GATA: GPS-Arduino Based Tracking and Alarm System for Protection of Wildlife Animals

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***Abstract*—In the present arena, wildlife and forest departments are facing the problem of movement of animals from forest area to residential area. The number of trees has reduced drastically from the forest that creates an unhealthy environment for animals to survive in the forest. This paper proposes a system we call *GATA for tracking and alarming for the protection of Wildlife Animals*. GATA combined Wireless Sensor Network (WSN) [1] and Global Positioning System (GPS) technologies to solve the above mentioned problem. Wild animals straying out of wildlife sanctuaries and natural parks have been tracked by auto generative location tracking and movement patterns. Automatic location and movement tracking has been implemented using GPS with the accelerometer and the WiFi shield. In the event of straying of a wild animal out of the predefined zone of sanctuary or natural reserve, an alert is sounded on a fixed base station (BS). As a prototype, we have tested this hardware on the cows, which shows that the proposed approach is very efficient in terms of flexibility and cost. This may be acting as a deterrent to various anti social activities poaching, train delays, railway accidents and danger to man due to the straying out of the animals off their habitation zone.**

Keywords–GPS monitoring; Arduino; WiFi Shield; Wildlife Sanctuaries; National Reserves.

I. Introduction

Currently, surveillance and monitoring of the wildlife is an important factor in helping the rangers to manage the wildlife sanctuaries and natural reserves for conservation. Surveillance protects the various species from straying out of the sanctuary and safeguarding the reserves for future. There is a need to have the latest information regarding the existing habitat and their present locations. Recording of different locations, movements of the rare and protected species, and monitoring the trends to make sure that the reserves are managed in an efficient manner is todays need

India have 514 wildlife sanctuaries, 99 national parks, 41 conservation reserves and 4 community reserves; effectively 155980 square km area is covered by the forest. There is always a need to track the animals in order to protect them form entering into residential areas, and accidents or killing by human beings. Biologists working on animal monitoring have been equipping the animals with the GPS modules to obtain more precise locations and motion patterns that will be integrated with the data from the micro controllers to study various factors of the animals behavior and the ecology concerned with them. In order to address the above mentioned issues many proposal exist, but they have their own problems like: delay for sending message alert to BS, and improper interfacing, among others. Therefore, we have proposed a new system called GATA: GPS- Arduino based Tracking and Alarm system for protection of wildlife animals. Here, GPS has been combined with sensor-based technologies which is used to collect the location and motion patterns of the animal through BS. According to the current survey of world wildlife federation (WWF), movement of animals from forest area is one of the major concerns; a survey of same is shown in Figure 1. Figure 1(a) reflects that major portion of north India is covered with the wildlife sanctuaries, hence, to track the movement of wildlife animals in this region is a challenging task for the forest department. Upgrading in technology over a span of time is shown in Figure 1(b). Recorded number of rhinos poached in south Africa year wise since 2007 to 2015 is shown in Figure 1(c) and movement of wild life animals inside and outside sanctuaries in Rajasthan, India is shown in Figure 1(d). The rest of the article is structured as follows. Section II highlights previous work done by researchers in this domain with challenges and our contributions. Section III presents the proposed hardware and its components. We present the performance evaluation results in Section IV and finally, Section V concludes the article with future scope.

II. Related Work

This section describes the previous work done by researchers in selected domain. Global navigation satellite system (GNSS) was defined for the navigation system that provides the grospatial positioning with global coverage, where whole system was made up of constellations of various orbiting satellites linked to the ground stations. The GPS has proved to be the most popular GNSS module, which has the potential to be a very efficient tool for wildlife studies [2]. When GPS is used in combination with WSN it provides higher amount of reliability on data that was received from the sensors finally sent to the BS. This makes real time monitoring of animals very easily and less cumbersome task as compared to earlier technologies of radio tracking and photo identification [3]. A lot of questions related to animal ecology can be answered using the data collected from the GPS modules, such as resource selection, animal movement, foraging behavior and predation. Existing software tools for the study of the

