A Better Input Device for PC Gamers

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Abstract

In competitive PC gaming, precision and fluidity of control are critical. Many players prefer using a mouse for camera and aim control due to its accuracy, but traditional keyboard controls such as WASD limit them to 8-directional movement, creating a gap in optimal gameplay experience. This project aims to design and prototype a left-hand controller that provides omnidirectional movement through a joystick while allowing players to retain precise mouse aiming. The controller features a thumb-operated joystick and 8 buttons (two for each finger excluding thumbs), enhancing both movement control and accessibility. By integrating joystick movement with mouse aiming, the prototype offers a solution that increases player fluidity and responsiveness in games in ways which are simply impossible with the traditional keyboard & mouse solution. The results demonstrate the potential for improved performance and comfort, making this controller an attractive alternative for PC gamers seeking both precision and enhanced movement control.

Keywords:

Omnidirectional Movement, Joystick Control, Mouse Aiming, PC Gaming Controller, Ergonomics in Gaming, Hybrid Input Devices, Gaming Precision

1 INTRODUCTION

In gaming, precision and control are critical for player performance, especially in first-person shooters (FPS) and action games. Players often use a mouse for accurate camera and aim control, as it offers superior precision compared to other input devices. However, the standard WASD keyboard layout restricts movement to eight directions, limiting fluidity and responsiveness, which is essential for high-performance gameplay.

Our project addresses the lack of omnidirectional movement in PC gaming without sacrificing the precision offered by a mouse. While game controllers with joysticks provide smooth, 360-degree movement, they don't match the mouse's accuracy for aiming, creating a gap in existing input systems. As a result, gamers must often compromise between fluid movement and precise aim.

The goal of this project is to design and prototype a left-hand controller that combines joystick-based movement with mouse aiming precision. The controller features a thumb-operated joystick for full-range movement and eight programmable buttons, enabling the player to control in-game actions with one hand while leaving the other free for mouse use. By improving both ergonomics and gameplay experience, this solution aims to enhance player performance without compromising comfort or control.

Ultimately, this design offers a more efficient and intuitive control scheme for PC gamers, reducing hand strain from the repetitive use of WASD keys. The result is a more natural, responsive method of movement that enhances the overall gaming experience.

2 BACKGROUND REVIEW

2.1 Scientific Research on Input Devices

In searching google scholar with keywords such as “PC Gaming Ergonomics”, “Controller vs Keyboard & Mouse”, “FPS Controls”, I found numerous relevant studies which gave insight into the key problems and solutions. Most of the studies which I discarded were ones which

focused on VR, or were comparing various controllers to each other.
The evolution of FPS game controllers [2], shows that current control schemes are often the result of compromises between usability and the constraints of general-purpose input devices like keyboards.

"FPS game control schemes evolved with no overall plan." "The present input system looks like a compromise between, on the one hand the simplicity of using all-purpose input devices and on the other, an acceptable level of usability. This is true in a very pragmatic sense. At least for the movement control the left hand takes high strain, the three middle fingers (index, middle. ring) constantly upon the WASD, while the little finger and the thumb move up and down in order to control Jump, Duck and other functions. To a lay observer the above movement control scheme looks terribly awkward."[2]

Another report emphasizes the significance of the controller for gameplay experience.
"There are instances where the configuration of the controller both constrains and enables how a game is played"[3].

Further research into the performance of various game controllers confirms that while joysticks offer superior movement control, they cannot match the precision of a mouse when it comes to aiming [1]. This trade-off has led to the development of hybrid input devices that seek to combine the best of both worlds, although these solutions often compromise in one area or the other.

2.2 Commercial Input Devices

Several commercial products have emerged in response to the need for more fluid movement in PC gaming. Devices like the Azeron Keypad [5] and Razer Tartarus V2 [6] have introduced innovative ways to combine joystick and button inputs for the left hand, while allowing the right hand to focus solely on mouse control. The Azeron Keypad, for example, offers customizable thumbsticks and an array of programmable buttons, making it a popular choice among gamers seeking more ergonomic control options. Similarly, the Razer Tartarus V2 integrates a thumb-operated joystick with mechanical buttons, providing players with the ability to move in any direction while maintaining precise control over in-game actions.

2.3 Limitations of Current Solutions

While devices like the Azeron and Razer keypads provide enhanced movement control, they do not fully solve the problem of balancing fluidity with precision. In a detailed three-year review of the Azeron Keypad on Reddit [7], user Davilmar notes that although some noted that the joystick helped them transition from controller to keyboard & mouse, the control stick seems to detract from the snappy nature of digital movement inputs. Other users discussed how the joystick feels superior for most FPS except a certain few which require more instantaneous movement. These reviews highlight both the strengths and limitations of existing devices, pointing to a need for continued innovation in this space.

