Semi-Truck Driver Assist Camera System with Trailer Kink Angle Adjustment

Bruce Griffin - Jeffrey Udall - James Witcher - Matt Fleetwood
Prof. Dan Hammerstrom

Introduction

The advancement of video camera technology has led to cost efficient bird’s eye view driver assist systems quickly becoming standard in new automobiles (Figure 1). With their added bulk, turning radius, and blind spots semi trucks could greatly benefit from these systems.

Figure 1 - Driver assist camera placement and display output for a Mercedes automobile

The primary challenge our team focused on was adjusting the video output based on the kink angle between cab and trailer (Figure 2). As the truck turns the video camera’s placed along a truck would move in relation to each other. This necessitates updating how the video output streams are placed and stitched together in the combined output display.

Figure 2 - Truck driver assist system needs to take into account the changing camera layout based on kink angle

Solutions

Kink Angle Calculation

A semi-truck is attached to a trailer via a kingpin (Figure 3). The angle between the cab and trailer is called the kink angle. This angle is used by the system to determine how the camera feeds are laid out and stitched together in final display. To get baseline layout settings we designed a 1:2 scale truck model with a king pin to attach our cameras to (Figure 4).

Figure 3 - King pin connects to truck via pin in kingpin (left) and 5th wheel seal (right)

Figure 4 - 1:2 scale PVC pipe model

We developed several solutions to calculate the kink angle. One was to use a rotary encoder attached to the kingpin (Figure 5). Another was to attach a linear potentiometer to the kingpin (Figure 6). We chose the latter because of technical issues with the former.

Figure 5 - Rotary encoder

Figure 6 - Potentiometer (left) in custom seal (ring) and 5th wheel seal (block)

Video Feed Placement and Stitching

Stitching the video feeds from the cameras placed around the truck involves several steps (Figure 7 & 8). Our program was developed in OpenCV (Figure 9) using Python in the Spyder development environment.

Machine Learning

We used machine learning (Figure 9) to perform the initial calibration and distribution of the various video streams for the output. Using the KNN (K Nearest Neighbors) clustering algorithm similar features in two images can be identified and stitched together creating a single combined bird’s-eye view for the driver.

Implementation

Driver Assist System Software

The final system was run on a MacPro (Figure 11) with six 1080p cameras connected via USB. We stacked tables on each other and placed cameras on top for the initial development phase (Figure 12). The cameras were calibrated using papers placed on the floor. We then manually set angles in the program and tested that the output would change. We then placed the cameras on the PVC model in order to be able to manually change the kink angle and then update the display based on this angle.

Figure 11 - OpenCV Python code in Subr IDE

Figure 12 - Alpha setup with camera set up on table

Figure 13 - Display output with three video feeds placed

We also developed image recognition features to identify potential hazards and label them for the driver. The VGNet Deep Learning architecture was used to classify truck, car, and road images for blind-spot object detection. The network was trained to approximately 97% accuracy.

Figure 14 - Blind spot hazard detection

We built a 1:2 height scale model of a semi truck in PVC pipe (Figure 15). The PVC model used a reduced width and a reduced trailer length as we had issues making all eight cameras run on our test setup and had to reduce this to six cameras. We placed the computer inside the model. We then moved the cab portion in degree increments and adjusted the layout and stitching of the camera feeds. Then when the kink angle is determined the layout and stitching data will be used to set the final display output.

Figure 15 - PVC truck model with camera attached side (left) and back (right)

Conclusions

Our system and models show that implementing a driver assistance system for a semi-truck is challenging, but possible. Using a robust kink angle calculation system and updating the video output on the display for the driver is vital for such a system. We believe the system we have developed is a viable option.

Future Steps

The next step for this project would be to integrate the angle sensor and camera system on a full scale semi truck. This would allow us to make final hardware choices and run robust testing in a real-world situation. We would probably want to use cameras that were more robust and waterproof on a full size model. We would like to test the blind-spot feature with real-world images from a system on a full size truck.

There are several other issues we would need to address for a commercial product, such as standardization of the camera hardware on the trailers, some sort of easy to assemble kit for truck drivers to outfit their trailers with the cameras, and optimization for nighttime and inclement weather. We would also need to interface with standard industry software such as Daimler’s ADTF (Automotive Data Time-Triggered Framework).

Contact:
Bruce Griffin - bruce@pdx.edu
Jeffrey Udall - jeff.udall@outlook.com
Matt Fleetwood - fleet@pdx.edu
James Witcher - jwitcher@pdx.edu
Dan Hammerstrom - dhammer@pdx.edu

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