Mobile Embedded Application for Egg Incubator

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Abstract-*This study aimed to develop "Mobile Embedded Application for Egg Incubator. This study was intended for poultry raiser and people who are interested in raising poultry animals. It focuses mainly on the development of mobile embedded system which is attached to the egg incubator. The study also includes the design and coding of programs specifically needed for the development of the embedded system. The embedded system has the capability to send and receive data from mobile application. The mobile application can send information such as: date and time the eggs are to be incubated; number of eggs to be incubated; types of eggs. The types of eggs which were included in this research were chicken, turkey and duck eggs. The embedded system has the capability to respond to real time mobile inquiry regarding hatching information. The incubator was powered by 220 volts AC voltage. The result revealed that the system's functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability and portability were "excellent".*

Keywords*: Egg Incubator, Embedded System, Mobile Application*

INTRODUCTION

The concept of embedded system is usually attached to the structure or equipment of an application. It can be an independent system or it can be a part of a large scale system. According to Sankar[1] embedded system offers many benefits such as sophisticated control, precision timing, low unit cost, low development cost, high flexibility, small size, and lightweight. These basic characteristics can be used to improve the overall performance of the system such as improved performance, more functions and features, reduced cost and increased dependability.

When using an embedded system there is a choice between the use of a microcontroller or a microprocessor. According to Benti [2], a microcontroller based system is composed of a central processor unit commonly known as CPU, an integrated memory and peripheral devices attached to the computer system. Since microcontrollers require fewer external components it is most widely used in embedded system design. On the other hand, the Microprocessor based systems contain a CPU and external memory chips and system peripherals. Microprocessors require more devices on the board, hence it allows more expansion and selection of required peripherals. This approach is commonly used for larger embedded systems.

One of the key elements of any embedded system is the software that is used to run the microcontroller. An embedded system is composed of the hardware where the system is attached as well as the software that makes the hardware functional. The software used in the embedded system is set of machine instructions which are also called a program. The microprocessors or microcontrollers used in the hardware circuits of embedded systems are programmed to perform specific tasks by following the set of instructions.

According to Aragal[3] all the assembled units of an embedded system worksall together following the set of program or set of rules embedded into the microcontroller. However, by using this microcontroller programming techniques only a limited range of problems can be solved. The range of the microcontroller capability is based on the capacity of the hardware component of the microcontroller on hand and the programming language used to run the entire system.

Embedded system can be used in different platform such as in Agriculture, Engineering, and Information and Communication Technology. Embedded system can also be used for specific applications such as foregg incubation. Due to the need for proper hatching procedure, one should follow the required temperature within the incubator, the tilting of eggs as well as the number of days the egg

should be incubated in order to obtain successful and higher hatchability rate of egg incubation.

Poultry raisers and incubator operator sometimes forget to check the status of the eggs inside the incubator on the important period of hatching process like candling, transferring of eggs from setter to hatcher and hatching date which leads to hatching of some eggs while others do not hatch at all. This scenario causes waste of time, money and effort on the part of the poultry raisers and owner. According to Bamikefa, Ogunwuyi, Agbolade and Ayoade [4], a devise should be developed in order to reduce the stress of monitoring and aiding the agricultural industry to increase productivity in poultry production.

Moreover, according to Clauer [5], many domestic bird owners incubate eggs to help them sustain their flock over time. This study is designed to assist those who wish to incubate small numbers of domestic poultry eggs. In the design of this incubator system, four factors were considered such as artificially temperature, humidity, ventilationand turning. Among these four factors, temperature considered the most critical.The Incubator temperature should be maintained between 99° and 100°F. The acceptable range is 97° to 102°F. Mortality is seen if the temperature drops below 96°F or rises above 103°F for a number of hours. If the temperature stays at either extreme for several days, the eggs may not hatch.

Several researches have been done to devise new innovative techniques in controlling and monitoring temperature inside an incubator. FeiLinyun [6] developed the Intelligent Constant-Temperature Incubator which is composed of incubator body, a temperature sensor, electric heater,and the camera shooting apparatus which are all connected with the controller. The incubator allows the temperature in the incubator to be constant and can be adjusted depending on the needs of the poultry grower.

The study is also anchored to Yujie [7] who developed the Egg Turning Mechanism of Incubator. The device is composed of a fixing frame which handles the movable rod containing the oscillating rod. Using the movable rod, the device is capable in turning eggs automatically or without human interventions.

Ming [8] also designed and developed a utility model for remotely monitored portable incubator. Thisincubator is composed of an incubator body, a box body and a cover. The device was designed to sends SMS notification when there is a change in the temperature inside the incubator.

