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Density Based Traffic Light Control

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ABSTRACT

The increasing volume of vehicles on the roads has led to traffic congestion and inefficient traffic signal control. To address this issue, this research paper proposes a Traffic Signal Control System (TSCS) that utilizes image processing techniques and artificial intelligence (AI) algorithms to optimize traffic signal timings. The TSCS aims to reduce traffic congestion, improve traffic flow, and enhance overall road safety. This paper presents the design, implementation, and evaluation of the TSCS, highlighting its potential benefits and challenges. Experimental results demonstrate the effectiveness of the proposed system in dynamically adjusting traffic signal timings based on real-time traffic conditions, leading to improved traffic management.

INTRODUCTION

Traffic congestion is a prevalent issue in modern urban environments, leading to significant delays, increased fuel consumption, and negative impacts on air quality. As cities continue to grow and populations increase, finding effective solutions to manage and alleviate traffic congestion becomes crucial. Intelligent transportation systems that leverage advanced technologies and artificial intelligence have shown promise in addressing this challenge. In this context, the development of an AI traffic light control system using Research Pepper, Haar Cascade method, OpenCV, .NET Framework 3.5, and Arduino offers a novel approach to optimize traffic flow and minimize congestion.

The Haar Cascade method, introduced by Viola and Jones, provides a robust technique for object detection. In the case of this project, the Haar Cascade method is employed to detect and count vehicles in real-time camera images. By overlaying positive images of vehicles on a set of negative images, a machine learning model is trained to accurately identify vehicles within the camera view. OpenCV and .NET Framework 3.5 software are utilized for image processing, enabling efficient analysis of the camera data and extraction of relevant vehicle information.

The AI traffic light control system leverages the data collected from cameras placed at different nodes to dynamically modify traffic signal timings. By continuously monitoring vehicle counts, traffic flow patterns, and other relevant parameters, the system optimizes signal timings to minimize congestion and improve traffic flow. Arduino, an open-source electronics platform, plays a crucial role in modifying signal timings based on the camera images obtained from the different nodes.

Furthermore, the proposed system includes a manual override capability for emergency situations, allowing the police to switch the system to manual mode and operate the traffic signals manually. This ensures flexibility and human intervention when necessary, enhancing the overall safety and efficiency of the traffic management system.

This research project aims to demonstrate the effectiveness of the AI traffic light control system using Research Pepper, the Haar Cascade method, OpenCV, .NET Framework 3.5, and Arduino. Through comprehensive experimentation, data collection, and analysis, this study seeks to evaluate the system's performance in reducing traffic congestion, improving traffic flow, and enhancing overall road safety. The results of this research can contribute to the development of intelligent transportation systems and pave the way for future advancements in traffic management technologies.

RELATED WORKS

The literature was carefully examined, and it became clear that numerous researchers had been working on intelligent traffic signal approaches.

According to a study by Darcy Bullock et al., image processing has advanced the deployment of new vehicle detecting systems. They introduced feed-forward neural networks and straightforward back propagation techniques [1]. A flexible traffic controller that uses image processing for vehicle detection and artificial intelligence for traffic control was proposed by Liang-Tay Lin et al. They did not, however experiment with it. [2]. Khaled Abdul Rahman Jomaa demonstrated a method that uses artificial intelligence to alter the timing of traffic signals while capturing traffic data from cameras [3]. Yu Yuan and colleagues tested a camera calibration system for traffic detection. The high-accuracy camera model was built by the researchers. [4]. A system with a neural network that may be used for phase generation and timing alterations at any moment was proposed by Amoeba T.S. Chang [5]. The intelligent method proposed by Mr. Somashekhar G.C. et al. can continuously monitor any movement occurring anywhere, and on the administrator's request, suspects can be traced using image processing [6]. Kohonen Feature map model and multilayer model were utilised by Takashi Nakatsuji et al. to increase estimation accuracy and computational effectiveness. Genetic and Cauchy algorithms were utilised by researchers to change traffic signals [7]. For the control of traffic signals, Xiangjun et al. applied machine learning and fuzzy theory. In order to count the number of autos, fuzzy clustering was utilised. Timing of traffic signals is controlled by a genetic algorithm. [8]. Real-time image processing was employed by Al Hussain Akoum and colleagues to develop the smart traffic controller. For analysing a series of cameras, edge detection techniques and object counting methods are used. Researchers developed a filtering mechanism for the image and displayed only the autos [9]. A system that can identify the car using image processing and determine the time accordingly was proposed by Pranav Maheshwari et al. [10]. Area traffic signal control based on AI Planning-based modelling was proposed by Chenmu Yu et al., who also provided the model identified by PDDL.

