Written Progress Report

Automated High Beam System

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Written Progress Report for an Automated High Beam System

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Overview

Lumos Technologies is well underway in the development and integration phases of the Automatic High Beam system. In the past 3 months, our team of engineers has strived to abide by our functional specifications we established for our product while adhering to the timeline and budget constraints.

We are currently still in the late development stages, although we will soon be ready to integrate the vehicle detection software, the camera and FPGA, and the redesigned car headlight circuit together into one system. This document describes what has already been accomplished and what needs to be done in the future. Furthermore, we summarize where we are with regards to our original budget and timeline plans.

Progress

The thresholding, object detection, distance measuring, and override components have been completed in MATLAB several weeks ago. These four components have been proven to function reliably through unit tests. Integration of these components has been successful and the system yields satisfactory performance on our test sequences. The component that filters red lights by converting the frame from RGB to HSV color space has been developed in MATLAB and tested individually but has yet to be integrated into the final software system. The most difficult part of software design thus far has been the design of an accurate, reliable object detection algorithm. It was determined early on that the best way to identify vehicles is by their headlights (the car's distance estimation also requires the width of the vehicle so this is a natural choice anyway). Unfortunately, bright light sources have a tendency to saturate in video, thus complicating this process. Good performance of our system has been observed with the current data samples we have. However, our dataset currently does not include any complex, highway driving scenes, and thus we haven't verified its performance in a natural environment. Finally, the runtime is thankfully quite low for such a large software system running in MATLAB (approximately 13

FPS). At this point, we can realistically speculate that the algorithm will be capable of running in real time (30 FPS) in its final implementation.

The Altera DE2-70 board is capable of streaming live video from the camcorder and displaying to a monitor instantaneously. Unfortunately, the resolution of the input video is limited by the Video-In IP core on the FPGA board. Resampling and scaling are required before any further processing actions can be applied.

The manufacturer's original headlight circuit has been redesigned to incorporate additional signals from our automated system. A model of this relay circuit has been built using LEDs and 12V power supplies instead of using a car battery and headlights. A car's multifunction switch has been tested and the original manufacturer's headlight feature still functions as expected. The hardware system also contains 3 signals from the FPGA's GPIO pins, two of which will control the brightness of the headlight in auto mode. With the model circuit we have built, the FPGA's GPIO signals are replaced by three 5V low current power supplies. Besides the On-Off option in the auto system, we also have a 50% light intensity option. We are currently using a variable resistor to calibrate the headlight to a desired brightness.

Remaining Tasks

The decision-making component of the software system needs to be developed and integrated. Although this is just a set of conditions on the output of the distance measuring component, and thus should be trivial to implement. The HSV filtering component needs to be integrated with the rest of the system as well. The distance measuring component has been tested extensively; however it is highly dependent on the resolution of the input video. Therefore, the parameters currently used in the distance measuring formula need to be calibrated once the resolution is finalized. Furthermore, it is preferable to have some video sequences of highway driving to provide more challenging, demanding tests for the current software system. Upon completion, the software algorithm will need to be re-implemented in C so that it can be used to program the NIOS II processor in the DE2-70 board.

Input video will need to be buffered and written to the on-board memory to allow the Nios II processor to manipulate each frame. Decisions made by the intelligence system will be output to the GPIO pins on the FPGA board. Indication of any type of errors will be signalled by the LEDs.

The headlight model circuit is built to verify some of the features we have designed. Another feature we have not tested is the feedback LED. The third GPIO signal from the FPGA is to give the user feedback on when the system has fully booted and is functioning without error. Once this feature is verified, a realistic model can be built using an actual 12V car battery and dual beam headlights. If we have enough time and the software is able to accommodate this feature, the circuit can be adjusted to include more increments in light intensity. Hence, as the system detects a car down the road, it will dim the headlights in several steps to prevent the surprise of suddenly turning off the driver's high beam.

Time & Budget

Lumos Technologies is currently well under the initial budget of $700. All the major parts have been purchased, including a camcorder, a car's multifunction switch, and two high beam headlights. We were fortunate enough to borrow the DE2-70 FPGA board from one of our professors and so no money was spent in obtaining our development board. Only a few minor electronic components still need to be purchased. We currently have about $200 in funds remaining, and hence we expect the final product cost far less than what we had initially projected.

The past few weeks have been difficult due to lack of lab access and licensing issues with Altera software programs, which significantly delayed our progress. Despite this setback, the basic framework of the FPGA component has been developed. The remaining hardware is up and running but needs to be re-implemented into a more realistic and large-scale model. The software system is in the late development stages and is expected to be finalized by the end of the week, along with all the aforementioned components. Overall, we are about one week behind on our original schedule, but due to extensive unit testing of individual components, we expect a straightforward integration.