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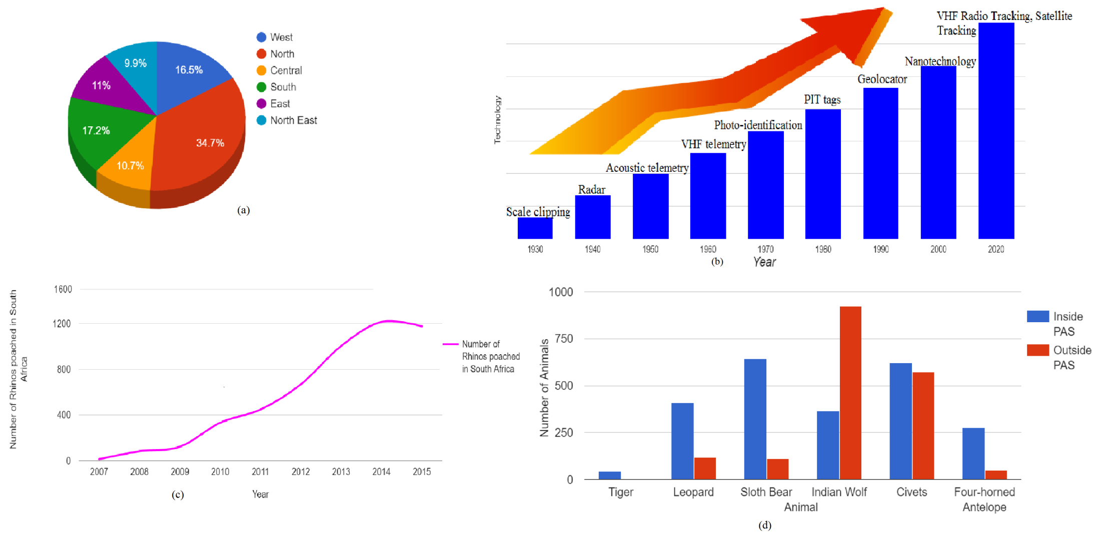

Fig. 1. World wide statistics of wildlife Animal tracking (a) Spread of wildlife sanctuaries across different zones in India, (b) Evolution of technology in animal monitoring through the years, (c) Recorded number of rhinos poached in South Africa year wise since 2007 to 2015, (d) Recorded wild animals inside and outside sanctuaries in Rajasthan

movement of the wild animals in sanctuaries have always been based on the radio tracking technology which have again focused more on data analysis than the required data management. This system of animal tracking with GPS has reported on GPS accuracy [4-5], selecting appropriate GPS collar sampling frequencies [6], and GPS errors on movement characterization. A persisting challenge is labor and huge cost for monitoring all animals in a group [7]. There has not been sufficient research regarding the way to implement a power efficient module consisting a microcontroller for monitoring, and hence sending less redundant data to the BS that effectively visualize the motion of animal on real time and keep a check on them. Another work was conducted with lots of sensors called zebranet and used solar energy out the zebranet suffered from the energy issues and the device was not handy to tie to the animal [8]. Current research included the tracing of entire path covered by animal for a period of time. However, this model suffered from lack of real time data [9-10]. Some tiny pet collars have been researched to track animals, but fail to provide monitoring feasibility. Inertial sensors were used [11] to monitor the behavior of wildlife accurately, but the proposals were lacking of their location. RFID-based tracking system was used in [12-13], but suffered from security issues due to presence of air interface between GSM and RFID. Zhou *et al.*[14] used infrared thermal camera to track and save the deers from getting killed in road accidents. In [15] GPS, GSM and RFID were combined onto a single platform to make the monitoring system more effective.

A. Research Contributions to the Work

Following are the research contributions of proposed work:

- We have presented an architecture to monitor the movement patterns of animals while they are under observation.

TABLE I
SPECIFICATIONS OF COMPONENTS

Components	Specification
Arduino Uno	Broadcom BCM2837, microprocessor: ATmega328, Operating Voltage: 5V, Input Voltage: around 7- 12 V, Flash memory of 32KB, SRAM: 2KB, EEPROM: 1 KB, Clock Speed: 16MHz.
Skylab SKG13BL GPS	Low power consumption: Typical 22mA@3.3V, Ultra high sensitivity: -165dBm
WiFi Shield	Operating voltage 5V, Connection via: 802.11b/g networks, Encryption types: WEP and WPA2
Accelerometer	Triple axis 3g sense range, Draws 0.9mA, Up to 360mV/g sensitivity

- With the help of proposed hardware module, any immediate decision can be taken as and when required.
- A GSM mobile layer was added to the BS that deals with the requests between the BS and GSM module.
- Estimate the performance evaluation of our proposed scheme over other existing approaches.

