Movement Monitoring of Pet Animal Using Internet of Things

Miss. Prajakta Sukumar Manakapure[1], Prof. Mr. A. V. Shah[2]

[1]M Tech Scholar Dept of Electronics, DKTE Ichalakaranji, Maharashtra, INDIA
[2]Asst Prof Dept of Electronics, DKTE Ichalakaranji, Maharashtra, INDIA

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Abstract - *Animals are become integral part of ecosystem. Now a days life of animal is in danger, there is need of protection to the animals. Therefore monitoring and tracking of animal is become more and more important. In proposed system four main applications have installed: location tracking, health monitoring, habitual movement monitoring and sending data on cloud. In location tracking system GPS is used for getting animal coordinates. In health monitoring unit temperature sensor is used for measuring the temperature of animal. Generally each animal having particular variety of body temperature. If the animal having any wounds or fever, the temperature can be mechanically multiplied. To display this, we are the use of temperature sensor. To monitor this, we are using temperature sensor. It continuously monitors the animal's temperature. In habitual movement monitoring unit accelerometer sensor is used to monitor the motion of animal. And these monitored data is send on cloud using the GSM and MQTT protocol. MQTT protocol is generally heat of IoT (Internet of Things) system. With the advancement in technology and the existence of the internet, practically connect any device to internet and implement concept of IoT.*

Key Words*: *GPS, GSM, IoT (Internet of Things), Broker, Client etc.

1. INTRODUCTION

Internet of Things (IoT) provides efficient technical support for the biology and zoology researches, in the past 15 years. In the past years, the native environment is spoiled in large amount, and the monitoring and protection of animal is become very important. In past years an animal tracking system has used to analyze behavior of animals for many reasons, such as to observe a shifting of animal around different region and interaction about ecosystem. Every living animal on this earth has same importance in the surrounding. But now a day life of animals is in danger. If any accident happens to animal in the forest, due to physical injury or any disease death of animals is fix. In such condition we cannot find out particular location of animal in such a wide area. To bypass such problems for finding specific geographical location of animal in the jungle, animal tracking system is used. Talking about current technologies in some countries, belts are placed on the animals neck. This belt has a wireless transmitter. A officer has receiver in his/her hand and by using receiver location of animal will found. After all main drawback of this technique is wireless transmitter range is small. Thus the animal tracking system is used to track the animals in zoo and forest.

For animal monitoring and tracking, Internet of Things are used. Also to report animal data to the base station different sensors are used. However, animal monitoring is difficult in remote areas due to the dangerous surrounding and the anxiety of animal movement patterns. In addition, the drawback of traditional sensor networks is the energy limitations, therefore sending the sensed information continuously is costly and also practically not possible. For the past few years, utilization of Internet of Things(IoT) have grown steadily. Wildlife monitoring is one of the trending applications of IoT technologies, where a number of heterogeneous sensors are deployed to monitor the activities of wild animals dwelling in a remote and geographically large habitat. It is known that wild animals depict similar physiological activities as a herd. Thus, a number of heterogeneous sensors (e.g. accelerometer, gyroscope, etc) could be deployed either as collars in the ground, to monitor the physiological activities. The sensors will be operating in a remote area with a limited source of energy. To these ends, it is important to achieve high energy efficiency, good reliability and low latency for a responsive animal monitoring system design.

In this system, four main applications of animal monitoring such as location tracking of animal, habitual movement recognition, health monitoring of animal and sending data on cloud have focused. A IoT platform consist of three component: sensing, wireless communication, and cloud service. In this paper, I have done an IoT system which will used to monitor the animal.

Strategy proposed in [1] uses communication module of the system is consists to three different communication networks, which supports the protocol of IEEE 802.15.4/ ZigBee networks, IEEE 802.11b WLANs and 3G. Also describes the design, development and overall study of an Internet of Things, which is used to monitor and protect the ecosystem of the wildlife. The adaptive sampling starts offevolved with random sampling of the network to collect the accelerometer information of distributed the animals in forest or national park. An Artificial Neural Network (ANN) is trained by using the collected accelerometer data[2]. Another strategy[3] also uses neural network for classification of behavior based on sensory information. To collect information about animals behaviors, hierarchical, wireless sensor network installed. Strategy [4] designed IoT Platform for monitoring of wildlife and focused on location tracking, behavior recognition, and health monitoring. Also analyzd the IOT platform for monitoring scenarios, and discuss system implementation from four aspects: identification, mobile access point, monitoring device and application. Also introduce the development of a GSM communication based tracker for wildlife tracking and behavior recognition.

