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Smart Control of Traffic Light Using Artificial Intelligence

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ABSTRACT:

Traffic congestion is becoming one of the critical issues with increasing population and automobiles in cities. Traffic jams not only cause extra delay and stress for the drivers, but also increase fuel consumption and air pollution. Although it seems to pervade everywhere, megacities are the ones most affected by it. And its ever-increasing nature makes it necessary to calculate the road traffic density in real-time for better signal control and effective traffic management. The traffic controller is one of the critical factors affecting traffic flow. Therefore, the need for optimizing traffic control to better accommodate this increasing demand arises. Our proposed system aims to utilize live images from the cameras at traffic junctions for traffic density calculation using image processing and AI. It also focuses on the algorithm for switching the traffic lights based on the vehicle density to reduce congestion, thereby providing faster transit to people and reducing pollution.

Index Terms: Traffic Congestion, Real-time Traffic Density Calculation, Image Processing, Artificial Intelligence, Traffic Management, Signal Control, Pollution Reduction.

1. INTRODUCTION

With the increasing number of vehicles in urban areas, many road networks are facing problems with the capacity drop of roads and the corresponding Level of Service. Many traffic-related issues occur because of traffic control systems on intersections that use fixed signal timers. They repeat the same phase sequence and its duration with no changes. Increased demand for road capacity also increases the need for new solutions for traffic control that can be found in the field of Intelligent Transport Systems. Let us take the case study of Mumbai and Bangalore. Traffic flow in Bangalore is the worst in the world while Mumbai is close behind in fourth position, according to a report detailing the traffic situation in 416 cities across 57 countries. In Bangalore, a journey during rush-hour takes 71% longer. In Mumbai, it is 65% longer.

1.1 CLASSIFICATION

Classification is a technique where we categorize data into a given number of classes. The main goal of a classification problem is to identify the category/class to which a new data will fall under. Image Classification is the task of assigning an input image one label from a fixed set of categories. This is one of the core problems in Computer Vision that, despite itssimplicity,hasalargevarietyofpracticalapplications.ManyotherseeminglydistinctComputer Vision tasks (such as object detection, segmentation) can be reduced to image classification.

1.2 CLASSIFICATIONALGORITHMS

Object Recognition is a technology that lies under the broader domain of Computer Vision. This technology is capable of identifying objects that exist in images and videos and tracking them. Object Recognition also known as Object Detection, has various applications like face recognition, vehicle recognition, pedestrian counting, self-driving vehicles, security systems, and a lot more. The two significant objectives of object recognition involve: Identification of all objects that exist in an image Filtration of the object that seeks attention In the following tutorial, we will understand how to perform Object Recognition in the Python programming language using the ImageAI library. We will create a basic object recognition model using the ImageAI library in Python by the end of this tutorial.

1.3 MACHINE LEARNING

Machine learning is a growing technology which enables computers to learn automatically from past data. Machine learning uses various algorithms for building mathematical models and making predictions using historical data or information. Currently, it is being used for various tasks such as image recognition, speech recognition, email filtering, Facebook auto-tagging, recommender system, and many more. Machine Learning is said as a subset of artificial intelligence that is mainly concerned with the development of algorithms which allow a computer to learn from the data and past experiences on their own.

Advantages of Machine Learning:

Machine learning is a field of computer science and artificial intelligence that deals with the task of teaching computers to learn from

data without being explicitly programmed. It is a type of data mining that allows computers to "learn" on their own by analyzing data sets and using pattern recognition. Machine learning has many benefits, including improved accuracy, efficiency, and decision-making.

Handling large amounts of data: With the ever-growing volume of data generated every day, it is increasingly difficult for humans to process and make sense of all this information. Machine learning can help businesses handle large amounts of data more efficiently and effectively and even use decision trees to take action on the information.

Reducing bias: Machine learning algorithms are not biased toward certain data sets, unlike human beings, who may have personal biases that can distort their judgment. As a result, machine learning can help reduce bias in business decisions.

Improving accuracy: Machine learning algorithms can achieve much higher accuracy than humans when making predictions or classifying labeled data. This improved accuracy can lead to better business outcomes and increased profits.

