IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

IJARSCT onal Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue1, November 2023

# AI Powered Traffic Management and Signal Monitoring System

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**Abstract:** *In response to the escalating challenges posed by the increasing number of vehicles and the consequent rise in traffic congestion globally, this paper introduces an innovative solution— an AI-powered traffic management and signal monitoring system. The prevalence of frequent traffic jams at major junctions not only disrupts the flow of vehicles but also leads to a substantial loss of man-hours. Recognizing the pressing need for an efficient traffic management system, our research focuses on implementing a smart traffic control system that utilizes real-time video processing techniques to measure traffic density. The core objective is to present a significant advancement over the existing manual traffic control systems. By dynamically assessing traffic conditions through artificial intelligence algorithms, our system aims to optimize signal timings in real time, thereby reducing congestion and saving valuable man-hours lost in traffic jams. This research represents a noteworthy progress towards developing a more adaptive and responsive traffic control system that can positively impact the efficiency of transportation networks*.

**Keywords:** Gaussian mixture model, Shortest Job First, Initialize Foreground Detector, Detect Cars in an Initial Video Frame, Threshold, Traffic Density

## I. INTRODUCTION

With the incessant growth of urban populations, the escalation of vehicular travel has given rise to a critical issue – traffic congestion. To tackle this challenge, our proposed solution introduces an AI-powered traffic management and signal monitoring system. Departing from traditional methods using electronic sensors embedded in pavements, our system employs advanced video processing techniques to seamlessly calculate the traffic density on roads. Vehicles are detected through images captured by cameras strategically placed alongside traffic lights, offering a more versatile and efficient alternative. In our envisioned system for a four-way road intersection, four cameras are integrated, each feeding data to a central processing unit (CPU) responsible for video processing. This CPU analyzes the images, counting the number of vehicles present on the road in real-time. Subsequently, the system dynamically allocates time to the road with a higher vehicle count, optimizing traffic light state changes. This iterative process, continuously adapting to evolving traffic conditions, plays a pivotal role in alleviating congestion issues and presents a forward-thinking approach to modernizing traffic management in urban environments.

## II. LITERATURE SURVEY

Traffic is a critical issue of transportation system in most of all the cities of Countries. This is especially true for countries where population is increasing at higher rate. There is phenomenal growth in vehicle population in recent years. As a result, many of the arterial roads and intersections are operating over the capacity and average journey speeds on some of the key roads in the central areas are lower than 10 Km/h at the peak hour. In some of the main challenges are management of more than 36,00,000 vehicles, annual growth of 7–10% in traffic, roads operating at higher capacity ranging from 1 to 4, travel speed less than 10 Km/h at some central areas in peak hours. It involves a manual analysis of data by the traffic management team to determine the traffic light duration in each of the junction. It will communicate the same to the local police officers for the necessary actions.[1]

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Reinforcement learning for traffic light control has first been studied by Thorpe He used a traffic light-based value function, and we used a car based one. Thorpe used a neural network for the traffic-light based value function which predicts the waiting time for all cars standing at the junction. Furthermore, Thorpe used a somewhat other form of RL, SARSA (State- Action, Reward-State Action) with eligibility traces [2]. Roozemond describes an intelligent agent architecture for traffic light control intelligent traffic signaling agents (ITSAs) and Road Segment Agents (RSAs) try to perform their own tasks, and try to achieve local optimality. One or more Authority Agents can communicate with groups of ITSAs and RSAs for global performance. All agents act upon beliefs, desires, and capabilities. No results were presented [3].

In G. Sathya, et al[3]achieved with the help of "AARSusing GPRS 3G TECHNOLOGY". Through this, we can provide a smooth flow for the ambulance by controlling the traffic light according to the ambulance location to reach the hospital. The location of the ambulance can be easily identified with the help of the GPS unit installed in it.[4] Then comes the Traffic light system using image processing. The system will detect vehicles through images instead of using electronic sensors embedded in the pavement. A camera will be installed alongside thetraffic light. It will capture image sequences. [5].

### 2.1 Problem Definition

All of the traffic light system used is the traditional system.These systems encounter many limitations i.e. timing is not based on number of vehicles due to this we have the following drawbacks.

