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Implementing an Internet of Things Livestock Strain and Stray Monitoring System

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ABSTRACT
Automated monitoring systems are becoming trends, creating easier method for identification and monitoring of items. The automated identification and tracking of individual livestock enables herds to be managed more effectively and efficiently. This work gives an in depth details on the development of a mobile application for the monitoring and identification of straying and strained livestock with user alert functionality. It proposes a Wireless Sensor Network that will be integrated with sensor technology over a GSM broadband network. A Global Positioning System (GPS) sensor and a pulse sensor is used to locate straying animals and for sensing any case of strain respectively on livestock by measuring their pulse rate. An online web service is deployed for event recording and an alarming system is integrated to alert the farmer about potential threats on the livestock through their smart phones.

Keywords : Internet of things, Livestock Monitoring, GPS Sensor, Pulse Sensor

1. INTRODUCTION

In the last few decades, the quality of farming has immensely transformed with small sized farms being replaced by much larger autonomous and industrialized farms. With these changing conditions, animal welfare becomes an increased concern. Conventionally, an experienced herdsman would take care of a comparatively fewer cattle and would have direct contact with them, while, on modern automated farms, very few people look after a large number of cattle, hence decreasing the direct contact with them. Thus, this creates a greater need to monitor the animal's health strain. Due to the high demand and supply of dairy products, dairy cattle are in a constant demand for high yield, leading to the need of continuously monitoring of the strain on livestock so as to ensure their fitness. More so, there may not be enough grazing land for livestock, which compels farmers to embrace nomadic farming whereby livestocks are allowed to wonder about within the farm vicinity for grazing pasture. Some pertinent challenges with this approach are the risks of theft, offense from humans, or attack from predators. There may also be cases of straying livestocks.

The advancement of "Internet of Things" (IoT) technology is bringing about a very positive remedy to the risks of staying and strained livestock. The IoT is the inter-network of things or objects that integrates embedded systems, hardware, software, sensors which enhances communication between objects. It links smart objects to the internet. Wireless Sensor Networks (WSN) is the foundation for enabling the IoT. In last two decades, researchers have developed several applications for sensor technology.

This paper gives in-depth details on how IoT technology would be applied to livestock farming system to monitor any strained and strayed livestock at distant grazing areas. This would help ranchers and farmers to monitor the strain on time that could befall any of their livestock and straying of animals from the herd at a given distance. The solution to this system would be based on the integration of Wireless Sensor Networks with with an android application that would be designed and installed in PDAs or smart phones.

2. RELATED WORKS

Livestock farming involves rearing of livestock animals. Livestock animals include domesticated animals like cattle, sheep, goats, pigs, horses, donkeys and so on. It can as well include captive wild animals like deers, antelops, bufalos, zebras amongst others. This type of farming has been very common to mankind since ancient times. Livestock farming is also practiced together with other types of farming like poultry farming, crop farming and others and such farming combined is called integrated farming. Livestock farming that involves a very extensive land and somehow far away from people is called a ranch. Benefits of livestock farming to mankind include meat and milk for consumption, skin for leather, wool for clothing e.t.c. It is a very lucrative business. It generates income for farmers and ranchers.

Any rancher and farmer involved in livestock farming would love to maximize profits from their sales of livestock animals and their products. In order for them to maximize their profits, these animals would need to graze very much on grasses for their health, for maximum growth (i.e for meat production), to boost milk production and so on depending on how large the grazing area of the ranch or farm may be. Sometimes, due to the fact that there may not be much grazing areas in the ranch or farm leading to scarcity of grasses, they need to wonder about within the vicinity to look for greener pastures. And in doing so, they could be subjected to strains. It may be attack from humans (probably theft), carnivores or otherwise and some may stray away from the herd. This would bring a very severe economic loss to the rancher/farmer. The advancement of "Internet of Things" (IoT) technology would bring about a very positive remedy to the risks that could be involved.

