Design of an IoT-based Smart Farming System

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ABSTRACT

Farming is a very vital sector for any developing country like Bangladesh. Therefore, smartly operating the farm is essential nowadays to get maximum productivity from the farm. In this paper, an automatic system is designed for the farm which is operated via the internet of things (IoT) technology. This proposed system is developed to implement advanced technology into the traditional farming system. The proposed approach incorporates feed and water level indicator control systems, health monitoring systems, fire and gas detection systems, temperature-based fan control systems, intelligent tracking systems, and cow dung cleaning mechanisms. Finally, different sensors will collect all the data and eventually be controlled by Arduino Nano micro-controller, which incorporates IoT features. Therefore, the users can handle their farm from any place and get real-time data from the farm through mobile. Furthermore, this proposed system is eco-friendly as well as cost-effective.

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1 INTRODUCTION

The population of Bangladesh is increasing day by day. So, livestock farming is a very vital sector for Bangladesh. But many farmers still use the traditional method to maintain the livestock farm, which requires a lot of skilled human resources and some facilities, which is very costly. As a result, many farmers cannot produce the top dairy product from the farm. Always they need skilled human resources to maintain the firm. In Bangladesh still, a big problem to find skilled human resources for the farm. So many farmers cannot find sufficient skilled human resources.

For this reason, they lose a significant amount of production. In that case, taking this type of initiative steps like an intelligent farming system is necessary and must. This technique enables farmers to monitor animals' individual needs better and adjusts their nutrition, thus preventing diseases and improving health. In this paper, an automatic system is designed for the farm, operated via IoT technology. This proposed system was designed to implement advanced technology into the traditional farming system. In this project, feed & water level indicator control systems, health monitoring systems, fire & gas detection systems, temperature-based fan control systems, smart tracking systems, and cow dung cleaning were simulated. By using this proposed project, productivity will be increased to a significant amount. It reduces the farmer's daily hard works as well as the labor cost. There have many technologies invented for livestock farming. But they are very costly. Many farmers cannot bear the cost.

The goal of this proposed paper is to develop smart livestock farming. Many farmers rely on humans to keep their farms running. However, this presents many issues, including the fact that hiring them is costly, and the owner must constantly monitor the business on his own. There will be a bunch of different sensors collecting data, and the machine will run on its own, such as a health monitoring system, food and water level indicator control system, smart tracking system, gas & fire detector, fan control system, cow dung cleaning system, etc. The sensors automatically work together and maintain the farm. As a result, the user will be more beneficial.

2 LITERATURE REVIEW

The innovation is always developing up with new innovative ideas and technologies for socio-cultural society to enhance productivity with low cost which has no negative impact on the environment. The smart farming system has the greatest potential for our country to encourage a major cattle sector. The Internet of Things (IoT) expects that billions of things will have an intended connection in the nearest future and will be accessible from anywhere on the planet. However, the internet of things (IoT) is the main factor behind

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the smart farming system. Some relevant articles were reviewed, with an emphasis on the research control systems and an analysis of their fundamental principles. Naeem et. all shows the use of IoT in smart farming for irrigation system [1]. According to [2], an IoT-based smart animal farm system was designed that was a low economical cost-effective system. This system includes a temperature control system, humidity control system, and feed filling system and shows the interfaces of the Thingspeak API platform. In [3], the authors investigate the livestock movement activity based on machine learning. This system was designed for individual livestock management where takes care of breeding information of individual livestock (cow), the number of days since calving, predict estrus, etc., using IoT and machine learning. In [4], six different types of farming systems were developed including IoT to automatically control the daily routine works. The designed system covered the feed control system, water level control system, incubator control system, biogas control system, fire detecting system as well as an IP camera-based surveillance system and used the LabVIEW software to create a graphical user interface for IoT enabled smart animal farms. In [5], a smart tracking system where cattle tracking was done which comprises latitude, longitude, date & time, the ID of Smart Tag, and support 24/7 with the applications. In [6], a health monitoring system including IoT has been developed. The proposed model includes identifying symptoms of diseases, regular observations, and various alarms like health alarms, estrus-related alarms, device-related alarms that send continuous data over the apps. In [7], the system works by two ways first there has some ultrasonic sensor which act as fence that are implemented in specific area. Then using this ultrasonic sensor livestock distance can be calculated and by this distance farmer can be tracked livestock in real time computer and mobile phone. The other way is if livestock go beyond the specific location a GPS tracking device will help to track the livestock by using GPS satellite. Akbar et all. proposed a smart idea for a dairy farm. The ideas are Geofencing, Automatic Disease Detection, Milking, Automatic Water and Food Supply. geofencing is area-based technique using GPS, RFID etc. that will track the cattle of the firm. Then automatic disease detection will help to detect the animal disease by using their behaviors. Then automatic water and food supply will help to feed the cattle timely as some result cattle will get the proper nutrition. Above all the ideas will help the farmers produce more dairy product by using less money [8]. The smart herd management method proposes a hypothesis for milk output that focuses on animal health and behavior. This research focuses on some of the challenges of adopting IoT-based dairy, such as Internet access in rural regions. Researchers presented a fog-based approach to cut lease expenses by 84 percent to investigate this critical topic [9]. An integrated Microcontroller and sensor chip can retrieve and store data including cow identity, heart rate and body temperature from cattle that are sent to the cloud server for storage and analysis. So, farmers don't need to worry anymore about the condition of their livestock that suddenly gets sick or die because there is a system that always monitors the health of the condition of the livestock in real-time [10]. In Bangladesh most of the farm are not using technology. Farmer will be more beneficial by using technology. Technology will help them to produce more productivity. Technology is fully automatic via IoT. A large farm can be control by one man. Farmer also can control the farm from remotely. All the data will be saved in computer. Later this data can be used to maintain the farm.

