AI POWERED TRAFFIC SIGNALLING SYSTEM USING YOLO, RASPBERRY PI AND ARDUINO MEGA

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ABSTRACT-*Traffic congestion has become a critical challenge in modern urban environments due to rapid population growth and an increase in the number of vehicles. Conventional traffic signal systems operate on fixed time intervals, which do not adapt to real-time traffic conditions, leading to unnecessary delays, fuel wastage, and increased environmental pollution. To address these limitations, this paper presents an AI-based intelligent traffic control system that dynamically adjusts signal timings based on real-time traffic density. The proposed system utilizes cameras installed at traffic junctions to continuously capture live video streams. These video feeds are processed using computer vision techniques and a YOLO (You Only Look Once) based deep learning model to detect and classify vehicles such as cars, bikes, buses, and trucks. Based on the detected vehicles, a traffic score is calculated using predefined weights, which represents the density of traffic in each lane. A scheduling algorithm is implemented to allocate optimal green signal duration to each lane, ensuring efficient traffic flow. The system architecture integrates Raspberry Pi for running AI models and processing video data, while Arduino Mega is used for controlling traffic lights, seven-segment displays, and buzzer systems in real-time. Communication between Raspberry Pi and Arduino is achieved using serial communication, enabling synchronized operation. Additionally, the system includes an emergency vehicle prioritization mechanism that overrides normal traffic flow and provides immediate green signal to the respective lane. The system also supports data logging and monitoring through a user interface for better analysis and control. Experimental results demonstrate that the proposed system significantly reduces waiting time, improves traffic flow, minimizes fuel consumption, and lowers carbon emissions compared to traditional traffic signal systems. The system is scalable, cost-effective, and can be integrated into smart city infrastructure for advanced traffic management and future intelligent transportation systems.*

Index Terms-Artificial Intelligence, Smart Traffic Control, YOLO, Computer Vision, Raspberry Pi, Arduino Mega, Traffic Density, Real-Time Monitoring, Adaptive Signal Control, Smart City

INTRODUCTION

Traffic congestion has become a significant issue in modern urban environments, particularly in rapidly developing countries like India. With the continuous growth in the number of vehicles, efficient traffic management has become increasingly challenging. Traditional traffic signal systems operate on fixed time intervals, without considering real-time traffic conditions. As a result, these systems often lead to unnecessary delays, increased fuel consumption, and higher levels of air pollution. In conventional systems, each signal is assigned a predefined duration regardless of the actual number of vehicles waiting at an intersection. This approach can cause inefficient traffic flow, where vehicles remain idle at red signals even when other lanes are empty, while heavily congested lanes receive insufficient green time. Such limitations highlight the need for a more intelligent and adaptive traffic control mechanism. To overcome these challenges, this paper proposes an AI-based smart traffic control system that dynamically adjusts signal timings based on real-time traffic density. Artificial Intelligence (AI) enables the system to analyze live traffic data, recognize patterns, and make decisions instantly. By integrating computer vision techniques with deep learning models such as YOLO (You Only Look Once), the system is capable of detecting and classifying vehicles including cars, bikes, buses, and trucks from live video feeds. In the proposed system, cameras are installed at traffic intersections to continuously monitor traffic conditions. The captured video is processed using AI algorithms to detect and count the number of vehicles in each lane. Based on this data, a traffic score is calculated, which is used to determine the optimal green signal duration for each lane. This ensures that lanes with higher traffic density are given priority, while less congested lanes receive shorter signal durations. The system aims to provide a fair, efficient, and adaptive traffic control solution that minimizes waiting time, reduces fuel consumption, and improves overall traffic flow. By leveraging modern AI technologies, the proposed approach offers a scalable solution that can be integrated into future smart city infrastructures.

