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Sensor Network Based Animals Feeding and Milk Production Management System

Abstract- *In general, the animals' feeding requires a lot of time and efforts spent by the cattlemen. Part of the feeding amount is consumed by the animal to save its life and the other part is considered for instrumental milk production. The type of food in addition to the number of feeding frequents are important factors in changing the amount of produced milk as well as the weight of an animal. In this paper, we propose a control system that manage the forage process and the amount of produced milk by determining the quantity and number of feeding animals using sensor network. The designed system includes two parts: allocated hardware and data center. The hardware part consists of a microcontroller (ARDUINO Uno), Radio Frequency Identification (RFID) tags, level sensor, and Bluetooth HC-06. Sensors send their real-time readings of the forage quantity of animals to the monitoring part of the system through the Bluetooth service and then save them in the database server. RFID tags are used to recognize the cow types. There are two types of cows considered in this paper depending on the amount of produced milk. In the data center, the database is built using SQL server 2015 for storing the sensor readings and control signals of the proposed system. While the related Graphical User Interface (GUI) frames is designed using Visual Studio C#. The proposed system has been presented in a prototype to show forage process and resulted in a clear reduction in a daily cattlemen effort. The proposed system has been tested over different scenarios and the obtained results show the efficiency in terms of management part and food saving part.*

Keywords- *Animals' feed, milk production, embedded systems, sensor network, database management.*

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1. Introduction

Development in electronics makes the daily work easier to be accomplished. Because of this advancement, an automatic Livestock system has been implemented to seek the flexibility and reduction in cattleman's work. The whole duty of a useful business in dairy farm goes to the cooperative rancher as Dairyman and cow are two primary parameters in the charge of carried on dairy cultivating [1]. In cows feeding, milk represents the most important aspect of the care and breeding as feeding costs ranging between 50-70% of the total cost of daily production [2]. It conveys fresh forage after drainage a milk to promote standing and decrease the danger of mastitis [3]. The benefit of using sensors is to monitor all related arguments for best feeding administration in real-time way, in which all changes in weather and feeding process can be detected early [4]. In this paper, the proposed automation animal's feeding system includes two processes: the first process is about animals' forage and the other process about cow milk production. In feeding cows, the proposed algorithm takes the sensor reading of food level to control the forage process in addition to monitor the amount of food level. Additionally, the proposed system uses RFID to recognize cow's milk, which needs more food, from the normal cow and this makes forage process simple. The other process is about controlling the exportation of produced milk to the market with full recording of each introduced package. As mentioned above, the proposed system includes two main parts: hardware and data center. Each of which perform the related jobs in parallel to obtain optimized work that can reduce the human efforts efficiently. Different scenarios have been introduced to test the system and the achieved results show the superior performance of it.

2. Related Works

Drishti et al. [5], the authors designed automatic animal farming system. The forage monitoring system calculated the rations of animals and reduced the cattleman work in the operation. This system used microcontroller as a central unit to

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receive data about times of the meals for the animals and control on the feeder. Angelo and *et al* [6], a project for feeding animals based Global System Mobile (GSM) technology was designed. The pet owner could start food preparation simply by sending an instant message to the framework through the adopted mobile phone. The framework utilized the idea of GSM innovation to get a flag from the proprietor. Arduino-based nourishment and water container enacted through GSM innovation. In the event that the framework received the message, the servo motor and solenoid valve were initiated. Once the bolstering was completed, the proprietor received an instant message from the framework to inform it of an effective feeding.

3. Proposed System Design

Figure 1 shows the hardware part architecture of the proposed cows' feeding and milk production management system. In the present system, the feeding system contains RFID tag and level sensor. The RFID tag is used for recognizing milk cows to determine the quantity and number of meals for cows, while the level sensor is employed to inform the adviser about forage amount. Another level sensor is utilized to inform the adviser about milk quantity and based on this reading the exported package becomes ready or not. All sensor readings are collected and controlled by Arduino that sends this information to the monitoring side for processing, statistical analysis and storing in the database. The Bluetooth device is used for wireless transportation of the signal between the Arduino and data center. The feedback control signals are sent back to the Arduino for controlling the feeder.

In addition, the hardware part includes the following components:

I. Arduino Uno

The Arduino Uno is a kind of microcontroller board that uses ATmega328. The Uno is the newest in a succession of USB Arduino. a CPU AVR can be programmed by the PC in C programming language by means of Universal Serial Bus (USB) port as shown in Figure 2 [7].