3 RESULTS

3.1 Ideation

3.1.1 Task Analysis

To better understand the challenges faced by PC gamers using the traditional keyboard-and-mouse setup, we conducted a task analysis comparing the standard WASD movement scheme with the movement facilitated by our joystick-based controller prototype. In the current WASD setup, players are limited to eight directions of movement, resulting in jerky transitions between directions during gameplay. Additionally, the left hand is often strained by performing multiple simultaneous actions such as moving, sprinting, crouching, and interacting with the environment.

In contrast, our joystick-based controller provides smooth, omnidirectional movement, freeing up the player's left hand for more precise and intuitive control over in-game actions. The thumb-operated joystick allows the player to

move effortlessly in any direction, while the eight buttons (two for each finger) allow for actions such as jumping, crouching, and interacting with objects. This design aims to reduce the cognitive load and physical strain experienced by players using traditional WASD controls, offering a more ergonomic and efficient alternative.

3.1.1 Design Thinking Outcome

Our ideation process began with a brainstorming session focused on how to integrate joystick control into a traditional PC gaming setup without sacrificing the precision of mouse aiming.

We made a list of functions that would be used by a typical FPS (i.e. CS:GO), and how they could be substituted for 4 button rows of 2 plus a thumbstick. We decided to position the joystick under the thumb, allowing it to be operated naturally while leaving the other fingers free to control the buttons. The buttons are laid out so that each finger controls two buttons, ensuring that common in-game actions like jumping, crouching, and sprinting can be performed quickly and comfortably.

Movement direction AND strength controlled by the analog stick.	Primary Keys (Combat / Movement) ● Crouch (pinky) ● Jump (ring) ● Interact (middle) ● Reload (index)
Secondary Keys (Requires fingers to relocate) ● 1, 2, 3, 4 ○ Weapon swapping, etc.	Tertiary Keys (Out of combat) ● Escape/Menu ● Drop Weapon ● Tab Menu

Needs	**Technical Requirements**
Controller Stability	Some way to affix the device to a desk/surface. Alternatively, a heavier weight design.
Comfort in Use	Buttons are large enough that fingers can rest on all buttons at a time, regardless of hand size. The shell funnels the hand into the best position for use.
Physical feedback for buttons	Use mechanical key switches for tactile feedback.
Ease of use across games	Ability to interpret stick inputs as keyboard inputs (analog-to-digital conversion). Should read as an HID-compliant controller for compatibility with most games.
Directional Movement is Intuitive	Allow player calibration of the control stick, so "forward" feels natural to each player.
Plug and Play	Use standard controller layout by default (ABXY, L1, L2, R1, R2, L-Stick) and common keybinds.
Customization	Provide configuration for keybinds, and potentially presets for different game genres or specific titles.

3.2 Electronics Prototyping/System Architecture

Using the insights gained from our task analysis and ideation process, we created a prototype of the controller that features a thumb-operated joystick and eight buttons for the left hand. The prototype is driven by an Arduino Micro microcontroller, and features: eight push buttons, an analog stick, and two LEDs to signify power state, and keyboard/joystick mode, respectively. The electronics diagram features a slide switch to change between these digital and analog modes, however the physical prototype uses the

stick click button due to lack of parts at this point in time. In addition, the prototype originally utilized an Arduino UNO R4, but was swapped out in favour of the Micro's HID functionality, suitable for game input devices.

The Arduino code uses the *Keyboard*, *Joystick*, and *HID-Buttons* libraries to provide clean and accurate input processing from the attached components.

4 CONCLUSION

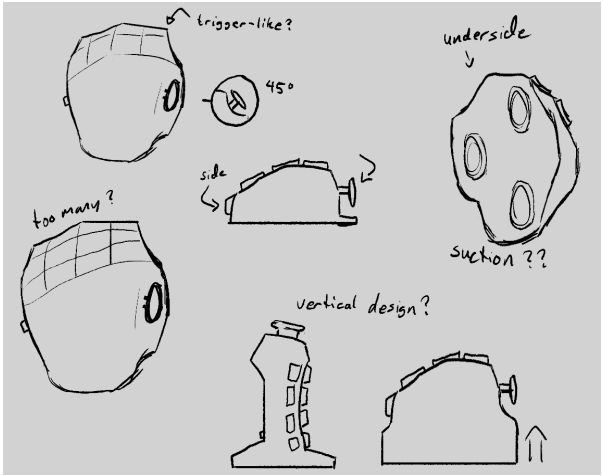
Our results demonstrated that the joystick-based controller prototype provides significantly improved movement fluidity and reduced hand strain compared to traditional WASD controls. Additionally, the layout of the buttons ensures that players can easily access critical in-game actions without sacrificing comfort or precision. Future work will involve testing the prototype to gather feedback and further refine the design.

