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DEVELOPMENT OF PROTOTYPE AUTOMATED EGG INCUBATOR WITH INTERNET-OF-THINGS (IoT) APPLICATION

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Abstract: Incubation is a technology that provides an opportunity for farmers to produce chicks from eggs without the need for the mother hen. It is one of the fastest ways of transforming eggs into chicks. To meet the high demand that the poultry industry is facing, the need to maximize poultry production should be addressed. Hence, this research study aimed to develop and test a digital egg incubator that can autonomously incubate eggs while allowing a user to remotely monitor the egg incubation and hatching process in a mobile app using Internet-of-Things (IoT) technology. The innovation of a prototype autonomous egg incubator with-internet of things application was developed overarching the objectives to determine the production yield of the prototype automated egg incubator, determine the efficiency of the prototype automated egg incubator in terms of the number of eggs hatched, humidity, temperature, and egg turning, evaluate the prototype automated egg incubator embedded system using the ISO-IEC 25010 system product quality evaluation, and determine its acceptability o in terms of its usability, functionality, and performance. Henceforth, the field testing and experimentation data of this study showed that the device garnered 100% efficiency score in terms of maintaining temperature, humidity, and CO_2 (ventilation), as well as managing the egg-turning mechanism. In addition, the IoT Egg Incubator and Hatching device's average output of 94% efficiency in egg hatching with a production yield of 0.94 further supports the claim. Furthermore, the conducted ISO-IEC 25010 System Product Quality Evaluation for the proposed device indicated that the evaluating panel of IT experts found the embedded system to be excellent in terms of functional suitability, performance efficiency, usability, and reliability. Moreover, the Acceptability Evaluation in terms of its usability, functionality, and performance was very acceptable and indeed useful and functional, and it can incubate and hatch poultry eggs adequately.

Keywords: Agriculture, Technology, Internet-of-Things, Developmental Research

I. INTRODUCTION

Incubation is a technology that provides an opportunity for farmers to produce chicks from eggs without the consent of the mother hen. It is one of the fastest ways of transforming eggs to chicks. The most important difference between natural and artificial incubation is the fact that the natural parent provides warmth by contact rather than surrounding the egg with warm air. For this reason, the project presented involves an intricate design of a IoT Egg Incubator and Hatching Device with a digital readout display and a microcontroller embedded with program for manipulating sensors, mechanical and electrical components. This machine is capable of automated continuous monitoring and maintaining the operating temperature and humidity using an automatic switching technique for poultry eggs.

The main objective of this study was to develop a prototype automated egg incubator using the Internet-of-Things (IoT) technology. Specifically, this project aimed to evaluate the prototype automated egg incubator embedded system using the ISO-IEC 25010 system product quality evaluation, determine the production yield of the prototype automated egg incubator, determine the efficiency of the prototype automated egg incubator in terms of the number of hatchability, humidity, temperature, and egg tilting, and determine the acceptability of the prototype automated egg incubator in terms of its usability, functionality, and performance.

II. METHODOLOGY

This qualitative descriptive research was purely data-derived, and that codes are generated from the data in the course of the study. A descriptive survey was developed and utilized to assess and determine the Production Yield of IoT Autonomous Egg Incubator, as well as determine the IoT Autonomous Egg Incubator Efficiency, and evaluate the IoT Autonomous Egg Incubator Embedded System (SAPE-IES) in terms of its usability, functionality, and performance using the ISO-IEC 25010 System Product Quality Evaluation.

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A Chick Hatching Chart adopted from saltinmycoffee.com were used to record the over-all progress of the Egg Incubation Process. In determining the Production Yield Efficiency, the Efficiency in terms of the number of hatched eggs (hatchability), and determining the Efficiency in terms of humidity, temperature, CO_2 (ventilation), and egg turning, the following datasheets were used as instruments: Candling Test Datasheet, Egg Incubation Datasheet. Temperature Datasheet, Humidity Datasheet, CO_2 Datasheet, and Egg Turning Datasheet.

The instrument adopted for the evaluation of the IoT embedded system of the Egg Incubator and Hatching Device is the ISO-IEC 25010 System Product Quality Evaluation Tool. ISO25010 (Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuaRE) – System and software quality models) is a software quality standard. It describes the models, consisting of characteristics and sub-characteristics, for both software product quality, and software quality in use together with practical guidance on the use of the quality models.

