Tracamal: AGPS Based Animal Tracking &Health Monitoring System

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Abstract **-** The involvement of various sub-tasks in the daily activities of the livestock makes the Livestock Management a strenuous task. Humans need to take care of en-numerous tasks that requires careful analysis and equal attention, whether it is pasturing of livestock or health checkup of the livestock. The livestock management sector is being insinuated by the Technology, and is making the tasks simpler and effortless by relieving the livestock of the tedious jobs. Firstly, this paper describes in detail the use of a GPS based leather collar to carry out the real time tracking of the livestock along with its monitoring. Tracking of the livestock is commenced through the use of an Android application which is equipped with a proper notifier. The task of the notifier is to notify the farmer or the owner of the upcoming health checkup dates along with dispensing an alert in case the livestock has moved afar from the intended holding area. Secondly, the paper also describes the built-in safety siren attached to the collar which would be used for the protection of the animal in case a predator attacks it. The sound sensor which is attached to the system will also warn the owner if the cattle is facing any kind of problem or if it is suffering from some kind of illness. In comparison to the already existing technologies available in the market, our technology has an edge in terms of providing an optimal solution to the existing problems alongside integrating the major activities of livestock management.

Index Terms: **GPS, Real Time Monitoring, WSN, RFID, mBed, Android App.**

I. INTRODUCTION

In an agricultural economy like India, animal husbandry practices like dairy framing, poultry farming etc is widely carried out throughout the country. But India being a developing economy, dairy farming and other animal husbandry practices are not equipped with technology. These practices are carried out in the age old traditions of animal monitoring which utilizes extensive human labour and energy. Due to lack of technology based animal husbandry practices, the yield of such practices is low if we compare them with animal husbandry practices of foreign countries. Pasturing of animals or livestock is an important activity as it requires an extensive labour and energy. Taking animals for pasturing and bringing the herd back to the stable is a time consuming and tedious task and even difficult to be handled by a single person. Animal Husbandry is an important source of self-employment as the owners are not dependent on anyone for their earnings except for the cost of fodder and medical care for the livestock.

Livestock Management is an important aspect which requires intensive human involvement. The major problem of associated with endless grazing of dairy farm animals is the loss of vegetation with time and soil erosion [1]. Dairy farm practices should be such that reduces the environmental degradation and at the same time it should take proper care of animals and thus enhance the milk production levels [2, 3]. Animal Health monitoring is also an important aspect of good dairy farming practices.

II. RELATED STUDY

Wireless Sensor Networks [WSN] is one of the widely proposed system for livestock management. WSN basically means deploying small sensors larger in number throughout the animal roaming area to monitor the behaviour of animals and at the same track the animals. In WSN based systems sensors are deployed heavily in and around the dairy farm area because the chances of sensors failure is very high in such networks. In this system a central gateway is required which enables the communication between the base station and the sensors. WSN can be implemented in a variety of scenarios like terrestrial WSN [4], underground WSN [5], multimedia WSN [6], mobile WSN [7] etc. The most recent advancement in the WSN based system is the use of LoRA as a protocol for ultra-low and long range communications [8]. The use ofnewer protocols for communications has improved the reliability of WSN by reducing the power requirements and enhancing the communication range. But the major hurdle which lies in the deployment of terrestrial WSN is the static deployment of dense sensor networks. As the sensors are static in their position and even their failure is also unpredictable. Static sensors cannot be employed for the purpose of animal tracking and monitoring purposes.