LITERATURE SURVEY

Year	Title	Methodology	Contribution	Limitation
2025	Optimizing Urban Intersection Management in Mixed Traffic Using Deep Reinforcement Learning and Genetic Algorithms	DRL + Genetic Algorithm for adaptive lane configuration in mixed traffic.	Average speed increased by 17.6%. Waiting time decreased by 33.3% when CAV > 60%.	Simulation only; requires CAV infrastructure.
2022	Traffic Signal Control System Using Deep Reinforcement Learning With Emphasis on Reinforcing Successful Experiences	Multi-agent DRL with Dual Targeting Algorithm (DTA).	Waiting time decreased by 33% compared to standard DQN; stable convergence in SUMO.	High memory/CPU cost; only simulation, no real deployment.
2023	Real-Time Adaptive Traffic Signal Control with CAVs	AI-driven adaptive control using Connected & Automated Vehicle (CAV) data in SUMO.	Reduced vehicle stops and emissions; improved adaptive traffic flow.	Only tested in SUMO, not real-world deployment.
2025	Artificial Intelligence in Intelligent Traffic Signal Control	Deep Q-Network (DQN) with real-time traffic data; tested in simulation + Beijing.	Traffic flow increased by 7%, travel time decreased by 25%, congestion decreased by 26.7%, accidents decreased by 40%.	Computationally expensive, integration challenges.

From the above studies, it is observed that most existing systems rely heavily on simulation-based approaches and require high computational resources or specialized infrastructure. In contrast, the proposed system in this paper focuses on real-time implementation using YOLO-based vehicle detection and cost-effective hardware such as Raspberry Pi and Arduino Mega, making it more practical and suitable for real-world deployment.

EXISTING SYSTEM

Existing traffic signal systems are primarily based on fixed time intervals and operate without considering real-time traffic conditions. In these systems, each signal is assigned a predefined duration, regardless of the actual number of vehicles present at the intersection. This approach often leads to inefficient traffic management, where vehicles are forced to wait unnecessarily at red signals even when other lanes have little or no traffic

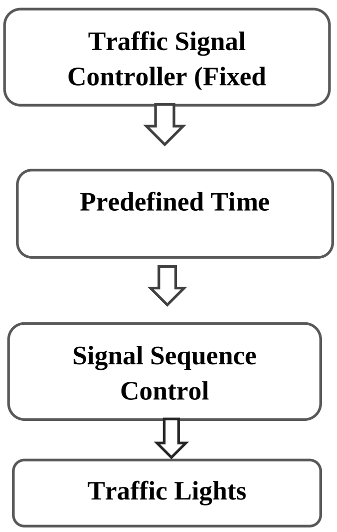

Fig. Existing System

Moreover, in cases of heavy traffic, fixed-time signals fail to provide sufficient green time, resulting in congestion and increased waiting time. These systems also contribute to higher fuel consumption and environmental pollution due to prolonged idling of vehicles. Although some advanced systems use sensor-based or simulation-based approaches, they are either costly, complex, or not widely implemented in real-world scenarios

PROPOSED SYSTEM

The proposed system presents an AI-based intelligent traffic control mechanism that dynamically adjusts traffic signal timings based on real-time traffic conditions. The system is designed to overcome the limitations of traditional fixed-time traffic signals by incorporating computer vision and embedded systems. In this system, cameras are installed at traffic intersections to continuously capture live video of each lane. The captured video is processed using a YOLO (You Only Look Once) based object detection model, which identifies and classifies vehicles such as cars, bikes, buses, and trucks. The detection process is carried out on a Raspberry Pi, which acts as the central processing unit for executing AI algorithms. Based on the detected vehicles, a traffic score is calculated for each lane using predefined weights assigned to different vehicle types. Heavier vehicles such as buses and trucks are given higher weights compared to cars and bikes. This score represents the traffic density and helps in prioritizing lanes with higher congestion. A scheduling algorithm is implemented to determine the optimal green signal duration for each lane. The green time is dynamically calculated based on the traffic score, ensuring that lanes with higher traffic receive longer signal durations, while less congested lanes receive shorter durations.