III. RESULTS AND DISCUSSION

Production Yield of the Prototype Automated Egg Incubator

A total of three incubation cycles were performed during this phase, namely 1st Incubation Trial, 2nd Incubation Trial, and 3rd Incubation Trial. On the 18th - 21st day of incubation, the hatching process took placed. 'Pipping' is when the chick begins to break through the inner membrane and then the shell itself, sometimes taking more than twenty-four hours. Also, chicks are very wet when they come out of the egg at which they need to be left in the incubator until they're dry and fluffed up. Then eventually, a thorough examination was made on the chicks for any abnormalities or undesirable characteristics. The researcher adopted the blank Egg Incubation Datasheets (EID) used by the local Egg Hatchery Farms for data gathering during the whole process.

Eventually, on the hatching days (between the 18th to 21st day of the incubation), out of seventy-six (76) healthy poultry eggs in the 1st Incubation Trial, seventy (70) successfully hatched, with six eggs failed to completely develop. During the 2nd Incubation Trial, out of seventy-four (74) healthy poultry eggs, seventy-two (72) successfully hatched, with two eggs failing to fully develop into chicks. Then on the 3rd Incubation Trial, out of seventy-five (75) healthy eggs, seventy (70) hatched, with five eggs failing to completely develop into chicks.

Efficiency of the Prototype Egg Incubator in Terms of Number of Egg Hatched

The efficiency of the prototype egg incubator in terms of the number of eggs hatched on the 18th - 21st day, the hatching process took place. On the hatching days (between the 18th to 21st day of the incubation), out of seventy-six healthy poultry eggs in the 1st Incubation Trial, seventy (70) successfully hatched, with six eggs failing to completely develop this means that in the first trial, the percentage of production yield is 92%. During the 2nd Incubation Trial, out of seventy-four (74) healthy poultry eggs, seventy-two (72) were successfully hatched, with two eggs failing to fully develop into chicks in the 2nd trial showing that 97% production yield. Then on the 3rd Incubation Trial, out of seventy-five (75) healthy eggs, seventy (70) hatched, with five eggs failing to completely develop into chicks with a 93% production yield.

Efficiency of The Prototype Egg Incubator in Terms of Humidity

The efficiency of the prototype egg incubator in terms of humidity the relative humidity of the air within an incubator for the first 18 days should be 50-60 percent. During the last 3 days (the hatching period) the relative humidity should be nearer 65-70 percent. Humidity is carefully controlled to prevent unnecessary loss of egg moisture.

Efficiency of the prototype egg incubator in terms of Temperature

IoT Egg Incubator and Hatching Device embedded software were pre-programmed to maintain an optimum favorable egg incubation temperature of 37.5- 38°C. The tables below show the temperature readings of the IoT Egg Incubator and Hatching Device. These readings were automatically forwarded to the cloud firebase database, then fetched by the partner mobile app through IoT protocols for the end-user incubator's temperature monitoring.

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Based on the observation of the device an average of (9 to 10) minutes that the heating bulb turn off and maintain the average temperature of 37.2 to 37.6 which is required for the egg incubation process.

Efficiency of the Prototype Egg Incubator in Terms of Egg Tilting

The efficiency of the prototype egg incubator in terms of Egg Tilting The automatic egg tilting of the IoT Egg Incubator and Hatching Device starts on the 2nd day of egg incubation (as programmed in the embedded software) and stops on the 18th day of incubation. Egg tilting is an important task in incubation to prevent egg yolks from sticking to the shell.
The IoT Egg Incubator and Hatching Device's incubation tray tilts at an angle of 40° on either side of the horizontal during the egg turning process. The egg tilting continuous back and forth tilting motion happens for four minutes only and at 5 hours intervals. Moreover, the Datasheet indicated that there were no observed errors in the egg turning mechanism all throughout the incubation period.

Evaluation on the Iot Embedded System of the Iot Egg Incubator and Hatching Device Using the ISO-IEC 25010 System Product Quality Evaluation

The evaluation of the embedded system of the IoT Egg Incubator and hatching device using the ISO-IEC 25010 System Product quality Evaluation A panel of IT experts specifically in the field of smart technology and IoT devices from West Visayas State University were invited to conduct an ISO-IEC 25010 System Product Quality Evaluation on the IoT Egg Incubator and Hatching Device IoT system.

