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Intelligent Traffic Management System

Ms K Shireesha, Boddu Greeshmika Reddy, Nishtala Nayanasri
[1]Associate Professor, Department Of Cse, Bhoj Reddy Engineering College For Women, India.
[2,3]B. Tech Students, Department Of Cse, Bhoj Reddy Engineering College For Women, India.

ABSTRACT

Congestion in traffic is a major problem these days. Despite the fact that it appears to pervade all over, urban cities are the ones most influenced by it. And it's ever increasing nature makes it imperative to know the road traffic density in real time for better signal control and effective traffic management. There can be different causes of congestion in traffic like insufficient capacity, unrestrained demand, large Red Light delays etc. While insufficient capacity and unrestrained demand are somewhere interrelated, the delay of respective light is hard coded and not dependent on traffic. Therefore, the need for simulating and optimizing traffic control to better accommodate this increasing demand arises. In recent years, image processing and surveillance systems have been widely used in traffic management for traveller's information, ramp metering and updates in real time. The traffic density estimation can also be achieved using Image Processing. This project presents the method to use live images feed from the cameras at traffic junctions for real time traffic density calculation using image processing. It also focuses on the algorithm for switching the traffic lights according to vehicle density on road, thereby aiming at reducing the traffic congestion on roads which will help lower the number of accidents. In turn it will provide safe transit to people and reduce fuel consumption and waiting time. It will also provide significant data which will help in future road planning and analysis. In further stages multiple traffic lights can be synchronized with each other with an aim of even less traffic congestion and free flow of traffic. The vehicles are detected by the system through images instead of using electronic sensors embedded in the pavement. A camera will be placed alongside the traffic light. It will capture image sequences. Image processing is a better technique to control the state change of the traffic light. It shows that it can decrease the traffic congestion and avoids the time being wasted by a green light on an empty road. It is also more reliable in estimating vehicle presence because it uses actual traffic images. It visualizes the practicality, so it functions much better than those systems that rely on the detection of the vehicles' metal content

1-INTRODUCTION

Over the last decade, the adoption and use of technologies like Mobility, Cloud and Social Platforms has made it possible for common, middle class users to use small, focused applications for making their life easier and comfortable. Whether it is simply paying your utility bills using mobile banking or getting that favourite movie ticket by just clicking couple of buttons, use of technology has really changed the way we live, play and work. Though we have been referring to Smart Cities and communities for some time now, let us look at how use of Information and data available to us can be used to really create some smart services, which in a true sense provide us with better living. We shall look at a key case, which impacts us almost daily: traffic management. Use of technology and real time analysis can actually lead to a smooth traffic management. The common reason for traffic congestion is due to poor traffic prioritization, where there are such situations some lane has less traffic than the other. Vehicular congestion is increasing at an exponential rate. Let us take the case study of Chandigarh, one of the Union Territories of India. Chandigarh has the largest number of vehicles per capita in India. According to Chandigarh Transport Undertaking, more than 45,000 vehicles were registered this year in Chandigarh making the total count of more than 8 lakhs vehicles on the road. While the number of vehicles are increasing at a fast pace, the infrastructure in the city is not being able to match this growth. Traffic jams during rush hours are becoming a routine affair, especially in the internal sectors where long queues of vehicles can be seen stranded. Therefore, we have tried to address the problem with the help of our project wherein the focus would be to minimize the vehicular congestion. We have achieved this with the help of image processing that can be obtained from surveillance cameras and eventually to deploy a feedback mechanism in the working of the traffic lights where the density of the traffic would also be factored in the decision making process.

Existing System

Road transport is one of the primitive modes of transport in many parts of the world today. The number of vehicles using the road is increasing exponentially every day. Due to this reason, traffic congestion in urban areas is becoming unavoidable these days. Inefficient management of traffic causes wastage of invaluable time, pollution, wastage of fuel, cost of transportation and stress to

drivers, etc. Our research is on density based traffic control. So, it is very much necessary to design a system to avoid the above casualties thus preventing accidents, collisions, and traffic jams. Connecting Smart Traffic Management System of the city and using the power of analytics is a key to smooth traffic management. Using real time analytics of data from these sources and linking them to some trends, we can manage traffic flow much better. Almost all urban cities in the world use traffic light signals to control the traffic on the roads.

