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RESEARCH ARTICLE

Smart Collar Short range signal triangulation for animal monitoring.

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Abstract

The paper introduces a viable short range signal triangulation method, which will enable users to identify and monitor animals in a given area. "Zig-bee-Zig bee pairs" are used as a more precise and a relatively long-lasting alternative to the traditional radio collars. Additionally, the collar itself 'broadcasts' the animal's current state (EEG, ECG , EMG) and can trigger an S.O.S signal in case of an emergency. Allowing authorities to react to certain cases where the animal might be in critical danger (for rescue) and also allow end users to map certain behavioral patterns in animals.

Introduction:-

In today's era where newer ways to evade human security are discovered every day, problems like poaching become a major threat to fauna , In such cases where any standard feedback such as the radio collars are not completely effective, since merely locating an animal does not produce any details of whether the animal itself is alive or any details regarding the condition the animal is in. henceforth it is necessary to implement another feedback network that will not only produce data on the location of the animal itself but also give a continuous feedback on the condition of the subject. This paper explores this idea from the point of view of a sensor network which provides intrinsic feedback from sensors on the subject and visual feedback from cameras at stationary points.

Existing methods:-

Although wildlife researchers made fruitful use of GPS devices for tracking animals, the technology has some disadvantages. The high cost of equipment puts

A strain on research budgets. Technical restrictions make it impractical for studying smaller species and limit the time scientists can spend tracking animals.

Many GPS collars use the Global System for Mobile Communications, also used by cell phones, as a way to retrieve data from the device. This protocol allows a researcher to collect information about an animal's movements without the need to recapture it. In order for GSM to work, the scientist must conduct her research in an area that gets cellular phone service. Non-GSM collars use Ultra High Frequency radio signals to transmit data. Although these do not require local cell towers, the scientist must know the animal's location to within a few hundred yards in order to collect data from the collar.

Being completely mobile devices, GPS tracking collars rely on battery power to function. The battery powers the GPS unit itself along with related electronic components which store data. Under ideal conditions, a battery in a typical GPS collar lasts about a year; for longer studies, researchers must recapture tagged animals and replace the battery. If the terrain is unfavorable to GPS signals, the unit takes longer to establish a location, leading to shorter battery life. Longer-lasting batteries would necessarily weigh more, adding cost and weight to the unit.

At the time of publication, a GPS package for tracking an animal costs about $10,000. This includes the collar, receiver, software for collecting data and accessories, such as a spare battery and a drop-off mechanism which automatically releases the collar from the

animal. A goal of scientific research is to obtain as much information as possible; the more data that supports a theory, the more supported the research. According to the United States Geological Survey, the high cost of equipment tends to restrict the numbers of animals tracked, leaving the scientist with less data.
A complete GPS tracking collar weighs about a pound. Scientists don't want equipment to impede an animal's movements or affect its behavior, as these encumbrances cause stress and interfere with the research. Although advances in technology have reduced the size and weight of many electronic components, some items, such as batteries and antennas, remain relatively bulky. GPS collars are best suited for animals larger than a medium-sized dog.

The analysis of tracks is complicated because of the effect of weather, livestock trampling on tracks, and the similarities between tracks of certain species, which may lead to a considerable amount of them being discarded. Finally, general tracking methods which offer valuable tracking results for scenarios other than wildlife passages can also be employed. This is the case of systems based on GPS receivers attached to animals.
Although they can be used for tracking animals over very large areas, they are not well suited for small areas as in the passage surveillance problem. These systems are also intrusive and restrict the studies to a few GPS-equipped individuals. A second drawback is that they are based on a periodic sampling of the target's location, with a separation between samples ranging between an hour and a whole day, since a higher sampling rate would deplete batteries too quickly. Consequently, the space-temporal resolution of the track is too low and samples are not usually performed while the animal is in the vicinity of the passage. Primary Design

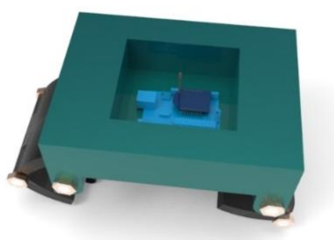


Figure 1 Proposed prototype with Arduino and ZigBee
The primary design basically consists of a housing for the Xbee and the MCU the design has a latch (shown below) that allow it to be strapped to animals. The belt , simillar to that of a watch allows for a study grip on an animal while providing greater flexibility for movement , the lid once locked(not shown in figures) will act as a waterproofing method.

