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Monitoring and controlling the chicken Incubation Process Using the Internet of Things System

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Abstract

Today, poultry and its products form an important part of the human food basket. The first step in the broiler production process is chicken production. In small-scale incubators for home use, one of the obstacles in production is a sudden power cut, which strongly affects the development of chickens because the embryos are highly sensitive to temperature and humidity stresses. This study aims to develop an Internet of Things (IoT) system to monitor and control the conditions inside the incubator. Due to the sensitivity of the eggs to the temperature, humidity, and ventilation inside the incubator, it is impossible to monitor the line by the user. In this study, the Arduino-at-Mega 2560 board was used as the central controller. The water level inside the humidifier tank, temperature, and humidity were sent to the AdaFriut Internet of Things cloud platform through the MQTT protocol using the sim800 Internet of Things module. In the developed Internet of Things system, the condition inside the incubator, including the temperature, humidity, and water level of the tank, is monitored every 30 seconds. By referring to the Internet of Things cloud, the user can use his mobile phone to find out about the conditions of the incubator without being at the location of the incubator. This system can send an SMS alert to the user in emergencies such as low water level inside the humidifier, power outage, or extreme fluctuations in temperature or humidity. After receiving the warning message, the user can go to the Internet of Things page and apply the necessary commands to solve the problem or go to the incubator. Also, in case of power failure, the 24-volt DC battery is used as a power source for the incubator.

Keywords: Arduino, Incubator, IoT, Remote control

نظارت و کنترل فرآیند جوجه‌کشی با استفاده از سامانه اینترنت اشیاء

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چکیده

امروزه طیور و فرآورده‌های آن بخش مهمی از سبد غذایی بشریت را تشکیل می‌دهند. اولین مرحله در فرآیند تولید طیور گوشتی، تولید جوجه است. در ماشین‌های جوجه‌کشی در مقیاس کوچک برای مصارف خانگی، یکی از موانع در تولید، قطع ناگهانی برق است که به شدت تکامل مرغ را تحت تاثیر قرار می‌دهد چراکه جنین‌ها به شدت به تنش‌های دما و رطوبت حساس هستند. هدف از این مطالعه توسعه یک سامانه اینترنت اشیا (IoT) برای نظارت و کنترل شرایط داخل ماشین جوجه‌کشی است. به دلیل حساسیت تخم‌ها به دما، رطوبت و تهویه داخل ماشین جوجه‌کشی، نظارت بر خط توسط کاربر غیرممکن است. در این مطالعه از برد Arduino-at-Mega 2560 به عنوان کنترل کننده مرکزی استفاده شد. سطح آب درون مخزن رطوبت ساز، دما و رطوبت با استفاده از ماژول اینترنت اشیاء sim800 از طریق پروتکل MQTT به پلتفرم ابر اینترنت اشیاء AdaFriut ارسال شد. در سامانه توسعه یافته اینترنت اشیاء، وضعیت داخل ماشین جوجه‌کشی شامل دما، رطوبت و سطح آب مخزن هر ۳۰ ثانیه یکبار پایش می‌شود. کاربر می‌تواند با مراجعه به فضای ابری اینترنت اشیا از تلفن همراه خود بدون حضور در محل قرارگیری ماشین جوجه‌کشی برای اطلاع از شرایط ماشین جوجه‌کشی استفاده کند. این سامانه می‌تواند در مواقع اضطراری مانند پایین بودن سطح آب داخل رطوبت ساز، قطع برق یا نوسانات شدید دما یا رطوبت، پیامک هشدار را برای کاربر ارسال کند. پس از دریافت پیام هشدار، کاربر می‌تواند برای رفع مشکل به صفحه اینترنت اشیاء مراجعه و دستورات لازم را اعمال کند و یا به محل ماشین جوجه‌کشی مراجعه کند. همچنین در صورت قطع برق از باتری ۲۴ ولتی DC به عنوان منبع تغذیه از ماشین جوجه‌کشی استفاده می‌شود.