Proposed System

This system proposes an advanced approach for predicting traffic density through image processing using an AI module. A camera will be installed alongside the traffic light to capture image sequences, which are then analyzed using digital image processing techniques to detect vehicles and estimate traffic density based on real-time road conditions. The system utilizes YOLOv5 and the AlexNet V3 convolutional neural network pre-trained models to accurately detect the number of vehicles, calculate the average vehicle area, and identify emergency vehicles, enabling dynamic traffic signal adjustments and smart rerouting to reduce congestion and prioritize emergency response.

2-LITERATURE SURVEY

An excessive amount of research has been conducted to mitigate the problem of vehicular congestion.

[1] Khekare, G.S., Sakhare A.V. proposed the development of VANETs (Vehicular Ad Hoc Networks), which are the quintessential of the new types of networks emerging in the wireless technologies. The salient features of VANETs are to provide communication between vehicles themselves and between vehicles and road side units. VANET also plays an important role in concepts such as smart cities. The paper is based on a framework of a smart city that will transmit information about traffic conditions and will go a long way in aiding drivers to take spontaneous and smart decisions to prevent themselves from vehicular congestion which will ultimately help in reducing the overall congestion.

[2] Badura S., Lieskovsky A. presented a new model for intelligent traffic systems which will encapsulate the features of surveillance via the cameras present on the junction and with the help of data delivery systems let the users access that data. Image Analysis and foreground/background modeling schemes would be the important elements of Surveillance and data transmission over a mobile Ad-hoc network will comprise the data delivery part of the entire system. Various experiments have been conducted in the project and they exhibit great potential in terms of efficiency and real time execution.

[3] Salama A.S., Saleh B.K. and Eassa M.M. provide a design of an integrated intelligent system for management and controlling traffic lights with the help of Photoelectric Sensors. The installation of the sensors is a very important criterion in this system because the traffic management department has to monitor cars moving at a specific traffic and then to transfer this data to traffic control cabinet which can then control the traffic lights according to the sensor's readings by employing an algorithm based on the relative weight of each road.

3. METHODOLOGY

Functional Requirements

1. **Image Preprocessing Module**:
   Automatically processes input images using OpenCV functions when the program starts.
2. **Object Detection Module:**
   Detects vehicle edges in images and outputs a binary image showing detected objects.
3. **Vehicle Count Module:**
   Compares real-time lane images with a reference (empty road) image to count vehicles and assess traffic density.
4. **Light Control Module:**
   Controls traffic lights based on vehicle density:
   - 0–10% match: Green light for 90 seconds
   - 10–50% match: Green light for 60 seconds
   - 50–70% match: Green light for 30 seconds

Non-Functional requirements

- **Performance:** Real-time response with minimal delay (<1 second).
- **Scalability:** Able to handle more vehicles and areas as the city grows.
- **Reliability:** System should work continuously with high uptime (99.9%).
- **Availability:** 24/7 system operation, especially during peak hours.
- **Security:** Encrypted data transmission and restricted access.
- **Maintainability:** Easy to update and debug without full system disruption.
- **Usability:** Simple, user-friendly interface for operators and users.
- **Interoperability:** Compatible with various GPS devices and traffic systems.
- **Accuracy:** Consistent and precise real-time vehicle tracking.
- **Compliance:** Follows government rules and traffic data standards.

Hardware Requirements

- HardDisk: Greater than 120 GB
- RAM: Greater than 4 GB
- Processor: Intel I3 and above

Software Requirements

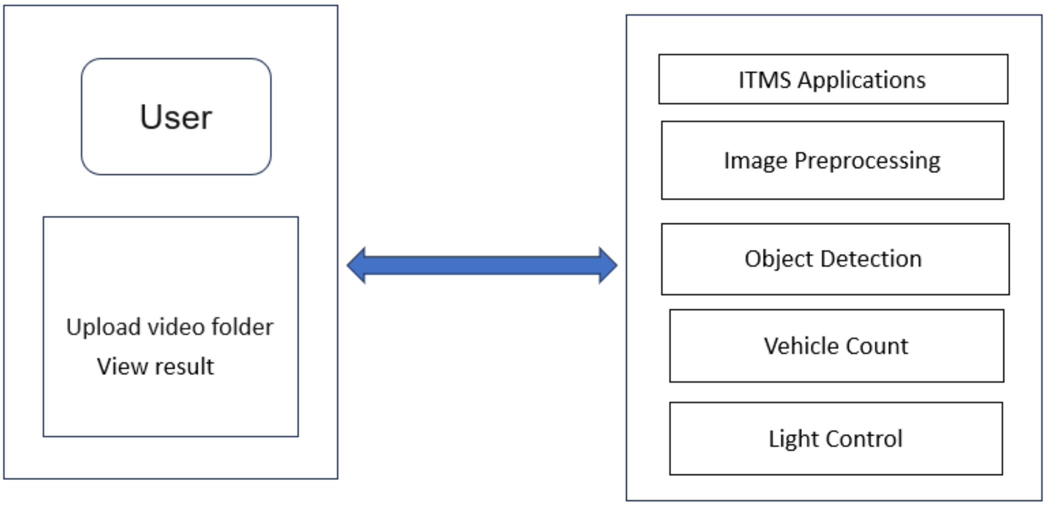
- Front End – Anaconda IDE
- Language – Python 3.7