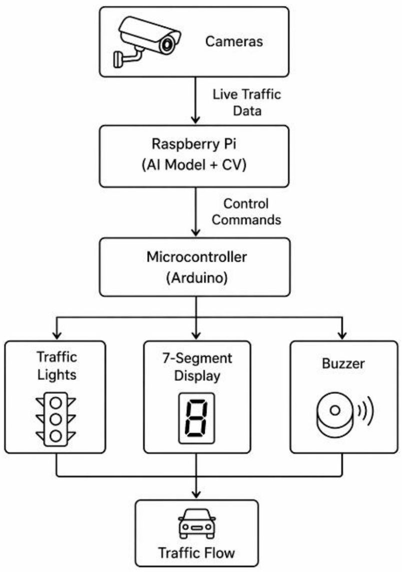

Fig. Proposed System

This improves traffic flow and reduces waiting time. The processed decision is then communicated to an Arduino Mega using serial communication. The Arduino Mega is responsible for controlling the traffic lights, seven-segment display, and buzzer system in real-time. It ensures accurate timing and smooth transition between green, yellow, and red signals. Additionally, the system incorporates an emergency vehicle detection mechanism. When an emergency vehicle is detected, the system overrides the normal scheduling process and immediately provides a green signal to the respective lane, ensuring faster clearance Overall, the proposed system provides a cost-effective, scalable, and efficient solution for real-time traffic management. It combines Artificial Intelligence, Computer Vision, and Embedded Systems to create a smart and adaptive traffic control system suitable for modern smart city applications

METHODOLOGY / ALGORITHM

The proposed system follows a structured methodology to perform real-time traffic monitoring and dynamic signal control. The overall process is divided into multiple stages, including data acquisition, vehicle detection, traffic analysis, decision-making, and signal control. Initially, cameras are installed at traffic intersections to capture live video streams of each lane. These video frames are continuously sent to the Raspberry Pi, which processes the data using computer vision techniques. A YOLO (You Only Look Once) based object detection model is applied to identify and classify vehicles such as cars, bikes, buses, and trucks from the captured frames. After detecting the vehicles, the system counts the number of vehicles in each lane. Based on the type of vehicles, a traffic score is calculated using predefined weights. Heavier vehicles such as buses and trucks are assigned higher weights compared to lighter vehicles like cars and bikes. This scoring mechanism helps in estimating the traffic density more accurately. The calculated traffic scores are then passed to a scheduling algorithm, which determines the optimal green signal duration for each lane. The green time is dynamically computed based on the traffic score, ensuring that lanes with higher congestion receive longer signal durations. Minimum and maximum limits are applied to avoid extremely short or long signal times. The final decision is transmitted to the Arduino Mega through serial communication. The Arduino Mega controls the traffic lights, seven-segment display, and buzzer system. It manages the switching between green, yellow, and red signals based on the received timing. Additionally, the system incorporates an emergency handling mechanism. When an emergency vehicle is detected, the system overrides the normal scheduling process and immediately provides a green signal to the respective lane for faster clearance. This methodology ensures real-time adaptability, efficient traffic flow, and reliable signal control using a combination of Artificial Intelligence and embedded systems.

Algorithm:

1. Start the system and initialize camera, Raspberry Pi, and Arduino.
2. Capture live video frames from traffic cameras.
3. Apply YOLO model to detect and classify vehicles.
4. Count the number of vehicles in each lane.
5. Calculate traffic score using weighted formula.
6. Compute green signal time based on traffic score.
7. Apply minimum and maximum time constraints.
8. Send control command to Arduino Mega via serial communication.
9. Arduino activates traffic signals (Green → Yellow → Red).
10. If emergency vehicle detected, override and give immediate green signal.
11. Repeat the process continuously.

