

# Instinctive Traffic Control and Vehicle Detection Techniques

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**Abstract**— Traffic congestion genuinely affects our living quality and environment in modern cities. Primary requirement is to increase the efficiency and capacity of the existing traffic monitoring network due to continues expansion in traffic quantity and limited construction of new highways in rural and urban areas. Traffic congestion is a rising problem in major cities as it leads the fuel wastage in volume of billion gallons per year. In this paper, Concept of Intelligent Transportation System (ITS) is proposed and to solve Traffic problem different alternatives are explored as well as survey has been carried out in field of vehicle and traffic control system.

**Keywords**— Intelligent Transportation System (ITS), Vehicle detection sensors, Traffic management, Intrusive and non-intrusive sensors, Environmental safety

## I. INTRODUCTION

The continuous increase in the congestion level on public roads, especially at rush hours, is a critical problem in many countries and is becoming a major concern to transportation specialists and decision makers. The existing methods for traffic management, surveillance and control are not adequately efficient in terms of the performance, cost, and the effort needed for maintenance and support. The number of vehicles and the need for transportation is continuously growing. Nowadays, cities around the world face serious traffic congestion problems Traffic jams do not only cause considerable costs due to unproductive time losses; they also augment the probability of accidents and have a negative impact on the environment (air pollution, lost fuel) and on the quality of life (health problems, noise, stress).

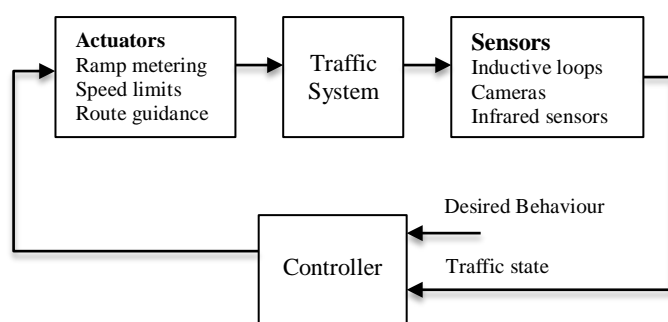


Figure 1. Block diagram of dynamic traffic management control loop

Figure 1 shows the schematic representation of the dynamic traffic management control loop. Controller determines the control signals based on the measurement provided by the sensors to the actuators [1].

Vehicle detectors are significant part of recent traffic control systems. Therefore such parameters need to be considered while choosing vehicle detector like types of traffic flow data, their reliability, consistency, accuracy, precision and the detector response time. As the number and types of detectors increases these above parameters becomes more critical. Since different data collected by different detectors and data interpretation and integration into the existing traffic control system may produce complications and the real-time control aspects of Intelligent Transportation System becomes complicated. Most of the vehicles generate mass air pollutions, which produce greenhouse gases such as nitrogen oxide, hydrocarbons and carbon dioxide. Due to the red light and traffic jams at intersection allow the vehicle to be halted, the result in wastage of mass amount of fuel and severely pollute the air. Especially, ineffective traffic management and the badly designed traffic signals lead to fuel wastage of billion gallons per year also produce disturbance to traffic flow and increase delays. Precise and real time measurement of traffic parameters such as type and number of vehicles, their individual speeds and overall flow pattern are important to successfully implement an Intelligent Transportation System (ITS) and thus enable optimal utility of existing roadways. For the accurate measurement of such traffic parameters, an efficient vehicle detector is essential. The sensors output should be such that the type, speed, and occupancy time of each vehicle can be determined. Conventional traffic control systems use the fixed signal interval and due to this it cannot adapt to real time traffic conditions whereas the adaptive traffic controls rely on collecting real-time traffic information from the detectors.

There are three types of the vehicle detecting systems: 1) Underground level detectors which can be also called intrusive type such as inductive loop, and magnetic detectors; 2) Ground level detector such as pneumatic tube; 3) Overhead level detector can be also called non-intrusive type such as video camera, microwave or radar, laser, infrared and ultrasonic detector [2]. The overhead level detector type

seems to gain more popular nowadays however they have a drawback on accuracy when the road is in a heavy traffic condition and other environmental effects such as temperature, dusty, raining and windy conditions.

