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Remote Health Monitoring using Implantable Probes to Prevent Untimely Death of Animals

* MOHIT S. THAKKAR

* Baccalaureate Student, Dept. of Computer Science & Engineering,
Parul Institute of Technology, Gujarat Technological University,
Vadodara, India
(E-mail: msthakkar121@gmail.com)

***Abstract*—Every creature on the planet is entitled to live in a mellifluous and safe environment. Unfortunately, animals are being casualties of untimely deaths due to multiple factors like climate change, loss of habitat, diseases, invasive species & human predation. These untimely deaths can lead to mass extinction of a particular breed of animals. Although extinction is a natural phenomenon, scientists estimate that we are witnessing animal extinction at a rate that is much more than the natural extinction rate. We can't control all of the factors that leads to animal extinction but considering the technology available at our disposal, we can definitely control some of it. My research presents a GPS & biometric based system that can wirelessly & remotely monitor the health of animals. This will prevent untimely animal deaths & eventually aid in reduction of extinction rate. Health monitoring probes are implanted inside the body of animal. These probes wirelessly monitor the vitals of the animal & sends it to the concerned authority in real time. This data can then be used to monitor the animal's health parameters. The system also reports the present location of the animal with the help of a GPS tracker. On detection of any unusual vitals, a team of veterinarians can be sent to the animal's location in order to determine & cure the ailment. The proposed system proves to be one of the most effective & affordable ways of monitoring the health of animals.**

***Index Terms*—Animals; Extinction; Health, Monitoring.**

I. INTRODUCTION

There have been five mass extinctions in the history of mankind [1], the most recent one entirely wiped out the existence of Dinosaurs from our planet. Scientists are predicting that we're on our way to sixth mass extinction [2].

When we think of extinction, we think of it as a natural phenomenon but unfortunately, the rate at which we're losing animals is 1000 to 10,000 times more than the natural rate of extinction [2]. The reasons that we're losing animals at such a rapid rate [3] have been listed as follows:

- Climate change
- Diseases
- Loss of Habitat
- Invasive Species
- Human Predation

We might not have had the technology to deal with the last extinction but we definitely have the necessary technology to prevent the next one. If we are able to stop the untimely deaths of the animals due to the above-mentioned reasons, we'll surely be able to stop the sixth extinction, or at least set it back to the natural rate.

The deterioration in the health of an animal can primarily be determined by change in sinus rhythm [4]. Clinical research shows that the causes for change in an animal's sinus rhythm could be Pain, Anxiety, Anger, Fright, Shock, Dehydration & many more [4]. If we set standard values for normal sinus rhythm of an animal and monitor the rhythm for any deviations, we can discover if the animal is in trouble. That is exactly what the proposed system does.

Health monitoring probe will be implanted inside the animal's body which will wirelessly monitor multiple vitals of the animal such as body heat & sinus rhythm in real-time. A GPS tracker will also be attached to the animal's body which will report the current location of the animal. The concerned authorities can remotely monitor the animal's vitals & location in real time. On detection of any unusual vitals, they can send in a team of veterinarians to perform diagnosis of the ailment & cure it.

I've studied various phenomena, such as heart rate sensing, global positioning system, and body heat measurement, that has helped me design the proposed system. Summary & deductions from these phenomena are described in the next section.

II. LITERATURE REVIEW

The heart is a muscular pump which sends the blood around the body. The blood vessels which carry blood away from the heart are called arteries and the ones which carry blood to the heart are called veins. When the heart beats, its muscles contract and sends blood out to the body through the arteries. When the heart muscle relaxes, the blood flows in to the heart through the veins. Every time the heart beats, it sends a pulse along the arteries [5]. The pulse can be felt at certain pulse points on the body. Pulse point for humans is the wrist. But for

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animals, pulse point may vary depending on the animal's body structure. Following are the pulse points for some of the animals [5]:

- Sheep & Goats: Inside of the top of the back leg.
- Cattle: Underside of the base of the tail.
- Horse: Inside of the cheek
- Camel: Underside of the root of the tail

By sensing the pulse rate & comparing it with the normal pulse rate, we can determine whether the animal is healthy or not. The electrocardiography (ECG) is the most effective way to measure the pulse rate for humans. For animals, we can use an implantable heartrate logger. They are made of biocompatible housing & are implanted inside an animal's body.

The normal pulse rates for some adult animals [5] are as follows:

- Sheep & Goats: 70-130 per minute
- Cattle: 40-80 per minute
- Horse: 35-40 per minute
- Camel: 35-45 per minute

Another important vital that helps us determine the health of an animal is its body heat. A change in temperature of the body is a sign of ill health [5]. Thermistors, thermocouples and infrared radiation sensors can be used to monitor the body heat of an animal [6]. The body temperature can be monitored by placing the thermistor against the animal's skin or fur [7]. Data obtained for body core temperature can be used to detect any abnormality in animal's health. It can also be used to detect mortality because dead animals are relatively colder as compared to alive ones [7].