4-DESIGN

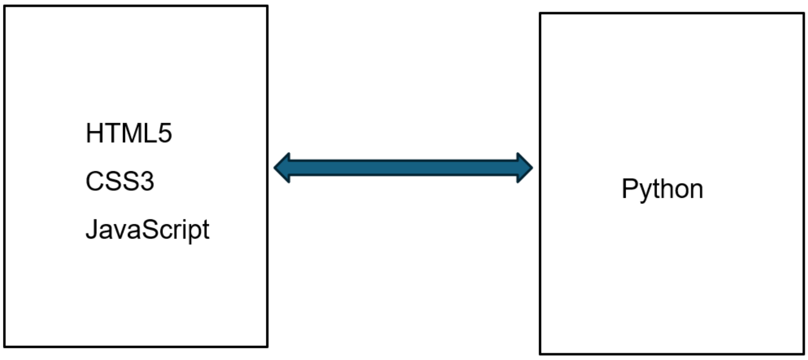
Architecture

Architecture of this project is designed to ensure seamless interaction between the user interface, data processing, and predictive algorithms. It incorporates modular components for better scalability, maintainability, and performance. Architecture is of two types. They are

Software Architecture



Technical Architecture



Design

The intelligent traffic management system starts by collecting real-time video feeds from cameras installed at road intersections. These video streams provide visual traffic data that is processed using computer vision techniques. To detect and track vehicles, the system uses a pre-trained object detection model like YOLO, which extracts spatial features from each frame and identifies different types of vehicles. This traffic data is then used to dynamically adjust signal timings. Lanes with higher congestion are allotted longer green light durations, while less congested lanes receive shorter intervals. If an emergency vehicle is detected, the system immediately overrides normal timing and grants priority to the corresponding lane.A graphical interface, developed using Tkinter, displays real-time data such as live traffic views, current signal states, detected emergency vehicles, and timing changes. The system is trained to continuously learn and adapt, improving efficiency over time. The final model ensures better traffic flow, reduced congestion, and faster emergency response by combining AI-based perception with intelligent signal control.

Data flow diagram

Data Flow Diagram (DFD) represents the flow of data within information systems. It provides a graphical representation of the data flow of a system that can be understood by both technical and non-technical users. The models enable software engineers, customers, and users to work together effectively during the analysis and specification of requirements.

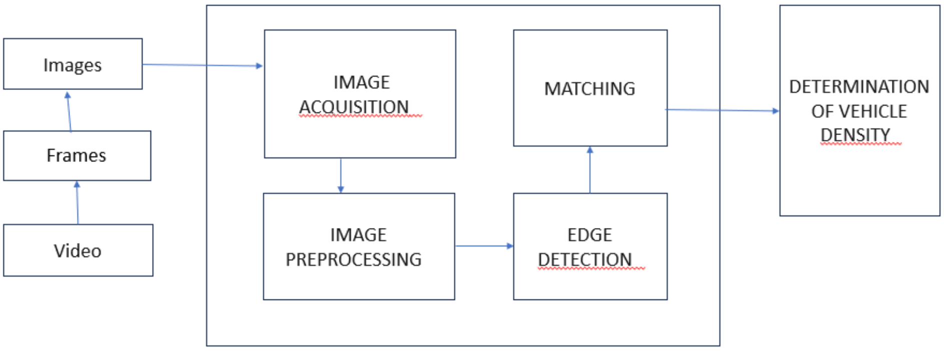


Fig 5.1.1 Data flow diagram

Algorithms

It involves description of the algorithm used.

