Digital-Based Red Light Running Detection

A Building Block Technology for ITS

By

George E. Frangos, P.E.
Engineer II
Traffic Division, Bureau of Highways
Department of Public Works
3450 Court House Drive
Ellicott City, Maryland 21043

Tel: (410) 313-2430
Fax: (410) 313-3435
E-Mail: trafeng@erols.com

Abstract

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George E.Frangos, P.E.
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Howard County, Maryland

During the winter of 1997-1998. Howard County, Maryland in collaboration with Montgomery County, Maryland, initiated a Federally-funded evaluation of at least two (2) digital-based red light running detection systems:

A. "Guardian" by Peek Traffic Systems of Great Britain

B. "Red Eye 77" by Driver Safety Systems of Israel

A late entry to the evaluation was "Smartcam" by Redflex Traffic Systems of Australia.

The Guardian digital enforcement camera system is activated either by inductive loop of detectors or by machine vision vehicle tracking technology with visual data stored via a WORM Drive. Automatic license plate reader software contained within the camera unit serves to identify the vehicle owner and the Computerized Office Processing Software (COPS) develops the citation. The digital camera by Piepont provides a resolution of 824 x 824 pixels.

Red Eye 77 is an automated, loop-activated, fully digital red light camera system based upon the MAROM Speed and Tailgating Enforcement System. Utilizing a Kodak Digital Camera providing a resolution of 1534 x 1024 pixels, the system is capable of wireless transmission of data to a central Data Processing Unit (DPW) as well as utilizing night-vision technology for nighttime detection.

Smartcam is an integrated digital camera, signal processing and non-intrusive system utilizing a modified commercial Kodak camera providing a resolution of 3072 x 2048 pixels. Utilizing a Kodak CD Imaging Workstation, digital images are processed utilizing a Redflex Auto Gate Controller to produce the citation.

The primary and chief benefits of ITS based, digital technology for automated enforcement is increased safety at signalized intersections, reduced levels of violations and real-time monitoring of signal operations. Further, because of the compatibility with existing surveillance cameras, digital systems can be integrated with existing traffic management systems. An extension of intersection monitoring may be detecting pedestrians or pedestrian groups so as to alter green phases and permit safe clearance at intersections. Current applications include toll booth monitoring, highway rail crossing controls and hazardous driving behavior.

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Correlation between the failure to obey traffic control devices and serious traffic accidents has been a concern to traffic safety officials for at least four decades. In 1971, the aerospace firm LTV developed ORBIS for use in speed limit enforcement. Applying modern photometric and telemetry technology, it was utilized by Irving, Texas for speed limit enforcement on arterials. Because it required a permanent installation and induced legal concerns under Texas Law, it was discontuinued and the technology was sold to foreign companies. However, the lack of portable detection units that are not manpower intensive and technologically advanced continue to constrain public officials in obtaining data on the causes, frequency, and location of violations in a cost-effective manner at traffic signals. The tort liability of cities and counties with associated increased settlement and legal defense costs has become a concern for law enforcement and public engineering officials. It is necessary to reduce the nunber of serious traffic accidents resulting from red light running without incurring the manpower costs associated with enforcement procedures currently utilized to mitigate this problem.

During the Winter of 1997-98, Howard County, Maryland in collaboration with Montgomery County, Maryland initiated the evaluation of three (3) digital based redlight running detection systems.

A. "Guardian" by Peek Traffic, Ltd. Of Great Britain;

B. "Red Eye 77" by Driver Safety Systems of Israel in collaboration with Eastman Kodak's Motion Analysis Systems Division; and

C. "Smartcam" by Redflex Traffic Systems of Australia.

The Guardian digital enforcement camera system is activated by inductive loop detectors or by machine vision vehicle tracking technology with visual data stored via a WORM Drive. Automatic license plate reader software contained within the camera unit serves to identify the vehicle owner and the Computerized Office Processing Software (COPS) develops the citation. The digital camera by Piepont provides a resolution of 824 x 824 pixels.

