Gun Controller and Tracking System for PC Gaming

Alexander Phillips, *E*than Zafra

***Abstract*—A gun controller is a type of game hardware, usually used in On-rail Arcade Shooter games, that takes input relative to where the controller is pointed on the screen to determine where hits are in the game world. With arcades slowly losing popularity over the years, games with gun controllers, like Time Crisis, and House of the Dead have been dying out as the controllers required for them are too expensive for the average customer. We aim to create a cost-effective alternative to the current commercially available controllers. For our controller, we would conduct research on the current commercial methods, and various alternatives for transferring real-world position and rotation over to the game world, and determine which method is the most cost-efficient while maintaining ease of use and immersion for customers. We've found that a controller that tracks the motion of the controller itself would be the most cost-efficient, and have created a prototype using the built-in accelerometer and gyroscope on the Microbit to track and send data into a Unity game. While the cost of commercial gun controllers can be further reduced, they would still be limited in demand due to their cost and lack of versatility.**

***Index Terms*—Gun Controller, Immersive.**

I. Introduction

CUrrently, On-rails shooters such as Time Crisis, and House of the Dead, have been on the decline, with the only major release recently being a remake of the original House of the Dead in 2022 gaining an estimated 270 thousand sales according to PlayTracker [5]. One of the main problems the genre has is accessibility, as players are restricted to playing the games in arcades or purchasing their own gun controllers, which can cost up to $157 CAD for a standard Sinden lightgun, or $249 for one with simulated recoil. These prices are financially discouraging for most players, especially as gun controllers are specialized mainly for on-rail shooters, and can be compared to a Playstation 5 controller, which can be used for a larger range of genres, and costs less than the standard lightgun. We aim to create a cheaper alternative to the current commercial gun controllers by using a combination of a gyroscope and an accelerometer to track controller movement over the use of IR trackers used by light guns. By creating a more accessible alternative, arcade-like on-rail shooters could increase sales, especially from individual players for household entertainment.

II. Background Review

A. Keywords

((“game” OR “simulation”) AND “Gun Controller” OR “arcade shooter” OR (arcade AND gun) OR “gun simulator” OR (“shooting” OR “aiming”)) OR (Virtual OR reality OR VR OR training OR simulation OR haptic) OR (gun OR controller OR games) OR “Light gun games”

These keywords relate to and share the idea of replicating a gun controller with an aiming system similar to those seen in an arcade, but vary enough to give diverse results. We found 4 scientific papers that fit our topic, with others that didn't fit our idea as they had intricate techniques of executing their ideas that didn't fit our vision.

B. Background

Bogatinov et al. [1], developed a relatively cheap firearms simulator based on the motion-tracking sensor provided by Microsoft Kinect for aiming as an alternative to aim training. They retrieved the data from the Microsoft Kinect that tracks the user's gestures and translated them into transform calculations by creating an application that collects data using the Microsoft Kinect SDK that does the necessary calculations, emulating mouse and keyboard input. The process required for the Kinect sensor's coordinates to be translated to the screen space includes a set of instructions that transform the calculated intersection point to the correct pixels on the screen. To test accuracy, they displayed circles on the screen, with the user's task being to hit the center of the target. Results showed that the initial experiments had good performance, with no latency and drift which are common issues for aiming simulators. However, its main limitation was the Kinect's ability to accurately portray coordinates from a long distance, facing other limitations such as the testing environment and loudness of sound they used to attempt to emulate a gunshot.

Choi et al. [2], however, proposed a new way of making arcade guns that can be used in various environments outside of the arcade. They used an infrared ray module in combination with the Wii remote's optical sensor to identify where the gun was shooting and interpolate the “aiming point.” They found some success, but errors appeared depending on the environment and screen or interpolation values. They could not predict wide-angle lens distortion and would need to create a step to check for it in the future.

Krompiec et al. [3], created an immersive VR FPS experience that utilizes the motion controller offering an alternative that feels more realistic. They designed two-handed interactions with guns, also using haptic feedback to help make the experience more convincing. To modify the feel of the controller, they made two guns, placing the motion controller within the models, aligning them in the virtual world, with meshes in the game that corresponded with the controller in the

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physical world. To test the controller, they made an FPS demo similar to old arcade games for performing actions such as fire, grab, attach and reload. Results showed their haptic feedback design was rated higher than previous simple and complex interaction models. Limitations of this approach depend on the hardware's precision, as the low-precision hardware lacks haptic feedback.