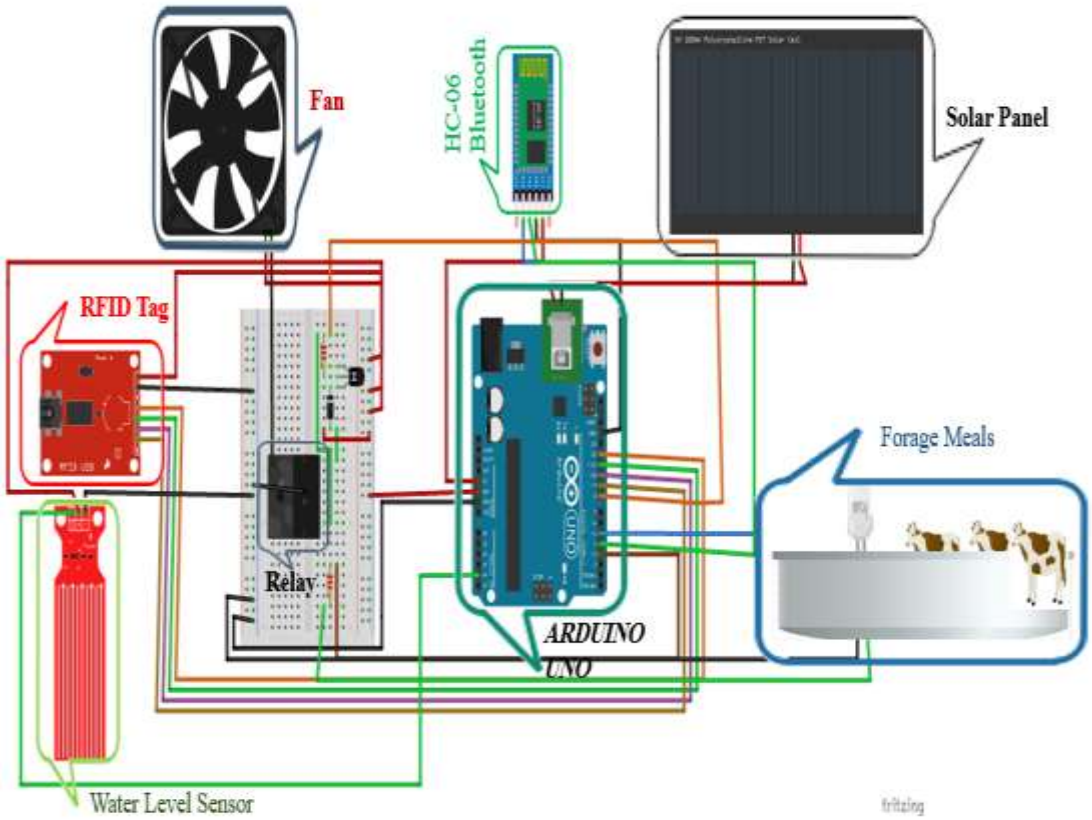


Figure 1: Hardware architecture of the proposed system.

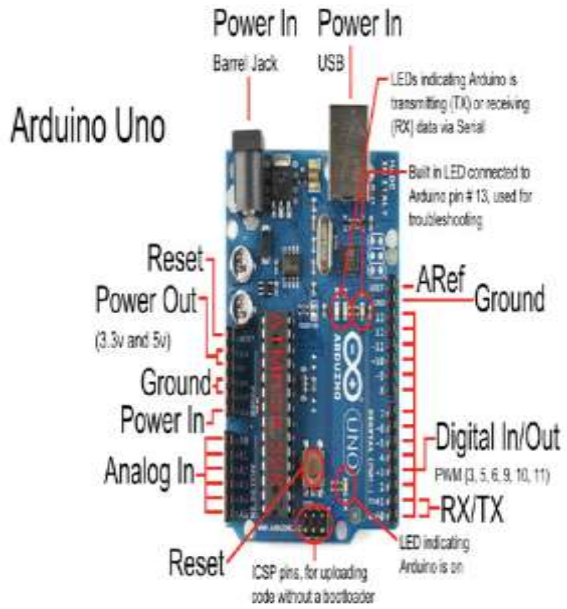


Figure 2: Arduino Uno board.

II. Level Sensor

This is easily and mini portable water level identification, disclosure sensor water that has high-cost execution. It can improve performance with Arduino 328 controller and sensor hand-off shield as shown in Figure 3, [8].

III. RC522 RFID Tag

MF RC522 is a very coordinated transmission module for contactless correspondence at 13.56 MHz This module is shown in Figure 4 [7].

