were quite satisfied with the performance of electronic system.

Ben Hadj Mohamed et al. (Ben Hadj Mohamed et al., 2012) established a wireless sensor network using Optimized Link State Routing (OLSR) protocol and Kinect technology to monitor the states of patients at home. The objective of Ben Hadj Mohamed et al. (Ben Hadj Mohamed et al., 2012) research is to facilitate the patients that system can generate alert message in case of emergency conditions. Chang et al. (Chang et al., 2013) developed a system to control the wheelchair using the Kinect technology. The system recognizes the gestures of disabled people whenever a wheelchair is required and it can move through a control panel.

2.2 Comparison of Existing Agile Methodologies

Main agile methodologies are Extreme Programming (XP), Scrum, Dynamic System Development Method (DSDM), Crystal and Feature-Driven Development (FDD) (Pressman, 2010). Table 1 shows the comparison of existing agile methodologies.

XP model was proposed based on ideas and practices from previously proposed process models (Beck, 1999) such as:

- concept of scheduling a project on the basis of user stories is taken from uses cases (Jacobsen, 1994).
- evolving nature of developing a SW is taken from evolutionary and spiral models.

XP model main advantages are time saving, cost saving, refactoring and suitability for small projects with small teams (Pressman, 2010). Refactoring is a technique to improve the software in terms of design and code throughout during the software development. However, some drawbacks of XP model are also reported in the literature. It is not suitable for medium and large-scale projects. Another drawback of XP process model is weak documentation (McCarey, 2005). XP model is not suitable for reusable component based development (CBD). It does not work for distributed development teams (Turk et al., 2002). XP is not suitable for outsourcing. There is a need to improve the management practices of XP. An XP project needs a high support from its stakeholders for its success (Turk et al., 2002).

The name of Scrum model was taken from an activity of rugby game. Scrum model was proposed in the early 1990s (Pressman, 2010). Scrum principles facilitate a software development team during analysis, design, evolution and deployment phases. Main activities of scrum are backlog, effort estimation, spring meetings, daily meetings and prototypes. Scrum is suitable for the development of small projects having small teams (Schwaber and Beedle, 2002). Team size should be less than ten members. Some limitations of Scrum are also reported in the literature. Scrum does not provide a comprehensive process model for development (Schwaber, 1995). Scrum is not suitable for large projects having large teams. Scrum model does not provide any guidance that how to run a thirty days release cycle throughout development of a SW.

Dynamic System Development Method (DSDM) was proposed in 1994 (Stapleton, 2003). The main phases of DSDM are 'Feasibility Study', 'Functional Model Iteration', 'Design and Build Iteration' and Implementation (Pressman, 2010). The secret of DSDM lies in small development teams like Scrum. According to Stapleton (Stapleton, 2003), DSDM is more suitable for business projects than scientific or engineering projects. DSDM works well for the development of small projects having small teams. However, there are few weaknesses in DSDM model. It is not suitable for development of medium and large-scale projects having large teams. A consortium is taken care of DSDM for its evolution. The members of consortium companies only can access to the documents and underlying procedures of DSDM model. Therefore, no significant research is found outside of the member companies (Abrahamsson et al., 2003). It can be integrated with other agile models such as with XP to get benefits of its practices but also inherits its weaknesses (Pressman, 2010).

Table 1. Comparison of Existing Agile Methodologies

Main Agile Methodologies	Main Drawbacks
XP Model	Main drawbacks of XP are weak documentation. Not suitable for distributed development teams, reusable component based development (CBD), outsourcing and all types of projects. XP needs a high support from its stakeholders for its success.
Scrum Model	Scrum is not a process model itself. It is not suitable for large projects having large teams. No guidance how to run a thirty days release cycle throughout development of a SW.
DSDM Model	DSDM is not suitable for development of medium and large-scale projects having large teams. DSDM can be integrated with XP model. But weaknesses of XP model are inherited into DSDM as well.
Crystal Family of Models	Crystal models are not suitable for distributed development teams. More validations are required to estimate its effectiveness for the development of small, medium and large-scale projects.
FDD Model	FDD is not a process model through which software is developed. It is a new model and still in the process of evolution and more works needs to be done to validate it for small, medium and large scale projects.