PROPOSED SYSTEM

To complete this work, an experimental methodology was applied. Figure 1 depicts the system's 2D design.

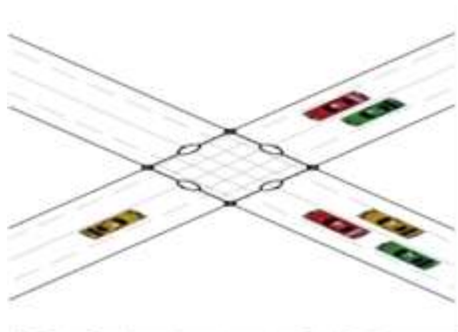
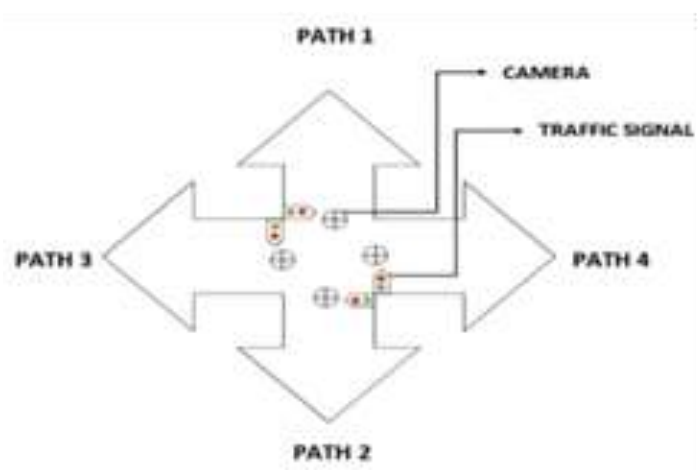


FIG. 1

The pathways in Figure 2 represent a four-node traffic system.



The block diagram of an automatic and manual traffic control system based on image processing is shown in Figure 3. In the event of automatic control, all cameras must first be turned on. OpenCV must then be turned on. After that, the Webcam Traffic Control Window (OpenCV) should switch to auto mode. Artificial intelligence and Arduino will help to count the traffic signals in each path, and image processing will assist in the detection of autos. In the event of manual mode, the OpenCV window must first be activated. Then, by disabling auto mode, the system should be in manual mode. From the OpenCV window, the operator can control the traffic lights.

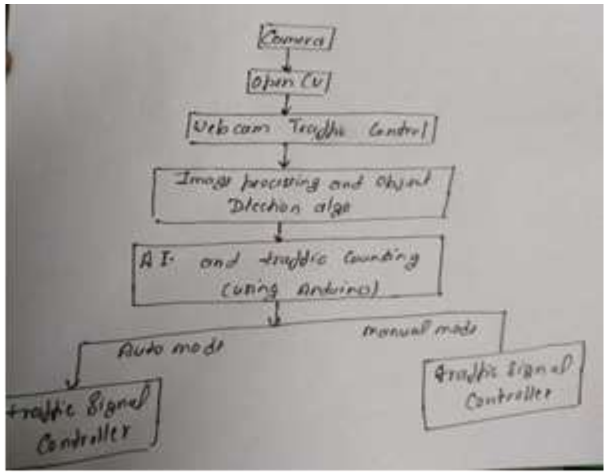


Fig. 3

The complete system's electrical diagram is shown in Figure 4. This traffic light control system's electrical circuit is made up of an Arduino Pro Mini microcontroller board and a PL2303 USB to TTL Module. The PL2303 USB to TTL Module is used by Arduino Pro Mini to control traffic lights. The computer is connected to this module.