Radio Frequency Identification [RFID] is one of the blooming technology for animal tracking and monitoring systems. Usually RFID tag is pierced in the ears of the animals and hence each animal bears a unique identification number. RFID tags basically consists of an antenna and a microchip. Whenever the tag is in the vicinity of RFID receiver, the signals sent from the receiver to tag energizes the tag and hence a return signal is being transmitted by the tag to the receiver. The major advantage which lies in the RFID technology is that it does not require the tag to be lying the straight line of sight location of the receiver and moreover it can be inserted into the animal's body for sensing different parameters [9]. RFID can be used effectively to segregate the genetic dissimilar species or different breeds of animals or depending upon the feeding habits of the animals and hence maintaining a record of entire livestock in an ordered manner using an integrated software for database management [10]. RFID technology has drastically reduce the labour required for the livestock management and introduced transparency in the process of livestock management when the livestock are shipped or transported to different locations. RFID technology is far better than the traditional method of animal monitoring and management systems as the traditional methods involved manual checking which introduces human error and labour costs [11 – 14]. One of the major limitation which exists in the RFID technology is that RFID tags are

pierced in the ears of the animals because of which it leads to ear infection called as otitis media which means the infection of middle ear. The ear infection normally remains unnoticed and hence chances are there that it may further worsen the health condition of the cattle by attacking the inner ear and in worst condition it also causes meningitis. Cattle suffering from otitis media is mentally dull, has a poor appetite and also has a fever. The diseased cattle may also develop pneumonia and problems in respiratory system. It has been proved that ear tagging of animals provides a passage for the entry of bacteria in the ear cavity and at the same time the chances of the animals contracting tetanus is greater in ear tagged animals [15]. RFID technology does not provide the real time location of the animals and hence it is also one of major hurdle in the development of RFID technology for outdoor applications.

III. METHODOLOGY:

Tracking and monitoring of the animals in a dairy farm reduces the human labour and any kind of error involved in the process in order to cause negligible pain and discomfort to the animals by making proper use of the technology at hand. However the existing proposed system for livestock management lacks certain aspects such as issued with range, material in use etc, which limits it. In order to overcome those limitation a new system needs to be established, one which is a combination or a hybrid of the existing system that can thrive to eliminate the drawbacks all the while incorporating the benefits from each system. Tracamal is a comprehensive system which deals with nearly all the elements thus providing great usability and very limited drawbacks. This is all based on the study carried out along with the comparisons of the various mentioned systems. The proposed system does not cause any kind of injury to the animals and at the same time it will make sure no harm befalls the animals under supervision.
The basic diagram of the system depicting the flow of data in the system is represented as below:

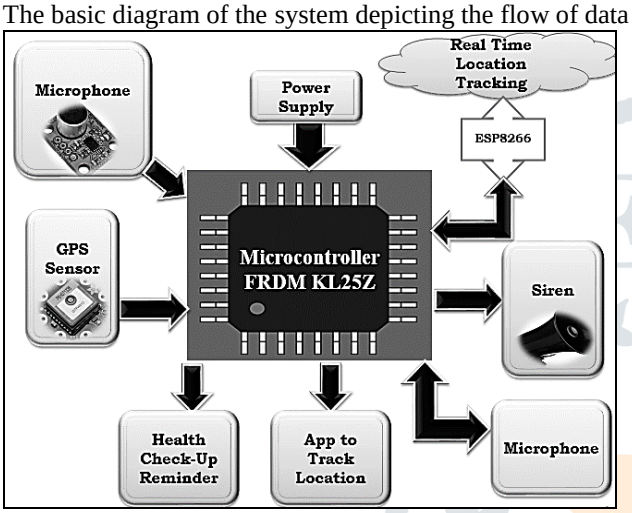

Figure 1. System Diagram showing various blocks

The system describes the functional diagram of the system. The brain of the system is the FRDM KL25Z development board. The data from the GPS module is directly sent to the board which uploads the data on the application using ESP8266 Wi-Fi module. The main feature of this proposed system is that it is totally safe for the animals as the entire system is fitted inside a collar which is tied around the neck of the animal using a leather strap. Hence this system ensure complete that the cattle under supervision is devoid of any health risks due to the implanted technology. The system though it is sued for tracking and monitoring of the dairy farm animal especially cattle, it can also be used for checking health status of the animal. The accelerometer present on board as well as the microphone which is attached in the system can be used to detect if the cattle suffering from any kind of disorder. Accelerometer is a very important device which can be used detect disease like fever, lameness, mastitis, ovarian cysts, pneumonia etc [18].
The Android Application which will be provided with this collar is a user-friendly application which can be easily used by the farmers to track their animal real time using the map. The application also has a notifier which will help the farmers to schedule their cattle health checkup dates and at the same time get reminders about the health check-up dates well before time so that health checkup will not be missed. Moreover the farmer or dairy farm owner can use this application to sense if the cattle is suffering from any diseases or problems. The application also has an inbuilt feature which warns the farmer or dairy farm owner when the cattle is goes to very long distance for pasturing. This feature also helps the famer to check if its cattle are not stolen by anyone as the application notifies the farmer accordingly that the cattle has gone far away from its shed.
The system as mentioned contains the GPS sensor which continuously updates the real time location of the animal on the Android App. The perimeter bound tracking of the animal enables the owner to keep a check that the animal has not gone beyond the natural limits of the grazing area. If the animal is leaving the designated area, the app notifies the owner regarding this problem. The system also monitors continuously the sound of the animal and if the animal is continuously making sounds, then the owner is informed that the animal is in some problem as the cattle moo's continuously only when it is attacked or when it suffering from any disease. The app also allows the owner to create notifications regarding the health checkup to be done for the concerned animals periodically.

IV. RESULTS AND DISCUSSION:

MIT App Inventor v2 has been used for developing and the construction of the app. The modelling of the android application has been carried out using the visible components such as Image Picker and non-visible components such as Notifier and Clock. The entire backbone and base structure of the application is constructed using the software, allowing Tracking and Health Checkup as well as the other functions such as the Perimeter Bound Alert as well. Each of the components in the application have been made interactive by applying a decision making algorithm and flow structure with the help of MIT Blocks that are pre-programmed. The real-time Longitude and Latitude along with the Sound Level is being processed and analysed within the system at a timely interval and being pumped out in the form of location of the animal meshed along with the safety of the animal. This is carried out by

sharing of data between each of the screens used in the app that have a common Database specific for the installed app on the device that is TinyDB. Along with implementation of excessive safety protocols and functions to store the detailed information of each user that creates an exclusive account for the application, which creates a tag along with its value structured in a table format in the Real-time Firebase Database. The proper working and functionality of the device has been incorporated with Mbed Online Compiler. The data that is being transmitted from the GPS as well as the Sound Sensor is being received and stored in the Realtime Firebase Database which is then accessed by the application to accurately track and provide real time feed on the animal. Thus the link between the device and app has been established using the Firebase DB. The Belt containing the device acts as a beacon which allows the user to pinpoint the whereabouts of the animal, the use of GPS makes sure the data being processed and analysed is quick and available over a very large range.

The collar which would be tied around the neck of the animal can be depicted as below:

Figure 2. Collar to be tied around cattle's neck

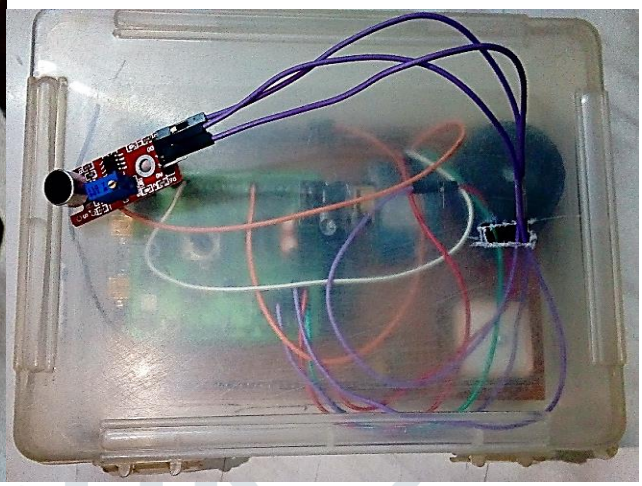

Figure 3. Robust Case for the entire circuitry

The collar which is made is completely safe for the animals as it is made from leather and at the same time the functioning of the system would be indicated by the light emitted from the LED. If the LED is ON it indicates that the system is functioning properly and if the LED light goes low, it indicates that the system battery needs to be recharged or replaced.