واژه‌های کلیدی: آردوینو، ماشین جوجه‌کشی، اینترنت اشیاء، کنترل از راه دور

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1-Introduction

Today, poultry and its products play an important role in the human food chain. The first step in poultry production is the incubation process, which requires an incubator. To achieve higher efficiency in the incubation process, several factors are influential, including fertility, the freshness of the eggs placed in the incubator, and the way the eggs circulate in the incubator. Setter pointed out that to prevent the embryo from sticking to the eggshell and also to control the temperature and humidity conditions in the incubator in the incubation process (Ebrahim Ahmad Ebrahim Hassan, 2017). In the embryo mortality curve of broiler chickens, more losses are observed in three stages. The first stage is from the second to the fourth day, during which failure may occur due to the inability of the fetus to face physiological and biochemical changes in the early stages of development. The second stage is from the eleventh to the fourteenth day, in which loss may happen due to the lack of nutrients such as pantothenic acid, and finally, the last stage is between the seventeenth to the twenty-first day, due to temperature and humidity fluctuations in the egg incubator, failure in the process may occur (Pourreza, 2000).

If the humidity is high, the air-containing chamber in the egg shrinks, and the oxygen supply to the fetus is disrupted. When the relative humidity of the environment is less than the desired level, the moisture of the egg is lost and increases the volume of the air chamber and the fetus sticks to the shell, causing the loss of the fetus (King'Ori, 2011).

Due to the sensitivity of the incubation process, this process requires online monitoring of the internal conditions of the incubator, which is time-consuming and costly. There are a lot of costs in the incubation process. In this research, we have tried to provide the ability to continuously monitor the incubation process by using the Internet of Things system.

Today, the Internet of Things in agriculture is expanding rapidly.

IoT in the chicken production process:

A study using IoT technology on the use of infant incubators to reduce the risk of using medical equipment and online management has been introduced to improve management and efficiency. It has been used in combination with IoT technology and temperature sensors to control online management (Wang *et.al.*, 2017).

To control the internal conditions of the incubator in a study, using the Internet of Things, which has three main systems, including the independent IoT system, web applications, and the Telegram robot. Web application software in an intelligent egg incubator was created using Object Oriented Analysis and Design (OOAD). Web-based applications can be used to monitor the condition of the incubator based on sensor data sent during the hatching process. While in the Telegram robot, temperature, humidity, egg transfer, and inversion of the inside of the incubator can be controlled online, short-term notifications can also be made if there are conditions in the incubator that change too much. Was also informed (Santoso *et al.*, 2020).

In one study, the proposed system is equipped with a DHT11 sensor that monitors the temperature and humidity of the incubator and is constantly updated via Wi-Fi. The user remotely monitors the temperature and humidity values and controls the light intensity of the lamp through an Android application on his mobile phone. The servo motor is connected to the egg spinner that is kept inside the incubator and is rotated according to the specified schedule to prevent the yolk from sticking to the eggshell and also to create a uniform temperature for the eggs. From the experimental results, it is inferred that better hatching can be done by controlling the machine conditions remotely (Mala & Jayanthy, 2017).

In another study, the protection and monitoring of the poultry environment by the Internet of Things is presented. The software-based hardware provided can monitor environmental components such as air temperature, humidity, oxygen level O_2, carbon dioxide concentration, CO_2 concentration, and ammonia NH_3 concentration. Wireless sensors are responsible for collecting the desired data and sending them to the monitoring and control center. Hardware runs successfully on various poultry sites. Very effective and accurate experimental settings were obtained (Lashari *et al.*, 2018).

In a study by Provence *et al.*, they created a remote monitoring system using a Raspberry Pi-3 board, which was able to control the incubator online with a camera and temperature sensor. In the Provence system, in case of a power outage, the system is automatically sourced. Electricity replaces the battery (Purwanti., *et al.* 2021).

