SPITS Road Side Sensor System

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Abstract

Intelligent Transport Systems (ITS) promise more safety and comfort, a smoother traffic flow, and a higher road capacity. A test site is required to implement, demonstrate and evaluate new ITS applications. We have developed and realized a 4.8 kilometer test site that is fully equipped with sensors and communication devices on the Dutch A270 highway. This was done within the SPITS project, a Dutch project tasked with creating ITS applications to improve mobility and safety. At the test site, SPITS has demonstrated intelligent traffic management applications such as local shockwave damping and assisted merging from the entrance ramp.

This paper describes the sensor system of the test site. The system contains 48 video cameras at intermediate distances of 100 meters. These cameras detect and track all individual vehicles throughout the entire test site. The sensor system integrates and fuses these vehicle trajectories with available floating car data. For every vehicle on the test track the speed and the longitudinal and lateral position is precisely known. This information is instantly available for the ITS services, as the data is processed real-time on a computer cloud along the road. In addition to the current ITS demonstrations, the test site can be used for research by traffic experts to improve their understanding of traffic flows and traffic behavior. In the future the test site will be deployed for more ITS experiments that are currently being designed. The precise and highly sampled vehicle trajectories deliver a unique insight into the working of these applications.

1. Introduction

Intelligent Traffic Systems (ITS) are made to improve mobility, safety and comfort. SPITS is a Dutch project that explores new ITS concepts. Applications, such as dynamic traffic management, shockwave damping and assisted merging, are tested and demonstrated. Therefore a test site has been realized consisting of 4.8 km of open freeway. A communication infrastructure and a sensor system are deployed along the entire trajectory. The sensor system monitors and tracks the vehicles and provides the applications with information. Applications use the trajectories of the vehicles to give advice to instrumented vehicles.

This paper describes the SPITS roadside sensor system. Cameras are placed along the test site at intermediate distances of 100 meters. The sensor system integrates data from cameras and floating car data. The sensor fusion takes into account the individual characteristics of each type of sensor to achieve maximum accuracy.

2. Sensor system

The road side sensor system of the SPITS project detects and tracks vehicles over a distance of 4.8 kilometers. Therefore the system includes many sensors that are placed along the route. The data of the sensors are fused to vehicle trajectories. A vehicle trajectory contains the position of the vehicle over time. The road side sensor system of the SPITS project may include different sensor types. Within the SPITS project two different sensor types are used and evaluated.

2.1 Sensors

Video Base Monitoring (VBM)

Using cameras alongside the road (placed at 100 distances), individual vehicles are detected and tracked. Figure 1 shows an impression of the camera images and the detection and tracking of the vehicles. The tracking is done using an advance sensor fusion algorithm.

Figure 1 VBM detections and tracks

Floating car data

A few percentage of the vehicles during the SPITS experiments have an on board unit, that broadcasts the position, speed and acceleration of the vehicle to the roadside.

These two type of sensors have different characteristics. VBM determines the lateral direction precisely and computes accurate short distance speed updates. Floating car data has a high speed and acceleration accuracy, but only a part of the vehicle fleet is instrumented. VBM has the unique ability that the video is available for visual inspection during experiments and can be looked back afterwards for evaluation.

2.2 Sensor fusion

The sensor system contains many sensors along the 4.8 km test site. All sensors deliver detections, which contain at least a timestamp and a position in a common coordinate system. They may also contain other information about the detection, such as speed and vehicle length. The data of these sensors are fused to unique vehicle tracks.

The sensor fusion tracking architecture contains the following steps:

1) detection-track association: New detections are associated to existing tracks. For each detection-track combination, an association likelihood is calculated. This likelihood depends on the predicted track position, the actual detection position and certain features of the detections. An example of such a feature is the accuracy and the probability of the detection position that is given by sensor. The detection-track combinations with the highest likelihoods are associated. Detections which are not associated, initiate new tracks.
2) track updating: After the detection is associated, the track is updated with a new current position using a Kalman filter. This position is a weighted sum of the predicted position and the detected position. The weights depend on the accuracy and the probability of the associated detection.
3) track prediction: New track predictions are made for the next timestamp. These are used in the next iteration to associate future detections to the current tracks.

The tracking results are communicated to the road side unit system. The road side unit is used by the ITS applications to retrieve the current traffic situation.

3. Results

In the SPITS project a test site is realized with 48 cameras over a distance of 4.8 kilometer (figure 2). The floating car data from instrumented vehicles is integrated into the sensor system.

