Cat Collar - Petronics

Team Number 42 - Taha Anwar,
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TA: Dongwei Shi

1) Introduction:

1.1 Objective:

Problem:

Cat owners do not always have time to play with their cats. The Mousr is a clever solution that accompanies your cat in your absence. However, Petronics still doesn't have a way to check if there is a direct correlation between a cat's overall activity and Mousr's activity.

Solution:

The Mousr unit developed by Petronics is already able to make event predictions such as 'inactive', 'engaged', 'needs charging' and so on. The motivation for the cat collar is to use the data collected from it to confirm the event predictions by the Mousr in order to assess the cat's actual engagement with Mousr. This will be instrumental for Petronics, as it will allow them to measure the effectiveness of Mousr in engaging with the cat.

1.2 Background:

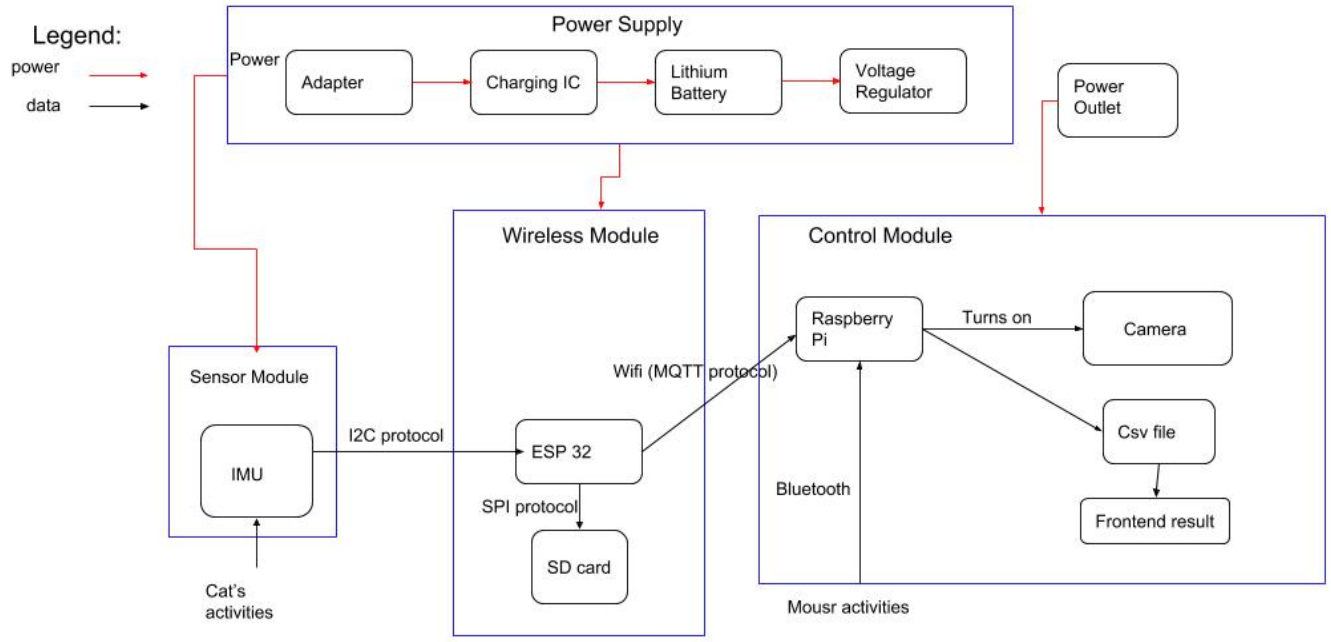
This project is sponsored by Petronics, a company aiming to build mouse robots that play and analyze cat activities, especially when there are no humans.

1.3 High-level requirements list:

1. Must be able to transmit IMU sensor data to Raspberry Pi wirelessly using the ESP32.
2. The entire PCB circuit should be small enough to be integrated within a traditional collar.
3. The battery lifetime should be at least 1 hour to be able to collect sufficient data for a play session.

2) Design:

2.1 Block Diagram:



2.2 Functional Overview:

2.2.1 Power Module:

A) Lithium Ion Battery:
We will be using a the the TATTU 450mAh LiPo Battery Pack in order to power our entire collar circuit. The main components it will need to power are the ESP32 and the IMU. Since the battery is rated at 450mAh and we are estimating 180 mA of current draw from the circuit, this will put us at 2.5 hours of constant usage.

B) Battery Charging IC:
We will be using the PRT-10217 Lipo charger. The charger charges 3.7V LiPo cells at a rate of 500mA and includes a micro-USB connector, a charging IC, status LEDs, and an appropriate port to connect to the lithium ion battery.

C) USB Charger:
The USB charger will just be a wall adapter with a usb cable that has a regular usb port on one end and a micro-USB connector on the other end.

D) Raspberry Pi Power Supply:
In order to constantly supply the Raspberry Pi, we can use the same USB charger as mentioned above. After charger our lithium batteries, we can simply use the charger to power the Raspberry Pi and then begin testing.

E) Voltage Regulator:
Our voltage regulator should take our Lithium Batteries as an input and output around 3.3 V to the ESP32 and IMU. We plan on using the TPS76333 Voltage regulator IC Chip in order to do this.

