Testing and Field Implementation of the Minnesota Video Detection System (AUTOSCOPE)

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Vehicle detection by video cameras is one of the most promising new technologies for wireless large-scale data collection and implementation of advanced traffic control and management schemes such as vehicle guidance and navigation. The breadboard fabrication of a wide-area multispot video imaging detection system (AUTOSCOPE) has been described previously. Recent developments concerning this detection system are described. Earlier work leading to its present state and the advantages of the AUTOSCOPE over other emerging devices are summarized. The new elements include preproduction prototype development, field testing, and plans for extensive field validation and verification. The latter include two large demonstration projects recently initiated in Minneapolis. In the first project, the AUTOSCOPE is used for incident detection over a section of Interstate 394; the second project involves implementation of the AUTOSCOPE at a signalized intersection.

As the problem of urban traffic congestion spreads, there is a pressing need for introducing advanced technology and equipment to improve the state of the art of traffic control. As a result of increased research and development funding worldwide, many new concepts and ideas are available to meet this objective. However, vehicle detection is the weakest link in implementing the most sophisticated traffic control concepts that have surfaced over the last several years. Detection through video image processing is one of the most attractive alternative new technologies as it offers opportunities for performing substantially more complex tasks than wireless detection. This concept entails detection of vehicles and extraction of traffic parameters in real time from images generated by video cameras overlooking a traffic scene.

Because of its conceptual appeal, major worldwide efforts have been initiated for developing a practical device. Development of a wide-area multispot video imaging detection system (AUTOSCOPE) was initiated at the University of Minnesota in 1984. Once funding was obtained from the Minnesota Department of Transportation (Mn/DOT), from FHWA, and from university sources, a fieldable preproduction prototype was completed and demonstrated in live benchmarks in several U.S. and European cities.

Michalopoulos et al. (*1*) have described the breadboard system design of the AUTOSCOPE and provided laboratory test results. Recent developments concerning the AUTOSCOPE and earlier work leading to its present state and its advantages over other similar emerging devices are summarized herein. The new elements are the development of the preproduction prototype, field testing, and plans for extensive field validation and verification. These plans are being implemented through two demonstration projects that were recently initiated in Minneapolis. In the first project, the AUTOSCOPE system is demonstrated on a large scale, tested extensively for robustness and reliability under continuous operation for 6 to 9 months at two freeway locations, and compared with loop detectors. In addition to these tests, software for automatic incident detection is being developed for implementation of Interstate 394, currently under construction in the Minneapolis–St. Paul metropolitan area. A system of approximately 25 coordinated cameras is used for implementing the incident detection portion of the project. This system also provides a unique large-scale laboratory facility for studying traffic characteristics. The second project involves implementation of the machine vision system at a signalized intersection and interfacing it with the controller to demonstrate its capability for replacing loop detectors.

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BACKGROUND

Vehicle detection appears to be the weakest link in traffic surveillance and control. Detection equipment available today for sensing vehicle presence on the roadway essentially uses technology of the late 1950s, has limited capabilities, presents reliability problems, and more often than not requires extensive and expensive installation for traffic-responsive control. The latter is particularly true in state-of-the-art surveillance and control systems, which often involve large-scale street or freeway corridor networks. With respect to reliability, most cities with mature systems in the United States report that at any given time 25 to 30 percent of their detectors are not functional or are not operating properly.

Perhaps the most important drawback of existing detectors is their limitation in measuring some important traffic parameters and accurately assessing traffic conditions. This limitation is because the technology represents a blind type of detection, that is, only the presence or absence of vehicles over the detectors can be assessed with sufficient accuracy. Traffic parameters such as speed, traffic composition, and queue length must be derived from presence or passage and therefore require multiple detection, which increases cost and exacerbates the reliability problems mentioned earlier. Furthermore, common detectors (such as loop detectors) do not have visual surveillance capabilities, and their placement is not flexible, that is, they detect traffic only at fixed points.

Among the most promising new concepts today for effective wireless vehicle detection is through video cameras (machine vision). A machine vision system for vehicle detection consists of an electronic camera overlooking a long section of the roadway; from the images received by the camera, a microprocessor determines vehicle presence or passage and derives other traffic parameters, preferably in real time. Figure 1 shows schematically the preproduction prototype of the video detection system. The concept of using video image processing for traffic surveillance and control is not new. Because of its conceptual appeal, research was initiated in the mid-1970s in the United States and abroad, most notably in Japan, France, Australia, England, and Belgium (*2–13*). Despite major worldwide efforts to develop a machine vision system for traffic surveillance and control, a real time fieldable device having the capabilities and performance required for practical applications has not been developed. Even though performance claims have surfaced in recent years, specific functionality performance and reliability verification are still lacking. No practical installations are presently known; the few installations that exist are experimental. However, recent advances in image processing, electronic cameras, special-purpose computer architectures, and microprocessor technology have made the machine vision alternative for vehicle detection attractive, economical, and promising.

