

Team B3: Mobile Steering Wheel

18-500 S23 Project Proposal

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Use case

- Gaming controller for **racing games**
- Buttons, triggers and joysticks like normal controllers
- With added **tilt sensing function** for steering input
- Display in-game vehicle info with **onboard screen**
- **Portable** (lightweight and wireless, with rechargeable battery)

Use case

Problem

- Current racing gaming controllers are
 - bulky and expensive.
- Even entry level racing controllers
 - require space to set up.
- Cheaper and portable controllers are
 - not tailored towards racing games.
- Generic portable controllers
 - does not provide enough immersion.

ECE Areas Covered

- Software Systems
- Signal & Systems
- Digital Circuits & Embedded Systems



Use case requirements

- 15 Buttons, 1 Joystick, 2 Analog Triggers
 - XBOX & PS5 Controller: 14 buttons, 2 joysticks, 2 analog triggers (pics)
 - Fanatec ClubSport Universal Hub V2: 15 buttons (pics)
- Weighs less than 400g
 - XBOX & PS5 Controller: Approximately 280g
 - XBOX Elite Controller: 345g



Use case requirements

- Analog Triggers have **10-12** bit resolution
 - Existing DIY controller examples lie in this range
- Has **360-degree** sensing capabilities
 - Thrustmaster Ferrari 458 Spider Racing Wheel:
 - 240-degree sensing (pics)
- **8-hour** battery life
 - PS5 DualSense Controller: 5-8 hours
 - Switch Pro Controller: 40 hours



Use case requirements

- 3.5 inch LCD screen at the center, just like race cars (pics)
- Size of controller similar to Formula One racing car steering wheels



Use case requirements

- Input delay less than **20 ms**
 - Xbox One Controller (7.6 ms), Switch Pro Controller Bluetooth (11.7 ms)
- Gyroscope with desired sampling frequency of **200HZ** and error of **$\pm 0.5^\circ$**
- Data rate less than **125kB/s**
 - Bluetooth 5.0 has a maximum data rate of 250kB/s (2Mbps)

Technical Challenges

- Gyroscope sensors
 - Too much **random movement** (user not having a steady hand) will make the car hard to control
- Size of data transmitted per second
 - **Payload size** should be less than the maximum size defined by the communication protocol
 - Extra data required to display game information on controller screen
- High latency
 - The game will be not playable if user needs to **wait a second** to observe effects on the game
- Battery life
 - Controller display screen can **consume extra power**

Solution Approach

- Gyroscope sensors
 - Purchase **higher quality** sensors with specifications that meet our requirements
 - Calibrate our program to make sure angle readings from gyroscope matches desired steering angle
- Size of data transmitted per second
 - Look into the game API and calculate the **minimum amount of data** needs to be transferred
 - **Change communication protocol** if Bluetooth cannot satisfy the requirements
- High latency
 - Increase the data **sampling rate** without overclocking the controller
- Battery life
 - Increase **battery size** without surpassing weight requirements
 - Use **less power consuming** screen to display data

Testing Verification & Metrics

Metric	Testing Method	Goal
Weight	Using electronic scale	< 400g
Battery Life	Connect the fully charged controller to the game. Measure the time it runs out of battery as the controller continuously communicates with the game.	8 hours
Input Latency	Use a slow motion camera. Count number of frames it takes for the game to react after user presses a button. Latency = # of frames * 1000ms/fps	< 20 ms
Tilt Error	Tilt the controller to a specific angle. Then compare the angle to the readings from the controller program.	0.5 degrees
Data Rate	Write a program to calculate the total size of data transmitted by controller and received from game per second.	< 125 kB/s

Tasks & Division of Labor

- Xiao - Circuits & Hardware
 - Component wiring; PCB design & verification; Hardware System testing
- Qiaoan - Signal Processing & 3D printing
 - Controller design; Gyroscope and button tuning
- Yuxuan - Communication Protocol & Software System
 - Wireless protocol; Controller system; Game API communication

Schedule

Mobile Steering Wheel

Qiaoan Shen
Xiao jin
Yuxuan Zhu

Project Start: Sun, 1/29/2023
 Display Week: 1

TASK	ASSIGNED TO	PROGRESS	Jan 30, 2023							Feb 6, 2023							Feb 13, 2023							Feb 20, 2023							Feb 27, 2023							Mar 6, 2023							Mar 13, 2023							Mar 20, 2023							Mar 27, 2023							Apr 3, 2023							Apr 10, 2023							Apr 17, 2023							Apr 24, 2023							May 1, 2023																																																							
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Project Planning and Presentation																																																																																																																																																					
Project Proposal	All	100%	█																																																																																																																																																		
Design Presentation Slides	All	0%																																																																							█																																																																												
Interim Demo	All	0%																																																																							█																																																																												
Final Presentation	All	0%																																																																							█																																																																												
Hardware Wiring and PCB Design																																																																																																																																																					
Research and purchase Buttons, Joysticks, Screen, etc.	X	0%																																																																							█																																																																												
Connect components and test basic controller function	X	0%																																																																							█																																																																												
Design and manufacture custom PCB(s)	X	0%																																																																							█																																																																												
PCB testing, Hardware operation testing	X	0%																																																																							█																																																																												
Signal Processing and Controller Design																																																																																																																																																					
Build prototype of the controller and revise design draft	Q	0%																																																																							█																																																																												
Research and purchase gyroscope	Q	0%																																																																							█																																																																												
Utilize control tools to tune throttle and break pedal	Q	0%																																																																							█																																																																												
Utilize control tools to tune gyroscope and remove noise	Q	0%																																																																							█																																																																												
Communication Protocol and Software Systems																																																																																																																																																					
Research game API & communication protocol	Y	0%																																																																							█																																																																												
Research reading inputs from gyroscopes	Y	0%																																																																							█																																																																												
Design control program with detailed diagrams	Y	0%																																																																							█																																																																												
Implement game communication program	Y	0%																																																																							█																																																																												
Test game communication program	Y	0%																																																																							█																																																																												
Implement gyroscope interaction section	Y	0%																																																																							█																																																																												
Test gyroscope reading program with a gyroscope	Y	0%																																																																							█																																																																												
Integration																																																																																																																																																					
Integrate electronics with mechanical parts and software	All	0%																																																																							█																																																																												
Test sensors, controls, and software can function properly	All	0%																																																																							█																																																																												
Test the overall system with game	All	0%																																																																							█																																																																												

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Conclusion

- Controller for racing simulators
- Less weight and smaller size
- Cheaper than current solutions
- Low latency wireless connection