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TRAFFIC VIOLATION METHOD AND SYSTEM

FIELD OF THE INVENTION

The present invention relates to a traffic violation
5 method and apparatus, of particular but by no means
exclusive application in providing an automated system for
traffic violation enforcement, such as for automatic
detection of red-light traffic violation.

10 BACKGROUND OF THE INVENTION

In general terms, automatic red-light enforcement systems
can be divided into two sub-modules, namely, the violation
detection module and the vehicle number-plate capture
module. During red-light operation, when a vehicle
15 crosses the intersection the violation detection module
detects the occurrence of a violation and triggers the
vehicle number-plate capture module. During green-light
operation, on the other hand, the violation detection
module is on stand-by.

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Referring to figure 1, a typical existing red-light
enforcement system 10 has the following main components: a
violation detection module comprising inductive loops 12
and a vehicle number-plate capture module comprising a
25 camera system 14. The loop interface/controller for the
inductive loops 12 are usually housed in the same cabinet
as the camera system 14.

Existing inductive loops technique for the detection of
30 red-light violation use the logic of the status of two
loop sensors 12, placing one after the other in front of
the vehicle stop line 16 at the traffic intersection 18.
Referring to figures 2A and 2B, during the red-light
cycle, a violation is considered to have occurred when the
35 triggering of the first inductive sensor 20a by vehicle 22
is followed by the triggering of the second inductive
sensor 20b. Such physical inductive loops (20a, 20b),

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which are installed underneath the road surface, have been used with high success rate in the past decades for such applications.

5 Attempts have also been made to replace the physical loop with a video camera as the sensor input (see for example International Patent Application No. PCT/SG99/00115, the disclosure of which is incorporated herein by reference). The detection of red-light violation would then be
10 achieved using image processing techniques; the physical inductive loop sensors are replaced by the 'virtual sensor' comprising the camera's view.

A video based detection red-light enforcement system, as
15 shown in figure 3 generally at 24, consists of the following components: a violation detection module comprising a detection camera (or virtual sensors) 26 and a vehicle number-plate capture module in the form of a camera system 28. The image processing unit (IPU) for the
20 detection camera 26 is housed in the same cabinet as the camera system 28. It should be noted that the placement of the detection camera 26 can be varied.

The detection camera 26 views a detection region 30,
25 within which are detection regions corresponding to the inductive loops of figures 1, 2A and 2B.

In the context of image processing, such virtual sensors are defined by a set of pixel coordinates, within the two-
30 dimensional area of the digitized image (depicting the coverage of the virtual sensor) of the video signal. During the detection process, pixel values within the virtual sensors are processed and analyzed, spatially within the image view and temporally within sequence of
35 video images, by the image processing unit to obtain the relevant violation information such as vehicle presence and speed information. Figure 4 shows the typical locations

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of the virtual sensors 32 within the camera view 30, which correspond to the placement of the physical inductive loops 20a and 20b of figures 2A and 2B. The presence of vehicle 34 would be detected owing to its intersection of
5 the virtual sensors 32.

The advantage of using a video camera, and hence a virtual sensor, is that it minimizes inconvenience, such as due to roadwork and the disruption of traffic, caused by the
10 installation and maintenance of physical inductive loops within a traffic lane. Further, virtual sensors are flexible; the effective position and number of the virtual sensors can be changed by means of the image processing unit software. Application of image processing
15 techniques, however, had not been very successful owing to several shortcomings. In particular, the performance of this technique is easily affected by changes in ambient lighting conditions, owing to the passive nature of the camera sensor with its sensitivity spread across the
20 visual light spectrum and, to a certain extent, the infra-red region. Hence, any changes in the video signal due to non-vehicular movement, such as pedestrian movement, changes of ambient lighting and vehicle headlight reflection, can easily cause the video sensor to 'false'
25 trigger the presence of a vehicle. A conventional inductive loop sensor, on the other hand, is an active sensor and only sensitive to metallic objects, so less sensitive to non-vehicular movement.

