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Internet of Things: Control and Monitoring System of Chicken Eggs Incubator Using Raspberry Pi

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Abstract Chicken breeders usually control and monitor their chicken eggs incubator machine manually and periodically to ensure the hatching process run well, it causes an inefficient time and energy. In order to avoid that, chicken eggs incubator machine is made with modern technology and make the duties of chicken farmer easier. Technology of "internet of things" allows the chicken breeders to control and monitor it in distance by using internet optimally in doing their job. Using Microcontroller Raspberry Pi technology which is combined with temperature and humidity sensors, light sensor, motor servo, webcam, and relay to produce control and monitoring system of chicken eggs incubator machine which can be accessed through website.

Keywords Internet of Things, Chicken Eggs Incubator Machine, Raspberry Pi

1. Introduction

Many kinds of technology have been created by human to make it easier for them in doing their job. One of important technology that has already grown rapidly is internet. Role of internet in human everyday life become a part that cannot be separated, and then creates a concept about "internet of things". Regarding to the analysis of McKinsey Global Institute [2], "internet of things" is a technology who allows to connect machines, equipment, and other physical things with network sensor and actuator to get data and manage its own performance, it allows the machine to collaborate and even do acts based on the new information that is gotten independently.

Breeding is a business activity in breeding animal, especially chicken. Some chicken breeders usually use an equipment to incubate chicken eggs, it is called chicken eggs incubator, which the incubator itself applies a same way with natural hatching that is done by hen. Chicken eggs incubator can be found easily with many kinds of features which are offered with the amount of hatching capacity is diverse, but some of those incubators still work manually. The stability of temperature and humidity in egg hatchery will be less effective if the monitoring is done manually. The manual control has not efficient anymore for the chicken farmers because it spends much time. Therefore, it needs a modern chicken eggs incubator tool that make it easier for the farmer to control and monitor it anytime and anywhere.

Solution that is needed to resolve that problem is creating a control and monitoring system of chicken eggs incubator based on "internet of things" which is worked automatically in doing control and monitoring of temperature and humidity in chicken eggs incubator. Internet users give an easiness to the breeders to control and monitor the chicken eggs incubator from distance. Chicken eggs incubator which is made, consists of microcontroller Raspberry Pi which is combined with temperature and humidity sensor, and also light sensor, which then give an output command to step motor, webcam, and relay. Data which are accepted by microcontroller Raspberry Pi, will be sent to the server through internet to be stored in database and accessed through website.

2. Related Work

The research in [3] had arranged a device that could measure temperature in chicken eggs incubator and sent the data in form of temperature telemetrically. The device could send the data in distance anytime it was needed, it gave an easiness to people who wanted to monitor the chicken eggs incubator without oversee it all day. Telemetry device was consisted of two main parts, there are transmitter and receiver. Transmitter part consists of temperature sensor component, Arduino Uno R3, and RF Module Board 433 MHz. The main function of Arduino Uno R3 in the research was as data processing from temperature sensor and sent it to the receiver. The weakness of the research was data transmission used telemetry system that had a distance

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limitation caused by the using of radio wave. Besides, there was no temperature control in the incubator space and also the data that were sent are only temperature.

The other research in [4] also made a same device by using a 60W light bulb that functioned to set the correct temperature for the eggs. DHT11 temperature and humidity sensor interfaced with Raspberry Pi is used to monitor the temperature and humidity in incubator machine. Stepper motor was used that rotated the egg turner and changed the position of the eggs. The status of the condition inside the incubator could be viewed remotely via cloud. An Android app was used to control the intensity of the light bulb by varying the duty cycle of PWM (in %) remotely. The difference was shown at temperature control through Android application by setting the intensity of the light bulb. Besides, the monitoring system that was made did not use web camera, so that users could not monitor the condition inside the incubator machine itself.

The researches that had been mentioned above had a significant contribution in designing and manufacturing control system and monitoring of chicken eggs incubator machine. Some differences of those researches is in using website for controlling and monitoring system that give a flexibility for the users. The system can be accessed through any device who have an internet browser, which is different with Android application who can only be used on android smartphone. Feature of monitoring using web camera is a new development that functioned to make users be able to see the condition inside the incubator machine. It is not mentioned on the previous researches.

3. Research Methods

Research methodology which is used in this research is SDLC (Software Development Life Cycle) method in form of waterfall model. The waterfall model is the most famous model among other approach models in SDLC method. It is a development model which works linearly and in sequence. It is also the first model formed. Every step should be finished before continue it to the next step.

