

Project Oliver GT

Design process of a custom controller for Oliver, who faces challenges playing Gran Turismo due to force and fatigue issues

Designers: Jack Burnett, Paria Shariati, Maria Schweiger, Katie Keillor

ASSIST HEIDI Summer School

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Estimated cost: 19€

When playing Gran Turismo, Oliver has been facing several problems. With the help of the new, custom-made controller, he is not only able to play Gran Turismo on a PlayStation without any major issues, but also any other game on any other device.

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Design Documentation

For full design documentation, see the Miro board: https://miro.com/app/board/uXjVlgNbEBY=

Challenges and solutions

Trigger Redesign

Challenge: Due to muscle fatigue, holding the trigger buttons (L2 and R2) on a traditional PS4 controller caused discomfort for Oliver during sessions of Gran Turismo; this limited Oliver's playtime and discouraged him from playing the game.

Solution: To solve this issue, the buttons were moved onto a 2D plane, alongside the usual buttons, allowing Oliver to have a hand placement more natural to his form; however, this would not solve the fatigue issue on its own, so an additional button was added to the controller that enabled for a button to be held/triggered in rapid succession as a toggle, this mitigated the need to hold buttons for extended periods..

Process: With the help of an unreleased experimental software for Android tablets, Oliver was able to design a button layout that fit his needs. This design was then moved to a low-fidelity paper-based prototype for further testing, before multiple iterations of a high-fidelity 3D-printed prototype were developed. Each iteration was tested with Oliver during the summer school, enabling fine-tuned adjustments to best meet his needs.

Joystick Redesign

Challenge: Due to Oliver's muscle fatigue, alongside his natural hand form, the joysticks of the traditional PS4 controller were too large and required excessive force; this problem also affected pressing the joystick buttons (L3 and R3), and furthered the muscle fatigue experienced by the trigger issue..

Solution: To resolve this issue, flat joysticks with minimal angular movement and lower force requirements were explored, with joysticks from PSP devices being selected; Touchpads for analogue movement were also identified, but were not tested due to sourcing issues.

Process: We ran a Wizard of Oz test with Oliver to 'test' potential joysticks, arriving at the decision for PSP joysticks, which allowed for low-force utilisation for aiming and movement.

Controller Shape Redesign

Challenge: The 'ergonomic' design of a traditional PS4 controller, which is built around able-bodied individuals, caused uncomfortable hand placement for Oliver; this issue was perpetuated through an inability to press all necessary buttons without excessive movement.

Solution: We found that Kailh Box V2 White enabled the suited force and tactility for Oliver, with the force being a physical requirement and tactility a personal preference, as these switches are commonly used in keyboard and controller designs, they should be suitable for 100 million keystrokes, and are easily sourced for simple replacement. Oliver preferred a button diameter of 12mm for common gameplay buttons, and a diameter of 8mm for utility buttons (such as select and share). The solution could have been improved with hot-swap switches, but these could not be sourced in time for the final product.

Process: We used Keychron's mechanical switch tester and low-profile switch testers to run through a quantitative testing process with Oliver; this testing process involved Oliver testing every switch and ranking them out of 5, based on force and tactility. From testing, we found that Oliver's preferences were an actuation force of 45 grams (+- 5 grams) and a 'clicky' haptic feedback. To test the optimal button diameters, we 3D printed a range of buttons from 6mm to 20mm in diameter, with steps of 2mm; Oliver tested each button on his preferred switch.

Weight Mitigation

Challenge: The weight of a traditional PS4 controller causes muscle fatigue for Oliver due to its weight; this issue is furthered by the lack of a suitable placement on his wheelchair for the controller to rest on. The material and weight of a traditional PS4 controller also cause the controller to consistently slip, requiring further effort from Oliver to prevent it from falling off his wheelchair while he's gaming.