The cameras are connected to a fiberglass network. 17 high end PCs in the server room do the processing of the cameras. Each PC processes three cameras. The data fusion with the tracker architecture runs on one PC. Data from other sensors are integrated in the tracker PC.
Figure 3 shows vehicle trajectories of a cooperative driving experiment. The position of the vehicle in driving direction is shown over time. The speed advice is based on the real-time

vehicle trajectory data. Afterwards the trajectories are used to evaluate the experiment. This experiment showed that shockwaves can be detected and dampened directly to get a smoother traffic flow. This resulted in a higher road capacity.

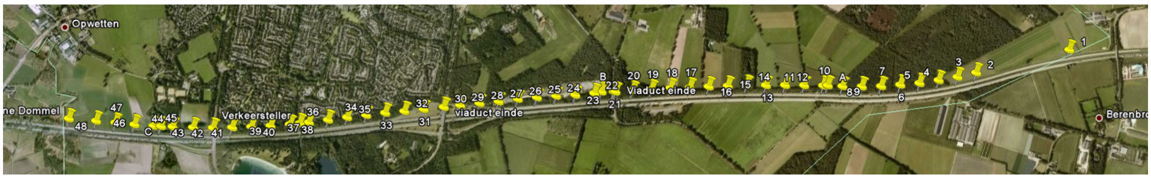

Figure 2 Ground plane of the test site with the camera positions.

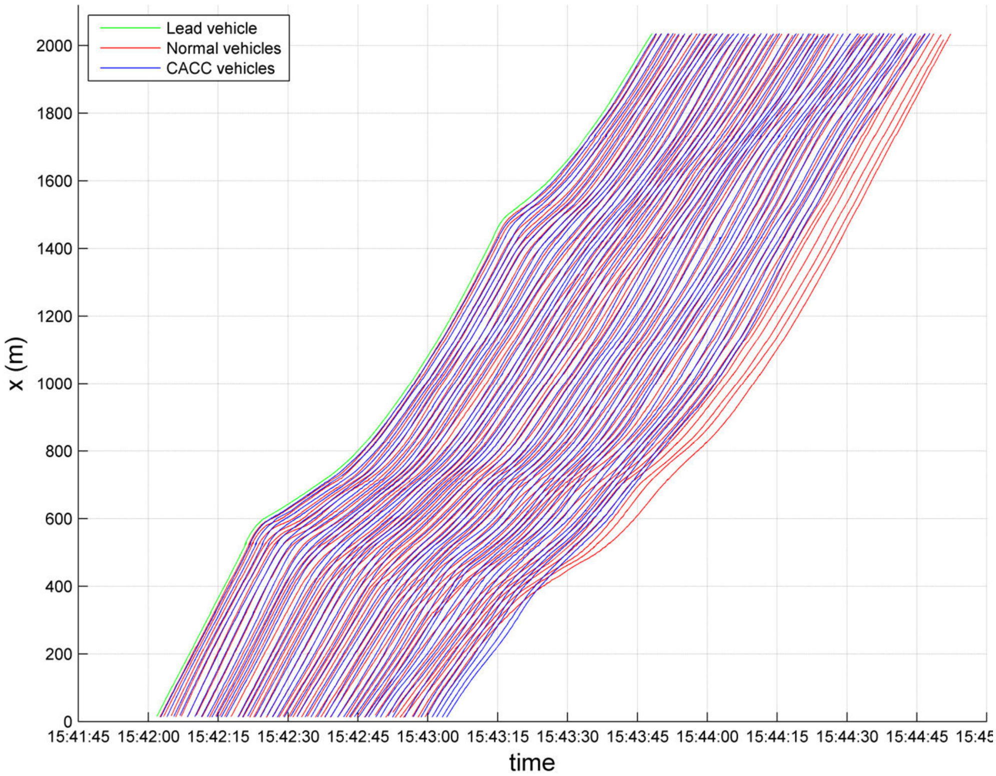

Figure 3 Vehicle trajectories of a cooperative driving experiment. Each line represents the position of the vehicle in driving direction over time. Red lines are vehicles on de left lane, which are not instrumented. Blue lines are vehicles with a speed advice instrument. The sensor system is able to track all vehicles over the entire test site.

4. Conclusions

The sensor system of the SPITS A270 highway test site computes accurate vehicle data real-time over a distance of 4.8 kilometers. The tracking system integrates information from different type of sensors. A maximum accuracy is achieved by exploiting the benefits of the different sensors.

This vehicle trajectories are deployed by ITS applications to deliver vehicle-specific advises to the instrumented vehicles. The data are also used for thorough evaluations of the applications. In addition to the current ITS demonstrations, the test site can be used for research by traffic experts to improve their understanding of traffic flows and traffic behavior. The precise and highly sampled vehicle trajectories deliver a unique insight in how vehicles interact.