In this paper, an IoT based model is designed to solve the maintenance problem of livestock farming with cost effective and sustainable operations. Feed & water level indicator control systems, health monitoring systems, fire & gas detection systems, temperature-based fan control systems, smart tracking systems, and cow dung cleaning systems are simulated. For designing the whole project different types of sensors and Arduino nano micro-controller were used. Hence, the system is operated automatically via IoT, so the users can handle their farm from any place and they will get the real-time data from the farm through mobile.

3 SMART FARMING SYSTEM MODEL

Figure 1 shows the proposed smart farming system block diagram which is designed for many different controlling systems and monitoring systems. According to this block diagram, the overall system was operated. A flow chart was created in this project which the users can modify. This proposed system fulfilled all the requirements which are needed to operate a smart farm via IoT. So, the users can handle the model remotely. After successfully running the entire farm smartly, the data is shown on Thing Speak API. The proposed system comprises two parts, 1st part consists water level sensor, ultrasonic sensor, flame sensor, MQ-2 gas sensor, LM35 temperature sensor, and one Arduino Nano microcontroller. 2nd part consists DHT11 sensor, heartbeat sensor, and GPS module which is placed in the livestock body part for monitoring the health condition and tracking the livestock. The data is transferred by ethernet shield through wi-fi. GSM mobile phone signals are used by GPS/GSM collars to acquire animal location. Users can operate their farm from any place and they will get all data on their mobile through IoT.

The fire, feed time, water level, gas, and room temperature will all be displayed in the first display. A different exhibit will focus on the health of animals. Users may view their heart rate, body temperature, humidity, and positioning via this display. The control system mechanism of all systems is shown in Figure 2

3.1 Feed and water level indicator control system

The feed control system consists of two main parts: 1. Hopper Storage, 2. Feed Storage. The hopper storage is used to keep bulk products for handling. The product needs to float continuously from the hopper to the feeder. In the designed model, the hopper storage has a valve that is turned on using the motor. The feed storage has an ultrasonic sensor that is used to sense the feed in the tub. If the feed in the tub is less than a threshold limit or a positive quantity, then the system turns on the feed valve to hold up to a specific level. Here, When the feed decreases to 10%, the valve turns on automatically, the feed can be filled in the tub. The water level control system consists of a water level sensor and a water pump. The primary feature of a water level controller is to direct the water flow and optimize the system performance. The water level sensor senses the level of the water in the tub. When the water level in the tub goes down to the minimal point, the water pump is turned on to fill the water tank. In the designed model, When the water level