2. SYSTEM DESCRIPTION

2.1 System Block diagram

The block diagram of animal monitoring system is shown in figure. It is important part of tracking system consisting of controller, GPS, GSM. Controller is soul of tracking system, which access and develope the position data from the GPS module. The GPS position satellite transmit the message will received by the GPS Receiver, calculates the longitude and latitude of animal coordinates, and converts it into GSM message and sends message on cloud.

Accelerometer is the motion detection sensor which is used to identify the movement of the animal in order to decide whether the animal is moving or not. The temperature sensor is integrated to controller to monitor the health of animal.

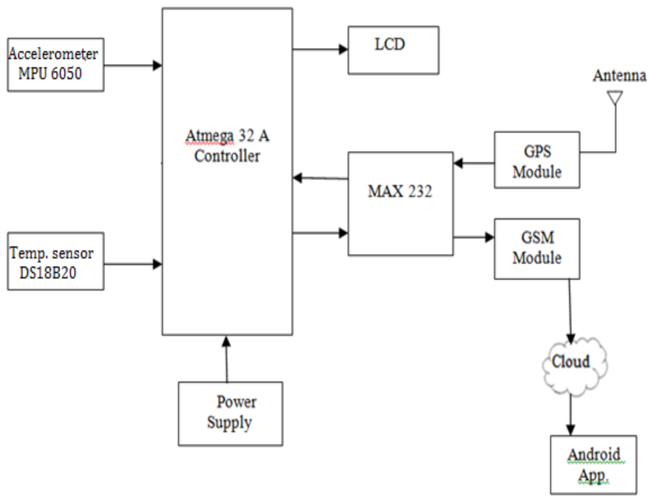


Fig -1: Block diagram of animal monitoring system

2.2 Methodology of Implementation

In proposed system, three application has implemented. These are as follows:

i. Location Tracking
ii. Habitual Movement Recognition
iii. Health monitoring

i. Location Tracking

In Location Tracking , tracking device is useful to keep record of animal. Tracking device will attach to the animal. A tracker with satellite positioning receiver sends the location data to data center. Tracking system will inform animal location. The primitive function of tracker device is to monitor and transmitte the latitude and longitude of animal location.

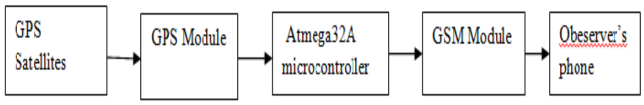


Fig -2: Block diagram of Location tracking with GPS

The GPS plays important role in location tracking. has receiver which receives the location information that means animal coordinates from GPS position satellites. Atmega32A microcontroller processes the coordinate data and controller unit command the GSM to send the data (longitude and latitude) to destination.

ii. Habitual Movement Recognition

Habitual movement recognition unit is useful to detect motion of animal such as running and standing. The movement recognition is done with acceleration sensor is installed in the tracker. An accelerometer is an electromechanical device which measure acceleration forces. An accelerometer provides acceleration forces in all direction such as X, Y and Z direction.

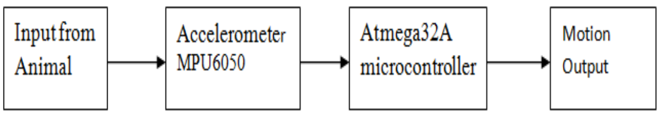


Fig -3:Block diagram of movement monitoring using accelerometer

Accelerometer MPU 6050 is MEMS(Micro Electro Mechanical system) accelerometer. MEMS accelerometer consists of proof mass which is movable with plates that is attached through a mechanical spring to a reference frame, as shown in Figure. Movable plates and fixed outer plates represent capacitors. The displacement of mass is measured, by using the capacitance difference. C1 and C2 are the capacitances between the movable plate and two stuck plates which are the functions of the corresponding displacements x1 and x2:

$$C_1 = \varepsilon_A \frac{1}{x1} = \varepsilon_A \frac{1}{d+x} = C_0\text{-}\Delta C \text{......................}(1)$$

$$C_2 = \varepsilon_A \frac{1}{x2} = \varepsilon_A \frac{1}{d-x} = C_0 + \Delta C \text{......................}(2)$$