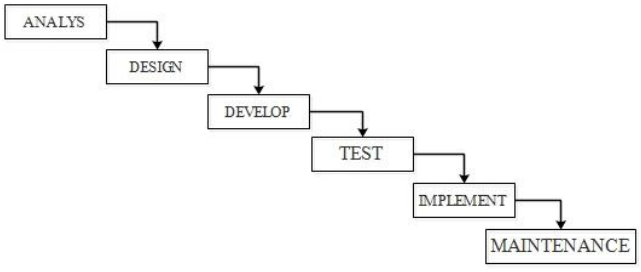

Figure 1. Waterfall Life Cycle Model [1]

4. System Overview

System overview explains about components in system and how are those components connected. The main hardware component in the system is microcontroller Raspberry Pi, various sensors such as temperature sensors and humidity, light sensor, relay, web camera, and step motor.

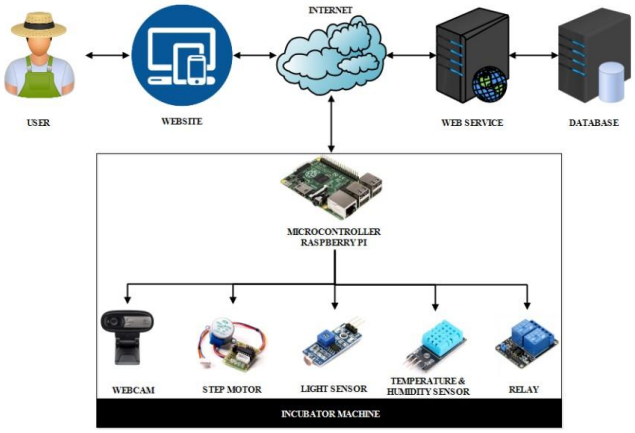

Figure 2. General overview of control and monitoring system of chicken eggs incubator

Figure 2 is a general overview of control and monitoring system of chicken eggs incubator. Application of the components which are found in it can be explained as follow.

1. Microcontroller Raspberry Pi

Raspberry Pi is a single-board component that has a same figure with the usual computer, such as program, office, watching video in high resolution, and others like it is made by Raspberry Pi Foundation. General purpose of input and output (GPIO) in Raspberry Pi is one of the component that can be found in Raspberry Pi board. GPIO is a generic pin on integrated circuits that input and output can be controlled by user using program in Python language or C/C++. GPIO pin in Raspberry Pi functions as input and output through other hardware communication. Raspberry Pi has the total amount of 40 GPIO pin with different functions.

Raspberry Pi in this system used as the centre of data processing which is received from other components. Raspberry Pi receives input data from temperature and humidity sensors, which then the light sensor gives an output command for step motor, web camera, and relay. The data that have been received by Raspberry Pi will be continued to the server through internet.

2. Webcam

Webcam (web camera) is the name of real-time camera which the image can be seen through WWW (World Wide Web), fast data processing program, or video call application. Webcam also can be interpreted as a small digital camera video connected to the computer by using USB port, COM port or Ethernet or Wi-Fi connection.

The webcam in this system is used to take images in incubator space condition. The chicken breeders can see the result of the images through web service in order to know how the condition of incubator space anytime they want.

3. Step Motor

There are some kinds of motor DC which are usually used in electrical and electronic circuits. The motor is named based on the source of electrical energy used by that motor to be able to work normally. So that, there are only two types of motor, motor AC (Alternating Current) and DC (Direct Current). Motor is one of actuator type used as output of a control circuit, whether it is a simple or complex control. Based on that kind of movement and its control, motor has some types, such as DC or AC. But the system used in this research is one of DC motor in stepper type. It is called stepper because the movement and control which is given and done is step by step, so that motor can rotate up to 360°. The movement of stepper motor will be easier to be controlled than other DC motor because motor stepper can rotate based on the degree we want, it is different with DC motor who may cause excess movement when you want to rotate it, so it will be less precision.

Step motor in this system is used to do a round on the eggs shelf automatically with specific slope which is controlled by Raspberry Pi. Step motor will move the eggs shelf along incubator eggs process.

4. Light Sensor

Light sensor is one of sensor who able to know the integrity of light around it. The light sensor is used to make a lamp who can on and off based on the integrity of the light around itself. The light sensor module can know the integrity of light by giving value 1 for the low light integrity and value 0 for the high light integrity.

The light sensor in this system is used to know the hot flame light of chicken eggs incubator. This prototype machine of chicken eggs incubator uses the light of incandescent bulbs as a heat source. The incandescent bulb is arranged to use a relay in order to make the temperature in the incubator space keep stable.

5. Temperature and humidity sensor

Temperature and humidity sensor is a sensor with digital signal calibration that can give temperature and humidity information. This sensor is a component who has a good degree of stability. High quality product, fast reading response, and a capability of non-interference, with an affordable prices. Temperature and humidity sensor has a highly accurate calibration feature. This calibration coefficient is stored in OTP memory program, so that when internal sensor detects a temperature and humidity, this module will read the sensor coefficient. Small size with signal transmission up to 20 meters long, make this product is good for many measure applications of temperature and humidity.