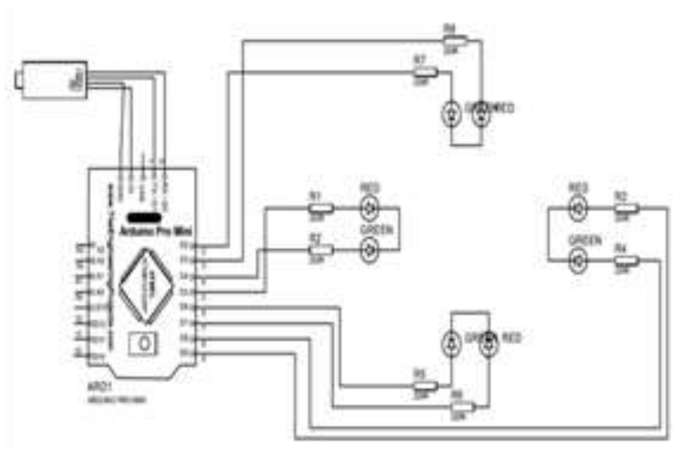


Fig. 4

A cock sheet board is used to set up the prototype. A USB hub connects the camera to the computer. A plastic stand holds the cameras in place. A cock sheet board is used to mount the Arduino Pro Mini, PL2303 USB to TTL Module, and the plastic stand. An image processing and artificial intelligence-based traffic signal control system's hardware configuration is shown in Figure 5.

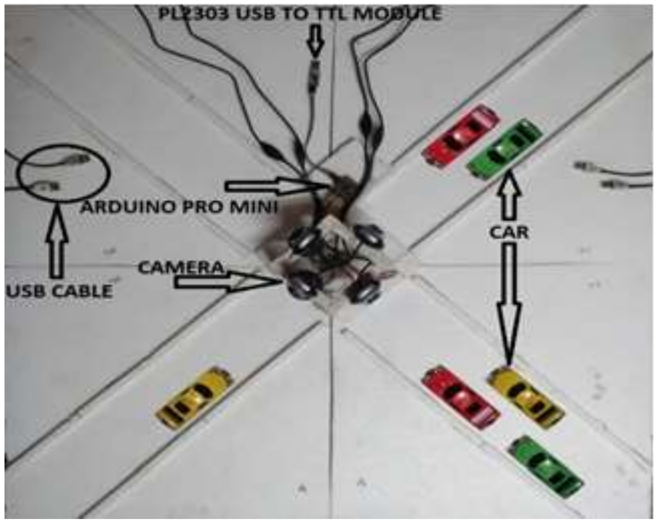


Fig. 5

The connection is displayed in automatic mode in Figure 6. In order to connect in automated mode, you must click OpenCV. In OpenCV, auto mode is displayed as HOST:AUTO. It is obvious that every camera counts the number of vehicles.

Fig. 6

The auto mode in OpenCV must be disabled in order to activate manual mode. In OpenCV, manual mode is displayed as HOST: MANUAL (Figure 7).

Fig. 7

The manual mode's operating mechanism was introduced in Figure 8. In the host window, the OpenCV window displays manual mode. When Road 3 is selected, the button will turn on the green light in node 3 and the red light in the other 3 nodes. Until the signal is changed, it will continue. The traffic light in node 3 in Figure 9 displays a green signal. There is a red signal at nodes 1, 2, and 4.

