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Vehicle Detector Devices

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Introduction

As the need for automatic traffic monitoring increases with the evolution of ITS, market opportunity and application needs urge manufacturers and researchers to develop new technologies and improve existing ones. A variety of detector technologies and methods currently are available. All kind of detector can be categorized in tree group: intrusive detectors (in-roadway), non-intrusive detectors (above roadway or sidefire), and off-roadway technologies. The tree map of vehicle detector technologies is shown in Figure 1.

The oldest of all traffic surveillance technologies are inductive loop detectors. Loop detectors are placed in the subsurface of the roadway and when utilized can provide real-time traffic information on that point of the road. However, it has been noted that the cost of installation and maintenance of loop detectors can be prohibitively high because of traffic interruption. Thus the quest for more cost-effective alternatives was soon made. Other technologies, such as video, radar, microwave, ultra-sound and acoustic, came to the market. These alternative technologies provide not only cost-savings but also have the ability to obtain a broader variety of traffic and incident-related data.

Different detection technologies show different characteristics and prove to be successful in different application areas. Traditionally, inductive loops provide ample information to direct traffic flows and assemble statistics. However the information produced by inductive loops is too limited for several more complex applications such as incident detection. [Versavel, J., 2007] Current complex traffic situations need more extensive information. To accomplish this goal Video Image Processing (VIP) and radar vehicle detector are developed. The following parts are a brief review of more robust vehicle detectors.

