Standalone Motorcycle Detection and Counting System Using Microphone Array, Stereo and Infrared Cameras

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June 5th, 2012
Presentation Outline

- Problems and existing methods
- Our approach
- Hybrid sensor for motorcycle detection
- Algorithm processing chain
- Performance evaluation
- Questions
Problems and Existing Methods

- The detection and counting are the key to enhancing motorcycle safety, motorcycle operations and motorcycle travel estimation. Average motorcycle fatalities per Vehicle Mile Traveled (VMT) are currently estimated at 30 times those of auto fatalities.

- Although it has been an active research area for many years, motorcycle detection and counting still remain a challenging task.

- Parameters such as visual length, visual width, and pixel ratio were used to detect the classes of motorcycle. This detection strategy is essentially to search for helmets to detect the motorcycles, which is not robust enough.
Other methods such as background subtraction and vehicle modeling have been reported. Although these methods are applicable for some vehicles and motorcycles, they are not robust enough for practical applications since the background is highly dynamic, and generic models for vehicles do not exist.

The feature-based classifier was reported to distinguish motorcycles from vehicles. The algorithm extracts some visual features focusing on the wheel regions of the vehicles. However, the camera needs to be installed accurately to capture the wheels, which is not always possible due to occlusions.
Our Approach

- Under FHWA SBIR program, we have developed a hybrid sensor for the detection of motorcycles. It is made of stereo camera, thermal IR camera and microphone array.

- The stereo camera is used to detect the motorcyclist, thus the motorcycle.

- Thermal IR camera is used to detect motorcycle through the thermal signature of hot engine.

- Microphone array is used to detect motorcycle through its unique low frequency signal components.

- The detection results from each of them are fused to achieve a better detection accuracy.
Hybrid Sensor

- IR LED Stereo Camera
- WiFi Antenna
- Microphone Array
- Thermal IR Camera
Sensor Signals

Stereo Images

Thermal Image

Acoustic Signal
Microphone Placement

- There are three unidirectional microphones in the microphone array, covered with wind screens.

- Their locations on the sensor platform were carefully selected through a series of experiments and analytical analysis. They are strategically placed to minimize the interference from surrounding sound such as rain and wind.

- Algorithms were developed to compensate the saturation of acoustic signals because the saturated acoustic signals have more low frequency components and could cause false detections.
Motorcycle Detection Using Stereo Camera

- Disparity map is estimated from a pair of stereo images. Motorcyclist is windowed out and detected through human body 3D features. Motorcycle is detected if motorcyclist is detected.
Motorcycle Detection Using IR Camera

- Thermal signatures of motorcycles and vehicles are different and can be used for their discrimination.
Motorcycle Detection Using Microphone

- Acoustic signal of motorcycles have more low frequency components which can be used for their detection.
Algorithm Processing Chain

- Stereo images, thermal images and acoustic signals are acquired from the hybrid sensor.
- Each sensor software module processes data in sequence.
- AND fusion is applied to ensure lower false calls, which is very important.
Some Detection Images
Performance Evaluation

- We have continuously collected data during daytime over a long period of time at our own test site that is next to a major highway, Rt. 1, in Walpole, MA. Images are saved and manually scanned to extract the ground truth.

- Detection results are compared with the ground truth. Both detection rate and number of false calls per hour are estimated. The detection rate is estimated based on the number of detections against the ground truth.

- Because of continuous vehicle flow, false calls are inevitable. We measure the false call rate as the number of false calls per hour.
Based on the live tests conducted at our own test site next to a major highway, the overall detection rate is over 90% on average.

The number of false calls is closely associated with the number of vehicles traveling on the road. Almost all of the false calls are from vehicles.

Based on the test results, the average number of false calls per hour is about 0.3% of vehicle volume per hour. There are about 1,000 vehicles per hour at our test site, and the number of false calls is about 3 per hour.
Performance Evaluation (cont’d)

- Although 0.3% false call rate over vehicle volume is low, the number of false calls could be too high if there are more vehicles per hour.

- One effective way to statistically improve the motorcycle counting accuracy is to estimate the vehicle volume and subtract 0.15% of vehicle volume from the motorcycle count.

- This approach can increase the motorcycle counting accuracy statistically, but requires that the motorcycle counting system is also capable of counting vehicles.
Performance Evaluation (cont’d)

- We have developed a vehicle volume estimation module using thermal IR camera. Its accuracy is over 95% based on a large amount of vehicle data collected at the highway where there are over 1,000 vehicles per hour.

- We are confident that thermal IR camera is very effective to count vehicles travelling individually or in group.

- Using vehicle volume estimation, our motorcycle detection and counting system has over 90% detection rate and about 1 false call per hour.
Conclusion

Under FHWA SBIR program, we have developed a new hybrid sensor for the detection and counting of motorcycles. This system has been independently evaluated by TTI at a motorcycle rally in May 2012.

This system features a number of new technologies including thermal IR camera for the discrimination between motorcycles and vehicles, stereo camera for the detection of motorcyclist, and acoustic signal for the detection of motorcycle from its low frequency signal components.

Vehicle volume can be estimated using thermal IR camera and has been incorporated into the motorcycle counting scheme to achieve lower number of false calls.
Questions

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