Optical Character Recognition Technology Applied for Truck and Goods Inspection

CLEDSION AKIO SAKRUA1, CLAUDIO LUIZ MARTE2, LEOPOLDO RIDEKI YOSHIOKA3, CAIO FERNANDO FONTANA1

1. Science of Sea Department - DCMAR
   Universidade Federal de São Paulo
   Av. Alm. Saldanha da Gama, 89 – 11030-400 – Santos, SP
   BRAZIL
   akio.sakurai@unifesp.br and caioffontana@gmail.com http://www.imar.unifesp.br/

2. Transportation Engineering Department
   Universidade de São Paulo
   Av. Prof. Luciano Gualberto, trav. 2, nº 83 - 05508-900 – São Paulo, SP
   BRAZIL
   claudio.marte@poli.usp.br http://www.usp.br/

3. Electronic Systems Engineering Department
   Universidade de São Paulo
   Av. Prof. Luciano Gualberto, trav. 3, nº 158 - 05508-900 – São Paulo, SP
   BRAZIL
   lryoshioka@lme.usp.br http://www.usp.br/

Abstract: - Technological evolutions at Intelligent Transport Systems (ITS) is allowing that ubiquitous society use the ITS facilities to conducting their activities. At this scenario the paper presents a study case that is being developed to SEFAZ (Treasury Department) of São Paulo state in order to use ITS technologies applied to conduct his activities, mainly for tax inspection. The study case presented in this paper uses the Optical Character Recognition to identify and monitor the vehicles that does not pay the IPVA (motor vehicle tax), all study case considers the use of existing ITS infrastructure, as well as the deployment of new infrastructure. The advantage of OCR is the ability to identify vehicles without disrupting the normal flow or even cause a decrease in speed and to be non-intrusive in perspective of vehicles owners.

Key-Words: - ITS, OCR, Inspection, Goods, Trucks, Tax.

1 Introduction

Several opportunities are central to bringing of diverse and substantial social and economic benefits to world, however, these decisions affect the design, accessibility and use of these technologies could open wrong ways [1]. This mobility permit to have information in anywhere, then the ITS systems can be more effective permitting to have real-time information. Also the accessible cost of devices and communications channels permit to use in more services in order to inspect the road and supply chain. For SEFAZ-SP (São Paulo Treasury Department) is important to make the inspection of goods to verify if the supplier is doing the correct statement of the goods transport. The cargo transport is a key step in the logistics supply chain, with 70% of all goods is transported via road transportation. So there is the need to adopt technologies that aid in enforcement against tax evasion in this activity [19].

Regarding the tax on transportation of loads, the ICMS (goods tax) represents 87% of the total collected by SEFAZ-SP in 2008, being 74 billion of brazilian reals (R$) refers to the ICMS of a total of R$ 85 billion revenue [1].

It is estimated that this tax evasion could reach about 26% of total (about R$ 18 billion annually) [2].

Possible actions include charges of tax evasion is not declared, simulation of interstate delivery, cargo tampering and others. Besides the issue of tax evasion, a problem that is extremely relevant to
companies linked to national supply chains and logistics refers to the theft charges. Around R$ 800 million in losses resulting from theft of cargo in Brazil in 2009, only the southeast (SP, RJ, MG and ES) accounted for 79.88%, and the State of São Paulo, in time, was responsible for 50% of total [3].

The theft of cargo has increased marketing and technology companies to provide tracking & monitoring services, offering logistical support facilities and technology for this purpose. Together, they account for up to 136,000 trucks - equivalent to 8% of current national fleet of 1.7 million cargo vehicles [4] [18].

The choice, design and deployment solutions that integrate the technologies for the electronic tracking & monitoring depend on the supervision objectives of SEFAZ-SP.

These goals can be broken down into requirements, which can be sorted and grouped into operational requirements for the purpose of SEFAZ-SP, requirements related to the object of tracking & monitoring requirements and the type of operation or fraud which SEFAZ-SP want to monitor.

The definition of the operational purpose is to determine whether a particular technological solution will be used to trace the statistical analysis of routes / locations / time / business • Support for monitoring in real time

2 Situation
Economic growth in recent years has led to increase in the number of vehicles in circulation, and consequently had an increase in nonpayment of IPVA (motor vehicle tax). At Sao Paulo State nonpayment of IPVA is the order of 9% [2], equivalent to US$ 400 million a year [3].

However, there wasn’t an increase in the number of fiscal required to enforce the new demand. And also, it appears that despite the fine for late payment of IPVA does not encourage the defaulters make the necessary payments. For this reason the SEFAZ (Treasury Department) need to identify the vehicles in transit and make the apprehension. [12].