III. SYSTEM ARCHITECTURE AND COMPONENTS

In our proposed approach, we have efficiently used the GPS technology for real time animal tracking. Arduino Microcontroller and a WiFi shield was also used between BS and wireless network, as shown in Figure 2. Here, BS is monitored by using appropriate modeling that can visualize the motion path and specific location of the animal. Specifications of the components used for tracking the movement of animal are summarized in the table-I. Complete working hardware module of the proposed approach(*GATA*) is shown in Figure 3.

GPS Module: The SKG13BL [16] is a complete GPS engine module that features super sensitivity, ultra low power and small form factor. The GPS module provides the microprocessor with different types of data related to the location of the animal. The connection will be made such that the transmitter pins of the GPS module are connected with the receiver pins of the arduino, and similarly the receiver pins of the GPS module

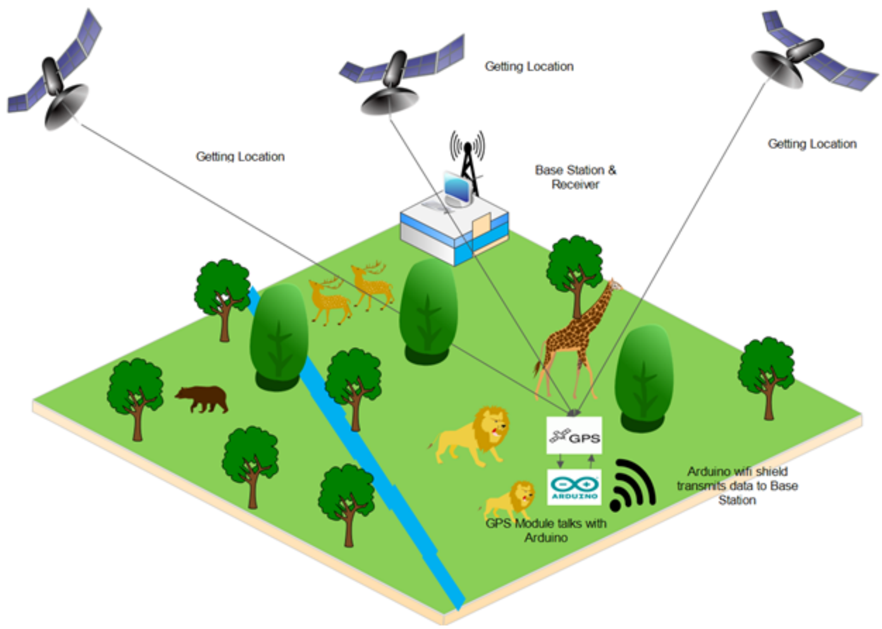

Fig. 2. System Architecture

are connected with the transmitter pin of the GPS module.
Arduino: The Arduino UNO [17] is used for the implementation of the proposed architecture that comes with the microprocessor: ATmega328. In our approach, general purpose of Arduino is to act as a link between user and the GPS module, which provides a path to read the data from GPS module.
Accelerometer: For hardware implementation, we utilize the DE-ACCM3D[18]. Here, the function of accelerometer is to determine the movement of the module, and initialize the location fetching from GPS module. When motion stops, the accelerometers will imply on GPS module to stop working.
Arduino WiFi Shield: The Arduino WiFi [19] will connect the Arduino board to the Internet by the IEEE 802.11 protocol. The HDG204 802.11b/g system in-package is the bases for the shield. A network stack is given by the AT32UC3, which has the capability of both UDP and TCP protocols. It connects to the Arduino board with wire wrap headers which move all through the shield, keeping the pin layout intact. The WiFi shield is capable of connecting all networks operations according to the 802.11b and the 802.11g Wi-Fi protocols.
Receiver: It is located at the BS and receives data transmitted from the Wi-Fi shield on the module attached on the animal and the location is detected.

A. *Scenario wise presentation of proposed scheme*

We tested our approach (GATA) in the real-time environment, using sensor nodes (SNs) on a cow in our society campus, with predefining boundaries that the animal should not cross. Verification of the data obtained is easily verifiable using this particular approach. We have used three scenarios as shown in Figure 4. In scenario 1, we have three animals under monitoring, with their motion paths being shown on the google API on the BS monitor and tracking is undertaken. In scenario 2, an animal crossed the set boundaries, an alert was sounded off at the BS. In scenario 3, the GPS module malfunctioned, and GPS became unresponsive and again an alert was activated. Different variables used throughout the paper are defined in the Table II. Next sub section includes the systematic execution of the proposed scheme with algorithm

