

# DESIGN OF AN IMPROVED ELEPHANT TRACKING SYSTEM

R.M.A. Priyadarshana<sup>1</sup> and D.N. Balasuriya<sup>2</sup>

<sup>1,2</sup>*Department of Electrical & Computer Engineering, The Open University of Sri Lanka*

## INTRODUCTION

*Elephas maximus maximus*, the Sri Lankan elephant is a native mammal which has been an icon of Sri Lanka over centuries. Domesticated elephants have carried much of the heavy labour workload in ancient constructions when heavy machinery was not available. The elephant also plays an important role in both Buddhist and Hindu cultures. However, both domesticated and wild elephant populations have decreased dramatically over the past 50 years. Hence since 1986, the Sri Lankan elephant has been named as an endangered sub-species. Loss of habitat due to deforestation, deaths due to the human elephant conflict and also hunting for tusks have reduced the elephant population by more than half. Today, less than 6000 elephants roam in Sri Lankan jungles.

Government and non-governmental organizations (NGOs) have realized the need to protect this majestic giant and have taken many measures. In this protection process, monitoring of elephants is very important where it allows tracking the movement of elephant herds. This in turn allows warning when elephants have crossed the boundaries and reached the farmlands or villages. Thus the human-elephant conflicts are minimized. At the same time, elephants are frequently threatened by the train. This monitoring helps to understand the elephants' routes and hence special care can be taken by the train drivers.

There are many electronic elephant tracking systems available in the world where most of them are radio collar based and transmit very high frequency (VHF) radio beacons. With a Yaggi antenna, trackers go in the field and are capable of receiving the beacons within a radius of approximately 3km from the elephant (Tchamba *et al.*, 1995). However, this approach involves a considerable amount of effort and risk as the tracker has to physically go in to the elephant territory. Another approach is where a global positioning system (GPS) receiver based elephant collar captures the position coordinates and transmits the same via a global system for mobile communication (GSM) link to a remote location (Alanti *et al.*, 2000 & Quaglietta *et al.*, 2012 & Savannah Tracking, 2013). The major drawback of this system is that it requires a GSM coverage which is not present in more than 50% of the elephant habitats of Sri Lanka. To overcome the issue, a satellite based tracking system has also been introduced (Verlinden & Gavorv, 1998). All these systems operate in a point-to-point topology. Thus, to avoid the high cost involved with many links, a limited number of collars have been fixed to a few elephants in the herd. Hence these systems are more concerned on herd monitoring. However, the behavior/movements of individual elephants within the herd is also important to be monitored which is impossible with the available systems. In this paper, we propose a GPS receiver and GSM link based remote tracking system equipped with a Zigbee network to facilitate monitoring each individual elephant in the herd.

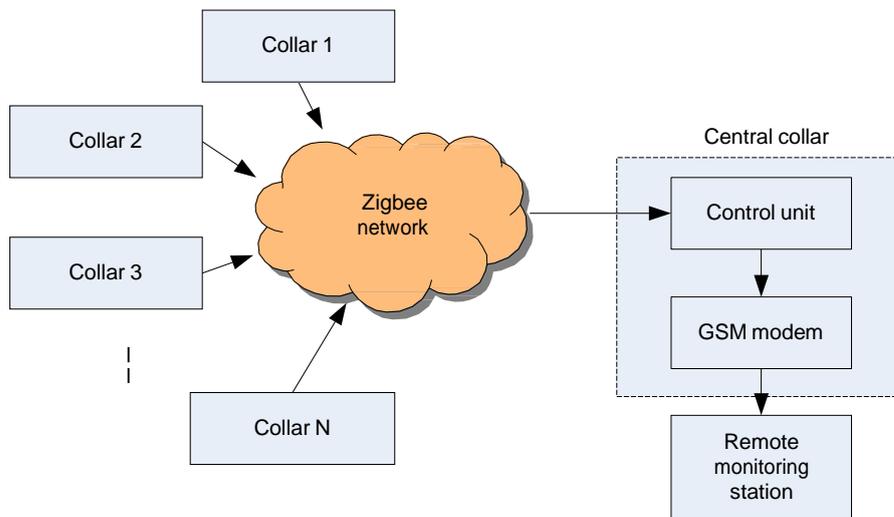
## METHODOLOGY

The proposed radio collar system operates on a star topology, where a large elephant is fixed with a central monitor node collar which collects the position information from other collars and communicates the information to a remote monitoring location via a GSM link (Figure1). Each individual collar is equipped with a GPS receiver and a Zigbee (Safaric, 2006) transmitter which captures the GPS coordinates of the elephant's position and transmits them to the central collar, respectively (Figure 2). The central node collar too consists of a GPS