When $x_1 = x_2$, the capacitances C_1 and C_2 becomes equal so that acceleration become zero. The proof mass displacement x results due to acceleration. If x ≠ 0, the difference between capacitance to be:

$$C_2\text{-}C_2 = 2\,\Delta C = 2\varepsilon_A \frac{x}{d^2-x^2} \text{...............................}(3)$$

By solving equation (3),

$\Delta Cx^2+\varepsilon_A x-\Delta Cd^2 = 0$..............................(4)

For small displacements, the term ΔCx2 is negligible. Thus, ΔCx2 can not be considered. Then,

$x = \frac{d^2}{\varepsilon_A}\Delta C = d\frac{\Delta C}{C_0}$ ....(5)

where, $C_0 = \varepsilon_A \frac{1}{d}$

from equation (5) it can be concluded that the displacement is about proportional to the capacitance difference *ΔC.*

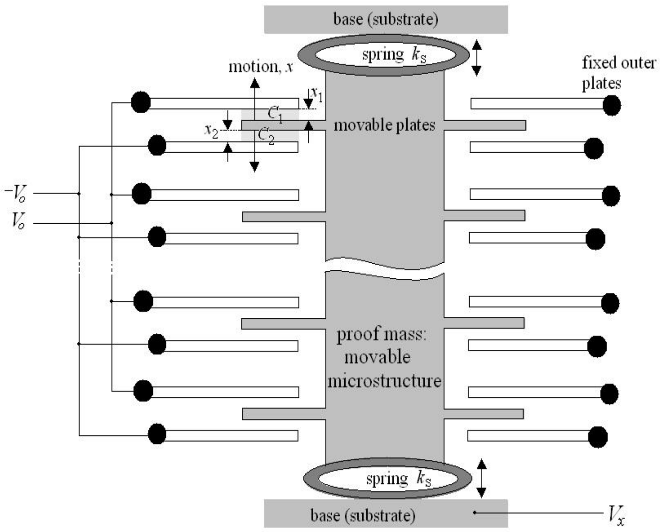


Fig -4: Accelerometer structure. Proof mass is attached through springs (kS: spring constant) at substrate.

By considering system as voltage divider, the voltage of proof mass,

$(Vx+V0)C1 + (Vx-V0)C2 = 0$ ....(6)

$Vx = V0\frac{C2-C1}{C2+C1} = \frac{x}{d}V0$ .... (7)

Vx is square wave with the right amplitude proportional to acceleration. whilst there may be no acceleration (a1 = zero), the evidence mass doesn't move, and therefore, the voltage output is zero. If we accelerate the sensor (a1 > 0), the voltage output Vx adjustments proportional to alternating voltage enter V0.

iii. Health Monitoring

For health monitoring of animal Temperature sensor is installed on the tracker device which will attach on animal body used to measure the temperature of animal. I have used DS18B20 temperature sensor.

Generally every animal having particular range of body temperature. If the animal having any wounds or fever, the body temperature will be automatically increased. To monitor this, we are using temperature sensor. It continuously monitors the animal's temperature. If any variation in the temperature, It will be displayed on the LCD.

2.3 Data on Cloud

Cloud is a carrier where data is remotely preserved, managed and retreated. The service is available to users over a network that is internet. It permits the consumer to keep data online so that the person can get right of entry to the data from any area the usage of the internet. Below figure shows the MQTT broker based architecture. The MQTT protocol uses a publish subscribe architecture. Publish Subscribe is event-driven and enables messages to be driven to clients. The central part of MQTT broker based architecture is MQTT broker, it acts as store and forward filter. MQTT protocol has broker and client. Main function of broker is run the topic that means it receives the subscription message from clients on topic. When publisher sends the message on server then it delivers message to subscriber.

i. Client

Client is referred as an MQTT client. This includes publisher or subscribers, both of them known as an MQTT client that is not only publishing but also subscribing to the topic. Generally a MQTT client can acts as both sender (publisher) & receiver (subscriber) at a time.