Solution: To mitigate weight from being a factor in usage, along with solving the placement issue, a 2D controller that is modelled around his wheelchair's dimensions and parts was developed; the shape prevents accidental usage of his wheelchair buttons and is mapped to sit flush on his wheelchair, with rubber pads to prevent slip.

Process: We designed a simple rectangular controller for Oliver, which was tested to identify the conflicts between the flat 2D plane and his wheelchair; based on these conflicts, we designed multiple iterations of controllers using a 'Crazy 8' design session, and iterated on the most suitable designs. We asked for Oliver's input on the designs before creating variations that resolve the conflicts, and allowed Oliver to choose his favourite design to be used as the controller base. We explored potential ways to prevent slips, such as hinges, clips, and rubber pads, and used Oliver's insights to understand which would be the least intrusive.

Solution Summary

The project tackled several accessibility barriers Oliver faced with traditional PS4 controllers. Muscle fatigue from holding trigger buttons was addressed by moving them to a 2D surface and implementing a toggle function that simulates holding without continuous pressure. The standard joysticks, which required excessive force, were replaced with low-resistance PSP-style alternatives, enabling easier and more precise control. To improve comfort and access, mechanical switches were selected based on Oliver's preferred actuation force and tactile feedback, and button sizes were customised to suit different gameplay functions. Additionally, a lightweight, flat controller was designed to sit securely on Oliver's wheelchair, with anti-slip pads preventing unwanted movement.

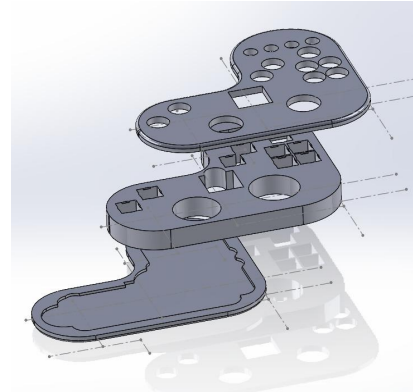
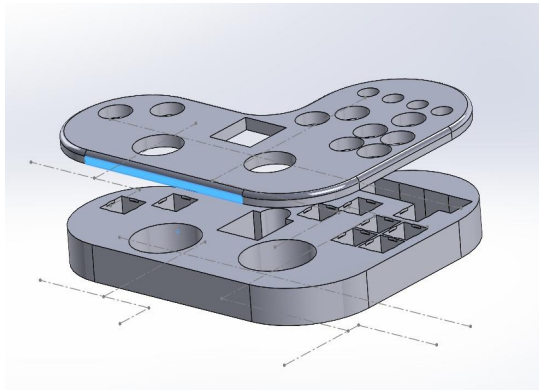
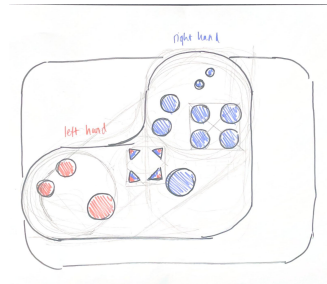
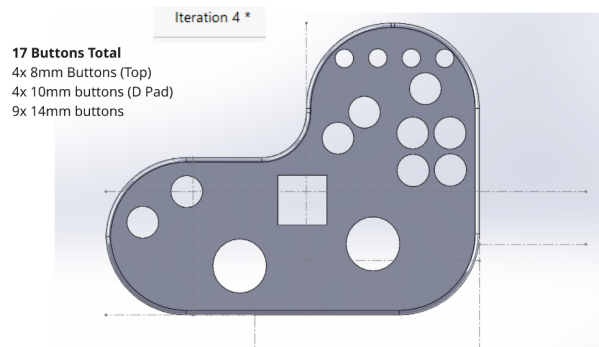
These solutions significantly improved Oliver's ability to engage with games. He can now comfortably play Gran Turismo and more demanding titles like Call of Duty, which require fast, accurate joystick inputs and sustained interaction. The custom layout supports his natural hand posture, reduces muscle strain, and allows for longer, more enjoyable gaming sessions without discomfort or fatigue.