SYSTEM ARCHITECTUR

The proposed AI-Based Intelligent Traffic Signaling System follows a modular and layered architecture designed to enable real-time traffic monitoring, intelligent decision-making, and adaptive signal control. The system begins with the **Camera Module (Data Acquisition Layer)**, where cameras are installed at traffic junctions to capture continuous real-time video streams of traffic. These video feeds provide raw data regarding vehicle presence, movement, and density across different lanes. The captured video is then forwarded to the **Edge Computing Unit (Raspberry Pi)**, which acts as the processing layer. In this stage, the system utilizes advanced computer vision techniques along with the YOLO (You Only Look Once) model to detect, classify, and count vehicles such as cars, bikes, buses, and trucks. This enables accurate estimation of traffic density in each lane. The processed data is passed to the **Decision-Making Engine**, which serves as the core intelligence of the system

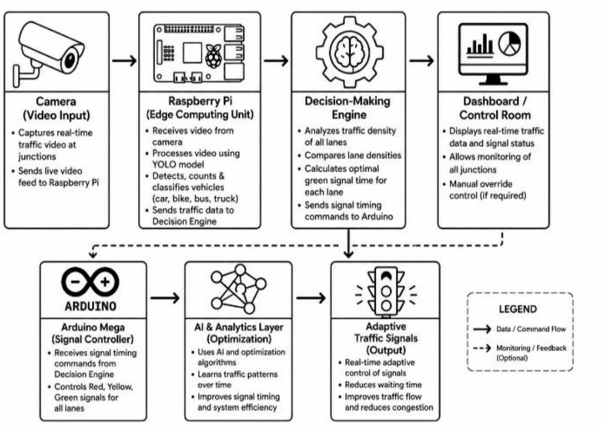

Fig. System architecture

This module analyzes the vehicle density data, compares traffic conditions across multiple lanes, and computes the optimal signal timing dynamically. The system ensures that lanes with higher traffic density are allocated longer green signal durations. A **Dashboard / Control Room Module** is also integrated to provide real-time monitoring and visualization of traffic conditions. It displays system status, detected vehicles, and signal timings, and allows manual override if necessary. The control commands generated by the decision engine are transmitted to the **Arduino Mega (Traffic Signal Controller)**. This microcontroller is responsible for controlling the physical traffic lights, including red, yellow, and green signals, based on the received instructions.

PIN DIAGRAM

The pin diagram of the proposed AI-Based Intelligent Traffic Signaling System represents the hardware connections between the Raspberry Pi, Arduino Mega, traffic lights, and seven-segment displays. The system starts with a **USB camera**, which is connected to the Raspberry Pi. The camera captures real-time traffic video, which is used for vehicle detection and analysis using AI algorithms. A **USB hub** is used to connect additional devices such as the Arduino board (for programming), keyboard, and mouse to the Raspberry Pi. This ensures easy communication and control of the system. The Raspberry Pi acts as the main processing unit. It processes video data using computer vision and sends control signals to the Arduino Mega through serial communication. The **Arduino Mega 2560** functions as the traffic signal controller. It receives instructions from the Raspberry Pi and controls the traffic lights and display units using its digital output pins. The system includes **four traffic signal units** representing four directions: North, East, South, and West. Each signal consists of three LEDs:

- Red (Stop)
- Yellow (Wait)
- Green (Go)

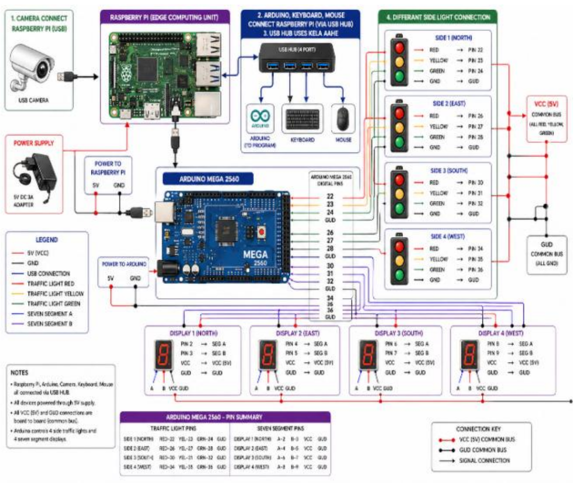

Fig. pin diagram

Each LED is connected to specific digital pins of the Arduino. All ground connections are connected to a common ground (GND bus), and power is supplied through a common VCC (5V) bus. Additionally, the system uses **four seven-segment displays**, one for each direction, to show signal timing or countdown. These displays are connected to the Arduino using digital pins, along with VCC and GND connections. A common breadboard is used to distribute power (VCC) and ground (GND) to all components efficiently.This pin configuration ensures proper communication between components and allows real-time control of traffic signals based on AI-generated decisions.