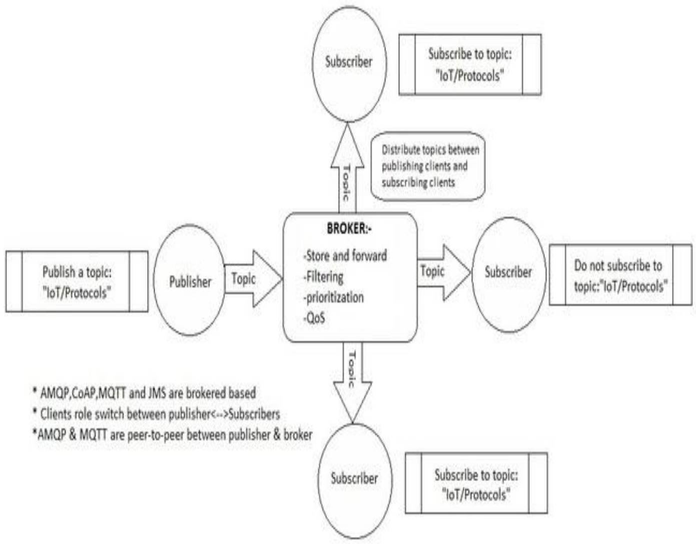


Fig -5: MQTT Broker based architecture

ii. Broker

MQTT broker is supplement to a MQTT client which is the heart of any publish/subscribe protocol. Depending on the real implementation, a broker can control to thousands of synchronously connected MQTT clients. Broker acts as intermediate between clients. The broker is responsible for receiving all messages from sender or publisher, filtering them, sending to messages to clients who is subscribed for them.

3. MQTT Connection:

The MQTT protocol is based on top of TCP/IP and both client and broker need to have a TCP/IP stack. The MQTT messages are transferred serially through the client server architecture. The basic working principle of MQTT protocol is exchange of a series of MQTT control packets which has specific purpose. The MQTT connection is forms in between client and the broker, in between two clients no connection is established directly. When a client send a CONNECT message to the broker then connection is done between client and broker and The broker response to the client by sending CONNACK code. After connection is formed, MQTT will keep it open until the client doesn't send a disconnect command. After forming the MQTT connection data is send on cloud using PUBLISH command. PUBACK command gives the confirmation of published message. In such manner data send on cloud.

Fig -6 shows that how to initialize the TCP connection and how to publish the data on cloud.

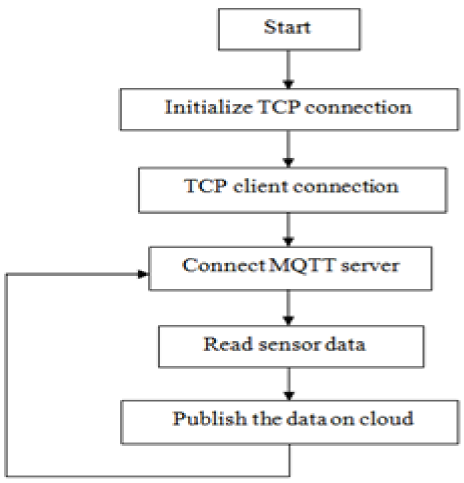


Fig -6: Flowchart for publishing data on cloud.

3. EXPERIMENTATION

In this section I describe the experiments and then present and discuss results for the movement of animal.

3.1 Description of Experiments

The experiments first requires to collect the raw accelerometer data in x, y and z axis. Table 1 shows the number of experiments taken on accelerometer. And following figure shows the acceleration plot for different raw values.

Table -1: Accelerometer raw values.

Ex. No.	ACC-X	ACC-Y	ACC-Z
1	18432	16259	0
2	12288	16256	-8192
3	12288	-16433	0
4	20480	16130	-32768
5	24576	16148	-32768
6	16384	15970	0
7	16384	-16678	-16384
8	-32768	-16520	16384
9	24576	16254	16384
10	12288	-16511	-16384
11	24576	-16580	-8192
12	0	-16588	8192
13	8192	16501	-32768
14	24576	-16623	-28672
15	0	-16960	0
16	-4096	16259	28668
17	24576	16254	16384
18	12288	-16511	-16384
19	24576	-16580	-8192
20	28672	-16591	20480
21	20480	16218	-16384
22	4096	16217	-32768
23	16384	16204	16384
24	8192	16191	24576
25	24576	16177	0
26	8192	16217	16384
27	-16384	16214	-32768
28	24576	16242	-16384
29	-28672	16238	0

From the raw values of accelerometer I have plotted the graph for acceleration plot of ACC-X, ACC-Y and ACC-Z versus Time (sec). Following graph shows the acceleration is changes at every 5 sec. From this graph I can conclude that the animal is moving anywhere.

