REMOTE MONITORING AND CONTROL SYSTEM FOR POULTRY FEED DISPENSER USING ANDROID AND WIRELESS FIDELITY SOCKETS

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***Abstract*—The application of primitive methods in agricultural production offer a major resistance to the effectiveness and yield of agricultural produce. Deploying precision agriculture to replace the traditional pattern is required to achieve better yield. A major challenge in poultry production is the method used in dispensing solid and liquid feed to poultry birds. Existing methods in the tropics are affected by fatigue, stress, contamination and feed wastage which all result in low return of investment, high mortality rate and lower growth rate. The automation of feed dispensing has improved on the traditional modes, but the existing automated feed dispensers mostly require physical presence and monitoring. This work develops an embedded system designed around Raspberry pi 3 microcontroller unit and an Android Software application System to actuate the DC motor and a solenoid valve in an automated poultry dispensing system. The onboard Wireless Fidelity (Wi-Fi) of the raspberry pi 3 was utilized for inter-communication between the microcontroller and the android application using Wi-Fi socket on the device. The evaluation of the system was carried out using the Wi-Fi signal strength at various distances to evaluate the response time of the system. The results obtained showed the system had a better response time within the wireless local area network. Hence, the system can be used to effectively administer feed within the range of the wireless communication for high yield, convenience and better return of investment in poultry production.**

Keywords—Raspberry Pi, Precision Agriculture, Precision livestock farming, Poultry, Socket, WLAN, Wi-Fi

I. INTRODUCTION

Poultry farming is the domestication of birds (usually of the *Galliformes* family) for the purpose of meat, egg, feathers, eggshells, and in rare cases cockfighting and bones. The poultry industry has high economic importance, as it is the major meat producer only second to beef. Poultry meat and egg provides highly nutritional protein with significant low amount of fat. Over 60 billion animals are slaughtered yearly with the figures expected to increase by 40% [1]. Effective management of poultry feed will lead to increase in yield and cost of production. Feed related cost is an important aspect of commercial poultry because it is primarily responsible for the growth and egg production of birds. Manual methods are used in administering feed thereby increasing cost of feeding production. The cost of feed and manual labour attributed to farm operations constitute to over sixty percent of variable costs involved in farm running[2]. Feed directly consumed by birds affects their growth rate, however, there is a maximum level to which the birds can grow, and hence, overfeeding of the birds does not result in increased growth. This leads to feed wastage and low feed conversion rate[3]. As a result of these factors of feed wastage and manual feed administration, the need arises for the development of an environmental friendly system that regulates feed dispensing which will minimize manual labour, wastage, cost, and unpredictable variations due to human intervention. This will in turn lead to a high yield as well as a high return on investment.

Precision Agriculture (PA) is a strategic farm management concept used in the identification, management and analysis of different variables in the field for sustainability, higher yield, and protection of farm resources [4]. Precision Livestock Farming (PLF) is one of the areas of PA dedicated to livestock agriculture and the needs of the modern society in food quality and safety, efficient and sustainable animal farming, animal health and well-being. The goal of PLF is to increase yield and management and distribution of inputs to maximise long term yield and reduce cost. Precision livestock farming is the Management of farm animals by the use of automated real-time techniques to supervise health, welfare, environmental impact, production and reproduction activities [5]. The benefits of PLF includes better feed monitoring and control, improvement of health, nutritional and environmental effects on animals as well as alerting farmers of early signs of diseases. Feed wastage, feed contamination, manual labour involvement directly affects the yield, quality of product and return of investment. Therefore, the application of PA will be vital in developing a system that will automate and time the feeding of the birds for effective poultry farm management.

This work addresses the problems of manual feed administration and feed wastage by developing a Wi-Fi controlled feed dispensing system that is capable of remote monitoring and control. This system uses an embedded system remotely controlled by a dedicated bespoke Android application with Wireless fidelity sockets in the poultry solid and liquid feed dispensing system. This is expected to increase production efficiency, increase yield, reduce cost, and produce a better return on investment. The remaining sections of the paper are divided into four. Section two provides a review of related baseline works and section three shows the methodology employed in the development of the feed dispensing system. The results obtained are shown in section four while section five concludes and gives recommendations for future works.

