UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Team 50
Fun-E-Mouse

ECE 445

Chuangy Zhang, John Casey, Yingyu Zhang

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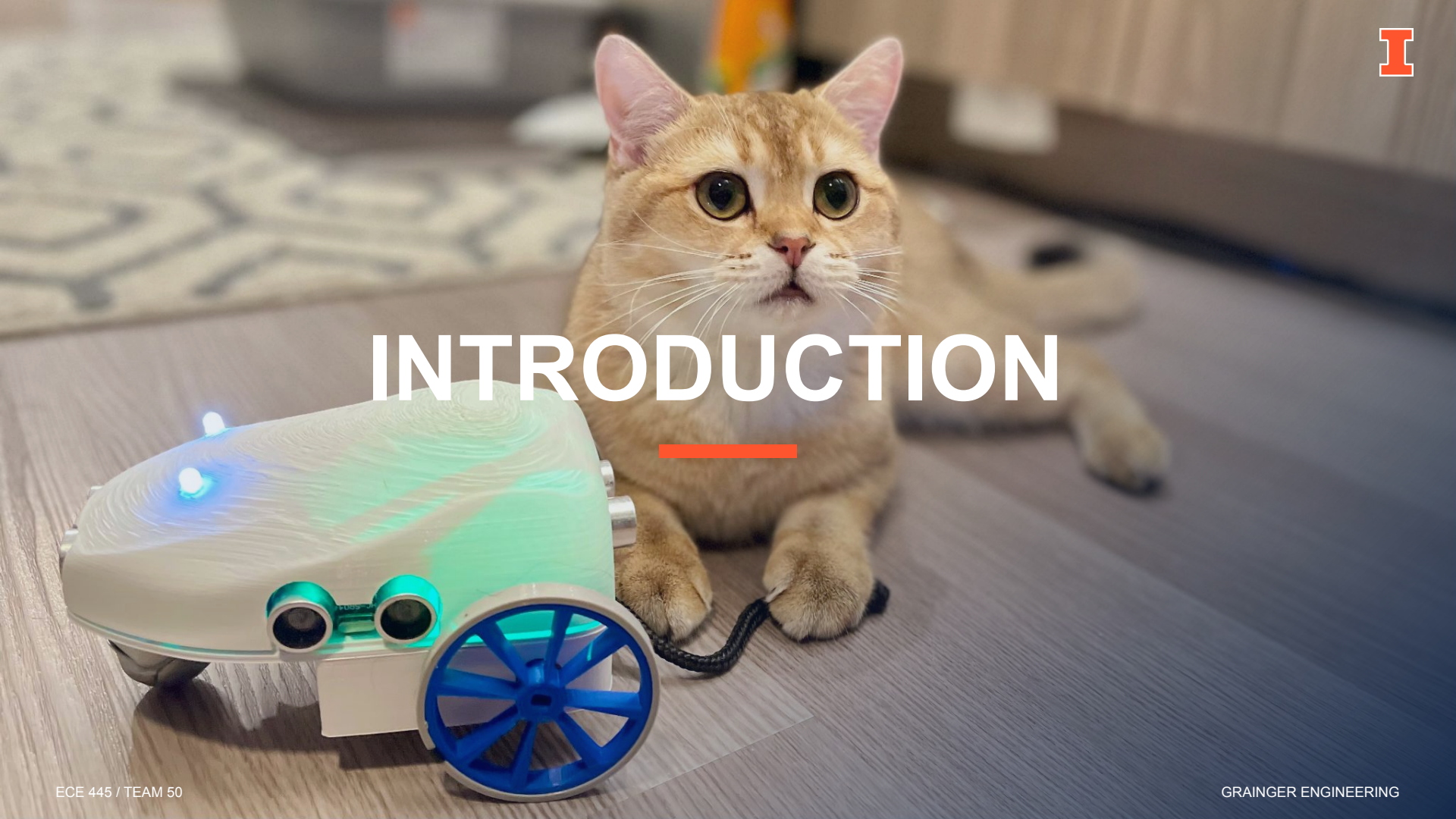


INTRODUCTION

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)

Hexbug Mouse Robotic Cat Toy
from chewy.com

Cheerble Ball Automatic Cat Toy
from cheerble.com

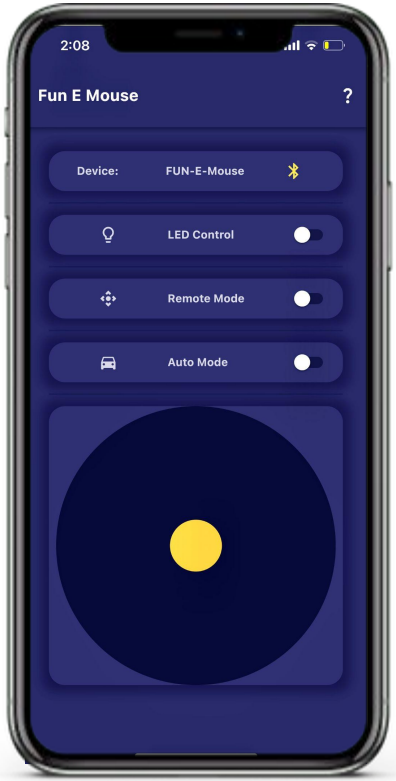
Mouse Hunt Cat Toy, App Controlled
from Meowingtons.com