Y.-S. Ho & H. J. Kim. [4], proposed an infrared LED tracking system that uses three infrared LED lights attached to a monitor to solve tracking problems caused by the physical environment. The system uses a CMOS camera attached to the controller to detect the infrared LED on the monitor. This solution takes into account the in-game movement and movement of the controller. Tests for the system showed that even in the worst-case conditions, the coordinates were still relatively accurate, displaying the success of infrared LEDs. The limitations of this experiment were not listed.

The Sinden Lightgun[6] and the AimTrak Light Gun[7] offer solutions that are available on the market. They use IR trackers and high-speed cameras to determine where the user is pointing. The problem arises with their costs, as the non-recoil version of the Sinden Lightgun is CAD$157.00 and the AimTrak Light Gun costs CAD$95.00, with their respective recoil versions going for CAD$249.00[6] and CAD$120.00[7]. Website solutions [8][9] provided ways to create weapon controllers, but were not lightguns, leaving far more space for circuitry.

The results of these experiments met our expectations of possible limitations regarding the distance from the controller to the screen and visibility of the controller as we intend to test these variables for our project for the most accurate representation we can achieve.

III. Results

1) Task Analysis: Our task is to create a cost-effective alternative to current gun controllers that can accurately detect where the gun is aiming at a screen while being able to give the user immediate and immersive feedback to their inputs. Currently, commercial gun controllers use IR sensors to detect the controller's movements, however, they're financially inaccessible to most people with controllers that simulate recoil costing up to $250 CAD. The benefit of a less expensive alternative would be to increase interest in on-rail shooters in households, further increasing the sales of games in those genres.

2) Design Thinking Outcome : We took in the opinions of 6 people to figure out how to create the **ideal lightgun controller**. It uses an accelerometer for finding where on the screen gets shot, servos to simulate recoil, and a button to detect reload [Fig. 1].

Interviews: Users would expect a unique controller, dual purpose, with the benefit of not carrying a traditional controller. Racking the slide on the controller or using pistons to simulate the force made by a slide going back would help with feedback. The controller should be lightweight and evenly distributed to allow for quick movement. The game should be centered around the gun as it's the main mechanic, and

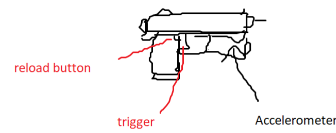

Fig. 1. Initial Sketch

the controller should use a USB cable for battery life, as Bluetooth may be an oversight. **Digging Deeper:** We must cater to people with canes who want a portable controller for their phone games and ensure the positions of the controls are the most comfortable when sitting down with a cane for accessibility. Controllers should feel similar to those who have used lightguns in the past for a familiar and reminiscent experience. **Capture Findings:** Needs include; Tracking where the gun is pointing on the screen and some sound within the controller for shooting feedback. Insights include; Having a calibration section for the accelerometer and gyroscope inside the gun and creating auditory and haptic feedback with speakers and rollers. **Problem Statement:** Ethan & Alex need a way to create an immersive gun controller for PC gaming to track where the gun is pointing on the screen in the real world and then generate a ray cast in the game world based on the hit on the screen. Unexpectedly, in our world, getting the location of an object in real life tends to be inconsistent. [Fig. 2] references the clay tangible prototype translated to the 3D space.

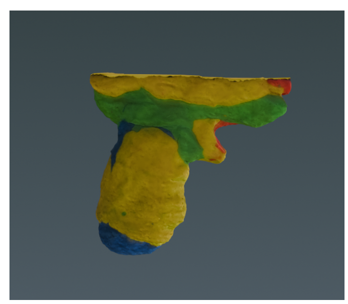

Fig. 2. 3D Model of Prototype

3) Electronics Prototyping : [Fig. 3] shows the schematic of the Microbit receiving input for two buttons, one for reloading and the other for firing, and an LED and a vibration motor as a method of giving physical feedback to the player.

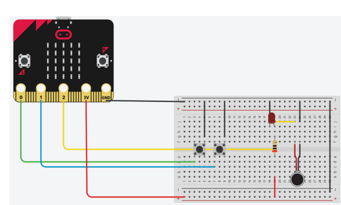

Fig. 3. Virtual Schematic

Additionally, the built-in accelerometer and gyroscope on the Microbit would be used to track the controller's movement

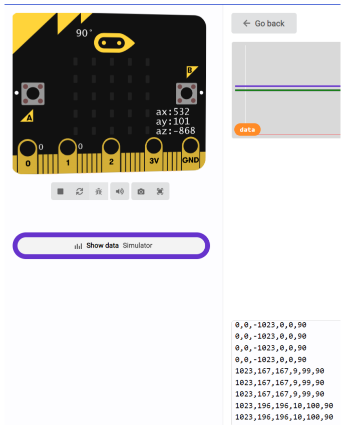

Fig. 4. Accelerometer, & Gyroscope Simulation

in the game world by sending its data to the game as seen in [Fig. 4].

