Behavioral Otter Tracking

Project Proposal

Abstract

When studying wildlife, it is difficult for biologists to track when and where an animal leaves or enters a specific area. This system will identify individual otter movement across a predetermined boundary, while recording time and ambient temperature. It will include RFID tags on the otter, a data acquisition unit, and a temperature sensor, all powered by a 12 volt battery. It will then store the data for later reading by the user. This project will cost much less commercial RFID systems and be tailored to the situation.

ECE 445
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Introduction

The motivation of this project is to give The Prairie Research Institute a system that can determine the time and ambient temperature when individual otters get in and out of a local pond. Very little behavioral research has been done on the North American River Otter in Illinois, and many commercially available tracking systems are extremely expensive. This system will provide a low cost alternative.

Due to their physiological aspects and environment, otters present an interesting challenge to monitor their behavior. Otters' heads are smaller than their necks; therefore, the most popular tracking device, a collar, is impractical. In addition, they spend significant time both in water and on land. This causes significant attenuation to a signal generated by a transmitter. In addition, otters will chew off devices attached to their paws or tails.

After extensively looking into the topic, we have found no other researchers who utilize RFID tags with otters. This project also has a unique goal in tracking specific behavior, rather than tracking real time location, such as by using GPS, which is also very expensive.

Objectives:

The end goal of this project is to sense and record the time and ambient temperature when an otter enters or exits the pond. An antenna will sense the tag inside the otter and communicate the tag ID to a central control unit. When the control unit receives this data, it will record the ID number, temperature, and time. The user can then extract the data with via a USB connection.

Benefits:

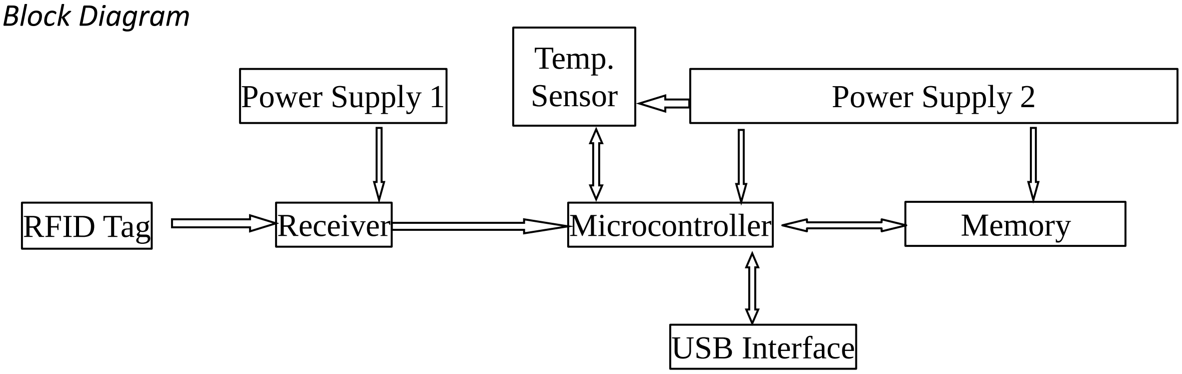
- Can track otter movement without requiring user presence
- Approximately one fifth the price of a commercial RFID reader
- Assists biologists' understanding of otter behavior
- Temperature dependent behavior tracking

Features:

- Recognition of RFID tag in outdoor environment
- Simultaneously records tag ID, time, and ambient temperature.
- Provides adequate onboard storage for tracking multiple individuals for 3 days
- Low power design for continuous use for up to 3 days
- Provides easy access through USB

Design

Block Diagram



Block Descriptions

<u>RFID Tag</u>
The RFID tag will be embedded inside the otter's torso. It will be the key identifying component of the design, allowing the system to determine which otter has crossed the boundary. It is a Passive Integrated Transponder (PIT). It reflects and modulates a 125 kHz carrier signal broadcast by inductive coupling with a loop antenna.

<u>Receiver</u>
The receiver is a loop antenna array that broadcasts a 125 kHz carrier signal to the PIT tag by LC resonance. The inductance is derived from the loop antenna. It receives its power from an oscillator. It will also have the demodulation circuitry.

<u>Power Supply 1</u>
The first power supply will provide more power than the one powering the main controller. It will need to power multiple antennas and withstand a large current draw.

<u>Power Supply 2</u>
This power supply powers the main control unit and the memory. It is a smaller source than the first, so it does not burn out any of the digital components in the main controller and the data logger (such as the micro controller).