Temperature and humidity sensor in this system are used to measure the temperature and humidity in incubator space.

6. Relay

Relay is a switch operated electrically and it is an electromechanical component who consist of two main parts, electromagnet and mechanical. Relay uses electromagnetic concept to move the switch contact so by using a small electrical current, it can deliver an electric high voltage.

Relay in this system is used to control the temperature and humidity control components in incubator space.

7. Internet

Internet is used as a data sender media who received by microcontroller Raspberry Pi to the server.

8. Web Service

Web service is an application of the server that is used to receive the data that have been sent by microcontroller Raspberry Pi and then save it in database.

9. Database

Database is used to save the data collection received by the server.

10. Website

Website is used to control and monitor the incubator machine of chicken eggs by the user.

11. User

User is someone or a group of breeders who use this control and monitoring system of chicken eggs incubator machine.

5. Prototype of Incubator Machine

Prototype of incubator machine is made by using 30x30x40 cm wooden board that can contains six chicken eggs in once incubation process by using 15 watt of 2 incandescent bulb as the heat source, water pump as the humidity controller, and air fan for air circulation in the incubator space as shown on figure 3. The circuit of microcontroller Raspberry Pi that is connected with the webcam, step motor, light sensor, temperature & humidity sensor, and relay are placed at the top as shown on figure 4.

Figure 3. Prototype of chicken eggs incubator machine from outside

Figure 4. Prototype of chicken eggs incubator machine from inside

6. Features of the Proposed System

6.1. Monitoring of Temperature, Humidity, and Light

This feature is used to monitor the condition of the temperature, humidity, and light in chicken eggs incubator space. How this feature works is Raspberry Pi gets temperature data through temperature and humidity sensor, and also the light sensor. After those data obtained, then is checking the data condition which is empty or not. If the data obtained is not empty, it continues the encoding data process in form of UTF-8, and then send it to the server and save it in the database. If the data obtained is empty, it have to do retrieve the data. Website application provides a graphical user interface (GUI) to access that data. Sending data to the server is done every 5 minutes until the incubation process finish.

6.2. Automatic Control of Temperature and Humidity

This feature is used to control temperature and humidity in chicken eggs incubator space to keep it stable at the normal level automatically. How this feature works is Raspberry Pi receives temperature data through temperature and humidity sensor. After the temperature data is received, then check the condition of the temperature itself. If the temperature is 38℃ or up to that, it is called high temperature, SET GPIO.LOW process in Raspberry Pi pin that is connected to relay is done, so that the bulb will turn off. Temperature of 37℃ or less than that is called low temperature, it means SET GPIO.HIGH process in Raspberry Pi pin that is connected to the relay is done, and the bulb will turn on. The data of humidity is received by checking the condition of the humidity itself. If the humidity is 51-60% is called normal. If it up to 60%, it is called a high humidity, then the SET GPOI. HIGH in Raspberry Pi pin process which is connected to the relay is done, so the water pump and air fan will turn off. If the humidity is only 50% or less than that, it means the humidity is very low, then the SET GPIO.LOW in Raspberry Pi pin process which is connected to the relay is done, so that the water pump and air fan will turn on. Beside that condition mentioned before, it is called abnormal condition, it can be happened because of the error when Raspberry Pi receives the temperature and humidity sensor from DHT11 sensor module.DHT11.

6.3. Automatic Turning of Egg Shelf

This feature is used to turn the egg shelf automatically in order to the temperature spread evenly on all sides and also to make the egg embryo not stick to one side of the egg shell. How the feature works is the turning of egg shelf is done every six hours. First position of the egg shelf faces to the centre, then Raspberry Pi moves the step motor which is set to the fore with approximately 45° degree angle and remains in this position for six hours. After those six hours, the egg shelf will be moved by the step motor facing backward with approximately 45° degree angle and remains in this position for six hours, and then back to the first position in the centre. It happens repeatedly until incubator process stopped.

6.4. Taking Images

This feature is used to monitor condition inside the incubator space by taking images using USB Web Camera. By using this feature, the condition inside the incubator space, whether the eggs have already hatched or not, is known by seeing the images that have already taken. Website application provides graphical user interface (GUI) to access this feature.

6.4.1. Taking Images through User Request

The way of this feature works is taking and sending the images after user does request process on the website. Raspberry Pi read the request, the bulb will turn on first, and then the USB camera will also turn on and take the images. Those images will be stored in saving memory of Raspberry Pi, then are sent and stored in the server.

