Critical Assessment Document

Video Analytics at the Edge

Luke Barber, Mikel Holmquist Castano, Shawn Sheng

Professor Yasin Yilmaz

University of South Florida

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# Abstract

This paper presents the design assessments planned for a design effort that strives to demonstrate edge computing techniques for video analytics. With the increase in bandwidth requirements for surveillance systems, the utilization of current advancement in machine learning for bandwidth reduction has a high industry interest. One key approach to achieve this is to utilize Edge Computing, in other words, pre-processing and analyzing the sensor data at the sensor node. “The Edge” defines effective video analytic methods, such as machine-learning based object detection, performed in the proximity of the optical instrument. Unlike the traditional approach, edge computing reduces the bandwidth requirement between the sensor and the central computer (known as the command center). The prototype developed in this design effort will optimize the cost, size, weight, and power envelopes (C-SWAP) of available off-the-shelf components. The prototype will generally operate autonomously to provide insights into anomalous objects or motions of interest.  Instead of transporting raw or compressed data of the captured video signal, the prototype will compute and process these signals to then deliver a set of pre-defined parameters of interest to the command center, where the decision process will ultimately take place. A user interface will allow users to customize the system so that desired anomalous threshold will be detected as well as giving the users some control and monitoring of the data. This effort will benchmark the differences between video analytics at the edge compared to a traditional surveillance system.

# Assesment Objectives

The following goals are defined for this design effort:

* The communication channel between the sensor and the user interface mainframe shall be operating on a dramatically reduced bandwidth.
* The system shall have the ability to detect multiple common objects, in congested environments.​
* The system shall automatically track-identify-and-document (TID) the object if motion is detected.​
* A high-fidelity capture of the object will be stored and be available for transmission upon request.
* Option to monitor anomalous items shall be offered.
* The system can be configured in “Alarm mode”. In this mode, if an anomaly is detected, the system shall activate an audio/visual alarm to alert a potential supervisor.

# Test Plan:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Title​ | Requirement​ | Verification Success Criteria​ | Verification Method​ | | Phase​ |
| Main Image Sensor and lens configuration ​ | A camera shall function and capture live video feed. ​ | Observable live feed. ​ | Demonstration ​ | | Preliminary ​ |
| Verify that the camera is capturing a live feed​ | Camera (webcam or pi-​cam) shall function properly.​ | Live video feed with appropriate quality and resolution.​ | Test​ | | Preliminary​ |
| Verify the correct resolution mode is set on the camera​ | Correct resolution shall be set on camera​ | The right resolution must be displayed when live.​ | Inspection​ | | Preliminary​ |
| Camera Frame Time​ | Frame time shall be set​ accordingly​ | System must be able to capture frames adequately​ | Test​ | | Preliminary​ |
| Camera Focal Length​ | The Camera shall have a focal length such that a sharp image is produced.​ | Zoom levels will be adequate​ | Test​ | | Preliminary​ |
| Physical obstacles​ | ​  Protectors that hold the camera in place during transportation shall be removed prior to powerup of the camera gimbal assembly​.  ​ | No protectors remain in place​ | Inspection​ | | Preliminary​ |
| Gimbal​  Centering​ | Camera Gimbal shall be able to center during initial powerup.​ | The gimbal must be centered (or in a neutral position).​ | Demonstration​ | | Secondary​ |
| Gimbal motion​ | The camera gimbal shall achieve an adequate range of motion in the pitch and tilt axis.​ | Camera gimbal must be able to rotate accordingly​ | Demonstration​ | | Secondary​ |
| Power input and current carrying capacity​ | Power source shall be capable of supplying enough current to the system without voltage sags at critical levels​ | Power levels required by the Jetson Nano, as recommended in the user manual shall be obtained​ | Test​ | | Secondary​ |
| Physical​  Connections​ | Physical connections to and from the main communication​   computer shall be secure.​ | Proper contact is obtained​ | Inspection​ | | Preliminary​ |
| System​  mounting​ | The mounting harness for the main communication computer shall be secure.​ | System is mounted such that no undesired movement is possible​ | Inspection​ | | Final​ |
| Grounding​ | There shall be adequate grounding of the main communication computer​ | Proper Ground (Zero Potential) is maintained​ | Inspection​ | | Final​ |
| Image​  processing​  capabilities​ | The image processing capabilities of the system shall be tested.​ | System can process images in real time​ | Test​ | Final​ | |
| Jetson Nano​ | Jetson shall run required software​ | Run code to confirm libraries are installed correctly​ | Test​ | Secondary​ | |
| Object​  Recognition​ | Object Recognition shall be​   successfully implemented.​ | Recognize at least 10 common objects.​ | Analysis​ | Final​ | |
| CSV files​ | Anomalous objects shall be recorded and logged into a text/CSV file​ | CSV file will log time, object, and internal file link to recorded video​ | Demonstration/Test​ | Final​ | |
| Audio-Visual​  Alarm​ | The system shall notify any anomalies​ | Once an anomaly is detected, the system should emit an audio- visual alarm.​ | Demonstration​ | Final​ | |
| Gimbal tracking​ | Camera gimbal shall track anomalies | When anomalous individual is detected, the gimbal should   move to track the individual for one minute before returning to neutral position​ | Inspection​ | Final​ | |
| Recording​  Anomalous​ | The system shall automatically begin recording anomalies​ | Once an anomaly is detected, the system should begin recording​ | Demonstration​ | Final​ | |

# Current assemenets

**On currently available assessments**

Due to the lack of availability of the current physical prototype, only the hardware and image capturing pipeline could be benchmarked.

**No compression with RAW 16 bit, no interlacing**

Prior to any data compression and compression techniques, the expected bandwidth requirements for a 30 frame per second video captured at 2.1 Megapixels (MP) or a resolution size of 1920 by 1080 pixels is roughly 1000 megabits per second (Mbps). This test is performed from a single frame raw capture from a system on a chip module with MIPI interface. Since the module is not capable of handling a video bitstream at this rate, the effective bitrate is calculated.

**No compression with RAW 16 bit, with half frame interpolation**

Frame interpolating the video achieved an estimated bit rate of 495.13 Mbps. Similar to the scenario without frame interpolation, the module is not capable of handling a video bitstream at this rate. The effective bitrate is calculated.

**Data compression with RAW 16 bit, with half frame interpolation**

With MPEG2 enabled, the video bitrate is measured, in average, at 19.2 Mbps.

**Metadata communication**

In metadata mode, only the metadata associated with all detected object is being transmitted. Depending on anomaly traffic, a significantly average bandwidth of 6 Kbps is achieved while the system tracks three targets.

# Critical Reflection

Upon initial reflection, this design effort has demonstrated a significant reduction in communication bandwidth. This is expected as only the metadata of captured object in frame is being transmitted from the sensor to the central station. It is therefore reasonable to assume that with continued improvement of the detection algorithm, a reliable edge computing platform could be realized.

# Summary

In summary, edge computing involves pre-processing and analyzing the data before the data is sent back to a processing or central node. 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.