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Proceeding Paper

Traffic Management System Using YOLO Algorithm †

Pankaj Kunekar , Yogita Narule, Richa Mahajan, Shantanu Mandlapure, Eshan Mehendale * and Yashashri Meshram

Vishwakarma Institute of Technology, Savitribai Phule Pune University, Pune 411037, Maharashtra, India; pankaj.kunekar@vit.edu (P.K.); yogita.narule@vit.edu (Y.N.); richa.mahajan21@vit.edu (R.M.); shantanu.mandlapure21@vit.edu (S.M.); yashashri.meshram21@vit.edu (Y.M.)

* Correspondence: eshan.mehendale21@vit.edu

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Abstract: The issue of traffic congestion is becoming worse day by day. The typical traffic lights are unable to effectively regulate the growing number of vehicular traffic; therefore, we mixed computer vision and machine learning to mimic complicated incoming traffic at signalized intersections. This was accomplished using the cutting-edge, real-time object detection system You Only Look Once (YOLO), which is built on deep convolutional neural networks. In order to maximize the number of vehicles that can cross safely with the least amount of waiting time, this paper presents an efficient method to use this algorithm, where traffic signal phases are based on the data obtained, primarily queue density and waiting time per vehicle. Embedded controllers that adopt the transfer learning methodology can implement YOLO.

Keywords: computer vision; machine learning; neural network; traffic density; waiting time

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1. Introduction

Nearly all facets of contemporary systems and their basics involve technology. Automation is therefore now necessary rather than just a luxury. The typical person in today's world sits in traffic for at least 8 to 10 days annually. This necessitates a significant amount of time that could be spent productively working and adding to fuel consumption, which is a huge problem right now. Several cities struggle with congestion, and stationary traffic light signal controllers are not capable of reducing the lengthy wait times at crossings. Rather than a traffic light, we have often seen a police officer controlling traffic who inspects the road conditions and calculates the authorized length for every route. This feat of sentient accomplishment motivates us to create smart traffic signal control that proactively handles intersections while taking into consideration current traffic circumstances. To put such a framework in place, two basic components are required: a gaze ahead to monitor virtual traffic conditions as well as a processing mind. The top priorities of a traffic signal system are to move as many vehicles through a junction as possible while minimizing traffic congestion. An instantaneous object recognition called YOLO version 7 (You Only Look Once) accurately recognizes specific things in images, streaming broadcasts, and videos. YOLOv7 employs properties that a deep convolutional neural network has learned to identify the objects and recognize them. After handling the input images and neural network, the resulting software will be activated by attaching the neural network to the hardware.

2. Literature Review and Methodology

2.1. Literature Review

For the purpose of determining the viability of our proposal and exploring the various ways it might be carried out, we read a considerable number of research articles. We gained knowledge from these papers, which helped us clearly define our project's vision and scheme of action. There are numerous ways to execute this project, but in order to do so, one needs to be knowledgeable in a variety of areas, including Python, image processing, computer vision, and machine learning. While browsing through numerous blogs, we found many that provided detailed explanations of how Yolo functions and how to use it in projects. We consulted this paper to gain a sense of how it might be carried out; it is advised to count and detect automobiles in a chaotic traffic situation [1]. Having read the research stating that deep learning-based methods are useful for visual vehicle recognition and counting in highway scenarios [2], we were able to better understand the YOLO algorithm. This research investigated how to compute an automobile's highway pace whilst attempting to avoid speeding charges. The same idea can be used to ensure that all the traffic laws are observed in order to stay safe on a typical city street. We determined which YOLO paradigm should be employed for enabling image processing after analyzing these and other works. To acquire a general understanding of how to estimate traffic variables, we referred to [3], an article explaining " YOLOv3 with deep learning techniques for Automated Moving-based Analysis of Location Information Vehicle Spectator Method" [4]. The proposed system aims to count the number of vehicles passing through a given road segment using real-time video analysis, which gave us good insight into how to calculate the number of vehicles in a specific section. Also, the research paper [5] showed that the proposed system using the YOLO algorithm for real-time vehicle counting, speed estimation, and classification achieved high accuracy and real-time performance, outperforming the existing methods in terms of both detection and classification accuracy, as well as speed estimation precision.