In this context, the system must be able to identify the vehicle through non-intrusive technology, such as LPR, and verify the database of tax payments about the situation of this vehicle. This process should be performed in real time, so that the defaulter vehicle is arrested [4].

3 Proposed Solution
To solve the problem presented in the anterior topic is necessary to use an integrated solution, consisting of vehicle identification, means of communication and integration with the database of tax payment. For this purpose, this paper proposes the solution presented in this topic.

3.1 LPR Technologies
The LPR (License Plate Recognition) has been implemented through a combination of sensors, cameras, software and other equipment for the recognition of characters on the plates, using OCR (Optical Character Recognition) algorithms on images captured on the road or street, as shown in Figure 1.

This paper presents an effective solution for the surveillance of vehicles through the use of LPR (License Plate Recognition) and integration with the system of tax payments, allowing in real-time to identify which vehicles will be stopped at inspection post.

Table 1: Electronic Tracking Objectives

<table>
<thead>
<tr>
<th>Classification</th>
<th>Possible requirements to be met by the solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Operational purpose</td>
<td>• Statistical analysis of routes / locations / time / business</td>
</tr>
<tr>
<td></td>
<td>• Support for monitoring in real time</td>
</tr>
<tr>
<td>2. Object</td>
<td>• Vehicles - trucks, others</td>
</tr>
<tr>
<td></td>
<td>• Cargo - containers, pallets, boxes, items, bulk, other</td>
</tr>
<tr>
<td>3. Type of operation</td>
<td>• Sales in the State</td>
</tr>
<tr>
<td></td>
<td>• Interstate sales</td>
</tr>
<tr>
<td></td>
<td>• Export</td>
</tr>
</tbody>
</table>

This paper presents an effective solution for the surveillance of vehicles through the use of LPR (License Plate Recognition) and integration with the system of tax payments, allowing in real-time to identify which vehicles will be stopped at inspection post.
Sensors and cameras of all stripes are usually connected to a local processing unit, whose main component is a computer that captures or select the images generated by cameras, processes the OCR algorithm, stores and / or send plates for later recognized processing.

Recent advances in computing performance with reduced costs, the OCR algorithms and communications channels (mobile, internet, etc.) enable LPR system evolve in terms of reliability (accuracy more than 90% of plates), operation facilities, maintenance and cost.

LPR systems operate with the vehicle stationary or moving (depending on the detection equipment) in inside or outside areas, but its performance is influenced by adverse weather conditions such as fog or heavy rain. Still, these systems can be used in various situations, even with vehicles traveling at high speed.

The detection of vehicles can be performed by sensors embedded in the lane, such as inductive loops, detector optics, among others. There more sophisticated LPR systems that rely on sensors, the cameras capture multiple frames per second (as in a movie) continuously and LPR software selects the most relevant images automatically - that is, vehicles license plates. Although relying on cameras and processing software, or more expensive, this option is the lower cost of installation and operation.

**3.2 Communication Channels**

Appropriate communication channels are required for the interconnection between the equipment that will make the identification of vehicles on the roads (LPR), the checkpoints (mobile or fixed), the databases in SEFAZ. The telecommunications industry provides several technologies for data transmission, with different profiles of cost, speed, mobility and availability. This work is being considered transmission via mobile.

In Brazil there are technologies available for data transmission via mobile, usually (GPRS) from second and third generation (3G), which are available along the main road, see figure 4. The main advantages of mobile technology are the mobility and wide availability of equipment and operators that offer such services. Moreover 3G technologies offer nominal speeds of up to 7 Mbps (the speed of business systems in real conditions, however, rarely exceed 1 Mbps). [14]

**3.3 Motor Vehicle Tax System (IPVA)**

The SEFAZ has a system of control of IPVAs which is connected directly to financial institutions, allowing that the situation of IPVA payment be changed in real time. For example, after processing IPVA payment, it is updated in the IPVA system of SEFAZ. This feature allows the effective utilization of IPVA system, since it reduces the error at proceeding of default.

**3.4 Identification Process through LPR**

This scenario assumes that the vehicles are traveling on a highway at speeds usual permitted by law. Automatic readers license plates (vehicle detectors and cameras) are installed in stopping places (such as ports, parks, gas stations, toll roads) or passage (such as roads and other routes).

When the vehicle passes through the detector, a photo of the board is captured and a system that uses an image processing algorithm for OCR (Optical Character Recognition) and get the license plate in question.