The accelerometer MMA8451Q which is present on board is used to measure the tilt of the cow's head. The position of cow's head displays a wide range of information regarding the health status of the cattle. The accelerometer was tied around the neck of the cattle.It was observed during the study that cattle with diseases like cerebral hypoplasia, bacterial meningitis etc have drooping head. The head droops towards the left or right side or remains in the intermediate position. Even when the cattle suffers from ear infections, the head of the cattle tilts towards the side of infected ear. The graph shown below demonstrates the accelerometer values for the calf suffering from ear infection in the left ear and the head remains tilted towards the left side of the calf.

Table 1. Table of Tilt Angles for Left Side Tilted Head of Calf

X axis Tilt Angles	Y axis Tilt Angles
1.011	1.999
1.009	2.001
1.010	2.002
1.015	2.002
1.015	2.003
1.017	2.008
1.012	1.999
1.007	1.992
1.015	2.009
1.014	2.004
1.017	2.005
1.009	2.001
1.016	2.002
1.014	2.002
1.014	2.001
1.009	2.008
1.006	2.001
1.015	2.009
1.014	2.001
1.007	1.994

The graph shows the various accelerometer readings which is taken for the calf suffering from left ear infections. The tilt usually lies in range of 1.01 – 1.05 radians for X-axis and for Y- axis the tilt angle lies in the range of 1.98 -2.00 radians. The accelerometer data is clustered for only these ranges of values.
When the calf is suffering from the infection in right ears, the head of the cattle gets tilted towards the right side of the body. The accelerometer values for the right sided drooped head is plotted in the following graph:

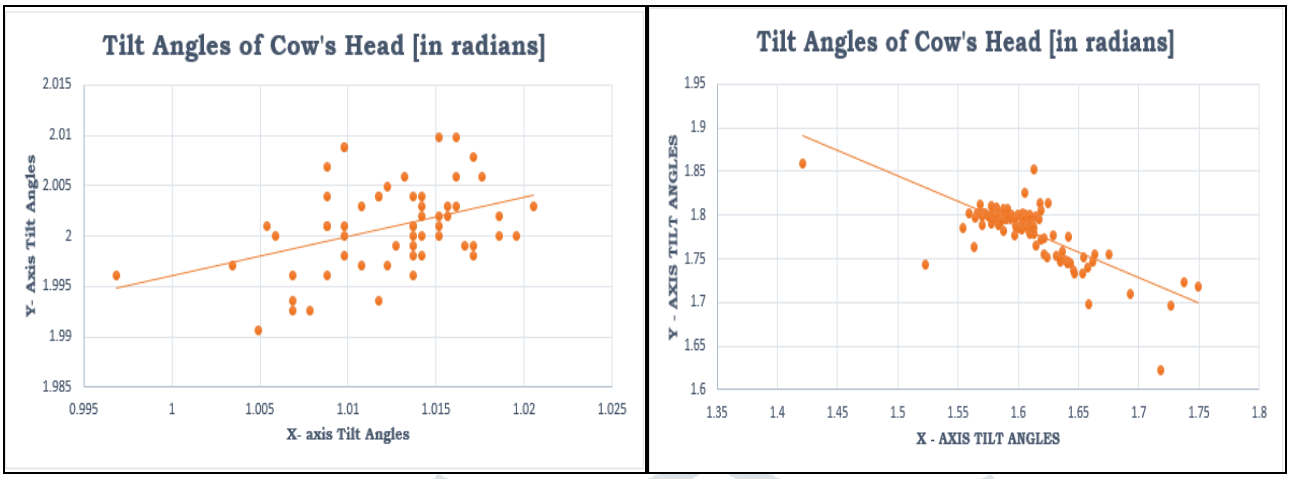

Figure 4. Graph of Tilt Angles for Left Side Tilted Head of CalfFigure 5. Graph of Tilt Angles for Right Side Tilted Head of Calf

For right side drooped head, the X- axis tilt values lies in the range of 1.55 – 1.62 radians and for the Y- axis the tilt angle values lies in the range of 1.75 – 1.8 radians.
It is not necessary that drooping of cattle's head for a prolong period of time indicates only ear infections but also it indicates a wide variety of other diseases like fever, lameness, mastitis, milk fever etc. Accelerometer can also be used for determining the feeding behaviour of the cattle as well as they can also be used for determining the behaviour of the animal. [19 – 22].