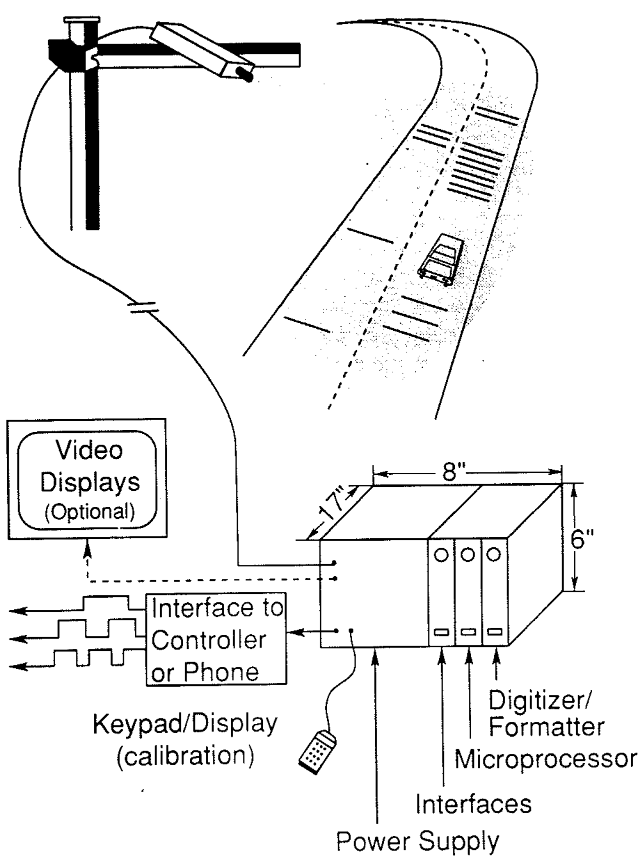

FIGURE 1 Real time AUTOSCOPE fieldable configuration.

Because of the many advantages of vehicle detection through video image processing, research concerning its feasibility and breadboard fabrication started at the University of Minnesota in 1984 (*14*). Funding was initiated by Mn/DOT through two successive projects: (a) feasibility and (b) breadboard fabrication. In 1987, FHWA awarded the same research team a contract for further detection algorithm development especially in the presence of artifacts; such artifacts include rain, snow, nighttime conditions, camera motion, fog, shadows, and their various combinations. Following the successful completion of these projects, a breadboard AUTOSCOPE system was developed, tested, and successfully demonstrated in live benchmarks in several North American and European cities.

FUNCTIONS—OPERATION

The AUTOSCOPE can detect traffic at many locations (i.e., in multiple spots) within the camera's field of view. These locations are specified by the user within minutes using interactive graphics and can be changed as often as desired. This flexible detection placement is achieved by placing detection lines along or across the roadway lanes on a TV monitor displaying the traffic scene. These detection lines are not physically placed in the pavement but only on the TV monitor. Every time a car crosses these lines, a detection signal (presence or passage) is generated by the device. This signal is similar to that produced by loop detectors. Thus, this video detection system emulates loop detectors and can easily replace them in existing installations. However, the advantages are that, in addition to being wireless, a single camera can replace many loop detectors, thus providing wide-area detection and cost-effectiveness.

By design, this video imaging detection system can be installed without disrupting traffic operations. Furthermore, it is not restricted to a particular detection configuration. The detection configuration can be changed manually or dynamically (i.e., by software as a function of traffic conditions). In addition to simple detection, the device shown in Figure 1 can also extract traffic parameters such as queue lengths that cannot easily or economically be derived by conventional devices, if at all.

FEASIBILITY STUDY

Phase I of the AUTOSCOPE development funded by Mn/DOT was initiated in 1984 and completed in 1985 (*14*). It established concept feasibility. Phase II, system breadboard fabrication and testing, was initiated in 1986 and completed in 1988.

During Phase I, schemes for video-based detection of vehicles were surveyed to determine the interest of the traffic control community as well as to evaluate previous development attempts. Functional requirements of a video-based detection were then defined, including derivable traffic data, accuracy of measurements, environmental conditions under which detection must occur, expected reliability, compatibility with existing equipment, and range of operation. A data base of colocated visible and infrared video data was collected from nine different locations in the Minneapolis–St. Paul area, with day, night, and varied weather conditions represented. Preliminary algorithms for presence, passage, and speed estimation were then developed and evaluated on videotaped data. The result was a preliminary off-line methodology for detecting presence and passage that was based on a combination of temporal and spatial features. Performance limitations caused by visibility, occlusion, and artifacts were studied. Finally, different potential sensor configurations were studied, and environmental constraints relative to the camera and processing electronics were estimated.