Fig.8

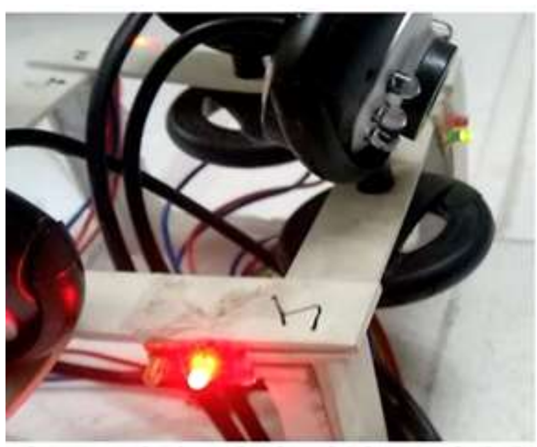


Fig.9

When camera 3 identifies two cars, automated mode operates as shown in Figures 10 and 11. Figure 11 displays the green signal in node 3. Green signal is active in node 3 for 20 seconds.

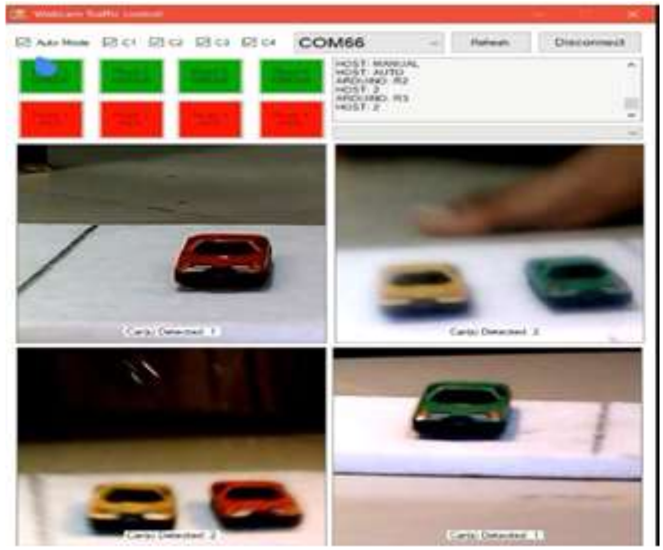


Fig.10

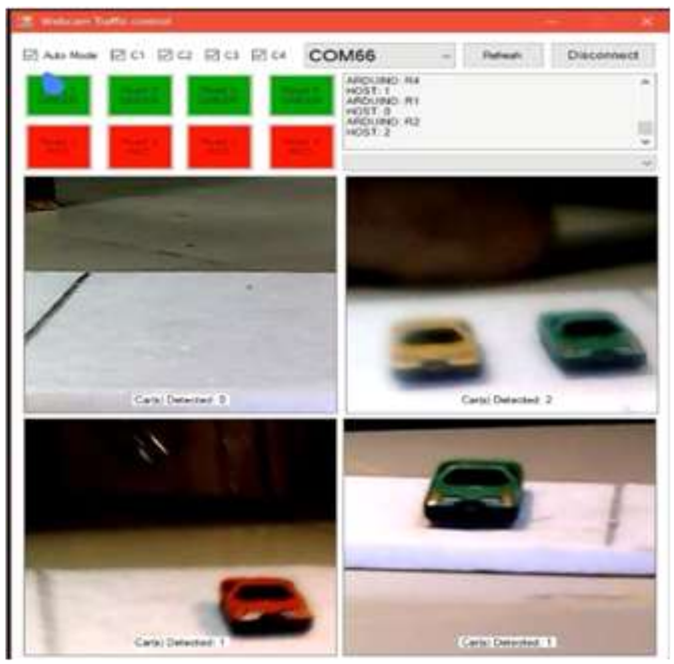


Fig. 12

When there isn't an automobile in node 1, Figure 12 depicts the automatic mode. In this scenario, the green signal will move on to node 2 after node 4.

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