II. RELATED WORK

The work in [3] is a survey about multifunctional data driven intelligent transportation system (D2ITS), in which huge amount of data can be collected from numerous resources: Vision-Driven ITS (input data collected from video sensors and used recognition including vehicle and pedestrian detection); Multisource-Driven ITS (e.g. inductive-loop detectors, laser radar and GPS); Learning-Driven ITS (effective prediction of the occurrence of accidents to enhance the safety of pedestrians by reducing the impact of vehicle collision) ; and Visualization-Driven ITS (to help decision makers quickly identify abnormal traffic patterns and accordingly take necessary measures). In extreme heavy traffic, the problem encountered regarding the object reorganization in such complex situations. It become very problematic to recognise each vehicle (object) and possibly to find out the centroid of each object. Hence it creates difficulties while calculating traffic density. Another problem is while doing object subtraction, if the colour of vehicle and the colour of background match then it is challenging to uniquely identify the object.

The work carried out in [4] is about adaptive traffic signal control system that is based on car-to-car communication. Delaying time of the vehicles as well as the reduction in queue length at the intersection can be minimized by this system. To understand this system, clustering technique is used for the vehicles approaching the intersection. The density of vehicles within the cluster is calculated using a clustering algorithm and sent to the traffic signal controls to set the timing cycle. DBCV algorithm is used in this system and it is the combination of cluster and opportunistic dissemination of cluster to collect the essential density information. The clusters are produced based on the direction of the vehicles in a given geographic region approaching the intersection. This direction parameter is computed within the vehicles by employing GPS and digital maps.

Vehicle to vehicle communication plays vital role in traffic control system. The system in [5] works based on vehicle-to-vehicle communication concept that can be shown in figure 2. The control of one vehicle depends on the incoming information of the other vehicles. Each vehicle has short-range communication device and controller nodes, which are located at the intersection with traffic lights as shown in above figure. Controller node acts as adaptive control signal system at the intersection. Two adaptive traffic light systems that are discussed in [4] and [5] are based on wireless between vehicles and static controller nodes arranged at intersections are designed. It increases traffic fluency; reduce the waiting time of vehicles at intersections and support to avoid collisions.

There are number of traffic flow sensors, however the most preferable is inductive loop detectors as they offer good sensitivity coupled with a cost effective solution. Continues improvement of inductive loop detectors for improved speed measurement is discussed in [7] and classification [8]-[10] were described for lane disciplined traffic conditions. However, exiting system that is based on inductive loop traffic sensor will not function accurately when the vehicle movement are parallel, as shown in figure 3.