Discovering patterns and correlations: Machine learning can help businesses uncover patterns and correlations in data that they may not have been able to detect otherwise. These learning systems can lead to better decision-making and a deeper understanding of the data.

Making predictions about future events: Machine learning algorithms can predict future events, such as consumer behavior, stock prices, and election outcomes.

1.4APPLICATIONS OF MACHINE LEARNING

Image Recognition

Image recognition is one of the most common applications of machine learning. It is used to identify objects, persons, places, digital images, etc. The popular use case of image recognition and face detection is,

Automatic friend tagging suggestion: Facebook provides us a feature of auto friend tagging suggestion. Whenever we upload a photo with our Facebook friends, then we automatically get a tagging suggestion with name, and the technology behind this is machine learning's face detection and recognition algorithm. It is based on the Facebook project named "Deep Face," which is responsible for face recognition and person identification in the picture.

Speech Recognition:

While using Google, we get an option of "Search by voice," it comes under speech recognition, and it's a popular application of machine learning. Speech recognition is a process of converting voice instructions into text, and it is also known as "Speech to text", or "Computer speech recognition." At present, machine learning algorithms are widely used by various applications of speech recognition. Google assistant, Siri, Cortana, and Alexa are using speech recognition technology to follow the voice instructions.

Traffic Prediction:

If we want to visit a new place, we take help of Google Maps, which shows us the correct path with the shortest route and predicts the traffic conditions. It predicts the traffic conditions such as whether traffic is cleared, slow-moving, or heavily congested with the help of two ways:

1.Real Time location of the vehicle form Google Map app and sensors

2.Average time has taken on past days at the same time.

Product Recommendations

Machine learning is widely used by various e-commerce and entertainment companies such as Amazon, Netflix, etc., for product recommendation to the user. Whenever we search for some product on Amazon, then we started getting an advertisement for the same product while internet surfing on the same browser and this is because of machine learning.

1.5 DEEP LEARNING

Deep learning technology is based on artificial neural networks (ANNs). These ANNs constantly receive learning algorithms and continuously growing amounts of data to increase the efficiency of

training processes. The larger data volumes are, the more efficient this process is. The training process is called deep, because, with the time passing, a neural network covers a growing number of levels.The deeper this network penetrates, the higher it productivity. DL algorithms can create new tasks to solve current ones.

Advantages of Deep Learning

Creating New Features One of the main benefits of deep learning over various machine learning algorithms is its ability to generate new features from a limited series of features located in the training dataset. Therefore, deep learning algorithms can create new tasks to solve current ones.

What does it mean for data scientists working in technological startups? Since deep learning can create features without human intervention, data scientists can save much time on working with big data and relying on this technology. It allows them to use more complex sets of features in comparison with traditional machine learning software.

Advanced Analysis

Due to its improved data processing models, deep learning generates actionable results when solving data science tasks. While machine learning works only with labeled data, deep learning supports unsupervised learning techniques that allow the system to become smarter on its own. The capacity to determine the most important features allows deep learning to efficiently provide data scientists with concise and reliable analysis results.

1.6 APPLICATIONS OF DEEPLEARNING

Automatic Speech Recognition

Large-scale automatic speech recognition is the first and most convincing successful case of deep learning. LSTM RNNs can learn "Very Deep Learning" tasks that involve multi-second intervals containing speech events separated by thousands of discrete time steps, where one time step corresponds to about 10 milliseconds. LSTM with forget gates is competitive with traditional speech recognizers on certain tasks.

The initial success in speech recognition was based on small-scale recognition tasks using the TIMIT dataset. The dataset contains 630 speakers from eight major dialects of American English, with each speaker reading 10 sentences. Its small size allows many configurations to be tried. More importantly, the TIMIT task concerns phone-sequence recognition, which, unlike word-sequence recognition, allows weak phone bigram language models. This lets the

strength of the acoustic modeling aspects of speech recognition be more easily analyzed.

Image Recognition

A common evaluation set for image classification is the MNIST database. MNIST is composed of handwritten digits and includes 60,000 training examples and 10,000 test examples. As with TIMIT, its small size allows users to test multiple configurations. A comprehensive list of results on this set is available. Deep learning-based image recognition has become "superhuman," producing more accurate results than human contestants. This first occurred in 2011.