IR Smart Sensing Snake Cat Toy
from amazon.com


OVERVIEW

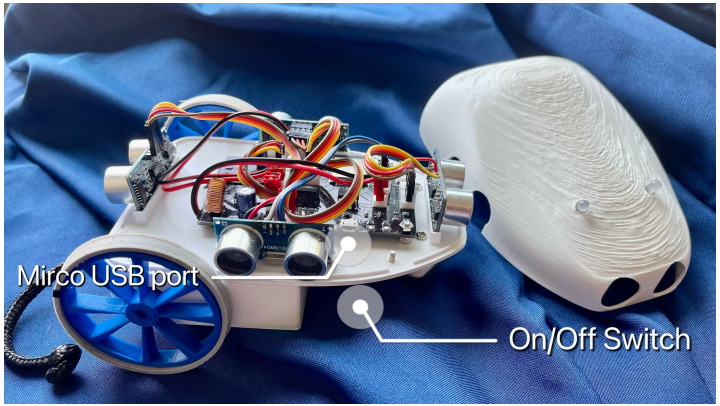
Overview

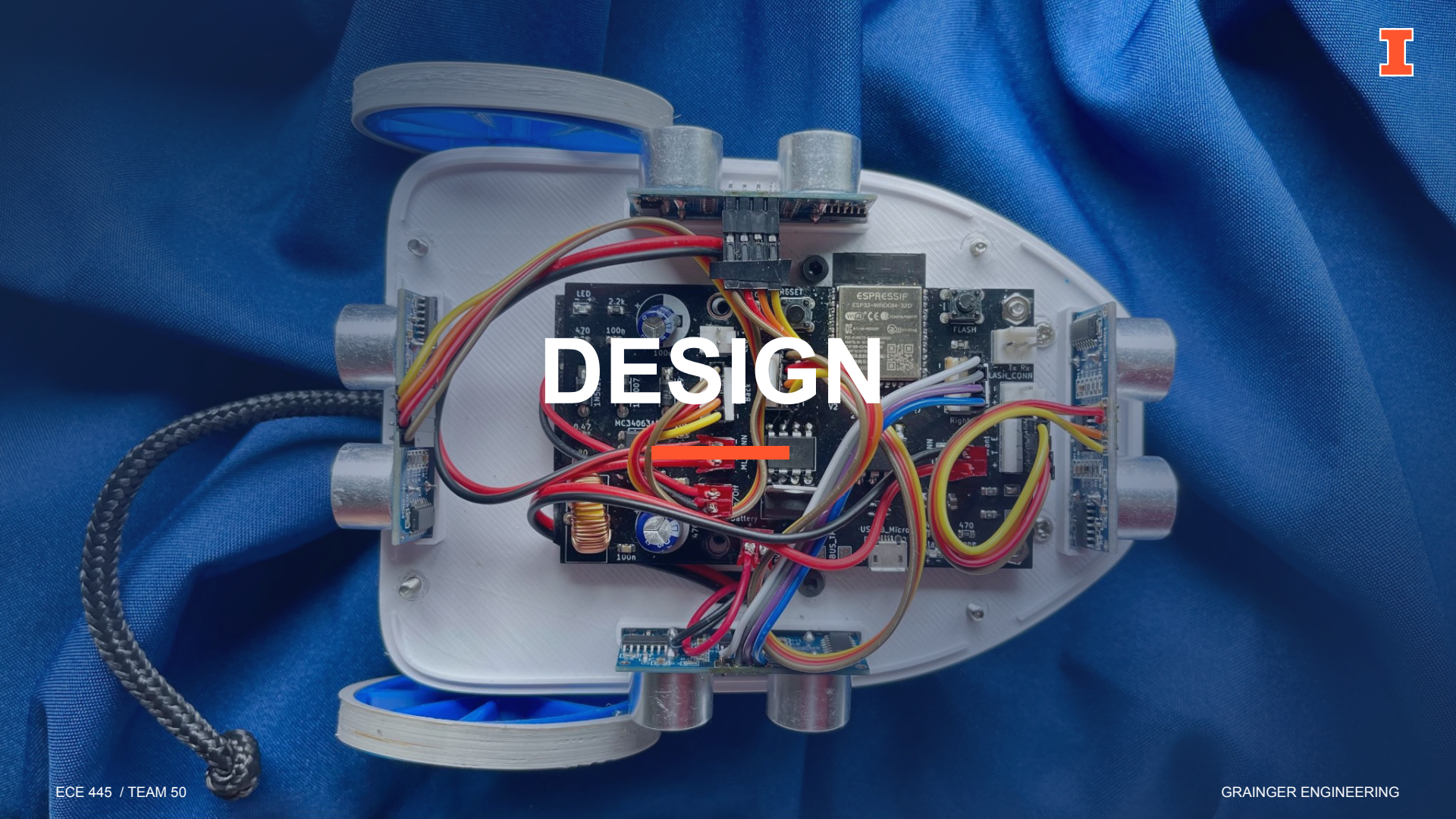
Video speed 2X



Our Design

