OPERATIONAL TRAFFIC MANAGEMENT BY USING VIDEO DETECTION

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ABSTRACT

Continuing to compare video detection with traditional detection technologies such as inductive loops makes no longer sense: It is true that first generation video detectors looked like nothing less than a kind of optical loops. It is equally true that the output from video detectors was often similar to what already existed. The reasons for these facts are obvious: The video detectors had to look familiar so that they could be more easily accepted by traffic operators. And the output of the new type of detector had to be compatible with existing traffic management systems.

But video detection has broken several barriers since its first appearance on the traffic scene: From triplewire systems like CCATS (Camera and Computer Aided Traffic Sensor), over line following systems like CCIDS (Camera and Computer aided Incident Detection Sensor) to wide area detection like CTRACK (Camera Tracking): Besides statistics, video detectors also offer AID (Automatic Incident Detection) which includes stopped vehicle or queue formation detection.

Obviously, the installation without closing roads or excavating the road surface and the fast repositioning of detection zones on a monitor are major advantages. Off-site analysis back at the office using video recordings of the traffic scene is another option.

But perhaps the most striking features of video detection is the transparency: Like other kinds of detectors, video detector boards can have LED signals to indicate proper functioning. Likewise, features such as detection quality or confidence level are programmed into the detection software. But imagine a detector where you can actually see whether it is functioning properly by simply watching the vehicles passing over the detection zones on a monitor. Video detection by its very own nature offers a kind of quality control no other kind of detector can match.

In this paper, the major reasons for using video detection for traffic monitoring and incident detection are discussed. Video detection is presented as the means by excellence to provide correct traffic data for both a reactive and a pro-active traffic management. A brief overview of Traficon detection algorithms is offered as a real world illustration of video detection principles. Video detection can be used in tunnels, on highways and at intersections. Installation and maintenance requirements essentially focus on the camera. To conclude, information on accuracy is provided.

INTRODUCTION

Large-scale applications of video detection technology are now feasible. It took years of continuous development. Now the required components for these systems are both high quality and affordable. Product reliability and accuracy on smaller applications have given professional users the confidence to invest in video detection systems on a large scale and these have proven to be successful too. Targeted application domains are traffic data collection and incident detection on highways, in tunnels and on intersections. Some techniques are similar to traditional traffic detectors (e.g. inductive loop detectors) while others offer the user additional features or something completely different:

- Providing conventional traffic parameters using a set of optical loops in a video image
- Following vehicle patterns on a series of detection lines
- Tracking vehicles in definable zones
- Providing digitized images based on standard JPEG compression
- Establishing transmission of both data and images

Especially when considering traffic safety, video offers new options: Traffic managers can easily obtain the information needed for the efficient handling of incidents. Road users can only benefit from a fast availability of information. If properly used, the information may lead to an enhanced safety level (by avoiding secondary incidents) and to a reduction of the time lost in traffic jams. Furthermore, wide area detection by means of video can lead to a reduction of air pollution by enabling a smoother traffic flow.

ADVANCED TRAFFIC MANAGEMENT

Advanced traffic management is based on the principles of **management by exception** and is both **pro-active** and **reactive**.

Traffic management by exception means that the traffic manager should focus on the problems in the traffic situation and that he should not be overloaded with excessive information. Only by providing the traffic manager with the most relevant information for action can effective traffic management be achieved.

This can be accomplished by automating the control functions where and whenever possible:

- Traffic flow – speed limits
- Limited overtaking
- Warning panels

All these can be run automatically, with information sent to the traffic manager when needed. The possibility to overrule or adapt decision parameters manually remains available.

As for video information, the aim is certainly not to overload the traffic control room with plenty of monitors. Only the number of monitors required to overlook the problem situation (and especially the sectors that are in need of monitoring) should be present.

Pro-active traffic management means that it is feasible to design a system that collects traffic data without human interference, to select the abnormal situations and trends, to use these to set the different controls and to inform the traffic manager on the action taken. The main purpose of these controls is to prevent incidents as long as possible.