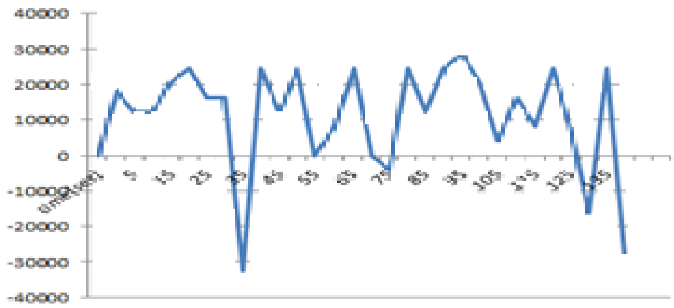


Chart-1: Acceleration plot of ACC-X vs Time(sec)

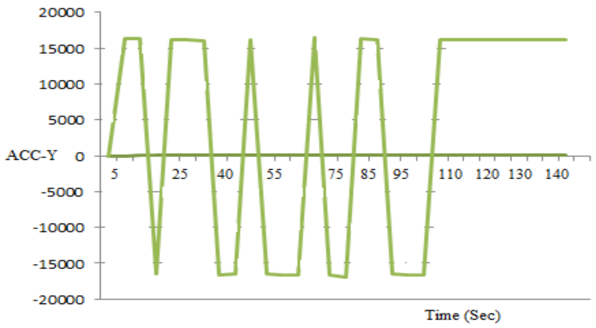


Chart -2: Acceleration plot of ACC-Y vs Time(sec)

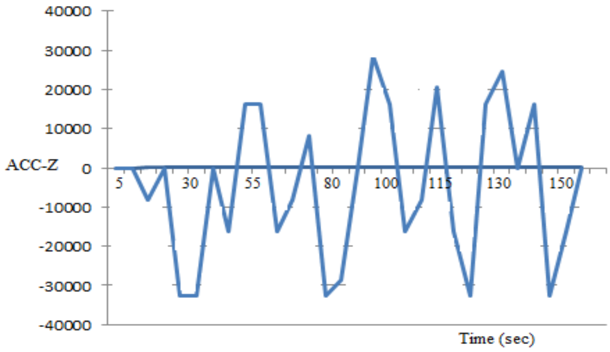


Chart -3: Acceleration plot of ACC-Z vs Time(sec)

3.2 Results

Following figures shows that the results on LCD and android app. In the result following parameters are shown: Temperature, motion and position of animal.

i. LCD output

Fig -7: Motion N(Normal condition)

Fig -8: X motion detected

Fig -9: Y motion detected

Fig -10: Z motion detected

Above fig 7-10 shows the temperature and motion of animal on different directions. In fig 7 motion is normal motion that is animal is not moving. In fig 8-10 animal is moving in different direction.

ii. Android app output

Fig 11 shows the output on android app. It shows the temperature, motion and GPS position. In fig 11. motion shows N that means animal is standing. And sometimes it shows motion X, motion Y and motion Z that means animal is moving in respective direction.

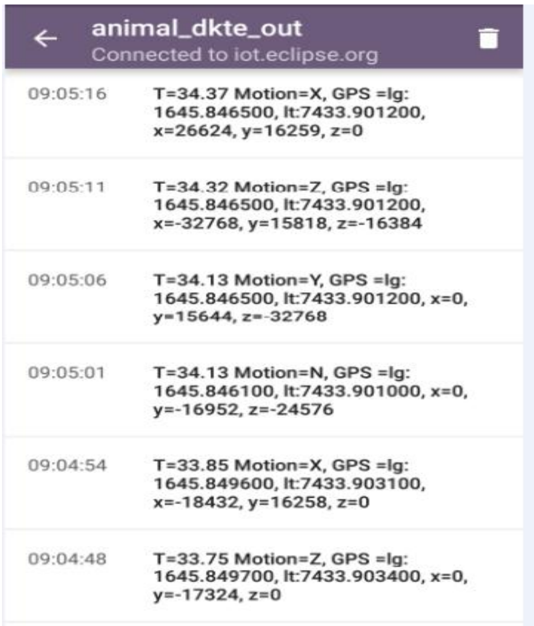


Fig -11: Results on android app

3.3 Performance parameter

The accuracy and sensitivity of the system depends on the four definitions: True positive, True negative, False positive and False negative.

i. True positive: A true positive test result is one that detects the condition when the condition is present.

Table -2: Number of readings taken for animal.