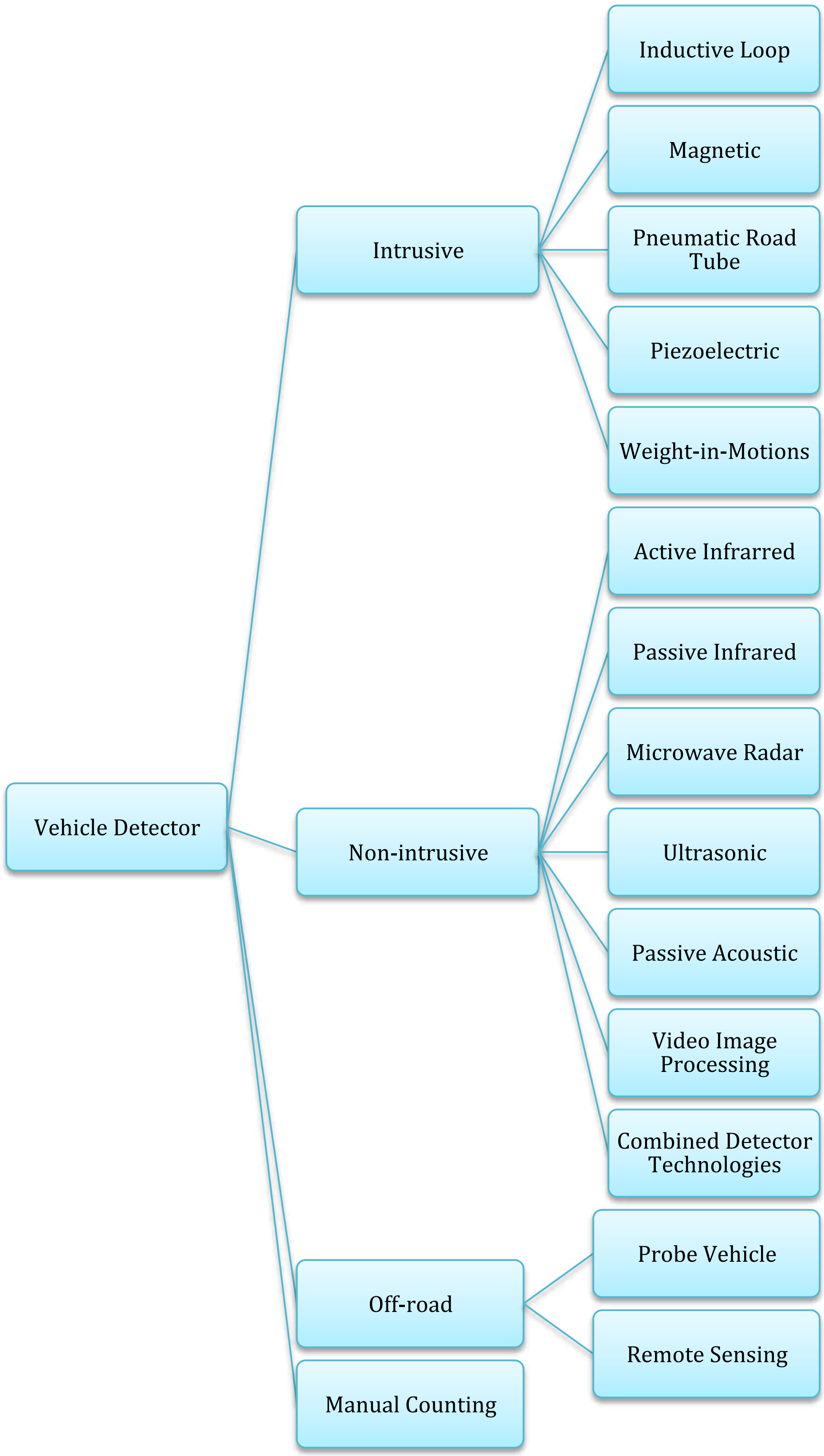

Figure 1 Tree map of vehicle detector technologies

Microwave Radar

Microwave radars used in the U.S. for vehicle detection transmit energy at 10.525 GHz, a frequency allocated by the FCC for this purpose. Their output power is regulated by the FCC and certified by the manufacturer to meet FCC requirements. No further certification is required of the transportation agencies for their deployment.

Two types of microwave radar detectors are used in traffic management applications. The first transmits electromagnetic energy at a constant frequency. It measures the speed of vehicles within its field of view using the Doppler principle, where the difference in frequency between the transmitted and received signals is proportional to the vehicle speed. Thus, the detection of a frequency shift denotes the passage of a vehicle. This type of detector cannot detect stopped vehicles and is, therefore, not suitable for applications that require vehicle presence such as at a signal light or stop bar.

The second type of microwave radar detector transmits a saw tooth waveform, also called a frequency-modulated continuous wave (FMCW), that varies the transmitted frequency continuously with time. It permits stationary vehicles to be detected by measuring the range from the detector to the vehicle and also calculates vehicle speed by measuring the time it takes for the vehicle to travel between two internal markers (range bins) that represent known distances from the radar. Vehicle speed is then simply calculated as the distance between the two ranges bins divided by the time it takes the vehicle to travel that distance. Since this detector can sense stopped vehicles, it is sometimes referred to as a true-presence microwave radar.

Wavetronix, LLC

Wavetronix is the current market leader in side-fire radar traffic detection. SmartSensor HD continues to offer unmatched performance with the consistent accuracy and reliability of true high definition detection. Cabinet Systems offer out-of-the-box network integration; and command data collection and management appliances provide valuable data monitoring and storage capabilities.

SENSOR TECHNOLOGY AND CONFIGURATION: The sensor transmits microwave energy and receives a portion of the energy reflected by vehicles and other objects in its path. The SmartSensor HDTM operates at 24 GHz using a 250 MHz bandwidth, giving a range resolution of 2 ft (0.6 m). It detects both stationary and moving targets.

INSTALLATION REQUIREMENTS: The SmartSensor HDTM can be mounted on light standards or poles (Side-Fired) or overhead structures (Forward-Looking). The first lane offset requirement is 6 ft (1.8 m) and the maximum detection range is 250 ft (76 m).

MAXIMUM NUMBER OF LANES MONITORED SIMULTANEOUSLY: 10

PRODUCT CAPABILITIES/FUNCTIONS: The SmartSensor HD provides vehicle-based detection, vehicle volume, vehicle presence, indicates lane-changers, per vehicle speed, average speed, 85th percentile speed, lane occupancy, four length-based vehicle classification categories, average headway, and average gap. The SmartSensor HD contains two receive antennas that are separated by a small distance. This dual-antenna design forms a radar speed trap that allows the sensor to measure the time it takes for a vehicle to pass between the two antennas to within a fraction of a millisecond. This time measurement is then used to calculate the speed of the vehicle. Traffic data and configuration settings are stored in flash memory, so the sensor can be remotely configured.