As stated from the previous literatures, the need for monitoring eggs inside the incubator still exists among the poultry owners and raisers. Yet there is still a need to notify owners of the candling and settling schedule of the hatching eggs since a delay in the egg transfer can cause valuable loss to the poultry owners. Thus, this study has been developed.

OBJECTIVES OF THE STUDY

The main objective of this study is to design, develop and evaluate a Mobile Embedded Application for Egg Incubator.

Specifically, the study was conducted to design and develop a mobile embedded applications for egg incubator that can send notification and respond to inquiry during candling and hatching period and evaluate the system based on ISO/IEC 25010 product quality model in terms of functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

METHOD

To depict how the user interact with the system and the functionality of the system itself, an Activity Diagram is used as shown in Figure 1.

An Activity Diagram presents the step by step actions or system flow of control in systematic way as depicted in a flowchart or dataflow diagram. Activities modelled in an activity diagram can also represent sequential and concurrent process flow to show behaviour or object flow with emphasis on the sequence and conditions of the flow [9].

The activity diagram shows the work flow of the system. As shown in Figure 1, the user will have to set the date and time using his/her mobile applications. The system will record the date and time and turn on the incubator.

The system will automatically turn and tilt the eggs as needed. In a specified period which the system automatically calculated based from the entered date, the system will automatically notify the user about the viewing, candling, transferring of eggs from setter to hatcher and hatching period.