2.2. Methodology

I. Workflow of the process:

Below Figure 1 shows Traffic estimation workflow of YOLOv7 model. So, first of all, an image input or video input will be given to the program in the microcontroller through a camera present at the junction. Then, the traffic density will be calculated using the algorithm, including the number of vehicles and the type of vehicle present, like a car, a bike, or a truck. Identifying the type of vehicle helps determine its speed and the time it takes to cross the road. There are four straightforward stages capable of illustrating the results, which are as follows:

1. Choose a live picture of every track.
2. Evaluate and estimate the traffic pattern.
3. Put this information in the timer calculation algorithm.
4. The result is going to recommend the intervals on every track and side appropriately.

YOLO Object Detection Path

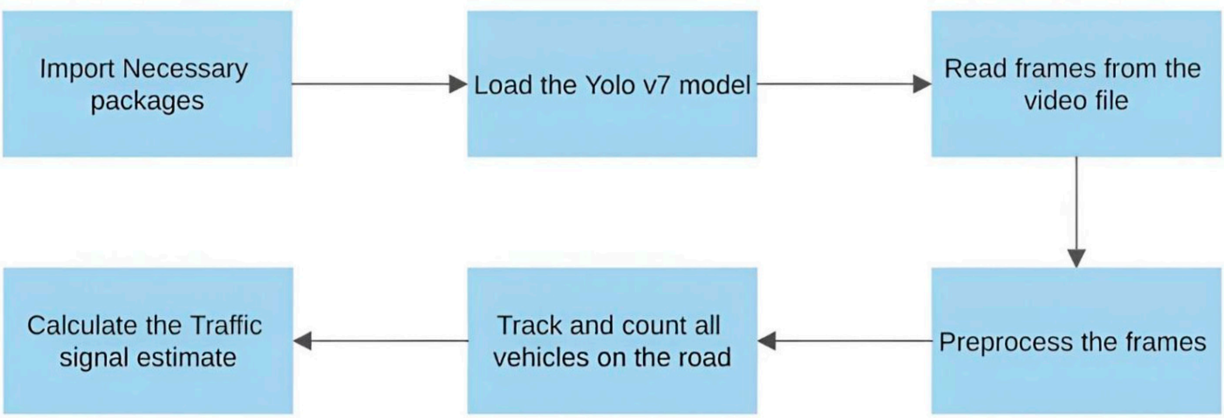

Figure 1. Traffic estimation workflow.

II. Theory Algorithm:

YOLO version 7 is the quickest and most precise context of the physical tracking system and identification framework for digital imaging workloads. Chien-Yao Wang, Alexey Bochkovskiy, and Hong-Yuan Mark Liao published the official YOLOv7 paper, "YOLOv7: Trainable bag-of-freebies sets new state-of-the-art for real-time object detectors", in July 2022. YOLO version 7 is a fundamental model that lends itself to conventional GPU computing the fastest. The YOLOv7-tiny model is a straightforward one, and its edge GPU is optimized. Tiny computer vision models are easier to execute on dispersed edge servers and devices, or mobile computing devices. Additionally, they are optimized for deep learning and edge AI applications. This strategy is essential for networked real-world computer vision applications. YOLOv7-W6 is a foundational model designed for cloud GPU computation. Figure 2 here demonstrates YOLOv7 architecture.