IV. Conclusion

The development of this immersive controller is still in progress, with the focus being on creating a working aim-tracking system. In this paper, we have listed all the model's requirements, and prototyped and tested solutions to determine what is the most reliable. In the future, we will develop and modify the physical model based on our findings and optimize the aim-tracking.

Appendix A
Contributions

- Alexander Phillips
  - Background Report
  - Task Analysis
  - Design Thinking Outcome
  - Conclusion
- Ethan Zafra:
  - Abstract
  - Introduction
  - Task Analysis
  - Physical and Virtual Prototyping

Appendix B

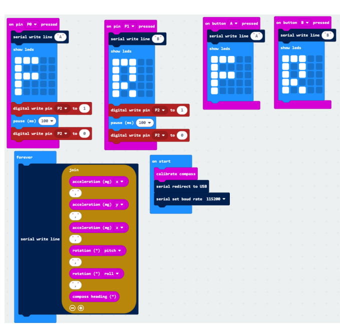

Fig. 5. Microbit Code

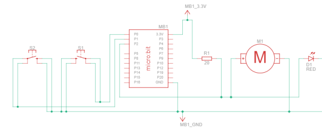

Fig. 6. Enter Caption

Name	Quantity	Component
MB1	1	Red micro:bit
S1 S2	2	Pushbutton
D1	1	Red LED
M1	1	Vibration Motor
R1	1	20 Ω Resistor

Fig. 7. Bill of Components

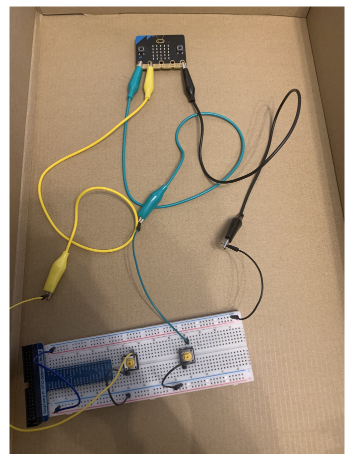

Fig. 8. Physical Prototype

References

[1] Bogatinov, D., Lameski, P., Trajkovik, V., & Trendova, K. M. (2015). Firearms training simulator based on Low Cost Motion Tracking Sensor. *Multimedia Tools and Applications*, *76*(1), 1403–1418. https://doi.org/10.1007/s11042-015-3118-z

[2] Choi, YoSeph, et al. "Algorithm of aiming point calibration in arcade gun using infrared LED and Wiimote Camera Module." *The 18th IEEE International Symposium on Consumer Electronics (ISCE 2014)*, vol. 6, June 2014, pp. 1–2, https://doi.org/10.1109/isce.2014.6884333.

[3] Krompiec, Przemyslaw, and Kyoungju Park. "Enhanced player interaction using motion controllers for first-person shooting games in virtual reality." *IEEE Access*, vol. 7, 18 Aug. 2019, pp. 124548–124557, https://doi.org/10.1109/access.2019.2937937.

[4] Y.-S. Ho and H. J. Kim, Advances in Multimedia Information Processing - PCM 2005: 6th Pacific Rim Conference on Multimedia, Jeju Island, Korea, November 13-16, 2005, Proceedings, Part I. Springer Berlin Heidelberg, 2005.

[5] d.o.o., Operon Design. "The House of the Dead: Remake Stats, Graphs, and Player Estimates: Playtracker Insight." *Stats, Graphs, and Player Estimates — PlayTracker Insight*, playtracker.net/insight/game/74585. Accessed 13 Oct. 2024.

[6] "Sinden Lightgun®." Sinden Lightgun, sindenlightgun.com/. Accessed 14 Oct. 2024.

[7] "Aimtrak Light Guns." Light Guns AimTrak Light Guns, www.ultimarc.com/light-guns/aimtrak-light-gun/. Accessed 14 Oct. 2024.

[8] "Making PUBG FNSCAR Gun Controller 1 Recoil Simulator." YouTube, YouTube, www.youtube.com/watch?v=OFJCo_HViy0. Accessed 14 Oct. 2024.

[9] R/Arduino on Reddit My Entry to DIY Light Gun - W.I.P., www.reddit.com/r/arduino/comments/17qov9y/my_entry_to_diy_light_gu_wip/. Accessed 15 Oct. 2024.