FUN-E-MOUSE

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ECE 445 Project Proposal - Spring 2022

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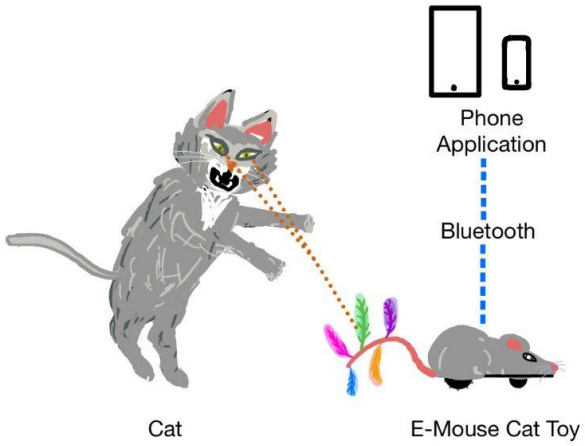
1. Introduction

1.1 Problem

Many existing electronic cat toys have preset modes that do not allow human control leaving the owner feeling not as involved in playing with their cat. The cat toys that do allow humans to play with their animals directly are not as accessible to those who may be wheelchair-bound or have disabilities. Current battery-powered cat toys on the market are rarely rechargeable leaving owners to purchase and go through lots of batteries. The use of remote controllers for some of these toys leaves them useless when the controller is lost or broken. Cheap motors or tires used on these devices often leave them struggling to move on certain floor materials like carpets, limiting many cat owners.

1.2 Solution, Visual Aid

Cat owners need a solution in the form of a smartphone remote-controlled mouse that their pets can chase around for hours. A strong lithium-ion battery will allow easy rechargeability and allow longer playtime than current toys on the market. For safety measures of the house and pet, sensors will be used to alert the toy to stop when approaching walls or when attacked by a pet. To allow use in any household flooring the mouse will be equipped with gripped rubber tires powered by strong motors to ensure it can transition from different flooring materials.



Objectives and Background:

- Goals: Create a high-quality interactive cat toy with adaptive features including smartphone remote control to allow greater usability for people with disabilities or injuries.
- Functions: Cats will love chasing this mouse toy that is remotely controlled via smartphone or self-driving with multiple modes.

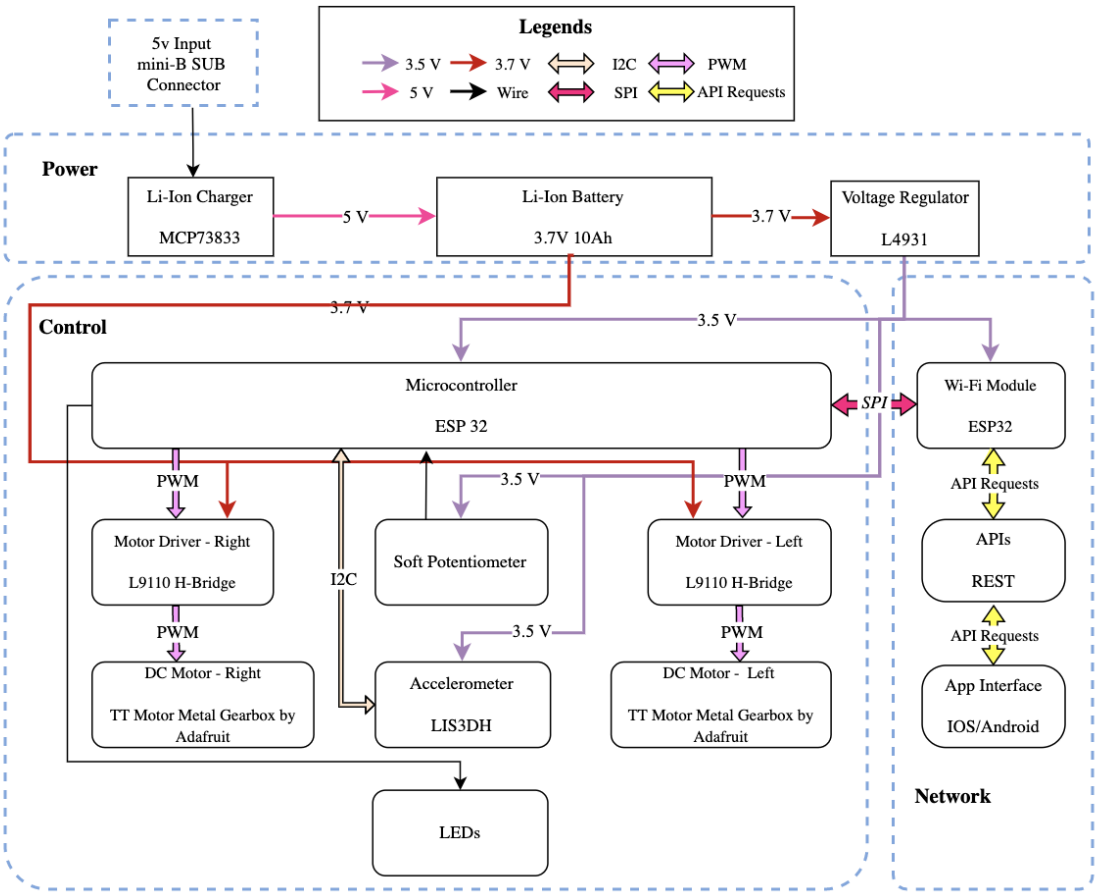
- Benefits: Fun safe way to engage your cat's inner prey drive, by letting them hunt and chase a toy that will go dormant when they pounce on it.
- Features: The toy works on any home flooring surface: tile, wood, carpet, concrete,..etc. It can also transition between floor types so users do not have to interrupt their cat's playtime to change rooms. A long-lasting lithium-ion battery allows it to go longer without needing to be charged, and no need to replace batteries, unlike other electronic cat toys.