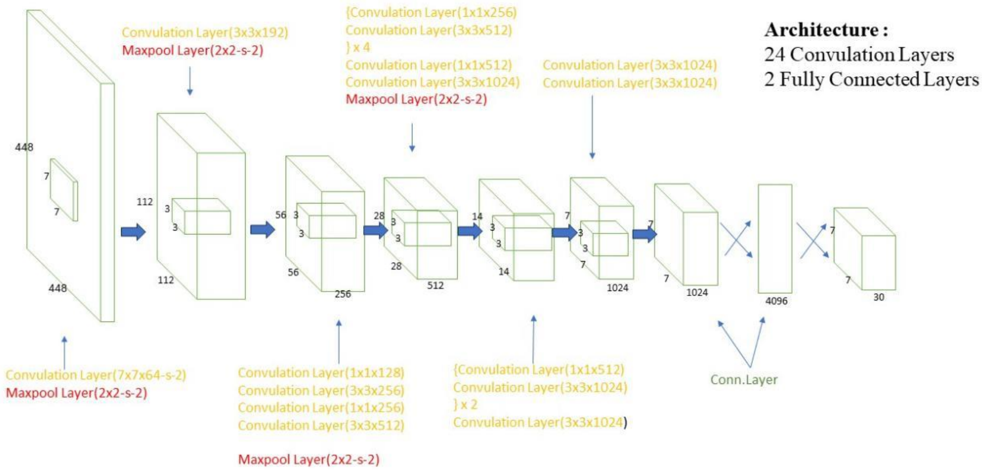

Figure 2. YOLOv7 infrastructure [6].

YOLO's Deep CNN comprises 24 convolutional layers altogether, the final 2 of which are bonded, which is inspired by the Google Net architecture. Below Figure 3 depicts image's division and packaging using YOLO.

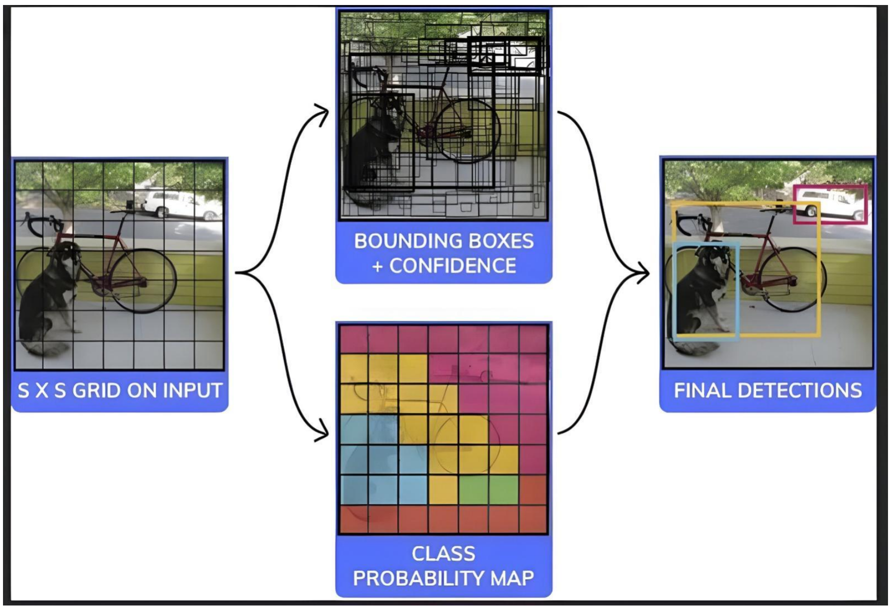

Figure 3. An illustration of the image's division and packaging using YOLO [7].