Normal body temperatures for some adult animals [5] are as follows:

- Sheep, Pig: 39.0°C
- Goat, Calf: 39.5°C
- Cattle: 38.5°C
- Horse, Llama, Alpaca: 38.0°C
- Camel: 34.5°C to 41°C
- Chicken: 42°C
- Buffalo, Donkey: 38.2°C

A thermistor is a resistance thermometer whose resistance changes with change in temperature [8]. The term "Thermistor" is derived from two words: Thermal & Resistor. When the body temperature increases, the resistance decreases and vice-versa.

We can also use implantable temperature loggers [9] to record the animal's body temperature. They are made of biocompatible housing & are implanted inside an animal's body.

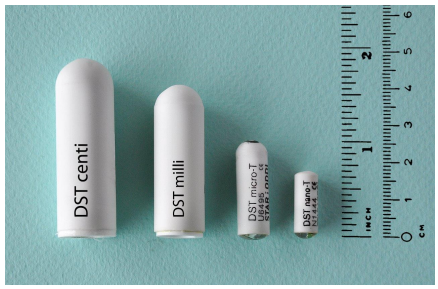

Fig.1. Implantable Temperature & Heartrate Loggers

To report the current position of an animal, global positioning system (GPS) is used. For this, a GPS tracker can be used in the form of a belt that can be attached to the limb of the animal.


Fig.2. GPS Tracking Belt

III. Components & Methodology

DST HRT ACT (Fig.1) is a biocompatible heartrate & temperature logger that is implanted inside the body of an animal. This implantable probe is cylindrical in shape and weights 1 gram. Its dimensions are 15mm in length and 4mm in diameter. It records the heartrate as well as body temperature of the animal and wirelessly sends it to the concerned authority's device in real-time. After implanting the probe in to the animal's body, we need to register it on the device on which we want to stream the health data. Registration can be done using the unique ID of the probe. It has a battery life of about 4 months to 19 months (depending on the size of the probe), after which the implant needs to be replaced.

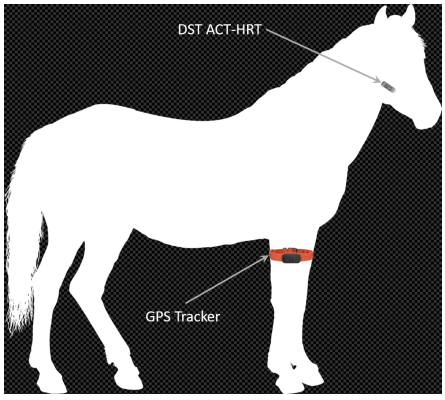

Fig.3. Horse with Body Implants

A GPS tracker used is in the form of a belt (Fig.2) that is externally attached to the limb of an animal. The belt records the current position of an animal using global positioning system. It reports the data in form of latitude-longitude in real-time to the concerned authority's device. After attaching

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the belt to the animal's body, we need to register it on the device on which we want to stream the location data. Registration can be done using the unique ID of the tracker. There are multiple belts available in the market with variable amount of battery life but in best case, it will have a battery life of 4 months to 6 months, after which the battery needs to be replaced or recharged.

The monitoring device is programmed in a way that if the body temperature or sinus rhythm of an animal deviates from its normal values, it generates an alarming notification.

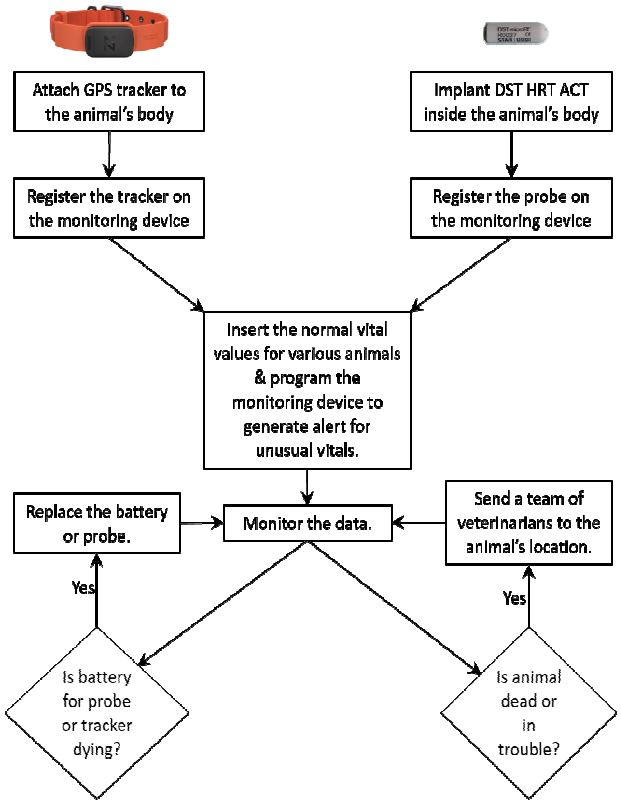

Fig.4. System Flowchart

Following are the steps that demonstrates the working of the system:

1. Attach GPS tracker to the animal's body and register it on the monitoring device.

2. Implant DST HRT ACT inside the animal's body using the help of a veterinarian. Then register it on the monitoring device.

3. Program the monitoring device:

   3.1. Set the values for normal heartrate & normal body temperature for different animals.

   3.2. Implement validations so that the device generates an alarming notification if the current values for heartrate & body temperature deviates from the normal values.

4. Monitor the data displayed on the device.

5. If an animal is dead or in trouble, send a team of veterinarians to the animal's current location to fix the issue.

6. If the battery for probe or GPS tracker is about to die, recharge the battery or replace the probe.

7. Go to step 4.

GIR Forest, India
Animal Health & Location Monitoring

Animal ID	Normal Heartrate (bpm)		Current Heartrate (bpm)	Normal Temperature (°C)		Current Temperature (°C)	Current Location	Status	Probe Battery	Tracker Battery
	From	To		From	To					
CTL_01	40	80	59	37.5	39.5	37.9	21.124679, 70.823071	NORMAL	85%	85%
HOR_01	35	40	36	37.0	39.0	38.2	21.123568, 70.826787	NORMAL	86%	86%
CTL_02	40	80	89	37.5	39.5	38.4	21.161965, 70.904146	HIGH SINUS RHYTHM	52%	52%
CML_01	35	45	0	34.5	41.0	22.0	21.220304, 70.756035	DEAD	64%	64%

Fig.5. Sample Data on Monitoring Device

IV. Advantages

1. Remote Monitoring: The wireless transmission of data allows the authority to monitor the animal's health remotely.

2. Biocompatibility: The implantable probe, DST HRT ACT, is biocompatible with the animal's body. This ensures that no damage is caused to the tissues inside the animal's body.

3. Low Power Consumption: Unlike traditional methods of health monitoring, the implantable probes & GPS tracker uses very less power.

4. Affordability: When there are large number of animals to monitor, the traditional methods might prove to be expensive and time consuming; but the proposed system is very much affordable & cost effective.

5. Real Time Data: Health data is streamed in real time with a lapse time of seconds. While using a traditional system, you might have to wait for hours before getting the data.

6. Scalability: The proposed system has the capability to function efficiently regardless of number of animals monitored.

V. Disadvantages

1. Battery Life: The life of the battery for probe & GPS tracker ranges from 4 to 6 months, after which you need to either recharger the battery or replace it. In a situation

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where there are large number of animals to monitor, this can be a cumbersome process.

VI. Applications

1. Monitoring health parameters of terrestrial animals in real time.
2. Tracking the current location of terrestrial animals in real time.

VII. Summary, Future Scope & Conclusion

In this paper, we studied that we're experiencing animal extinction at a rate that is extremely high in relation to the normal extinction rate. The reason for this was identified as the untimely death of animals due to various factors such as diseases, invasive species, human predation & so on. The efficient method to prevent this was to monitor the health of the animals in real time.

To do this, implantable probes were used. These probes were implanted inside the animal's body & they reported the health parameter of the animal to the monitoring device. These probes are biocompatible and will cause no harm to the animal. We also attached a GPS tracker to the animal's body which will report the current location of the animal to the monitoring device. The GPS tracker is in the form of a belt that can be attached to the limb of the animal.

The only disadvantage of the proposed system is that the probes & the GPS tracker operates on a battery whose life time ranges from 4 to 6 months. After exhaustion of the battery, you either have to recharge the battery or replace it.

In future, the proposed system can be modified in the following ways:

- Battery can be made rechargeable using the mechanical movement of the animal as a power source.
- Current GPS tracker can be replaced with a waterproof one in order to use this system for aquatic animals.

To conclude, the proposed system proves to be an effective & affordable method to remotely monitor the health of animals in order to prevent their untimely deaths.

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Mohit S. Thakkar (Born: India, 26 January 1997) is a baccalaureate student at the department of Computer Science & Engineering, Parul Institute of Technology, Vadodara, India (affiliated to Gujarat Technological University, Ahmedabad, India). He is currently in the final year of the baccalaureate program & will be graduating in May, 2018. His research interests include: Artificial Intelligence, Holography, Human-Computer Interaction & Internet of Things.