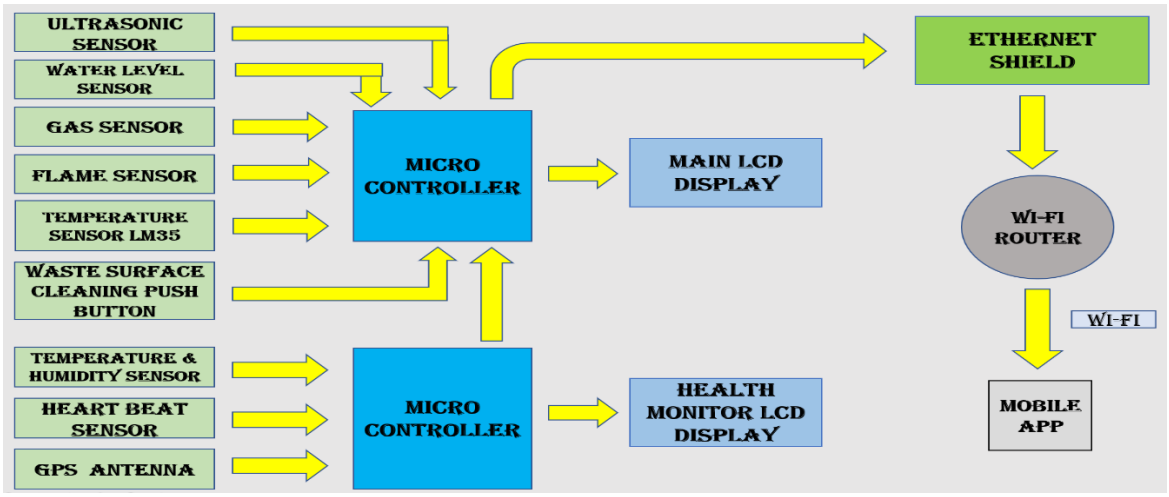

Figure 1: Smart farming system model

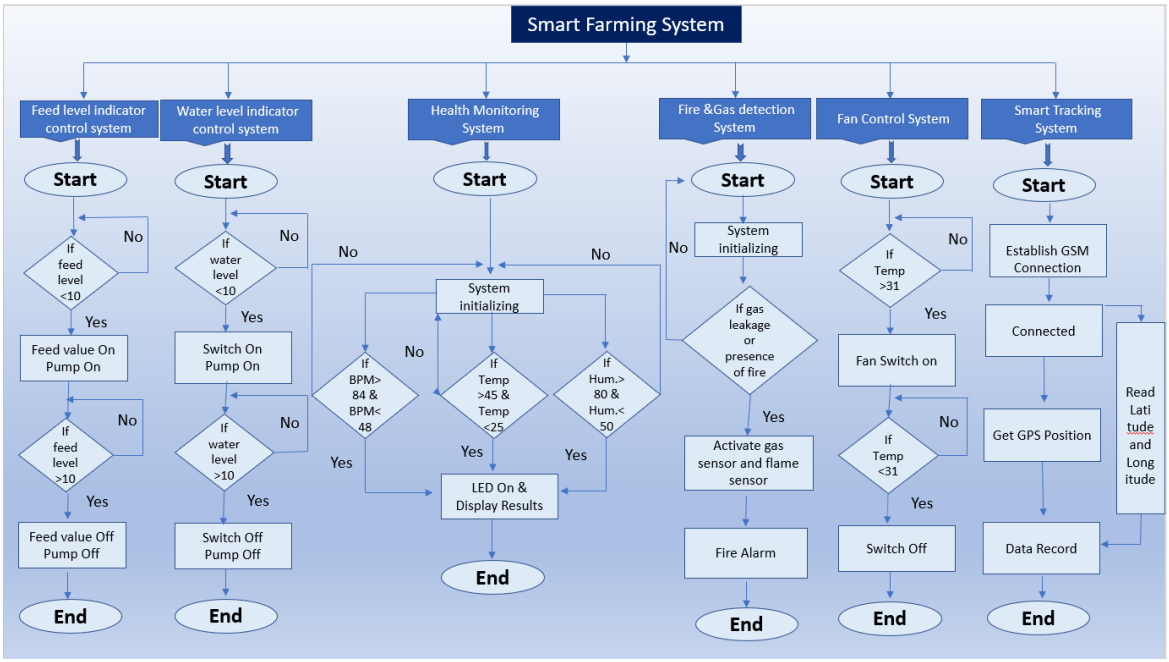

Figure 2: Control system mechanism of smart farming

decreases to 10%, the pump turns on, and automatically water can be filled in the tub.

3.2 Health Monitoring System

The health monitoring system consists of heartbeat measurement and temperature & humidity measurement. In the heartbeat measurement, the heartbeat sensor measures the BPM. The basic principle of the heartbeat sensor is based on the photo plethysmography. This sensor measures the change in blood volume via any organ that occurs a change in the light intensity via that organ. The light passes through the skin, and the sensor detects how much is reflected back. Heartbeats can be seen as changes in light reflections. The heart rate measurement is, in essence, an indirect method. Indirect contact is often referred to as invasive contact. Heart rate must always be monitored using non-invasive ways. They have an advantage over approaches that have a detrimental impact on an animal's condition. When breeding livestock animals, it is necessary from an ethical standpoint to check their capabilities using the most sophisticated electronic instruments. In the designed model, the setting range of bits per minute (BPM) range is in-between 80 bits to 120 bits. The cause of the standard heart rate of an adult cow

is an average of 66 bits. If the BPM increases to 120 bits or decreases to 80 bits, it will automatically turn on the LED and display the results.

In the temperature & humidity measurement, DTH11 sensor measures the temperature & humidity in the designed model, the setting range of temperature range is between 25°C to 45°C. Cause of the standard temperature of an adult cow is between 38°C-39.3°C. If the temperature increases to 45°C or decreases to 25°C, it will automatically turn on the LED and display the results. The setting range of humidity range is between 50% to 80%. Cause of the standard humidity of an adult cow is 75%. If the humidity increases to 80% or decreases to 50%, it will automatically turn on the LED and display the results.

3.3 Fire & Gas detection System

In the Fire & Gas detection system, two detection method was used. 1. Fire Detection & 2. Gas Detection. In the gas detection part, gas sensor is used to detect dangerous gases like ammonia, carbon dioxide, nitrogen dioxide, bromine, arsine, ozone, and some other gases. These sensors help to alarm people when toxic or explosive gases are present in the atmosphere. Gas detection is possible with a concentration sensing range of 300 ppm to 10,000 ppm.

In the flame detection part, flame sensor uses for the detection of flame. This sensor is a short, thin metallic rod that generates a tiny current of electricity to certify that there is fire in the furnace. The existence of a fire or other infrared source is detected by the IR flame sensor Flame or a light source of a wavelength in the range of 760 nm to 1100 nm can be detected.

3.4 Temperature based Fan Control System

This fan control system model is placed in the animal farm to maintain the room temperature. This is an automatic system that will control fan speed automatically with changing temperature. Control of the fan is necessary for a farm because livestock will feel uncomfortable if the temperature emerges as extremely high. In this control system, when the room temperature is increasing then the fan speed is also increasing. The fan is turn off in below 30°C, in this temperature, the system is turned off. When the temperature is above 30°C, the system starts to work, and according to the microcontroller's instruction, the fan speed changes. The fan speed increases when the temperature is above 30°C.