The findings of the Phase I study were promising. In the limited laboratory tests performed under fair weather conditions, passage detection during daytime was 98 percent accurate with 1 percent false alarms; during nighttime it was 94 percent accurate with 6 percent false alarms. This performance testing did not include artifacts caused by rain, snow, etc. Speed was determined to be accurate within 15 percent at 60 mph and within 7 percent at 30 mph. It was found that the real time video detection system could be built for the most part with existing technology, using off-the-shelf components. A visible detector was preferable to an infrared detector, on the basis both of performance and cost. Infrared detection had 70 percent daytime detection accuracy, 3 percent daytime false alarms, 92 percent nighttime detection, and 1 percent nighttime false alarms.

Night, rain, and snow did not offer insurmountable difficulties for vehicle detection. Severe fog could always be a problem. However, when fog is severe enough to create a problem for the video-based vehicle detection, drivers of vehicles have such limited visibility (of traffic lights and taillights of other vehicles) that they are best advised to pull off the road and not attempt to drive under such dangerous conditions. Traffic lights would operate in a pretimed mode in such cases.

The average installation cost per intersection was estimated to be 30 percent lower than for loop detectors, and maintenance cost was estimated to be 35 percent lower.

BREADBOARD FABRICATION AND TESTING

Following the successful completion of the feasibility study, a Phase II contract, for breadboard fabrication and testing, was awarded by Mn/DOT. Work on this contract began in 1986 and was concluded in December 1988. The overall objective of this project was the design and implementation of a system capable of robust video-based vehicle detection in real time, under fair weather conditions, that is, without the presence of serious artifacts such as snow, headlight reflections, occlusion, and camera motion.

The necessary software and hardware modules for implementing a real time vehicle detection system were developed in the feasibility study; some of these modules were then reused to construct the necessary algorithm development facility. Several ancillary tools were constructed for various support functions: a video disk interface for seeking and playing of sequences of frames on video disk under program control; a detector placement editor for setting up and editing of arbitrary detector configurations; and a ground truth editor to facilitate entry of the manually derived traffic parameters used to evaluate system performance.

A software module was devised to extract average image intensities. This module, termed the software formatter, was not capable of real time operation (i.e., 30 frames per second) and instead signal-stepped the video disk when ready for a new image. Subsequently, the hardware formatter, a hardware implementation of the software formatter that allowed for the real time extraction of detector intensity values, was created. The hardware formatter, developed along with support (test and setup) software, was integrated into a real time control system that repeatedly applied the detection algorithms to each frame video data in real time.

In addition, a result recorder that could be described as another real time system, hosted on a personal computer separate from that of the detection system, and that monitored system performance and displayed traffic measurements on a time-averaged basis, emulating the capability of a loop controller, was developed.

OTHER DEVELOPMENTS

Through competitive bidding following Phase II funding, the research team obtained FHWA funding for developing special detection algorithms to treat artifacts such as shadows, snow, rain, and pavement reflections (*14*). These algorithms allow the system to operate under all conceivable conditions for continuous all-year operation.

Following development of the initial algorithm, testing was performed for algorithm optimization using videotaped data. A video disk containing the most hostile environments (i.e., nighttime and rain, congestion and vehicle occlusion, and other combinations) for video detection was prepared from the tape for more detailed frame-by-frame validation to ensure reliability. Subsequently, the system was installed at the freeway surveillance and control center of Mn/DOT in Minneapolis and tested against live data from several cameras. The results to that point were encouraging, suggesting performance comparable to or better than that of loop detectors. For example, accuracy in volume measurements was on the order of 92 to 98 percent and speed accuracy (94 to 97 percent) was generally higher than that of loop detectors. More detailed field testing is currently underway.

Further funding for the development of a video-based vehicle detection system has been supplied by the University of Minnesota's Center for Transportation Studies. This money, appropriated by the U.S. Department of Energy, has been earmarked for the implementation of energy conservation technology, and has been invested in the AUTOSCOPE system to improve its ability to generate various indicators of energy efficiency with respect to traffic flow. To this end, funds were used to supplement development of the detection algorithm (especially regarding congestion), to make necessary improvements to the design of the hardware formatter, and to address problems encountered in adapting the system to work around the clock on existing surveillance facilities.