30 Referring to figure 5, to replicate the performance of conventional inductive loop sensors, a detection video camera 40 should be mounted at a very high angle 'looking' directly top-down at the intended detection region 42, so that the presence of vehicle 44 can be detected accurately
35 at its actual physical location. It can then be determined whether the vehicle 44 corresponds to a violation, on the basis of whether it lies over virtual

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sensors 46. In this view, vehicle 44 does not lie over virtual sensors 46, so no violation is detected.

5 However, owing to the physical constraints on the mounting structure supporting the camera 40, at most intersections it is not possible to achieve such a mounting position and angle. Referring to figure 6, a camera 50 mounted so as to be directed at an oblique angle to the vertical, providing a camera view 52, can result in the false
10 detection of a violation. Non-violation vehicle 54 is shown travelling (in traffic direction A) towards virtual presence sensors 56, but does not yet coincide with those sensors. However, second vehicle 58 (travelling in traffic direction B, out of the page in this view)
15 entirely obstructs the view of the 50 of the virtual presence sensors 56, so camera 50 detects a violation, even though neither vehicle 54, 58 is over the sensors 56.

Figure 7 is the corresponding camera view 52 from
20 detection camera 50. As the detection camera 50 is mounted to 'look directly at the approach of traffic moving in direction A at an intersection, in order to detect red-light violations of vehicles travelling in direction A, vehicle 58 travelling in direction B
25 (perpendicular to direction A) falsely triggers both the presence sensors 56. A false red-light violation is recorded for a vehicle travelling in direction A.

SUMMARY OF THE INVENTION

30 In a first broad aspect, the invention provides a method of checking a possible traffic violation to determine whether said possible traffic violation should be rejected or processed further, where said violation comprises the forbidden entry of a vehicle travelling in a predetermined
35 traffic direction into a monitored region and said possible traffic violation is detected by monitoring a first portion of said region and detecting said vehicle in

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said first portion, the method comprising:

rejecting said possible traffic violation if any one or more of the following events occur:

- an object is detected in at least one
- 5 predetermined external region lying outside said monitored region and in the path of vehicles travelling in a different direction from said traffic direction;
- said vehicle is determined not to have a positive component of velocity in said traffic direction;
- 10 said vehicle is determined not to have a consistent velocity; and
- a further vehicle or object is detected in said first portion before said vehicle is detected in a second portion of said region, said second portion being after
- 15 said first portion in said traffic direction.

Preferably the method includes confirming said possible violation only if said vehicle is detected to be said second portion of said region after said vehicle is

20 detected to be said first portion.

Preferably the method includes disregarding any detection of said vehicle in said first portion of said region while any object is detected to be in said at least one external

25 region.

Preferably the method includes photographing said vehicle if said violation is confirmed.

30 Preferably the external region is one of a pair of such external regions on opposite sides of said monitored region.

Preferably the monitoring is performed by means of at

35 least one video camera. However, the monitoring of the first and second portions and of the external region or regions may be by other means, such as inductive loop

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techniques.

Preferably the method includes determining whether said velocity is consistent by collecting and comparing a plurality of values of said velocity.

Preferably the method includes monitoring for all of said events.

- 10 In one embodiment, the forbidden region comprises an intersection during a red-light phase for traffic travelling in said traffic direction. Preferably the method includes monitoring said intersection during a green-light phase, determining a maximum velocity of vehicles entering said intersection during said green-light phase and a minimum velocity of vehicles entering said intersection during said green-light phase, calculating a reference maximum velocity from said maximum velocity and a reference minimum velocity from said minimum velocity, and rejecting any possible violation in which said component is greater than said reference maximum velocity or less than said reference minimum velocity.
- 25 Preferably the reference maximum velocity equals said maximum velocity plus a predetermined first constant, and said reference minimum velocity equals said minimum velocity plus a predetermined second constant.
- 30 In general, the maximum reference speed will be determined by adding a positive constant to the maximum velocity, and the minimum reference speed will be determined by adding a negative constant to the minimum velocity. However, in some applications this might be otherwise. For example, it may be desirable to have negative first constant and a positive second constant, negative first and second constants, or positive first and second constants.