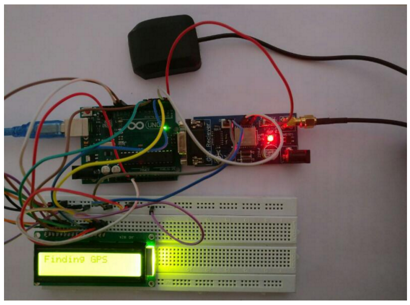

Fig. 3. GATA: Working Hardware Module

B. *Algorithm*

Based upon the above discussion systematic execution of our proposed scheme is presented in the form of algorithm 1, algorithm 2 and algorithm 3.

IV. Results and Discussion

For the implementation of the various scenarios as discussed in earlier section, we have implemented our proposed approach and were able to get the desired results. The GPS module works only when the accelerometer detects motion in a plane. As we have seen in Figure 5, whenever absolute difference in

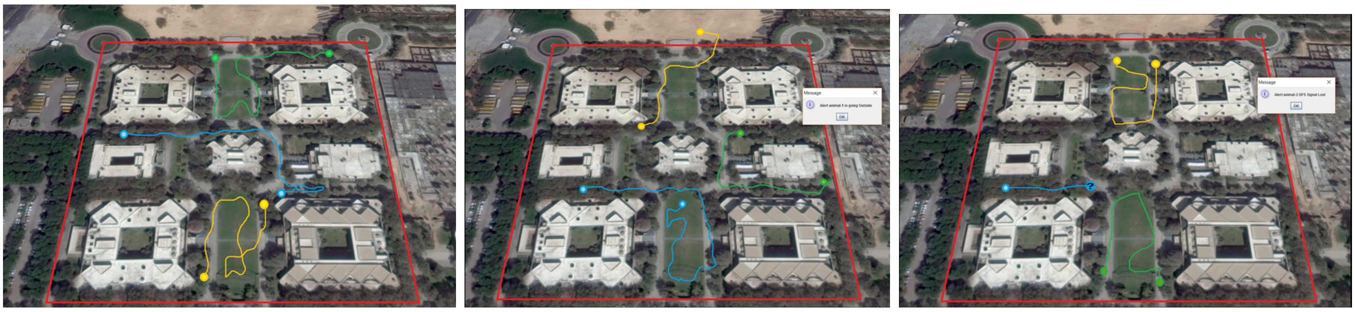

Fig. 4. Different scenarios of proposed scheme (a) Scenario: 1 Three animals under monitoring, (b) Scenario: 2 An animal crossed the boundaries that was defined, an alert was sounded off at the BS, (c) Scenario: 3 GPS module malfunctioned, and the GPS became unresponsive and again an alert was sounded.

TABLE II
DEFINITION OF DIFFERENT VARIABLES

Abbreviations	Terms
L^t	Latitude
L^g	Longitude
G^s	GPS status
G^d	GPS data
A^s	Accelerometer Status
X	Coordinate of X axis
Y	Coordinate of Y axis
Z	Coordinate of Z axis
L^s	Location String
C^m	Comma Counter
T^s	String to Find
S^l	String Length
Cng	Changed
Ots	Outside
L^{tn}	Latitude Normalized
L^{gn}	Longitude Normalized
Normalized	Conversion from Degree to Degree and Minutes

Algorithm 1 Pseudo code of Proposed Approach

Input: $P(A_r)$
Output: G^d
while $P(A_r) > 0$ **do**
  $A_s = Get - Move()$
  while $As == true$ **do**
    $Get - Location()$
    relay to BS
    $A_s = Get - Move()$
  end while
end while

position is greater than zero, the location is transmitted to the BS via WiFi shield.

For actual implementation of the proposed approach, module was tied on the neck of a domestic cow, as shown in Figure 6. Cow was allowed to move around freely in our society campus, while the data of its location was recorded on our systems that were connected via the WiFi Shield.