PROTOTYPE DEVELOPMENT

The completion of the breadboard system was only recently followed by development of a preproduction prototype that can be installed at a central location, such as a traffic surveillance center, and connected to live cameras located in the field. This arrangement is also shown in Figure 1. The system contains all the necessary components—video digitizer, hardware formatter, a microprocessor, and telephone line communications—required to extract volume, occupancy, speed, flow rate, headways, and other traffic parameters. Any or all of the traffic parameters measured from these detection spots can be transmitted to a central computer for control. In order to achieve the preproduction prototype, user interfaces for detector setup and initialization were improved, a printed circuit board version of the hardware formatter was developed, and sources for industrial versions of the microprocessor system were identified.

Additional functionality currently being completed includes vehicle classification, remote detector setup and initialization, and interfaces to traffic controllers for intersection control. With an interface to a traffic controller, the system will also be able to use the derived traffic parameters to control variable message signs for motorists as well as notification of impending congestion at a particular location.

The system is currently being tested in two chassis configurations. The first configuration is a shelf-mount, shoebox style that has dimensions of 8 in. high, 6 in. wide, and 17 in. long. The second configuration is a standard 19-in. rack mount configuration 8 in. high and 24 in. deep. The system can currently meet standard industrial temperature and shock ratings and can be installed in the field given that monitoring equipment is also installed that limits the system operation to within these specifications.

FIELD TESTING AND VALIDATION

The performance of the AUTOSCOPE system is being continuously evaluated as improvements are being made. Laboratory and field tests were presented as of summer 1988 (*1*). These tests were performed on almost 36 hr of videotaped data, and in two live cameras: one monitoring a freeway section and the other an intersection. In the live tests, all-day evaluations were performed. The 36 hr of videotaped data were selected from a videotape library of traffic sequences collected throughout the United States covering a large combination of artifact conditions (shadow, rain, snow, nighttime, reflection on cars or pavement, dusk, dawn, etc.) as well as congestion.

The on-line evaluations using live data were performed from cameras at the Mn/DOT Traffic Management Center (TMC). Michalopoulos et al. (*1*) provided the results of the first all-day live evaluation that was conducted in July 1988. The results of the second all-day evaluation, which was performed in January 1989, are provided herein. Between these two evaluations, improvements to the detection algorithms were made and tested in the laboratory both using videotapes and traffic sequences recorded on the optical video disks. The live evaluations required installation of the AUTOSCOPE system in the TMC, which monitors freeway traffic in the Minneapolis–St. Paul area through 38 camera installations. The AUTOSCOPE system was connected with most of these cameras to allow visual inspection of the detection outputs.

The second all-day evaluation of the AUTOSCOPE system was conducted on Friday, January 27, 1989 at the TMC. System performance was sampled for 10 min out of each half-hour, starting before sunrise (6:30 a.m.) and proceeding until after sunset (6:00 p.m.). The goal of this evaluation was to measure improvements to system performance since July 1988 (the last all-day evaluation), and, at the same time, assess performance during the dawn and dusk rush hours that occur during late fall and early winter. Because of the Mn/DOT camera placements, this evaluation was concentrated on freeway data. None of the camera placements are placed ideally for intersection detection nor close to heavily traveled intersections. Two video-based detectors were placed on the second and third lane of southbound I-35W just north of the 42nd Street overpass in Minneapolis. Performance of the system was tabulated with a manual count of the correct, missed, and erroneous detections in the same manner as the July 1988 on-line evaluation, except no intersection evaluation was performed in January 1989.

The evaluation took into account passage (volume) detection to determine how well the system counts vehicles. Performance was measured by counting three variables [i.e., the number of correct detections (number of errors)], as follows. A correct-passage detection was defined as a single turn-on of the detection signal that corresponded to a single vehicle. A missed-passage detection was a vehicle that passed under the detector without the detector's turning on. Finally, a false-passage detection was a detector that turned on with no vehicle passing under it.

From these three counts, the detection and error rates were derived. First, the total number of vehicles was determined, the sum of the total number of detected vehicles and the total number of vehicles missed. Then detection rate was computed as the ratio of the total number of detections to the total number of vehicles, and error rate was the ratio of the total number of errors to the total number of vehicles.

Table 1 presents the results from this all-day evaluation compared with the results of the July 1988 evaluation. A more complete picture of performance improvement is shown in Figure 2. The top line in each graph is the detection percentage, and the bottom line is the error rate. Detection performance improved 1.4 percent and the error rate dropped by 0.5 percent. Most important, performance was far more consistent across the course of the entire day than during the July 1988 evaluation, especially with respect to error rate.

However, once again the on-line evaluation was able to highlight problems with system performance that had been previously overlooked. The detection percentage (93.2 percent) was not optimal during this recent all-day evaluation for two different reasons. First, the placement of detectors was not ideal, causing vehicles to overlap one end of the detector. This caused a problem for vehicles of low contrast, causing the system not to count them. Thermal expansion of the camera mounting aggravated the problem over the course of the day, as the detectors drifted farther and farther from an ideal location. Up to 1 out of 10 vehicles were missed in any half-hour period because of this problem, which can most likely be corrected by better detector placement.