Appendices

Progress Github Project

https://github.com/DylanMills/ControllerDesign
(All images in the appendices are also featured in the Github project)

Design Thinking

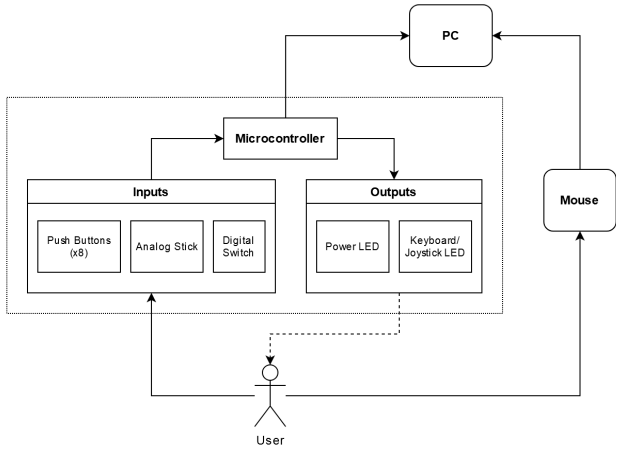


Ideation sketches and concepts.

Paper prototype model using clay, molded for an average hand shape.

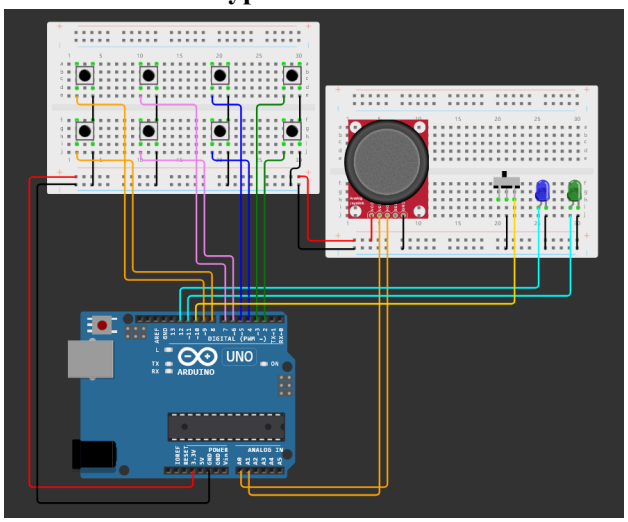
Model version of the paper prototype using RealityScan is featured in the Github project.

System Architecture

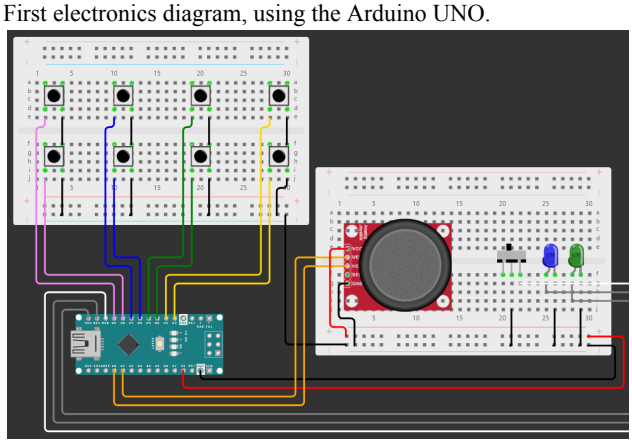


The primary components of the system architecture can be split into inputs and outputs, interacting through the user and microcontroller.

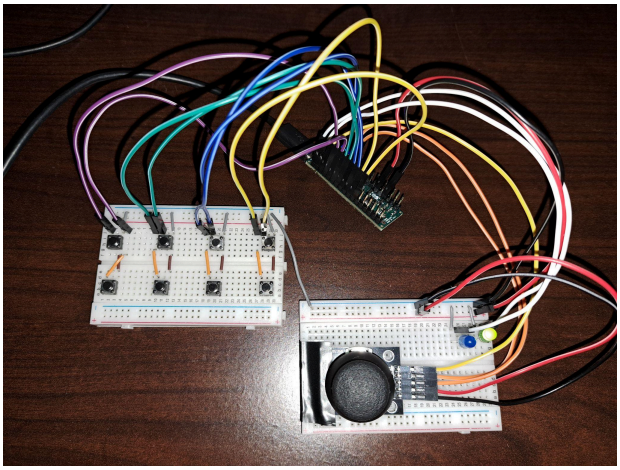
Electronics Prototype



First electronics diagram, using the Arduino UNO.



Second diagram, using an Arduino Nano (substituting for a Micro, which has the same arrangement of pins).



Physical electronics prototype using Arduino Micro.

Video demonstrations of the electronics prototype are featured in the Github project.

Contributions

Dylan Mills

- **Lead Designer:** Developed the initial concept for the input device.
- **Documentation**: Developed the abstract, background research, and technical overview for the report

Willow Forte

- **Prototyping**: Designed and implemented the electronic components of the controller, as well as the paper prototype.
- **Presentation**: Developed the presentation materials, including visual mockups and diagrams.

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