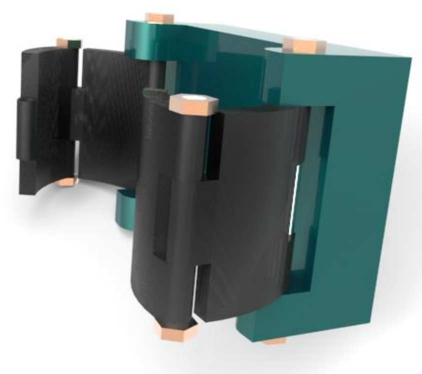


Figure 2 the latching belt for smart collars

System layout:-

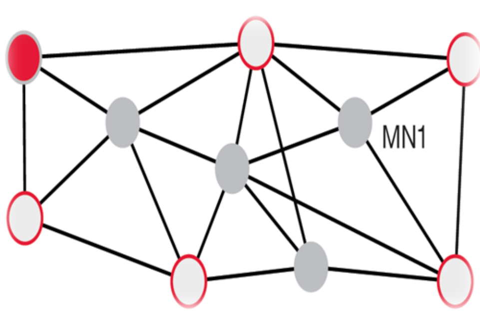
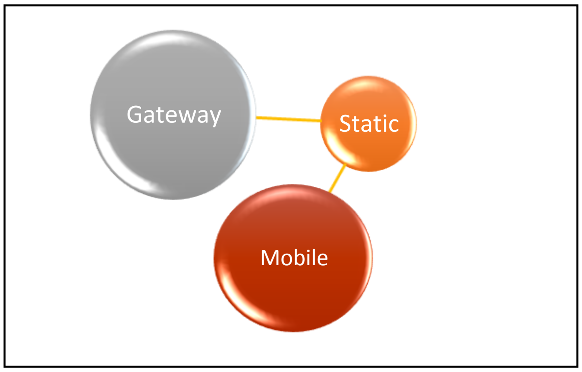


Figure 3System Architecture

The system has been divided into 3 major nodes:-



A. STATIC NODES

These nodes are stationary points that have a long range. These are ZigBee units that have a definite coordinate relative to which the others can be located with reference to these serve the same purpose as the satellites in a gps system but since the ZigBee modules themselves are placed in a relatively higher density and are limited in their range and get a relatively steep fall in their signal strength which is assumed to be linear.

B. DYNAMIC NODES

The dynamic nodes are all tags placed on the subjects along with the Epic sensor which keeps a note of the EEG and ECG value of the animal and pass it to the nearest stationary node at a fixed interval.

C. GATEWAY NODES

These are the primary nodes located in locations with access to cellular networks. such hotspots are connected to miniature processing unit that creates logs of all values simultaneously uploading all values to a server as well as trigger a video feedback from the nearest stationary nodes and signal the user in case of any anomaly.

Signal triangulation using the zigbee mesh:-

900 MHz	250 mW	45 km**

1) Bee pro xp

The xbee pro xp can send signals up to 45km at 900 MHz
The system aims at maximizing target detection probability while keeping energy consumption as low as possible. For this purpose several issues have been taken into account including sampling frequency, system synchronization, and medium access control mechanism and, finally, tracking and identification criteria. The sensor values are stored in the flash memory and forwarded to the Locator Net Server through the data link for processing. Freescale's MC13224V ZigBee Platform in Package™ (PiP) is a low-power platform for ZigBee devices. The highly integrated C13224V PiP simplifies RF design, A 433 MHz transmitter/receiver pair was constructed and tested to show signal range at the same level as earlier measurements at significantly lower power consumption rate. Mentioned below are its characteristics.

