Three-Dimensional Vision System for Traffic Monitoring
MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)

The Problem and Goal:

Traffic monitoring systems detect traffic accidents and congestion for immediate assistance and/or traffic flow control. Conventional loop detectors are installed under the pavement and require regular maintenance which is disruptive to traffic. TV-camera based systems are an alternative solution providing non-disruptive monitoring. An advantage of TV-camera-based traffic monitoring systems over loop detectors and acoustic detectors is that the traffic control centers can have a first hand view of the traffic situation. The problem with conventional TV-camera-based systems is that the systems are confused with overlapping vehicles and shadows, and the systems cannot provide highly accurate measurement results. To avoid overlapping vehicles, overhead structures are used. These structures usually cost more than the machine vision systems.

Our goal is to develop a three-dimensional system for reliable traffic monitoring solving the problem of overlapping vehicles and shadows.

Approach:

Our traffic monitoring system is a TV-camera based system to provide traffic control centers with a real-time view of the traffic situation. We use our three-dimensional vision system described on page 15 to address the accuracy problems with conventional two-dimensional systems. The cameras are located on the side of the road as shown in Figure 1 and expensive overhung structure is unnecessary. The system uses three-dimensional data to eliminate problems with overlapping vehicles and shadows.
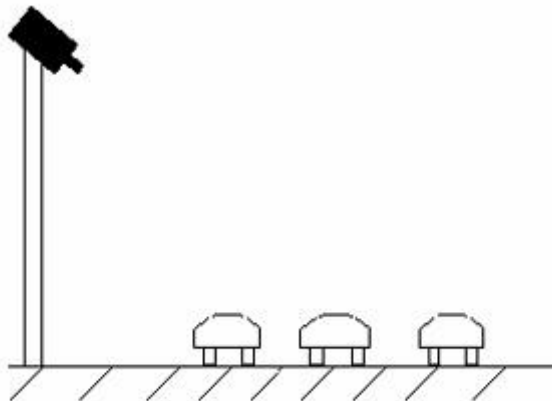

Figure 1: Roadside Video-camara Based System

The three-camera system produces an edge depth map containing the distances of the edge of objects in the image. The three-dimensional data is used to distinguish between vehicles and enable traffic monitoring. Figure 2 displays the center image and the edge depth map. The colors indicates the different distances of the object.

Figure 2: Center Image and Depth Map

Figure 3 is a histogram of the distance vs. number of edges in the depth map. Therefore vehicles are distinguished by the distance from the cameras. Each peak in the histogram correlates to an object in the image.
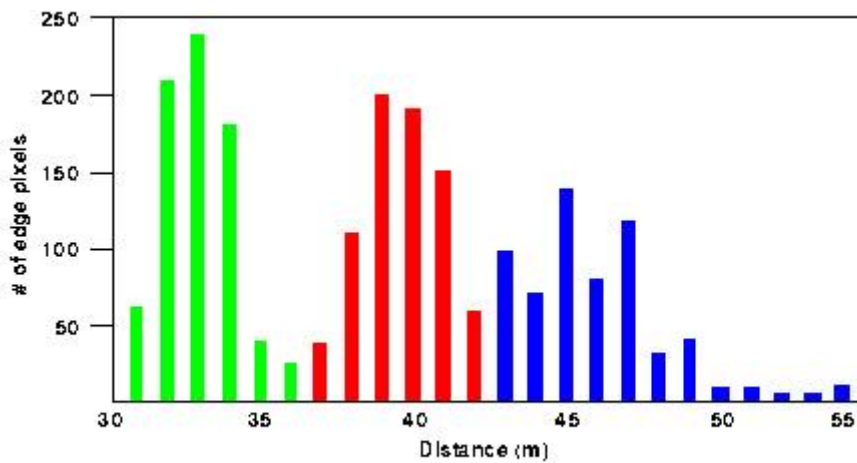

Figure 3: Histogram and Distances

Current Status and Future Work

Currently the cost-effective real-time three-dimensional vision system is completed and research is being done on distinguishing between overlapping vehicles and shadow elimination. Short term goals consist of vehicle classification, counting and speed measurements. Long term goals involve the development of an automatic incident detection algorithm.

VISION SYSTEMS FOR INTELLIGENT VEHICLES:

Intelligent Cruise Control, Obstacle Detection, and

Reliable Lane Sensing

MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)

The Problem and Goal:

Our goal is to develop an integrated a system architecture which carries out various intelligent vehicle functions with the single versatile vision system described on page 15. Examples of the functions are intelligent cruise control, obstacle detection, and reliable lane sensing.

Conventionally, three-dimensional vision systems for intelligent cruise control and obstacle detection were too slow or too expensive to achieve the required distance resolution. Conventional two-dimensional lane sensing algorithms have the problem of tracing the lane and continuing the trace up the side of the vehicle.

Previous Work:

For intelligent cruise control and obstacle detection, laser radar and millimeter-wave radar were investigated intensively. The laser radar is sensitive to the reflection characteristics of object surfaces, and the outputs of the millimeter wave radar depend on the material of object. Various models were proposed to increase the reliability of lane sensing which is based on two-dimensional image processing. Most previous work considered intelligent cruise control and lane sensing separately.