A second reason was responsible for the decrease of the detection percentage far below 90 percent, around 3:30 p.m. At this time of day, the detectors were within the mottled

TABLE 1 IMPROVEMENT IN RESULTS OF ON-LINE EVALUATION

	% Detection	% Errors
Jan. 1989	93.2%	1.8%
Jul. 1988	91.8%	2.3%

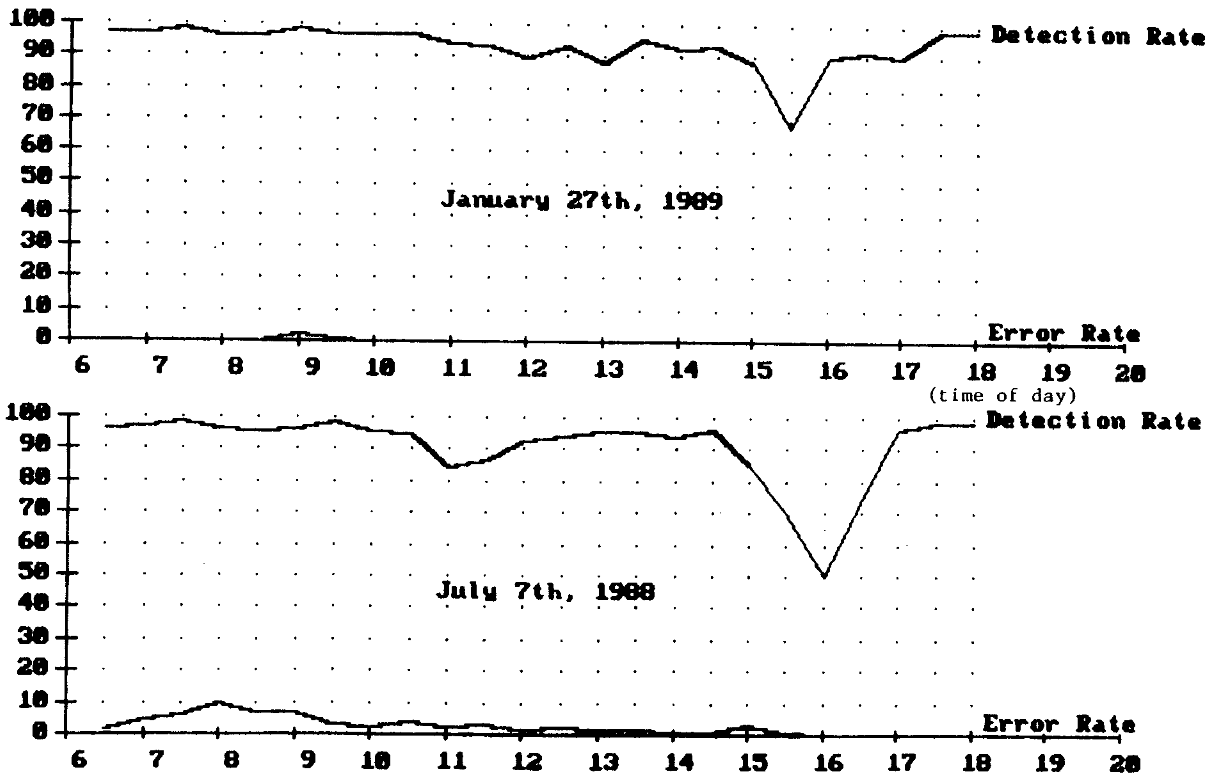

FIGURE 2 Improvement in AUTOSCOPE all-day performance.

shadow of a nearby tree. The strength of signals collected from vehicles in the shadow was judged to be insignificant by the algorithms, when in fact it would have been a simple matter to separate these vehicles from the background by better adjusting the significance level. However, in other imaging conditions encountered, the strength of the signal from the shadowed vehicles would have been in the noise, and a lower setting of the significance level would result in a much higher error rate. The technique used for the setting of the significance level has recently been improved, to improve the adaptation to different imaging conditions. Finally, the system ran continuously for 24 hr, since it had been installed and initialized at the TMC the previous evening. In this manner, the algorithms, software, and hardware have now been demonstrated in around-the-clock operation.

