DEPARTMENT OF
Electrical and Computer Engineering

11-203 Donadeo Innovation Centre for Engineering
9211-116 Street NW
University of Alberta
Edmonton, Alberta
Canada T6G 1H9

Proposal Response: Acoustic and Environmental Monitoring System for Lab Animals

Proposal Sponsor: Dr. Keith Fenrich, University of Alberta Faculty of Rehabilitation Medicine

Objective

To develop an acoustic and environmental monitoring system designed to acquire, save, and organise acoustic and other environmental data from lab animals either in their home cage or while performing behavioural tasks.

Introduction

Biomedical researchers often conduct research using animals as human analogues. Lab rats are typically used for this purpose and therefore monitoring their behaviour, physical condition, and environment becomes an important consideration for researchers. Lab rats are particularly sensitive to changes in environmental conditions such as temperature, humidity, vibrations, and gas concentrations. By monitoring their vocalisations, which are in the ultrasonic frequency range, it becomes possible to analyse their stress levels and understand their health in response to these environmental factors.

Combined systems for logging several environmental conditions simultaneously whilst also continuously monitoring for ultrasonic audio do not currently exist. Solutions exist for monitoring each individual environmental condition and recording ultrasonic audio but manual synchronisation and logging is usually unfeasible and becomes extremely expensive quickly. We propose the creation of a new combined solution which can greatly simplify the laborious and difficult process of monitoring the conditions of lab rat cages, while also doing so at a much lower cost than using individual solutions.

Proposed Solution

Based on the requirements from our clients' request for proposal, we present two considerable designs for a solution. Common to both is the idea of a self contained enclosure which houses an assortment of sensors and an ultrasonic microphone. The proposed system would contain wireless capabilities for

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interfacing, to be used to configure acquisition parameters, and would have removable storage for data collection.

One possible design is an integrated solution which makes use of a low power embedded microprocessor. This design would potentially be battery powered and could be conveniently set up in any location for long periods of time. A fully integrated solution could be more easily developed further into a commercial product as well, although commercialisation may not be a factor with intellectual property requirements.

However, the constrained computing resources of a microprocessor might be a concern considering the amount of data we anticipate to collect. The ultrasonic microphone will generate at least 200 Ksamples/second for a maximum frequency of 100 kHz. This design will almost certainly not have enough memory to store a substantial buffer for this data and would necessitate the use of techniques using concurrent direct memory access transfers to external storages. Embedded systems also have a limited interfacing capability which may limit design flexibility.

The second possible design is a solution which makes use of a raspberry pi as a development platform. Advantages to using a raspberry pi are that it provides a large amount of computing resources in addition to substantial connectivity / interface capabilities. This potentially allows for quite a sophisticated system which includes features such as web connectivity or onboard processing. Development may also potentially be easier with reduced concerns for issues created by high data rates of ultrasonic audio and the availability of many useful libraries.

The primary major drawback to using a raspberry pi however is that it has substantial power consumption even before including that of any sensors. With a very rough expected current draw of >500 mA, an operational lifetime of 24 hours would require the use of a very large and perhaps unfeasible battery. Another drawback is that using a raspberry pi isn't suitable for product commercialisation, however this largely is not relevant due to the project intellectual property requirements.

Our goal for our project is to at least reach a prototype stage achieving the minimum functionalities of autonomously recording ultrasonic acoustic data and environmental parameters including temperature and humidity. Once a prototype can be confirmed to meet minimum requirements, our goal is then to continue development with the inclusion of additional sensors such as vibrations, and gas monitoring. We would also try to further design a housing and a battery source for the system to realise wireless operation.

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Project Overview Statement (POS)

Table 1 Project Overview Statement

Project Overview Statement	Project Name Acoustic and Environmental Monitoring System for Lab Animals	Project Number AEMS	Project Manager Haoyang Cheng

Problem/Opportunity

Address the need to autonomously monitor the volicalisations and environmental conditions of lab animals in research.

Goal

Develop an acoustic and environmental acquisition system embedded with various sensors to autonomously record environmental and acoustic data from lab animals and perform simple processing to assist later analysis.

Objectives

1. System shall capture animal vocalisations from 20 Hz - 100 KHz
2. System shall record ambient temperature
3. System shall record ambient humidity
4. System may record other environmental conditions (vibrations, gas monitoring)
5. System acquisition parameters must be configuriable by technicians
6. System may be battery powered
7. Data may be stored in external storage device
8. System may be compact
9. System may be wirelessly interfaced

Success Criteria

1. Prototype in 2 months.
2. Final compact product design in 4 months.
3. All requirements are met

Assumptions, Risks, Obstacles

1. Ability to source all required components in a timely manner
2. Ultrasonic microphone recordings are of good quality
3. Other sensors produce reliable measurements
4. Chose microprocessor has sufficient compute resources to fulfil all requirements
5. Prototype can be completed on time without excessive delays

Prepared by	Date	Approved by	Date
Jehanzeb Mirza Junrui Zhu Haoyang Cheng	2022/01/21		

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Intellectual Property Statement

Note: Public presentation and, hence, disclosure is a course requirement.

- Any open source materials used in this project will be identified to the client prior to inclusion.
- All results and intellectual property created will be owned by the Faculty of Rehabilitation Medicine, represented by Keith Fenrich.
- Students from the capstone group have the right to obtain a royalty-free licence for the technology as it exists May 30, 2022 (written agreement required).

Contacts

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