High-Speed Hand Tracking and Augmented Reality Juggling

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Goal

The goal of this project is to design a low-cost, high-speed, augmented reality (AR) system that uses computer vision and machine learning to track human hands and render a virtual ball that the user can toss between their hands.

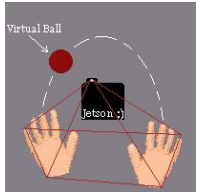

Figure 1: Simple conceptual drawing.

Background and Motivation

- Tracking the shape and motion of hands are essential for virtual and AR systems.
- Real-time hand tracking is a complicated problem, as performance needs to be balanced with the accuracy of the tracker for it to run in real-time.
- Currently, there are some hardware accelerators and advanced algorithms that improve this process, but there is room for more advancement.
- We will be working to develop an integrated, real-time hand tracking system for the purpose of demonstrating what is possible with cheaper components and potentially discover new ways of optimizing the process.

Objectives

Specifications	Features	Considerations

• Operate at **30 frames per second** or more
• Operate with a latency below **100 milliseconds**
• Operate at a resolution of **640x480**
• Meet a rating of **IP 2 0** of the IEC 60529 mechanical housing code. (Effective protection of items larger than 0.5 inches)
	• Actively track human hands
	• Render a virtual ball
	  • That can interact with the physical environment
	  • Contains realistic physical features
	• Allow the user to toss the virtual ball between their hands
		• Image sensors may require digital filtering due to inherent noise of the sensors
		• The power source and consumption that may be needed to ensure portability
		• Human hand tracking should work for all people
		• Delays due to COVID-19, such as lab access or supply chain delays

Final Design

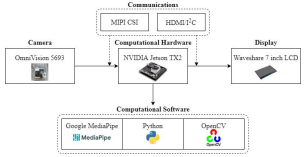

Figure 2: Block diagram of the final design.

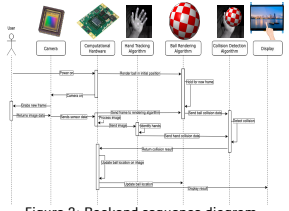

Figure 3: Backend sequence diagram.

Status of Prototype

- Functioning Hand Tracking, Juggling, GUI
- Constructed Portable Power Supply
- Designed Electrical Housing CAD Model
- Performed Performance Metric Testing
- Performed User Tests
- 60% Under Total Budget

Figure 4: Current hand-tracking and augmented reality juggling prototype.

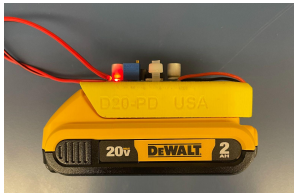

Figure 5: Current portable power supply.

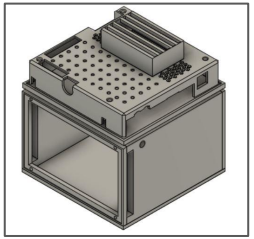

Figure 6: Electrical housing 3D CAD Model

Evaluation of Prototype

Specification	Description	Result
FPS	Operate at 30 frames per second or more	24 FPS
Latency	Operate with a latency of 100ms or less	40 ms
Resolution	Operate at a resolution of 640x480 or higher	1024 x 600
IEC Housing Standard	Protection against objects wider than 0.5 inches	Awaiting Results
Inclusion	System works effectively for all people	Yes
Ball	Ball can render over a live video feed	Yes
Hand-tracking	Accurately tracks two hands in real time	Yes

Table 1: Objective Validation Table.

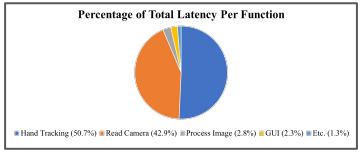

Figure 7: Pie chart used to determine the bottlenecks within the system

Conclusion & Future Work

This project made significant progress towards a final prototype of a low-cost, high-speed, AR system that allows the user to juggle a virtual ball. Future work includes utilizing more parallel processing, targeting the bottlenecks, improving the physics, testing and integrating the power supply, and constructing the enclosure.

Acknowledgements

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Figure 8: Troy Sims (left), Corey Dotson (center), Samuel Fischer (right)