Reactive traffic management is based on incident detection . The most important characteristics of incident detection are:

- High detection rate
- Short time to detect
- Small false alarm frequency
- Fast incident verification

This must allow effective incident management actions such as:

- Fast and effective intervention (especially where victims are concerned)
- Secondary incident prevention
- Fast recovery of the traffic flow (economic factor)
- Efficient dissemination of the incident information

Video detection can provide all data required as input for these actions. Moreover, all these features are available in one integrated system.

VIDEO DETECTION: OUTPUT & APPLICATIONS

What is video detection

Video Image processing is a relatively new technology for traffic- and incident detection. The Traficon video detection technology is based on 15 years of experience in this field with approximately 2500 video detectors operational worldwide. Three major families of detection algorithms make up the core of Traficon products:

CCATS: Camera and Computer Aided Traffic Sensor

CCATS analyses the variation of the gray levels of a series of pixels on the video image. A group of pixels (one or more detection lines) is called a detection zone. These zones can be positioned on the image in an interactive and easy manner (See Figure 1). With this type of detector, the traditional traffic data (such as volume, traffic density, concentration, occupancy, speed, length and length classification) can be obtained.

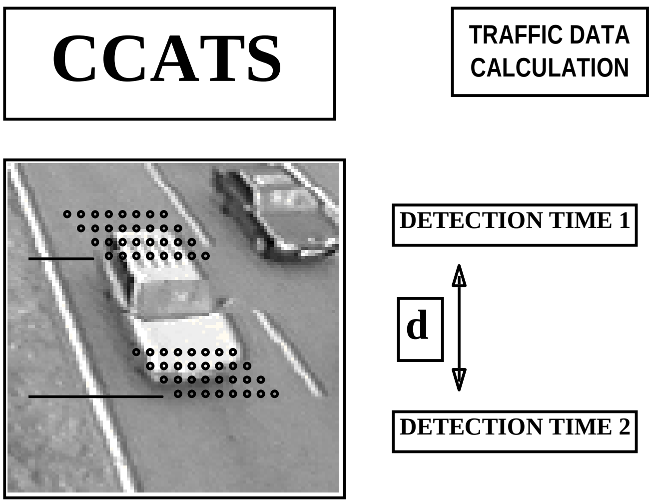

Figure 1. CCATS traffic data and queue detection

CCIDS: Camera and Computer Aided Incident Detection Sensor

Stopped vehicle detection

CCIDS analyses the gray level profile of a long line consisting of several pixels. By positioning the detection lines in parallel with the route of the vehicles on the road, CCIDS can follow the vehicles alongside that line. This tracking allows to detect stopped vehicles. Precisely on this rapid detection of stopped vehicles is the automatic incident detection (AID) based. Figure 2 illustrates the basic principle of the CCIDS algorithm.

Traffic speed monitoring

Calibrated CCIDS detection lines can be used to measure traffic speed. Even in a queue or in stop & go traffic situations, the analysis of the movement on those lines allows very accurate speed measurement. Following the movement is also used to detect the direction of a vehicle, which enables the detection of vehicles driving in the wrong direction.

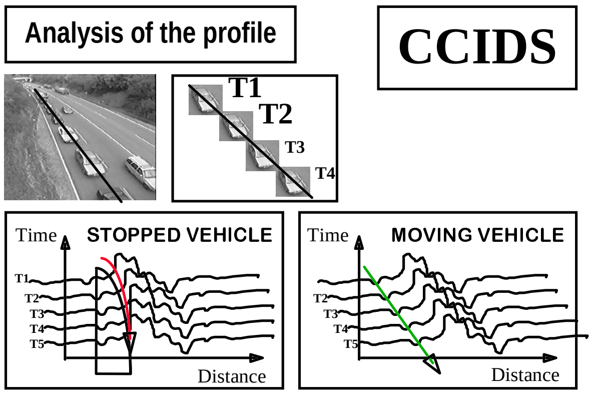

Figure 2. CCIDS gray level profile analysis

CTRACK: Camera Tracking Sensor

A video image is analysed as a matrix of detection pixels. Each pixel reacts on the passage of a moving vehicle. The analysis of the movement of one or several groups of pixels in the matrix-zone is used to analyse the vehicle movements in the video image. (See figure 3). CTRACK provides the basic information to detect the presence of stopped vehicles or to detect turning movements.