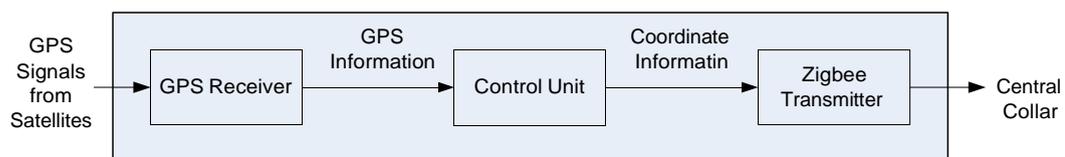
---

<sup>2</sup> All Correspondence should be addressed to Mr. D.N. Balasuriya, Department of Electrical & Computer Engineering, The Open University of Sri Lanka (email: dnbal@ou.ac.lk)

receiver for monitoring the same elephant's location and also a Zigbee module for receiving the information from the other collars. Furthermore, the central collar has a GSM module to convey the collected information to the remote location. The controlling of the operation at each collar and also at the central station is carried out by microcontroller based circuits.



**Figure 1: Block diagram of the proposed system**



**Figure 2: Block diagram of the proposed elephant collar**

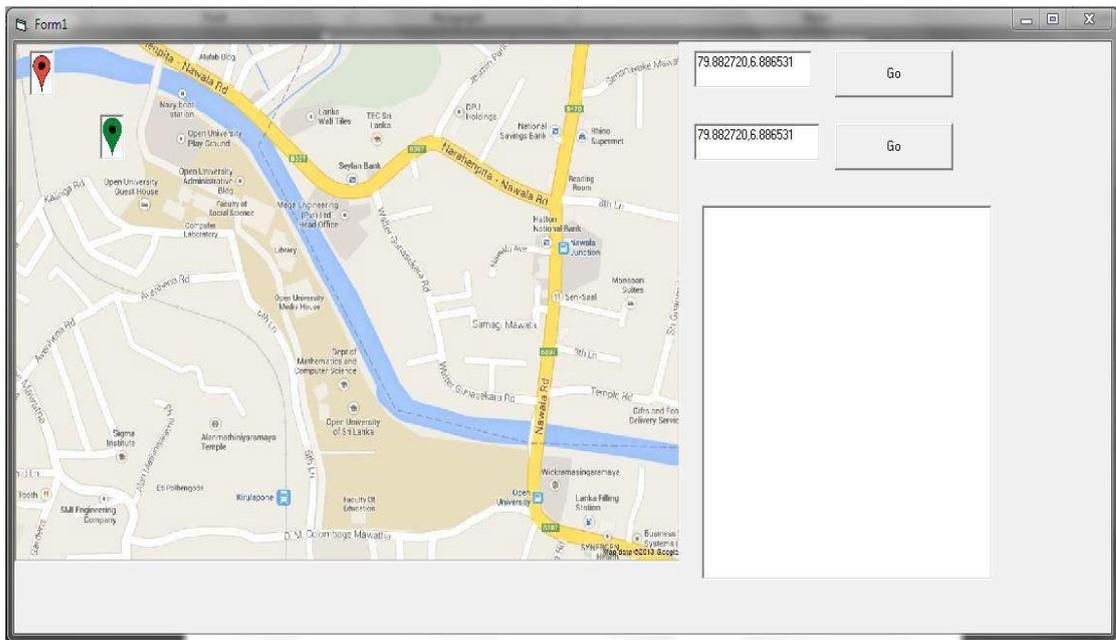
When the collars consisting of the tracking system are fixed to the elephants, it is almost impossible to replace the battery, hence a special battery with a longer life is used for powering the units and also a sleep-wake up mechanism is used to save power. The collars wake up every 15 minutes, capture GPS information and compare the reading to the previous reading. If the reading designates a point at least 100m (equivalent to a change in the third decimal point in GPS coordinates) away from the previous, then transmits the captured GPS information to the central node together with the unique collar identification number. This conditional transmission is also a vital power saving mechanism introduced in to the Zigbee sensor network. At the same time, relays / central collar listen in a 2 seconds window and compile all the received information to a single frame with the individual collar identification number tags and relays the information via the GSM link to the monitoring station. At the monitoring station, a Visual Basic 6.0 coded software interface displays the locations of the elephants in a map (Figure 3). Moreover, all the elephant collars are perfectly synchronized within the 2 seconds time slot to avoid collisions between the information of different transmitters.

