Mario Kar

Team A6: **Caitlyn Fong**, Enrique Gomez, Nicolas Keck

9/15/2025

Why are we still driving RC cars with joysticks, when our hands are the most intuitive controllers?

Traditional Video Game / RC Car	Our Gesture-Controlled Kart
• Controlling requires joysticks, buttons or a remote	• Natural **hand-gestures** with an IMU glove
• Visual only immersion on video games, limited car movement on RC	• Continuously **physical + tactile** immersion
• Game sounds + rumble (if any) :(	• **Real-world racing feedback**: glove buzz for crashes, turns, speed

Users: Spectacle User, ‘Gesture’ Driver

ECE areas: Software, Hardware, Signals & Systems, Circuits

Use-Case Requirements

- Fast response time: <50ms for fluid control
- Wearable controller: hands-free operation
- Lightweight: ~60-80g for comfort
- Haptic feedback: vibrations tied to kar movement
- Safety: reset input for idle state

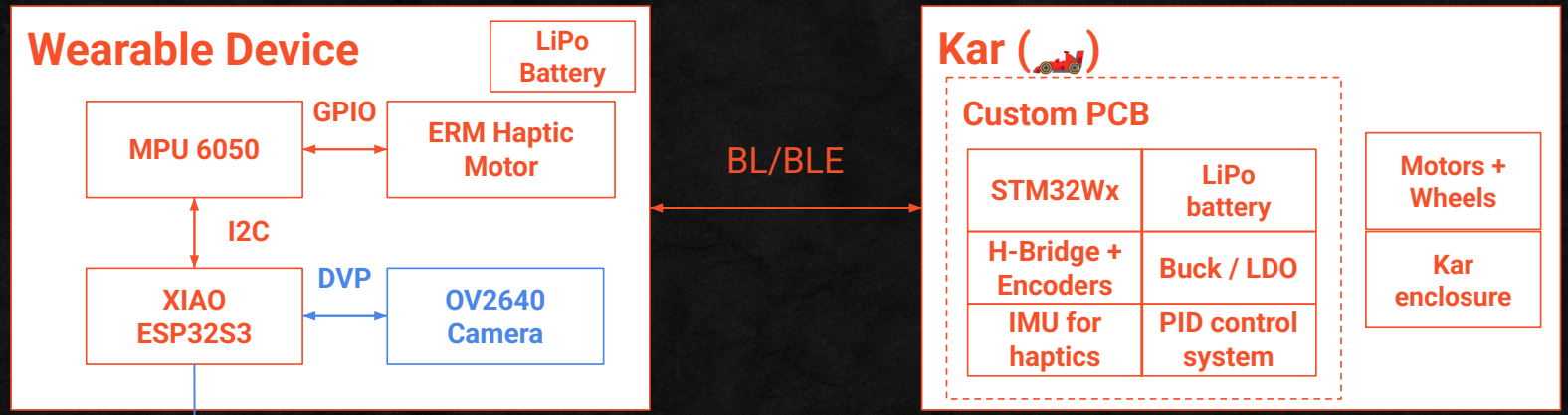
Key Technical Challenges

- Meeting the <50ms response time
- Optimal yet comfortable placement of hardware on user hand
- Light and small embedded controller system
- Realistic mapping of vehicle state to haptic output
- Safe and reliable transition into safe idle state

Challenge Mitigations

- Response time
  - Localize the critical path
  - Explore multiple communication protocols
- Utilize user testing to adjust hardware mounting / strap design
- Set weight limits on controller hardware
- Test filters / mapping functions before embedding
- Add watchdog timers for reliable recovery

Solution Approach



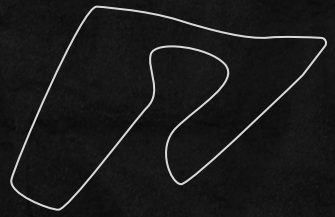
MVP
Stretch Goal

Wi-Fi (HTTP requests)

Testing, Verification, and Metrics

Validation Method	Verifiable Requirement
Analysis	• 50ms Kar response time
Inspection	• Controller wearability • Controller weight • Haptic feedback implementation
Demonstration	• 50ms Kar response under real conditions • Kar safety reset
Testing (UAT)	• Control scheme viability • Haptic feedback sensation

Division of Labor



Caitlyn	Enrique	Nicolas
FreeRTOS setup for STM32 and ESP32 (multithreaded tests)		Custom PCB schematic
IMU raw-value interpretation and filter experimentation	Bluetooth communication (STM32 ↔ESP32)	Custom PCB layout
Haptic controller	Coverage tests / CSV reports / graphs for safety analysis	PCB bringup
PID system for motor control and encoder state logic		Prototype hardware verification

Schedule

WBS NUMBER	TASK TITLE	TASK OWNER	PCT OF TASK COMPLETE	September					October				November				December
				08/31-09/06	09/07-09/13	09/14-09/20	09/21-09/27	09/28-10/04	10/05-10/11	10/12-10/18	10/19-10/25	10/26-11/01	11/02-11/08	11/09-11/15	11/16-11/22	11/23-11/29	11/30-12/06
1	**Logistics and Setup**																
	Website Setup	Everyone	100%														
	Slack	Everyone	100%														
	Proposal Presentation	Everyone	100%														
	Design Presentation	Everyone	0%														
	Interim Demo	Everyone	0%														
	Final Presentation	Everyone	0%														
	Poster PDF	Everyone	0%														
	Final Video	Everyone	0%														
2	**Project Planning**																
	Abstract	Everyone	100%														
	Order Materials	Everyone	10%														
	Finalize Design	Everyone	0%														
3	**Project Definition**																
	Custom PCB Schematic	Nick	0%														
	Custom PCB Layout	Nick	0%														
	Breadboarding Components	Nick	0%														
	FreeRTOS Setup Research	Caitlyn & Enrique	0%														
	FreeRTOS Setup for ESP32/STM32	Caitlyn & Enrique	0%														
	IMU raw-value interpretation	Caitlyn	0%														
	IMU FIR experimentation	Caitlyn	0%														
	IMU Kalman filter experimentation	Caitlyn	0%														
	Bluetooth research and prototyping	Enrique	0%														
	Bluetooth communication implementation	Enrique	0%														
	Haptic controller	Caitlyn	0%														
	PCB Bringup	Nick	0%														
	PCB Design Fixes	Nick	0%														
	PID system for motor control	Caitlyn & Enrique	0%														
	Final PCB Bringup	Nick	0%														
	Final Software Fixes	Enrique	0%														
	Construct Track (Slack)	Caitlyn & Nick	0%														
	Integrated Camera (Slack)	Enrique	0%														

Questions & Future Work

MVP

- Meaningful Sensor Data
- Communication between controller / kart
- Haptic Feedback

Future Work

- Drivable Track
- Integrated Camera

Q/A: Latency Stack

User Input / Sensor Sampling — *1-10ms*

Controller MCU — *1-2ms*

Bluetooth Transfer

< 30ms

Bluetooth Receive

Kar MCU

<10ms

Motor driver / actuators

Q/A: Algorithms

Filters we are considering:

- FIR - Very simple to implement but potentially limited performance
- Kalman - Difficult to implement but better performance
- Bandpass - Potentially good performance but cutoff frequencies difficult to determine