1. Heavy traffic jams.
2. Violation of traffic rules.
3. Wastage of man hours daily.
4. Increase in pollution in the consistent area.
5. Green Light for an empty road.
6. No traffic, but the pedestrians still need to wait.
7. Loss of Fuel and Money.

## III. PROPOSED SYSTEM

System is based on the measurement of traffic density using real time video processing technique. The computed traffic density is compared with other parts of the traffic inorder to control the traffic signal smartly. In this model, there will be four cameras in one intersection for a four way road. The hardware's that we will be using are: HD Camera, CPU (For video processing), (we can install n number of cameras to resolve the congestion problem forn number of roads).

A High definition camera placed on poles will observe the vehicular traffic flow continuously on a road then using frame by frame Real-time video analysis through our developed algorithm, we can detect how much cars are present on the road.

Depending on the number of detected vehicles we have developed and implemented a sequential traffic timer system. Micro controller will detect the signal from CPU and start the sequential traffic light. While the light phase goes from green to red, our micro controller or Arduino will send a signal to CPU.

The HD camera will be installed in the traffic light post at aheight of 19-25 feet (for practical implementation) above the road. This camera will take the live video footage of the road and send it to a computer where video analysis will be done.

For a 4 way intersection, CPU will detect each and every car and will count the vehicle number in the road by using our developed algorithm. It will also do the same thing with other road by using another camera.

CPU then compares vehicle number of both roads. The road which has more vehicles will get the preference and green light for that road will be on and red signal will be shown automatically to the other road.

### 3.1 Algorithm

**Gaussian mixture model** is a probabilistic model for representing the presence of sub-populations within an overall population, without requiring that an observed data set should identify the sub-population to which an individual observation belongs.

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A Gaussian mixture model is a distribution assembled from weighted multivariate Gaussian* distributions. Weighting factors assign each distribution different levels of importance. The resulting model is a super-position (i.e. an overlapping) of bell-shaped curves.

The Basic Formula for GMM is

$$f_{\alpha,\mu,\sigma^2}(X) = \sum_{j=1}^{m} \alpha_j \frac{1}{\sqrt{2\pi\sigma_j}} e^{-\frac{(x-\mu_j)^2}{2\sigma_j^2}},$$

Gaussian mixture models are semi-parametric. Parametric implies that the model comes from a known distribution (which is in this case, a set of normal distributions). It's semi-parametric because more components, possibly from unknown distributions, can be added to the model.

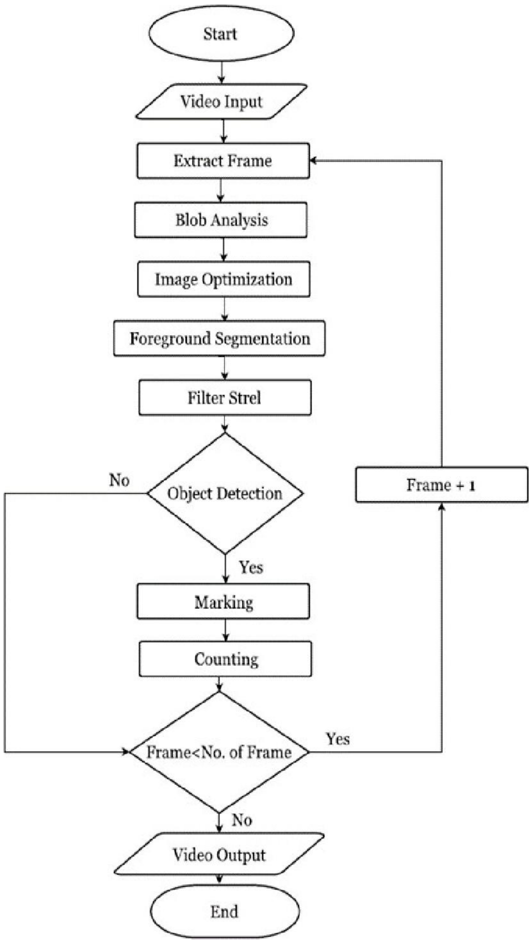


Fig -1: Flowchart

**3.2 Shortest Job First**

Shortest job first (SJF) or shortest job next, is a scheduling policy that selects the waiting process with the smallest execution time to execute next. SJN is a non-preemptive algorithm.

Shortest Job first has the advantage of having minimum average waiting time among all scheduling algorithms.