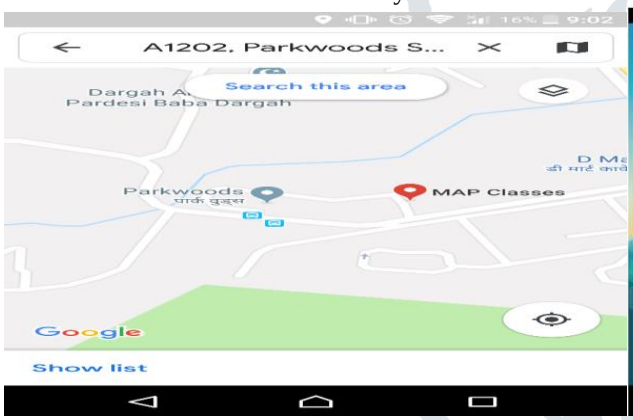

Figure 6.Real Time Location of Cattle Shown on Google Map

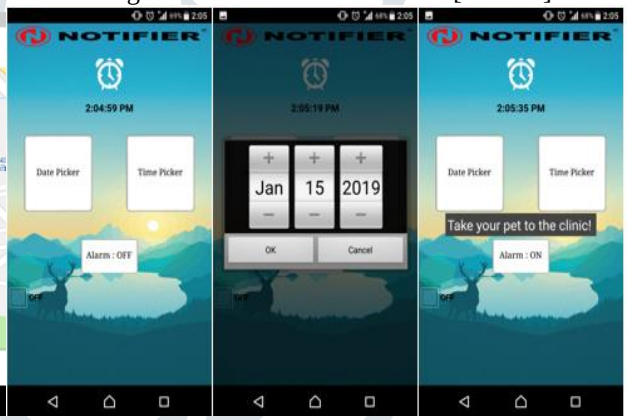

Figure 7. Notifier for Health Check-up Reminder

The Android application was also tested for various test cases. The real time location of the cattle was also tracked using the Google map feature of the app. The picture shown above represent the real time location of the cattle using the application.
The notifier which is present in the app reminds the owner regarding various health check-up dates for the cattle. Health-Checkup function of Tracamal provides top notch and timely notification alert whenever the User needs to take the Animal for a checkup. Depending on the needs of the User, there are various other options to notify the User such as through Ring alert or a Message as well set the time simply by putting appropriate date and time. The testing of the notifier is as shown above.