YOLOv5 is primarily designed for object detection, meaning it identifies and locates objects within an image, while Earlier AlexNet focuses on image classification, meaning it identifies the overall category of an image; YOLOv5 is generally considered a more modern and efficient model, especially for real-time object detection tasks, compared to the older AlexNet architecture.It is a state-of-the-art, single-stage object detection algorithm renowned for its speed and accuracy. It's particularly well-suited for real-time applications like intelligent traffic systems where processing speed is crucial Steps include:

1.Input image and grid division:

The input video frame from the traffic camera is fed into the YOLOv5 network. The image is divided into an S*S grid of cells. Each grid cell becomes responsible for detecting objects whose center falls within its boundaries.

2.Convolutional Feature Extraction (Backbone):

YOLOv5 utilizes a deep convolutional neural network (CNN) backbone (e.g., CSPDarknet53) to extract a rich set of hierarchical features from the input image. These convolutional layers learn to identify various visual patterns, from basic edges and textures in the early layers to more complex object parts and shapes in the deeper layers.

3. Feature Aggregation (Neck):

A "neck" network (e.g., PANet, BiFPN) is employed to collect and fuse feature maps from different stages of the backbone.This helps the network to see objects at various scales and improve the accuracy of detection, especially for objects of different sizes in the traffic scene (e.g., small cars, large trucks).

4.Prediction Head

The "head" of the network makes the final predictions. For each grid cell, it predicts:

- **Bounding Boxes:** Multiple bounding boxes are predicted per grid cell. Each bounding box is defined by its center coordinates (x, y), width(w), and height(h) relative to the grid cell.

- **Objectness Score:** A confidence score for each bounding box, indicating the probability that the box contains an object (any vehicle). This score also reflects the model's confidence in the accuracy of the bounding box.
- **Class Probabilities:** A set of conditional class probabilities for each bounding box, representing the likelihood of the detected object belonging to each predefined class (e.g., car, truck, bus, bike). These probabilities are conditional on an object being present in the bounding box.

5.Anchor Boxes

YOLOv5 uses predefined anchor boxes (prior boxes with specific shapes and sizes) to aid in predicting the dimensions of the bounding boxes. The network learns to adjust these anchor boxes to better fit the detected objects.

6. Loss Function and Training

During training, the network learns to minimize a loss function that measures the difference between its predictions and the ground truth annotations (manually labeled vehicles in training images). The loss function considers errors in bounding box coordinates, objectness scores, and class probabilities.

7.Non-Max Suppression:

Non-Max Suppression is a post-processing technique that filters out these redundant boxes based on their confidence scores and the degree of overlap (Intersection over Union - IoU). It keeps the box with the highest confidence and discards highly overlapping boxes with lower confidence.

