OKLAHOMA Transportation RESEARCH

PROJECT TITLE
DEVELOPMENT OF INTELLIGENT VEHICLE COUNTING AND CLASSIFICATION SENSOR (iVCCS)

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HIGHLIGHTER

DEVELOPMENT OF INTELLIGENT VEHICLE COUNTING AND CLASSIFICATION SENSOR (iVCCS)

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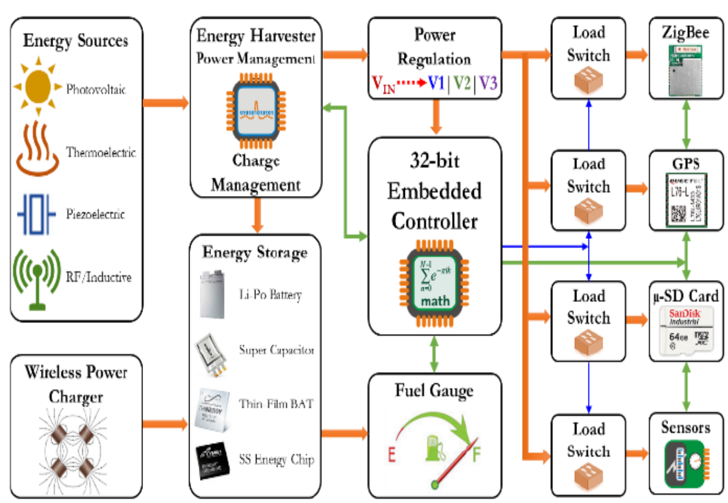
OVERVIEW For a strong and continually prosperous economy, it is necessary for the underlying transportation infrastructure to be equipped and up-to-date with technological advancements common in other industry sectors. Hence, it is imperative that transportation systems integrate and are interoperative with others. The Internet of Things (IoT) is reshaping our world. Research shows that fleet management and transportation sectors lead others in IoT growth (e.g., sensor integration for roadways, bridges, airports) This study presents the design, development, and implementation of a novel, autonomous, and intelligent wireless sensor for various traffic surveillance applications. This project advanced three generations of the proposed sensor, each adding intelligence, performance, accuracy, and lifetime to its predecessor.

RESULTS The work detailed in this project is an extension to a project that focused on designing a low-cost, reliable, and low-power intelligent vehicle counter and classification sensor (iVCCS) system in which the sensor exploits the physical phenomenon of magnetic field disturbance caused by ferrite materials in the body of a vehicle. The first generation advanced in this project serves a proof-of-concept design/implementation for a novel, fully-autonomous, intelligent wireless sensor for real-time traffic surveillance. Multi-disciplinary, innovative integration of state-of-the-art, ultra-low-power embedded systems; smart physical sensors; and wireless sensor networks, coupled with intelligent algorithms will address the component composition of the developed platform, namely Intelligent Vehicle Counting and Classification Sensor (iVCCS). Second generation (G) iVCCS (whose block diagram is illustrated right) introduced several algorithms for optimizing power consumption and were introduced based on an event-driven methodology wherein a control block orchestrates the work of various components and subsystems.



Two operation modes (i.e., HP and LP) were designed for iVCCS 2nd G to balance a tradeoff between consumed energy and response time, which affects detection accuracy relative to traffic flow. A Reinforcement Learning (RL) approach was proposed to design a dynamic power management (DPM) algorithm for observing traffic and controlling the system's power policy according to the environment and agent states. Experimental results showed that overall battery life of the system was extended to over 200 days for a 2300 mAh battery.

iVCCS 3rd G incorporated advanced wireless communication capabilities via Bluetooth Low Energy 5 (BLE 5) with higher data rates, long-range operation, and over-the-air firmware upgrades. The data storage unit has been upgraded with an on-board flash array, and the power management subsystem has been simplified by eliminating the energy harvesting. The sensor is now powered by a high capacity (i.e., 10000 mAh), ultra-wide-range operating temperatures and compact size batteries that use Lithium-Thionyl chemistries.

All three generations were tested in several field studies and evaluation deployments during the associated research. Eight field tests were conducted using iVCCS 1st G 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 Road Runner 3 (RR3) by Diamond Traffic. Constant communication with the sensors was achieved throughout the deployments, demonstrating ability for real-time data reporting to access points. The system achieved detection accuracy as high as 98% and on average 88.66%. Reported speed values were compatible with respective speed limits to measured speed by RR3.

Several enclosure designs were proposed to protect sensors from environmental effects and mechanical forces exerted by passing vehicles. Additionally, materials with minimum effect on radio communication quality were researched. These investigations were crucial for design, as these affect both communication with the sensor using BLE and the GPS ability to receive and lock-on clear constellation. A robust and light-weight enclosure design that meets necessary requirements was designed and manufactured by NCTronics, Inc.

POTENTIAL BENEFITS This project presented the design, development, and implementation of a novel, autonomous, and intelligent wireless sensor for various traffic surveillance applications that provides real-time traffic monitoring, which plays a major role in the transition toward smart cities and more efficient ITS. Autonomous traffic sensing is at the heart of smart city infrastructure, wherein smart wireless sensors are used to measure traffic flow, predict congestion, and adaptively control traffic routes. Such information enables a more efficient use of resources and infrastructure.