It is a common incident that the GSM mobile coverage is not present in a considerable fraction of the elephant habitats. Therefore, the central collar unit is having a capability to store the information frames and forward them when the mobile coverage becomes available with the roaming elephant's movement.

## TEST RESULTS AND DISCUSSION

In order to test the accuracy of the proposed tracking system, a prototype system consisting of two collars and a central collar together with the monitoring station software was

implemented with a Fastrax UP501 GPS receiver (Fastrax, 2010), PIC16F252 microcontroller and SIMCOM 20300 GSM modem (Texas Instruments, 2012). A test was carried out at the university premises and the received coordinates from the tracking system were compared to the actual position coordinates which were taken from the Google maps. Moreover, the test was repeated for different distances between the end collar and the central station. Note that even though the selected test terrain was not having the same foliage density as in a real elephant habitat, it could adequately approximate a real habitat for testing purposes. Results are as shown in Table 1 where the readings corresponding to the distances up to 50m were communicated directly from the detected node to the central collar while the distances beyond 50m needed a relay collar for communication. It is clear that the difference or the position error is accurate to the third decimal point irrespective of the distance between the two collars and also independent of the use of the relay, which is adequate in real time elephant tracking requirements.



**Figure 3: Monitoring interface**

**Table1: Comparison of tracked positions and the actual positions**

Distance from the central collar (m)	Detected position		Actual position	
	Longitude	Latitude	Longitude	Latitude
5	79.8900833	6.8992171	79.8899711	6.8989801
10	79.8900833	6.8992171	79.8899680	6.8989769
15	79.8900833	6.8992171	79.8899654	6.8989771
20	79.8900833	6.8992171	79.8899635	6.8989745
30	79.8900833	6.8992171	79.8899523	6.8989656
40	79.8900833	6.8992171	79.8899464	6.8989561
50	79.8900833	6.8992171	79.8899363	6.8989450
60	79.8900833	6.8992171	79.8899205	6.8989371
70	79.8900833	6.8992171	79.8899050	6.8989285
80	79.8897111	6.8984772	79.8898722	6.8989100

## CONCLUSIONS

This paper has proposed an improved elephant tracking system which addresses the shortcomings of many existing elephant tracking systems. The key feature here is that rather than monitoring each animal separately, the collars fixed to all individual elephants are monitored as a group where the information is captured together. This reduces power consumption; thus increasing the battery life time considerably. At the same time, the proposed system is highly scalable and of low cost.

The requirement to store data in the absence of mobile coverage is a considerable burden for the power saving process. If a satellite based link is employed, it would be able to capture and transmit the data immediately which would relieve the storage requirement.

## REFERENCES

- Tchamba, M.N., Bauer, H. and De Jongh, H.H.(1995). Application of VHF-radio and satellite telemetry techniques on elephants in northern Cameroon. *African Journal of Ecology*. 33(4):335-346.
- Alanti, V., Osi, G., Ssi, R. and Foley, C. (2000). The use of GPS radio-collars to track elephants (*loxodonta africana*) in the Tarangire National Park (Tanzania). *Hystrix*. 11(2):27-37.
- Quaglietta L., Martins B.H., De Jongh A., Mira, A. and Boitani, L.(2012). A Low-Cost GPS GSM/GPRS Telemetry System: Performance in Stationary Field Tests and Preliminary Data on Wild Otters (*Lutra lutra*). *PLoS ONE*.7(1):1-3.
- Savannah Tracking. (2013). GSM/GPS Wild Life Collar. Retrieved from <http://www.savannahtracking.com>.
- Verlinden, A. and Gavorv, N. (1998). Satellite tracking of elephants in Northern Botswana. *African Journal of Ecology*. 36(2):105-116
- Fastrax. (2010). UP501 GPS Receiver. Retrieved from <https://www.fastraxgps.com>.
- Safaric, S. and Malric, K., (2006). Zigbee wireless standard. In Proc. 47<sup>th</sup> International Symposium ELMAR: 259-262.
- Texas Instruments. (2012). SIMCOM20300. Retrieved from <http://www.datasheetarchive.com/simcom20300-datasheet.html>.