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Preferably the method includes monitoring said intersection during a green-light phase, determining a maximum convolution output (where convolution output is defined according to equations 14 and 15 of International Patent Application No. PCT/SG99/00115 (WO 01/33503)) for vehicles entering said intersection during said green-light phase and a minimum convolution output for vehicles entering said intersection during said green-light phase, calculating a reference maximum convolution output from said maximum convolution output and a reference minimum convolution output from said minimum convolution output, determining one or more vehicle convolution outputs for said vehicle during said red-light phase, and rejecting any possible violation in which one or more said vehicle convolution outputs are greater than said reference maximum convolution output or less than said reference minimum convolution output.

Preferably the reference maximum convolution output equals said maximum convolution output plus a predetermined first constant, and said reference minimum convolution output equals said minimum convolution output plus a predetermined second constant.

In a second broad aspect, the invention provides a system for detecting a traffic violation comprising the forbidden entry of a vehicle travelling in a predetermined traffic direction into a monitored region, comprising:

a video camera system; and
a computer processor for determining whether said violation has occurred and in electronic communication with said video camera system;

wherein said system is configured:
to detect a possible traffic violation by monitoring a first portion of said region and detecting said vehicle in said first portion; and

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to reject said possible traffic violation if any one or more of the following events occur:

an object is detected in at least one predetermined external region lying outside said monitored region and in the path of vehicles travelling in a different direction from said traffic direction;

said vehicle is determined not to have a positive component of velocity in said traffic direction;

said vehicle is determined not to have a consistent velocity; and

a further vehicle or object is detected in said first portion before said vehicle is detected in a second portion of said region, said second portion being after said first portion in said traffic direction.

Preferably the processor is further configured to confirm said possible violation only if said system detects said vehicle to be in said second portion of said region after said vehicle is detected to be said first portion.

Preferably the processor is further configured to disregard any detection of said vehicle in said first portion of said region while any object is detected to be in said at least one external region.

Preferably the system includes a camera for photographing said vehicle, operable by said processor to photograph said vehicle if said vehicle is determined to have entered said forbidden region.

Preferably the external region is one of a pair of such external regions on opposite sides of said monitored region.

Preferably the system is configured to determine whether said velocity is consistent by collecting and comparing a plurality of values of said velocity.

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Preferably the system is configured to perform all of said events.

5 In one embodiment, the forbidden region comprises an intersection during a red-light phase for traffic travelling in said traffic direction. Preferably the system is configured to monitor said intersection during a green-light phase, and said processor is configured to
10 determine a maximum velocity of vehicles entering said intersection during said green-light phase and a minimum velocity of vehicles entering said intersection during said green-light phase, to calculate a reference maximum velocity from said maximum velocity and a reference
15 minimum velocity from said minimum velocity, and to reject any possible violation in which said component is greater than said reference maximum velocity or less than said reference minimum velocity.

20 BRIEF DESCRIPTION OF THE DRAWING

In order that the invention may be more clearly ascertained, preferred embodiments will now be described, by way of example, with reference to the accompanying drawings, in which:

25 Figure 1 is a schematic view of a prior art inductive loop sensor red-light enforcement system;

Figures 2A and 2B are schematic views of the configuration of the prior art inductive loop sensor red-light violation detection of figure 1;

30 Figure 3 is a schematic view of a prior art a video based red-light enforcement system;

Figure 4 is view of the virtual sensor configuration of the red-light violation detection system of the system of figure 3;

35 Figure 5 is a view of the ideal camera mounting configuration for the virtual sensor of figure 3, to replicate physical inductive loop sensors;

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Figure 6 is a view of a false detection of a red-light violation owing to a restricted camera angle in a prior art video based system;

5 Figure 7 is a view of the false detection of a red-light violation of figure 6 from the view point of the detection camera;

10 Figure 8A is a schematic view of the virtual sensor configuration of a red-light violation detection system according to a preferred embodiment of the present invention;

Figure 8B is a further schematic view of the virtual sensor configuration of the red-light violation detection system of figure 8A;

15 Figure 9 is a view of the virtual sensor configuration of the red-light violation detection system of figure 8A as seen from the detection camera;

Figure 10 is a flow diagram of the red-light violation detection method of figure 8A; and

20 Figure 11 is a flow diagram of the violation detection and verification process of the method of figure 8A.

DETAILED DESCRIPTION OF THE INVENTION

25 According to a preferred embodiment of the present invention, there is provided a red-light violation detection system shown generally at 60 in figures 8A and 8B.