1.3 High Level Requirements

1. The device will have four engaging modes for cat playtime that will be accessible via smartphone.
2. The wheels and motors will be capable of driving on and transitioning the mouse over five different floor types.
3. The battery will be powerful enough to supply 10+ minutes of charge, while retaining signal from 15+ feet away.

2. Design

2.1 Block Diagram



2.2 Physical Design / Encasing

1. We will 3D print the shape of mice. We will have the sensors interlocks onto the shell of the mouse; the PCB, motors, and battery mount on the bottom of the mouse inside the “stomach” of the mouse.
2. This shape of mice needs to enclose all the components of the electronic mouse and reserve openings for a small portion of the three wheels to be exposed, as well as the USB charging port. There will be some accessories attached to the outer shell of the electronic mouse to make it attractive for cats, such as feathers, bells, ribbons, or strings. We will make sure the material we use is strong and safe enough for cats. We will consider putting some catnip in the “stomach” of the mouse if there is enough space left at the end.

2.3 Control Unit

The Control Unit consists of a microcontroller, 2 motor drivers, 1 soft potentiometer, 1 accelerometer sensor, 2 LEDs, 1 Wi-Fi module. This control unit can handle, process, analyze the data from the potentiometer, accelerometer, and Wi-Fi module. Then, it can compute the data and send out control signals to those 2 motor drivers and LEDs.

2.3.1 Microcontroller

The microcontroller that we chose is the ESP32 because it is a low-cost and low-power SoC and it also has Wi-Fi and Bluetooth capabilities. This microcontroller will serve as a standalone web server that allows us to control the movement of the electronic mouse in real-time. The microcontroller will process the data from a soft potentiometer and an accelerometer, then it will determine when the cat is playing with the electronic mouse or if there is an obstacle that prevents it from moving.

Requirement 1: The microcontroller must be able to maintain serial and SPI while controlling the movement of the mouse
Requirement 2: The microcontroller must be able to communicate wirelessly with IOS or Android Apps

2.3.2 Motors

The motor that we chose is the TT motor by Adafruit. These motors are durable and low-cost that can get our electronic mouse moving on any surface. It has a gear ratio of 1:90 which provides high torque with lower speed. We can provide these motors with 3V up to 6V.

Requirement 1: we must be able to control the speed and direction of these motors by PWM.

2.3.3 Motor Drivers

The motor driver that we chose is the L9110 H-Bridge motor drive to control our 2 DC motors. The manufacturer recommended this driver with our DC motors. This driver can drive 2 solenoids or a single DC motor bi-directionally. This driver is great for any motor power voltages from 2.5V up to 12V under 800 mA. It also can handle 1.5A for a short amount of time. In addition, we can control the motor speed and direction by PWM.

Requirement 1: These two motor drivers must be able to control the speed and direction of the electronic mouse.

2.3.4 LEDs

We decided to use two LEDs that act like real mouse's eyes. These LEDs can be controlled wirelessly. LEDs can be turned on, flash, and off.

Requirement 1: The user must be able to control the LEDs wirelessly.

2.3.5 Soft Potentiometer, Accelerometer Sensor

We decided to use the accelerometer sensor to determine if the cat is playing with the electronic mouse. We are looking for a triple-axis accelerometer that can sense x,y,z directions.

We decided to use the Soft Potentiometer sensor to determine if the electronic mouse hits an obstacle. The soft potentiometer can be used as a position sensor, and we can determine which side of the mouse hit an obstacle.

Requirement 1: The accelerometer sensor must be able to read the x, y, z coordinates of the electronic mouse.
Requirement 2: The soft potential sensor must be able to read the correct position of where it is.

2.4 Power Unit

We are planning to use a high capacity (5 Ah - 10 Ah), 2.5V - 3.7 volts lithium polymer battery to enable the long-last usage of the robotic mouse. And a USB lithium polymer ion charging circuit to charge the battery. We will use Mini-B USB Connector wires to make a *5V USB power supply cable* as the charger for the electronic mouse. The voltage regulator will generate a 3.3v fixed output voltage and a 250 mA fixed output current. The regulated output will connect with IR sensors, LEDs, motor drivers, and microcontrollers.