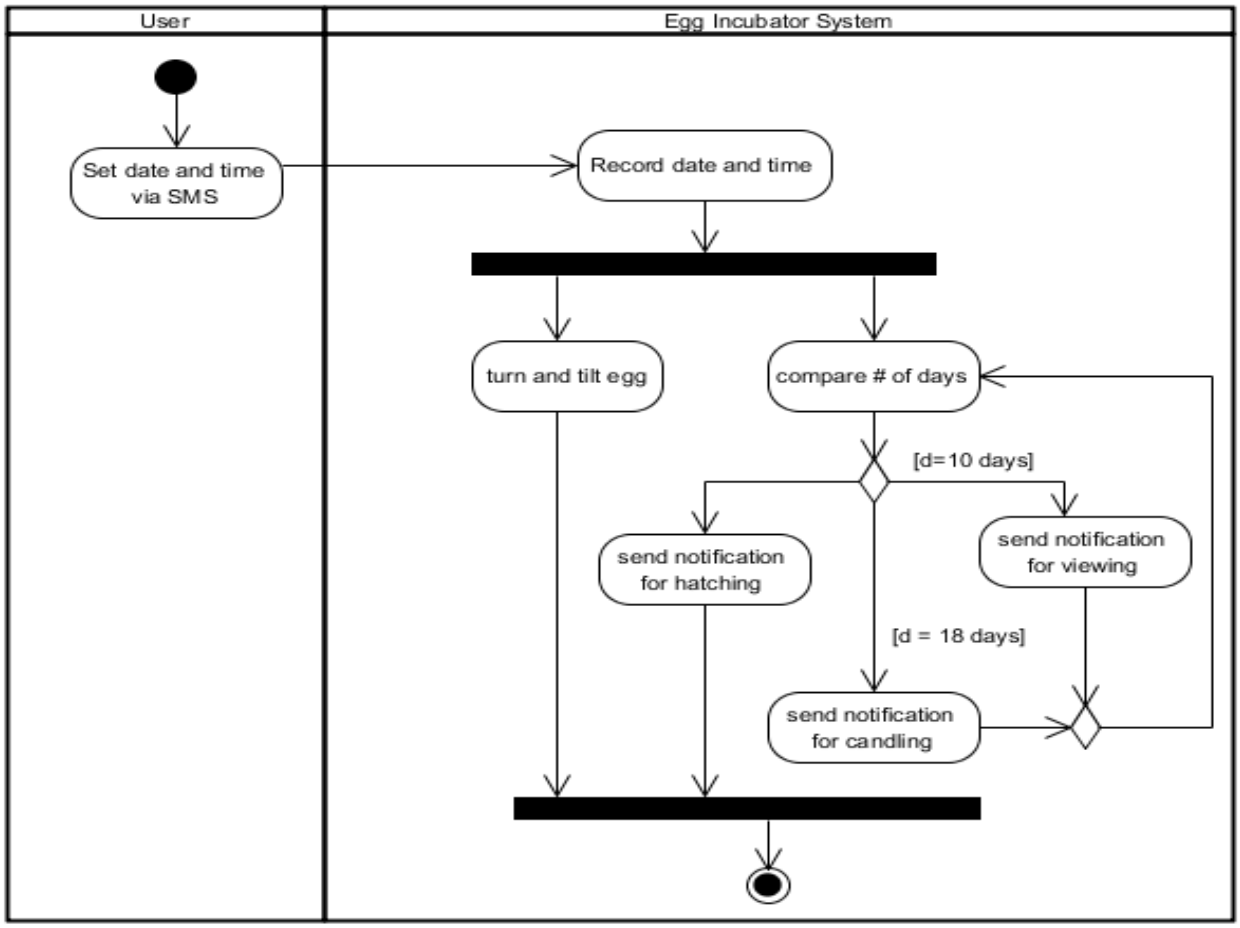

Figure 1. Activity diagram of the study

The system will continually do the entire process if the system receives an input from the mobile application about the newly placed egg inside the incubator.

To show how the system will be deployed, a deployment diagram is presented in Figure 2. Deployment diagram according to uml-diagrams.org [10] is a UML diagram which shows the architectural design of the system as it is deployed or distributed to the target clients.

Deployment diagram could be a specification level deployment diagram and Instance level deployment diagram. The Specification Level Deployment Diagram shows the overview of deployment of artifacts to deployment targets without referencing to a specific instances of artifacts or nodes. On the other hand, Instance level Deployment Diagram shows deployment of instances of artifacts to specific instances of deployment targets. It could be used for example to show differences in the deployment of servers and server devices as stated in uml-diagrams.org [10].

The device is designed with an embedded system attached to it. The GSM module is in the system as well to allow the system to send and receive messages from the mobile application.

The user of the system can use his/her mobile phone in entering essential data to the system for the embedded system to function. The user should send the date whenthe egg is placed inside the incubator, the egg type and the number of eggs placed inside the incubator. The system stores this data in the external memory. The system automatically calculates the number of days the group of egg has stayed in the incubator. Once a specified time was reached, the system sends a message to the user or owner to transfer the egg.

The user can also send inquiries to the system. The system sends its reply to the user containing the egg details inside the incubator.

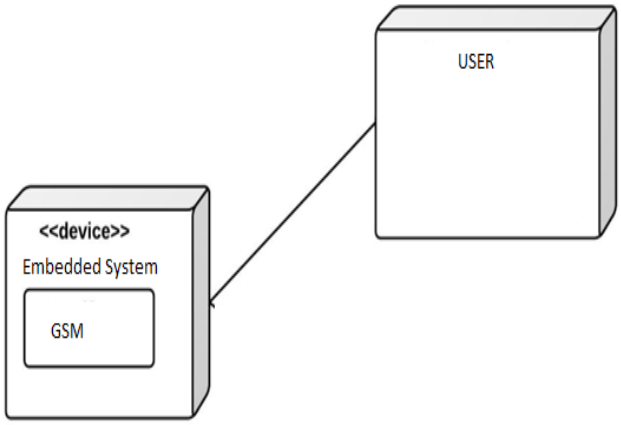

Figure 2. Deployment Diagram of the Study

The system was evaluated using the white box and black box testing using the test case methods. Black Box Testing as stated in software testing fundamentals.com [11], is a testing techniques that is design to test the overall functionality of the system instead of the system codes and logical flow. The test is done to determine incorrect or missing functionalities of the system, and errors in the system's behaviour and performance.

To test the system using black box testing several poultry raisers were invited to test the functionality of the system. Using this method, the researcher was able to determine whether the system operates in accordance to the specifications needed by actual poultry owners and raisers. This group of people were invited for black box testing since their expertise and experience in poultry raising can help assess the efficiency of the study.

To test the system using White Box testing, the researcher invited Information and Communication Technology (ICT) professionals such as programmers, database managers and embedded system designers since this group of people is knowledgeable to the various ICT concepts used in the study. The system was then evaluated based on ISO 25010.

The researcher used purposive sampling techniques to identify the respondents of the study. According to Crossman [12] Purposive sampling is used for the evaluation of the system in which every member of the group or population is given the chance to be a respondent of the study. Purposive sampling is advantageous when sampling does not require proportionality or one is in need to reach the target respondents more quickly.

A questionnaire is prepared for the evaluation of the system's output and functionality. This questionnaire is used as a tool to evaluate the system's conformance to ISO 25010 by the selected Information and Communications Technology experts and end users. The respondents were given a questionnaires and the result were computed to get the arithmetic mean using a Microsoft Excel.