5.RESULTS

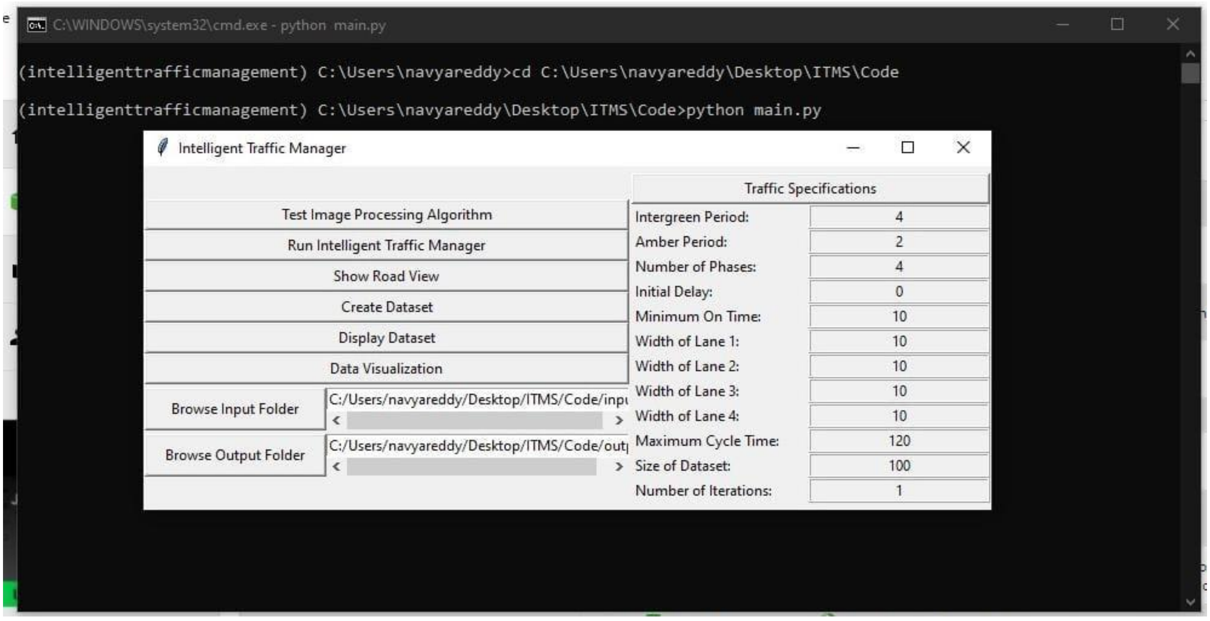
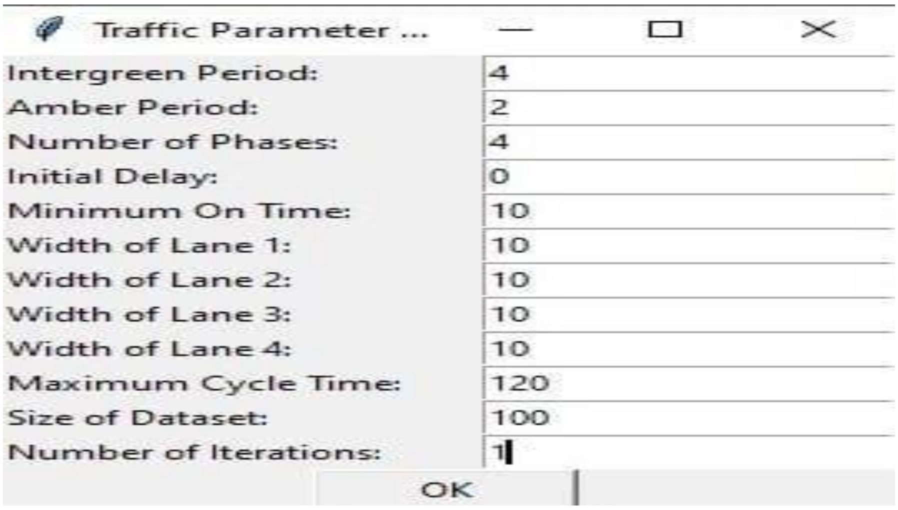
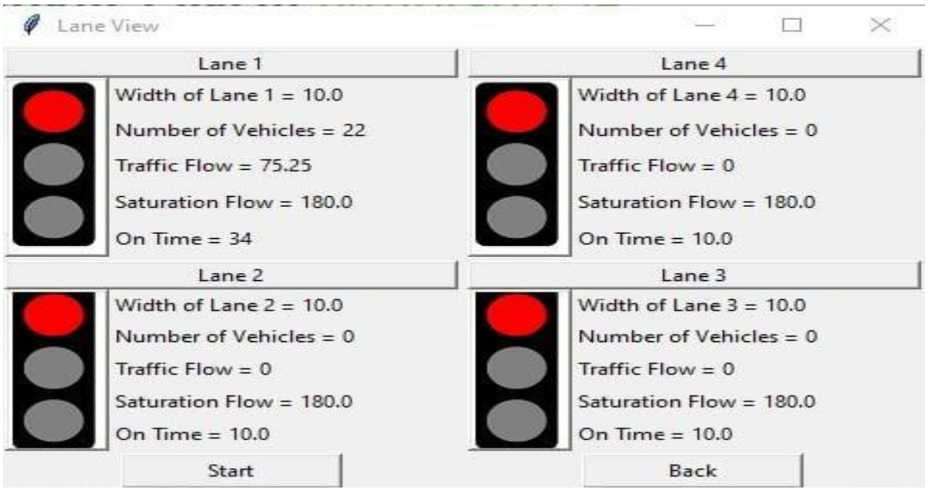