During the second on-line evaluation, the video detectors were placed near an existing detector station on southbound I-35W. After the on-line evaluation, the actual 5-min loop volumes and occupancies for this detector station were dumped from the TMC computer. In the laboratory the following week, the system was rerun on videotapes that had been collected simultaneously during the on-line evaluation, and the volume and occupancy (5-min averages) generated by the AUTOSCOPE system were compared with those collected from the detector station, for a 2-hr period from 16:00 to 18:00 hours. This period was chosen because of the relative difficulty of the following conditions: congestion, vehicle shadows, tree shadows, and transition to dusk. The measurements by both devices were close although AUTOSCOPE-generated volumes were consistently slightly lower than those of the loop detectors. Overall results of six different testing locations showing the range of accuracies found are presented in Table 2. Over 8 hr of video data was processed. Evaluations were done under light, medium, and heavy traffic flow conditions, with some occurrence of stationary and moving shadows.

The speed, total travel, and total travel time at these sites were evaluated by comparison with speeds collected by a radar

TABLE 2 OVERALL EVALUATION OF AUTOSCOPE PERFORMANCE AT SIX DIFFERENT SITES

Traffic Measure	Accuracy %
VOLUME	92.19 - 98.32
SPEED*	94.57 - 97.66
TOTAL TRAVEL	90.76 - 96.06
TOTAL TRAVEL TIME	92.08 - 97.21

* the speeds measured were in the range 40 to 65 mi/h (64 to 105 km/h).

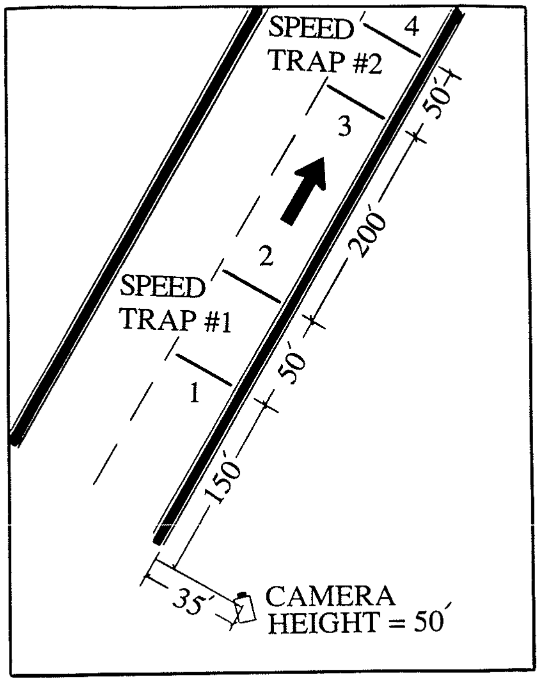

FIGURE 3 Comparison of AUTOSCOPE speed detection to radar detection at Test Site 2.

detector temporarily set up in the field. For example, at Test Site 2, shown in Figure 3, two speed traps were constructed in Lane 1, each trap 50 ft (15 m) in length, separated by 200 ft (61 m). A radar detector was mounted upstream from each speed trap. Results for Test Site 2 are presented in Table 3.

At Test Site 6, shown in Figure 4, the output of the AUTOSCOPE system was compared with the output of two collocated loop detectors, at two different times of day. Both outputs were contrasted to manually entered volumes. Results are presented in Table 4. In this test case, the AUTOSCOPE system actually outperformed the loop detectors.

FIELD IMPLEMENTATION AND FREEWAY DEMONSTRATION

Because the test results achieved to this point were encouraging, the next logical step was to implement the system in the field to facilitate its widespread use. Two field applications are currently underway in the form of demonstration projects. The first project, funded by Mn/DOT and the FHWA, deals with automatic incident detection through the AUTOSCOPE (unpublished proposal to Mn/DOT). The second project, funded by the Mn/DOT and the Minnesota Local Road Research Board, deals with implementation of the AUTOSCOPE at signalized intersections. The incident detection application, initiated in July 1989, was to consist of three phases. During the first phase (currently under way), a small-scale AUTOSCOPE demonstration was to be performed. The objective was to demonstrate that the AUTOSCOPE system can be used as a freeway mainline detection station in a loop detector replacement application. Convincing evidence should be presented showing that the AUTOSCOPE supports at least existing freeway surveillance and control functions. Elimination of the need for loop detectors permits the installation of video cameras both for automated surveillance as well as for manual viewing of traffic conditions. The ability to install and operate a fully integrated video surveillance and detection capability should lead to a significant increase in freeway management effectiveness while reducing the life cycle cost of surveillance and control systems.

Other important objectives were to be accomplished in the first phase. The system was to be extensively tested and validated in the field over a sufficiently long period of time (6 to 9 months) to ensure its robustness and reliability in future applications, to identify unexpected problems, and to fine-tune it. This testing involves continuous 24-hr operation under all weather, lighting, and artifact conditions. The second objective was to familiarize traffic engineers with the use of the system and to build their confidence with AUTOSCOPE capabilities, performance, and potential applications. The third objective was to obtain feedback for improving the design of the system for encouraging its use in advanced traffic monitoring and control applications. The last objective was to complete testing on the automatic derivation of traffic parameters and measures of effectiveness.