II. REVIEW OF RELATED WORKS

The domain of poultry feed management has received significant interest and a lot of researchers have proposed various techniques, however, there are a number of limitations in existing works. Table 1 shows a summary of the related works in the development of poultry feeding systems.

Table 1: Summary of related works.

S/No	Author	Work	Limitation
1	[6]	- Self-propelled poultry feed dispenser with feed level sensing capabilities. - Employed parallel port connection with computer	-Limited range due to parallel port -High cost of parallel port maintenance
2	[7]	- Mobile intelligent poultry feeding system. - Obstacle detection and avoidance - Dispenses solid feed	-No liquid feed dispensing capabilities
3	[8]	- Mechanical poultry feeder - Limited feed dispensed using weight of feed on trough	-No liquid feed dispensing capabilities -Requires physical presence for monitoring
4	[9]	- Intelligent poultry feeding system - Dispenses Liquid feed - Feed level sensing capabilities - Employs fuzzy logic	-No solid feed dispensing capabilities
5	[10]	- Mobile intelligent poultry feeding system - Dispenses Liquid feed - Employs Genetic Algorithm and PID control	-No solid feed dispensing capabilities
6	[11]	- Mobile intelligent poultry feeding system - Dispenses solid and liquid feed - Employs Particle Swarm Optimization and PID control	-Requires physical presence for monitoring

Due to the limitations of the existing works aforementioned, this paper presents a poultry feeding system with remote monitoring and control capabilities. The system uses wireless communication which gives the user the opportunity of remotely monitor and control the feeding of poultry birds, hence, reducing wastage, manual feeding and the need for physical presence.

III. METHODOLOGY

This section describes the materials and methods employed in the development of remote monitoring and control capabilities for poultry feed dispensing system. The system's hardware and software design configurations, as well as the integration of the hardware and software to form a unified mechatronic system are discussed in this section.

A. System Overview

The developed dispensing system was designed around Ameh et al., (2017) mechatronic poultry feed dispensing mechanical assembly (shown in Figure 1) and a wireless fidelity network controller. The system is designed to be remotely controlled by an android application wirelessly connected to the control unit to serve as an interface to control the system without any physical contact. Figure 2 represents the conceptual integration of the wireless sensory network controller and the mechatronic system. The system consists of feeder, troughs, DC motor, drinker, solenoid valve, Raspberry Pi, ultrasonic sensor, relay TIP transistors, feed conveyor, brushes, belts, and plastic pipes.

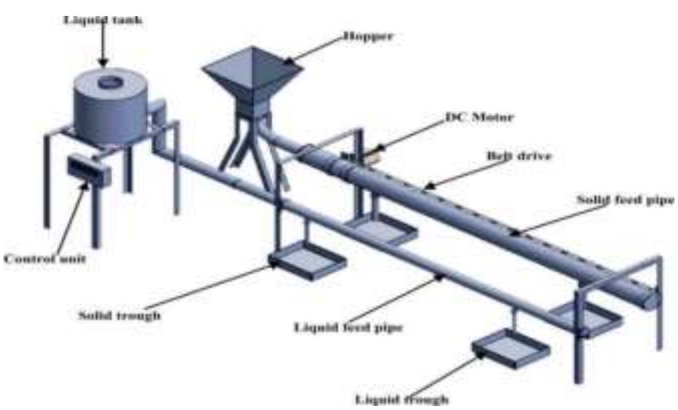

Figure 1: Overview of the main Feed System assembly [12]