Crystal family of agile models was proposed by Cockburn and Highsmith (Highsmith and Cockburn, 2001. Crystal Clear, Crystal Orange and Crystal Orange Web were the main models of Crystal family (Cockburn, 2002). Crystal Clear was proposed for the development of small projects having small teams not more than six members. Crystal Orange was introduced for the engineering of medium-scale projects having a team size of ten to forty members (Cockburn, 1998). Crystal Orange Web has not yet been practiced and evaluated. Main activities of Crystal Orange for incremental development were staging, monitoring, reviewing and parallel development (Cockburn, 1998). The main objective of introducing Crystal family was to provide a range of models so that agile teams can select a suitable model according to nature of a project (Pressman, 2010). Few constraints of Crystal family of models are also observed. These models are still in the process of evolution. Crystal models have not gained the interest of researchers for their validations. Therefore, more validations are required to estimate their effectiveness for the development of small, medium and large-scale projects (Abrahamsson et al., 2003). Crystal models are not suitable for distributed development teams and only effective for co-located agile teams in a single office building (Cockburn, 2002). This is because of recommended restricted communication structure for the successful implementation of Crystal models (Abrahamsson et al., 2003).

Feature-Driven Development (FDD) is not a process model but it does provide five FDD procedures (Palmer, 2002). The five FDD procedures are ‘develop an overall model’, ‘builds a feature list’, ‘plan by feature’, ‘design by feature’ and ‘build by feature’ (Pressman, 2010), (Abrahamsson et al., 2003). It was validated initially in the late 1990’s by conducting a case study of large-scale banking software (Palmer, 2002). Palmer also suggested that FDD is equally suitable for development of new software and upgrading existing software (Palmer, 2002). FDD model also has some shortcomings like other agile models which have discussed above (Abrahamsson et al., 2003). It is a new model and needs further validation using more case studies. FDD model is still in the process of evolution. Therefore, it’s also early to comment on its suitability for the development of small, medium and large-scale projects.

A suitable agile method is hard to suggest for specific nature of projects (Abrahamsson et al., 2003). Therefore, software industry needs a suitable model that can be effectively used for small, medium and large projects. Extreme Programming (XP) and Scrum are selected to develop the proposed electronic assisting system because they are the most widely used models among all agile models. XP has been successfully implemented in several small-scale projects and most documented process model among all agile models (Abrahamsson et al., 2003) whereas Scrum is a management framework and it is suitable for medium and large projects. Another inspiration for the selection of the XP and Scrum models is that these models lie in the list of good models which are widely accepted and practiced in software industry. Therefore, there is a pressing need to integrate them to enrich their strengths and eliminate the limitations of both XP and Scrum.

3. Problem Definition

A number of attempts have been made to integrate XP and Scrum models in the last few years. However, there are few issues which are still unaddressed and there exist possibilities of improvement in the proposed integrated solutions. Therefore the first part of the research problem is:

Question 1: How to integrate XP and Scrum models to enrich strengths and eliminate limitations?

This research is focused to develop an electronic assisting system using Kinect technology. The objective of the electronic assisting system is to provide services to patients and physically disabled people. Therefore second part of research problem is.

Question 2: How to develop a system to facilitate the patients and physically disabled people using Kinect technology?"

This research integrates both XP and Scrum to propose a customized XP-Scrum agile methodology as per nature of the system to be developed. The customized KXPRUM model is validated using electronic assisting system as a case study.

4. The Proposed KXPRUM Model

The proposed electronic assisting system is developed using customized agile methodology following incremental approach. Figure 2 shows the graphical representation of the proposed XP-Scrum methodology.

Plan Phase- Plan phase deals with understanding and capture the core business requirements. Domain understanding depicts in the form of use cases. The captured data in the form of user stories, scope and vision of the system are discussed and evaluated in terms of feasibility with the organizational current status like available technical and manpower resources, user and business needs.

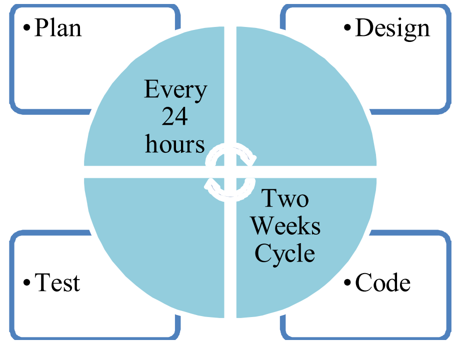

Figure 2. The Proposed KXPRUM Methodology

Product backlog is prepared at this stage. Product backlog contains the use cases and its related functionalities. These are the user requirements that are properly captured and estimated. Product owner can also attaches some priority value with these business requirements in a formal meeting with scrum master and developers. XP highly focuses to deal with complexity and keep the system as simple as it could be, so in order to achieve simplicity and to cope with complexity, use case diagram should be in refined form. Use case model contains not only use cases but also highlights the relationship among these use cases.