POWER REQUIREMENTS (watts/amps): 9 to 28 VDC, 8 W

Performance Maintenance

No cleaning or adjustment necessary

No battery replacement necessary

Recalibration is not necessary

Based on the literature review, the Wavetronix SmartSensor Advance detectors are used in the City of Denton, Texas; the TxDOT Corpus Christristi District; the TxDOT Houston District, the TxDOT Traffic Operations Division, and the Utah Department of Transportation (UDOT). In all cases, wavetronix works pretty well in all weather conditions and all users expressed positive comments (more information is available in Midelton, 2009)

In comparing the Wavetronix Advance to video, UDOT has found the Wavetronix Advance detector to be far better as long as the radar detector is aimed correctly. Cost comparisons by UDOT indicate that the Wavetronix Advance is sometimes less expensive than other alternatives, especially if no stop line detection (in intersections) is needed. There are a few disadvantages of the Advance detector that are worth noting. In a horizontal curve, the detector might not provide continuous coverage of 400 ft. Also, the radar detector sometimes generates false calls when aimed at large metal signs that move with the wind. So we should be careful to choose best place for installation. The Radar based detector does not have immediate visual feedback, which can be much useful for checking the site by operator after detectors alarm.

Image Sensing Systems (ISS)

ISS, Inc. is the world leader in ITS detection with nearly 100,000 units sold worldwide. Brand solutions include Autoscope® video and Remote Traffic Microwave Sensor (RTMS®). Unlike other systems, the RTMS G4 is the only advanced radar to combine 12 lanes non-intrusive detection, Zero-Setback, low wattage, NTCIP, communication options, power management and a built-in IP video camera. With a broad portfolio of integrated solutions, the All-in-One concept removes field integration complexities. The G4 is a small roadside pole-mounted radar, operating in the microwave band. It provides per-lane presence as well as volume, occupancy, speed and classification information in up to 12 user-defined detection zones, simultaneously. Output information is provided to existing controllers via contact closure and to other computing systems by its serial or IP communication port or by an optional radio modem. A single RTMSTM can replace multiple inductive loop detectors and the attendant controller. Some general information and application is as follow:

GENERAL DESCRIPTION OF EQUIPMENT: The RTMS is a low-cost, all weather, true RADAR (Radio Detection And Ranging) device, which provides presence, multiple zone, vehicle detection. Its ranging capability is achieved by frequency-modulated continuous-wave (FMCW) operation. The RTMS is capable of detecting vehicle presence and measuring other traffic parameters in multiple zones. The G4 incorporates: (1) a phased-array antenna that provides improved spatial resolution and (2) a camera so that the operator can watch the traffic flow as it is detected and analyzed by the RTMS.

SENSOR TECHNOLOGY AND CONFIGURATION: The sensor transmits microwave energy and receives a portion of the energy reflected by vehicles and other objects in its path. The nominal 10.525 GHz frequency is varied continuously in a 45 MHz band. At any given time, there is a difference between the frequencies of transmitted and received signals. The difference in frequencies is proportional to the distance between the RTMS and the vehicle. The RTMS detects and measures that difference and computes range (distance) to the target. The range resolution of the RTMS is 2 m (7 ft). It detects both stationary and moving targets.

MOUNTING CONFIGURATION: The RTMS is mounted over the roadway in side-fired and forward-looking configurations. Side-Fired: The G4 can monitor up to 12 lanes of traffic in this configuration. Forward-Looking: One RTMS unit, mounted on an overhead structure, aimed at the front or rear of the vehicles, will monitor one approach of traffic. This configuration provides higher accuracy per vehicle speed measurements

INSTALLATION TIME (Per Lane): 30 minutes (approx.)

INSTALLATION REQUIREMENTS: The RTMS can be mounted on light standards or poles (Side-Fired) or overhead structures (Forward-Looking). The recommended mounting height is 5 m (17 ft) above the road. Side-fired requires a setback from the first lane monitored. To include all lanes of interest within its antenna beam footprint, the RTMS is set back from the detection zones about 1 m (3 ft) for each equivalent lane monitored (with a minimum setback of 3 m).