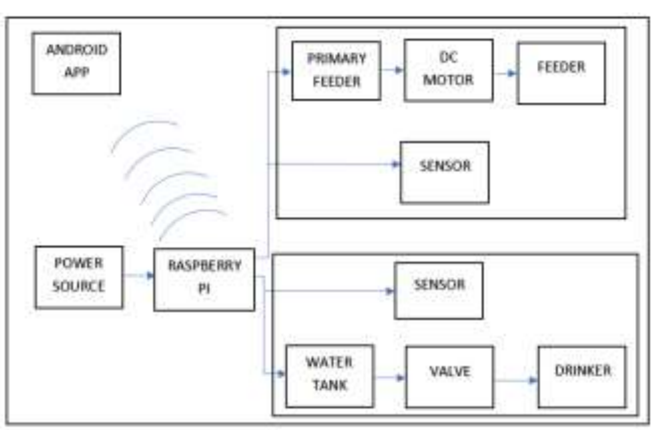

Figure 2: System block diagram

From Figure 2, the Raspberry Pi is used as a wireless fidelity hotspot and a server socket connection is initiated to send and receive data and commands from the Raspberry Pi to the mobile application for remote monitoring and control of the dispenser.

B. Hardware Design Specifications

A 12V Direct Current (DC) supply was used to power the DC motor and the DC solenoid valve which constituted the mechanical unit in the assembly in Figure 1. The 12V is stepped down to 5V in order to power the microcontroller. An l298n motor driver module was used to connect the signal of the Raspberry Pi and the 12V needed to operate the mechanical unit. This is because the 12V is greater than the voltage required by the Raspberry Pi and the Raspberry Pi 5V cannot be used to power the mechanical unit.

The integration of a Raspberry Pi 3 for processing and a DC motor was used for driving the belt to generate force. The belt rotates and transfers force to the pulley which makes the brushes move in a rotary motion conveying the feed to the feed outlet for dispensing the solid feed in the assembly in Figure 1. The Raspberry Pi triggers the relay signals to control the solenoid valve which controls the liquid dispensing process.

The onboard wireless fidelity card of the raspberry Pi 3 B+ was a major determining factor in the selection of the microcontroller. The embedded unit is completed by the inclusion of ultrasonic distance sensor (SR-O4) for calculating the water and feed levels in the primary feeder tanks. A relay switch is used to control the power sent to the DC motor and the solenoid valve. Various hardware components used for the development are listed in Table 2.

Table 2: Hardware specification of the system.

S/N	Hardware Components	Specifications
1.	Micro Controller	Raspberry Pi 3.0
2.	Ultrasonic sensor	5V HC-SR04
3.	DC Motor Driver	l298n
4.	Bulk Converter	LM2596 DC-DC
5.	Relay	12V
6.	Battery	Lead acid 12V-18Ah
7.	DC pumps	12V
8.	DC motors	12V

The mechanical assembly (shown in Figure 1) consists of a DC motor, solenoid valve, feed conveyor, belts and water Pipes. The 12V DC motor is responsible for driving the belts that convey the feed down the feeding trough. The 12V solenoid valve is responsible for controlling the liquid dispensed to the drinkers. The Raspberry Pi signals sent to the motor driver are used to control both the DC motor and solenoid valve the dispense command is sent from the android bespoke application software.

C. Software Design Specifications

This section describes the software design considerations for the remote monitoring and control system for poultry dispensing. It includes the computer applications used for the simulation of the system software programming of the microcontroller as well as mobile application development environment.

Socket is one of the fundamental distributed network sharing technology in Computing. Socket is an end-to-end connection between two or more pieces of software. Socket provides Inter-process communication (IPC) using relatively small and simple Application Programming Interfaces (APIs) to create a Client/Server connection between the nodes within a network. The client is the program that initiates connection and the Server accepts connection request from the client. The network can be a logical, local network to the computer, or one that is physically connected to an external network, with its own connections to other networks.

Wi-Fi sockets end-to-end connection was used to connect the two programs running on the created Wi-Fi network. The Wi-Fi network was created using the Wi-Fi 802.11n module of the Raspberry pi. The connected programs running on the Raspberry pi and android device are binded using a port number and IP address of the Raspberry pi. The Raspberry pi serving as the server node listens to connection request from the android client program. The client's request to connect to the server program is accepted if the port number and IP address corresponds to that of the network. The user is then allowed to send commands, receive feedback and control the mechanical system.