Beyond personal usability, the controller was designed to be cross-platform compatible, making it suitable for various gaming systems. It is built entirely from readily available and replaceable parts, ensuring affordability, ease of maintenance, and future adaptability. The final product is not only a tailored solution for Oliver but also a model for accessible controller design more broadly.

Solution Issues

This solution supports only a single analog stick, either left or right, but not both simultaneously. However, the design files accommodate the use of either stick. A REV2 version is currently in development, featuring a Waveshare RP2040-Zero and upgraded analog stick components, which will enable support for dual analog sticks.

Design Process Sketches



3	4	1	3	4	1	1
2	2	3	2	4	1	1
1	2	5	2	1	1	3
5*	4	2	2	2	1	4
2	4	5	2	2	4	1



Oliver rated button force on a scale of 1–5 (5 = easiest, 1 = hardest).

Technical Documentation

How can it be reproduced by somebody else?

Design Files

CAD Files

The enclosure and housing were created using SolidWorks 2023, with the buttons generated using CadQuery; the IPython notebook, STEP, and design files can be found here:

<https://drive.google.com/drive/folders/1nmmYu7QtQSakIkiweFlzNvnl2qlXSoC7?usp=sharing>

OrcaSlicer Premade Files

Orcaslicer print files for the Bambu Labs X1 Carbon can be found here:

<https://drive.google.com/drive/folders/1yO6pyLCsViJNrmURDF6kvVg0Yy5FFK6?usp=sharing>

Tool (and Material) Requirements

Soldering Iron and Solder

A basic soldering iron and lead-free solder were used to connect the Kailh switches directly to the GPIO pins on the Raspberry Pi Pico. Precision is key, as the switches interface directly with the microcontroller for responsive input.

Recommended Tools:

- 15W–30W temperature-controlled soldering iron
- Fine-point tip for detailed work
- Flux core solder (0.6mm or thinner recommended for tight joints)

Potential Alternatives:

- Pre-crimped jumper wires with sockets (for prototyping or hot-swappable builds)
- Conductive adhesive (experimental, not recommended for long-term use)

Note: *Soldering requires moderate skill; we recommend practicing on a spare board or scrap components if you're unfamiliar with the technique.*

ABS/PLA (and 3D Printer)

We used a Bambu Labs X1 Carbon 3D printer to fabricate the controller's custom enclosure exclusively with ABS filament. ABS was chosen for its superior durability, heat resistance, and long-term wear performance, making it ideal for a controller shell subjected to regular handling and stress.

Recommended Tools:

- ABS (high strength, better thermal resistance than PLA)
- A 3D Printer with a 0.4 nozzle size

Estimated Print Weight: ~[INSERT GRAM ESTIMATE] grams

Recommended Print Settings:

- Nozzle size: 0.4 mm
- Layer height: 0.2 mm
- Infill: 20–30% (Grid or Gyroid for structural integrity)
- Enclosure: Rec
- Heated bed: 100–110°C
- Nozzle temp: 230–250°C

- Cooling: Minimal to none (to prevent warping)

Potential Filament Alternatives:

- PLA: Easier to print and widely available; however, it is more brittle and softens at lower temperatures (~60°C), making it less ideal for devices that experience prolonged contact with skin or pressure. Suitable for prototypes or low-stress applications.
- ASA: Similar to ABS but with improved UV resistance, useful for outdoor use
- PC (Polycarbonate): Even stronger than ABS, but more difficult to print and may be overkill for standard controller use
- PETG: Easier to print but offers less impact resistance and rigidity compared to ABS

Note: ABS requires good ventilation due to off-gassing during printing. The Bambu X1 Carbon's enclosed chamber and built-in filtration system help mitigate this.