In scenario 1, a cow moved in three different paths, not

Algorithm 2 Pseudo code for Motion of Accelerometer

Input: X, Y, Z
Output: M_o
$Get - Move()$
if $(X \geq Cng)||(Y \geq Cng)||(Z \geq Cng)$ **then**
  return true
else
  return false
end if

Algorithm 3 Pseudo code for Fetching Location Of GPS

Input: $P(A_r)$
Output: $i = 0, x = 0, c =$ “”, $S^l = 0, L^t = 0$
$L^g = 0, C^m = 0, L^s =$ “”
$Get - Location()$
$T^s = GPGGA$
while $G^d.available() \geq 0$ **do**
  $c = G^d$
  $L^s += c$
  $i += 1$
  if $(i \leq 6)$ **then**
    if $(L^s[i-1] != T^s[i-1])$ **then**
      i = 0
      $L^s = null$
    end if
  end if
  if $(c == newread)$ **then**
    if $(i > 65)$ **then**
      $G^s = 1$
      break
    end if
  else
    $G^s = 0$
  end if
end while
$S^l = i$
if $(G^s = 1)$ **then**
  while $X < S^l$ **do**
    if $(Ls[x] ==$ “,”$)$ **then**
      $C^m = C^m + 1$
    end if
    if $(C^m == 2)$ **then**
      $L^t += L^s[x+1]$
    end if
    x=x+1
  end while
  i = 0, x = 0
else
  $L^t = 0, L^g = 0$
end if
$Give - Info(L^t, L^g)$
$L^{tn} = Normalized(L^t)$
$L^{gn} = Normalized(L^n)$
if $(L^t \geq O^{ts}||L^g \geq O^{ts})$ **then**
  report station
end if

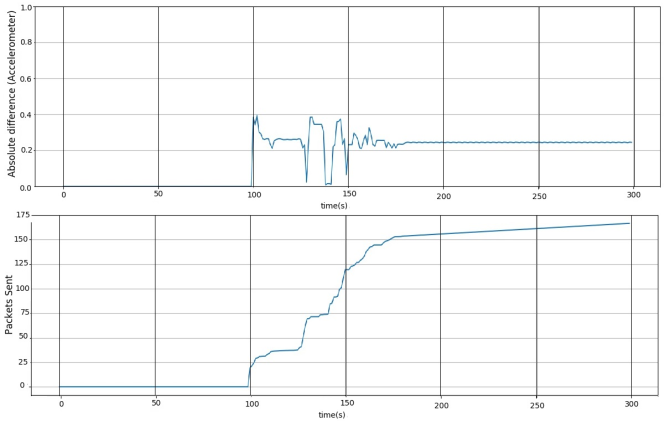

Fig. 5. Accelerometer vs Time Graph and accordingly Packets sent via Wifi Shield vs. time.

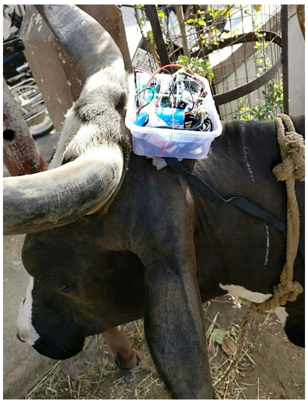

Fig. 6. GATA: Working Hardware Module

triggering any alert as it was in the vicinity of the defined boundaries. Scenario 2 disrespects the event when the cow moved out of the boundaries and sounded an alert at the BS. Scenario 3, defines when the GPS signal is lost, i.e. when the module had drained its battery, an alert was sounded regarding the same and pointing its last known location. With the intention of presenting the benefits of the accelerometer and the given approach, an analysis was made of the total data packets sent in a time domain, according to the motion in the accelerometer tied on the cow, so as to efficiently use the bandwidth of the medium. We can observe that when the cow is at rest, power is also conserved and unnecessary usage is also avoided.

V. Conclusion

Due to rise in movement of animals from the forest area to residential area, now time has come to take strict decisions by the Government agencies to monitor the animal tracking on a continuous basis. This would eliminate human, animal death and injuries and can also help the forest departments or any other responsible authorities to monitor their movement so that they do not stray out of their habitation zone. This paper proposes a new system called *GATA (GPS-Arduino Based Tracking and Alarm System for protection of Wildlife Animals)* that combined GPS technology, Arduino Wi-Fi Shield and WSN network. Our proposed architecture was also implemented in hardware and tested on animals using an Arduino UNO, Wi-Fi Shield and an accelerometer. The module was utilized to keep a check on the animal to not cross predefined boundaries and sound an alert if it does so. Each module used so far, is known to be very less complicated to be troubleshooted, and for further analysis. This, obtained data can be utilized further for in depth analysis of the motion paths of the particular animal. Moreover, the accelerometer proves to add a very efficient angle to the architecture, because of its limitation on the data packets sent and the powering on-off of the GPS Module.

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