RESULTS AND DISCUSSION

This research was evaluated based on ISO/IEC 25010:2011 System and Software Engineering – Systems and Software Quality Requirements and Evaluation Models. The system was evaluated based on its functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

As shown in Table 1 is the result of the ISO 25010 evaluation of embedded mobile system for egg incubator hatching system. The grand mean as to the evaluation of the end users is 4.68 which is denoted as Excellent and the grand mean for the ICT experts is 4.67 which is also denoted as Excellent. The evaluation of the system as a whole has a mean rating of 4.69 which is denoted as Excellent.

Table 1. Summary of ISO Evaluation of Embedded Mobile Application for Egg Incubator

Characteristics	End Users		IT Experts		Entire Group	
	M	Description	M	Description	M	Description
Functional Suitability	4.87	Excellent	4.82	Excellent	4.84	Excellent
Performance Efficiency	4.60	Excellent	4.64	Excellent	4.62	Excellent
Compatibility	4.47	Excellent	4.41	Excellent	4.55	Excellent
Usability	4.55	Excellent	4.80	Excellent	4.68	Excellent
Reliability	4.60	Excellent	4.68	Excellent	4.64	Excellent
Security	4.64	Excellent	4.56	Excellent	4.60	Excellent
Maintainability	4.75	Excellent	4.64	Excellent	4.85	Excellent
Portability	4.75	Excellent	4.73	Excellent	4.76	Excellent
Grand Mean:	4.68	Excellent	4.67	Excellent	4.69	Excellent

The result of the evaluation means that the embedded mobile system for egg incubator hatching system has conformed to the software quality standards set by ISO/IEC 25010.

The functional suitability characteristic of the system was evaluated and was given a mean rating of 4.87 which is denoted as excellent by the end users and a mean rating of 4.82 which is also denoted as excellent by the ICT experts. As a whole, the functional suitability characteristic of the system has a mean rating of 4.84 and is also denoted as excellent. This means that the system was able to meet the set of functions that covers the entire specified task and user objective, the system provides the correct results with the needed degree of precision and the system facilitate the accomplishment of specified task and objectives.

This is supported by FeiLinyun [6] which states that functional suitability ensure the compliance of the needs of clients, reduce errors in software operation and improve confidence and satisfaction of the clients. The result of the evaluation shows that the potential end users and ICT professionals agreed that the system meets the specified requirements and thus, evaluated as excellent. This implies that the system's functionality conforms to the set of standards as stated in ISO 25010 and meet the system requirements as stated in the objectives of the study.

The performance efficiency of the system was rated by the end user with a mean of 4.60 denoted as Excellent and the ICT experts rated the performance efficiency of the system with the mean of 4.64 denoted as excellent. The grand mean for the system's performance efficiency has a mean rating of 4.62 which is denoted as excellent. As stated by Berander [13] it is important to measure performance efficiency since it will affect customer satisfaction, productivity, scalability, and response time and resources allocation. The result of the system evaluation implies that the system response time and processing time is acceptable given that the response of embedded system to the SMS application is in real time. This means that the system's response time, processing time and throughput rates meets the system requirements, the amount and type of resources needed by the system and the maximum limit of the system meets the needed requirements. The result also shows that the system use the computer resources efficiently.

The Compatibility of the system is rated by the end user with a mean of 4.47 denoted as Excellent and the ICT experts rated the Compatibility of the system with the mean of 4.41 denoted as excellent. The grand mean for the system's Compatibility has a mean rating of 4.55 which is also denoted as excellent. This means that the system can perform its specified functions efficiently while sharing resources with other system components and exchange valuable information to other components of the system.

According to Liu [7] compatibility evaluation ensures that the system can be install and function on multiple environments and only need minimum computer specification to run the software. This shows that the system conforms to the Compatibility characteristics of software under ISO 25010. The result of the evaluation implies that the system can work effectively with other platform like the SMS gateway or web application. Moreover, the system was able to work with the different modules and pass and receive data from the data repository.

The evaluation of usability characteristic of the system shows that the system is easy to learn and use. The end users rated the system's usability with the mean of 4.55 which is denoted as excellent. The ICT experts rated the system's usability with the mean rating of 4.80 which is denoted as excellent. The overall evaluation shows that the respondents rated the usability of the system with the mean of 4.68 which is denoted as excellent. This means that the system is recognized by the user as appropriate for their needs, the system enables the user to learn how to use the system efficiently, the software is easy to operate, controls and menus are appropriately available for use, the system protects the user against errors in data entry, the system provides the user with pleasing and satisfying interaction for the user and the system allows the user to perform specified goals in a specified context of use.

According to Walters [14] an egg incubator is usable when the user can learn how to use the application without the need for technical support and training cost. Moreover, usability ensures increase in user satisfaction and acceptance. The result of the evaluation supports what has ISO 25010 has stated since the result of the system evaluation in terms of usability implies that the system meets the requirement for the usability of the system. This implies that the system is easy to use, learn and is appropriately design for its intended users. Moreover, the result of the evaluation shows that the system protects the user from entering wrong data inputs by providing them easy to use menu and controls.