RECOMMENDED APPLICATIONS:

- Freeway traffic management and incident detection systems
- Multi-lane intersection control, stop-bar and advanced loop replacement
- Ramp metering
- Off ramp queue control and signal control actuation
- Work zone and temporary intersection control
- Permanent and mobile traffic counting stations
- Enforcing of speed and red light violation

POWER REQUIREMENTS (watts/amps)/OPTIONS:

- Standard: 12 to 24 AC or DC @ 4.5 Watt derived from battery, solar, or controller
- Optional: Commercial 115 VAC

COMPUTER REQUIREMENTS:

- RTMS setup is performed using an IBM-compatible notebook PC. An intuitive, user-friendly setup program allows the user to define the operating mode, required number of zones and their locations, and to verify correct operation of the unit. During setup every vehicle within the field of view is shown on the PC screen as a "blip" at its corresponding range. The user recognizes the blip as belonging to a vehicle seen on the road at that moment, and simply moves a zone-box on the screen to surround the blip. This defines the zone's location. A zone can include one or more lanes. After a zone is defined, its corresponding contact pair closes every time a blip is contained in it. After all zones are defined, a simple observation or manual count comparison with the RTMS count completes the calibration. A wizard is included in the software to automate the setup process and assist users.

- Data collection and analysis are implemented with an IBM-compatible notebook PC.

DATA OUTPUT: Output information is provided to existing controllers via contact pairs and to computer systems via a RS-232 serial communications port.

SUPPORTING DATA BASE MANAGEMENT SYSTEM: Optional data collection and analysis program can format traffic data in Paradox or Dbase.

CURRENTLY USING THIS EQUIPMENT: Country/State

Country/State	**Contact name**
USA/California	TRAVINFO; Bay area
USA/Colorado	I-25 Colorado Springs, Denver, Grand Junction
USA/Florida	Various
USA/Indiana	BORMAN
USA/Kentucky	TRIMARC
USA/Louisiana	Baton Rouge I-12
USA/Maryland	CHART II
USA/New Jersey	MAGIC I-80; NJ Turnpike; Garden City Parkway
USA/New York	NY City (Intersections); Van Wyck Expressway, Long Island Expressway
USA/North Carolina	CARAT
USA/Missouri	Interstate –Metro St. Louis
USA/Nebraska	Counting stations
USA/Ohio	ARTIMIS: City of Jackson (Intersections)
USA/Pennsylvania	TOP
USA/South Carolina	Incident Detection System I 85, 77, and 26

USA/South Dakota	Various
USA/Virginia	Hampton Roads Phases II and III
USA/Wisconsin	MONITOR
USA/Washington State	Various

RTMS WATER

RTMS WATER (Wide Area Traffic Event Reporting) provides real-time traffic measurement and data collection over a wide area. An enterprise-level system capable of monitoring traffic in thousands of locations. Traffic is measured by multiple sidefired RTMS™ data collection stations in a specific area. Data is then typically sent by external CDMA/GPRS modem or concentrated by a Wireless Cluster Hub and cost-effectively transmitted to a Traffic Operations Center (TOC) for storage in a real-time SQL database.

The affordable WATER system is not only unparalleled for reliability and accuracy in all weather conditions and for large scale projects, it is also quick to install with no lane closures and no ongoing maintenance required. Suitable for both highway and urban traffic management applications.

Detector Summery

Selection of an advance detection system depends on numerous criteria. These include installation cost, functionality, and maintenance cost. The cost-effectiveness of a particular detector or type of technology can only be judged when applied to a specific application and should include total life-cycle costs (i.e., take into account purchase price, installation, data interface preparation, and maintenance over an extended time period of 10 to 20 years) and the equivalent number of lower cost detectors (e.g., inductive loops) that it replaces. It is very difficult to quantify the maintenance/life-cycle costs. These costs vary from one district to another and within the same district from one location to another. Good engineering judgment and past experience should be used to estimate the life-cycle cost of each technology. Based on the information currently available, a rating of the advance detection systems was generated and is illustrated in Table 1. Table 1 is summery of advanced detectors.