Military

The United States Department of Defense applied deep learning to train robots in new tasks through observation.

Bioinformatics

An autoencoder ANN was used in bioinformatics to predict gene ontology annotations and gene-function relationships. In medical informatics, deep learning was used to predict sleep quality based on data from wearables and to predict health complications from electronic health record data.

Self-Driving Cars

Deep learning is the force that is bringing autonomous driving to life. Millions of data sets are fed to a system to build a model, train the machines to learn, and then test the results in a safe environment. Data from cameras, sensors, and geo-mapping is helping create succinct and sophisticated models to navigate through traffic, identify paths, signage, pedestrian-only routes, and real-time elements like traffic volume and road blockages.

Fraud Detection

Another domain benefitting from deep learning is the banking and financial sector, which is plagued with the task of fraud detection with money transactions going digital. Autoencoders in Keras and TensorFlow are being developed to detect credit card frauds, saving billions of dollars in recovery and insurance costs for financial institutions. Fraud prevention and detection are done by identifying patterns in customer transactions and credit scores, identifying anomalous behavior and outliers.

CNN Architectures

Convolutional Neural Networks (CNNs)

Convolutional Neural Networks (CNNs, or ConvNets) are a special kind of multi-layer neural network designed to recognize visual patterns directly from pixel images with minimal pre-processing.

Advantages of CNN:

- Once trained, the predictions are pretty fast.
- CNNs can train with any number of inputs and layers.
- Neural networks work best with more data points.
- They are powerful models for classification.

Disadvantages of CNN:

- High computational cost.
- They require a lot of training data.

VGGNet

VGGNet consists of 16 convolutional layers and is very appealing because of its uniform architecture. Similar to AlexNet, it uses only 3x3 convolutions but with lots of filters. Trained on 4 GPUs for 2-3 weeks, it is currently the most preferred choice in the community for extracting features from images. The weight configuration of VGGNet is publicly available and has been used in many other applications and challenges as a baseline feature extractor. VGGNet, which stands for Visual Geometry Group, performed very well in the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2014, scoring first place on the image localization task and second place on the image classification task.

VGG-19

VGG-19 is a convolutional neural network architecture developed by the Visual Geometry Group (VGG) at the University of Oxford. It is a deep neural network with 19 layers, introduced as part of the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2014. VGG-19's deep architecture allows for a more expressive representation of image features and it is trained on the ImageNet dataset, consisting of millions of labeled images from thousands of categories.

Inception v3 Algorithm

Inception-v3 is a convolutional neural network architecture developed by Google for image recognition and classification tasks. It is an improvement over the original Inception model, designed to be deeper and more powerful than previous CNNs. It consists of 48 layers, including

convolutional layers, pooling layers, and fully connected layers. Inception-v3 also includes several unique features, such as the Inception module, which reduces the number of parameters in the model, helping to reduce overfitting and improve performance.

Applications of CNN

Image Recognition

CNNs are often used in image recognition systems. In 2012, an error rate of 0.23% on the MNIST database was reported. Another paper on using CNN for image classification reported that the learning process was "surprisingly fast." In the same paper, the best-published results as of 2011 were achieved in the MNIST and NORB databases. Subsequently, a similar CNN called AlexNet won the ImageNet Large Scale Visual Recognition Challenge in 2012. Image recognition, in the context of machine vision, is the ability of software to identify objects, places, people, writing, and actions in images. Computers can use machine vision technologies in combination with a camera and artificial intelligence software to achieve image recognition.

Video Analysis

Compared to image data domains, there is relatively little work on applying CNNs to video classification. Video is more complex than images since it has another (temporal) dimension. However, some extensions of CNNs into the video domain have been explored. One approach is to treat space and time as equivalent dimensions of the input and perform convolutions in both time and space. Another way is to fuse the features of two convolutional neural networks, one for the spatial and one for the temporal stream. Long short-term memory (LSTM) recurrent units are typically incorporated after the CNN to account for inter-frame or inter-clip dependencies. Unsupervised learning schemes for training spatial-temporal features have been introduced, based on Convolutional Gated Restricted Boltzmann.