The small-scale AUTOSCOPE demonstration (Phase I) involves field installation at two locations on Interstate-35W in Minneapolis. In both sites, AUTOSCOPE was to be collocated with loop detectors for direct comparisons. Furthermore, an automated evaluation system is being built that compares the results both of the AUTOSCOPE and of loop detectors and saves the actual traffic sequences on videotape

TABLE 3 COMPARISON OF AUTOSCOPE TRAFFIC PARAMETER ESTIMATION TO RADAR-BASED MEASURES AT TEST SITE 2

Traffic Measure	Accuracy %	
	5-Minute Interval	Overall
VOLUME		
Detector #1	93.24 - 99.92	95.73
Detector #2	94.59 - 99.06	96.77
Detector #3	89.38 - 98.20	94.87
Detector #4	88.87 - 97.14	93.72
SPEED*		
Trap #1	93.47 - 99.87	96.90
Trap #2	92.83 - 99.93	97.14
TOTAL TRAVEL	92.42 - 99.27	95.39
TOTAL TRAVEL TIME	88.21 - 98.65	95.02

* the speeds measured were in the range 40 to 65 mi/h (64 to 105 km/h)

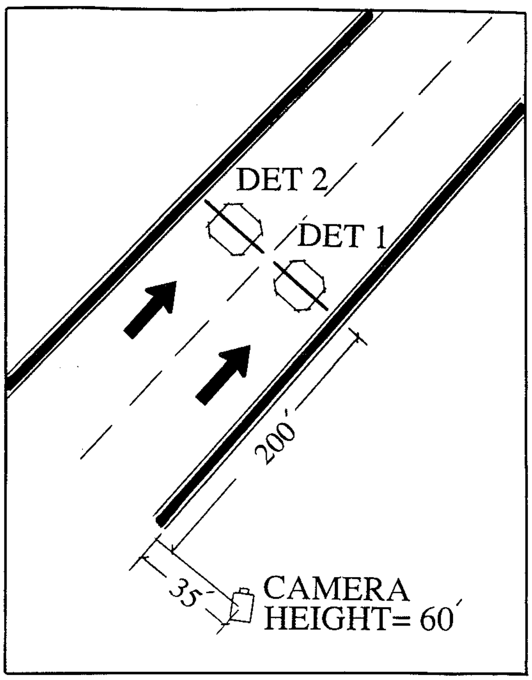

FIGURE 4 Collocated AUTOSCOPE and loop detectors at Test Site 6.

when discrepancies are diagnosed; in this manner, visual inspection will allow correct adjustments if the AUTOSCOPE is indeed malfunctioning. In the second of the two locations, a weather station for monitoring and recording weather conditions (wind, moisture, temperature, etc.) is installed along with two speed trap and volume stations monitoring four freeway lanes (using a total of 16 loop detectors). The first site involves a standard surveillance camera mounting (nonideal placement), whereas in the second site the camera is centered over the lanes being monitored (ideal placement).

The second phase of the incident detection application involves system design and engineering for automated incident detection using AUTOSCOPE technology. The design includes instrumentation on a selected section of Interstate 394 in Minneapolis for performing incident detection in both directions of travel (including reversible high-occupancy lanes). Design specifications are being developed including special equipment, interfaces, cabinets, and other components such as AUTOSCOPE system communications, cameras, etc. About 20 to 25 cameras are needed for the purposes of this project. The associated costs for all materials and equipment along with a time table for installation are currently being estimated. The design takes into account that the AUTOSCOPE information-gathering capabilities should provide a large-scale live laboratory for studying traffic characteristics, such as capacities under varying environmental and traffic conditions, merging, diverging, and weaving dynamics, shock wave propagation, queue formations and dissipation, etc.

The third phase of the incident detection application involves development, testing, and laboratory evaluation of a fully operational enhanced incident detection system through the AUTOSCOPE. This system should have reliable incident detection capabilities for the selected demonstration site on I-394, that is, from the I-94 interchange to the east side of the Trunk Highway 100 interchange. This incident detection system should also be generally applicable to other freeways. Given the AUTOSCOPE capabilities, it is expected that the incident detection system designed in this project should exceed the performance of existing ones. The design performance

TABLE 4 COMPARISON OF AUTOSCOPE PERFORMANCE TO LOOP DETECTORS AT TEST SITE 6

	Accuracy %	
	VIDS	Loops
I. (7:45 - 8:55)		
Detector #1	97.12	97.72
Detector #2	98.38	97.16
II. (15:25 - 16:55)		
Detector #1	98.57	97.16
Detector #2	96.99	95.46

objective for this project is an incident detection probability of 95 percent with 1 percent false detection rate and an average detection time of 2 min.