Figure 3: Water level sensor.

Figure 4: RC522 RFID tag

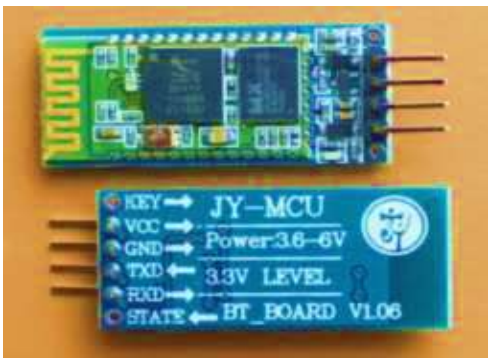


Figure 5: Bluetooth HC-06

IV. Bluetooth HC-06

HC-06 module is a wireless technology utilize for data communication over short range, purposed for direct wireless serial exchange setup [9]. This type of Bluetooth module is shown in Figure 5, [10].

4. Proposed Algorithm

The proposed algorithm of the introduced system involves two sub-algorithms: feeding and milk production. The adopted feeding algorithm is represented as a flowchart in Figure 6. After powering up the system, the Arduino begins sending the readings of the considered sensors to the server at the data center. The feeding algorithm analyses the received data and based on reading it decides to start the feeding process or not. At the beginning, the Arduino sends the available forage quantity to evaluate if it enough along day meals of cows. If it is enough, it starts feeding process otherwise am alarm message of" *The forage quantity available is under threshold average, must refill forage tank*" is displayed. The feeding process is summarized by filling the feeding tank with food and open the get for cows to be entered. In addition, a real-time monitoring procedure is continued on the feeding process and the amount of food. At the other hand, the milk production algorithm considers the procedure of exporting the milk to the market. This algorithm can be presented as shown in Figure 7. The Arduino sends the readings of the considered sensors to the server at the data center for processing and storing. The milk production algorithm processes the received data to decide if the collected amount of milk is enough for exporting or not. Produced milk level is the only indicator of the product. Normally, if the level of the collected amount of milk above the threshold value, the algorithm starts the procedure of exportation, otherwise the following alarm message is shown" The milk quantity available is under threshold average, wait until milk quantity required become ready*"*.