Sprint planning meeting is incorporated into KXPRUM methodology. A sprint planning meeting is conducted at the beginning of iteration. Two weeks are the deadline to complete iteration/release. Developers, managers and customer all sit together and look at the user stories in the product backlog during sprint planning meeting. Customer may change, add or remove requirements at this stage. The developers and customers have a conversation with each other and developer assigns estimates to each requirement. Customer decides that which requirement should be implemented in the next iteration. The customer prioritizes the requirements on the basis of time, budget and business goals.

Once the requirements for a particular iteration have been finalized and sprint backlog is ready to work for a single iteration/release. Sprint Backlog also contains the prioritized list of use cases and statistics like time and budget.

Design Phase- Metaphor is one of the important design activities. It helps to manage non-functional requirements like usability issues. Design class and object models to establish a link between use cases and code. One of the most important logical activities is to develop test cases by involving customer. All the tasks associated with design activity like metaphor, class diagram, object model, refine vision, scope documents and test case development practices are continuously and constantly monitored by the Scrum master through daily scrum meetings. Scrum master plays an important role in evaluating usability issues. Scrum master shows continuous prototypes to customer to take approval of customer. The objective of the design phase is to implement effective practices to achieve a sprint within budget and schedule to meet deadlines.

Code Phase- The sprint is ready to code following XP practices by preparing test cases first. Pair programming, Test driven development, refactoring, code ownership, coding standard and continuous integration practices are integrated into the proposed XP-Scrum model to achieve efficiency.

Test Phase- Unit, integration, system and acceptance tests are performed using automated tools. NUnit tool is used for unit testing. FitNesse tool is used for integration and system testing. NCover tool is used for code coverage. TestDriven.Net tool is used integrate the NUnit, FitNesse and NCover tools with Visual Studio.Net to cut down the testing effort, resources, time and cost. Sprint release is ready to deploy at the customer side after his approval during acceptance testing.

Sprint retrospective quality assurance practice is applied on each sprint. Sprint is reviewed to maintain a feedback cycle to improve the next sprint. This is achieved by discussing the problems of current sprint and planning the improvements.

5. Validation of the Proposed KXPRUM Model

A case study (electronic assisting system using Kinect technology) is used as a research method to validate the proposed KXPRUM model. A controlled case study is conducted by a team of six members. Team is formed as per the guidelines of XP model. Six students are selected from the 'Software Engineering' course to complete this case study as a course project. First four releases of the case study are included in this research to conclude the results. Completion time to complete four releases is eight weeks. Patients are visited to different hospitals in the locality to gather requirements. Five patients are voluntarily involved in this case study to act as the role of customer. These five patients, who took part in the electronic assisting system case study, are described hence onwards in this paper as customer.

Scrum master showed prototypes to the customer to validate system. First release was completed after three weeks, whereas second, third and fourth releases were accomplished after 2, 2 and 1 weeks respectively. The authors acted the roles of 'product owner' and 'scrum master' simultaneously as per the guidelines of XP and Scrum. The authors' assigned different roles and responsibilities to team. The authors monitored and managed all tasks during this case study to ensure validity of the proposed KXPRUM model.

The results of case study are reported based in Table 2. The results are reported based on the first four releases of electronic assisting system. Table 2 shows that the total size of first four releases is 68.17 kilo lines of code (KLOC). The first release is 30 kilo lines of code (KLOC) within duration of 3 weeks. The sizes of next three releases are 20.46 KLOC, 18.4 KLOC and 26.31 KLOC within duration of 2 weeks, 2 weeks and 1 week subsequently. Release 1 took more time to complete than the next three releases due to its larger size and team was in the learning phase of KXPRUM model. 69 user stories are completed during the four releases. 23 errors per KLOC are discovered as compared to 2.456 defects per KLOC. 80% pair programming is practiced during the completion of four releases. 40% customer's involvement with 88.5% customer's satisfaction is achieved after completion of the first four releases. The validation of the first four releases of electronic assisting system using Kinect technology depicts the usefulness of KXPRUM model.

