INTRODUCTION
Problem and Solution Overview

**Problem:**
- Need of chaseable toy for cats
- Entertains when owner is busy
- Accessible controls for any owner
- Erin an ECE faculty member pitched this

**Solution:**
The Fun-E-Mouse is a smartphone remote-controlled/self-driving cat toy.
Objectives

- Accessible, easy-to-use smartphone control
- Chasable auto-mode: reacts to cat’s movements
- USB rechargeable with high capacity battery (6600mAh)
- Fast enough to exercise cats (~1m/s)
- Powerful drivetrain: works on different flooring
- Safe product; no exposed wires; small
Competitors In the Market

Automated Cat Toys
Drawbacks:
- No owner interaction
- Can run into objects or cats
- Non rechargeable

App Controlled Cat Toys
Drawbacks:
- No auto mode
- Short battery life(<1hr)
Overview
Our Design

- A On/Off switch
- Long lasting battery life
- A micro-USB port for recharging
- A software application
- Two Operating Modes:
  1. Auto Driving
  2. Remote Control
DESIGN
Package Design
Current Package Design

3D-Printed Top Shell
3D-Printed Wheel
Space Reserved for PCB/wiring
3D-Printed Chassis
LI Battery Pack
TT DC Motor
Front Roller-Ball Wheel
3D-Printed Under Chassis
Ultrasonic Sensor
5mm LED
3D-Printed Spacer
Current Package Design
Current Package Design

Wheel
Ultrasonic Sensor
PCB
Chassis

LED
Ball Caster
Battery Pack

Top Shell
Motor
Bottom Shell
Tail
Design - Power Management Subsystem
## Design - Power Management Subsystem

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide a nice clean 3.3V and 5V output voltages with 5% regulation</td>
<td>No</td>
</tr>
<tr>
<td>2. Able to recharge the battery from Computer, Wall USB adaptor, or power bank</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Able to power the Fun-E-Mouse for at least 30 minutes of continuous running</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Design - Power Management Subsystem

3.3 V Regulation = \( \frac{3.30V - 3.227V}{3.227V} \cdot 100 = 2.26\% \)

6 V Regulation = \( \frac{6.032V - 5.917V}{5.917V} \cdot 100 = 1.94\% \)
Boost Converter - Power Management Subsystem

Boost converter DC-DC circuit Calculation

**Target Values**

- **Output voltage:** 5 V
- **Output Current:** 300 mA
- **Frequency:** 45 kHz

**Values**

- \( C_T = 470 \text{ pF} \)
- \( L_{\text{min}} = 100 \text{ uH} \)
- \( R_{\text{SC}} = 0.25 \Omega \)
- \( R = 180 \Omega \)
- \( R_1 = 2.2 \text{ k}\Omega \)
- \( R_2 = 10 \text{ K}\Omega \)

Datasheet of Boost Converter MC3x063A
Performance

- Takes ~ 8 hours to charge fully
- Able to supply for more than 12 hours in one charge

Battery Status Indicators

- Fully charge: red & orange LED
- Battery charging: orange LED
Design - Control Subsystem
## Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Able to maintain a stable Bluetooth connection of at least 15 feet</td>
<td>1. Yes</td>
</tr>
<tr>
<td>2. The latency of the real time control must under 300 milliseconds.</td>
<td>2. Yes</td>
</tr>
<tr>
<td>3. The ESP32 should be programmed through a USB bootloader and should be able to transmit data at a baud rate of 115200</td>
<td>3. Yes</td>
</tr>
</tbody>
</table>

~ 36 ft
Design - Drive Subsystem
<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Able to move forward and backward at speed of 1m/s</td>
<td>1. No. 0.333 m/sec</td>
</tr>
<tr>
<td>2. Able to turn a 90-degree right turn or a 90-degree left turn</td>
<td>2. Yes</td>
</tr>
<tr>
<td>3. Able to stop at a forwarding speed of 1m/s</td>
<td>3. No</td>
</tr>
</tbody>
</table>
Actual Speed

\[
\frac{2 \text{ meters}}{6 \text{ seconds}} = \frac{1 \text{ meters}}{3 \text{ seconds}} < \frac{1 \text{ meters}}{1 \text{ seconds}}
\]

- Voltage and Current are not enough for faster driving
- Speed is directly proportional to the input voltage

Theoretical Top Speed

\[
\left( 6.5 \text{ cm} \cdot \pi \right) \cdot \frac{250 \text{ revolutions}}{1 \text{ minute}} \cdot \frac{1 \text{ minute}}{60 \text{ seconds}} = \frac{0.85 \text{ m}}{\text{seconds}}
\]

- According to the datasheet of the TT motor, it can draw 160 mA @ 250 RPM at 6 VDC and draws 1.5A when stalled.
Design - Network Subsystem
### Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Able to scan and connect with any 2.4GHz Bluetooth (Original was Wi-Fi)</td>
<td>1. Yes</td>
</tr>
<tr>
<td>2. Able to control the mouse to move left, right, forward, or backward in 1 sec</td>
<td>2. Yes</td>
</tr>
<tr>
<td>3. Able to configure the 2 different modes (AUTO, REMOTE)</td>
<td>3. Yes</td>
</tr>
</tbody>
</table>
Design - Network Subsystem

Changed WiFi to Bluetooth

1. Control commands were bounced from App to server, then server to ESP32
2. High Latency occurs App to server, and server to ESP32
3. Not able to connect to WiFi/HotSpot for demo
4. No ideal for real-time control device
User Interface displays:

- Shows the connected device
- Driving the mouse with the joystick when Remote Mode is on

- Tap the toggle switch for LED Control to turn the LED eyes on
- Auto Mode, sensors are activated, then the mouse drives based on sensor readings to achieve object avoidance
Design - Network Subsystem

**Automatic Mode**

- Ulstronic Sensors Noise
- Cannot detect small objects
- Ultrasonic sensors running in serial

*Speed at 2x*
CONCLUSIONS
Conclusions

Challenges

- Using the same power source for the microcontroller and the rest of the circuit
  - Fast direction-switching motor commands cause current spikes
  - Spikes affect the microcontroller by causing a brownout reset
  - Add some decoupling capacitors nearby the ESP32
  - Disable brownout detector in ESP32 in Arduino (Software)

'Brownout detector was triggered'
Conclusions

What would we do differently?

- Improve the speed by using a 7.4 volts battery instead of 3.7 volts

- Substitute Ultrasonic sensors with Limit Switch Module to improve performance of the AUTO drive mode
Conclusions

Future Work

- A On/Off Power Switch
- Control the mouse even when the user is away from home
- Keep the sensors working even when the REMOTE control mode is on
Thank You