- 32-bit ARM7TDMI-S™ CPU
- IEEE 802.15.4 standard-compliant on-chip transceiver/modem
- 2.4 GHz
- 16 selectable channels
- Advanced encryption/decryption hardware engine
- (AES 128-bit)
- Low power
- 21 mA typical current consumption in RX mode with MCU active
- 29 mA typical current consumption in TX mode with MCU active
- SPI port with programmable master and slave operation
- 8-pin keyboard interface (KBI) supports up to a 4x4 matrix
- Two 12-bit analog-to-digital converters (ADCs) share eight input channels
- Up to 64 programmable I/O shared by peripherals and GPIO

ZigBee is a type of high level wireless communication protocols based on the wireless personal area network (PAN) standard IEEE 802.15.4. Its goal is the applications that require reliable communications, due to mesh topology, low data transmission rate and long lasting batteries. ZigBee usually is based in mesh networks, so it uses mesh technology what provides a higher reliability because multiple transmission paths exist. This allow some nodes of the network to be asleep while others take the control of the propagation and avoid a whole network to block if ones node gets down The RSSI values are stored in BBREG6 register. The Master asks for RSSI to a specific number of slaves which destination address is known. Each slave then sends a reply to the Master. The Master then, gets the number of slaves and their addresses. Mapping is carried to find RSSI values for fixed distances and is stored in database. It compares and finds the value nearest to it in database.
The squared Euclidean distance from each sample's RSSI values to all other samples was computed and sorted for each sample in order to find the first K nearest neighbors in signal space, for K from 1 to 100. We combined the PSD of the K nearest neighbors as follows:

$$w_k = \frac{s_k}{\sum_{j=1}^{K_{max}} s_j}$$

$$\hat{w}_k = \frac{\frac{1}{w_k}}{\sum_{j=1}^{K_{max}} \frac{1}{w_j}} = \frac{1}{s_k \sum_{j=1}^{K_{max}} \frac{1}{s_j}}$$

$$\hat{d} = \sum_{k=1}^{K_{max}} \hat{w}_k d_k \qquad E_{ranging} = \left|\hat{d} - d\right|$$

The above formula was implemented on the bluetooth modules of android phones to achieve signal triangulation for the given phone with an error of 22% since bluetooth works on relatively closer proximites the drop in signals over distance will be exponentially higher. If implemented on a zigbee mesh , it should reduce further, and with a samplig speed higher than 30 seconds , the output data from the gateway nodes can be filtered using more complex algoriths to obtain a more stable ouput.

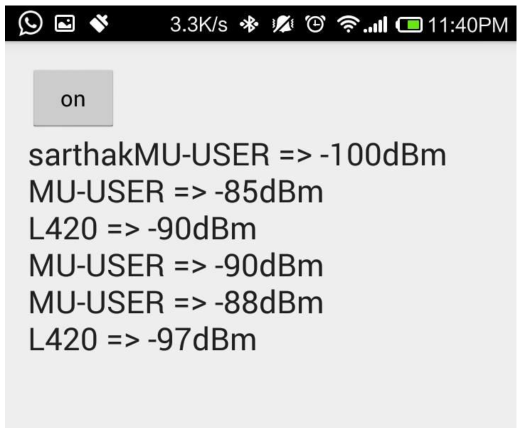
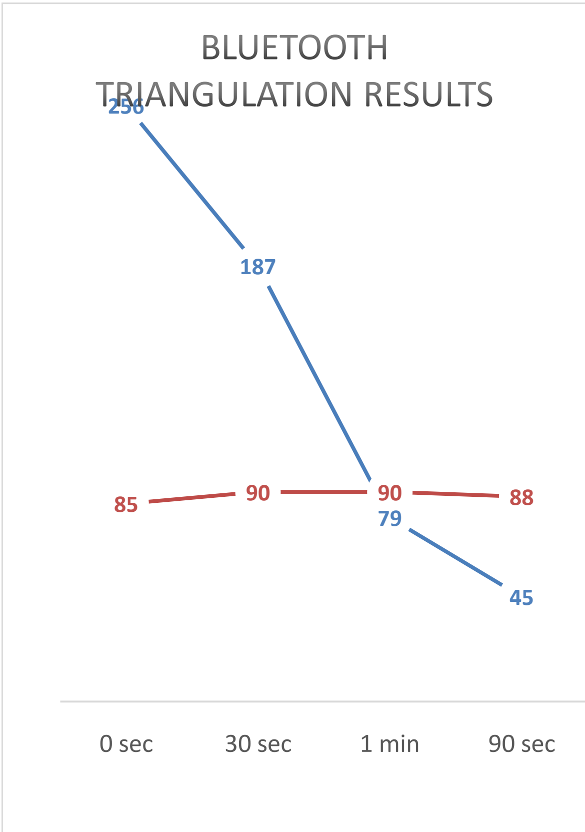