The YOLOv7 workflow is as follows:

- Pre-processing: The algorithm takes an input image or video frame and pre-processes it by resizing it to a fixed size and normalizing the pixel values.
- Feature extraction: The algorithm then extracts features from the pre-processed image using a convolutional neural network (CNN). The CNN is trained on a large dataset of images and learns to extract features that are useful for object detection.
- Grid creation: The algorithm divides the image into a grid of cells, where each cell is responsible for detecting objects that fall within its boundaries.
- Object detection: For each grid cell, the algorithm predicts a set of bounding boxes and a confidence score for each box. The confidence score represents how likely it is that the box contains an object.
- Non-maximum suppression: The algorithm applies non-maximum suppression to the predicted boxes to remove duplicates and overlapping boxes.
- Classification: For each remaining box, the algorithm classifies the object inside it using a SoftMax function. The SoftMax function assigns a probability to each possible object class.
- Output: Finally, the algorithm outputs the coordinates of the bounding boxes, the class labels, and the confidence scores for each detected object.

Traffic Signal Calculations:

We calculate and allocate the signal time for each road based on its traffic density. When no vehicle awaits, the road is completely skipped.

For the calculation, the following parameters are used:

(a) Maximum allowed time (Tmax).
(b) Column density (Cd).
(c) Crossing time (CrT).
(d) Road width (Rw).
(e) Crossing distance (AVl).
(f) (d) Allotted time.
(g) Leftover vehicles (Lo).
(h) Buffer distance (Bd).

Waiting time = total time that the number of vehicles is waiting for on the other three roads and the leftover of the current road allotted time.

3. Results

In Figure 4, input is given to the YOLOv7 model. Different sorts of cars have been successfully spotted and distinguished in Figure 5. The program may also keep track of how many vehicles are parked at the traffic light at any given moment. From there, readers can shorten the moment that the automobiles must wait during the indication as a result of this initiative. Fewer vehicles can pass under the static system (with a fixed green signal period) as compared to the proposed system. This can be performed by adjusting the indication for “go”, which is dependent on the volume of the vehicles during the indication. Make sure that the green signal is in place for a longer period of time in the direction with more traffic than it is in the way with less traffic. So, by dynamically adjusting the duration of the green signal based on the volume of traffic, the proposed system could help reduce congestion and improve the overall traffic flow. This could lead to shorter travel times and reduced frustration for drivers. Also, this proposed system could lead to significant energy savings, as the traffic lights would only stay green for as long as needed based on the number of vehicles at the intersection. This would reduce energy consumption and greenhouse gas emissions. The system can be connected to a central control center that monitors traffic across the city or region, allowing for coordinated management of traffic signals and other traffic-related activities.