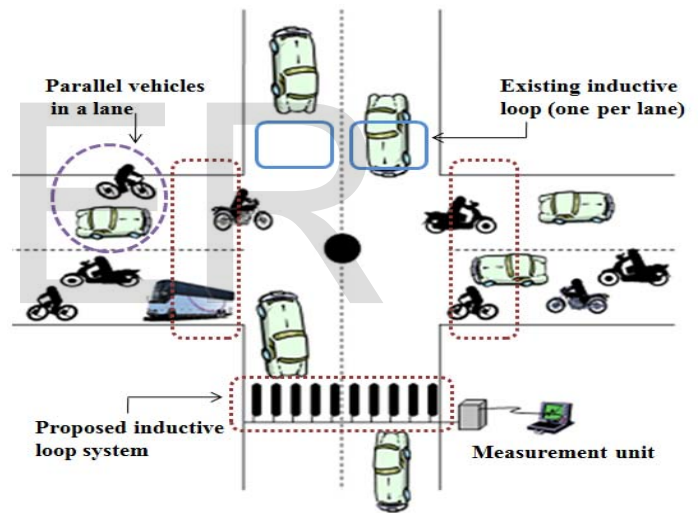


Figure 3. Illustration of an inductive vehicle detection scheme at the junction

Existing loop detectors are appropriate only for lane disciplined and homogeneous traffic conditions. Thus, a novel and simple inductive loop structure is proposed in [6]. The structure that senses both large as well small sized vehicles and distinguishes the large one from the small. Unique signature is delivered by sensor for each vehicle. Possible solution is presented for heterogeneous and lane-less traffic condition based on a new multiple loop inductive sensor technique. Test results from prototype system develop are provided to establish the efficiency of the proposed method. It can be concluded from the results that multiple inductive system sense and segregate the number of vehicles and their type. It detects large (e.g., Bus) as well small (e.g., bicycle)

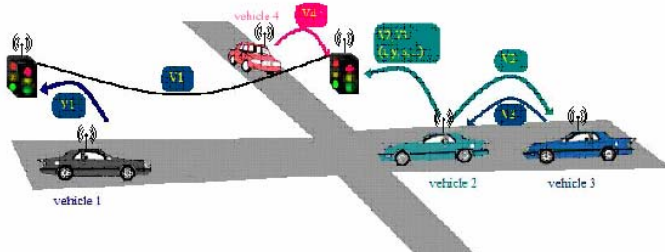


Figure 2. Traffic light communication with cars to adapt timing

vehicles that making it suitable for heterogeneous traffic conditions. The data provided by the measurement system is in digital form and hence it is easy for transmission to traffic management centres for real time traffic control.

### III. VEHICLE DETECTION TECHNIQUES

The numbers of vehicle detection sensors are discussed that provides overview of the operation of in-roadway and over-roadway traffic flow sensors most used today.

#### A. Inductive-loop sensors

An inductive-loop detector senses the presence of a conductive metal object by inducing currents in the object, which reduce the loop inductance. Inductive-loop detectors are installed in the roadway surface. They consist of four parts: a wire loop of one or more turns of wire embedded in the roadway pavement, a lead-in wire running from the wire loop to a pull box, a lead-in cable connecting the lead-in wire at the pull box to the controller, and an electronics unit housed in the controller cabinet. The electronics unit contains an oscillator and amplifiers that excite the embedded wire loop. The electronics unit also supports other functions such as selection of loop sensitivity and pulse or presence mode operation to detect vehicles that pass over the detection zone of the loop. When a vehicle passes over the wire loop or is stopped within the area enclosed by the loop, it reduces the loop inductance, which unbalances the tuned circuit of which the loop is a part. The resulting increase in oscillator frequency is detected by the electronics unit and interpreted as vehicle detection by the controller [11].

#### B. Magnetic sensors

These sensors are the considered as passive devise which detect the presence of a ferrous metal object through the perturbation, that cause in the earth's magnetic field. Magnetic sensors are further classified into two types, which are used for traffic flow parameter measurement. The first type is two-axis fluxgate magnetometer, senses the vertical and horizontal components of the earth's magnetic field created by the ferrous metal vehicle. It contains two primary winding and two secondary windings on a bobbin neighbouring a high permeability soft magnetic material core. Due to the magnetic field anomaly, i.e., the magnetic signature of a vehicle, magnetometer's electronic circuitry measures the output voltage caused by the secondary windings. The vehicle detection condition is for the voltage to exceed a predetermined threshold. The second type of magnetic field sensor is the magnetic detector, more properly referred to as an induction or search coil magnetometer. It detects the vehicle signature by measuring the distortion in the magnetic flux lines induced by the change in the Earth's magnetic field created by a moving ferrous metal vehicle. These devices comprise a single coil winding on a permeable magnetic material rod core. Related to the fluxgate magnetometer, magnetic detectors generate a voltage when a moving ferromagnetic object perturbs the Earth's magnetic field. Induction magnetometers do not detect stopped vehicles since

they require a vehicle to be moving or otherwise changing its signature characteristics with respect to time. However, multiple units of some magnetic detectors can be installed and utilized with specialized signal processing software to generate vehicle presence data.