Fritzing simulation software running on a Windows 10 HP envy x360, 6th generation Intel core i5 (2.3-2.8GHz) processor, 8GB RAM and 500GB Hybrid Hard drive was used in designing and verification of the circuit diagram of the remote monitoring and control system. Python programming language was used to program the Raspberry Pi 3 and android studio integrated development environment was used to develop dispenser dedicated be-spoke mobile application. All the selected hardware components of the dispensing system are connected to the Raspberry Pi 3 microcontroller and Wi-Fi 3 module and were simulated in Fritzing virtual environment as shown in Figure 3. The system flowchart is shown Figure 4.

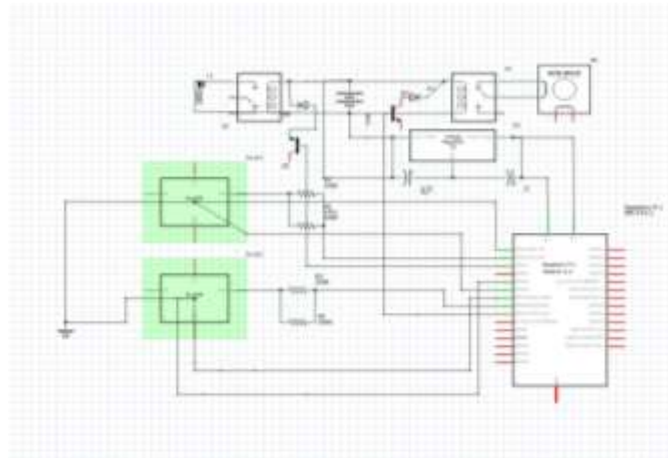

Figure 3: Complete system circuit diagram using Fritzing

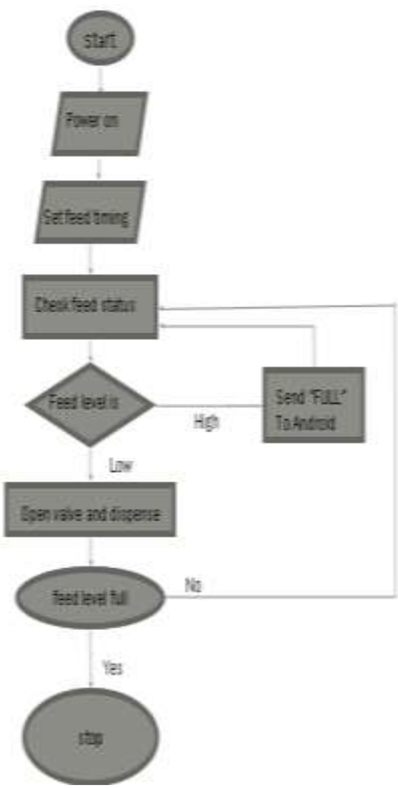

Figure 4: System flowchart

IV. RESULTS AND DISCUSSION

Figures 5 and 6 show an overview of the developed prototype of the remotely monitored and controlled poultry feed dispenser system subject to design specifications in section 3. The developed prototype from assembly in Figure 1 is made of two sub-systems: Liquid and solid subsystems. Figure 5 shows the solid feed dispensing sub-system and Figure 6 shows the liquid feed dispensing subsystem. Both are able to dispense when the command to dispense is sent and also dispense without human intervention when set in automated mode from dedicated be-spoke mobile application shown in Figure 7. To operate, the microcontroller and the mobile phone are connected to the wireless local area network (WLAN) created by the Raspberry Pi. The Wireless Access Point (API) created by the controller has a passkey which will serve the purpose of verification to operate.