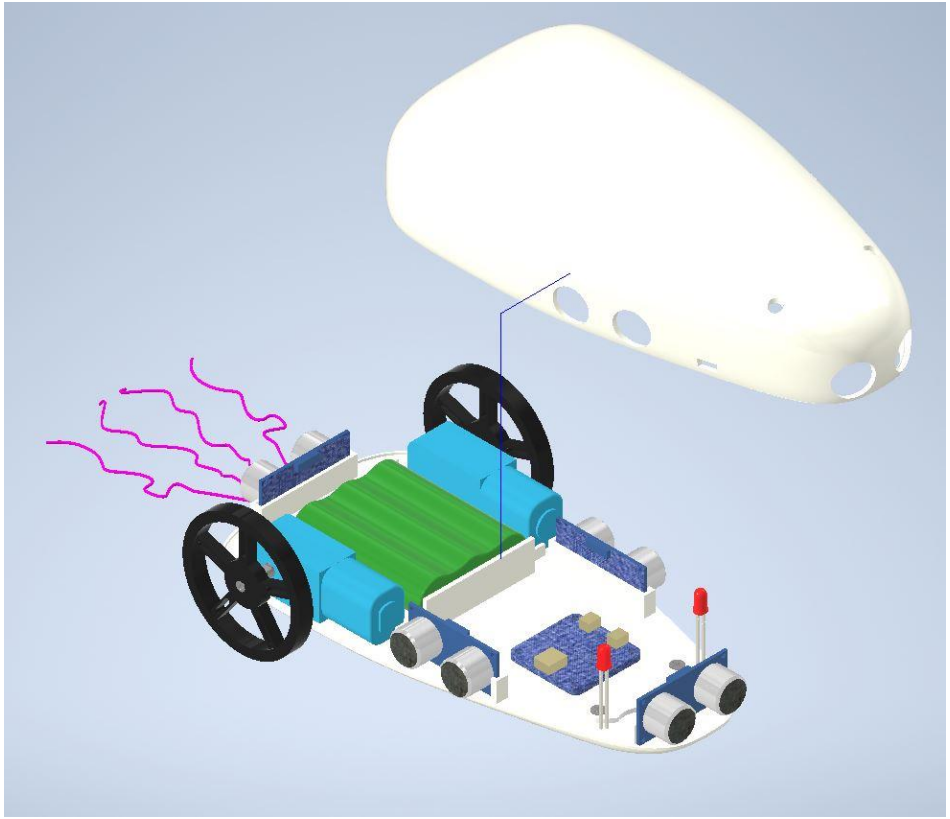
- A On/Off switch
- Long lasting battery life
- A micro-USB port for recharging
- A software application
- Two Operating Modes:
    1. Auto Driving
    2. Remote Control