In automation and monitoring of the desired level of internal conditions of a poultry farm, Thomas *et al.*, used sensors and microcontrollers to monitor and observe the line environmental conditions inside the poultry farm (Thomas *et al.*, 2020).

Sebastian *et al.*, in the development of a control system in an incubator using the Arduino-Uno board and the Lab-view programming environment and with the help of MET-Inverto were able to control the temperature, humidity, and rotation of the eggs inside the incubator (Gutiérrez *et al.*, 2019).

Due to the impossibility of online monitoring of the incubator to control its internal conditions to prevent damage to it, in this study, an attempt was made to monitor the conditions inside the incubator by providing a remote monitoring and control system.

2-materials & method

An incubator with a capacity of 108 eggs was built on one level inside the incubator with the ability to place eggs in separate cells for research in the Campus of Agriculture and Natural Resources, University of Tehran, fig.1.

After building the incubator, the machine control system was simulated and launched in Proteus software, Fig. 2. In the developed control system, the Arduino Mega 2560 board was used as the central controller, and the temperature and humidity were measured by the SHT75 module. The water level inside the humidifier module was monitored by an electric float. Using a four-channel relay operator, the temperature, humidity, and water level in the tank as well as the circulation of eggs were controlled. LCD 4*16 and Keypad 4*4 modules were used to communicate with the central controller. To solve the problem of the power outage and shock to the fetuses in case of a power outage, the required power of the incubator was provided by $24V_{DC}$ voltage converters so that, if necessary, the energy required for the incubator could be supplied from the $24V_{DC}$ battery provide.

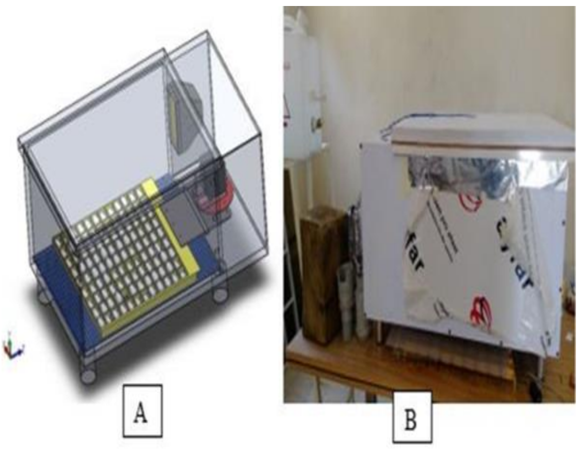

Fig 1. A) Incubator simulated in SolidWorks software B) Developed incubator.

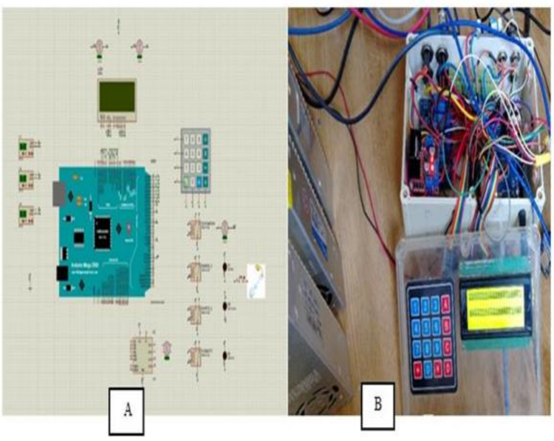

Fig 2. A) Simulated control system in Proteus software B) Developed control system.

To use the IoT system inside the incubator, the sim800 module (Fig. 3) with the ability to install a SIM card was used. This module sends the temperature and humidity read by the SHT75 module, the water level inside the humidifier module, and the spin time of the eggs to the IoT server on the Adafruit site by connecting to the Internet through the MQTT process. The user can visit the site to make the desired decisions. Next, an alarm system was developed by which, in necessary cases, according to the flowchart of Fig. 4, an emergency text message was sent to the user to inform the user of the conditions inside the incubator. The order of H_{set} and T_{set} inside the incubator and H_{in} and T_{in} are the humidity and temperature measured by the sensor, respectively. A phone number stored in the program was used to send a warning to the user to prevent possible damage to the incubator and eggs by visiting the IoT server and executing the desired commands or by visiting the location of the incubator in person.