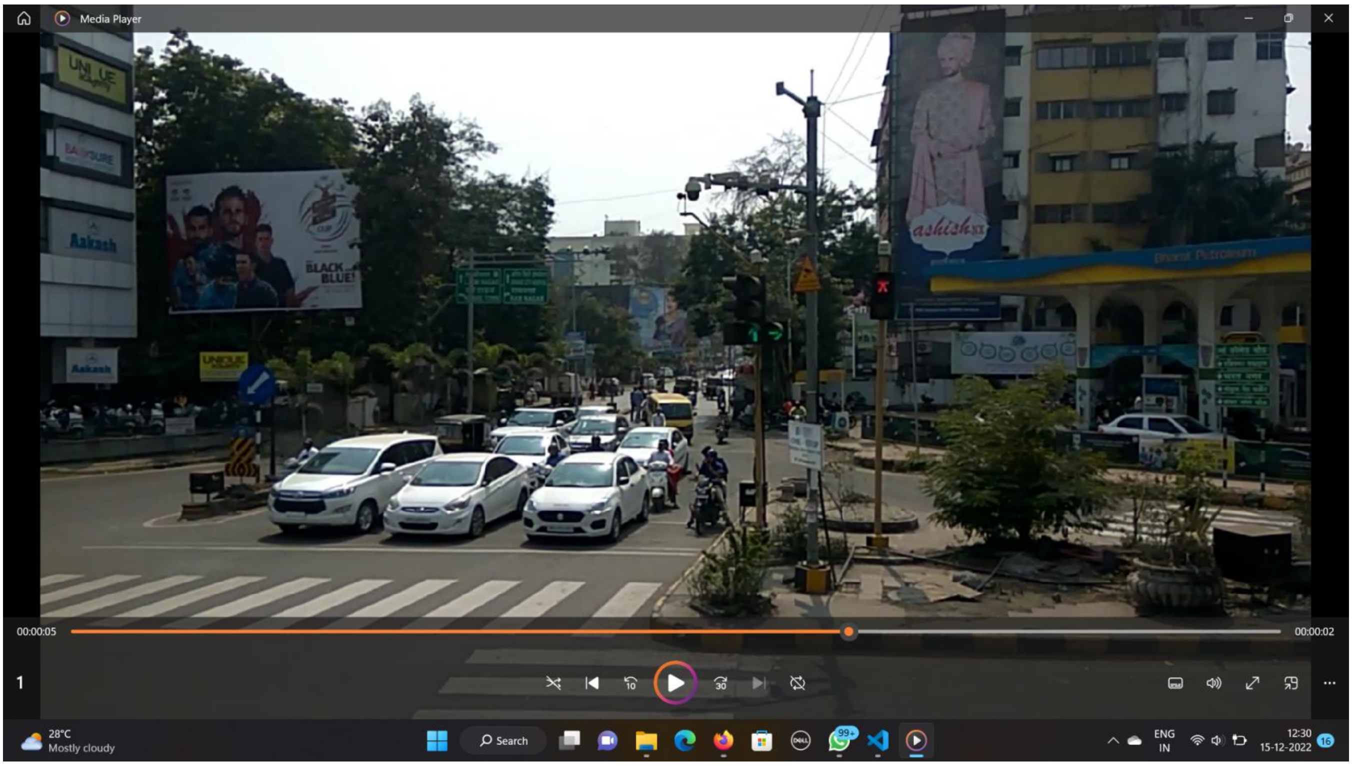

Figure 4. Input given to the project.

