HIGHLIGHTER

DEVELOPMENT OF INEXPENSIVE VEHICLE SENSOR NODE SYSTEM FOR VOLUME, TURN MOVEMENT AND COLLISION AVOIDANCE

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PROJECT TITLE
DEVELOPMENT OF INEXPENSIVE VEHICLE SENSOR NODE SYSTEM FOR VOLUME, TURN MOVEMENT AND COLLISION AVOIDANCE

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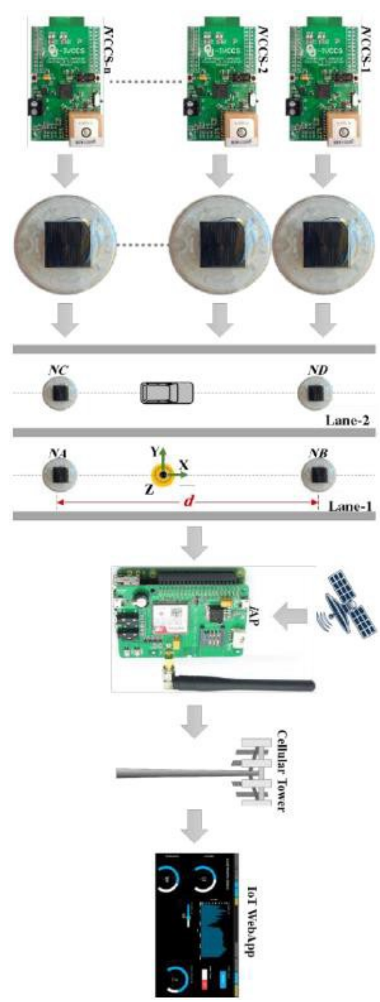
Implementation of Research for Transportation Excellence

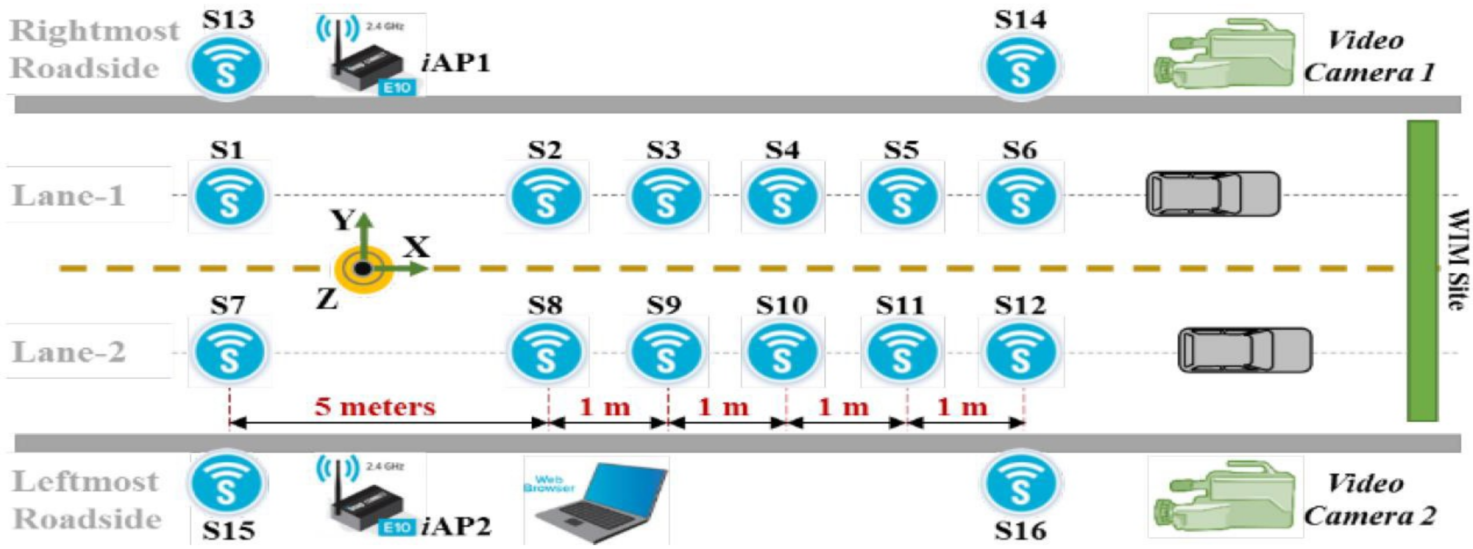
OVERVIEW Real-time traffic surveillance is essential in today's intelligent transportation systems and will surely play a vital role in tomorrow's smart cities. This project reports on the development and implementation of a novel smart wireless sensor for traffic monitoring. The system is portable, reliable, and cost-effective. The system can also be used on the highway, roadway, and roadside for short-term deployment (e.g., work zone safety, temporary roadway design studies, traffic management in an atypical situation such as evacuations, and other similar situations), as well as long-term deployment (e.g., traffic management, turn movement, and collision avoidance). Implementation cost of a single node including enclosure is US $40.