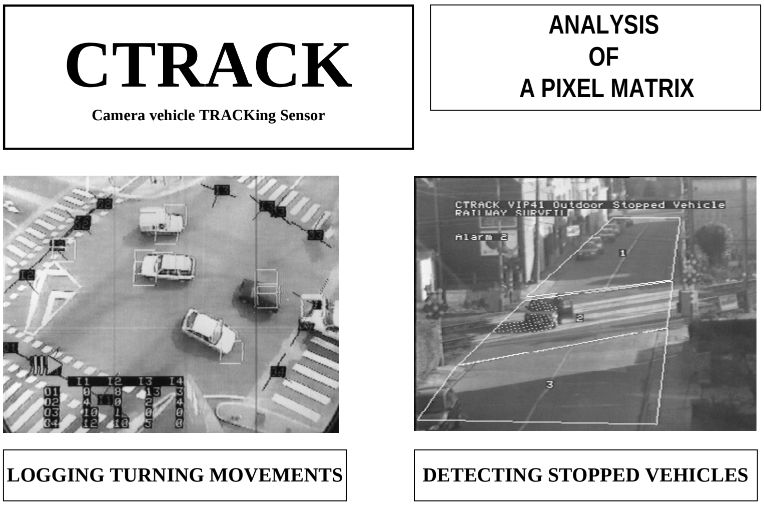

Figure 3. CTRACK

Stopped Vehicle Detection

The CTRACK VIP41 Outdoors Stopped Vehicle Detector is an incident management tool: It detects stopped vehicles outdoors.

Origin - Destination Analysis

CTRACK VIP42 Turning Movement Logger is revolutionary new. It is used for automating traffic data collection at intersections and small roundabouts. The algorithm is used to detect a vehicle the moment it arrives at or departs from the intersection and track its movements on the intersection. The counting results (per direction) provide an impression of the relative importance of the arteries of the monitored intersection.

Application domains

<u>Tunnels: Safety first</u>

Even when using video detection as the only tool for information gathering, several functions can be satisfactorily performed. Examples are:

- Automatic switching of the CCTV system to the incident location
- Fast information and alarm exchange with rescue services
- Increase of ventilation
- Warning panels and messages both inside as outside the tunnel
- Lane and/or tunnel closures

The automatic flow monitoring and incident detection will inform the traffic manager within seconds of any anomaly happening in the tunnel. This short detection time can help to save lives.

Highways: Coping with queues

The corner stone of our approach to dealing with queues is the accurate measurement of low speeds. The algorithm of one of our detectors allows us to follow traffic movement, even in stop and go traffic, while measuring speeds from 0 to 150 kilometers per hour.

This information is now being used for calculating the expected travel time and locating the queue tail in a European project called AVS-TDC (Advanced Video Surveillance - Time to Destination Calculation). Warning road user in advance by displaying messages on VMS will help to prevent queue tail incidents and the subsequent closure of lanes. This information can also be distributed to the road users, so that they can adapt their time schedules or take an alternative route.

But not only safety and mobility can be improved in this way: The environmental hazard of high ozone concentrations could be countered as the length of queues is being reduced. Transmission of compressed images (e.g. in case of traffic jams or other incidents) to the traffic control center remains an available option.

Intersection control

Cameras in combination with presence and turning movement detectors are used as input for intersection control. Nowadays, sensors detect the directional presence of a vehicle waiting or approaching an intersection. Some sensors can also monitor the speed and the occupancy when no vehicles are waiting. This opens completely new possibilities for optimizing traffic light controllers. It seems only logical to take this one step further to the integration of the detection sensor in higher level traffic control systems like SCATS or SCOOT.

