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Automatic Detection of Red Light Running Using Vehicular Cameras

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Abstract: *The red traffic light running is a very common areas with greater pedestrian flow, the type and amount of traffic violation. Nowadays, vehicles running red traffic lights are accidents, among others. The rule, in General, is the same applied detected by sensors fixed on the streets. However the very small along the main routes. Percentage of all traffic lights are equipped with such sensors. Is this reason, this work proposes the red light runner detection to be performed by the system that consists of the camera and the computer embedded in the vehicle. An algorithm is also proposed to process the recorded videos and the prototype was implemented. The prototype's goal is to monitor work vehicles without any intervention in driving, acting only in as an educational tool. Tests are performed with video recorded in the streets of Belo Horizonte during the day and with the video benchmark using the implemented prototype. The results are compared based on the execution time and accuracy. The video processing took less one tenth of the video's duration and the accuracy was about 95.8%.*

Keywords:
Traffic light Detection, Red light running, monitoring driver, Autonomous vehicles, Video processing

1. INTRODUCTION

With the increasing amount of vehicles. The most frequent violations logged in first half of 2013 in Belo Horizonte were advancing red light and parking on site. The amount of infractions by advancement of red light suffered a great reduction of 80% in the first half of 2014 in over the same period of the previous year, from 123,878 to 25,470. However, this reduction in registrations not necessarily mean that the infractions not fined fell in the same proportion. Drivers end up doing a mapping the traffic lights that have advance registration and consequently, know which disrespect without being penalized. Currently, the city has about 122 equipment advance registration of red light. Devices feature great precision, sometimes coupled with human aid, as in. However, the cost produced each year, the automotive industry has the installation of such equipment on all invested in more intelligent transport systems with the objective of assisting the driver to make decisions and thinking timely manner in situations of risk, helping to save lives and resources. A system that gives the vehicle the ability to understand and interpret what's in your back can in the short term improve the security of those drivers directly and the Middle term enable the development of autonomous vehicles. The advance of red light is one of the infractions common and is considered a serious infraction. However, neither all the lights are monitored by advance registration. Thus, there is a need to monitor the vehicles in traffic lights without advance registration. A possibility, explored in this work, is to use a system with a on-board camera on the vehicle, which could accomplish. In places where there is no fixed radars or officers in via. In addition, a same camera could be used for other purposes (in some cities, there are cameras on buses, for example). As the characteristics of the traffic and routes differ from a route to another, in addition to the difficulty of adapting the signaling on an entire city, various sensors consisting of cameras can perform the task to assist the interpretation of signaling and register a possible bad conduct before a red light. Several radars and electronic sensors are installed in roads and strategic locations of major cities such as Belo Horizon, based on technical studies that detect intersections with traffic lights in the city makes the project unfeasible at first, which is why the intersections candidates are selected based on statistical data, to receive advance registration equipment. With an advance detection system of red light embedded in the vehicle, the driver could have better conduct and respect signs regardless of the existence of military officers or of fixed speed cameras on the road simply by knowing you're being monitored. With this, there could be a reduction in the statistics and, mainly, of accidents. There are several works related to detection and traffic sign recognition in General replacing the conventional sensors for processing images. Two common ways to start the detection and recognition of traffic signs through images are based on color segmentation and segmentation based on edges. Techniques that use colors tend to have better control over the lighting. An example using the HSV color space is described by Fleyeh. Several papers have been published using

Vision Computer to control or monitor the situations traffic. The works of Cosmo, Salles and Ciarelli perform pedestrian detection using a vector Machine Support (SVM) to train and test Windows scanned the image of being a robust classifier in pedestrian detection. Also use Histogram of oriented gradients (HOG), proposed by Dalal and Triggs, the high performance of the descriptor. The hit detection is around 63.8%. Fairfield jobs and Urmson and Levinson et al dealing with the detection and recognition of traffic lights with the aid of geospatial queries to detect intersections on the road, through the Google Maps API, for discard distant images of crosses. However, this rule does not apply in Brazil, where, in many places, is common meet traffic lights on a simple crossing of pedestrians. In addition, the system would become highly dependent on the connection to the GPS. Images are labeled to from sources of light red, yellow or green. The away from the traffic light is estimated on the basis of calculations involving the actual size of the objects. Shenetal propose a modeling of hue and saturation (HSI space) based on 2D Gaussian distributions, where the parameters are obtained from candidates labeled manualment. In addition, it is proposed a method to eliminate false candidates based on information in post-processing of the image. The end result is a combination of information from the post processing and a historical base. The results of this approach, in though, come to present an accuracy exceeding 99% for some videos. The scope of these works is limited to detection of traffic lights. On the other hand, feed detection methods of signal Red are proposed by Yung and Lai and Luo, Huang and Qin with the camera located at a fixed point of the via where are visible the semaphore, the retention range and the cars passing by. The method of Yung and Lai identifies the nearest traffic light (the higher the image) and uses the processing. The detection is done based on the color: white for retention range and red, yellow and green for the traffic light. The test results achieved 100% hit in the tests. Luo, Huang and Qin perform the tests on a intersection with free right, i.e. where the light is not valid for convergence to the right (only for vehicles that converge to the left or move on). The results feature slightly lower precision, around of the 90% for unmetered traffic lights, failure to signage still exists and remains unpunished. Aiming at the reduction of advances of traffic lights at intersections do not monitored, this paper proposes a methodology for detection of advancement with the on-board camera on the vehicle, uniting signal detection techniques and advance detection using computer Vision.