RESULTS AND DISCUSSION

1) The hardware setup of the proposed system consists of a Raspberry Pi, Arduino Mega, traffic signal LEDs, cameras, and supporting electronic components. The Raspberry Pi acts as the main processing unit, where the YOLO-based object detection model is executed to analyze real-time traffic video. The live video feed is captured using cameras and processed to detect and count vehicles in each lane. The Arduino Mega is connected to the Raspberry Pi through serial communication and is responsible for controlling the traffic lights and display modules. LED lights are used to represent traffic signals (red, yellow, and green), demonstrating real-time signal switching based on traffic conditions. A seven-segment display is used to show the signal timing. The entire system is interconnected using jumper wires and powered through a regulated power supply. The setup demonstrates the practical implementation of an AI-driven adaptive traffic control system using embedded hardware components

Fig. 1: Hardware Setup of AI-Based Traffic Control System

2) The above figure shows the real-time vehicle detection output generated by the YOLO (You Only Look Once) model. The system processes live video frames

and identifies different types of vehicles such as cars, buses, and trucks. Each detected object is highlighted with a bounding box along with a confidence score, indicating the accuracy of detection. The detected vehicles are counted for each lane, and this information is used to calculate the traffic density. Based on the number and type of vehicles, a traffic score is generated, which helps in determining the optimal signal timing. The system continuously updates the detection results in real-time, ensuring accurate and dynamic traffic analysis. This output demonstrates the effectiveness of the AI model in detecting vehicles under different traffic conditions and plays a crucial role in enabling adaptive traffic signal control.

Fig. 2: Real-Time Vehicle Detection using YOLO Algorithm

APPLICATIONS:

1. The proposed system can be used in urban traffic intersections to manage high traffic density efficiently.
2. It can be integrated into smart city projects for intelligent transportation systems.
3. The system can be used in highways and busy roads to reduce congestion and improve traffic flow.
4. It is useful for emergency vehicle management, such as ambulances and fire trucks, by providing priority signals.
5. The system can be deployed in areas with frequent traffic jams to reduce waiting time and fuel consumption.
6. It can also be used for real-time traffic monitoring and analysis by traffic authorities.

ADVANTAGES:

1. Reduces traffic congestion and waiting time at intersections.
2. Minimizes fuel consumption and environmental pollution.
3. Provides dynamic and adaptive signal control based on real-time traffic.
4. Improves overall traffic flow and road efficiency.
5. Supports emergency vehicle prioritization.
6. Cost-effective solution using Raspberry Pi and Arduino.
7. Scalable and can be extended to multiple intersections.

Enhances safety by reducing chances of accidents

CONCLUSION

The proposed AI-based intelligent traffic control system demonstrates an effective solution for managing urban traffic using real-time data and advanced technologies. By utilizing computer vision and YOLO-based object detection, the system accurately detects and counts vehicles in each lane. The integration of Raspberry Pi for processing and Arduino Mega for signal control ensures a reliable and efficient implementation. The system dynamically adjusts traffic signal timings based on traffic density, which helps in reducing waiting time, minimizing fuel consumption, and improving overall traffic flow. The inclusion of an emergency vehicle prioritization feature further enhances the system's practicality by ensuring faster clearance for critical situations. Compared to traditional fixed-time traffic signal systems, the proposed approach offers better adaptability, efficiency, and scalability. It also provides a cost-effective solution suitable for real-world deployment and smart city applications. The system can be further enhanced by integrating advanced AI models, cloud-based monitoring, and predictive traffic analysis for future improvements. Overall, this project highlights the potential of Artificial Intelligence and embedded systems in transforming conventional traffic management into a smart and adaptive system.

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