Clearly, the incident detection system does not rely only on the AUTOSCOPE technology, but also on additional incident detection software that capitalizes on the AUTOSCOPE capabilities. Two approaches are being taken during the incident detection software development. The first approach involves adaptation of existing incident detection techniques that are enhanced with the decision-making capabilities of modern artificial intelligence methods to fully use the wide area sensing abilities of the AUTOSCOPE. The second approach relies on the development of new concepts that are based on advanced modeling of traffic flow dynamics, artificial intelligence techniques, and neural networks.

The incident detection software takes into account information derived from all cameras before deciding whether an incident is in progress. For this purpose, a large number of incident sequences are being videotaped throughout the United States and Canada, and an incident detection algorithm development facility is being built. The latter is needed to support the incident detection algorithm development. After extensive testing with this facility, the incident detection software will be ready for field implementation. However, this task will follow only after the laboratory tests are judged satisfactory.

INTERSECTION DEMONSTRATION

During the live demonstrations of the AUTOSCOPE, practicing engineers repeatedly requested an intersection demonstration project not only for exposing the technology to its end users but also to establish its commercial viability. For this reason, Mn/DOT and the Minnesota Local Road Research Board funded a second demonstration project leading to intersection control through video image processing. The project is scheduled to start in fall 1989 and should be completed in 1990.

Because the AUTOSCOPE was developed by using only limited videotaped data at intersections, the major objective of this project is to demonstrate that the system can be used for its originally intended purpose, that is, wireless detection for intersection control. If the results are satisfactory, the intent is to use the AUTOSCOPE for developing advanced control strategies both for critical intersections and oversaturated corridors; however, development of such strategies is not intended in this project. Instead, the objective is to field test and calibrate the AUTOSCOPE at an intersection on a 24-hr 6- to 9-month operation under all conditions; during this time period, the AUTOSCOPE will be directly compared with loop detectors at an intersection setting to demonstrate accuracy, reliability, and performance.

This project consists of two phases. In the first phase, the AUTOSCOPE will only be applied on one approach to observe how it performs relative to loop detectors and manually collected ground truth data. The comparison will be automatic but, in case of discrepancy, videotaped sequences will be examined manually. A special-purpose device will be built for the automatic comparisons and video recording. Following successful testing and calibration, the AUTOSCOPE will replace loop detectors on the approach under consideration. This will be accomplished by interfacing the AUTOSCOPE with a standard NEMA or Type 170 controller, as appropriate, and switching off the loop detectors on that approach. Laboratory tests will be performed before the actual field implementation, which will be executed in stages to ensure functionality and safety.

Phase two of the intersection demonstration project involves experimentation to determine the number of cameras required to detect traffic on all four approaches at the test intersection. If detection is required at long distances upstream of the stop line (i.e., on the order of 100 to 200 ft), then it is likely that one video camera per approach will be needed.

CONCLUSION

AUTOSCOPE technology has advanced significantly over the last year. Synergy between the various research projects ensured that a robust real time video detection system with true wide-area multispot detection capabilities is now available, albeit in a preproduction prototype stage. Even so, the AUTOSCOPE is suitable for demonstration projects such as the ones described. Unlike video detection systems being developed elsewhere, the AUTOSCOPE can be demonstrated with live video input and allows instant visual verification. Most important, its system capabilities can be confirmed either at the Minneapolis TMC where the system is installed, or at any location receiving live video input from traffic surveillance cameras. The flexible detection placement through interactive graphics, the ability of the AUTOSCOPE to work with any camera, and its capability to work under congested flow and other artifact conditions while still being able to use the camera for surveillance should be reassuring to practicing engineers.

Although more work remains to be done in order to establish reliability as well as performance on a long-term continuous operation, by all indications the elusive goal of wide-area video detection research and development is now extremely close to fulfillment—the cost-effective ability to detect vehicles by video cameras with satisfactory accuracy for traffic surveillance and control. The live benchmark demonstrations of the AUTOSCOPE in the United States and abroad clearly confirmed the AUTOSCOPE capabilities. In these benchmarks, the system was connected to several live cameras and the detection results were visually verified.

Before implementation of the AUTOSCOPE technology, a word of caution is appropriate. The device should not be viewed as a simple replacement of loop detectors, which will continue to serve their intended purpose for some time. Instead, AUTOSCOPE should really be considered as a wide-area detection system. As such, it leads to new potential applications that have not been seriously attempted before. Therefore, to capitalize on the AUTOSCOPE capabilities, initial application of the technology should be selected with caution. Given the momentum of the European and Japanese research initiatives in advanced traffic control technologies, there are few areas in which the United States is still leading. Machine vision seems to be one of these few.

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