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The remote sensing of traffic operations at traffic control devices combines electronic sensors, visual scanning, and telemetry. For example, the TSS Speedmaster is a video camera that videotapes a violation based upon a sensor signal and processes data via elaborate software. Other systems continuously video monitor the traffic signal and send a signal to a 35MM camera to photograph violators detected by sensors. The Monitron Digital System can record up to 30,000 photographs and associated data on one digital tape and automatically downloads at night from the remote location to a central PC type computer. The images and data can then be processed the next day into a violation notice with minimal manual involvement. (3)

The principles of red light running detection involve the ability to (1) process a sequence of video images of oncoming traffic to detect, classify and provide continuous tracking of detected vehicles; (2) calculate from image information real world vehicle displacements with sufficient accuracy to support mesurement of vehicle speed and acceleration for all vehicles in the camera field of view; (3) provide continuous, real time measurement of vehicle position, speed and acceleration; (4) develop and implement a decision model using among its inputs, measures of vehicle position,, speed, acceleration and classification in order to determine the likelihood of a vehicle stopping; and (5) update the decision model in real time as a result of changing values of vehicle parameters (e.g. position, speed, accleration) for each oncoming vehicle in the camera's field of view.

The digital camera/system requirements that share a common need feature:

1. Data Management: Facilitate the ability to easily capture, transmit, process, store and recover captured data for both image and text formats.

2. Resolution: Sufficient to meet all the intended uses for the image-reading of the license, clear detail of the vehicle and if required., allowing identification of the operator.

3. Anti-Blooming: Prevention of spreading of overexposed portions of the image (i.e., vehicle headlights or sunlight from highly reflective surfaces).

4. Contrast Lattitude: Adequate differentation of light to dark areas within an image to aid detail recognition.

5. Stopping Power: Blur-free images of moving vehicles.

6. Sensitivity: Ability to detect at low light levels as well as into near-IR spectral region.

7. Image Enhancement Circuitry: Camera electronics to eliminate major sensor defects such as bright or dark columns, which detract from the visible presentation of the image.

8. Frame Rate: Continuous read out of images to support monitoring along with single frame capture capability for recognizing several successive vehicles committing a violation.

9. Installation Flexibility: Ability to mount into permanent or mobile settings.

As implied, an automated enforcement project must account for many design parameters to meet both short-term and long-term objectives.

The prinmary and chief benefit that automated enforcement will bring to ITS is increased levels of safety at intersections. The innovation will support the use of cameras for intersection monitoring/control and surveillance. Beyond the camera necessary for control and operation of an intersection, no additional pavement sensors or other infrastructure are required to support this safety application.Importantly, as feasibility is shown for these techniques, the concepts can be applied to other safety considerations:

A. Detection of vehicles approaching toll booths;

B. Railway crossings at excessive speeds;

C. Detection of out-of-control Vehicles; and

D. Detection of hazardously driven vehicles.

A video camera serving a red light running application has multiple uses: to monitor (for surveillance) for measurement of traffic parameters (counts, turning movements, approach stops, queue lengths), control of an intersection as a loop replacement, and safety enhancement through detection of NSV's and signalizing time until an "all clear" condition at the intersection is assured. A typical 4-way, 8-phase intersection will require only two suitably positioned video cameras (as shown in Figure 1) to achieve the intersection area coverage necessary to support automated enforcement functionality. (9)

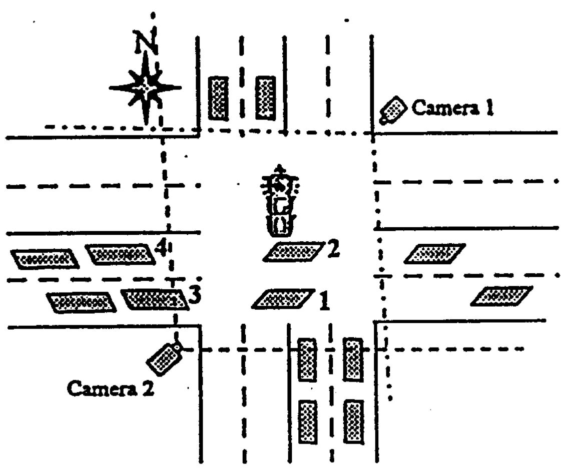
Potential Impact of Result for Application to ITS Practice

The primary and chief benefit to ITS of automated enforcement technology is increased levels of safety at intersections. This technology offers several other benefits to ITS as well.