30 System 60 employs a video detection camera (not shown) to provide two vehicle presence sensors 62a, 62b, one velocity sensor 64 and two horizontal traffic sensors 66a, 66b. These sensors are all virtual sensors, in that they are all provided by means of a video camera system.

35 The system 60 also includes a conventional number-plate capture (NPC) camera (not shown), comparable to that of camera system 14 of figure 1. The system 60 is operated

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by an electronic controller (not shown) that collects and processes data from the various sensors, and triggers the operation of the NPC camera.

5 During the violation detection process, the output of the video camera system signal is digitized into a sequence of two-dimensional images. Pixels values of the image area depicted by the various virtual sensors as defined by a set of coordinates are extracted from the sequence of
10 digitized images. The pixels are analyzed, spatially and temporally, for the extraction of various violation parameters, such as vehicle presence status (on the virtual sensors) and vehicle speed information.

15 The two vehicle presence sensors 62a, 62b provide the presence status of vehicles crossing the stop line during a red-light period. First presence sensors 62a is located just into the intersection, the second further into the intersection; their positions are thus comparable to those
20 of conventional inductive loop sensors; so too is their role. The sequence of detection of the two presence sensors 62a, 62b provides the detection logic of a possible violation. That is, a possible violation is detected when the first presence sensor 62a is triggered
25 by a vehicle 68 entering the intersection despite facing a red light (see figure 8A), raising a vehicle presence status flag from low to high, followed by the triggering of the second presence sensor 62b (see figure 8B) if the vehicle 68 advances further into the intersection.

30 Figure 9 is a view of the scene as monitored by the video detection camera, depicting vehicle presence sensors 62a, 62b, velocity sensor 64 and horizontal traffic sensors 66a, 66b.

35 The velocity sensor 64 measures the speed and direction of any object within the overall virtual sensor detection

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region (cf. region 42 of figure 5). The measured velocity vector is used to determine whether a genuine violation has occurred when a possible violation is first detected by the presence sensors 62a, 62b. A true violation
5 vehicle will be travelling in the direction of the monitored traffic (direction C in figure 8A), and this direction is defined - as the velocity sensor's direction - within the image collected by the velocity sensor 64. The velocity sensor 64 determines the component of
10 velocity only in that direction. The false triggering of the presence sensors 62a, 62b by (for example) traffic moving (in the view of figure 8A) in direction D at right angles to direction C, on the other hand, generates a perpendicular velocity vector; in the case of a vehicle
15 moving in direction D, the velocity sensor will determine zero velocity as there is no component in direction C. False triggering of the presence sensors 62a, 62b by non vehicular movement or changes of lighting condition (such as shadow, headlight reflection, pedestrian, etc.) will
20 not generate a consistent, positive velocity vector over a sequence of image frames. By analyzing the consistency of the measured velocity vector, over several image frames, the occurrence of false detections can thereby be eliminated.

25 The horizontal traffic sensors 66a, 66b sensors are used to detect the presence of 'horizontal' traffic (i.e. crossing - often perpendicularly - the traffic direction being monitored), and thereby further minimize the false
30 detection of violations due to such traffic. Thus, a violation detection by presence sensors 62a, 62b is only verified as true if a consistent positive velocity is determined by the velocity sensor 64, and a null detection is provided by the horizontal traffic sensors 66a, 66b.

35 Figure 10 is a block diagram of the overall violation detection process of system 60. After the process

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commences, a sequence of image frames is continuously digitized for subsequent image processing for violation detection. During a red-light cycle, the system 60 continuously detects the occurrence of violation vehicles.