Thus, it is possible to verify that a vehicle passed or was present at the site where the LPR equipment is installed, without the same need to
stop or even slow down. At scenario described can be made are the following, see figure 5:

1. Sensors detect the passing or stopped vehicles;
2. The cameras capture images of vehicles detected;
3. The local processing unit processes the OCR algorithm at image to recognize the license plate;
4. The local processing unit sends the identified plate to central control through communication channel, to find the information of the vehicle in question. At central control is installed the IPVA System;
5. Central control query default of IPVA for the license plate;
6. Central control sends back plate of vehicles that need to be investigated;
7. The local processing unit displays message at electronic board with the vehicle plate, notifying him to stop at the next inspection post. The message also is sent to the fiscal at the inspection post.

A wide range of devices and systems for detection of vehicles for use in conjunction with LPR, which can range from the popular inductive links to systems via microwave for multiple purposes (including weighing) as described in Table 2

The comparison presented in Table 2, the more complete detection system is the optical scanner, however the maintenance is tricky because it requires that the sensors are always clean.

The more traditional sensors such as inductive loops, while popular and lower cost of acquisition, have higher operating cost, lower precision and high failure rate, partly explained by the fact that they are intrusive, or engaged at lane.

Alternatively, there are LPR systems that do not require sensors, because image capture is continuous as in a video camera, around 30 frames per second. But this solution requires most sophisticated LPR system, due to the necessity to select the image which containing vehicles and their license plate, without repetition and in real-time, before processing of OCR algorithm.

<table>
<thead>
<tr>
<th>System</th>
<th>Detection Precision</th>
<th>Classification Precision</th>
<th>Installation Facility</th>
<th>Maintenance Requisites</th>
<th>Mounting Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductive Loop</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
<td>Intrusive</td>
</tr>
<tr>
<td>Magnetic Sensor</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Intrusive</td>
</tr>
<tr>
<td>Pneumatic Tube</td>
<td>Good</td>
<td>Poor</td>
<td>Excellent</td>
<td>Poor</td>
<td>Intrusive</td>
</tr>
<tr>
<td>Optical Scanner</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Non Intrusive</td>
</tr>
<tr>
<td>Passive Infrared</td>
<td>Good</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Non Intrusive</td>
</tr>
<tr>
<td>Microwave Radar</td>
<td>Good</td>
<td>Poor</td>
<td>Excellent</td>
<td>Good</td>
<td>Non Intrusive</td>
</tr>
</tbody>
</table>

Table 2: Comparison between main vehicle detection systems

3.5 Requirements for Information System

This item presents the requirement for information system necessary to implement the proposed solution.

3.5.1 Lane Requirements

For each lane, it is necessary the following equipments:

- Detection Equipment (optical scanner, inductive loop or other);
- Infrared Camera;
- Post to mounting the cameras - in the case of roads or streets with three or more lane, it is recommended to build a portal, or a set of cameras in signaling structures, bridges, or toll plazas;
- Cabling and devices for interconnection of equipment’s and power suppliers.

Independently of amount of role, it is required:

- Local unit processing with computer to execute OCR algorithm to automatic license plate reading, communication channel with central control and sending messages to electronic board;
• Electronic board (optional item) installed after the detectors and cameras infrastructure in order to notify the drivers to stop in the next inspection post. The board must be installed a distance ahead that is sufficient to identify them by LPR / OCR, cross-checking the license plate by the central control and notify the driver to stop the vehicle at electronic board;
• Power supply;
• Communication channel with the inspection post to sending the vehicles to being stopped.

Alternatively, the scenario may include:
• Mobile System - Installation of the system in to a box, containing camera, processing system, communication channel through mobile technology, power supply (batteries). This box could be installed anywhere on the road or street;
• Embedded System - Installation of the system inside a police car, which own camera, processing system, communication channel through mobile technology and power supply.

3.5.2 LPR Systems Requirements
The LPR system must meet the following requirements:
• It should be possible to identify the characters of license plate for at least 90% of the stored images, regardless of the situation or lighting;
• The rate of false positives (plates whose reading differs from the real characters) must be less than 2% of the plates read by LPR, except cases of fraud. A high rate of false positives implies higher cost of operation of the LPR, depending on required processing;
• The maximum speed for image recording should be greater than 160 km / h;
• Each system must be able to record the images and perform LPR in following condition: a road or street with at least 4 lanes with traffic of 500 vehicles per minute, traveling at 120 km / h.