Ex. no.	Temperature	Motion	GPS longitude	GPS Latitude
1	33.89°C	X-Direction	1645.85	7433.90
2	34.32°C	Z-Direction	1645.85	7433.90
3	34.32°C	X-Direction	1645.85	7433.90
4	34.37°C	N-Direction	1645.85	7433.90
5	34.51°C	Z-Direction	1645.85	7433.90
6	34.51°C	X-Direction	1645.85	7433.90
7	34.51°C	Y-Direction	1645.85	7433.91

8	34.55°C	Z-Direction	1645.85	7433.91
9	34.32°C	X-Direction	1645.85	7433.91
10	34.32°C	Y-Direction	1645.85	7433.91
11	33.94°C	N-Direction	1645.84	7433.90
12	33.94°C	N-Direction	1645.84	7433.90
13	33.89°C	N-Direction	1645.84	7433.90
14	34.32°C	N-Direction	1645.84	7433.90
15	34.32°C	N-Direction	1645.84	7433.90
16	34.51°C	N-Direction	1645.84	7433.90
17	33.85°C	N-Direction	1645.84	7433.90
18	33.75°C	N-Direction	1645.84	7433.90
19	33.61°C	Y-Direction	1645.85	7433.90
20	33.94°C	N-Direction	1645.84	7433.90

ii. True negative: A true negative test result is one that does not detect the condition when the condition is absent.

iii. False positive: A false positive test result is one that detects the condition when the condition is absent.

iv. False negative: A false negative test result is one that does not detect the condition when the condition is present.

From these above definitions accuracy and sensitivity is calculated using the confusion matrix as shown in Table-3.

i. Accuracy: Accuracy is ratio of correctly predicted observations and indicates the overall effectiveness.

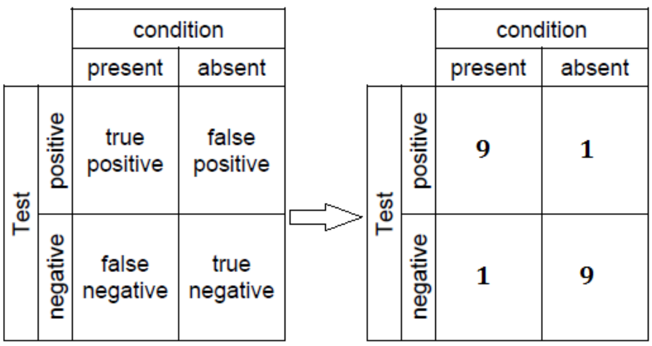
Accuracy=[(TP+TN)/(TP+TN+FP+FN)] x 100%.

ii. Sensitivity: Sensitivity measures the ability of a test to detect the condition when the condition is present.

Sensitivity=[TP/(TP+FN)] x 100%.

For finding the accuracy of system total 20 readings are taken for moving animal which shows in Table2. In this table first 10 readings are taken when animal was moving and next 10 readings when animal was taking rest.

Table -3: Confusion matrix



Four values such as TP, TN, FP and FN constitute a confusion matrix as shown in Table 3: TP(True positive)=9

TN(True negative)=9

FP(False positive)=1

FN(False negative)=1

From above four values accuracy and sensitivity is calculated as:

i. Accuracy= $\frac{(TP+TN)}{(TP+TN+FP+FN)}$ x 100%

$= \frac{(9+9)}{(9+9+1+1)}$ x 100%

Accuracy= 90%.

ii. Sensitivity= $\frac{TP}{TP+FN}$ x 100%

$= \frac{9}{(9+1)}$ x 100%

Sensitivity= 90%.

4. CONCLUSION AND FUTURE WORK

In this paper we propose a framework for habitual movement monitoring of animal using Internet of Things which uses to transmit the data which is sensed from remote animal to the server by using wireless transmission technology GSM. It is completely integrated so that it is possible to track anytime from anywhere. It has real time capability. The accuracy of system is affected by some factors such as weather, environment around the mobile animal, GPS receiver having accuracy is 90% and sensitivity of system is 90%.

Animal security and safety: GPS tracks position of animal anywhere in globe and also health system monitors animals temperature parameter.

Less complex circuit and: Modules used are smaller in size and also lightweight so that they can be carried around. So that concept of animal monitoring system is very useful.

The future work will be extending for monitoring the more than one animal and monitoring the health by adding pulse rate parameter.

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