2.4.1 Li-Ion Battery

This is the power source for the Voltage Regulator and the Motor Driver. The 3.3V supply will be used to power the microcontroller. The microcontroller has an operating voltage of 2.7V - 3.6V.

Requirement 1: Must be able to power the device for the duration of at least 10 minutes
Requirement 2: Must be rechargeable
Requirement 3: output ranges from 2.5V - 3.7V

2.4.2 Li-Ion Battery Charger

It is working as the charger for lithium batteries, with a USB power source to charge the battery while plugged in.

Requirement 1: able to charge the battery cell at a rate of 3000mA or less
Requirement 2: can be plugged into any USB port

2.4.3 Voltage Regulator

The voltage regulators change the Li-battery output to the appropriate voltage levels needed to provide the power supply for the microcontroller, sensors, and LEDs.

Requirement 1: able to output a regulated 3.3v ± 0.1v at 250mA
Requirement 2: able to operate normally with an input voltages range from 3.7V - 5.0V

2.5 Network Unit

2.5.1 Wi-Fi

The Wi-Fi module enables us to control the electronic mouse wirelessly. The Wi-Fi module receives and sends data by SPI protocol. The purpose of the Wi-Fi module is to receive commands from the APP and transfer the data to the microcontroller.

Requirement 1: The Wi-Fi IC module must be able to communicate with the Microcontroller by SPI protocol.
Requirement 2: The Wi-Fi module must be able to communicate with the APP in IOS or Android platform.

2.5.2 Application Program Interface

We decided to build some Application Programming Interfaces that can enable the APP to control the electronic mouse. With that, we can build a more stable software environment, and we are able to control the electronic mouse in real-time.

Requirement 1: The APIs must be able to communicate with the App Interface and the electronic mouse simultaneously.

2.5.3 App Interface

The App interface allows us to control the electronic mouse such as moving right, left, forward, and backward. It also can control the status of the LEDs and can configure the different play modes of the electronic mouse.

Requirement 1: The App interface must be able to control all the functionalities of the electronic mouse.

2.6 Risk Analysis

Our control module poses the greatest risk to the successful completion of our project. Being able to be controlled remotely by a web interface (or App) is the biggest attraction in the cat toy field. We are expecting our app to be able to control the mouse to either move forward, backward, left, or right. As well as being able to Turn on / off / flash the LED eyes of the mouse. In addition to these functions, we want the App to keep the cat owner informed about the battery level of the mouse and change the mode of the action of the Electronic Mouse(such as ON, Cat Activates, Run Intermittently, and OFF). We need an App that allows control of the Electronic Mouse in real-time, transmits commands, and allows the monitoring of the battery level to take place. The user app communicates with the Electronic Mouse using the network. A properly working signal transmission transceiver (Wi-Fi module) is one of the indispensable parts of our project. To be able to monitor the battery level and charging state of the Electronic Mouse is we also need to implement a battery charger circuit that shows how much energy is left in the battery. This brings out the second biggest challenge of our project which is the power subsystem. We need to make sure that if our battery does meet our expectations for the duration of the Electronic Mouse on one charge.

3. Safety and Ethics

We will conduct ourselves according to the Code of Ethics published by IEEE[1] and ACM[2]. We will be sure “to not engage in harassment or discrimination, and to avoid injuring others”[1]. We will not make use of user data without consent while users are using our mobile app that controls the electrical mouse. We will be sure to adapt the principle of justice, ensure all users are equal.

We will be sure to avoid harm and ensure “to minimize the possibility of indirectly or unintentionally harming others”[2], including pets. The outer shell of the electronic mouse might contain some electrical (sensors) and mechanical (wheels) parts. We need to make sure that they are safe and not harmful to pets or humans since this is designed to be a toy for cats. We will make sure the outer shell is firmly mounted, with no external parts that can easily be ripped off, or swallowed, causing life-threatening damage to cats.

Further, we need to protect ourselves and others in the lab when working with batteries. Batteries have many hazards, such as electrical shock, flammable gasses that could fire or explosion, and battery acid that can burn skin or eyes. We will adhere to the guidelines set forth in the document of General Battery Safety[3] provided on the ECE445 course website. We also need to consult the battery’s manuals for safety precautions and proper handling, as well as hazard identification. We need to make sure that the battery is properly secured in the equipment for the finished product to prevent injuries in end users (ex: cats) while improving our battery's performance.

4. Reference

[1] “IEEE Code of Ethics.” *IEEE*, IEEE Policies, Section 7 - Professional Activities (Part A - IEEE Policies), <https://www.ieee.org/about/corporate/governance/p7-8.html>. [Accessed 10 February 2022]

[2] “ACM Code of Ethics and Professional Conduct.” *Association for Computing Machinery*, ACM, <https://www.acm.org/code-of-ethics>. [Accessed 10 February 2022].

[3] “General Battery Safety.” *Safe Practice for Lead Acid and Lithium Batteries*, [Online]13 April 2016, <https://courses.physics.illinois.edu/ece445/documents/GeneralBatterySafety.pdf> [Accessed 10 February 2022].