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Smart Robot Design and Implementation to Assist Pedestrian Road Crossing

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Introduction

This research addresses a pressing issue: pedestrian safety, especially in school zones. With a high number of pedestrian fatalities and injuries reported annually, particularly among children, there is a critical need for innovative solutions to enhance safety at crossroads. Traditional methods, such as deploying school personnel to assist children, are often impractical and inefficient. This study proposes a novel approach: the development of a digital twin, a smart robot, to assist pedestrians and cyclists safely across the street. Equipped with sensors and artificial intelligence, the Smart Robot detects pedestrian and cyclist presence and traffic flow, ensuring safe crossings. In case of danger, the system alerts both drivers and pedestrians/cyclists, enhancing overall road safety. This research not only addresses the immediate need for safer school crossings but also offers potential applications for assisting the elderly in crossing streets without traffic lights, both during the day and at night. By leveraging technology like LiDAR and video cameras, this system could significantly improve pedestrian safety in vulnerable areas like school zones.

Study Methods

This study proposes using a smart robot to assist in safe street crossings. The robot is equipped with various sensors and artificial intelligence to detect pedestrians, cyclists, and traffic flow. Mounted on top of the robot is a traffic light signal with walking and stop signs to guide pedestrians and alert drivers. This upgrade has a LiDAR system and four visible light cameras to monitor traffic and pedestrian presence. Using advanced machine learning algorithms programmed in Python, the robot can accurately detect pedestrians, cyclists, and vehicles in real time. By combining information from sensors, the robot makes intelligent decisions about when it is safe to cross. If it detects potential danger, it sounds an alarm to warn drivers and pedestrians. This system, tested on Fresno State University streets, aims to improve pedestrian safety, and reduce accidents, especially in areas without traffic lights.

Findings

- Successful Detection: The smart robot system demonstrated high accuracy in detecting pedestrians and incoming vehicles during road crossing experiments. The trained machine learning algorithms effectively and identified pedestrians and vehicles with precision.
- System Operation: The developed system integrates

advanced software, machine learning neural networks, and hardware subsystems to manage pedestrian and traffic flow at crossings. A traffic control flowchart ensures safe pedestrian crossings while coordinating traffic signals.

- Continuous Monitoring: The system continuously monitors pedestrian presence and traffic flow, adjusting traffic signals accordingly. It initiates a red light for traffic, positions the robot in the street, and activates a green light for pedestrians to cross safely. After all pedestrians cross, it reverts traffic signals and resumes monitoring.
- Successful Development: The smart robot designed for pedestrian road crossing has been successfully developed and tested. The integration of Velodyne LiDAR, cameras, and software enables autonomous control and functionality. Machine learning models achieve high accuracy in pedestrian and vehicle detection.
- Model Accuracy: Deep neural networks achieved average validation accuracies of 90.48% for pedestrian and cyclist detection and 90.1% for vehicle and road cyclist detection. These models exhibit a high level of accuracy in real-world scenarios.
- Real-time Visualization: Experimentation with the smart traffic light was conducted on roads at Fresno State. Real-time captioning and visualization of LiDAR sensor data allow for identification of cars and pedestrians with percentage predictions.

Policy/Practice Recommendations

Implementation of Smart Traffic Control Systems: The successful development and testing of the smart robot for pedestrian road crossing suggests the potential for integrating similar systems into traffic control infrastructure. These systems can manage pedestrian crossings at intersections, enhancing safety for both pedestrians and drivers.

- Adoption of Advanced Technologies: Policymakers and traffic management authorities should consider incorporating advanced technologies, such as machine learning algorithms and sensor-based detection systems, into traffic control mechanisms. These technologies can improve real-time monitoring and decision-making at intersections, leading to safer road conditions.
- Comprehensive Safety Systems: The study highlights the importance of comprehensive safety systems that address the needs of all road users. By accurately detecting pedestrians and vehicles, especially in high-risk areas like school zones, these systems can mitigate risk.
- Training and Education: Traffic management personnel and stakeholders should receive training on the operation and maintenance of smart traffic control systems. Additionally, educational programs can raise awareness among pedestrians and cyclists about the presence and functionality of these systems, promoting safer road-crossing behaviors.
- Collaboration and Funding: Collaboration between research institutions, government agencies, and industry partners is essential for the development and implementation of smart traffic control solutions. Adequate funding should be allocated to support research and development initiatives aimed at enhancing pedestrian safety.

About the Author

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Dr. Kulhandjian is an Associate Professor in the Department of Electrical and Computer Engineering at California State University, Fresno. His current research interests are in applied machine learning, wireless communications, and networking with applications to unmanned aerial vehicles, autonomous vehicles, and Intelligent Transpiration Systems (ITS).

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2353

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