CornellEngineering
Electrical and Computer Engineering

Hacking a Power Wheelchair

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Remote Control of a Power Wheelchair

This project reverse-engineers the internal communication system between the joystick and the motors of a power wheelchair to enable autonomous control. By decoding the data bus, a microcontroller-based device is developed to issue independent commands. This approach opens up new possibilities for creative interactions, such as summoning the wheelchair with a sound.

The Hacking Process

1. Disassemble the Joystick

Begin by carefully disassembling the joystick to access the internal components and wiring. Identify which wires correspond to the transmission of joystick signals.

2. Characterize the Joystick Signal

Using an oscilloscope, test the solder pads on the circuit board to identify which pins are carrying signals for communication between the joystick and the wheelchair.

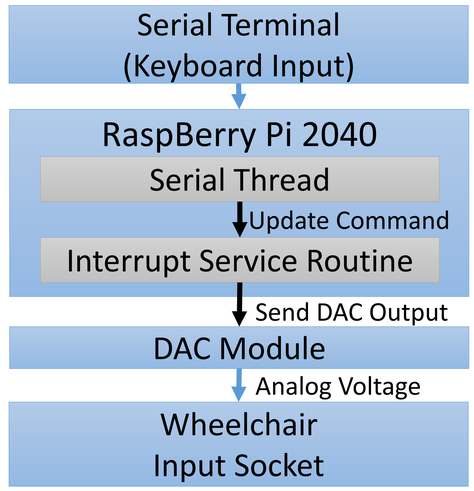
3. Identify the Pins Corresponding to the Socket

Using a multimeter, trace the wiring to match the correct pins to their respective sockets, ensuring proper identification for further signal manipulation.

- Pin 1: Ground
- Pin 2: Ground
- Pin 3: Forward/Backward(1V/4V)
- Pin 4: Right/Left(1V/4V)
- Pin 5: Right/Left(1V/4V)
- Pin 6: Forward/Backward(1V/4V)
- Pin 7: Ground
- Pin 8: Power (5V)

Emulating the Joystick

Replacing the joystick requires emulating the analog voltage signals it generates. I used an RP2040 microcontroller paired with an external DAC, I recreated these voltage levels to mimic the joystick's output. I also implemented a serial input interface, allowing users to control the wheelchair directly via keyboard commands. This setup enables the microcontroller to simulate user input and send precise control signals to the wheelchair.

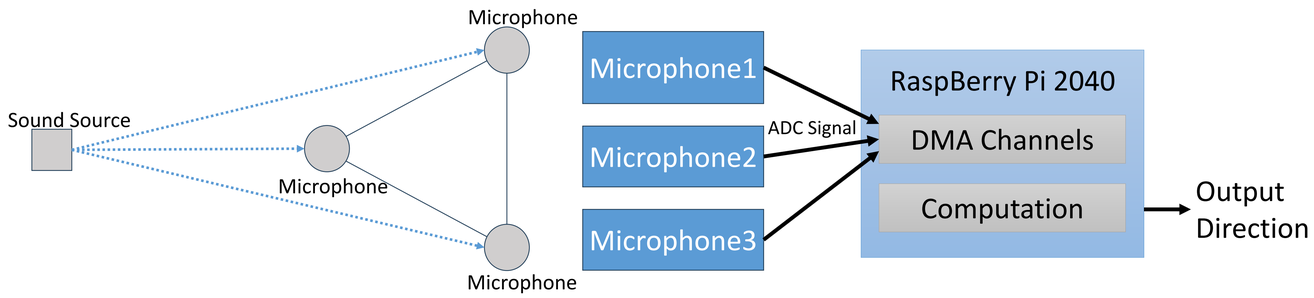


Matching the Signal, Missing the Mark

I first used an oscilloscope to confirm that my signals matched the original joystick. Although the waveforms appeared correct, testing on the wheelchair resulted in a "joystick error," indicating that the system did not accept the signals. However, with the signal data and test reports in hand, we are in a good position to reach out to the manufacturer and see if they can provide more technical details.

Toward Sound-Based Wheelchair Control

To enable remote summoning of the wheelchair, I implemented a sound localization system using three microphones. ADC values are captured through DMA channels for efficient, continuous sampling. By computing the cross-correlation between microphone inputs, the system estimates the direction of the sound source.



References & Acknowledgments

Special thanks to **Hunter Adams** for his guidance and mentorship throughout this project.
Hardware access and support provided by the MAE Motion Capture Lab.
Technical documentation and reference materials:

- RP2040 Datasheet: https://datasheets.raspberrypi.com/rp2040/rp2040-datasheet.pdf
- MCP4822 DAC Datasheet: https://ww1.microchip.com/downloads/aemDocuments/documents/OTH/ProductDocuments/DataSheets/20002249B.pdf