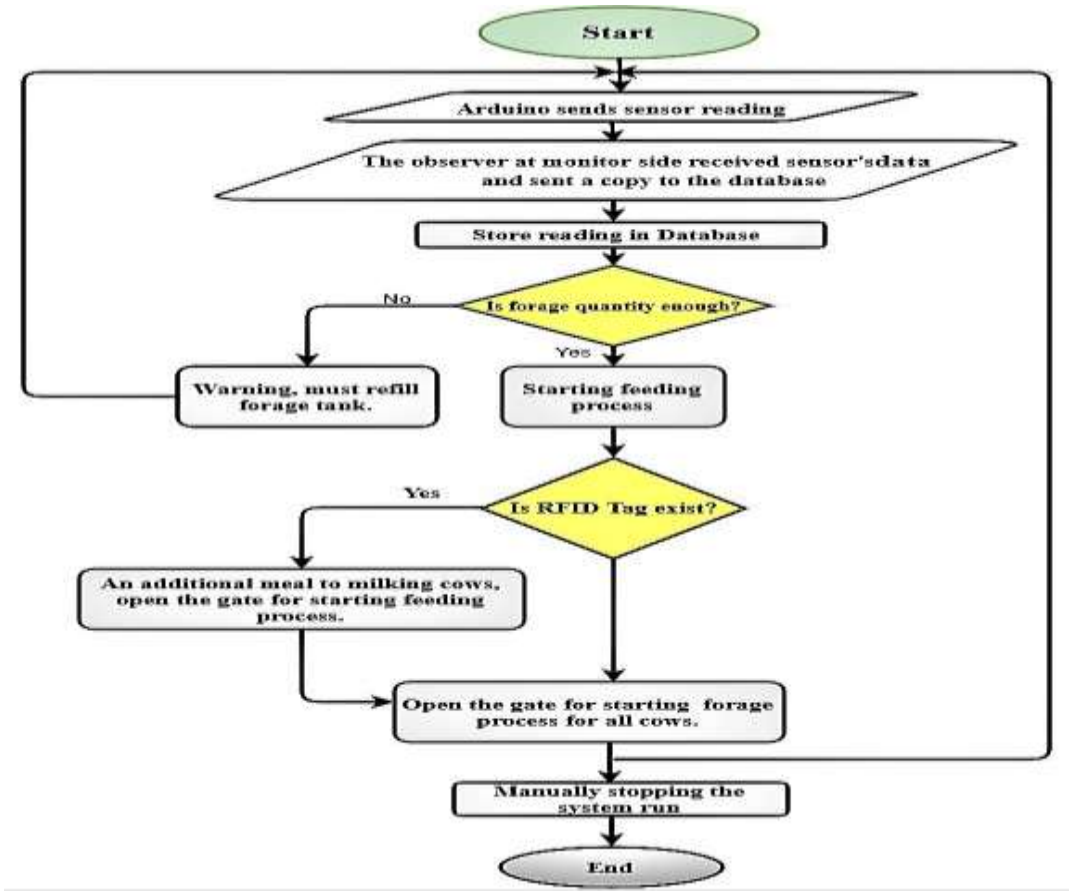


Figure 6: Feeding algorithm flowchart.

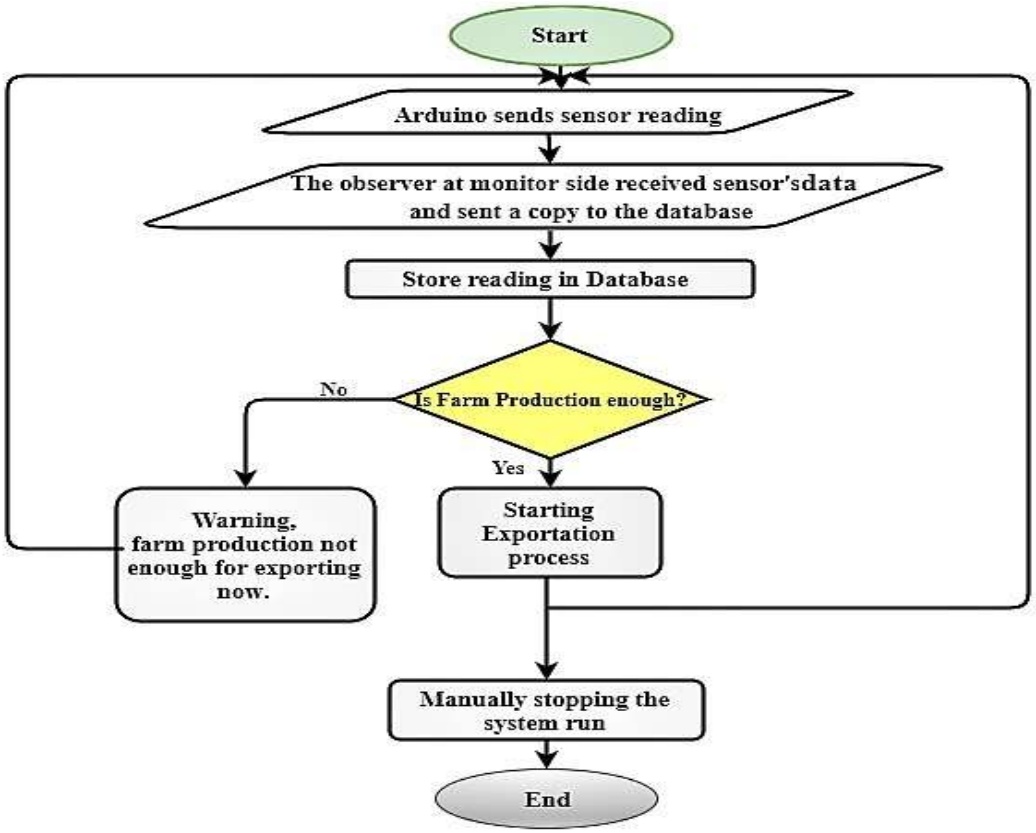


Figure 7: Milk production algorithm flowchart.

4. Database Building

Database, which is a collection of existing data elements in the associated tables with each other and there are relationships between these tables, which include records of stored [10, 11]. The built database is accessed utilizing Structured Query Language (SQL), which is a programming language utilized for managing social databases and performing different operations on the information in them [12, 13].

In this work, a database called *FEEDING* has been built using local SQL server with three structured tables which is: ***Reading Table, Forage Table, Milk Production Table***. Each table includes different elements and each of which is represented by an individual column in the table. Table 1, shows ***forage table*** for feeding process which involves the collected data of time and number of meals, ID of cow (for milk cow only) date as well as duration of meal. Table 2, shows ***Reading*** table of the produced milk quantity that includes time, date and of readings of the milk level in milk tank.