Historic and Environmental Collections

CNNs are used for more complex purposes such as natural history collections, documenting major parts of history such as biodiversity, evolution, habitat loss, biological invasion, and climate change.

Understanding Climate

CNNs can help understand the reasons behind drastic climate changes and

experiment with curbing the effects. Data in natural history collections can provide greater social and scientific insights, but this requires skilled human resources such as researchers to physically visit these types of repositories.

Decoding Facial Recognition

Facial recognition is broken down by a convolutional neural network into the following major components:

- Identifying every face in the picture.
- Focusing on each face despite external factors such as light, angle, pose, etc.
- Identifying unique features.
- Comparing all the collected data with existing data in the database to match a face with a name. A similar process is followed for scene labeling as well.

Analyzing Documents

Convolutional neural networks can also be used for document analysis, which is useful not only for handwriting analysis but also for recognizers. For a machine to scan an individual's writing and compare it to a wide database, it must execute almost a million commands a minute. The use of CNNs and newer models and algorithms has brought the error rate down to a minimum of 0.4% at the character level, though complete testing is yet to be widely seen.

2.LITERATURE SURVEY

Title: Smart Control of Traffic Light System using Image Processing

Authors: Khushi

Abstract: The congestion of urban traffic is becoming a critical issue with increasing population and automobiles in cities. Traffic jams not only cause extra delay and stress for drivers but also increase fuel consumption, transportation costs, and carbon dioxide air pollution. The traffic controller is a critical factor affecting traffic flow. Conventional traffic patterns are nonlinear, complex, and time-dependent rather than traffic-dependent. This paper proposes a traffic control system based on image processing using MATLAB code, which changes the time of green, amber, and red lights with respect to traffic density and traffic count. Two Arduino UNOs are used, one for controlling green and amber lights and the other for controlling red lights. This is a continuous process.

3.EXISTING SYSTEM

In the first method, VANETs are used to get information and the location of every

vehicle, which is passed on to the nearest Intelligent Traffic Light (ITL) with the help of installed GPS. These ITLs update the statistics and send them to nearby vehicles. In case of accidents, information is sent to drivers to choose an alternate route to avoid congestion. However, this technique is not feasible as its deployment is expensive.

In the second method, infrared sensor-based microcontrollers capture the unique ID of every car using a transmitter and receiver. In case of an emergency, vehicle radio frequency tags can identify them and let other vehicles move. This method detects red light violations. However, this technique is not flexible as infrared sensors need to be in sight.

3.2 Limitations of Existing Methods

In the third method, the fuzzy logic technique uses two fuzzy logic controllers: one to optimize the signal and the other to extend the green phase of a road at an intersection. Sensors collect input data through video cameras placed at incoming and outgoing lines. The controller utilizes the information collected through these sensors to make optimal decisions and minimize the goal function.

In the fourth method, fuzzy logic takes the number of vehicles and the average speed of traffic flow in each direction as input parameters. The number of vehicles and the average speed of traffic flow can be determined using sensors placed on the road.

4.PROPOSED METHOD

4.1Proposed System

To manage increasing vehicle numbers efficiently and reduce journey duration and petrol consumption, standard techniques such as manual traffic control, static time traffic control, and sensor-based traffic management have limitations. This paper proposes utilizing traffic cameras and YOLO object detection algorithms to estimate traffic density at all lanes and then adjust red and green signal times accordingly. Cameras take snapshots of all lanes every five seconds, estimate traffic at lanes, and adjust signal times based on density.

4.1.1 Proposed Methodology

The number of vehicles of each class (car, bike, bus, truck) is detected to calculate traffic density. The signal switching algorithm uses this density, among other factors, to set the green signal timer for each lane. The red signal times are updated accordingly. The green signal time is restricted to a maximum and minimum value

to avoid the starvation of a particular lane. A simulation is developed to demonstrate the system's effectiveness and compare it with the existing static system.