Several authors have attempted various models for monitoringlivestocks. In [1], girth belt with receiver was used to measure the heart rate of milking cows of different periods as well as cows with different ages and sizes. The work of [2] shows a framework of the use of sensor information in dairy farm management. The scheme describes the steps from a sensor to a decision. It talks about firstly, sensor systems developed for detection of locomotion problems, mastitis, estrus, and metabolic problems; secondly, the performance of these sensor systems; thirdly, the tools for decision support coupled to these sensors; and lastly, the economic effect of using these sensor systems for farm management. The study of [3] was based on activity tag records for heifers and cows in the experimental herd at the Danish Cattle Research Centre (DCRC), Tyele, Denmark. The animals were equipped with activity tags as part of the management routine for cows to facilitate heat detection. Records taken on the animals included visual estrus scores, A.I service, pregnancy check, calving dates, milk progesterone based C-LA and repeated BCS for cows. The works of [4] gives a detailed description of PerPos as a platform providing cloud services for pervasive computing. The purpose for the PerPos is to serve as a middleware for positioning and location based applications. A system named CowBAR i.e. Cow Behaviour and Activity Recognition which was developed for activity recognition using standard machine learning algorithm on position data and also data from other sensor modalities. CowBAR is developed as an integrated module in PerPos and it is thereby extending PerPos toolbox.

RFID-based monitoring system was developed to solve problems associated with handling of laboratory equipments and library items which is an automated tracking applications integrated by web services. Components involved in the design were RFID Tag, RFID Reader, PC's, RS232 cable, LAN HUB and CCTV camera. The master server contains the database which is used to store all data collected from RFID Reader where user can read or change information in the database [5]. In [6], primary sensors for temperature, accelerometer and microphone were used for automatic identification, to measure diseases and behavioural changes of livestocks. A model developed called Resource-Aware Activity Classification (RAAC) approach bases the activity classification on numerical variation of data coming from accelerometers. The RAAC approach model coded in a standard hardware description language and implemented in a reprogrammable and scalable platform, is able to provide accurate activity classification data to algorithms that model important situations in sow's life. An interesting use of this approach is to detect the onset of farrowing. Acceleration data were collected from devices pervasively attached to the sows' earrings [7]. The next section describes the system design and methodology for this work.

3. METHODOLOGY

The IOT based monitoring model known as the proposed model is explained in details. The system operations and design focuses on the wireless sensor network, and the main controller hardware (Arduino board), a Global Positioning System (GPS) sensor and a Pulse sensor.

3.1 System Design

In this section, the hardware implementation consists of GPS sensors and pulse sensors. The system operation entails monitoring, remote services and information management. The livestock are monitored by wearable GPS and pulse sensor devices on a 24/7 basis. Remote services entail both location and Pulse rate services. These are delivered remotely through the internet and field devices. Information management is enabled by the global connectivity of the IoT. All the livestock information can be collected, managed, and utilized through a well-structured database.

The System Architecture of the proposed system is shown in Figure 1 below:

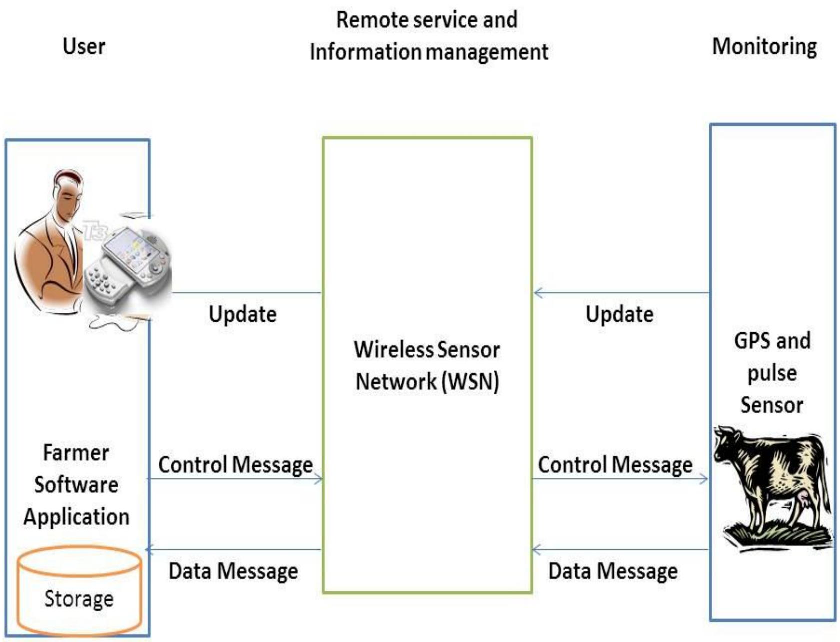

Figure 1: System Architecture of livestock monitoring system

The data of GPS location and body pulse which obtains from the livestock should be analyzed first. In this project, the pulse rate of livestock is obtained from the livestock pulse sensor meanwhile the location is obtained from the GPS sensor. The GPS chip outputs the positioning information which is transferred over a GPRS link to the mobile operator's GGSN (Gateway GPRS Support Node) and then to a remote server over a TCP connection. The TCP server stores the incoming positional data in a mySQL database on the cloud. When a user clicks on the tracking page, an open source web application server, serves up a page with an embedded java code. The java code would run in the user's mobile application platform and has instructions to retrieve the positional information from the mySQL database every second. It then integrates this information into Google Maps through Google Maps API which displays the position on a map. Since the positional information is retrieved every second and the maps updated at the same frequency, a real time GPS tracking effect is achieved. The model is depicted below:

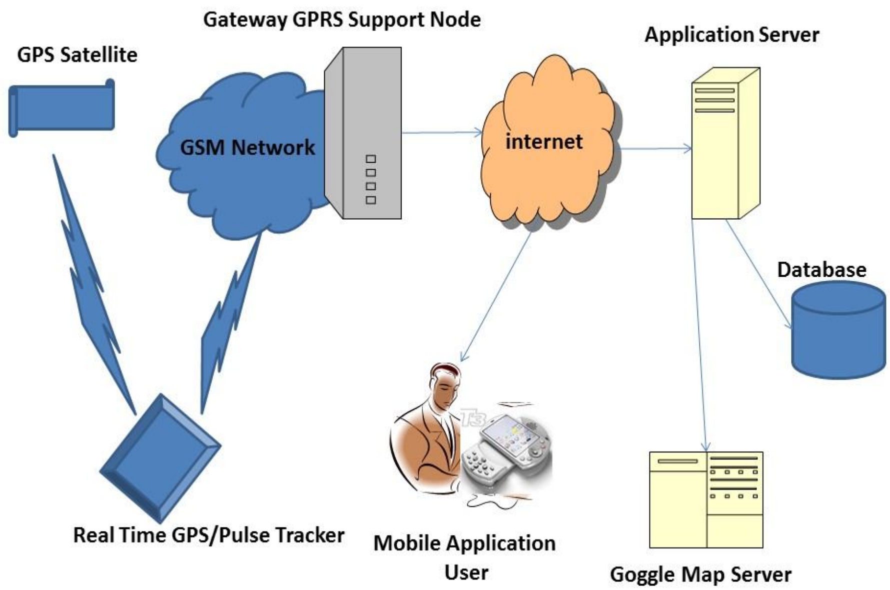

Figure 2: GPS/ Pulse sensor system Interaction

This work proposes a mobile and wide area deployable WSN communication architecture that will be successfully applied to the livestock monitoring IoT solutions. It converges the wireless wide area network and sensor area network into the miniaturized and battery-powered Main Node, and thus the mobility is enhanced by avoiding the fix installed power supply and access network. Optimized power consumption enables all the devices to work with small batteries.

The livestock monitoring IOT applications both require the WSN and sensor devices to integrate very rich functionalities including numerous sensors, actors, and storage. All these would be implemented under restrict limit of power consumption. These architectures would enable the seamless integration of the proposed WSN and sensor devices in practical. Interoperability of devices and services from different suppliers and proper operational workflow would also be implemented into the system with best practices. Finally, the architectures should be verified by implemented prototypes and trials in field.

4. IMPLEMENTATION

This section discusses the implementation of the system. It discusses the relevant information on how the important modules work and correspond to the designed model.

The program has been compiled into an executable application that can be installed on any Android Mobile Phone that meets the specified minimum requirements. The program requires every user to register and then log-in to the system. The user is thereby privileged to access the functionality of the application. The primary program interface is illustrated in the figures 3 below:

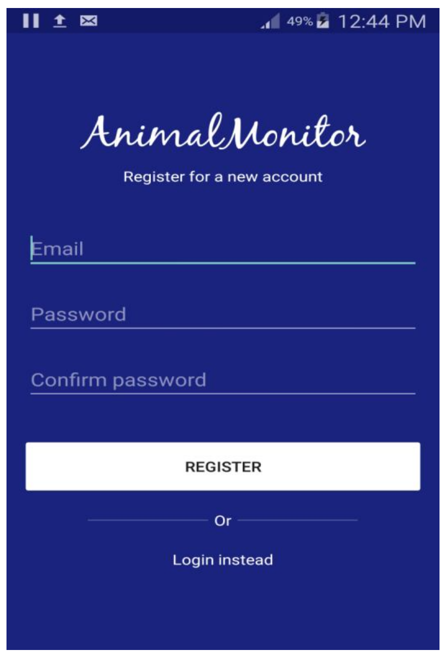

Figure 3: Registration Page

Every registered user is expected to enter the livestock monitoring system with their unique identification in order to load their personal settings and data. Fig 4 below depicts the log in page.