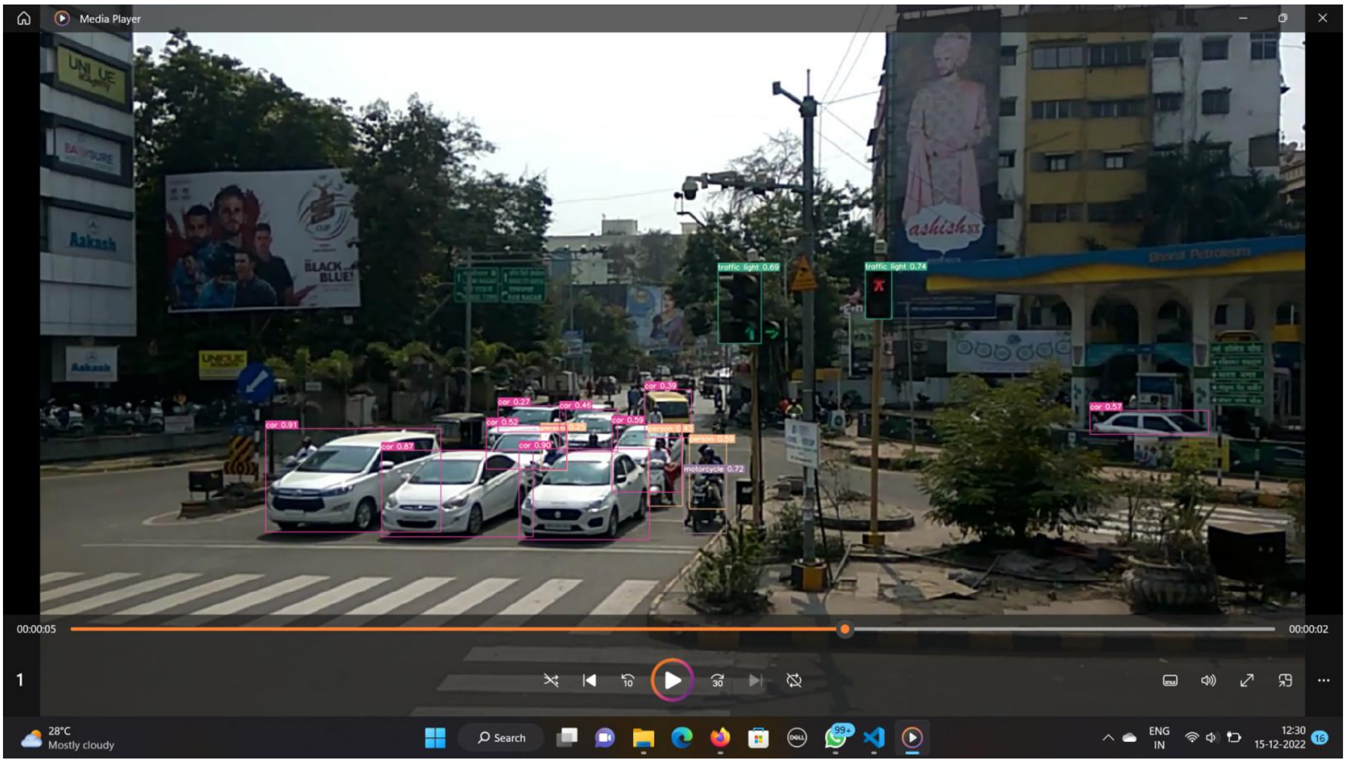

Figure 5. Output generated.

4. Limitations and Future Scope

Due to the increased cost of installation as well as the upkeep of recording devices and certain equipment, this project has a high starting cost. A substantial investment will be necessary for this kind of technology. The other restriction is that poor weather conditions like rain or fog reduce road visibility, which directly affects the accuracy of traffic counts and leads to inaccurate traffic estimates. The system must also have the right street lights in place for it to work correctly at night. The design of this system must be faultless because a human life is at stake, and even a small flaw in it can cause an accident. It is challenging to determine the precise number of cars because there is no designated lane for each type of vehicle. This is so that the two-wheelers can be seen even with a large vehicle in the front. The accuracy of the vehicle count will be affected [8–10].

Over the years, technology has progressively migrated across fields, but in the area of traffic management and control, inventions have been considerably less noticeable. Intelligent transportation systems (ITS) have gained popularity recently thanks to their many benefits, which go beyond traffic information and control to include effective infrastructure use and road safety. The knowledge gained from censored traffic lights can be applied to operational management to keep it current and make adjustments. By operating on the cloud, traffic control centers can lower expenses while proactively responding to changing traffic circumstances and outages, enhancing the citizen experience, enhancing traffic safety, and improving signal performance. Also, this system can be integrated with other traffic management technologies, such as adaptive cruise control and lane departure warning systems, to further enhance traffic safety and efficiency. Also, we can implement this further. In addition to traffic volume, the system can also take into account other factors that affect traffic flow, such as weather conditions, road closures, and special events. Finally, the system can be enhanced using machine learning algorithms that can learn from historical data to predict traffic patterns and adjust traffic signals accordingly [11,12].

5. Conclusions

This project was performed with the intention of developing a smart transportation management system that makes use of a self-adaptive and robust optimizer for deep learning-based congestion control and a convolutional neural network. The proposed model is expected to perform better than the traditional systems as the amount of data collected grows. More accurate forecasting will be possible. By utilizing cutting-edge tools like machine learning and vision for computing, we will be able to automate traffic. This new system makes it easier for cars to move through crossing points, leading to less overcrowding, lower releases of carbon dioxide, and so on. Considering the wealth of information pertaining to the clip, it emphasizes the implications of pushing fundamental limits for pattern recognition, classification, and monitoring of existing works. YOLOv7 has a lightning-fast reasoning rate at a minor loss of reliability, particularly for tinier items and less clarity.

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