Fig 3. SIM800L module

By applying the shutdown command of the machine by the user, the relay used in the power path is cut off for a short time (Fig. 4), and the incubator waits for the control commands to be applied after restarting in standby mode. The user must be present at the location of the incubator to apply the control conditions.

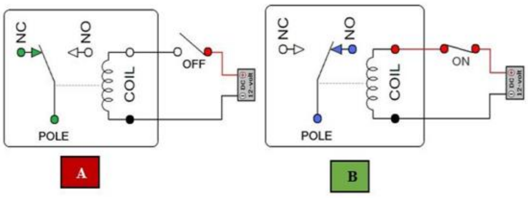

Fig 4. A) Normal mode of the incubator B) Receiving the command to turn off the incubator.

3-Results & Discussion

In this study, measurement and monitoring of all parameters including temperature, humidity, egg circulation, and the water level inside the humidifier module were successfully monitored and controlled. Also, in the developed program, the remote control of the device (Fig. 5) was successfully performed. Fig. 6 is the webpage created in the Internet of Things cloud. Fig. 6 shows the instantaneous data on temperature and humidity as well as the water level inside the humidifier chamber in the incubator.

The control system test was successfully evaluated to cut off the power in the circuit, by clicking on the power button on the webpage, the developed objects of the incubator were put into standby mode after turning off and on. The SMS system was also successfully evaluated, Fig. 7.

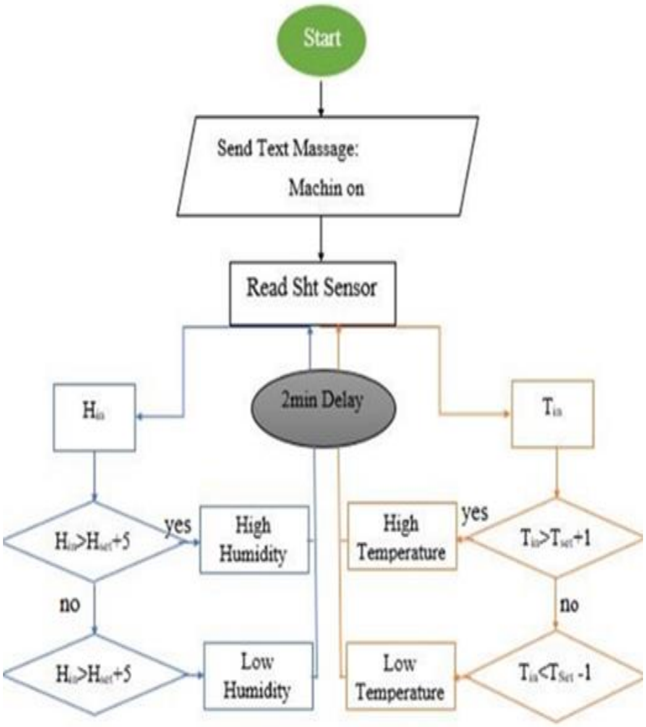

Fig 5. Flowchart of emergency SMS system in the incubator

Fig 6. IoT page created in the incubator developed.

In this study, in comparison with the research done by Sebastian *et.al.*, and Purwanti *et.al.*, from the Arduino board, which is a cheap board, all the factors inside the incubator were monitored. Turns off the cache, and also sends a short text message to inform the user of the necessary conditions of the incubator. This feature is an important application, especially for rural areas where the Internet speed is low. Also, due to monitoring the duration of the method and turning off the water flow valve, the amount of water used in the incubation process can be measured.