5.SYSTEM DESIGN

5.1 SYSTEM ARCHITECTURE :

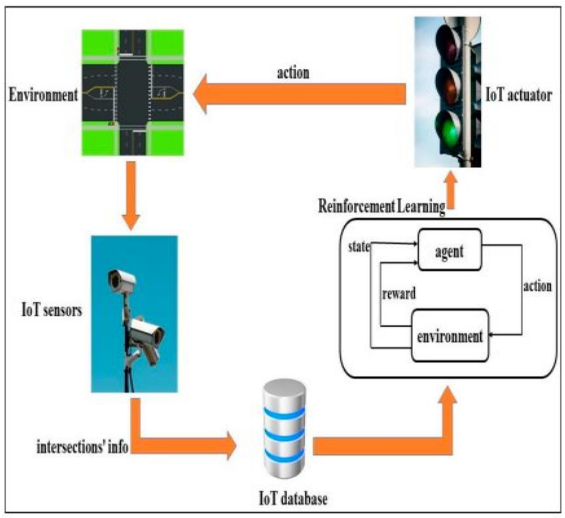

Figure .1 System Architecture

5.2 Data Flow Diagram

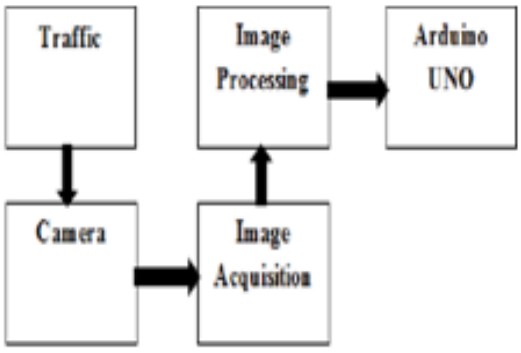

Figure .2 Data Flow Diagram

6.RESULTS

To run project double click on 'run.bat' file to get below output

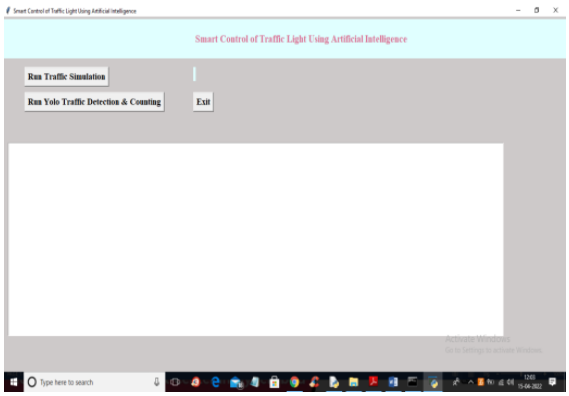

Figure .3 Application Screen

In above screen click on 'Run Traffic Simulation' button to start PYGAME simulation and get below output

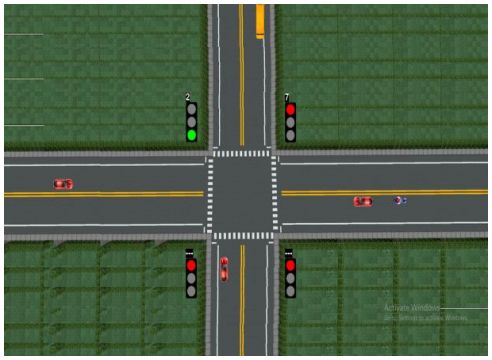

Figure .4 Traffic Simulation Screen

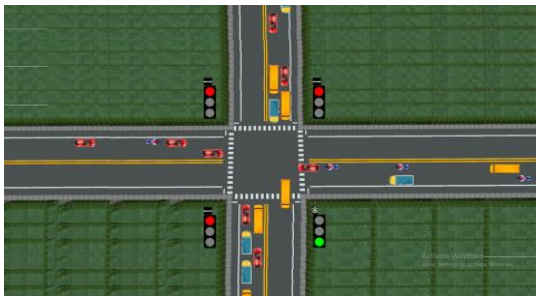

Figure .5 Traffic Simulation Screen

In above screen you can see PYGAME simulation output and at each lane traffic density is calculated and then adjust green and red line. This simulation run in INFINITE loop so you press 'windows' key from keyboard and then close application and then restart and run second YOLO module