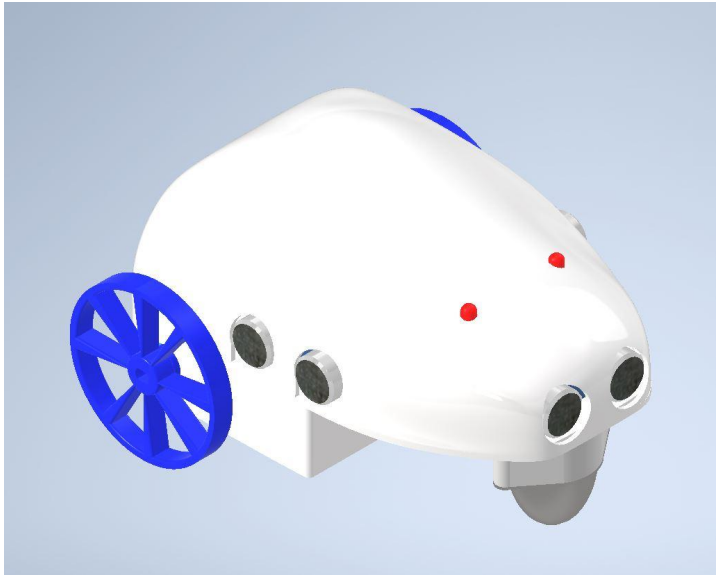

DESIGN

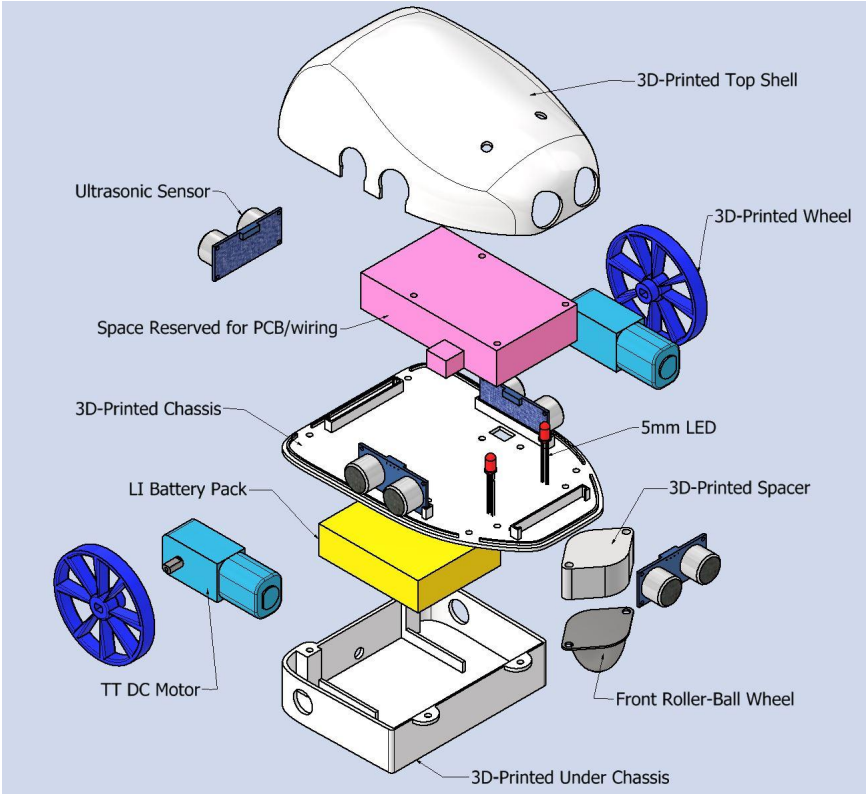
Package Design

Original Package Design

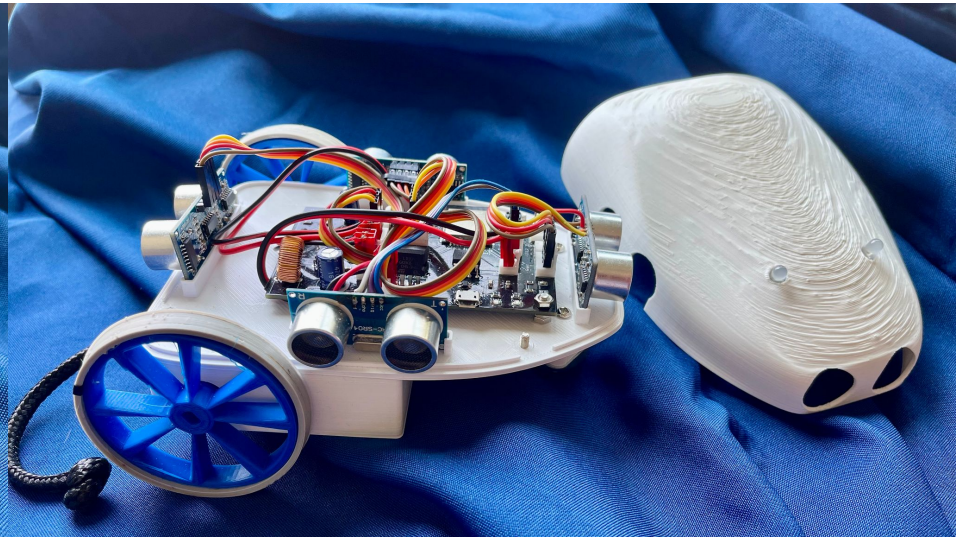


Current Package Design

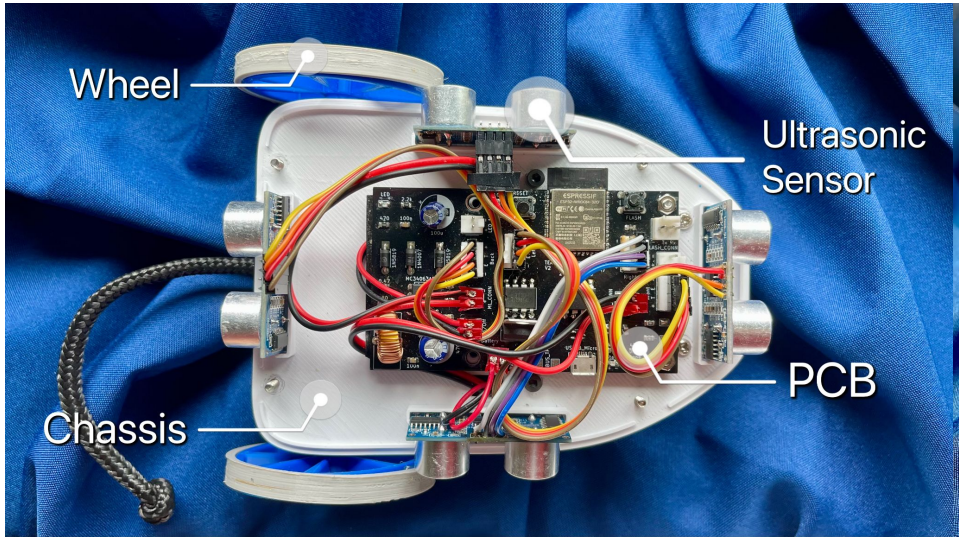


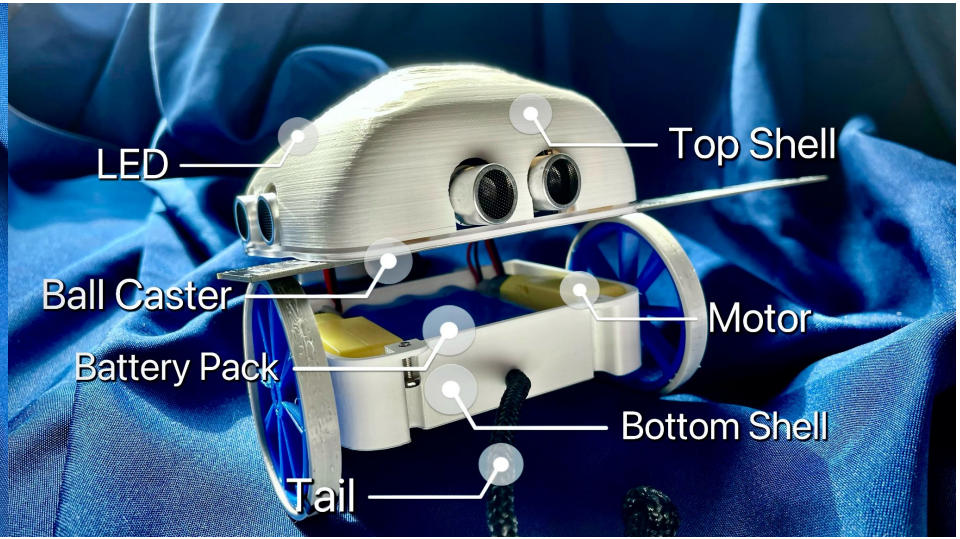


Current Package Design

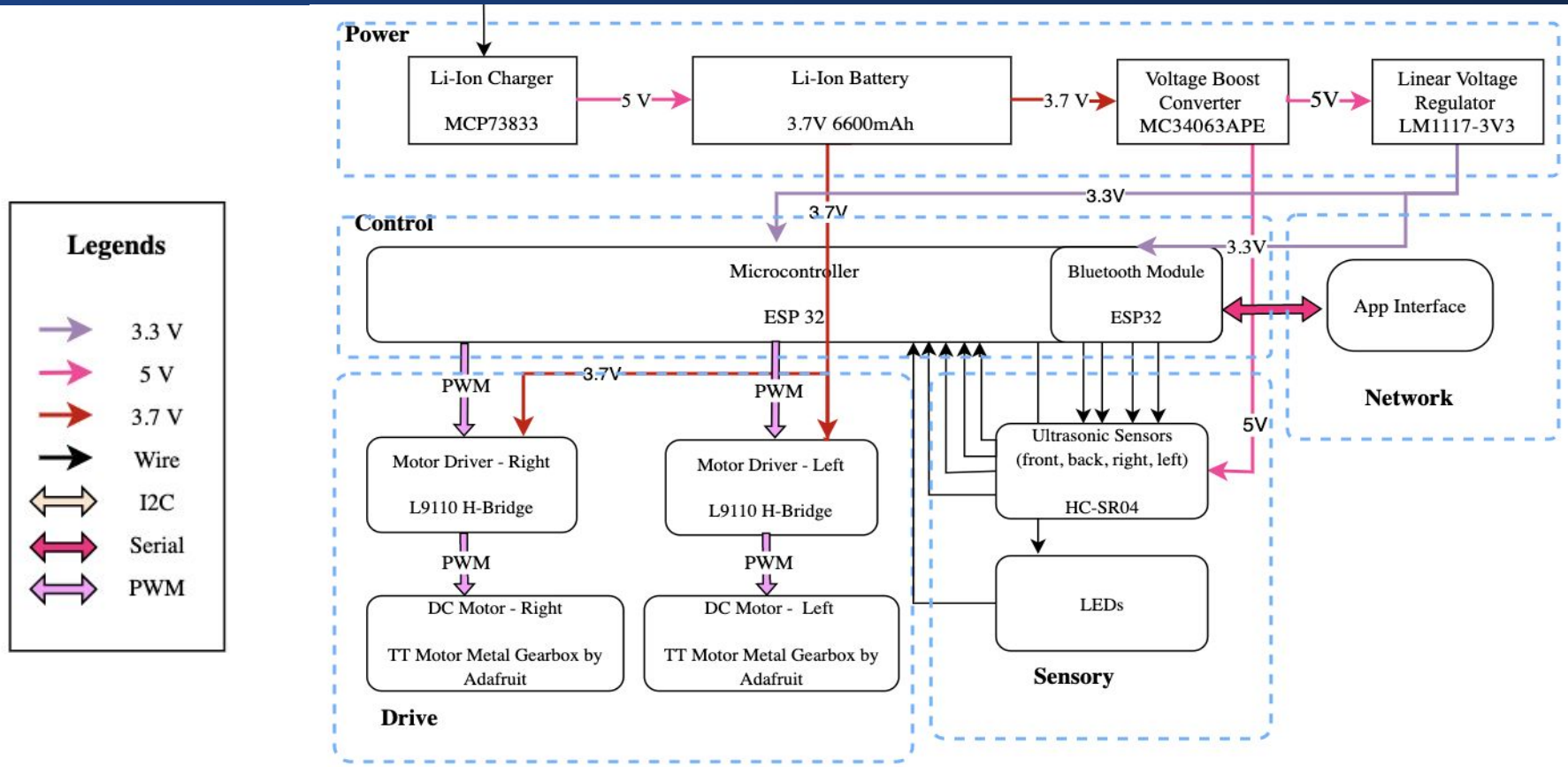


Current Package Design





Block Diagram



Design - Power Management Subsystem

Design - Power Management Subsystem

Requirements	Verified
1. Provide a nice clean 3.3V and 5V output voltages with 5% regulation	1. No
