Problem Statement: Multi-Camera, System-on-Chip (SoC) Based, Real-Time Video Processing for UAS and VR/AR Applications

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19 October 2017

CS-461, Senior Software Engineering Project, Fall 2017

Abstract

This project aims to recreate a system that uses multiple cameras to combine their respective images in real time to provide a near-real-time composite video feed. Our clients industry-specific solution is too costly for all of their customers in the aviation industry. The solution is composed of three main pieces of off-the-shelf hardware, and when integrated the input from multiple cameras will be fused together and displayed on an output screen. Our initial goal will be to integrate all parts of the system and create an output of one camera, and eventually fuse the input from multiple cameras.

1 Introduction

Rockwell Collins is looking for an economic solution regarding a flight deck product that they currently offer for their clients in the aviation industry. The product is a head-up display (HUD) that is transparent, and assists pilots during low visibility conditions during the day, night, and inclement weather for all phases of flight. When lowered in the pilots forward field-of-view (FOV), the HUD displays a variety of indications, from on-board sensors and databases to real-time images taken from on-board cameras. Specifically, Rockwell Collins has focused on duplicating the Enhanced Vision System (EVS) of their HUD, which uses input from three detection channels of the electromagnetic spectrum to display images that are beyond human vision. The output from the channels provide thermal images of the landscape and various types of lighting, for example incandescent, halogen, and LED lights, etcetera.

2 Problem

The in-house development and custom manufacturing of this system is very costly, and therefore the company is unable to attract all customers from public and private airline industries. Since a HUD device costs almost half million dollars, it will not be used for the realistic case, so the issue is to find a way to cut down the cost. An idea to solve the problem is to build a multispectral camera system based on the same features as transparent display device. This project will figure out a way to create a system from the off the shelf components and achieves real-time image and video processing. The desired outcomes will be a stand-alone system, which is a development platform using a visual computing module, to communicate with an interface board. Due to the size limitation, we do not use DevKit or other larger interface board. The stand-alone device is required to provide a data stream that can be analysed without being connected to a computer. A suggestion product to deal with graphic processing is NVIDIA Jetson TX1 and TX2, which supports up to six cameras and can build a video processor and display/recording system suitable as a UV/light air vehicle payload. This project also requires the device to provide attractive size, weight, power and cost (SWaP-C) for this application.

3 Proposed Solution

An EVS that has system hardware composed of affordable off-the-shelf hardware, which reduces the total cost of the HUD for airline industry customers of Rockwell Collins. For multiple cameras and spectral band image processing and the added size, weight, power, and cost (SWAP-C) constrained due the projects application, the EVS will need to be deployed with the use of a system-on-chip (SoC) or a system on a module (SOM). These SoCs and SOMs integrate systems that typically would plug into the motherboard of a personal computer. Due to our project requiring image processing our SoC or SOM must have a graphics processing unit (GPU), and the perfect example of a product would be the NVIDIA Jetson TX1 and TX2. With the latest being the TX2, internal real-time processing is one of its many capabilities that make this an attractive solution. In addition to the Camera Serial Interface (CSI) of the TX2 being capable of supporting six cameras simultaneously. The TX2 also supports High Efficiency Video Encoding (HEVC) or H.265, which is the new video compression standard capable of providing double the compression efficiency than the previous standard. To allow for future compatibility of future cameras, a camera interface board is a likely solution, and is required to be compatible with the SoC or SOM selected for the project. Another limitation that must follow the projects SWAP-C constrained is the need for the system to run independent of a development kit or external computer. The cameras selected to attach to the camera interface board simultaneously must include the desired bands of the electromagnetic spectrum to mimic the current EVS output.

To reach the goal, the first work in this project we will do is system research. The GPU, camera interface board, and cameras must be capable of being integrated for the system to produce an output to a screen. Researching compatible components for system integration will be the first major step, and most specifically a camera interface board capable of communicating with the GPU. This is potential that the camera interface board may require minor modifications to meet full requirements of the project. These components must also meet size, weight, power, and cost (SWAP-C) requirements due to the application for the EVS. With a Jetson TX2 currently available, research and tinkering will occur during this process to gain better understanding of it. Once the system components are narrowed or finalized, purchased and in-hand, system integration is required for the major components to communicate. This may be capable of being confirmed without an output display and signal input from a camera, but until more information is gathered on the hardware this metric will be confirmed by such. All desired wavelengths that provide input to the existing EVS utilize will be tested for output.

4 Performance Metrics

The system should be capable integrating the GPU, camera board, and cameras for a video output near-real-time. The EVS will generate a visible image to help the pilot see the runway and surrounding environments during inclement weather. The price of our EVS is estimated be around four to five thousand dollars total, and may change due to our final hardware selected.

Initial system integration will be established upon the output of one camera to an output display. The EVS requires input from multiple cameras, and the goal for the project will be to have at least two camera inputs fused together on an output display. Three wavelengths that provide input to the existing EVS will be tested for a fused output. Completion of this step will be verified once all cameras have been tested for output, and that multiple combinations of camera outputs are capable of being fused together.

Since the EVSs primary benefit during flight is low visibility conditions, different conditions will be tested with the cameras, and the recording and plotting of data will be expected. Additional camera inputs will be added one at a time and fused together on an output screen. Once the fused output is tested satisfactorily this will be repeated for up to six total camera inputs.