2. FEED DETECTION

Advance detection systems red light usually use fixed cameras at strategic points via, becoming part of the traffic control system at that location. The proposal assumes that the camera It is shipped as part of the vehicle, turning the system in a vehicle and monitoring driver. The purpose is to monitor work vehicles, as buses, trucks and taxis, since the system is not interesting for RVs. The methodology addresses from capture images from your camera shipped to the detection, in real time, of the progress of the traffic light. There is concern to display any alert or generate any penalty for the driver, either there is no interference on driving. First, the images are captured by a camera serve and transferred to a laptop present inside of the vehicle. The camera should be facing forward. Fig. 1 contains an example of image captured by the camera run. Then, in a second stage, the images are preprocessed to reduce any noises from the procurement process. The image passes by, respectively, the average filter, erosion and dilation.

Figure 1. Vehicle camera view.

In the third stage, targeting, the system determines which regions of the image are relevant to proceed with the processing. Segmentation is based on tom the colors of the lights of the traffic light, traffic lights have shades the so-called green, yellow and red. The RGB image is converted to HSV space for ease in if separate color and lighting information, working best in shadows and in the evening, and search for elements Reds. As there is no problem in passing through the traffic lights yellow or green, these colors were excluded from the segmentation. The next stage, detection and recognition, checks whether a region of interest contains a traffic light. Used to find red circles. As the lights the traffic lights are round, candidates have no way about rounded are discarded. As lights of vehicles also are red and usually have the form approximately round, only the upper region of the image, about 1/3, is considered and the other candidates are discarded regardless of shape. In addition, the semaphore is important only when the vehicle is next him, to confirm or not the advance depending on the color of traffic lights at the time. Going on more than one possible light, as close to the vehicle is chosen based on time within the image (the higher, closer to the vehicle). The light is only taken for granted if found in two consecutive frames to reduce the impact of noise is not eliminated in the preprocessing. As the traffic light has a standard way that is relatively simple with few relevant characteristics, for simplicity, any technique of classification was used. Finally, if the previous steps a semaphore was found, the trace phase checks the vicinity the traffic light until he leaves the field of view of the camera using Cam shift. If he gets out of the picture at the top of the image, and while red, confirmed the advance. Otherwise, the light may have been green or it could just be a temporary occlusion. While the red light is in the camera's field of view, the new position of the semaphore is used in the following tables for tracking until the light disappears. This prevents any image have to be processed again. A small set of images extracted from a video with approximately 3 minutes, recorded in Belo Horizon, was used for calibration of parameters.