3.5 Smart Tracking System

With the support of GPS tracking collars, GPS tracking devices allow for the remote location of animals in need. The tracking gadgets can offer the animal's exact worldwide satellite position and provide location updates at specified intervals using the Global Positioning System (GPS). Locations are recorded and can be retrieved in a variety of ways. The position data from earlier GPS collars could only be stored until the collar was found. Modern GPS collars, on the other hand, allow position data to be obtained remotely. GPS/GSM collars use GSM mobile phone signals to acquire and transmit data. GPS collars use geostationary satellites to relay location and other data to a tracking server or PC. In the designed model, using the microcontroller module and blynk application, the GPS tracker displays values on a led display and tracks latitude, longitude, speed, direction, number of satellites, and time in UTC.

3.6 Proposed cowshed design model

A cowshed is a location where cows may relax and sleep throughout the night. In the resting area, each cow has his or her own cubicle. The cubicles must be covered with a roof made of iron sheets, grass thatch, or makuti. The shed should be surrounded on three sides by a wall that is at least 10-15 feet high. Figure 3. Shows the proposed shelter design can easily accommodate 10-12 cows. The structure is 80*50 feet in length and width. The cubicles are protected from the sun's heat by a 40-foot roof from ground to top, as well as a 20-foot ceiling from ground to sunshade. A 3-foot roof is built over grass or hay that is stacked beneath it; it must be high enough so that a cow cannot consume it. On three sides of the walls of this model, we employed fire-resistant fiberglass roof sheets that give great protection from wind, rain, and storms. The cubicle is meant to keep the cow clean at all times.

4 SIMULATION PERFORMANCE

Overall smart farming system simulation has been performed the simulation software proteus and Arduino IDE software shown in Figure 4

In this simulation different types of system are simulated like feed control system, health monitoring system, gas, and fire detection system, fan control system, smart tacking system, and waste management system. Here (figure 3) demonstrates the complete simulation structure, which consists of many different controlling systems and maintaining systems. Here a lot of equipment is associated which is used to run the whole system. The overall simulation will be implemented with machine learning which is used inside the C++ coding.

The 1st part of the system consists of feed control system, fire& gas detecting system, and fan control system. In the feeder part, ultrasonic sensor, relay module, motor, and other components are used. The ultrasonic sensor detects the feed quantity in the tub and the water sensor detects the water level in the tub. Flame sensor detects presence of fire in the surrounding of the farm and another MQ-2 gas sensor detects the leakage of gas. Fan control system is an automatic system that increasing the fan speed by changing the room temperature. Health monitoring system and smart tracking system are connected with the 2nd Arduino nano.

In this simulation, an Arduino nano is connected to a health monitoring system for livestock, and a DHT11 sensor for measuring the body temperature & humidity of livestock. A GSM module is used to communicate the animal's coordinates to a mobile phone through text message. In the simulation, a motor turns the traction through the wheel, causing the manure plates to operate, completing the dung cleaning technique. And all the health-related results are shown by a separated LCD display.

5 RESULTS ANALYSIS

To increase more significance to our proposed design, combined the separate systems into a single system. Figure 5 shows the whole simulation outputs data where the outputs are in the range of the