5 During green-light cycle (i.e. 'red-light=No'), the system 60 continuously updates its reference parameters for the velocity sensor 64, the horizontal traffic sensors 66a, 66b and vehicle presence sensors 62a, 62b.

10 Figure 11 is a block diagram of the violation detection process using image processing techniques according to system 60, during a red-light cycle.

During the operation of violation detection, the detection
15 process is operated in either of two operational modes: first violation detection mode and second violation detection mode.

During the first violation detection mode, the system 60
20 continues to analyze the sequence of images for the detection of a new violation. Upon detection of a violation, the system 60 sends a trigger signal to the number-plate capture (NPC) module for the capturing of the violation vehicle's number-plate. The system 60, after
25 confirmation of a first violation trigger, operates in the second violation detection mode, that is, to continuously detecting the violation vehicle 'arriving' at the second vehicle presence sensor (second VPS) 62b, and hence to provide the second violation trigger signal to the NPC
30 module for the capturing of the second violation images.

FIRST VIOLATION DETECTION MODE

During the first violation detection mode, the horizontal traffic sensors (HTS) 66a, 66b are first analyzed for the
35 detection of horizontal traffic. If horizontal traffic is detected by either of the two HTS 66a, 66b (i.e. HTS status=1), the vehicle presence sensors 62a, 66b are not

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activated. If the status of HTS is 0, on the other hand, the first VPS 62a is activated for the continual detection of violation vehicles. If the first VPS 62a is triggered, indicating a possible violation, the presence status of the first VPS 62a goes from low to high (0 to 1). Upon detection of a possible violation by the first VPS 62a, the velocity sensor (VS) 64 analyzes an image sequence, from image frame $f-(k-1)$ to frame f (where k is typically in the range 3 to 30 for a typical video frame rate of 25 to 30 frame per second), for the analysis of the vehicle's velocity.

The resultant velocity parameters are compared with that of standard or reference parameters to determine the validity of a true violation. This comparison, which also verifies the consistency of the measured speed over the sequence of image frames, enables the system 60 to eliminate false triggers caused by external factors, such as horizontal traffic, pedestrians, and shadows. Upon confirmation of a true violation, the variable of first violation detection is set to 0, indicating the change of detection operation to the second violation detection mode.

At the same time, a timer variable, TC, is reset to 0. The purpose of TC is to keep track of the time lag between the first violation trigger and the second violation trigger. Keeping TC to a limited range of (time) values ensures that the first and second violations are triggered by the same violation vehicle.

A trigger signal is then sent to the NPC unit for the capturing of the first violation image of the vehicle.

SECOND VIOLATION DETECTION MODE

During the second violation detection mode, the system 60 essentially keeps track of the time lag between the first

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violation trigger and the second violation trigger, by means of the second VPS 62b. If the time lag exceeds a maximum set value, typically in the range of 0.5 to 5 seconds depending on the intersection, the second
5 violation trigger is not triggered and the system returns to first violation detection mode. If the time lag is within the set limit when the second VPS 62b is triggered, a second violation trigger signal is send to the NPC module for capturing the second violation vehicle number-
10 plate images.

The main function of the horizontal traffic sensors 66a, 66b is to detect the presence of vehicles travelling across the monitored traffic. During a red-light, when a
15 'horizontal' traffic vehicle crosses the horizontal traffic sensors 66a, 66b before triggering a presence sensor 62a, 66b, it triggers an internal signal indicating the presence of a horizontal traffic vehicle at the vicinity of the vehicle presence sensors 62a, 62b. This
20 signal, in turn, deactivates the vehicle presence sensors 62a, 62b, hence eliminating the false trigger of the vehicle presence sensors. The placement of the horizontal traffic sensors 66a, 66b is such that, during the occurrence of a true violation, the violation vehicle will
25 not trigger the horizontal traffic sensors 66a, 66b before triggering the first and second vehicle presence sensors 62a, 62b.