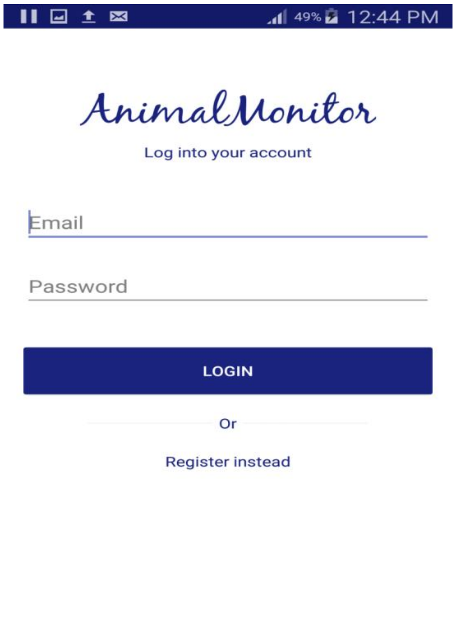

Figure 4: Log-in Page

Farmers/ Ranchers are expected to uniquely register each animal by assigning a unique name to the animal to ease identification as shown in fig 5 below:

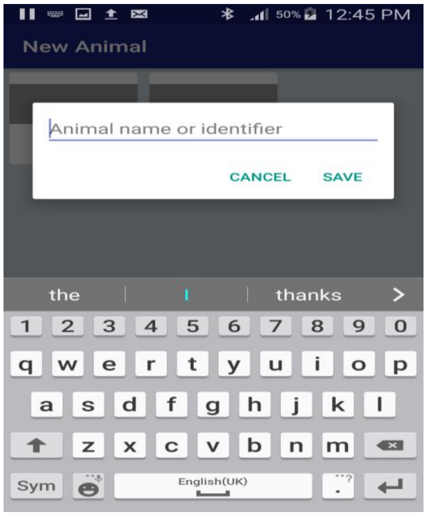

Figure 5: Animal Registration/Identifier page

Having registered each animal, a prompt page is shown on the livestock monitoring application indicating that the animal is successfully registered as depicted below in Fig 6

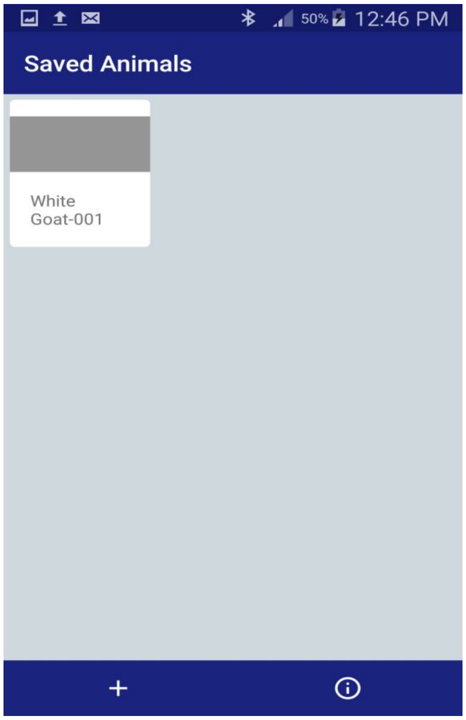

Figure 6: Registered Animal Indicator

The animal monitor utilizes a pulse sensor to get pulse reading from the animal and a GPS tracker to get the animals' location. These data are processed via an Arduino board which will be strapped on the animal along with the sensors. These data after processing are sent serially via a GSM module also attached to the Arduino board. Fig 7 below shows the experimental setup for the monitoring system.