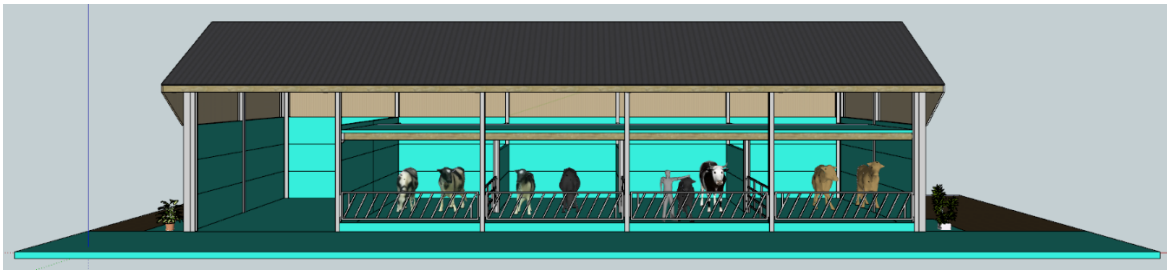

Figure 3: Front View of the cowshed model

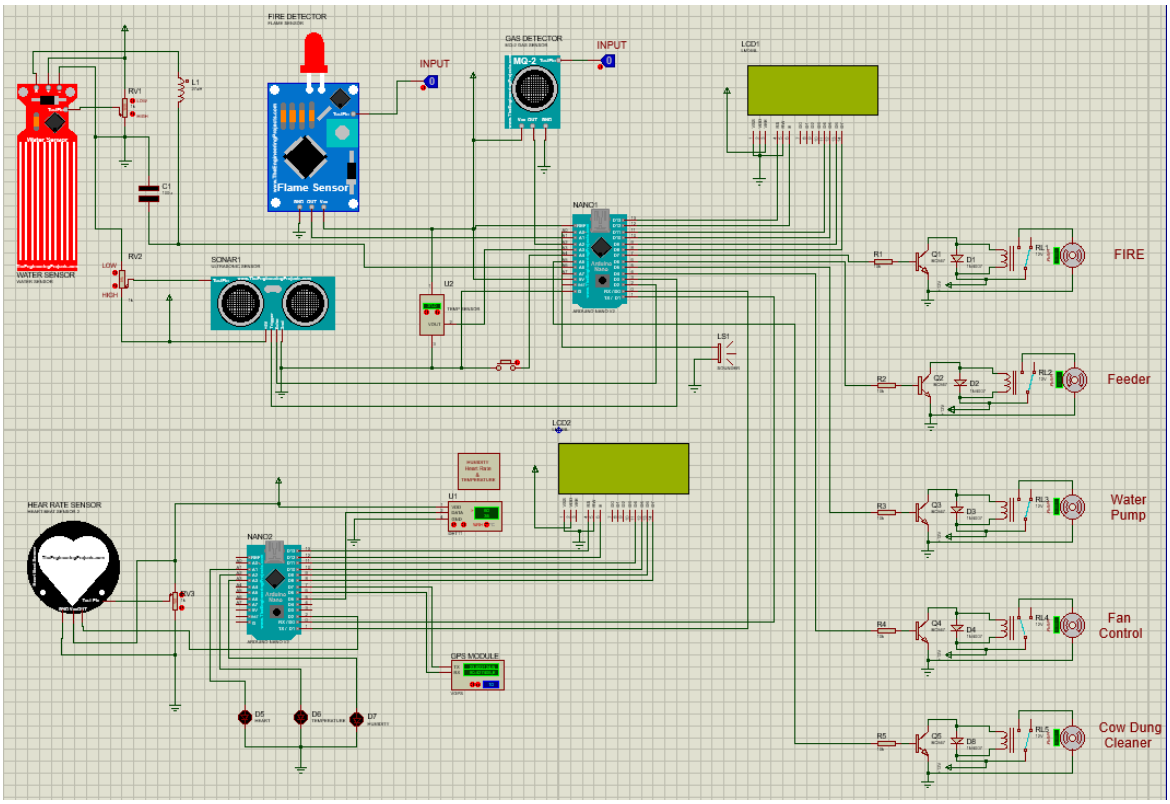

Figure 4: Overall Simulation Diagram

conditions and motors are off. If the outputs are out of the range of the conditions, then the motors are automatically on.

Another part of the proposed scheme includes a health monitoring and GPS positioning system, which provides current temperature, humidity, heart rate, and animal location data. Figure 6. shows the temperature, humidity and heart rate data that indicates the health of cow is good now cause of the data is in the range of the conditions. If the temperature, humidity and heart rate are out of the range of the conditions, then animal condition is too bad and needs to consult with the consultant immediately. Figure 7 shows the actual latitude and longitude position of the animal with time over the phone.

Figure 8 and Figure 9 shows the hourly results for the water and feed level indicators respectively. Water and feed level should be going up and down at several times in a day specially in afternoon and evening times cause of cows have constant access to eat feed and water 2 or 3 times per day.

Figure 10 shows the thirty minutes' results for the adult cow heart rate respectively. Heart rate should be dramatically going up and down every minute's cause of the diseases, movement, and feeding time.

Figure 11 and Figure 12 Shows the hourly results for the adult cow body temperature and temperature-humidity respectively. The body temperature and temperature-humidity should be a rise in the afternoon time due to the summer season are running now also outputs will change in other seasons.