2. Able to recharge the battery from Computer, Wall USB adaptor, or power bank	2. Yes
3. Able to power the Fun-E-Mouse for at least 30 minutes of continuous running	3. Yes

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 convertor DC-DC circuit Calculation

Target Values

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

Ct = 470 pF

Lmin = 100uH

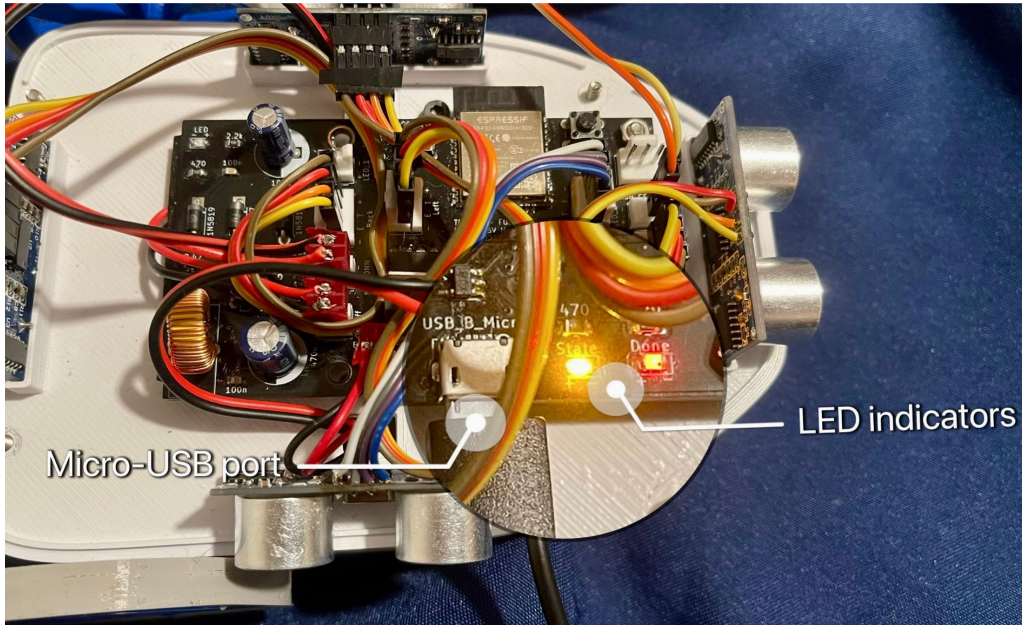
Rsc = 0.25 Ohm R = 180 Ohm

R1 = 2.2k Ohm R2 = 10K Ohm

CALCULATION	STEP UP
t_{on}/t_{off}	$\frac{V_{out} + V_{F-Vin(min)}}{V_{in(min)} - V_{sat}}$
$(t_{on} + t_{off})$	$\frac{1}{f}$
t_{off}	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
t_{on}	$(t_{on} + t_{off}) - t_{off}$
C_T	$4 \times 10^{-5} t_{on}$
$I_{pk(switch)}$	$2I_{out(max)}\left(\frac{t_{on}}{t_{off}} + 1\right)$
R_{SC}	$\frac{0.3}{I_{pk(switch)}}$
$L_{(min)}$	$\left(\frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}}\right) t_{on(max)}$
C_O	$9\frac{I_{out} t_{on}}{V_{ripple(pp)}}$
V_{out}	$1.25\left(1 + \frac{R2}{R1}\right)$ ee Figure 10