Figure 4 Bluetooth based triangulation for android enabled phones



Sensing:-

An EPIC is an acronym for "an Electric Potential Integrated

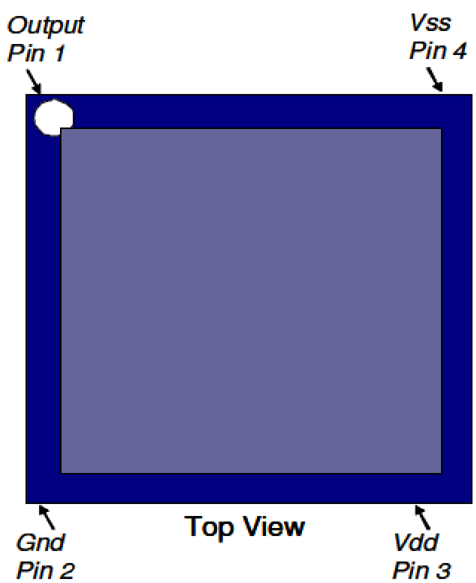


Figure 5: Pin assignment PS25201B

Circuit" but the term has also become synonymous with the sensor itself. An EPIC is a non-contact electrometer, so there is no direct DC path from the outside world to the sensor input. The input is protected by a capping layer of dielectric material to ensure that the electrode is isolated from the body being measured.

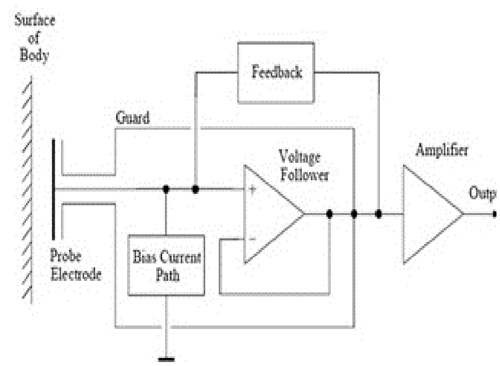


Figure 6: Block diagram of the EPIC sensor (Plessey Semiconductors, 2013)

The EPIC sensor above is a high-impedance solid state ECG sensor. Which has to be modified with an external feedback to allow guarding, bootstrapping and neutralization.

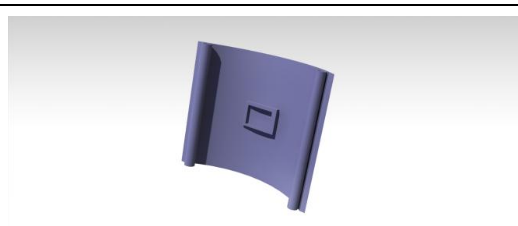


Figure 7 EPIC Sensor housing, Dynamic Node

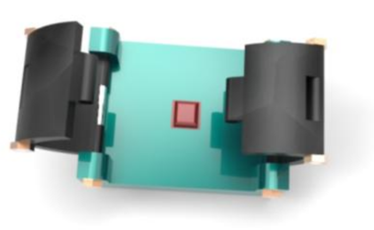


Figure 8 epic sensor in its housing

The Epic sensor is safely stored in the housing as seen in the view above to ensure proper contact at all times.
A typical ECG signal at the surface of the skin is 1mV p-p. Heart rate can be calculated by finding the time taken for 10 heart beats. Normal heart-rate of each animal is pre –fed into the system. This heart-rate can be checked to find if it is fast or normal. Incase of an anomaly, the values are cross referenced with database and the visual feedback on the static points are triggered.
An event where there are no other factors around and yet a subject shows anomalous behavior, it might be indicative of external influences (poachers, natural calamity et al.)

Conclusion:-

Smart collar is in a nascent stage as a concept, it is now required to create such intelligent tracking devices to keep the depleting fauna in check as well as help enthusiasts monitor and study animal behavior at its best without bothering to interfere with the animal or try to hide in its habitat which not only hinders animal activity and also endanger the life of the observer.

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