3 EXPERIMENT

To check the operation of the proposed technique in this work, we used two different videos. The videos were stored submitted for implementation of the algorithm is explained in the previous section. A video for testing has been made available on the site. The video refresh rate of 25 fps (*frames per second*-frames per second) at VGA resolution (640 x 480 pixels), 8 bits per pixel, color, and frame-by-frame was separated in JPEG format images (acronym for *Joint Photographic Experts Group*), how it is distributed. The video has a total of 11,179 frames. The refresh rate has been reduced to 5 and 2 frames per second just experimental character. The vehicle carrying the camera passes over the video 8 red lights, but does not advance any. The images were obtained during a commute of about 8 minutes on the streets of Paris, in France. This is a generic video for *benchmark* in video processing techniques, so the camera was placed specifically to view traffic lights suspended above the vehicles. Another video was recorded with a camera relaying in Minas Gera is, in the streets of Belo Horizonte and Contagem When the vehicle is moving at approximately 50 km/h (disregarding the reductions under a traffic light). The video was recorded in 25 frames per second in resolution of 640 x 480 pixels, 16 bits per pixel. The video lasts approximately 24 minutes recorded during the day, totaling paintings about 43,200. The same reduction on taxa was made to frame 5 and 2 frames per second, and each table stored as an image in JPEG format to a fair comparison with the French video. However, the tests with this video included the original format, with 25 fps, for real-time validation. The vehicle passes through 24 traffic lights in total, of which 8 are red. In this video, recorded for tests on this work, the camera was properly positioned in order to capture the lights on position just above the vehicle to facilitate the detection of advance. To validate operation in the event of a real advance, forward simulations were made with the camera being tilted vertically, from top to bottom, so that the traffic light go out of sight of the camera in the upper region of the image. The simulated behavior is similar to what occurs when the vehicle passes under the traffic light. The vehicle remain standing during the process. These simulations of advancement are illustrated by fig. 2 and allow the testing of and detection of false negatives. The video has a total of 41 seconds with a total of 16 simulations of advancement during the day. The lights come with both intersections as simple pedestrian crossings. Times are compared implementation and the relationship between the amount of false positives and false negatives for each situation. The method has been implemented in C++ with use of the library Open CV. The tests were performed on a computer with Core i3 processor 2.3 GHz dual core with 6 GB of RAM and running Ubuntu 14.04. Some of the parameters, when not specified, have been defined with the calibration using a small group of images to Google's Street lights View and images obtained by the same vehicle camera used to capture test videos. The parameters used were the following: pre-processing: the filter of average uses 3 x 3 dimensions array and dilation and erosion with structural element dimensions 3 x 3 square *pixels* ; Segmentation: the search for Red elements accept only the points in HSV space where S and V are superior to 75%. In the video of Belo Horizonte, the H value for Red remained around 0 with tolerance of 20 in the calibration, while, in the video, H benchmark has been set as 40° with a tolerance of 10. The difference is due to the fact different cameras being used in the capture of the two videos; Detection and recognition: Canny uses threshold less than 40 and top 100 threshold with a 3 x 3 window *pixel*. The Hough transform for circle accepts aminimum distance of 30 *pixels* between the centers of the circles for the test images 640 x 480 *pixels* so there are noexcess of detected circles. The minimum and maximum RADIUS allowed are 3:20, respectively, based on size expected light inside the 640 x 480 image *pixels* ; Trace: the Cam shift method executes at most 10 iterations in the search of the convergence of *m (x)* (weighted averagethe density of the window set by the Kernel), default value used in tracing method of Open CV.

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4. ANALYSIS OF THE RESULTS

The processing of the recorded video during the day in Beautiful Horizon with 25 frames per second it took a while 1567-second average (26.1 minutes). With 5 frames per Second, the time required was 247 seconds and no false positive. Reducing the refresh rate to 2 frames/second, the time dropped to 98 seconds still no false positives. Fig. 3 contains a semaphore detected and processed correctly as don't advance.

Fig 3.Example in which the light has been detected correctly and no traffic light advance was registered.

For the simulation of advance processing time with 25 fps took 22 seconds with 17 (1 records false positive). With 5 fps processing took 6 seconds and found 15 advances of light among the simulated 16, While with 2 fps was 3 seconds and 9 advance detections were recorded. The fall is due to detection "jumps" the traffic lights give the image, disappearing before we even to get close to the top edge of the image. Fig. 4 exemplifies a case in which the light disappears on the top of the image (same with othe) and the stem is properly identified. Already the Fig. 5 shows the case where not detected the simulated breakthrough. The light was out of the field of vision of the camera before close enough to the top edge of the image. Right the main consequence of the reduction in the rate of frames per According to the video.

Figure 4. Example of simulation in which the red light has been detected and the advance accounted for.

Figure 5. Simulation example in that the red light was not properly detected.

For the video of Paris, the processing took 137 seconds with 5 fps and 58 seconds to 2 fps. The rate of errors revealed extremely high with 2 fps, with 9 advances in only 8 traffic lights, but the amount of errors was still better than the 15 advances with 5 fps (8 false positives). This is due to mainly to the positioning of the camera, which is virtually horizontal. With that, several lights and elements Red, as the lights of other vehicles, for example, are confused with traffic lights because they are at the top of the image, even if they are not really suspended over the road. In Fig. 6 you can view a case of erroneous processing with the vehicle considerably away from the traffic light due to bad placement of the camera. However, in a scenario in which the camera was properly positioned, the progress exemplified would be considered a success, since the red light came out of the field of vision the camera at the top of the image

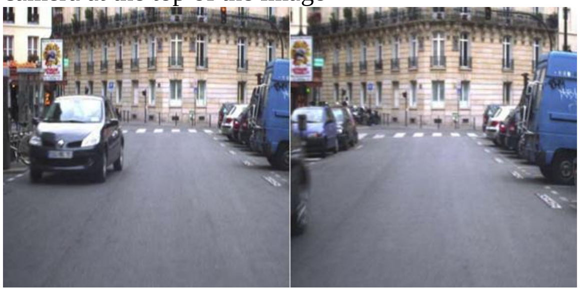

Figure 6. Traffic light coming out of the camera's field of view, a feature advance.

Despite the high number of false positives, there have been cases When the detection occurred correctly and was not computed advance. Fig. 7 shows a case in which there was correct processing in French video. As the time for the video of Belo Horizonte with 25 fps was higher than the duration, making real-time execution in this configuration, the video benchmark tests of Paris were made only with 5 and 2 fps.