The vehicle detection process, for both day and night
30 detection, is implemented on the basis of the system disclosed in International Patent Application No. PCT/SG99/00115. One of the main functions of the velocity sensor 64 is to determine the velocity of the possible violation vehicle. The processing technique used to do so
35 is based on the Profile-Speed-Extraction process disclosed in Section 5.3.1 of International Patent Application No. PCT/SG99/00115.

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During green-light cycle, when the system is not operating in detection mode, the velocity sensor 64 continuously computes the velocity characteristic of the current through-traffic. The updated velocity characteristics are used as reference data for subsequent red-light phase detection operation of the system. Using this continual reference update of the through traffic characteristic enables the system 60 to self-adapt to the changing operating traffic, lighting and weather conditions.

During the green-light cycle, the following parameters, obtained from each passing vehicle, are constantly measured and updated as reference data:

S_{MAXG} , maximum speed during green-light cycle;
 S_{MING} , minimum speed during green-light cycle;
 C_{MAXG} , maximum convolution output during green-light cycle;
 C_{MING} , minimum convolution output during green-light cycle.

During red-light cycle, the following velocity parameters of possible violations are obtained:

S_i , for $i = 0$ to $k-1$, where i is the speed obtained at frame $f-i$;
 S_{AVE} , average speed obtained from frame f to frame $f-(k-1)$;
 C_i , for $i = 0$ to $k-1$, where i is the convolution obtained at frame $f-i$;
 C_{AVE} , average convolution obtained from frame f to frame $f-(k-1)$;

A possible violation is confirmed when the obtained velocity parameters, for frames f to $f-(k-1)$, fulfill the following three conditions:

1) speed range: all the speed values, for frames f to $f-$

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($k-1$), must lie between the minimum and maximum Reference values, S_{MAXR} , S_{MINR} respectively;

2) convolution output range: all the convolution outputs, for frames f to $f-(k-1)$, must lie between the minimum and maximum Reference value, C_{MAXR} , C_{MINR} respectively;

3) consistency: the speed and convolution values obtained from frames f to $f-(k-1)$ must lie within a limited range within the respective average speed and average convolution values.

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To fulfill the speed range condition, all the vehicle speeds, S_i , obtained from frame $f-i$ must lie within the following speed limits.

15 The first condition of a Violation is:

$$S_{MAXR} > S_i > S_{MINR}, \text{ for } i = 0 \text{ to } k-1$$

where S_i is the speed obtained at frame $f-i$, and

20

$$\begin{aligned} S_{MAXR} &= S_{MAXG} + S_A; \text{ and} \\ S_{MINR} &= S_{MING} + S_B. \end{aligned}$$

S_{MAXG} and S_{MING} are variables obtained during the green-light cycle. S_A and S_B are configurable constants such that

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$$\begin{aligned} (S_{MAXG} + S_A) &< \text{maximum speed}; \text{ and} \\ (S_{MING} + S_B) &< \text{minimum speed}. \end{aligned}$$

30 The maximum speed of a vehicle is typically set at about 120 km/h, but otherwise as preferred by users of the system 60. The minimum speed is set such that only moving vehicles, with at least the minimum speed, are detected.

35 For different lighting, weather, road surface texture and video image quality conditions, the ranges of convolution outputs of the speed measurement varies. However, for

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speed measurements of vehicles within the particular time-period (say, within several minutes) and at the same location, the convolution output varies within a limited range, as lighting, weather, road surface texture and video image quality conditions are assumed to be constant. Hence, for speed measurements within a short time-period and at a particular, it is assumed that the convolution output values will fall within the same limited range of values.

Thus, one way to verify the validity of a violation is to check if the convolution output of the speed measurement of the violation vehicle lies within a narrow range of reference values. The reference values of the convolution output are obtained from passing vehicles during the green-light period. The convolution output is obtained using the equations 14 and 15 of International Patent Application No. PCT/SG99/00115.

The second condition of a violation is:

$$C_{MAXR} > C_i > C_{MINR}, \text{ for } i = 0 \text{ to } k-1$$

where C_i is the convolution obtained at frame $f-i$, and

$$\begin{aligned} C_{MAXR} &= C_{MAXG} + C_A; \quad \text{and} \\ C_{MINR} &= C_{MING} + C_B. \end{aligned}$$

Where C_{MAXG} and C_{MING} are variables obtained during the green-light cycle, and C_A and C_B are delta values to control the sensitivity of the verification.