#### C. Video Image processor sensors

A video image processor (VIP) is a grouping of hardware and software, which extracts desired information from data provided by an imaging sensor. This imaging sensor can be a conventional TV camera or an infrared camera. A VIP can detect speed, occupancy, count, and presence. Because the VIP produces an image of several lanes Advantages of VIPs are that they are mounted above the road instead of in the road, the placement of vehicle detection zones can be made by the operator, the shape of the detection zones can be programmed for specific applications Disadvantages are the need to overcome detection artifacts caused by shadows, weather, and reflections from the roadway surface [11].

#### D. Microwave radar sensors

The word radar was derived from the functions that it performs: *R*ADIO *D*ETECTION AND *R*ANGING. The term microwave mentions to the wavelength of the transmitted energy, usually between 1 and 30 cm. This corresponds to a frequency range of 1 GHz to 30 GHz. Principle of operation is discussed in [11] where roadside-mounted microwave radar sensors spread energy about an area of the roadway from an overhead antenna. The area in which the radar energy is broadcasted is organized by the size and the distribution of energy across the aperture of the antenna. The advantages of the microwave detectors are that it considered as a mature technology because of past military applications, detect velocity directly and a single detector can cover multiple lanes.

#### E. Infrared sensors

*Active* and *passive* infrared sensors are manufactured for traffic applications. The sensors are mounted overhead to view approaching or departing traffic or traffic from a side-looking configuration. Infrared sensors are used for signal control; volume, speed, and class measurement, as well as detecting pedestrians in crosswalks. With infrared sensors, the word detector is also used to refer to the light-sensitive element that converts the reflected or emitted energy into electrical signals. Real-time signal processing is used to analyze the received signals for the presence of a vehicle. Active infrared sensors illuminate detection zones with low power infrared energy supplied by laser diodes operating in the near infrared region of the electromagnetic spectrum at 0.85  $\mu\text{m}$ . The infrared energy reflected from vehicles traveling through the detection zone is concentrated by an optical system onto an infrared-sensitive material mounted at the focal plane of the optics. Passive infrared detectors can supply vehicle passage and presence data, but not speed. They use an energy sensitive photon detector located at the optical focal plane to measure the infrared energy emitted by objects in the detector's field of view. Passive detectors do not transmit

energy of their own. When a vehicle enters the detection zone, it produces a change in the energy normally measured from the road surface in the absence of a vehicle. Active infrared detectors function similarly to microwave radar detectors. The most prevalent types use a laser diode to transmit energy in the near infrared spectrum a portion of which is reflected back into the receiver of the detector from a vehicle in its field of view. Laser radars can supply vehicle passage, presence, and speed information. Speed is measured by noting the time it takes a vehicle to cross two infrared beams that are scanned across the road surface a known distance apart.

#### F. Ultrasonic sensors

Ultrasonic sensors transmit pressure waves of sound energy at frequencies between 25 and 50 KHz, which are above the human audible range. Pulse waveforms measure distances to the road surface and vehicle surface by detecting the portion of the transmitted energy that is reflected towards the sensor from an area defined by the transmitter's beamwidth. When a distance other than that to the background road surface is measured, the sensor interprets that measurement as the presence of a vehicle. The received ultrasonic energy is converted into electrical energy that is analysed by signal processing electronics that is either collocated with the transducer or placed in a roadside controller. Ultrasonic sensors may be used in conjunction with other sensor technologies to enhance presence and queue detection, vehicle counting, and height and distance discrimination

#### CONCLUSION

Present paper highlights the different techniques of vehicle detection and survey of automatic traffic control system. The primary aim of this paper is to provide the better understanding of present vehicle detection technologies as well as traffic control systems. A reasonable approach is essential in the design and planning, development and implementation that address the problem of the user requirements. Detectors demonstrative of all technologies were found to satisfy current traffic management requirements. Though, information such as queue length and vehicle turning movement needs to be better accuracy and may require decent detector for future traffic management applications.

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