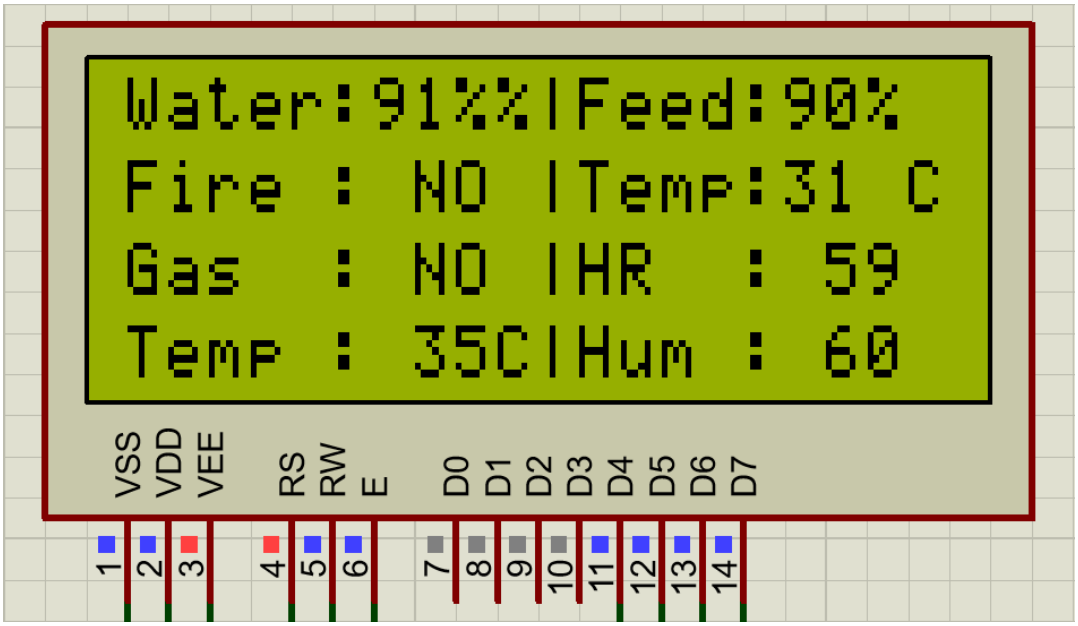

Figure 5: The overall output display of the system

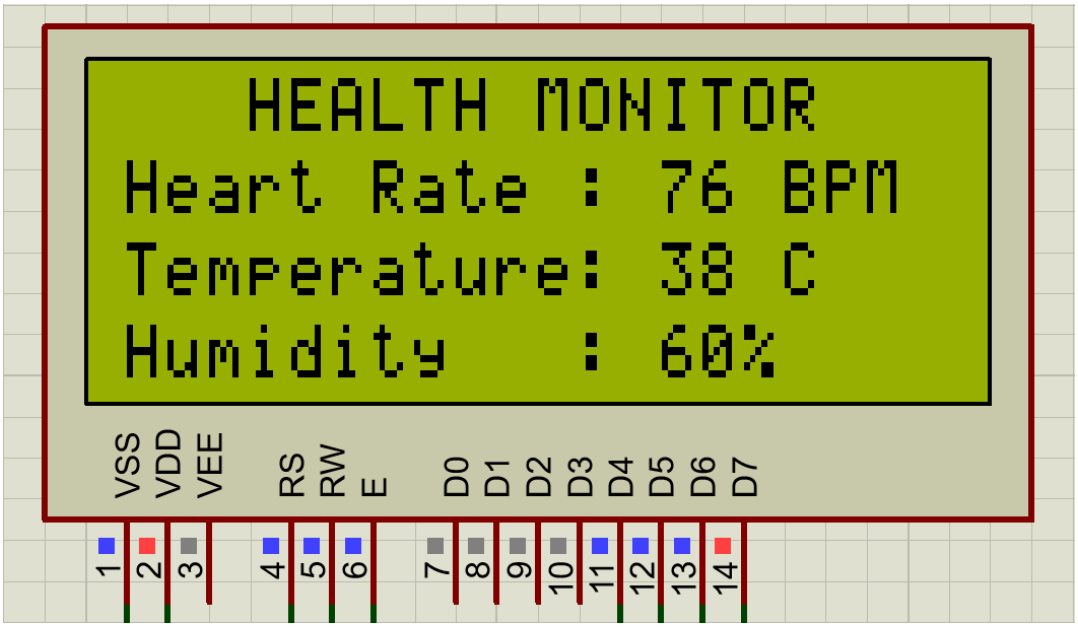

Figure 6: The output display of health monitor system scheme

Figure 13 shows the hourly results for the environmental temperature-based fan control system. Due to the summer season, the temperatures should be a rise in day time and the fan system will be operating as the conditions. The results should be fluctuating in different seasons and the fan will operate to maintain the farm temperature.

Table 1. indicates the condition in an emergency circumstance where a quick response is necessary to address the problem. Automatically operate the full process and doesn't need to wait for a response from the user.

The proposed system can increase the maximum productivity of the farm and reduce the total labor cost., the farm workers can utilize the above control system automatically and get maximum profit from the farm by using IoT. Design of an automatic feed