6.4.2. Taking Images Automatically

The way of this feature works is taking and sending the images every once hour which is done automatically after incubation process is started. First thing to do is checking whether there is an incubation process or not, if there is an incubation process, the bulb turn on first, then the USB camera will also turn on and take the images. Those images will be stored in saving memory of Raspberry Pi, then are sent and stored in the server. This process is done repeatedly every once hour after the incubation process ended.

7. Results

System and hatching experiment of chicken eggs were conducted at the same time to know which were the system

and tools that had already made are success for chicken eggs incubator process or not and also to make it sure that the system was worked well or not.

7.1. System Experiment

Control and monitoring system experiment of chicken eggs incubator machine is a test for system and the components inside the incubator machine. It is conducted to know which the system and its components used can be success.

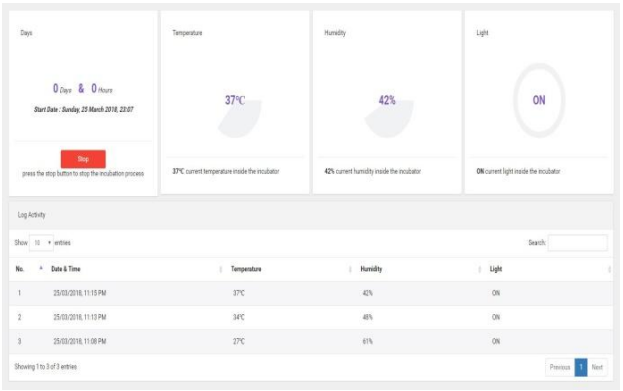

Figure 5. Website display to show the data

Figure 5 shows an information that can been seen by user through website. Its information is the time duration of incubation process that has been going on, temperature data, humidity, and light. On the figure, shown some data examples as the result of the first experiment.

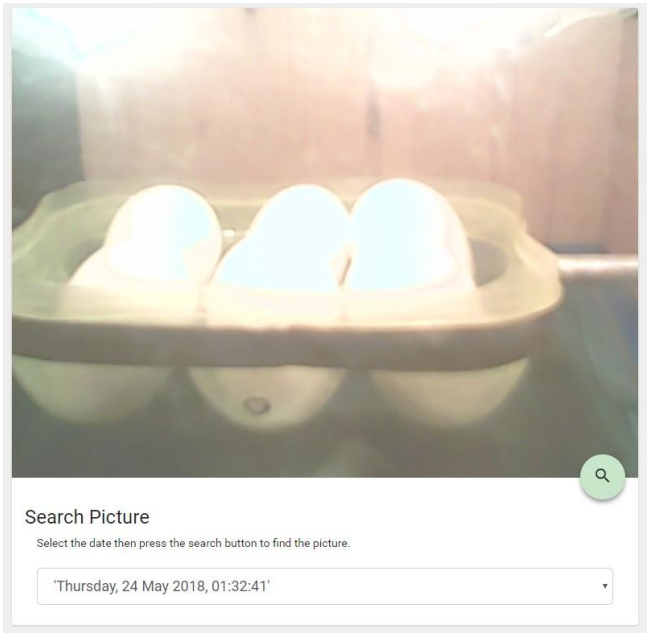

Figure 6. Website display to show images which are taken from webcam

Figure 6 shows image that has been taken through website using webcam and can be seen by user through website itself. User can search the images based on the sending time of them.

Table 1. The Result of System Experiment

No.	Information	Total
1	Total Amount of Temperature and Humidity Data	6.266
2	Average of Temperature/ Day (The most frequency)	38°C
3	Average of Humidity/ Day (The most frequency)	51%
4	Total Amount of image request	28
5	Total Amount of Time-lapse Image	530

7.2. Hatching Eggs Experiment

Hatching chicken eggs experiment is conducted to know that the system and tools which are made is success to do the chicken eggs incubation process. It is done by using six eggs of local Bali chicken type that have been fertilized by rooster. The eggs used in the experiment have already passed the process of checking eligibility to minimize hatch failure. The experiment is conducted for 23 days with the result of four hatching eggs and two eggs failed to hatch. Those eggs that have failed to hatch after the checking is known that its embryo has grown but failed to grow.

8. Conclusions

Control and monitoring system of chicken eggs incubator machine by applying "internet of things" technology using Raspberry Pi has succeed to be conducted. This system gives solution to the chicken breeders that it gives an easiness in monitoring and controlling process of incubator machine and also an easiness in hatching chicken eggs process so they can work efficiently. By using this system, they can control and monitor through their own incubator machine anywhere and anytime. Using website application as graphical user interface (GUI) gives an easiness to use this system because it can be accessed through internet browser from various devices, such as smartphone, tablet, desktop computer, and others.

In the future, it hopes that the system can be developed to the bigger scale by using more modern and complex components completed with a better technique. For example is making the same machine with bigger amount capacity and also using better set technique of temperature and humidity.

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