<u>Microcontroller</u>
The microcontroller is the central control unit of the system. When the receiver senses a tag, the microcontroller will record the temperature, time, and ID to memory. It will have an Analog to Digital Converter (ADC) to convert the analog temperature reading to useful digital format. When the user desires access to the data, the microcontroller will retrieve it from memory for output.

<u>Memory</u>
The memory will store the recorded data for later access by the user.

Temperature Sensor

The temperature sensor is a TI LM35 Temperature Sensor. It outputs 10 mV per one degree Celsius. This signal will be recorded by the microcontroller when needed.

Performance Requirements:

- Senses otter 100% of the time
- Sensor range of 6 inches
- Records time, tag ID, and ambient temperature for 10 otters entering and leaving the pond 15 times a day
- Power life of 3 days

Verification

Testing Procedure:

The testing procedure is designed to be modular in nature. Each module can be initialized and tested separately. The digital and analog components would be separate until each is confirmed to work. If the components pass each of the following tests, the entire system can be integrated.

- First, the RFID tag will need to be tested. This will be accomplished by passing the tag over the antenna, and reading the output on the oscilloscope. If the signal is FSK/ASK modulated, then the tag is working.
- Next, the antenna must be tested to see if it meets the desired range of 6 inches, including passing through otter tissue, dirt, grass, etc.
- To test the receiver, the output must be confirmed to be the demodulated signal. The demodulated signal would be the analog version of the digital signal. Using a signal analyzer, the proper frequencies and power output can be confirmed.
- The temperature sensor can be tested by connecting it to a power source and reading the output voltage on a DMM using different thermal sources. Dividing the output by 10 mV will result in the temperature in degrees Celsius.
- The next test is checking to see if the microcontroller records the required data to memory. This can be done by simulating the program in real time on the microcontroller and viewing the memory locations.
- The final test is to confirm that the data transfers to the USB interface.

Tolerance Analysis:

A key component to this system is the receiver. Every Receiver has a Dynamic Range and a certain Noise Factor. The Dynamic Range of the receiver will be tested using a signal generator and a spectrum analyzer. The main test, to determine the Dynamic Range, is the “two-tone” intermodulation distortion test. Essentially, two tones of equal amplitude within the allotted bandwidth of the signal are input into the system. Their power input is gradually increased while the power of the 1^{st} and 3^{nd} order is recorded. These power output curves will statistically produce the dynamic range and gain compression. Using a spectrum Analyzer, a simple Noise test can be used to determine the Noise Factor.

Cost and Schedule

Cost Analysis:

Labor:

Name	Hourly Rate	Total Hours	Total = Hourly Rate x 2.5 x Total Hours
Jared Lesicko	$40	200	$20000
Kenji Nanto	$40	200	$20000
Miceal Rooney	$40	200	$20000
Total			$60000

Parts:

Part	Cost	Quantity	Total
Microcontroller	$25	1	$25
Wire	$20	1	$20
Capacitors	$5	-	$5
Resistors	$5	-	$5
Inductors	$5	-	$5
Car Battery	$100	2	$200
TI LM35 Temperature Sensor	$2	1	$2
12V Battery Pack	$25	2	$50
PCB	$15	2	$30
USB	$5	1	$5
RFID Tag	$5	10	$50
Memory	$10	1	$10
Total			$407

Grand Total:

Section	Total
Labor	$60000
Parts	$407
Grand Total	**$60407**

Schedule:

Week	Task	Member
2/6	Complete Proposal	Kenji
	Research RFID	Jared
2/13	Sign-up for Design Review	Miceal
	Use DAQ to Implement Modulation	Jared
	Research Microcontroller	Kenji
	Research Timer	Jared
	Research Thermometer	Miceal
	Research Memory	Kenji
2/20	Design Review	-
	Build Antenna	Miceal
	Order Parts	Kenji
2/27	Link Demodulator with Antenna & Test	Miceal
	Program Microcontroller	Kenji
	Test Temperature sensor	Miceal
3/5	Connect Receiver to Microcontroller and Test	Jared
3/12	Individual Progress	-
3/19	Spring Break	-
3/26	Test Whole Project	Jared
	Sign-up for Mock-up Demos Mock Presentation	Miceal
	Mock-up Demos Mock Presentation	-
4/2	Build Desirable Casing	Miceal
4/16	Test at Otter Location	Kenji
	Sign-up for Demo & Presentation	Kenji
4/23	Demo/Presentation	-
	Final Paper Due	Jared
4/30	Presentation	-