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Intelligent Blind Crossings for Suburban and Rural Intersections

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Introduction

Blind intersections—which lack stoplights and have limited visibility—are unique safety challenges, especially in areas with inadequate infrastructure and high traffic speeds. The issues created by blind intersections are especially present in suburban and rural areas, where traffic development infrastructure may lag. The Internet of Vehicles (IoV) in combination with connected and autonomous vehicles (CAVs) has been looked at as a solution to this challenge in the past. The IoV would allow connected vehicles to communicate pertinent information like geographical location, speed, and intention to change lanes with each while roadside units share other crucial information to vehicles like updates on traffic accidents and road conditions. This project proposes using the IoV and a specially designed roadside unit (RSU) using a distinctive algorithm and Field-Programmable Gate Arrays (FPGAs) to improve visibility, manage traffic, and increase safety at blind intersections.

Study Methods

This project designed a comprehensive roadside unit system to address safety issues at blind intersections. The team developed a RSU prototype uniquely tailored to the challenge presented by blind intersections in suburban and rural areas featuring two-way stop signs. They also proposed an FPGA-based system for the RSU device to oversee vehicle interactions at a rural blind intersection, involving the following steps:

- Determine Interaction Flowchart: Define the interaction algorithm that governs how vehicles will communicate and interact at the rural blind intersection.
- Design Embedded System: Design the embedded system using Quartus Prime and Qsys, integrating the determined algorithm. Program the algorithm using NIOS II Software Build Tools for Eclipse.
- Optimize System Power Consumption: Implement measures to optimize power consumption within the designed FPGA-based system, ensuring efficient energy utilization.

- Create a Communication Module for the RSU Device: Establish a communication module to facilitate seamless communication among vehicles at the rural blind intersection.
- System Integration: Develop and integrate the 802.11 interface for effective communication as well as conduct integration testing to ensure harmonious operation between the communication module and the FPGA-based system.
- Optimize System Power Consumption: Employ strategies to minimize power consumption in the communication module as well as design and configure a power system tailored to the specific needs of the RSU device.

Careful experimentation and simulations followed these steps to test the proposed system and its potential for solving the safety issues of blind intersections.

The Internet of Vehicles and a roadside unit (RSU) may be a critical safety solution at blind intersections in suburban and rural communities.

Findings

Various traffic scenarios were simulated and successfully facilitated by the RSU. The beginning of one such scenario is as follows:

Four vehicles at the intersection are broadcasting their positional information to the RSU: Vehicle 16, Vehicle 11, Vehicle 12, and Vehicle 17. Vehicles 11, 16, and 17 are determined to be the lane leaders for Lane 1, Lane 3, and Lane 4, respectively. The RSU then issues unicast messages to the lane leaders asking for their intention. Vehicle 11 responds with a unicast message indicating it intends to turn left, Vehicle 16 states its intention to turn left, and Vehicle 17 states it plans to turn right. Because Vehicle 11 is on the main road and there is no vehicle in Lane 2, it is issued a green light.

The project, which included the modification of a virtual traffic light algorithm to delegate substantial computational tasks to a roadside unit, was found to successfully enhance efficiency and effectiveness in these scenarios. The algorithm was also successfully implemented on a FPGA development board, indicating the practicality and feasibility of the proposed approach. A novel solar-powered system, specifically designed for lightweight roadside units, was prototyped for this project. This system operates off the grid, contributing to sustainability and energy efficiency in roadside unit power management. Overall, the findings demonstrate the functionality of roadside unit communication through the utilization of software-defined radios, validating the efficacy of the communication system.

Policy/Practice Recommendations

Findings from this project suggest several potential policy and professional practice recommendations to enhance safety at rural blind intersections. Integrating energy-efficient, solar-powered systems like the prototype in this project could help support sustainable infrastructure development. Additionally, future traffic management policies could use connected vehicle technologies in high-risk intersections to reduce accidents in the future as the IoV system becomes more ubiquitous. Furthermore, intersection design that incorporates RSU-based systems may help address visibility challenges and improve real-time traffic flow management to improve safety. Further research should be conducted to determine the system's validity outside of a simulated environment.

About the Author

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2351

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