

# ANALYSIS OF METHODS AND TECHNICAL TOOLS FOR TRAFFIC CONTROL SYSTEMS

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**Abstract:** In this article we analyse different methods for remote non-contact counting of moving objects at different speeds: video, mechanical, optical, ultrasonic. The principles of their implementation, advantages and disadvantages are described and the reliability of information processing methods is evaluated. A model of road traffic measurement and analysis system is presented. It is specially emphasized on application of different sensors in real-time data acquisition, management and analysis of traffic intensity.

## 1 INTRODUCTION

Nowadays, everyone is faced with road traffic problems due to the ever growing urban population, the formation of mega-cities, the inability of the road infrastructure to take the ever increasing road traffic stress and inefficiency of the existing traffic management systems. To solve those problems it is necessary to collect, analyse and systematize traffic information - when and where traffic is densest, what vehicles cross the road - cars, vans, trucks, buses. Obtaining the data requires the use of different methods and tools for identification and counting of the moving vehicles.

Once the information is obtained it can be organized and used to build intelligent systems for traffic management and statistical databases. It will be useful in various business areas such as logistics, navigation, courier services in search of the most efficient way of transportation to reduce fuel costs, saving time and hence reduce air pollution. Therefore, information needs to be frequently updated and to be with the highest precision. Collected information can be used for traffic signalization systems, opening or closing highway roadbeds. It can also be stored in databases and analysed at later stages in case a decision have to be taken if a road must be created, when a maintenance should be carried out or how road infrastructure must be changed.

This article aims to make comparisons between various methods of traffic detection, highlighting their strengths, weaknesses, areas of application,

efficiency, the most common errors in measurement and finally make brief conclusions.

## 2 ROAD TRAFFIC DATA COLLECTION SYSTEM

As defined by The National Electrical Manufacturers Association [NEMA] it is "a system for indicating the presence or passage of vehicles." An information system responsible for collecting data about road traffic in real time from one or many junctions, highways, roads or streets requires sensors to be deployed to count the passing cars. To obtain more detailed information multiple sensors have to be placed on a sufficiently large number of places. Therefore, the designed systems should be cost-effective, with great accuracy, not to be easily broken, to require minimal (or not any at all) changes on the existing road infrastructure, without interference with the natural flow of vehicles, to be easily moved from one place to another, to be easily accessible.

All mentioned requirement demand sophisticated, intelligent systems that can manage to process and analyse all the acquired data from the sensor network and detect certain events on the road. On Figure 1 presents intelligent traffic monitoring and analysis system. It includes several traffic detection units which count and transmit data to the data acquisition and analysis unit for processing. All

data and result could be monitored and further processed.

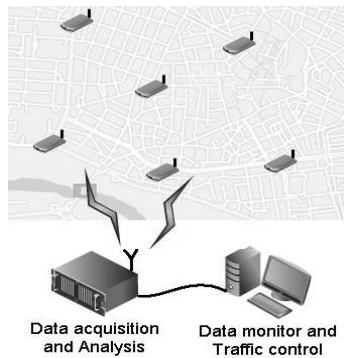


Figure 1: Road traffic data collection and analysis system.

### 3 ROAD TRAFFIC DATA COLLECTION METHODS AND SENSORS

Nowadays there is a great variety of efficient vehicle detection methods. “In order to assess the present and future traffic demands, for the development of need-based infrastructure accurate information and continuous monitoring of traffic is necessary” (Ministry of Works and Transport of , Gaborone, Botswana, 2004, Chapter 1.2)[MWTGB]. Traffic count technologies can be in general divided by the place, where sensors are situated - in-the-roadway (intrusive) and over-the-roadway (non-intrusive).

#### 3.1 Intrusive Methods

Intrusive methods rely on direct interaction between the vehicle and the sensors along the road. The implemented sensors are deployed can be divided in three groups - embedded in the road pavement, embedded in the sub-grade of the road, taped or attached to the surface of the road. Typical representatives of the in-the-road methods include inductive-loop detectors, which are saw-cut into the pavement; magnetometers, which may be placed underneath a paved roadway or bridge structure; and tape switches, which are mounted on the roadway surface.

##### 3.1.1 Pneumatic Sensors

Pneumatic sensors rely on a direct hit of a vehicle to detect it. In most cases a “rubber tubes are placed across the road lanes to detect vehicles from pressure changes that are produced when a vehicles’

tires passes over the tube. The pulse created is recorded and processed by a counter located on the side of the road. The main drawback of this technology is that it has limited lane coverage and its efficiency is subject to weather, temperature and traffic conditions. This system may also not be efficient in measuring low speed flows (Leduc, 2008).

Another drawback is the great wear factor of the tubes - the more vehicles cross the tubes the bigger chance of micro punctures to appear. Constant changes of seasons will make the rubber degrade more rapidly than usual. Another drawback is the tubes must be filled with temperature independent gas, like Nitrogen, so the pressure inside them will not rely on any environment changes. Also if two or more cars hit the tube at the same time, sensor will miscount. On the other hand they are very easily deployed on the road. They need no other preparations (like digging the road or mounting on poles). Suitable for short-term counts of roads with low traffic (suburb roads, etc.).

##### 3.1.2 Optical Fiber Sensing

Optic fibers placed in plastic and/or rubber tubes could be implemented as detection sensors. When a vehicle passes over the fiber a fluctuation of the light stream appears. A photo-receiver detects the changes in the optical signal and converts them in electrical impulses. Due to tenderness of the fiber core it can be easily damaged by heavier or high-speed moving vehicles. Therefore this method needs a thicker housing for better protection of the optic fiber. Some of the drawbacks due to weather conditions in pneumatic sensors are missing – like weather and temperature dependencies. For insurance, the fiber optic cable can be put into pre-cut line in the road, and then fixed with flexible gum. Figure 2 presents a measured signal of external interference on the optical fiber. As seen there is a noticeable change in measured signal which could be utilized in traffic measurement and analysis.