3.5.3 Infrared Cameras Requirements
References [8] and [9] provide examples of cameras dedicated to LPR, and the minimum requirements for the cameras to meet the proposed scenarios are:

• The camera's shutter must have exposure time of 1ms or less (this feature typically allows capture of vehicles at speeds up to 190km / h) and auto-iris;
• They must be used cameras that have a gun led's that emit infrared light, since there are tricks and illegal devices that makes it possible for cameras with flash commit mistakes and errors, mainly. Cannon and infrared filter must operate close to the range of 850 nm, which is in reference to this type of application, with sensitivity of 0 lux for night capture;
• The camera should have a mechanism for correction of intense illumination (DSP or other method);
• Another important factor in the choice of camera in use is the resolution that can be expressed by number of lines of horizontal sweep circuit that the camera has. The camera must have a minimum of 480 lines for LPR;
• The cameras capture images and LPR should be cameras fixed sized (30 cm long or less), ie, the cameras are generally classified by the size of the CCD (charge coupled device or charge-coupled device) that is the camera sensor that captures images, typically 1 / 3 ’1 / 4’ inch for the application in question, with lenses 18-50mm;
• The camera should be resistant to external conditions and adhering to the IP66 specification [18], which is the classification standard for equipment resistant to external environment.

3.5.4 Detection Systems Requirements
The equipment for the detection and classification presented in Table 2 should be taken into account the following general requirements:
• The system should offset any adverse weather and reflective effects (track and other areas not related to vehicles) automatically;
• The maximum speed for detection and classification must be inferior to 160 km / h;
• Each system must be able to detect and classify all vehicles in following condition: a road or street with at least 4 lanes with traffic of 500 vehicles per minute, traveling at 120 km / h.
• The equipment and external components must be resistant to external conditions and adhering to the IP66 specification.

3.5.5 Electronic Board Requirements
The electronic board considered in this article must meet the following requirements:
• Technology emitting diodes (LEDs);
• Use outdoors, being adherent to the IP66 specification;
• Control visibility day and night;
• Minimum of 2 lines with 12 characters each;
• Alphanumeric characters with a minimum height of 50 cm (which generates a maximum visibility of about 200 m);
• Display of messages received by serial interface;
• In the scenarios proposed, if only a hypothetical situation in which:
  o The vehicles travel at 120 km / h;
  o The driver needs 5 seconds to recognize and read a message on the panel within the distance of visibility;
  o The distance traveled by a vehicle until the driver can read the message is 120 x 1,000 / 60 / 60 x 5 = 167 meters.

Thus, panels with visibility of 200 m are appropriate to the assumptions above.

3.5.6 Communication Requirements
This item describes the requirements for the communication channel between the LPR System and Central Control. The bandwidth needed for transmission of data already processed on the identification of vehicles (LPR). If these situations is considered as a premise that:
• Road with total flow of 500 vehicles per minute, as in the previous situation;
• Identification of 100% of the vehicles via LPR;
• Each identify has 200 bytes;
• In those circumstances are sent 500 x 200 / 60 = 1,667 bytes / s, or 13.3 kbps data useful.

Therefore, in these conditions any link available in the locality can be used, because it is not necessary broadband channels.

3.5.7 Local Processing Unit Requirements
Since the local processing unit and other equipment will be unattended area:
• The equipment of the unit should be kept in box with resistance to vandalism or theft;
• The enclosure must be weatherproof according to IP66;
• The local software is designed to not require processing more than a desktop computer.

3.5.8 Central Control Requirements
The hardware requirements (servers), infrastructure (communications equipments, channels, power supply, etc.) and other devices (network and others) will be determined by the features, software and integration with databases or other systems required in each situation.

4 Conclusion
The present proposal permit to have an efficient system that permit to monitor vehicles though license plate, where the main advantages are:
• Ability to identify vehicles without disrupting the normal flow or even cause a decrease in speed;
• The scenario is "non-intrusive" in perspective of owners or users of vehicles, ie not rely on devices or tags installed in all vehicles, as opposed to RFID;
• There is not demand for sending images or other types of high-volume data by the communication channel.

On the other hand there are points of attention that must be followed to the stage of LPR:
• The safety of vehicle identification technology using radio (like RFID) is more sophisticated than identification by LPR. The LPR is subject to fraud (such as products, adhesives or mud applied on the plate);
• The LPR may have read rates with less success than RFID. This can result in higher operating costs, mainly associated with inspections generated by errors on LPR. Moreover, the performance of LPR can be harmed by adverse climatic conditions, such as storms.

The next step of project is to store information of license plates at database, and monitor the displacement of vehicles. Depending on the amount of LPR systems may be possible to track each vehicle in real-time.

References:
[16] Universidade Federal do Rio Grande do Sul – UFRGS. Instituto de Física. Produção de Raios X available at http://www.if.ufrgs.br/ tex/fis142/fismod/mod05/m_s01.html