The third condition used for the violation verification is to determine the consistencies of the speed measurement parameters, obtained within the k frames of image sequence. Two types of consistencies are employed: the speed consistency and the convolution output consistency.

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The speed consistency is used to ensure that the measured speeds of the violation vehicle, within the k number of consecutive image frames, remain consistent. Hence, the
 5 third condition of a violation for speed is:

$$| S_i - S_{AVE} | < S_D, \text{ for } i = 0 \text{ to } k-1$$

where

$$S_{AVE} = \frac{\sum_{i=0}^{k-1} S_i}{k}$$

10 and S_D is a constant value to control the sensitivity of the consistency.

The convolution output consistency is to ensure that the convolution output of the measured speeds of the violation
 15 vehicle, within the k number of consecutive image frames, remains consistent. Hence, the third condition of a violation for convolution is:

$$| C_i - C_{AVE} | < C_D, \text{ for } i = 0 \text{ to } k-1$$

20

where

$$C_{AVE} = \frac{\sum_{i=0}^{k-1} C_i}{k}$$

and C_D is a constant value to define the sensitivity of the consistency.

25 Modifications within the scope of the invention may be readily effected by those skilled in the art. It is to be understood, therefore, that this invention is not limited to the particular embodiments described by way of example hereinabove. Further, for the purposes of this
 30 specification it should be understood that the word "comprising" means "including but not limited to", and that the word "comprises" has a corresponding meaning.

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CLAIMS

1. A method of checking a possible traffic violation to determine whether said possible traffic violation should be rejected or processed further, where said violation comprises the forbidden entry of a vehicle travelling in a predetermined traffic direction into a monitored region and said possible traffic violation is detected by monitoring a first portion of said region and detecting said vehicle in said first portion, the method comprising:
rejecting said possible traffic violation if any one or more of the following events occur:
an object is detected in at least one predetermined external region lying outside said monitored region and in the path of vehicles travelling in a different direction from said traffic direction;
said vehicle is determined not to have a positive component of velocity in said traffic direction;
said vehicle is determined not to have a consistent velocity; and
a further vehicle or object is detected in said first portion before said vehicle is detected in a second portion of said region, said second portion being after said first portion in said traffic direction.
2. A method as claimed in claim 1, including confirming said possible violation only if said vehicle is detected to be said second portion of said region after said vehicle is detected to be said first portion.
3. A method as claimed in claim 1, including disregarding any detection of said vehicle in said first portion of said region while any object is detected to be in said at least one external region.
4. A method as claimed in claim 1, including photographing said vehicle if said violation is confirmed.
5. A method as claimed in claim 1, wherein said external region is one of a pair of such external regions on

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opposite sides of said monitored region.

6. A method as claimed in claim 1, wherein said
monitoring is performed by means of at least one video
5 camera.

7. A method as claimed in claim 1, including determining
whether said velocity is consistent by collecting and
comparing a plurality of values of said velocity.

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8. A method as claimed in claim 1, including monitoring
for all of said events.

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9. A method as claimed in claim 1, wherein said forbidden
region comprises an intersection during a red-light phase
for traffic travelling in said traffic direction.

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10. A method as claimed in claim 9, including monitoring
said intersection during a green-light phase, determining
a maximum velocity of vehicles entering said intersection
during said green-light phase and a minimum velocity of
vehicles entering said intersection during said green-
light phase, calculating a reference maximum velocity from
said maximum velocity and a reference minimum velocity
25 from said minimum velocity, and rejecting any possible
violation in which said component is greater than said
reference maximum velocity or less than said reference
minimum velocity.

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11. A method as claimed in claim 10, wherein said
reference maximum velocity equals said maximum velocity
plus a predetermined first constant, and said reference
minimum velocity equals said minimum velocity plus a
predetermined second constant.