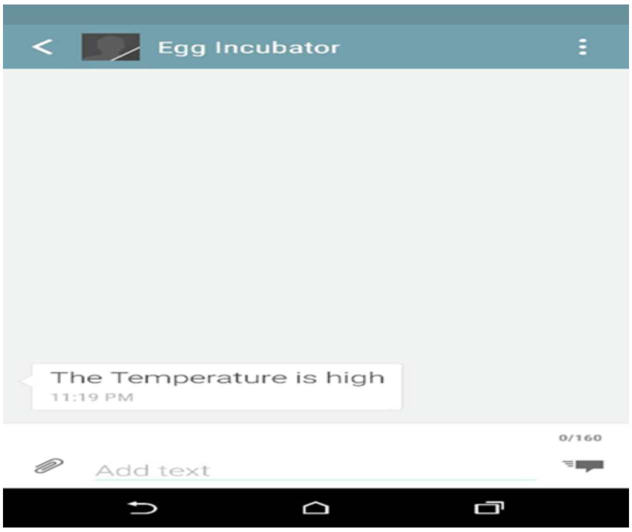

Fig 7. Warning SMS system

4-Conclusion

This study describes the implementation of a prototype of a remote monitoring and control system on a low-capacity incubator. In this project, using the Internet of Things, the ability to monitor and control the operating conditions online on the incubator has been provided to increase the incubator efficiency without a continuous presence in the incubator environment. Using this system, the user can view and control the conditions inside the incubator on a smartphone, tablet, or laptop by connecting to the Internet, so that the user can be informed about the operating conditions of the incubator online for a small fee.

References

Ebrahim Ahmad Ebrahim Hassan. (2017) *Ph.D. Design, implementation, and evaluation of prototype hybrid incubator based on fuzzy inference system.*

Pourreza, J. (2000). *Scientific and practical principles of poultry breeding*, Isfahan University of Technology Publications.

King'Ori, A. M. (2011). *Review of the factors that influence egg fertility and hatchability in poultry. International* Journal of Poultry Science, 10 (6), 483-492.

Wang, W., Peng, D., and Gu, N. (2017). *Development of Monitoring System for Infant Incubator Based on IOT Technology*. Zhongguo yi liao qi xie za zhi= Chinese journal of medical instrumentation, 41(3), 181-184

Santoso, S. B., Adhy, S., Bahtiar, N., and Waspada, I. (2020). *Development of The Smart Chicken Eggs Incubator Based on Internet of Things Using The Object Oriented Analysis and Design Method.* In 2020 4th International Conference on Informatics and Computational Sciences (ICICoS) (pp. 1-6). IEEE

Mala, S. B., and Jayanthy, S. (2017). *Development of Cloud Based Incubator Monitoring System using Raspberry Pi.* International Journal of Education and Management Engineering, 7(5), 35.

Lashari, M. H., Memon, A. A., Shah, S. A. A., Nenwani, K., and Shafqat, F. (2018). *Iot based poultry environment monitoring system.* In 2018 IEEE International Conference on Internet of Things and Intelligence System (IOTAIS) (pp. 1-5). IEEE.

Purwanti, S., Febriani, A., Mardeni, M., and Irawan, Y. (2021). *Temperature Monitoring System for Egg Incubators Using Raspberry Pi3 Based on Internet of Things (IoT).* Journal of Robotics and Control (JRC), 2(5), 349-352.

Thomas, D. A., Reji, C., Joys, J., and Jose, S. (2020). *Automated Poultry Farm with Microcontroller based Parameter Monitoring System and Conveyor Mechanism.* In 2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS) (pp. 639-643). IEEE.

Gutiérrez, S., Contreras, G., Ponce, H., Cardona, M., Amadi, H., and Enríquez-Zarate, J. (2019). *Development of Hen Eggs smart incubator for hatching system based on internet of things.* In 2019 IEEE 39th Central America and Panama Convention (CONCAPAN XXXIX) (pp. 1-5). IEE