Table 1: Vehicle Detector Summery

	Traficon	Autoscope solo pro	Wavetronix	EIS G4
Vehicle count	√	√	√	√
Weather effect	√	√		
Sensitive to Light	√	√		
Shadow	√	√		
Video image	√	√		√
Individual Vehicle speed	√	√	√	√
No. of lane	6-8	6-8	8-10	12
Cost	$5000	$ 6000-7000	$ 3500-4000	$ 3300
Life-cycle cost	Low to Moderate	Moderate	Low	Low (200 $/yr)

Conclusion

Most traffic operators have a long experience with loops; most of the classic traffic monitoring systems is still based on the use of loop data. For example one of the travel time prediction algorithms is based on the use of single loop data that give only counts and occupancy. This algorithm normally works within the 5-10% error margin, which is sufficient in most cases. The only problem arises with stop and go traffic where the results are no longer useful. It is impossible to determine the absolute accuracy of a specific detector technology or device. However, the comparison data provides useful information for selecting a detector.

Since loops were the de facto reference all new detection systems were first compared with loops and the loop characteristics, thus neglecting the real potential of other detection systems. The literature review shows some radars and laser systems can give better results in speed measurements; Some ultra sonic detectors will perform better for occupancy; Video detection with its wide area possibilities will create a lot more possibilities (e.g. for automatic incident detection) but sometimes is still not well understood with respect to the different applications that require different cameras and different camera positions. The validity of traffic data using video is mainly dependent on the **visibility attribute of the CCD camera**. The main obstacles will be weather conditions linked to the cleanliness of the camera (lens). The Mean Time Between Failures (MTBF) of video detection systems is extremely high (e.g., more than 20 years for all Traficon material).

The main advantage of video based AID is that there is a combination of numerical data with immediate visual feedback, enabling the operator to make informed decisions and deploy appropriate resources. In general, video imaging systems are more complex than some other technologies and are affected by some weather, lighting, and traffic conditions compared to other technologies. For maintenance, any video system will require periodic lens clearing depends on environmental factors but will probably need to occur two to four times per year. The advantage of video over other technologies is being able to verify traffic conditions based on the image that is available from the detectors.

TTI researchers conducted a comprehensive literature search covering the past decade and an Internet search to determine emerging and promising vehicle detector systems that are worthy of further consideration. TTI researchers found that inductive loops with contact closure radio were very accurate in counts, classification, and speeds. Traficon video detection system was very accurate in counts and measuring vehicle lengths during daytime and measuring speeds during both daytime and nighttime. The counts and classification can improve by providing some ambient light near the detector station. SAS-1 acoustic detector can be very cost-effective as it contains detection as well as a communication system. However, the performance needs to be checked by requesting the vendor to provide individual vehicle speeds and classification, which the unit is already measuring.

Recent findings of TTI indicate that, of the detectors tested, the following technologies appear to be most promising for freeway applications based on cost, accuracy, and ease of setup: microwave radar and magnetometers. One of the VIVDS units tested was also accurate but its cost and ease of setup were inferior to the other two. It is essential that the engineer evaluate not only the installation cost of these systems but also the life-cycle cost of the system due to maintenance. Maintenance costs for some systems such as inductive loops can increase the life-cycle cost significantly.

The choice of a detector for a specific application is, of course, dependent on many factors, including data required, accuracy, number of lanes monitored, number of detection zones per lane, detector purchase and maintenance costs, vendor support, and compatibility with the current and future traffic management infrastructure.

As mentioned before, according to literature review, the two best technologies are video and radar. Since radar is not affected by weather and light like video is, it is overall the best choice among the non-intrusive detectors tested for detecting vehicles. Microwave radar detector can be perfect but it is not possible having an immediate visual feedback and enabling the operator to make informed decisions and deploy appropriate resources. The combination of video and microwave radar detector can be the best option for the incident detection. The ISS developed this kind of detector under the name of RTMS G4, which has all the things that we want.

Non-intrusive, radar-based RTMSTM G4 is the most advanced sensor for the detection and measurement of traffic on roadways. It is easy and safe to install and remove without traffic disruptions or lane closures. Since it is all-weather accurate and we can have the vision of site it can be the best choice for us. But it is in fact new and the official report the application is not available yet. Some news are available that prove customer are satisfied with the RTMSTM G4.

Refrence

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