Datasheet of Boost Convertor MC3x063A

Design - Power Management Subsystem



Performance

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

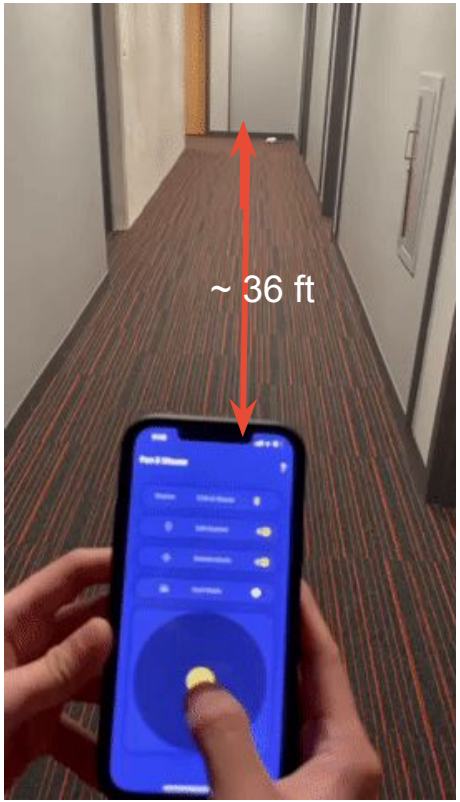
Battery Status Indicators

- Fully charge: red & orange LED
- Battery charging: orange LED

Design - Control Subsystem

Design - Control Subsystem

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



Design - Drive Subsystem

Design - Drive Subsystem

Requirements	Verified
1. Able to move forward and backward at speed of 1m/s	1. No. 0.333 m/sec
2. Able to turn a 90-degree right turn or a 90-degree left turn	2. Yes
3. Able to stop at a forwarding speed of 1m/s	3. No

Design - Drive Subsystem

Actual Speed

$$\frac{2\ meters}{6\ seconds} = \frac{1\ meters}{3\ seconds} < \frac{1\ meters}{1\ seconds}$$

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

Theoretical Top Speed

$$(6.5\ cm \cdot \pi) \cdot \frac{250\ revolutions}{1\ minute} \cdot \frac{1\ mintue}{60\ seconds} = \frac{0.85\ m}{seconds}$$

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

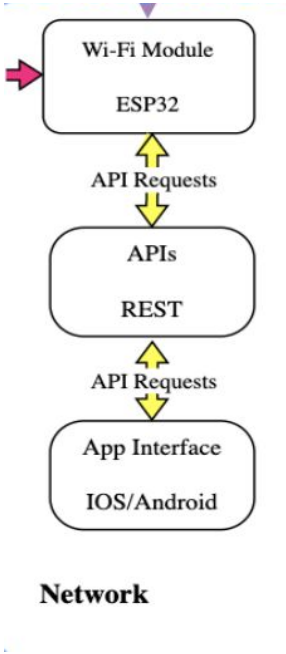
Design - Network Subsystem

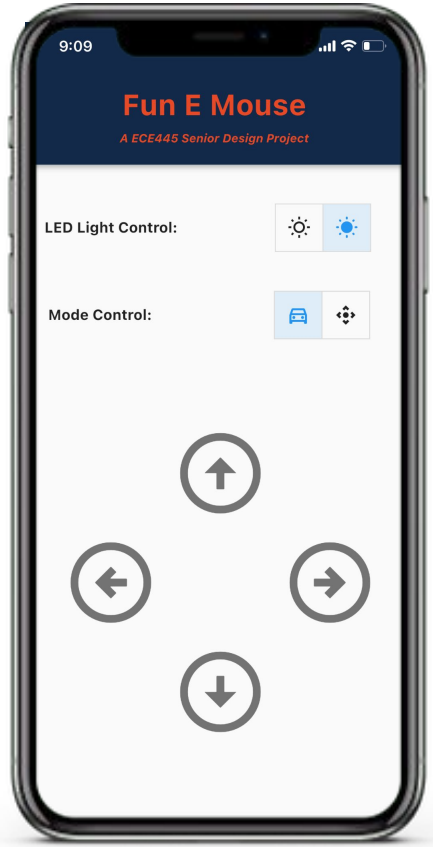
Design - Network Subsystem

Requirements	Verified
1. Able to scan and connect with any 2.4GHz Bluetooth(Original was Wi-Fi)	1. Yes
2. Able to control the mouse to move left, right, forward, or backward in 1 sec	2. Yes
3. Able to configure the 2 different modes (AUTO, REMOTE)	3. Yes