RESULTS Reliable and computationally efficient algorithms for vehicle detection, speed and length estimation, classification, and time-synchronization were fully developed, integrated, and evaluated. Comprehensive evaluation for the traffic monitoring system (conceptually illustrated at right) and extensive data analysis were performed to tune and validate the system for a reliable and robust operation.



The novel, fully-autonomous, intelligent wireless sensor integrates state-of-the-art components, including an ultralow power, high-performance embedded microcontroller; an energy-efficient wireless transceiver; smart embedded sensors (i.e., 3D MAG and ACCEL); a highly-accurate low-power embedded Global Positioning System (GPS) receiver; dual data storage units; a battery fuel gauge; and atmospheric sensors. All components are managed by distinctive algorithms for implementing various traffic monitoring applications. A 3-axis MAG sensor is used for measuring magnetic disturbance to the Earth's magnetic field caused by an overpassing vehicle, and a 3-axis ACCEL sensor is used for measuring road surface vertical acceleration resulting from the motion of dynamic loads. Other components include a GPS module for auto-localization and global-synchronization; and an RF module for wireless data transmission. Sensor node firmware can be upgraded over-the-air, which allows a customizable configuration to support various studies and applications. The sensor is functional in either standalone or peer-network mode wherein an intelligent access-point (*i*AP) manages WSN data transfer.

Several field studies and evaluation tests were conducted during this research, many of which were conducted in parking lots at the *University of Oklahoma-Tulsa campus*. Eight additional field tests were conducted on *highways* and *urban roads* in the state of Oklahoma under various traffic conditions. System performance evaluation was conducted using real-time data, offline data, video images, and reports from the highly accurate *RoadRunner 3 kit by Diamond Traffic Inc*. The system layout for one of the field studies is illustrated in the following figure.



The system output had 99.98% detection accuracy, 97.11% speed estimation accuracy, and 97% length-based vehicle classification accuracy. System functionality testing revealed consistent behavior and accurate performance that can be exploited for more advanced applications. System cost was estimated at less than $1000 for eight sensor nodes and an access point, meaning that the system could be promoted as a replacement for expensive and invasive traditional traffic surveillance systems that depend on piezoelectric sensors, inductive loops, and/or pneumatic tubes.

Currently, vehicle classification based on vehicle magnetic signature (VMS) collected using MAG is not feasible for more than six classes. The reasoning behind this conclusion centers on the fact that each vehicle has a unique composition of materials causing a unique VMS. Characteristics of VMS for vehicles of the same class are quite different. it is nearly impossible to cluster vehicles based on their classes by only analyzing their magnetic signatures. During this research, several machine learning methods including deep neural networks were investigated for vehicles classification. Two of such methods achieved acceptable classification accuracy.

POTENTIAL BENEFITS This solution will maximize existing transportation infrastructure capacity and improve efficiency, making transportation systems safe, efficient, and more reliable for the rapidly approaching era of smart cities. It also responds to the critical need of the Oklahoma Department of Transportation for an autonomous surveillance technology to monitor various traffic conditions. Results can be used to supplement current ITS installed throughout the state.