Table 2- Summary of the Case study Results

Item	R1	R2	R3	R4
Calendar Time (weeks)	3	2	2	1
Total Tasks Defined	5	5	5	5
Number of user stories	20	17	15	17
Classes	4	3	8	4
Total KLOC	30	20.46	18.4	26.31
Pre-release errors	8	5	6	4
Post Release defects per KLOC	0.333	0.733	1.086	0.304
Pair Programming %	80%	80%	80%	80%
Customer Involvement (sprint Hours/week)	40%	50%	40%	30%
Customer Satisfaction	90%	99%	95%	70%

6. Conclusion

There are two problems taken up in this research. First is to propose KXPRUM model to solve the industry problem to select a suitable agile model for small, medium and large projects. Second problem is to develop an electronic assisting system using Kinect technology to facilitate people with disabilities to perform their daily lives tasks. XP and Scrum are selected to solve the first part of research problem after comparing agile models due to their effectiveness and usage in software industry. XP is suitable for small projects whereas Scrum is suitable for medium and large projects. There is a need to propose a suitable model that can be effectively applied for all types of projects. This is accomplished by proposing an integrated KXPRUM model by combining the strengths of both XP and Scrum models and eliminating their limitations. Electronic assisting system is developed as a case study research to validate the proposed KXPRUM model to deal with second part of research problem. The results are concluded based on the first four releases of proposed system. The results show the usefulness of KXPRUM model. The first four releases are completed within estimated budget and schedule. The proposal of KXPRUM, by combining the strengths of XP and Scrum, is a guideline for software industry to show its suitability for small, medium and large projects.

Acknowledgements:

This work was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, under grant No. (611-005-D1434). The authors, therefore acknowledge with thanks DSR technical and financial support.

Corresponding Author:
Dr. M. Rizwan Jameel Qureshi
Department of Information Technology
Faculty of Computing & Information Technology, King Abdulaziz University
80221 Jeddah 21589, Saudi Arabia
E-mail: rmuhammd@kau.edu.sa

References

1. Tolgyessy M, Hubinsky P. The Kinect Sensor in Robotics Education. Proc. of 2nd International Conference on Robotics in Education, Vienna, Austria, 2011.
2. Davaasambuu E, Chiang C, Chiang JY, Chen Y, Bilgee S. A Microsoft Kinect based virtual rehabilitation system. Proc. of 5th International Conference on Frontiers of Information Technology, 2012.
3. Microsoft Corporation. Kinect for Windows Sensor Components and Specifications. 2014.
4. Ben Hadj Mohamed A, Val T, Andrieux L, Kachouri A. Assisting people with disabilities through Kinect sensors into a smart house. Proc. of International Conference on Computer Medical Applications, 2013.
5. Ben Hadj Mohamed A, Val T, Andrieux L, Kachouri A. Using a Kinect WSN for home monitoring: Principle, network and application evaluation. Proc. of International Conference on Wireless Communications in Unusual and Confined Areas, 2012.
6. Chang C-L, Chen C-C, Chen C-Y, Lin B-S. Kinect-based Powered Wheelchair Control System. Proc. Of 4th Internation Conference on Intelligent Systems Modelling & Simulation, 2013.
7. Pressman RS. Software Engineering. McGraw Hill Press, USA, 2010.
8. McCarey F. Agile software reuse recommender. Proc. 27th Int. Conf. Software engineering, St. Louis, MO, USA, 2005.
9. Turk D, France R, Rumpe B. Limitations of Agile Software Processes. Proc. 3rd Int. Conf. eXtreme Programming and Agile Processes in Software, Ireland, 2002.
10. Schwaber K, Beedle M. Agile Software Development with Scrum, Prentice Hall, USA, 2002.
11. Schwaber K. Scrum Development Process. Proc. Of the OOPSLA'95 Workshop on Business Object Design and Implementation. Springer-Verlag, 1995.
12. Stapleton, J. DSDM: Business Focused Development, Addison Wesley, London, 2003.
13. Abrahamsson P, Juhani W, Mikko TS, Jussi R. New Directions on Agile Methods: A Comparative Analysis. Proc. 25th Int. Conf. Software Engineering, Portland, Oregon, 244-254, 2003.
14. Highsmith J, Cockburn A. Agile Software Development: The People Factor. Computer 2001; 34:131-133.
15. Cockburn A. Agile Software Development, Addison Wesley, USA, 2002.
16. Cockburn A. Surviving Object-Oriented Projects, Addison Wesley, USA, 1998.
17. Palmer SR, Felsing JM. A Practical Guide to Feature-Driven Development, Prentice Hall, USA, 2002.

8/12/2014