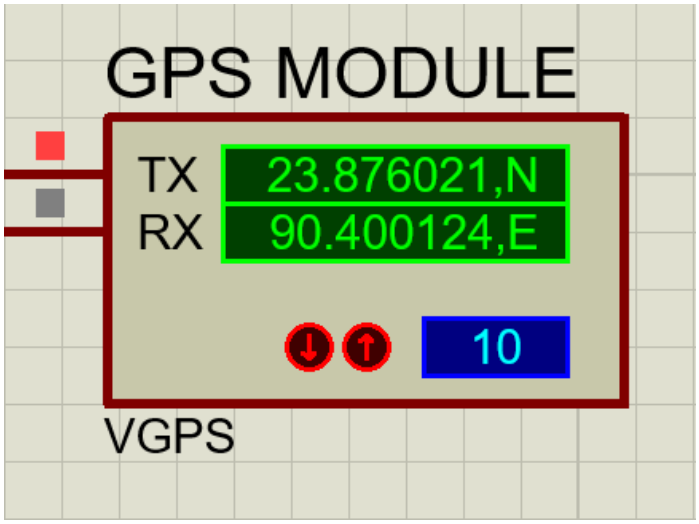

Figure 7: GSM Module Display

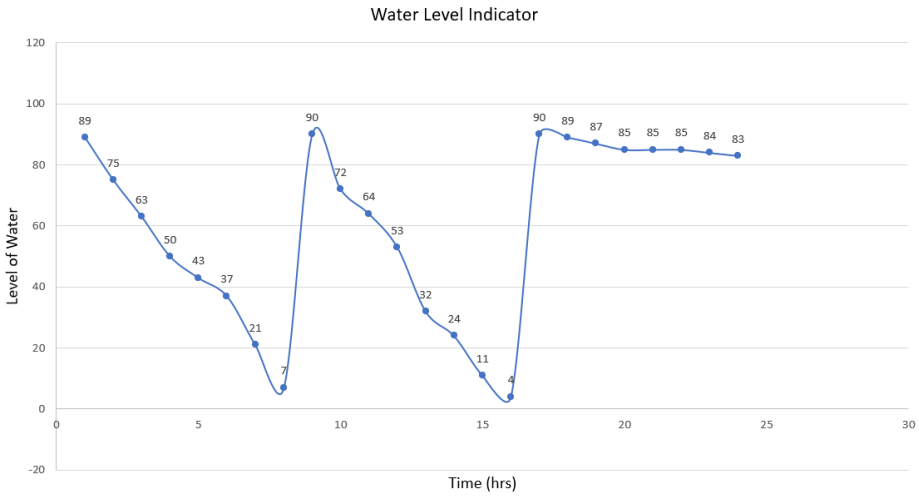

Figure 8: The Output Graph of water level indicator System

Table 1: Smart faming system measurement and conditions

No.	Measuring	Condition
1	Feed & Water Level Indicator	Level < 10, Motor & Valve On Level > 90, Motor & Valve Off
2	Fire & Gas Detection	Gas Leakage or Presence of fire ⟶ Alarm & LED Blink
3	Temperature Based Fan Control	Environmental Temperature > 31
4	Heart Rate	BPM > 84 || BPM < 48
5	Body Temperature	Temperature > 45 || Temperature < 25
6	Temperature-Humidity	Humidity > 80 || Humidity < 50

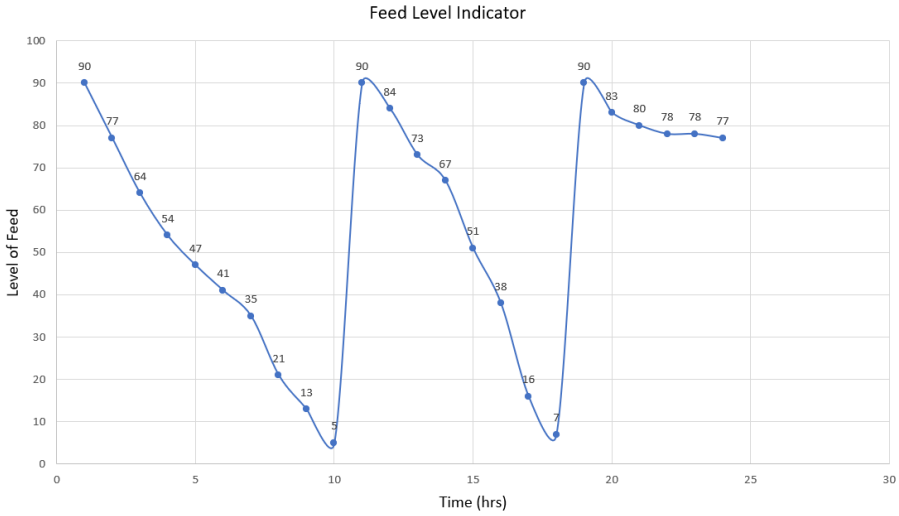

Figure 9: The Output Graph of feed level indicator System

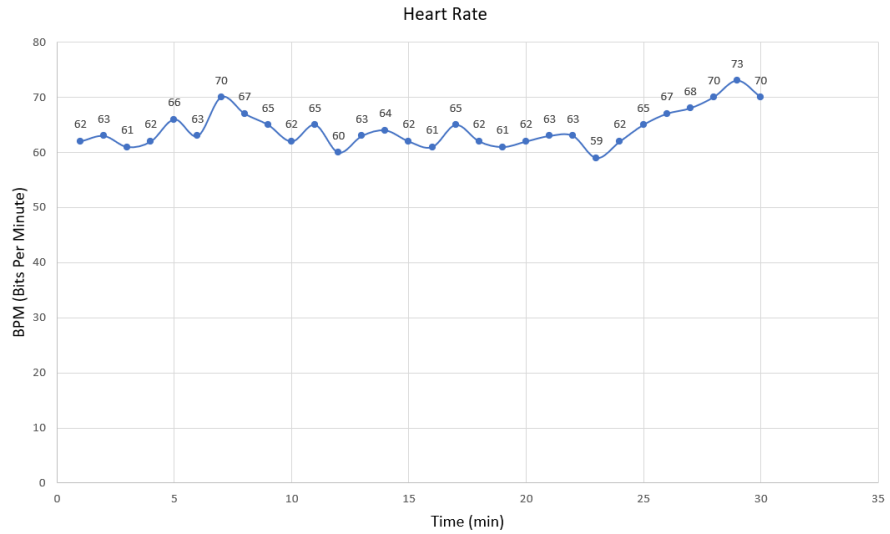

Figure 10: The Output Graph of animal heart rate

control system is helpful for the farm workers. The farm owner can understand the animal's health condition, and according to the health data, the owner can call the veterinary doctor for treatment. Also, it helps to reduce the death rate of the livestock of this farm. Therefore, it increases the production of the farm. Also, for safety of the farm, fire and gas detection system is designed. And fan control system is designed to maintain the farm temperature which is suitable for the livestock. From GPS tracking system, the farm workers can track the individual livestock. So, the farm workers can monitor the livestock from their home. So overall all designed system increases the farm productivity.