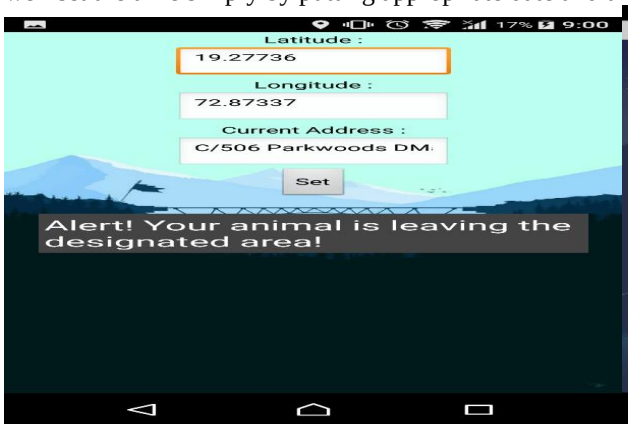

Figure 8. Perimeter Bound Tracking for Cattle Safety

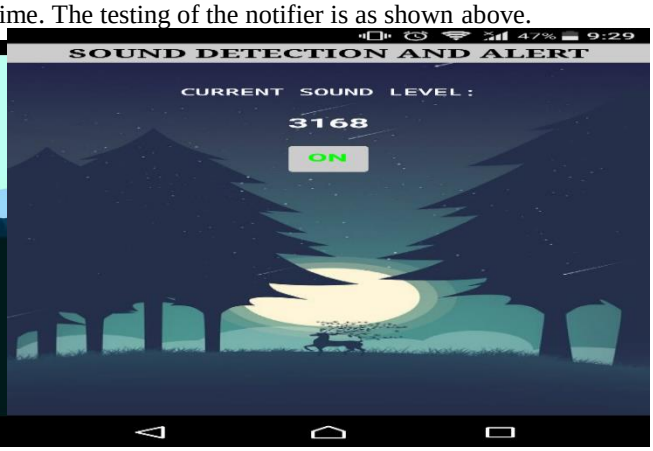

Figure 9. Sound Detection & Alert Mechanism of App

The app is also equipped with a notification which warns the owner when the cattle is making loud mooing sound continuously. In case of some diseases, cattle moo's continuously because the cattle feels uneasy and uncomfortable in such conditions. The mooing

of cattle is detected by the microphone present in the system and this data is sent to the app which displays an alert message for the owner to take a quick action.

Table 3. Power Consumption of entire circuit components

Component	Voltage Required [in V]	Current Required [in mA]	Power Required [in mW]
FRDM KL25Z	4.3	6.4	27.52
Sound Sensor	3.4	5.3	18.02
GPS Module	1.8	3.78	6.804
ESP8266	3.12	4.33	13.509
Buzzer	3.54	2.023	7.161
Total Power Required			73.105

So Total power required for the entire circuitry to work is 73.105 mW. Now if we have 300 mAh battery then

$$\text{Power in Wh} = \frac{\text{Power in mAh} \times \text{Voltage Rating of Battery}}{1000}$$

$$\text{Power in Wh} = \frac{300 \times 7}{1000}$$

Power in Wh = 2.1W

So a battery with 300 mAh power having a rating of 7 V then the battery will deliver 2.1 W of power per hour.

The total power required by circuitry is 73.105 mW

So Total duration of circuit operation by battery with 300 mAh power and voltage rating of 7 V is given as follows:

$$\text{Time in hours} = \frac{2.1}{73.105 \times 10^{-3}}$$

So with this battery rating the circuit can operate with full efficiency for 28 hours which is roughly 1 day and four hours. Now to sustain the battery for much longer duration following things can be implemented in the circuits as follows:

1. Introduce sleep modes in the circuit when tracking is not required.
2. Fabricating the entire circuitry on a single PCB instead of discrete components can reduce the power consumption to very greater extent.

V. CONCLUSION

The system proposed in this paper is effective for the purpose of livestock management and it is also equipped with multiple features which can be in utilized for monitoring the livestock including the health of the livestock, health checkup reminders as well as the safety siren which will protect the cattle from the predators. The proposed system is also efficient in tracking the animal using the Android application which can be easily installed on the smartphone of the dairy farm owner or the farmer. The application is provided free of cost to the farmers or dairy farm owners along with the collar for the animal. The system mentioned in this paper can be directly utilized for the purpose of an integrated animal tracking and monitoring system. The system is a complete model for tracking the animal while pasturing and at the same monitoring the health conditions of the cattle.The major limitation which exists in the current system is that the entire system is not placed on a single board. It is possible to include the entire components on one single board which reduces the spaces required for the entire system and at the same time it will also reduce the power consumption of the system. The system can also be equipped with certain more sensors like temperature sensors, load sensors etc which can be used to determine if the cattle is suffering from diseases like fever, pneumonia etc. The system is checked for all the test cases which includes the testing of the system for sound notification, perimeter bound testing and also the notification for the health check-up. All the notifications were notified accordingly on the Android application and the application is also functioning successfully. This system is the first of its kind for an integrated animal tracking and health monitoring system.

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