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12. A method as claimed in claim 9, including monitoring
said intersection during a green-light phase, determining
a maximum convolution output for vehicles entering said
intersection during said green-light phase and a minimum
40 convolution output for vehicles entering said intersection

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during said green-light phase, calculating a reference maximum convolution output from said maximum convolution output and a reference minimum convolution output from said minimum convolution output, determining one or more vehicle convolution outputs for said vehicle during said red-light phase, and rejecting any possible violation in which one or more said vehicle convolution outputs are greater than said reference maximum convolution output or less than said reference minimum convolution output.

13. A method as claimed in claim 12, wherein said reference maximum convolution output equals said maximum convolution output plus a predetermined first constant, and said reference minimum convolution output equals said minimum convolution output plus a predetermined second constant.

14. A system for detecting a traffic violation comprising the forbidden entry of a vehicle travelling in a predetermined traffic direction into a monitored region, comprising:

- a video camera system; and
- a computer processor for determining whether said violation has occurred and in electronic communication with said video camera system;

wherein said system is configured:

- to detect a possible traffic violation by monitoring a first portion of said region and detecting said vehicle in said first portion; and

- to reject said possible traffic violation if any one or more of the following events occur:

- an object is detected in at least one predetermined external region lying outside said monitored region and in the path of vehicles travelling in a different direction from said traffic direction;

- said vehicle is determined not to have a positive component of velocity in said traffic direction;

- said vehicle is determined not to have a consistent velocity; and

- a further vehicle or object is detected in said

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first portion before said vehicle is detected in a second portion of said region, said second portion being after said first portion in said traffic direction.

5 15. A system as claimed in claim 14, wherein said processor is further configured to confirm said possible violation only if said system detects said vehicle to be in said second portion of said region after said vehicle is detected to be said first portion.

10 16. A method as claimed in claim 14, wherein said processor is further configured to disregard any detection of said vehicle in said first portion of said region while any object is detected to be in said at least one external region.

15 17. A system as claimed in claim 14, including a camera for photographing said vehicle, operable by said processor to photograph said vehicle if said vehicle is determined to have entered said forbidden region.

20 18. A method as claimed in claim 14, wherein said external region is one of a pair of such external regions on opposite sides of said monitored region.

25 19. A method as claimed in claim 14, wherein said system is configured to determine whether said velocity is consistent by collecting and comparing a plurality of values of said velocity.

30 20. A system as claimed in claim 14, wherein said system is configured to perform all of said events.

35 21. A system as claimed in claim 14, wherein said forbidden region comprises an intersection during a red-light phase for traffic travelling in said traffic direction.

40 22. A system as claimed in claim 21, wherein said system is configured to monitor said intersection during a green-

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light phase, and said processor is configured to determine a maximum velocity of vehicles entering said intersection during said green-light phase and a minimum velocity of vehicles entering said intersection during said green-
5 light phase, to calculate a reference maximum velocity from said maximum velocity and a reference minimum velocity from said minimum velocity, and to reject any possible violation in which said component is greater than said reference maximum velocity or less than said
10 reference minimum velocity.

23. A system as claimed in claim 22, wherein said reference maximum velocity equals said maximum velocity plus a predetermined first constant, and said reference
15 minimum velocity equals said minimum velocity plus a predetermined second constant.

24. A system as claimed in claim 21, wherein said system is configured to monitor said intersection during a green-
20 light phase, and said processor is configured to determine a maximum convolution output for vehicles entering said intersection during said green-light phase and a minimum convolution output for vehicles entering said intersection during said green-light phase, to calculate a reference
25 maximum convolution output from said maximum convolution output and a reference minimum convolution output from said minimum convolution output, to determine one or more vehicle convolution outputs for said vehicle during said red-light phase, and to reject any possible violation in
30 which one or more said vehicle convolution outputs are greater than said reference maximum convolution output or less than said reference minimum convolution output.

25. A system as claimed in claim 24, wherein said
35 reference maximum convolution output equals said maximum convolution output plus a predetermined first constant, and said reference minimum convolution output equals said minimum convolution output plus a predetermined second constant.