Compressed video images of the local traffic situation can be sent to a traffic control center in case of abnormal traffic behavior. Here the off road installation is a major argument: The system can be installed without road closures and has a very high reliability. This is especially interesting when one knows that in many countries at about 30% of the intersections the inductive loops have broken down and immediate repair is too expensive.

INSTALLATION CHARACTERISTICS

The main installation characteristics are focussed on camera characteristics and can be summarized as follows:

- Camera position
- Focal length
- Distance between successive cameras
- Camera angle
- System architecture
- Maintenance of cameras

The camera should be placed as high and as near to the middle of the road as possible. A solid mounting is obviously preferred.

The longer the focal length, the further one can detect stopped vehicles. But a long focal distance limits the view on traffic near the camera. The selection of the appropriate camera objective will be determined by the type of application (e.g. counting and speed measurement or stopped vehicle detection). For a full coverage of a road stretch or tunnel, the distance between successive cameras is another important factor.

The camera should be mounted in such a way that there is no light flashing directly into the camera. Usually, the top line of the image is just below the horizon. When accurate speed and classification information is requested, the camera angle should be 45°.

The simplest architecture is the one in which all the video images arrive in one central unit where the video processing and the switching can be done. This saves on communication modems, individual power supplies, housing and maintenance costs.

The maintenance consists largely in the cleaning of the cameras. This is often done together with the cleaning of the illumination. A two-three monthly cleaning is sufficient. It makes no sense to use special camera housings with automatic water and wiper functions. After maintenance, the position of the camera must be checked: Bad detection results could be caused by misplaced (i.e. moved) detection zones.

OPERATIONAL PERFORMANCE

A report on video image processing systems in transportation was published by Calpoly in 1995 (1). In the framework of the DRIVE V2022 Euro-Triangle project (Busch F.ZHang X et al. 1995), guidelines for incident detection were presented (2).

A full evaluation during 6 months in 1996 in the EKEBERG TUNNEL in Oslo gave the following global results:

Detection Rate	> 99%
Mean Time To Detect	10 seconds (no occlusion situation)
FAF/day/camera	< 0,025 per day per camera

An evaluation study of video image processors for road traffic took place in June 1996 at Bern, Switzerland (Eggiman & Tschirren, June 1996)(3). In the final report, video detection systems were described as being very useful and able to meet requirements with success. Their large flexibility and reduced need of maintenance were considered to be an open invitation to use video image processors within the traffic domain.

In the report of the comparative test of image processing traffic detection systems from January 1997 at Stockholm, Sweden (Lindgren, January 1997)(4) both traffic data collection and incident detection tests were carried out.

At present and provided that the camera position is good, the expected performance of our detectors is as indicated below.

Table 1. Expected performance CCATS

Counting	Speed	Queue	Time to Detect
> 98 %	> 95 % show error within 5%	99%	< 20 sec

Table 2. Expected performance CCIDS

	Detection rate	False detection frequency	Time to detect
Stopped vehicles	> 99%	< 0,025 per camera/day	10 sec.

CONCLUSIONS

The use of video signals for detecting traffic data and incidents has proven to be reliable as a means for improving safety, while keeping the road capacity at an optimum.

1. It is cost effective.
2. It is efficient.
3. It is reliable.
4. It is transparent.
5. The required traffic data are provided.
6. Installation requirements essentially focus on the characteristics of the camera.
7. These conclusions are based on the experience of more than 2500 operational video detectors.

END NOTES

1. Alypios Chatziioanou et al., “Video Image Processing Systems Applications in Transportation Phase II Final Report”, (California Polytechnic State University, San Luis Obispo, California, 1995)
2. Busch F.ZHang X et al., (Ertico AID Task Force), “Guidelines for implementation of Automatic Incident Detection Systems”, (April 1995)
3. Eggiman S & Tschirren J., “Benchmarking Bildverarbeitungssysteme für den Strassenverkehr”, (Bern, June 1996)
4. Lindgren S., “Final Report of the Comparative test of Image Processing Traffic Detection Systems at Klarastrandsleden - Centralbron”, (Stockholm, Sweden January 1997)

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