2.2.2 Wireless Module:

The ESP32 microcontroller will be programmed with the raspberry pi to take the IMU sensor signals and transmit the data wireless to the raspberry pi. This will be implemented using MQTT protocol or data stream with microPython.

SD Card:

To save data on the microSD card with the ESP32, we use the following microSD card module that communicates with the ESP32 using SPI communication protocol. This unit is an extra security in case wireless data is transmitted erroneously.

ESP 32 Development Board:

Initially, we will be using a ESP32 development board for testing purposes which has a built-in voltage regulator and supports USB-based programming. However, we plan on actually designing our custom development board where we will have a voltage regulator IC and a mounted USB connector and ESP32 chip on the PCB.

2.2.3 Sensor Module:

This module contains the IMU, which will provide us with accelerometer readings in x,y,z axes. This will be our primary source of data to run analytics on and determine the cat's activity. The data is then sent directly to the esp32 microcontroller chip using I2C protocol.

2.2.4 Control Module:

This part of the system contains the Raspberry pi and a Picamera. The raspberry pi receives the IMU data from the esp32 Wifi signals. We will be using the Picamera to record the entire play session to serve as ground truth for our algorithm. The raspberry pi simultaneously receives bluetooth signals, the Mousr's activity, from the Mousr.

Mousr activities and cat's sensor activities are inputs to our analysis program. This software stores the timestamps of these two activities every 5ms in a csv file. It also runs an algorithm at the end of each session to determine when the cat is in engagement. At the end of each session, lasting approximately two hours depending on the battery life, an analysis report will be generated. The report consists of various information like, how much time the cat spends on sleeping, walking or engagement with Mousr, and what are Mousr's activities during these scenarios. This report will be generated in a csv as well as a frontend web page hosted locally.

2.3 Block Requirements:

2.3.1 Power Unit:

A) Lithium Ion Battery:

Requirements:

- *Battery must supply 180 mA to the ESP32 and 6.1mA to the IMU*
- *Battery must supply 3.3V to the ESP32 and IMU*
- *Battery must be able to supply sufficient current and voltage to other circuit elements*
- *Battery must be able to provide minimum 1 hour of constant usage*

B) Battery Charging IC:

Requirements:

- *Must take the USB charger as input and output must go to Lithium Ion Battery pack*

C) USB charger/Adapter:

Requirements:

- *Must be able to connect to a usb port which can be connected to a circuit*
- *NOTE: At the moment, the development board for our*

D) Raspberry Pi Power Supply

Requirements:

- *Separate power supply which must be able to provide 5.1 V (+/- 5%) to the Raspberry Pi for the same time as the Lithium Ion battery requirement*

E) Voltage Regulator

Requirements:

- *Output a voltage of 3.3V (+/- 5%) to the ESP32 and IMU*
- *Operate continuously for at least 1 hour.*

2.3.2 Wireless Module:

A) ESP 32 Microcontroller:

Requirements:

- *Must be supplied a voltage in range 2.2 - 3.6 V with ideal voltage at 3.3 V.*
- *Must be able to send sensor data to Raspberry Pi wireless using MQTT protocol*
- *Must be able to store the sensor data to SD card*
- *Must be able to build the circuit*

2.3.3 Sensor Unit:

A) IMU Sensor:

Requirements:

- *Must be supplied a voltage in range 2.2 - 3.6 V with ideal voltage at 3.3 V.*
- *Must be able to send information to ESP32.*

2.3.4 Control Module:

A) Raspberry Pi:

Requirements:

- *Must meet Power requirements mentioned above*
- *Must be able to communicate with ESP 32 through bluetooth or wifi*

B*)* Software Module:

Requirements:

- *Must generate timestamps of IMU sensor data and mousr activity in a csv file*
- *Must detect cat's engagement with mousr with 75% accuracy*
- *Must turn on accessory camera when cat's engagement is detected*

2.4 Risk Analysis:

We believe that the control unit with the ESP32 microcontroller will pose the greatest risk to success. This unit is the centerpiece of the project because it collects sensor data and sends it to the raspberry pi for processing. It is also a challenging, because it involves creating our own development board and integrating all the necessary components within a required size. Moreover, it needs configuration to take in sensor data, and programming or networking protocols to wirelessly transmit data wirelessly.

3) Ethics and Safety:

One of the safety concerns in our project is battery's temperature. Misuse of the batteries can cause to overheating and burning the circuit. In order to prevent this, we plan to use a thermistor to avoid overheating and make sure to use full batteries during demos.

Another issue is using cats for experiment. Our project itself does not pose great danger on the cat, since it is only a cat collar. However, we will take extra measures to prevent battery related hazards as mentioned above or any physical discomfort for the cat when wearing the collar.

References:

i) "IEEE Code of Ethics." IEEE - Advancing Technology for Humanity, IEEE, www.ieee.org/about/corporate/governance/p7-8.html.

ii) Long, Thomas R., and Michael Kahn. "Lithium-Ion Battery Hazards ." Effectiveness and Reliability of Fire Protection Systems - SFPE, SFPE, www.sfpe.org/page/2012_Q4_2/LithiumIon-Battery-Hazards.htm