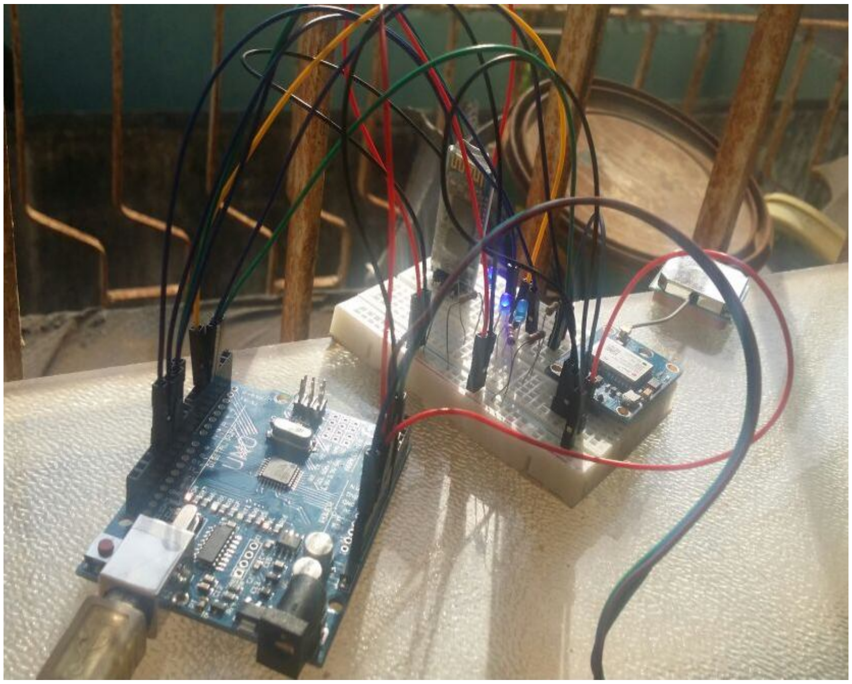

Figure 7: Experimental setup for the monitoring system.

The devices' MAC addresses are used as unique identifiers and data is transmitted serially. GPS coordinates and pulse values are obtained and sent both serially. The Arduino Board acts as the server while the android app acts as the client. A vice – versa implementation would also be possible, however this model has been adopted to increase efficiency. These data when received are further processed by the android app and sent to an online service.

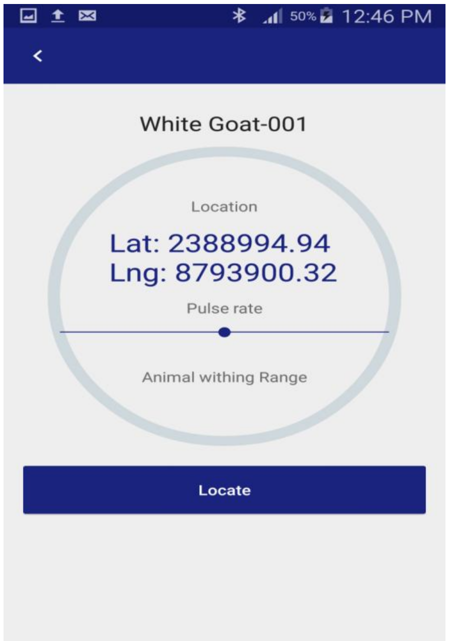

Figure 8 : Livestock Monitoring Status

It is worthy of note that the farmer has the responsibility for assigning a unique name to the animal to ease identification as described previously. After pairing the Animal to the app, tracking can then commence. The required radial distance for monitoring the livestock is integrated in the application. Once a connection to the animal is lost due to exceeding the required radius, an alert is triggered on the application and the farmer can either check his device for the last known location or check the online service for the last known location. A buzzer is also attached to the animal which can be triggered either by the farmer to locate the animal or in event of when the animal strays and losses connection with the farmer.

5. CONCLUSION

This work gives an in depth details on how IoT technology is applied to livestock farming system to monitor any strained and strayed livestock at distant grazing areas. This helps ranchers and farmers to monitor the strain on time that could befall any of their livestock and straying of animals from the herd at a given distance. This work has been undertaken in order to establish specific sensor technologies as a significant means to monitor livestock location and health and to ensure animal well-being in the fast changing conditions of farms.

The implementation proved that such a system can be created and could be a cost effective solution to some more expensive commercial systems. As with any system, however, a continued refinement is necessary to create a polished end product. In order to commercialize the device for public usage, some improvements need to be considered. Therefore, for the future works, more vitals parameters should be added to make it more valuable to the livestock. For example, a pulse oximeter can be added to monitor oxygen concentration of livestock. An alarm sensor can also be implemented with the livestock pulse monitor to give a warning to the users that the condition is critical and dangerous to the health. Thus, a special attention should be given to the livestock.

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