Table 1: Cows feeding table

PK_Ration	Cow ID	Date	Start_Time	Duration	No. of Feeding
1	531361731170	2015-01-01	05:00:00	30min	3
2	531361731170	2015-01-02	05:00:00	30min	3
3	531361731170	2015-01-03	05:00:00	30min	3
4	531361731170	2015-01-04	05:00:00	30min	3
5	531361731170	2015-01-05	05:00:00	30min	3
6	531361731170	2015-01-06	05:00:00	30min	3
7	531361731170	2015-01-07	05:00:00	30min	3
8	531361731170	2015-01-08	05:00:00	30min	3
9	531361731170	2015-01-09	05:00:00	30min	3
10	531361731170	2015-01-10	05:00:00	30min	3
11	531361731170	2015-01-11	05:00:00	30min	3
12	531361731170	2015-01-12	05:00:00	30min	3

Table 2: Reading data table

PK_Forage_ID	Date	Time	Cow_ID	No. of Feeding
1	2015-01-01	14:17:44	531361731170	1
2	2015-01-02	14:17:45	531361731170	2
3	2015-01-03	14:17:47	531361731170	3
4	2015-01-04	15:43:11	531361731170	1
5	2015-01-05	15:43:12	531361731170	2
6	2015-01-06	15:43:14	531361731170	3
7	2015-01-07	14:53:16	531361731170	1
8	2015-01-08	14:53:18	531361731170	2
9	2015-01-09	14:53:19	531361731170	3
10	2015-01-10	20:27:25	531361731170	1
11	2015-01-11	20:27:26	531361731170	2
12	2015-01-12	20:27:28	531361731170	3

Table 3, shows order table for daily exporting milk process after milk quantity become ready to export and it includes five columns which are order no, date and time of the order, SL_No used to recognize milk cow from cow living, and Milk Quantity.

Table 3: Milk order table.

PK_Export_Package_ID	Date	Time	Milk_Quantity
1	2015-01-01	07:00:00	25000
2	2015-01-02	07:00:00	25000
3	2015-01-03	07:00:00	24000
4	2015-01-04	07:00:00	25000
5	2015-01-05	07:00:00	24000
6	2015-01-06	07:00:00	24000
7	2015-01-07	07:00:00	24000
8	2015-01-08	07:00:00	24000
9	2015-01-09	07:00:00	23000
10	2015-01-10	07:00:00	23000
11	2015-01-11	07:00:00	25000
12	2015-01-12	07:00:00	25000

5. GUI Design

The system user interfaces are designed using Visual Studio C# in a simple and understandable way to given flexibility to who using it without required skilled in programming. Figure 8 shows feeding management system page with five buttons: *Feeding Table*, *Delete*, *Update*, *Statistical Information* and *Arduino Connection*. The *Feeding Table* button is used to allow adviser for adding information of forage quantity based on number and weight of cows. Moreover, the *Delete* button is utilized for deleting the feeding table completely. The *Update* button is employed to update existing data, while the *Statistical Information* is used for displaying a statistical evaluation of how feeding is consuming by cows along a year and last button. In addition, the *Arduino Connection* button is to interact with Arduino for starting daily process and receive sensor reading about exist forage amount then it is stored in database.

Figure 9 shows Milk exporting page with five buttons of: *Production Table*, *Delete*, *Update*, *Statistical Information* and *Arduino Connection*. The *Production Table* button is used to add new order to the production table, the *Delete* button is utilized to delete milk exporting table completely. The *Update* button is employed to update existing data; the *Statistical Information* button is used for showing a statistical information regarding the exportation of milk amount along a year. The last button, *Arduino Connection* is used to show the Arduino activity for starting daily process and receiving sensor reading of existed milk amount then it is stored in database.

Figure 8: Feeding page.

Figure 9: Milk production page.