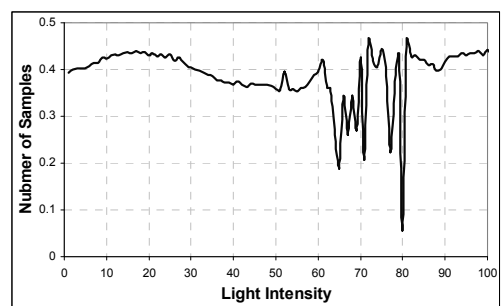


Figure 2: Fiber optic signal and movement detection.

### 3.1.3 Piezoelectric Sensors

Piezoelectric sensors described by Vehicle Detector Clearinghouse (2000)[VDC], are sensors that use piezoelectric effect to detect passing vehicles. Drawbacks of this method are that a certain part of the pavement must be cut. In winters if a pile of snow is on the road the sensor may miscount. Sensor can brake if it is exposed to extreme stresses. They are independent to weather and climate changes. Also a miscount may occur when the road's surface extrapolates due to extreme temperatures.

### 3.1.4 Inductive loop Sensors

Inductive-loops sensors (Figure 3) are wires that are placed under the road surface in square-like shape. They are connected to a detection unit which collects traffic data. Then an electrical signal is fed to the wires and electromagnetic field is created. When a car passes over it the induction of the loop changes and a vehicle is detected ([VDC, 2000],[MWTGB, 2004]). However this method is expensive due to the fact that the inductive-loop must be placed beneath the road surface.

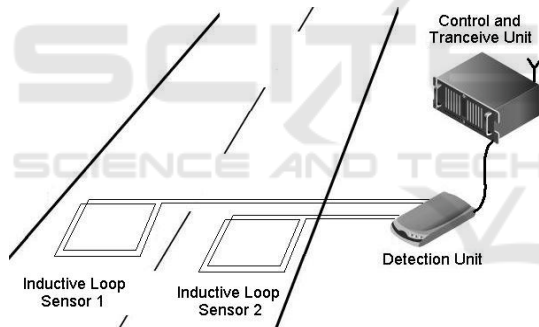


Figure 3: Implementation of inductive loop sensors.

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## 3.2 Non-intrusive Methods

Non intrusive methods are methods where traffic counting sensors do not interact directly with the passing vehicles. They need less preparation time, efforts and investments. Most of them are located above the road lanes, others like video image processing cameras, can be placed next to the road, which leads to minimum or to none deployment time, money and work. „Examples of over-roadway sensors are video image processors that utilize

cameras mounted on tall poles adjacent to the roadway or traffic signal mast arms over the roadway; microwave radar, ultrasonic, and passive infrared sensors mounted in a similar manner; and laser radar sensors mounted on structures that span the lanes to be monitored“ [USD,2006].

### 3.2.1 Manual Counting

Manual counting is quite common method for counting traffic. Not too expensive, does not need any preparations. Data is recorded on a paper or in a computer by one or two specially trained professionals (Klein, Mils, Gibson 2006). However it's not suitable for long-term data collection or highways with intense traffic. Some counting error may occur due to “human error” factor.

### 3.2.2 Ultrasonic Sensors

Ultrasonic sensors can be also divided in two groups active and passive. Passive are not very accurate on high-intense traffic areas. That's why they are not widely-accepted. On the other hand active sensors count at greater precision. They emit their own sound wave which reflects form vehicle's surface and is received by a sensor.



Figure 4: Sideway and over-road ultrasonic sensor implementation and detection.

Using some signal-processing algorithms speed and direction could be measured and vehicle classification could be estimated. They are weather-independent, cannot be easily tricked and can be used on high-traffic roads and highways. Also they can determine with increased accuracy vehicle types even detect trailers [VDC, 2006].

### 3.2.3 Video Image processing

Video image processing is a method where instead of sensors a video camera is used to detect traffic and vehicles. Images from the camera are sent by wire (or wirelessly) to a remote station where images are stored and processed. There are many

algorithms for detecting vehicles on the road – like signal processing, artificial neuron networks, bitmap processing etc. After a vehicle is detected another algorithm is started to detect its speed, direction, and even dimensions.

This method can provide us with different kind of information. As this is still a developing methodology there are some miscounts and system can be easily fooled. It depends on the weather conditions for example in foggy or too snowy conditions nothing will be detected. Front protecting glass of camera has to be cleaned frequently otherwise the camera will not be able to detect anything [VDC, 2007],[MWTGB, 2006], (Klein, Mils, Gibson 2006).

#### 4 CONCLUSIONS

Intrusive methods for vehicle counting purposes need preparation steps, such as cutting big parts of the road surface, deploying sensors, reconstruction of the cut slots after sensors were deployed. This with no doubts leads to more expenses, inconvenience to drivers since the road has to be closed for a certain period of time (depending on the size of the project). Sensors can be easily broken due to constant interaction with the passing vehicles or due to cavities in the pavement, which will uncover the sensors. They are suitable for small roads, where traffic is not quite intensive and closing the road will not lead to major inconvenience for drivers. The accuracy and the reliability in some of them depend on weather conditions and sometimes they may give wrong information.

On the other hand non-intrusive methods are more easily-installable to the existing infrastructure. Their positioning is easier than intrusive sensors, because there is no need of any road modifications. Some of them are vulnerable to weather conditions, but measure with greater accuracy. Further more there is no need traffic to be stopped during their installation. If a short-term measurement is needed without road interventions, pneumatic method or optical sensors are most appropriate.

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