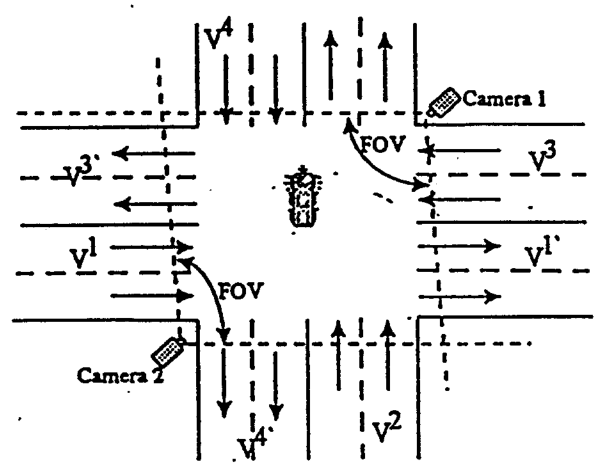
The applications leverage the investment that municipalities make in deploying video cameras at intersections for surveillance and or traffic monitoring and flow control purpose benefits as well. Because it supports dual use of video cameras, significant cost savings result. Additionally, because of the compatibility with surveillance uses of the video cameras, it can be actively monitored in a traffic control center, offering the potential for integration with larger ITS traffic management systems.

Additionally, the red light running concepts, once successfully demonstrated, can be extended to provide intelligent green light delays based upon the detection of pedestrians that are in the process of crossing an intersection at a well defiend crosswalk. In some cases, late crossing pedestrians are not visible to motorists who are waiting for a green light. (A motorist's views may be obstructed by a truck or bus in an adjacent lane). An extension of intersection monitoring could be developed that would identify pedestrians or pedestrian groups and communicate information on expected time to crossing completion that could be optionally used to delay activation of a green light until pedestrians were safely clear of the intersection.

Other potential safety considerations include the detection of vehicles moving at excessive speed approaching toll booths or other controlled roadway structures (lane reducers, etc.); monitoring vehicles approaching a rail crossing. Additonally, and to the extent that such monitoring is able to accurately interpret driver behavior, the concepts can be extended to provide detection of more gerneral haxardous driving behavior.



Vehicles 1 through 4 are detected as likely red-light violators.



Camera 1 monitors flows V^1 and V^2.
Camera 2 monitors flows V^3 and V^4.
Camera 2 ensures flows $V^{1'}$ and $V^{2'}$ are clear.
Camera 1 ensures flows $V^{3'}$ and $V^{4'}$ are clear.

Figure 1. Application for Intersection Safety

The most imediate payoff of the red light running detection system is improved safety at intersections; specifically, a reduction in the number of collisions involving red light running vehicles colliding with vehicles or pedestrians startng to enter the intersection from the crossing directions. When merged with other options described above, such monitoring can offer a reduction in fatalities, personal injury, and property damage associated with intersection accidents.

Quantification of the safety benefits of autonmated enforcement may be illustrated by Table 1. This comparison of USA Traffic Deaths for the interval of 1991 through 1995 cites Alcohol Related Fatalities and Red Light Runnuing (RLR) Fatalities as national totals. During this time period, Alcohol-based deaths declined while RLR fatals increased. This serves to define the significance of RLR problem and simple set-theory analysis indicates minimal double-counting in this set of data. (7)

Table 1.
USA TRAFFIC DEATHS

YEAR	TOTAL	ALCOHOL RELATED	PERCENTAGE FATALITIES	RLR RELATED	PERCENTAGE FATALITIES
1991	41,508	19,887	47.9%	2,425	5.8%
1992	39,250	17,858	45.5%	2,597	6.6%
1993	40,150	17,473	43.5%	2,690	6.7%
1994	40,761	16,580	40.7%	2,791	6.9%
1995	41,798	17,274	41.3%	2,866	6.9%

Source: Insurance Institute for Highway Safety

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