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AI-Based Smart Traffic Signal Control System

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ABSTRACT

AI-based traffic signal management system that employs convolutional neural networks (CNNs) and image processing techniques for real-time traffic prediction and adaptive signal control. By utilizing intelligent agents and object detection algorithms, the system detects vehicle count, calculates speed, and dynamically adjusts traffic light phases to reduce congestion. Implemented using Python and trained on real-time traffic footage, the model achieved high prediction accuracy with a Mean Absolute Percentage Error (MAPE) of 1.3%. The system proves to be efficient, scalable, and suitable for real-world urban traffic environments.

KEYWORDS: Intelligent Traffic Systems, Ai, Cnn, Image Processing, Traffic Management, Object Detection, Real-Time Signal Control

HIGHLIGHTS

- **Real-time adaptive traffic control system** developed using CNN and image processing techniques.
- **Dynamic signal timing** based on vehicle count and speed analysis from live video feeds.
- Uses **intelligent agents and neural networks** to monitor and predict traffic congestion

1. INTRODUCTION

The increasing traffic congestion in urban areas due to population growth and limited infrastructure calls for innovative solutions. Traditional traffic lights operate on fixed cycles, failing to accommodate dynamic traffic patterns. This paper proposes an intelligent traffic signal system using CNNs and image processing to provide adaptive signal control, reduce delays, and improve urban mobility.

Traditional traffic signal systems operate on pre-defined timers that do not adapt to the real-time traffic conditions, resulting in inefficient traffic flow, longer waiting times at intersections, increased fuel consumption, and elevated levels of air pollution. Moreover, such static systems fail to account for special conditions such as emergency vehicle prioritization or pedestrian activity, further reducing their effectiveness in modern urban environments.

2. PROBLEM DEFINITION

Manual traffic control by police personnel during peak hours is still a common approach in many cities. However, this method is labor-intensive, prone to human error, and not scalable for large-scale or complex intersections. Infrastructure-based solutions like road expansion or underpasses are costly and often impractical in densely populated urban areas. Therefore, there is a pressing need for an intelligent traffic control system that can accurately sense, analyze, and respond to real-time traffic patterns with minimal human intervention.

3. OBJECTIVE

The primary objective of this research is to design and develop an **AI-based traffic signal management system** that intelligently analyzes real-time traffic flow and dynamically controls signal timings to reduce congestion and improve overall road efficiency. The system aims to utilize **Convolutional Neural Networks (CNN)** and **image processing techniques** to detect, classify, and count vehicles in video feeds captured from traffic surveillance cameras.

Scalability and adaptability of the system for different urban environments and traffic patterns. **Integration of a centralized monitoring platform** to allow traffic authorities to visualize, analyze, and manually intervene if required.

4. SUMMARY OF ISSUES

- Fixed-Time Signal Systems
- Manual Traffic Monitoring
- Inability to Detect Vehicle Density
- No Priority for Emergency Vehicles
- Increased Wait Times
- **Environmental Impact**

5. EXISTING SYSTEM

The current traffic management systems implemented in most urban and semi-urban areas are based on fixed-time traffic signal controllers, which operate on pre-defined schedules irrespective of actual road conditions. These systems lack the ability to adapt to fluctuating traffic volumes, resulting in inefficient traffic flow, long waiting times, and driver frustration. Even during low traffic periods, vehicles are often forced to stop at red lights due to rigid signal timing, causing unnecessary delays and fuel wastage.

In many cities, manual traffic control by traffic police is still widely practiced, especially during peak hours or at congested intersections. While this method may provide temporary relief, it is labor-intensive, prone to human error, and not scalable for realtime, city-wide traffic optimization. Furthermore, these systems do not have the capability to detect or prioritize emergency vehicles, pedestrian crossings, or vehicle density-based lane preferences, which are critical for modern traffic control. DISADVANTAGES

- Police always needs to stand and monitor the traffic
- person with the higher speed not known

6. PROPOSED SYSTEM

The tremendous growth of the transportation systems and the increased number of vehicles during the last decades has created a significant problem in urban areas, that of traffic congestion. In the current paper, a novel system targeted to predict the road traffic, using intelligent agents, is proposed. The accurate prediction of traffic will enable the road operators to proactively take appropriate measures, such as changing the traffic light strategy to alleviate the congestion problem. For the prediction process of the intelligent agents, artificial neural networks are employed in order to estimate the vehicles' speed on the road as an indicator of the traffic congestion. The results showed that the proposed system provides high accuracy with a mean absolute percentage error of about 1.3%. Specifically, the intelligent agents will employ artificial neural networks in order to predict the forthcoming speed in the road as an indicator of the traffic congestion.

ADVANTAGES

- Image classification
- speed of the vehicle get detected.
- The speed get recognized an intimation will be made to the control room
- The police men to detect the traffic and high speed vehicles in highway and the city area Offline Capabilities

7. SYSTEM REQUIREMENT SPECIFICATION

purpose of this System Requirement Specification (SRS) document is to provide a comprehensive overview of the hardware and software requirements necessary for the development and deployment of the AI-Based Intelligent Traffic Control System. This intelligent system is designed to monitor realtime

traffic flow, classify vehicles, predict congestion, and dynamically control traffic signals using computer vision and machine learning techniques. The document outlines both functional and non-functional requirements, serving as the foundation for the system's design, implementation, and validation. The purpose of the SRS document includes:

- **Facilitating Communication:** Establishes clear communication among system designers, developers, traffic authorities, and end-users by detailing the system requirements.
- **Foundation for Design:** Serves as a blueprint for the system design phase, ensuring that the architecture and components align with the required functionalities.

- **Supporting Testing:** Provides a basis for validation and verification processes, allowing testers to ensure that all system functionalities operate as expected..

8. SYSTEM REQUIRMENTS

HARDWARE REQUIREMENT

Processor: Dual-core processor, 2.6 GHz or higher RAM: Minimum 8 GB

Hard Disk: 256 GB

Monitor: 15-inch color monitor Keyboard: Standard

CD Drive: 650 MB (if needed for installation from disc)

SOFTWARE REQUIREMENT

IDE: PyCharm Community Edition Operating System: Windows 10 or higher Libraries & Tools:

OpenCV (for image/video processing) PIL (for image handling in Tkinter GUI)

Data2Vector / GRNN (for feature extraction and classification) tkinter (for GUI development)