Figure 5: Solid Feed Dispenser

Figure 6: Liquid Feed Dispenser

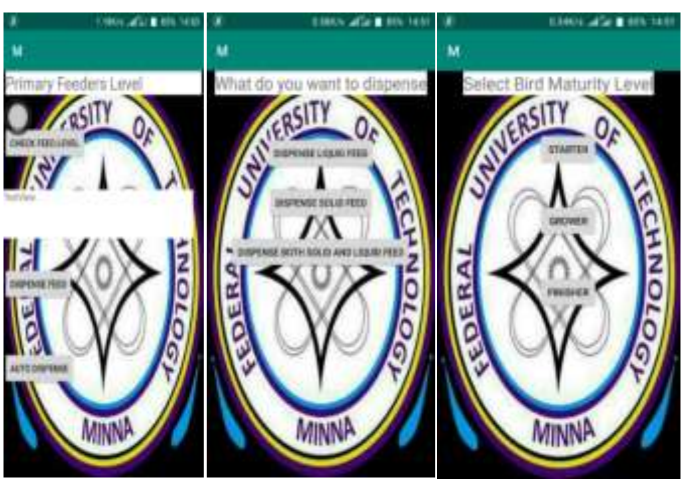

Figure 7: Dedicated be-spoke mobile application screen shots for the dispenser

From Figure 7 android application for controlling the system has three fragments for performing different functions. On the first fragment page titled ***Primary feeder level*** has three buttons. The first button *"Check Feed level"* when clicked sends a command to the Raspberry Pi to get the feed level which send back the reading from the ultrasonic sensor and is displayed on the *Textview*. The ***Dispense feed*** button navigates to the second fragment where options for feed dispensing are given. The ***Auto Dispense*** button navigate to the third Fragment where the options for setting the Raspberry on Automated mode can be selected.

The second Fragment (in Figure 7) titled ***what do you want to dispense*** has three buttons each performing a feed dispensing action. The first button is used to dispense Liquid Feed, the second button is used to dispense solid Feed, while the Third Button is used to dispense both solid and liquid feed. The third Fragment titled ***Select Bird Maturity Level*** is used to set the system in an automated dispensing mode based on the feed requirement of the poultry bird selected. The first button sets the dispensing mode to starter where birds require less frequent dispensing and the systems dispenses at an interval of seven hours. The second button set the automation mode to Grower where birds require more regular dispensing and the system dispenses every five hours. The third button set the automation mode to finisher where feed demand is most, and the system dispenses every four hours.

A. System Performance Evaluation Measure

The performance of the system was evaluated using the response time of the wireless fidelity of the system. Table 3 and Figure 8 show the results of the response time of the dispensing unit at various distance when remote communication was initiated with the dispenser for different tests and distances (measured in feet).

Table 3: Dispenser responses at different distances

TEST	DISTANCE (Ft)	RESPONSE (ms)
1	1	0.8
2	3	1.7
3	6	1.9
4	9	2.1
5	12	2.3
6	15	2.5
7	18	2.6
8	21	2.7
9	24	2.9
10	27	3.0
11	30	3.1
12	32	3.8
13	33	-

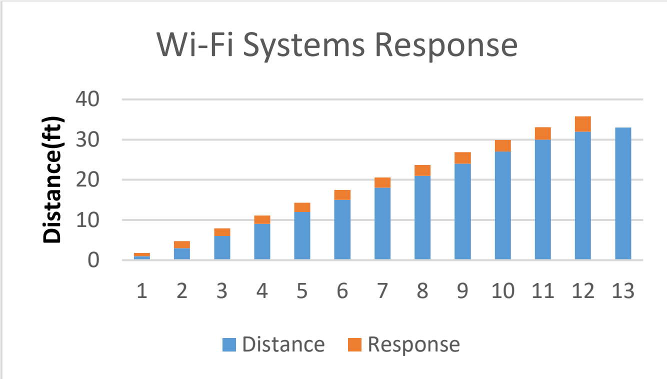

Figure 8: Dispenser responses with Mobile device

V. CONCLUSION AND RECOMMENDATIONS

The development of the android application controlled system for poultry feed dispenser was achieved successfully. The system was developed in line with the system model designed by Ameh *et al* (2017). The application of the developed system in poultry industry will reduce manual labour involved in poultry feed dispensing. The system also serves as an effective way of reducing contamination, feed wastage and a user friendly method of feed dispensing that can be easily accepted by farmers. This will increase yield, profit and quality of farm produce. The system can be improved in the following ways:

a. The use of internet of things technology can be implored to improve the accessibility of the system anywhere within the globe and also improve the flexibility of operation.
b. Using the system to control the whole farm activities such as air vents, farm lighting, temperature and humidity sensing rather than only feed related activities.
c. Inclusion of grinding feed for the starters birds.
d. Use of wireless fidelity repeaters to increase the wireless fidelity range.

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