Approach:

Our approach is to use a three-dimensional vision system for both intelligent cruise control and lane sensing functions. This integrated approach is expected to be more effective than addressing those two functions separately. In the first step, the distance to each vertical edge is calculated by using real-time three-dimensional vision system described on page 15. In the second step, a histogram is calculated as shown in Figure 1.
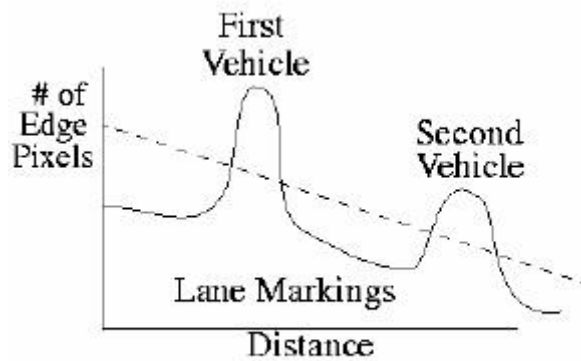
Figure 1: Histogram with Threshold Line

The vehicles have a large concentration of edges at a particular distance and the lanes have a small number of edges at the majority of the distances. Therefore the vehicles correspond to the peaks in the histogram and the lane markings correspond to the lower region of the histogram. Thresholding is used to distinguish the lanes from the vehicles indicated by the dotted line in Figure~1. Figure~2 is a diagram of how the system distinguishes between the lanes and vehicles. Figure~3 shows the center original image, edge image and depth map. The colors correspond to the various distances. This information along with lane sensing creates an intelligent cruise control system.
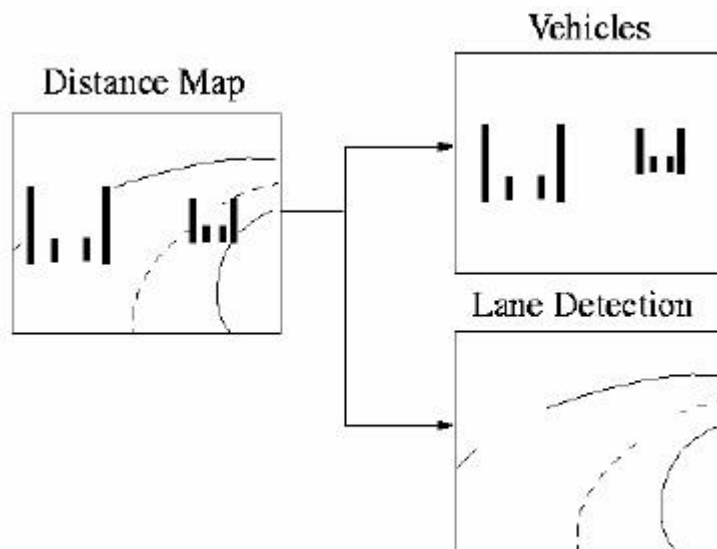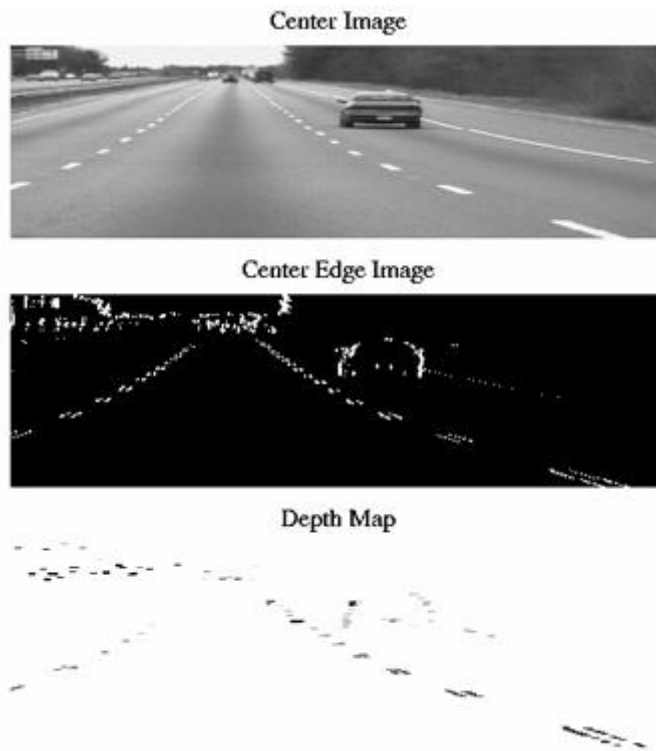

Figure 2: Vehicles and Lanes

Center Image

Center Edge Image

Depth Map

Figure 3: Depth Map

Current Status and Future Work:

Early experimental results were obtained as shown in Figures 4 and 5, and some improvements are under way.

Figure 4: Car Elimination

Figure 5: Lane Sensing