The Reliability characteristic of the system was evaluated by end user with the mean of 4.60 which is denoted as excellent. The ICT professionals rated the system with a mean of 4.68 which is denoted as excellent. The overall mean of the system's reliability is 4.64 which is denoted as excellent. This means that the system is reliable to operate under normal circumstances, the system is accessible to its intended users, the system operates despite hardware and software failures and the system can recover after a system fault. This result conforms to Aragal[3] that said that system's reliability is shown when the system is failure free for a period of time under a certain environment and is capable to restore itself when failure occur. The result implies that the system meets the requirement for the reliability characteristics of ISO 25010 standard. This result denotes that the system as perceived by the respondents handles incoming data while maintaining performance level. This also means that the system is consistent in the storage and retrieval of the needed data and the user interface elements of the system functions properly. The result also implies that the system can also be easily restored when a system failure occurs.

The Security characteristic of the system was evaluated by end user with the mean of 4.64 which is denoted as excellent. The ICT professionals rated the system with a mean of 4.56 which is denoted as excellent. The overall mean of the system's reliability is 4.60 which is denoted as excellent.

This result means that the system can ensure data accessibility only to those who are authorized. The system prevents unauthorized access to and modification of the program. The system can prove that actions have taken place so that it cannot be repudiated later. Actions can be traced to the entity and the system can identify a subject or resource to be the one claimed [15].

This result also conforms to what Viswanathan [16] has stated that there is a need to ensure that information remains confidential and only those who should access the information can access it. The result of the evaluation implies that the system was able to provide security measures to the users of the system. The system was designed to have a user log in to ensure that only authorized users can view and modify data within the system. The authorized person was given the privilege to manage all the functionalities of the system as well as view logs, and recordings.

The Maintainability characteristic of the system was evaluated by end user with the mean of 4.64 which is denoted as excellent. The ICT professionals rated the system with a mean of 4.85 which is denoted as excellent. The overall mean of the system's reliability is 4.75 which is denoted as excellent. This means that the system is composed of several components such that a change to one component has minimal impact on other components, the system can use more than one resource, and the system can diagnose itself for deficiencies or causes of failures.

This result conforms to what is stated in Bajaj [17] that maintainability is a property of a software product that guarantees software's efficiency to go through the modification process and meet the frequently changing requirements of the clients or customers. The result taken from the respondents implies that the system provides a mechanism for analysis to determine the cause of an application error such as an error page. The result also implies that the system has a well-designed hierarchy of interfaces which is easier to follow, understand and maintain. The system applied the process of normalization to the application's database which ensures consistency and reliability of data. The table is normalized to avoid repetition of information and data entry.

The Portability characteristic of the system was evaluated by end user with the mean of 4.73 which is denoted as excellent. The ICT professionals rated the system with a mean of 4.76 which is denoted as excellent. The overall mean of the system's reliability is 4.75 which is denoted as excellent. This means that the system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments, the system can be successfully installed and/or uninstalled in a specified environment, and the system can replace another specified software product for the same purpose in the same environment.

The result conforms to what is stated in SoftwareTestingClass.com [18] that portability is a type of testing in which software application is installed from one environment to other, may be from one platform to another platform with different hardware and software configuration. The whole purpose is to check whether application is able to run and can be deployed in different applicable environment, in order to satisfy business needs of the customer.

The result of the evaluation implies that the system conforms to the concept stated by SoftwareTestingClass.com [18]. The system adheres to the idea that the system should be portable and can

be deployed using several applications like camera, email SMS and the database. The system was designed to provide an automated deployment system which eases the installation of the application, the system is adaptable on different platform, and the system provides the capability to install its needed component using a standard set-up.exe file.

The over-all excellent rating obtained by mobile embedded application for egg incubator indicates that the stated requirements of the system has been achieved and performed.

CONCLUSION AND RECOMMENDATION

Based on the results as earlier presented, the system has achieved and meet all its specified requirements and objectives. These include the design and development of mobile embedded application that specifically can send notification and respond to inquiry during candling and hatching period. Moreover, based on the perception of respondents from the Information and Communications Technology (ICT) sector and potential end users the system was excellent in all the eight software quality characteristics as based on ISO 25010.

To enhance the device functionality, future researchers could connect the application online and generate reports for documentation. Moreover, it is also recommended for future researchers to improve the study by sending notification to the registered users if there is a loss of primary power source in the incubator system.

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