6 CONCLUSION

In this paper, a smart farming system was designed. The designed model picks up all traditional system which is used to preserve a farm. This designed system is eco-friendly. This system observes the real-time farm data, and the users can have monitored the farm automatically through IoT. The smart farming system strives to exhibit upgrades in quality practice in any livestock management work. Keep in questioning the motive of ensuring the proposed model's competencies and strengths. So, this proposed, designed system fulfills all the critical requirements which are needed to operate a farm smartly.

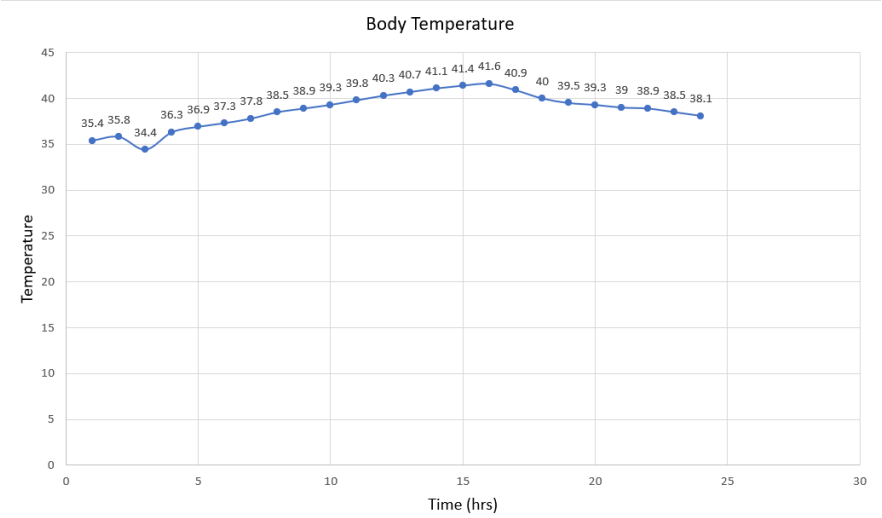

Figure 11: The Output Graph of animal body temperature

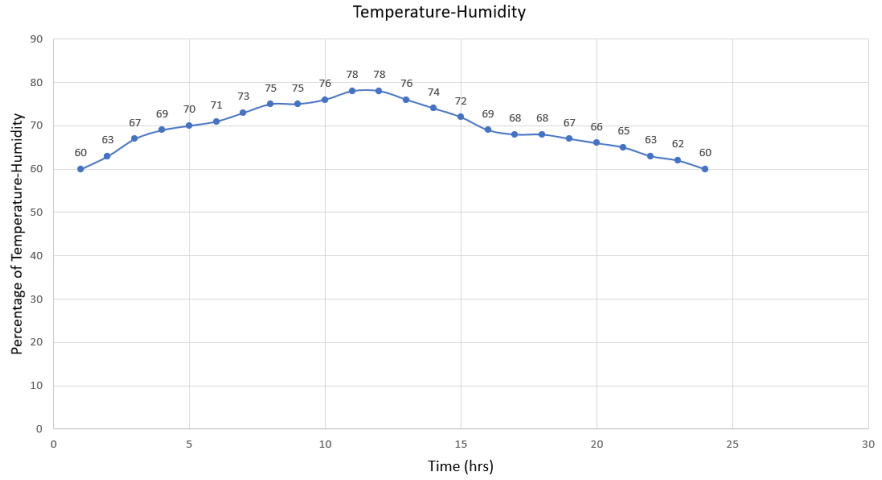

Figure 12: The Output Graph of cow temperature-humidity

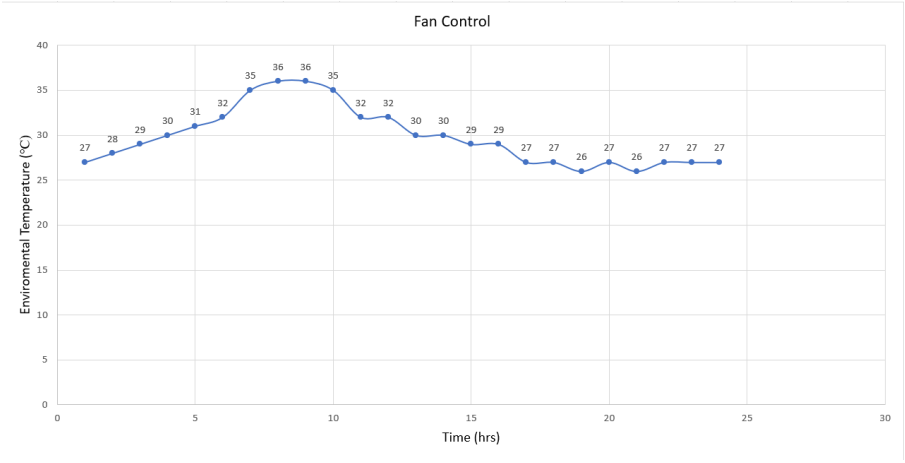

Figure 13: The Output Graph of Fan Control System

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