Descriptive statistics was used to describe the gathered evaluation forms basic features, and then the Mean and frequencies were calculated for the descriptive data. The characteristics and sub-characteristics stated on 25010 System Product Quality Evaluation is referenced to the IoT Egg Incubator and Hatching Device IoT system and then evaluated by the panel of WVSU IT experts in the field of smart technology and IoT devices. The result of the evaluation is presented in the table below with its corresponding Mean Score and remark. The result showed that based on the characteristics and its sub-characteristics stated in ISO 25010 System Product Quality Evaluation, the IoT system of the proposed device is rated excellent with Mean of 4.61 and with the verbal interpretation of "Excellent".

Acceptability Level of the Prototype Automated Egg Incubator in Terms of its Usability, Functionality, and Performance

Table shows the Acceptability of the Prototype Automated Egg Incubator in Terms of its Usability, Functionality, and Performance A respondent's made user survey questionnaire was distributed to end-users to perform Acceptability Evaluation based on the usability, functionality, and performance of the IoT Egg Incubator and Hatching Device. The hypothetical range with interpretation was used to interpret the derived weighted mean. The result of the End-user Acceptability Evaluation activity shows that the end-users have rated "Very Acceptable" with a mean of 4.89 the IoT Egg Incubator and Hatching Device. The User Usability Evaluation Score garnered a mean of 4.90 with the verbal interpretation of "Very Acceptable" which implies that most of the end-users strongly agree that this device is easy to learn, easy to operate, user-friendly, and easy to learn. Moreover, the User Functionality Evaluation Score garnered a mean score of 4.87 with the verbal interpretation of "Very Acceptable" which also implies that most of the end-users find this device functional. Lastly, the User Performance Evaluation Score showed a mean score of 4.91 with the verbal interpretation of "Very Acceptable" which signifies that almost all end-users strongly agree that the device can perform well in incubating and hatching poultry eggs.

TABLE I Acceptability level of the prototype automated egg incubator in terms of its usability, functionality, and performance.

Variables	Characteristic	Mean	Remarks
Functionality	Functional completeness. This device automatically incubated eggs and hatched them.	4.87	Very Acceptable
	Functional correctness. This device has correctly incubated and hatched eggs.	4.83	Very Acceptable

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	Functional appropriateness. This device successfully and automatically hatched eggs because the egg turning mechanisms, environment control and management using sensors, and IoT communications were effectively handled.	4.93	Very Acceptable
Performance	Time behaviour. When I executed commands (like setting the incubators temperature), the device responded immediately without delays.	4.93	Very Acceptable
	Resource utilization. The device computer processed the sensors reading, gears and IoT components without system error, delays.	4.90	Very Acceptable
	Capacity. The device was able to perform well all throughout the incubation and hatching process.	4.90	Very Acceptable
Usability	Appropriateness recognisability. This device is needed for egg incubation.	4.90	Very Acceptable
	Learnability. This device is easy to learn.	4.93	Very Acceptable
	Operability. This device is easy to operate and control.	4.87	Very Acceptable
	User error protection. This device provided me visual and hearing warning signs if I will push wrong buttons.	4.93	Very Acceptable
	User interface aesthetics. The device is user-friendly with neat and organized arrangements of buttons and monitor.	4.93	Very Acceptable
	Accessibility. This device is operable even to a novice user.	4.87	Very Acceptable

IV. CONCLUSIONS

Based on the above End-user Evaluation Result mentioned findings of the study, the following conclusions were drawn: The IoT Egg Incubator has met the specified design criteria for a working egg incubator and hatching device. The datasheets generated from field testing and experimentation later further proved that the device's IoT embedded system was indeed functional, effective, and efficient in managing the system components (egg turning mechanisms, sensors and automations, heaters and fans, and IoT architecture), and garnered 100% Efficiency score in managing every incubating factor (Temperature, Humidity, CO2 (ventilation), and Egg Turning). This claim is further supported by the of IoT Egg Incubator and Hatching Device output of 94% Efficient in egg hatching with Production Yield of PY= 0.94.

Also, ISO standard evaluation activity implied that the IT-experts on smart technology and IoT devices finds the IoT embedded system of the IoT Egg Incubation and Hatching device to be Excellent in terms of Functional Suitability, Performance Efficiency, Usability and Reliability. Moreover, because of the positive implementation and field-testing output, the End-user Acceptability Evaluation activity shown that the end-users Strongly Agrees that IoT Egg Incubator and Hatching Device is indeed usable, functional, and can perform well in incubating and hatching poultry eggs.

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