7. Result

The proposed system has been tested over different scenarios to obtain a complete vision on the performance and efficiency of managing the underlying jobs. As mentioned earlier, the used software environments are: Visual Studio C#, SQL server as well as the Arduino interfacing. The proposed system is represented as a prototype as shown in Figure 10 that shows the installation of the considered components (Arduino, sensors and Bluetooth). At the server side, the received of wireless sensors' readings are processed and the right decision of feeding and milk exportations are taken automatically. It is important to note that the feeding storage is represented by water container with water level sensor, where the water is a sample of cow's food. In addition, the milk container is viewed with the level sensor. Before the starting of the feeding process, the sensors check forage quantity at the food storage and in case of sensor readings are below the adopted quantity level of a forage an alarm message is appeared as shown in figure (11-a). In Figure (11-b), the forage quantity level is in allowed limits of performing the forage process, while in figure (11-c) shows the status of full filling forage storage and this before starting forage process.In the milk production and exportation process, we monitor level of milk production from cows via using milk level sensor to evaluate the milk quantity if it is ready to export or not. Figure 12 shows sensor's readings at the monitoring side and based on these received reading, the proposed system decides to start export process. Figure (12-a) shows that the milk level is below the allowed quantity level to be exported by informing the adviser using alarm message. At the other hand, when the produced milk level reaches the allowed quantity of exportation as shown in Fgure (12-b.), the proposed system starts the exportation process.

In the statistical information, different statistical graphs to illustrate the amount of consumed cow's foods and the exported milk. These graphs can be drawn for specific dates and time. Figures (13-a) and (13- b) show statistical analysis of a feeding drainage by cows during entire year (2016) in addition to milk quantity export through 2016, sequentially.

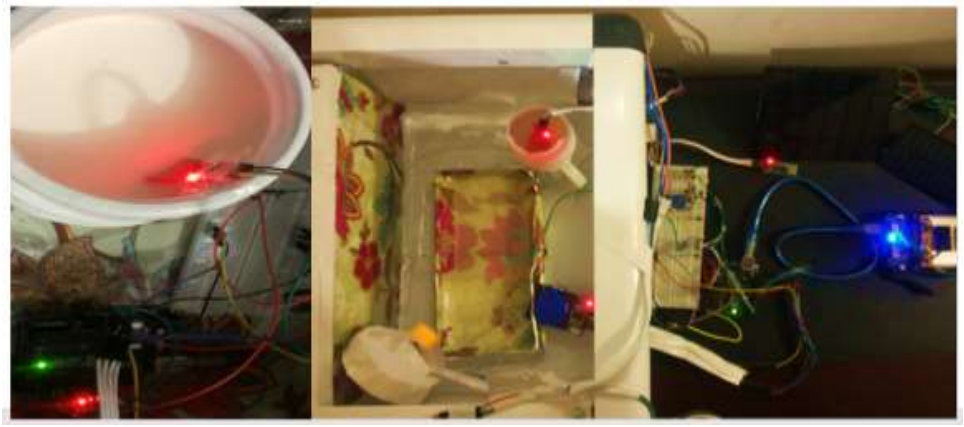


Figure 10: The proposed system prototype.

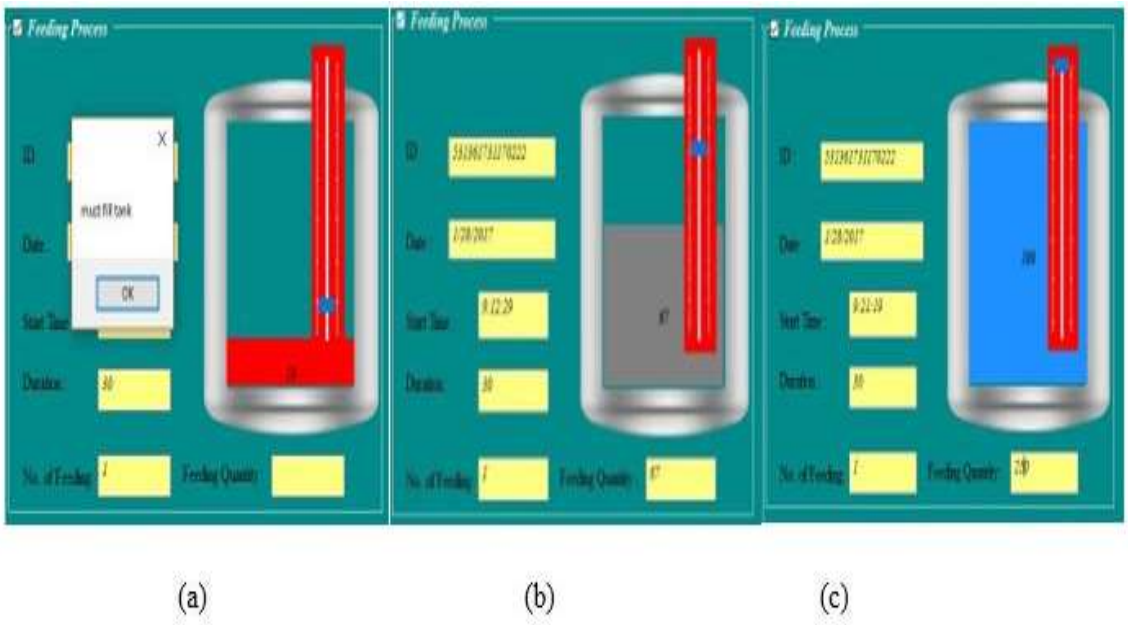


Figure 11: Forage quantity during feeding process.