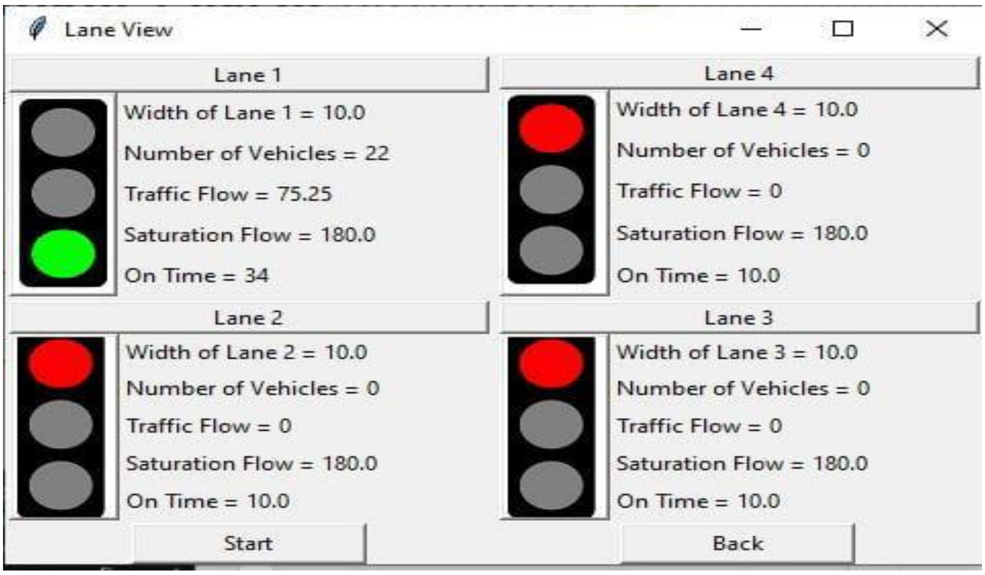
Fig 5.1 Running main.py file



5.1.1 Traffic Specifications



5.1.2 Initial signal



4.1.3 Green signal for the heavy traffic lane

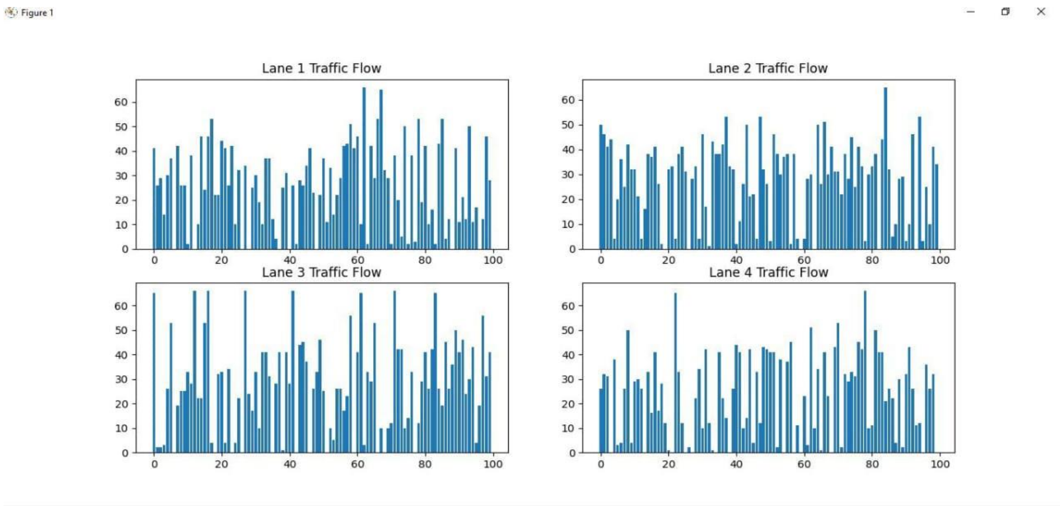
4.1.4 Similarly for the other lanes

5.1.5 Vehicle Detection

Save | Back

Number of Vehicles in Lane 1	Number of Vehicles in Lane 2	Number of Vehicles in Lane 3	Number of Vehicles in Lane 4	ane 1 Traffic Flov
0	18	24	9	0.0
12	1	0	24	25.25
26	4	37	17	41.5
26	12	17	5	41.5
4	1	0	24	4.0
18	2	0	14	28.75
22	4	24	16	32.58
9	5	18	0	12.5
38	0	12	38	51.25
7	27	24	21	11.0
24	0	18	12	32.25
4	0	26	26	5.5
3	18	7	24	3.0
42	16	37	38	65.0
25	30	9	24	42.5
2	16	24	42	2.75
25	12	25	0	36.0
4	17	0	16	4.0
12	9	4	38	19.5
16	9	1	24	20.5
10	16	12	4	14.25
0	9	33	12	0.0
26	12	16	24	29.41
30	3	19	9	43.75
9	4	17	38	12.5
38	30	0	29	51.25
27	14	12	27	34.25
16	7	25	16	20.5

5.1.6 Create DataSet



4.1.7 Visual traffic Flow of all Lanes

6- CONCLUSION

This project tries to introduce a new method for traffic Estimation based on vehicle density, which is found to be very efficient method.

As opposed to digital image processing using bulky computers, this method use AI module, a microcomputer for image processing which greatly reduces the space and processing time.

To determine traffic density different object detection techniques can be used.

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