Hardware Requirements

Raspberry Pi Pico

Link to Official Raspberry Pi Pico Website: <https://www.raspberrypi.com/products/raspberry-pi-pico/>

The Raspberry Pi Pico is a low-cost, high-performance microcontroller board based on the RP2040 chip. It offers dual-core processing, low-latency USB communication, and ample GPIO pins, making it ideal for responsive, custom controller designs. Its wide adoption and strong community support also make development and troubleshooting easier.

Potential RP2040 alternatives:

- Pimoroni Pico Lipo / Pico LiPo with SHIM: Adds onboard battery charging and power management, ideal for portable builds.
- Adafruit Feather RP2040: Includes built-in battery charging, STEMMA QT connector, and is breadboard-friendly for compact designs.
- Seeed Studio XIAO RP2040: Ultra-compact, great for space-constrained setups, though it offers fewer GPIO pins.
- SparkFun Pro Micro RP2040: A form factor similar to Arduino Pro Micro, helpful for projects requiring tight integration or backwards compatibility.

GP2040-CE Firmware

Link to firmware: <https://gp2040-ce.info/>

GP2040-CE is open-source firmware tailored for custom game controllers using the RP2040. It supports ultra-low latency input, cross-platform compatibility (PC, Switch, PS3, etc.), and extensive button mapping and customisation. It's also easy to update and configure via a web interface.

Potential Firmware alternatives:

- QMK Firmware: Best for custom keyboards, but limited support for analogue inputs or gamepad-style layouts.
- PicoFightingBoard: Simple to use for button-only setups, but lacks advanced features like analogue stick support.

Note: A custom configuration file is required to set up Oliver's unique control layout. This includes toggle functionality, button remapping, dead zones for joysticks, and accessibility-focused input behaviour. The configuration files can be found in the setup section.

Kailh Box V2 White Switches

Link to the Kailh Box V2 Switches: <https://www.kailh.net/products/kailh-box-v2-switch-set>

These mechanical switches provide a precise, clicky tactile response with a consistent actuation force of ~45g, matching Oliver's muscle capabilities and personal preference. They're highly durable (rated for up to 100 million presses) and easily replaceable.

Potential switch alternatives:

- Cherry MX Blue/Brown/Red: Widely available, but may not offer the preferred tactility or exact actuation force.
- Gateron Low-Profile Switches: Good for compact designs, but with a different feel and travel distance.
- Hot-swappable sockets (**RECOMMENDED**): Would enable easier switch swapping without soldering, but were unavailable during final development.

Note: We recommend purchasing a mechanical switch tester that has either Gateron or Kailh switches, to enable your controller to be tailored specifically for the final user.

PSP 1000 Joysticks

Link to Adafruit PSP 1000 Joysticks: <https://www.adafruit.com/product/444>

These joysticks are compact, lightweight, and require minimal force to operate—ideal for users with muscle fatigue or limited hand strength. They provide an analogue input suitable for precise movement and aiming.

Potential Joystick alternatives:

- Nintendo Switch Joy-Con Joysticks: Small and low-force but prone to stick drift over time.
- Alps RKJXV Series Thumbsticks: High-quality precision sticks, though bulkier and harder to mount in a compact design.
- Touchpads (capacitive or resistive): Explored as a no-force alternative, but couldn't be tested due to sourcing constraints and compatibility concerns.

Creation, Installation, and Setup

- Print the three parts of the controller (base, housing, and top) using either PLA or ABS
- Place the desired switches into the switch holes
- Solder each switch to a wire and then its respective GP2040-CE GPIO pin, using the Wiring guide (found here <https://gp2040-ce.info/controller-build/wiring/>)
- Upload the custom firmware for R2 hold macro if this is required (found here: <https://drive.google.com/file/d/1ii30jQySSUmB6w8BP9papuRcM15kAejb/view?usp=sharing>), or create a custom GP2040-CE configuration with the analog add-on enabled
- The controller is now ready for PC/Xbox 360/Switch usage; for PS4/5 and Xbox One/Series, you will have to find a method of authenticating the controller, either using an external device (such as a Mayflash X) or by uploading authentication files onto the GP2040-CE software.