Video Analytics at the Edge

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EEL 4914 - EE Design 2

Introduction

The number of devices that require processing power has increased significantly in the past several years. Edge computing can optimize load on central servers. Surveillance systems particularly stand to benefit from Edge Computing, since they consume a large amount of bandwidth and memory. Gartner estimates that by 2025, 75% of all computing will be performed on edge devices (IBM, 2023).

Additionally, by incorporating machine learning, the performance of the surveillance system should improve, as they have historically proved unreliable.

Objective

To develop a microcomputer system with machine learning capabilities in order to improve surveillance systems by detecting anomalous objects and movement in real-time while addressing latency and bandwidth limitations of traditional cloud-based systems.

Project Design

Our project includes a high-resolution camera, a camera gimbal, a Nvidia Jetson Xavier NX as the processor, and an enclosure for protection. The design allows for efficient processing and a wide field of view for high-fidelity imaging.

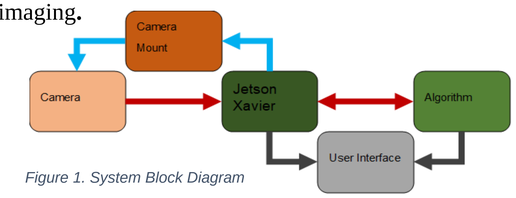

Figure 1. System Block Diagram

Considerations

Some design elements that need to be taken into consideration:

- User Interface: Designing a user interface that notifies an individual when an anomaly is detected
- Storage Capacity: While edge devices are great for improving latency and response times, their storage is usually limited, which may require the transferal of data manually or through the connection to a central server
- Processing Power: The data limitations of edge devices may limit their performance

Prototyping

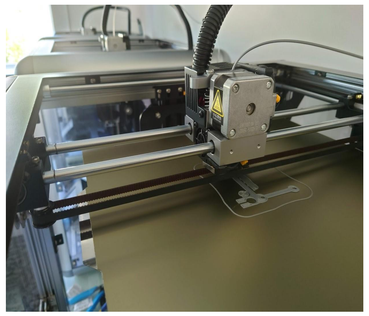

Figure 2. 3D printing of fixtures for the physical frame.

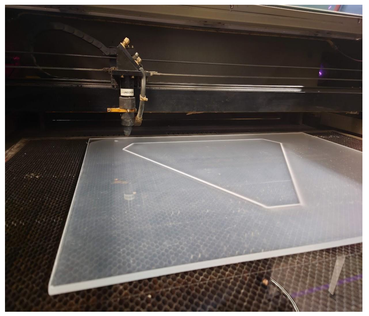

Figure 3. Cutting acrylic sheet using laser cutter

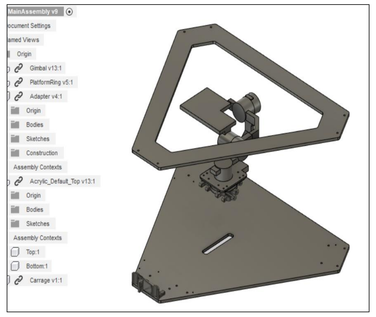

Figure 4. Fusion 360 Model of Camera Gimbal

Our preliminary prototyping included:

1. Assembling the hardware components (Nvidia Jetson, Raspberry Pi boards, optical imager, and enclosure).
2. Installing the OS, Python, and libraries on the boards.
3. Collecting and preprocessing data.
4. Training of AI model 5. Implementing and testing the statistical detection algorithm.

Results

To establish a baseline for data bandwidth usage with traditional techniques, seven commonly used data encoding techniques were selected. The following metrics are measured from the ethernet bandwidth usage transporting a 10-minute frame sequence (Special 4K HDR 120FPS Dolby Vision Demo by @DolbyVisionDemo4K acquired from YouTube) (Dolby Digital, 2023). The video's audio channel is removed and, in addition, is pre-processed to be at a frame rate of 30 frames per second at resolution of 1920 by 1080 pixels (3MP).

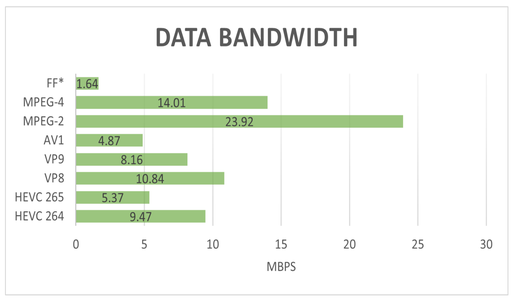

Figure 5. Data Bandwidth Consumption of alternative methods

Discussion

Future Improvements:

- Development of a User Interface: A UI could be developed to enable users to customize the system such that the relevant anomalous threshold activates the expected visual and auditory feedback outputs. Thus, users could have more control over the system which would allow them to modify it to their specific needs.
- Incorporation of multiple sensors: Including additional sensors such as thermal imaging, infrared, or sound sensors may provide further information and improve the system's accuracy.
- Integration of Systems: To construct a more comprehensive automated system, the prototype could be combined with additional systems and technologies, such as drones or autonomous cars. This has a wide range of uses, including surveillance, security, and transportation.

Summary

Our testing indicates that all primary target requirements and specifications were successfully achieved:

- Gimbal movement works as expected.
- Image and Lens configuration was already performed
- The system was able to accurately detect objects and movements in the environment
- The system has the potential to save a significant amount of bandwidth
- The system is more reliable than traditional methods of surveillance

Conclusions

We observe that this design prototype satisfied the critical parts of its design requirement as the bandwidth between the sensor and the user interface was dramatically reduced. This effort has achieved a reduction of the compute power envelope required of a surveillance system. In the following phases of this design effort, the team aims to finish the prototype via utilizes multiple off-the-shelf components under an industry-ready design doctrine.

The project offers substantial benefits as a security system. The designed system has the potential to reduce the bandwidth occupied by older security cameras. Furthermore, with the addition of AI into a security system, the designed system has the potential to become even more effective than the traditional systems, which are often unsupervised and unreliable.

Work Division

Luke B: Jetson Compatibility, Software, Website
Mikel H: Training AI, Software, Testing
Shawn S: Training AI, Hardware, Software

References

Dolby Digital. (2023, March 6). *Special 4K HDR 120FPS Dolby Vision Demo*. Retrieved from YouTube: https://www.youtube.com/watch?v=Jrh5idPduJA

IBM. (2023). *What is Edge Computing?* Retrieved from IBM: https://www.ibm.com/cloud/what-is-edge-computing