Changed WiFi to Bluetooth

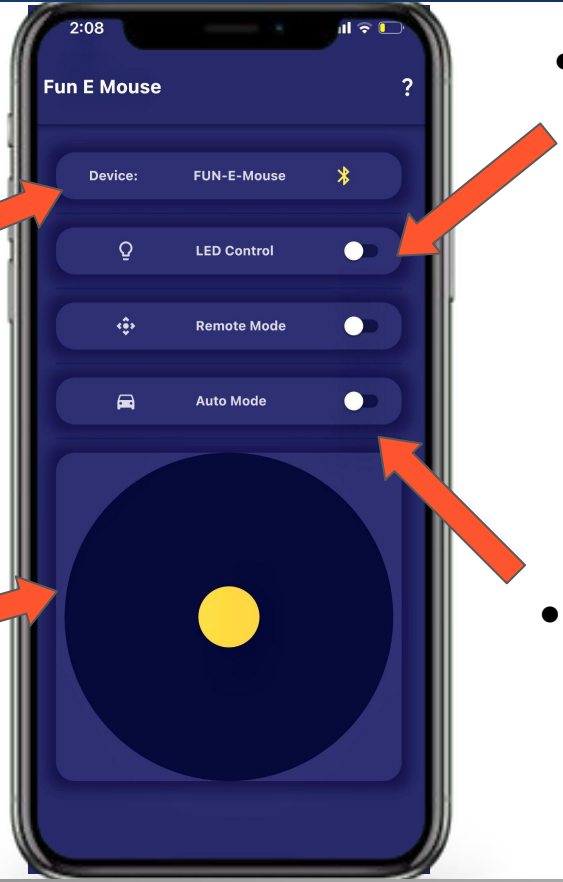
1. Control commands were bounced from App to server, then server to ESP32
2. High Latency occurs App to server, and server to ESP32
3. Not able to connect to WiFi/HotSpot for demo
4. No ideal for real-time control device





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

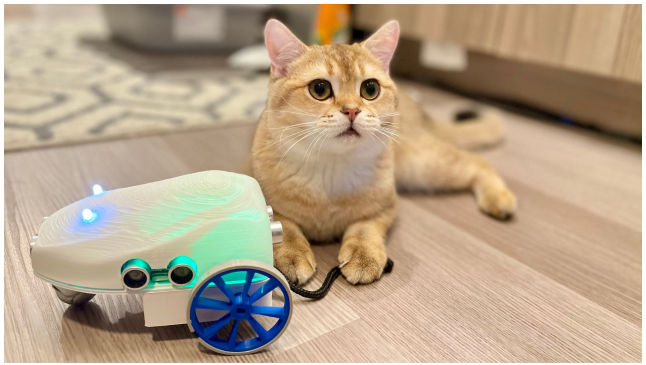
Automatic Mode

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

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)



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'Brownout detector was triggered'
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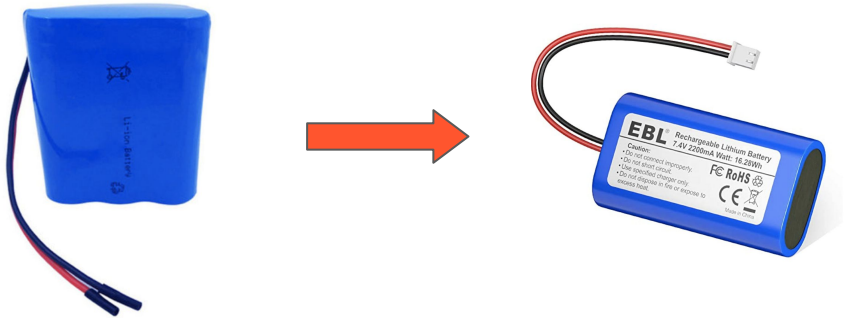
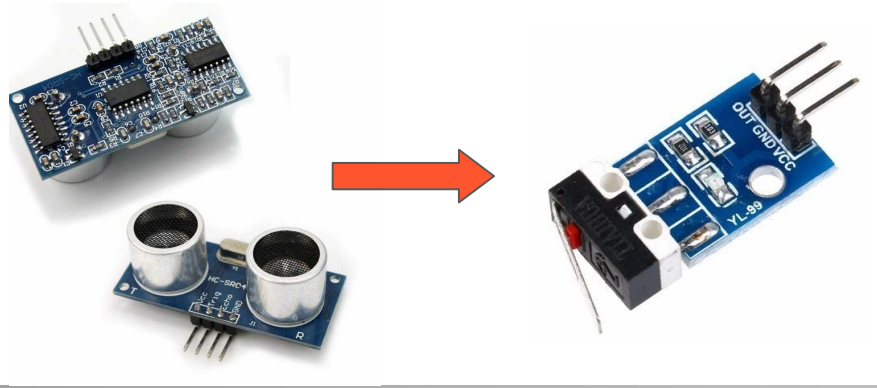
What would we do differently?

- 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



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

The Grainger College of Engineering

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