It is a Greedy Algorithm.

It may cause starvation if shorter processes keep coming. This problem can be solved using the concept of aging.

It is practically in feasible as Operating System may not know burst time and therefore may not sort them. While itis not possible to predict execution time, several methods can be used to estimate the execution time for a job, such as a

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weighted average of previous execution times. SJF can be used in specialized environments where accurateestimates of running time are available.

## IV. METHODOLOGY

The methodology of our AI-powered traffic management and signal monitoring system involves a systematic approach to address the challenges of traffic congestion through real-time video processing and adaptive signal control. The key steps are outlined below:

### 4.1 System Architecture

The foundation of our system lies in a well-designed architecture. Four strategically positioned cameras capture real-time video footage at a four-way road intersection. These cameras feed data into a central processing unit (CPU), the system's brain, responsible for video processing and decision-making.

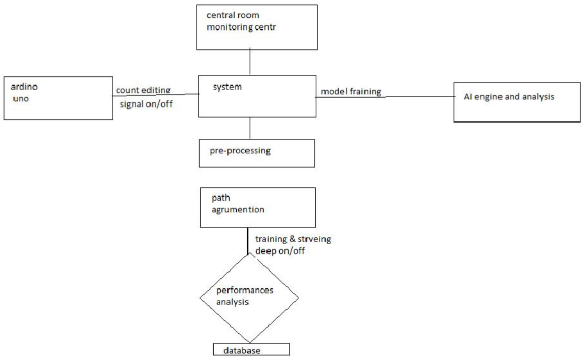


Fig 2: System Architecture

### 4.2 Data Acquisition

Continuous video streams from the cameras serve as the primary data source. The acquired data provides a dynamic and comprehensive view of the traffic scenario, ensuring that the system operates based on up-to-the-minute information.

### 4.3 Vehicle Detection

Advanced computer vision techniques, particularly the application of Gaussian mixture models, are employed for accurate vehicle detection. The Initialize Foreground Detector process ensures precise identification of moving objects, focusing on vehicles within the video frames.

### 4.4 Traffic Density Estimation

The system utilizes the Shortest Job First (SJF) scheduling algorithm to prioritize the processing of vehicles based on their presence in the frame. This prioritization facilitates an efficient estimation of traffic density, a critical parameter for adaptive signal control.

### 4.5 Adaptive Signal Control

Real-time traffic density information serves as the basis for dynamic signal timing adjustments. A threshold mechanism is applied to intelligently allocate more time to the road segment with a higher vehicle count, optimizing traffic light state changes and responding promptly to changing traffic conditions.

### 4.6 Iterative Optimization

The entire process operates in a continuous loop, allowing the system to adapt iteratively to evolving traffic conditions. This iterative optimization ensures that the traffic management system remains responsive, providing an effective and adaptive solution to alleviate congestion.

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### 4.7 Performance Metrics

To evaluate the system's effectiveness, performance metrics such as reduction in congestion percentage, average travel time, and overall traffic flow efficiency are measured. These metrics provide quantitative insights into the system's impact on traffic management.

By integrating these methodological components, our AI-powered traffic management system presents an innovative solution that leverages real-time data processing and adaptive signal control to address the challenges of traffic congestion, marking a significant advancement over traditional manual traffic control systems

## V. SYSTEM ANTIQUATION

### 5.1 Hardware

**PC & Cameras:** A PC is used as a central device for various image processing operations and Cameras to capture the video to execute the project.

### 5.2 Software

**Yolo Algorithm:** It is used in the entire processing for signal as well as image processing.

## VI. ADVANTAGES

- Heavy traffic jam reduced.
- Decreased the pollution.
- save human time which waste in traffic.
- Save fuel and money.

## VII. CONCLUSION

Video detection technology became a new frontier in case of vehicle tracking because of its dependability. Each area needs to be exclusively programmed and the RFID equipping and maintenance is somewhat costly. Unlike any other system, our system confirms high accuracy and we are confident about its success and feasibility. However, further research and development in this management system could bring that extra edge. So far we've made this system to ease the traffic law enforcement agencies. Knowing about the traffic pressure of the adjacent node would make the system more artificially intelligent. We hope these methods will be adopted as soon as possible so that the limitations we are experiencing with present method can be overcome.

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