Figure 7. Example of correct processing without advance light

TABLE I

AMOUNTS OF ERRORS AND SUCCESSES ADVANCING DETECTION TO 5 FPS

	Real progress	Not Advance	Total
detected Forward	15	0	15
Forward not detected	1	8	9
Total	16	8	

Configuration with better performance for the video Belo Horizonte was with 5 fps. The video with the frame rate original per second (25 fps) would render unfeasible the real time processing and video with 2 fps reduces the detection rate of advancement. A summary the results with tests for 5 fps is presented in the table (I) by the fact 5 fps to present the best ofcompromise between detection and error rate. Was taken in account the General test, including both the video with the camera static as the video of the simulation. Similarly, table II contains the result of the including processing all the lights on the *benchmark* French. Were considered as advance all the lights coming out through the top of the image as in Figure 6, which is the main feature of progress evaluated by the algorithm. In other words, whenever the traffic light Red out of the field of vision of the camera through the top, a breakthrough must be considered. Otherwise, we will have a false negative.

TABLE II

AMOUNTS OF ERRORS AND SUCCESSES IN ADVANCING DETECTION TO 5 FPS FOR VIDEO BENCHMARK

	real progress	Not Advance	Total
detected Forward	7	8	15
Forward not detected	1	9	10
Total	8	17	

Only for a possible performance test execution in real time, a test was done with the video from Belo Horizonte in 1024 x 768 resolution with the same rate of 5 fps. The time processing, however, was 113 seconds for each minute of recorded video. The increased time disproportionately greater than the increase in resolution makes the decisions more time processing high. However, Considering the VGA resolution proposal and the average execution time 10.3 seconds per minute recorded with 5 fps, you can deduce that if you can increase the frame rate up to 20 fps and, with it, the speed maximum of the vehicle could reach close to 200 km/h without large impacts on detection. This refresh rate (20 fps) is under 25 fps to knowingly spend longer than the duration of the video.

5. CONCLUSION AND FUTURE WORK

In Belo Horizonte, less than 1% of traffic lights has equipment for detection of advance of red light. With the large number of infractions by advancing all semaphore year, needed a new way to identify these advances in non-suitable equipment lights for the record. For this reason, this paper proposed that the monitoring is done from inside work vehicles, no longer on the intersections of the road. The proposal part of the use embedded cameras and processing techniques image. The images are recorded with vehicular and camera videos processed later. The precision has been satisfactory for videos recorded during the day since the camera was well placed, in addition to the runtime have been greatly reduced, leading less than 250 seconds to render 24 minutes video at 5 fps with accuracy exceeding 95.8%. The implementation requires adjustments and a better definition of parameters for dealing with better lighting and other elements in the image that can confuse the algorithm. The runtime is less than the length of the videos for processing with reduced frame rate/second, opening possibility for real-time processing. For the benchmark, there have been many false positives by placing the camera. With that, the use of a generic camera (used for other purposes) has become a problem, since the light comes out of the field of view with the vehicle still very far from the traffic light. Even with many false positives, the hit rate was 64% of traffic lights rendered correctly. Due to the impossibility of moving lights legally and capture videos of tests with these real advances, testing were conducted with advance simulation based on movement of the camera in front of the red light. The tests had better results for the video from 5 fps, but still haven't detected all simulated, advances have other Red elements rose to the top the image and mistook the algorithm. The hit rate on simulation reached 95.8%, even with the other problem lights and Red items they put in place of the traffic lights. This work brings a new perspective as a contribution of advance detection of light with the camera on board, regardless of whether the traffic light is monitored by other advance registration forms. Related jobs found dealing with a fixed point of the route. Although less accurate than a fixed feed detector on the road, yet the solution appears to be feasible for the flexibility of record of advancement in any unmonitored semaphore. There are several possibilities of technical improvement proposal. Based on the results, shows up viable processing in real time with a computer embedded in the vehicle connected directly to the camera. It is recommended, in this case, assessing your performance in a low-power system, as a minicomputer based on Intel Mini-ITX or Raspberry Pi, for example, since this work has adopted a Core i3 processor computer. Another proposal includes tests with recorded videos with a better camera quality that reduces the distortion of colors, to compare the aspect of accuracy. There is also a need to deal with videos recorded at night and with traffic lights dinning arrows bright which restricts the movement only to certain vehicles, because this type of approach was Treaty within the scope of this work. Another possibility is the parallel processing, which would make better use of the features of a low-power system. Although the benchmark video used in testing not be adequate for the placement of the camera, tests with other benchmark videos should be conducted. Tests with registry systems of similar progress can be made by evaluating, in addition to accuracy and processing time, mobility, the cost of implementation and deployment.

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