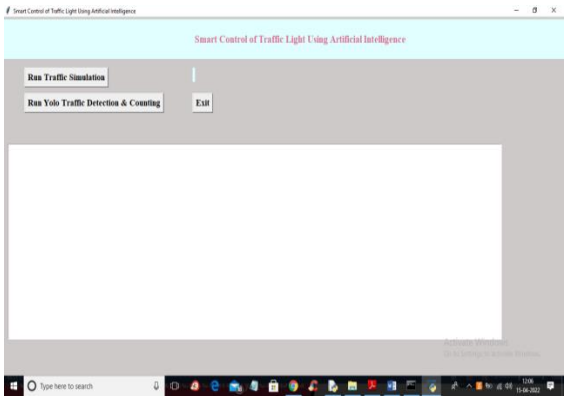

Figure .6 Yolo Screen

Now in above screen click on 'Run Yolo Traffic Detection & Counting' button to upload traffic video and then estimate traffic density

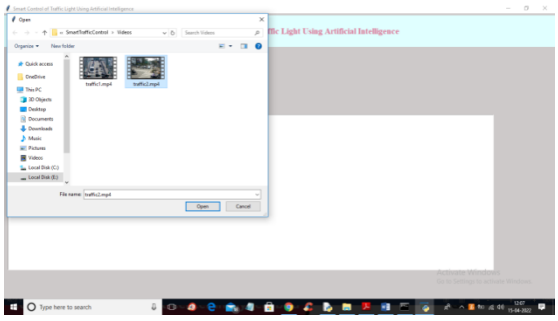

Figure .7 Uploading Screen

In above screen selecting and uploading 'traffic2.mp4' video and then click on 'Open' button to get below output

Figure .8 Detecting Traffic Screen

In above screen detecting traffic and then estimating its count and based on that traffic time will be adjusted. YOLO runs very slowly in normal laptop so let it finish all frame processing then u will get output.mp4 file which you can play as normal video with traffic density.

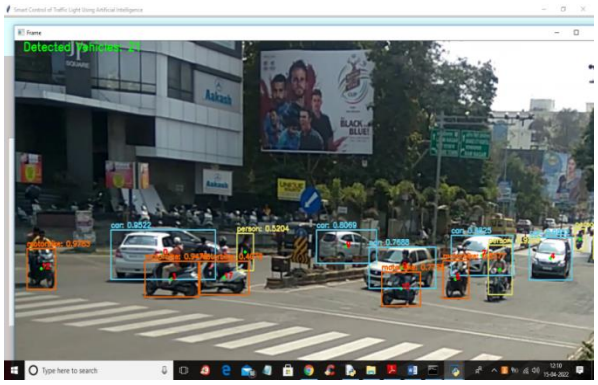

Figure .9 Detecting Traffic Screen

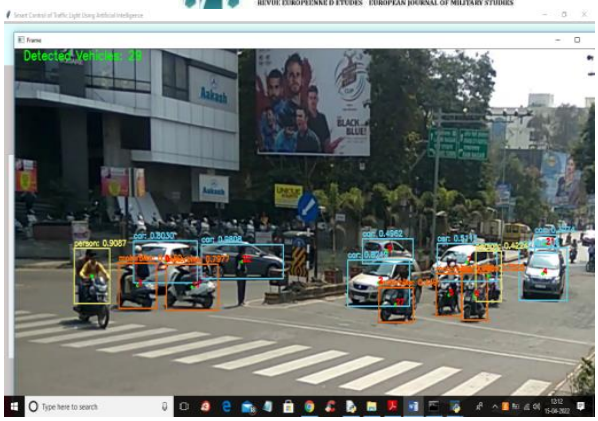

Figure .10 Detecting Traffic Screen

Figure .11 Detecting Traffic Screen

7. CONCLUSION

In conclusion, the proposed system sets the green signal time adaptively according to the traffic density at the signal and ensures that the direction with more traffic is allotted a green signal for a longer duration of time as compared to the direction with lesser traffic. This will lower the unwanted delays and reduce congestion and waiting time, which in turn will reduce fuel consumption and pollution. According to simulation results, the system shows about 23% improvement over the current system in terms of the number of vehicles crossing the intersection, which is a significant improvement. With further calibration using real- life CCTV data for training the model, this system can be improved to perform even better.

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