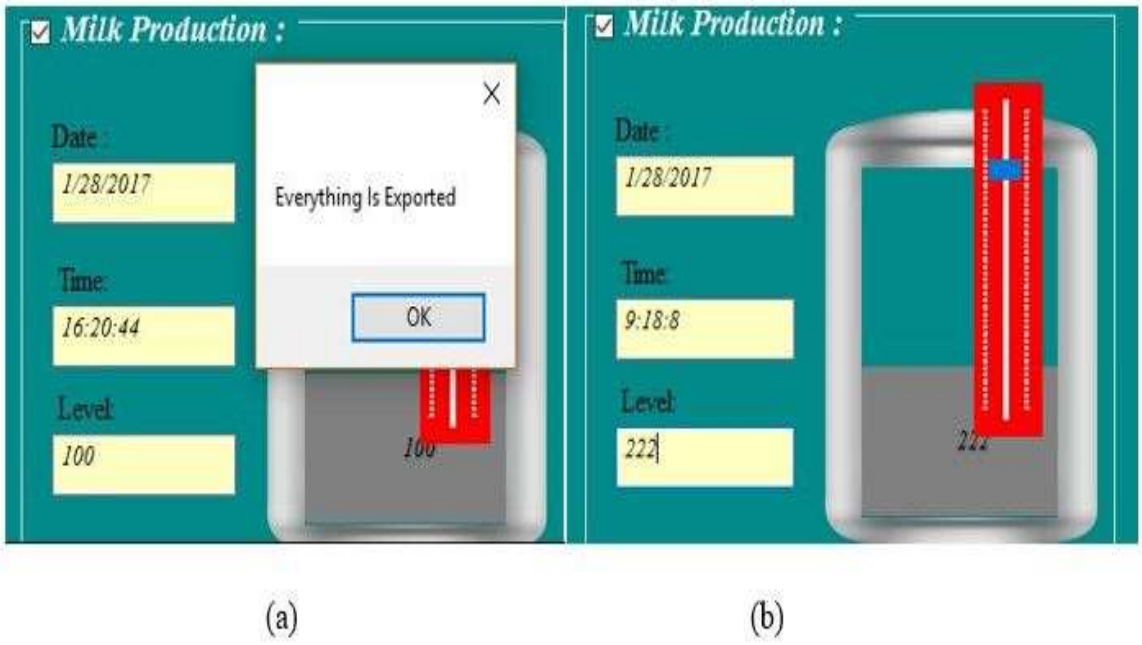
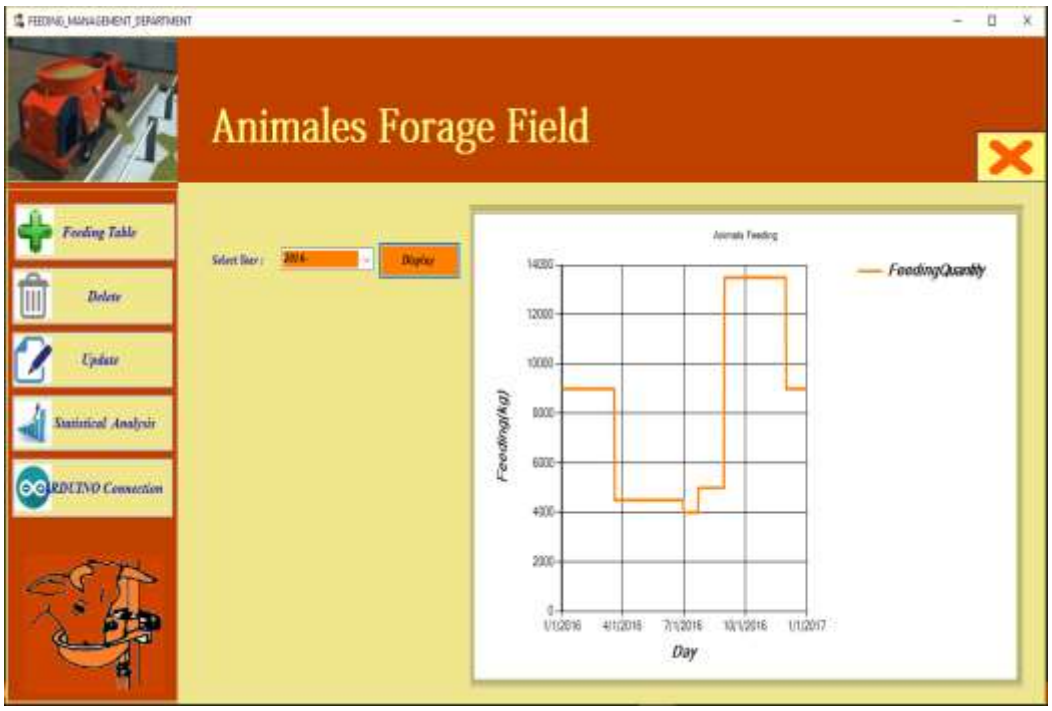
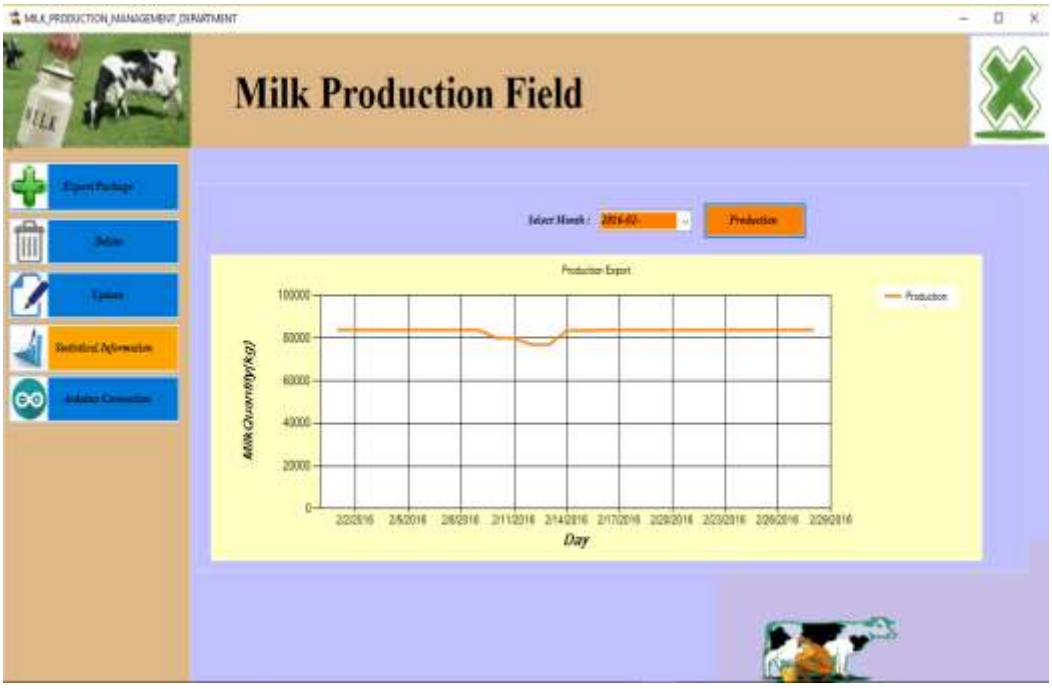


Figure 12: Milk export process.



(a)



(b)

Figure 13: Statistical Analysis of (a): feeding drop during year via cows, (b) Milk quantity export through year (2016).

8. Conclusion

An automated cow's feeding and milk exportation system using sensor network was introduced. The conclusions of the proposed system can be summarized as follows: The building of database management system and designing of Graphic User Interface is achieved to facilitate the observer work.

1. This system offered a services to cattlemen's daily operations to be more comfortable and resulted in time conserving.
2. In the animal's feeding management system, the proposed algorithm adopted the sensor readings of forage level in the storage for two reasons. Firstly, it controlled the feeding process in terms of time and date; this could help in

saving wastage forage up to ratio of 33%. Secondly, it monitored the amount of forage level before and after feeding process to alarm the farmer at a time. This could reduce the required time to 50%. Additionally, the proposed system used the RFID tags to recognize milk's cow needed more food over the normal cow. At the other hand, the labors were reduced to ratio of 30%.

3. In addition, the proposed system controls the milk exportation process. Based on the received sensor readings, the management system could activate the exportation process, this will result in improve exportation process at ratio 10%.

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