International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7s
DOI: https://doi.org/10.17762/ijritcc.v11i7s.7014
***Article Received:** 05 April 2023 **Revised:** 26 May 2023 **Accepted:** 04 June 2023*

Enhancing Traffic Flow Using Computer Vision Based - Dynamic Traffic Light Control and Lane Management

[1]Rajesh Phursule, [2]Dhirajkumar Lal, [3]Sandhya Waghere, [4]Mohammad Abdul Mughni, [4]Sarvesh Ransubhe, [4]Chinmay Shiralkar
[1]Associate Professor, Information Technology
[2]Associate Professor, Civil Engineering
[3]Assistant Professor, Information Technology
Pimpri Chinchwad College Of Engineering, PCCOE, Pune
Pune, Maharashtra
Email: rajesh.phursule@pccoepune.org, dhirajkumar.lal@pccoepune.org, sandhya.shinde@pccoepune.org
[4]Student, Information Technology
Pimpri Chinchwad College Of Engineering, PCCOE, Pune
Pune, Maharashtra
Email:mughniabdul23@gmail.com, sarvesh.ransubhe21@gmail.com, chinmay2106@gmail.com

Abstract— Traffic congestion is a persistent problem in many metropolises worldwide. Despite the existence of traffic control systems, they are not always efficient enough to manage the ever-changing traffic density environment. The traditional approach of allocating specific times to each lane with the green light, regardless of the traffic situation, has not been very effective. In fact, it often can make the traffic congestion worse. Thus, the need for a more sophisticated system has emerged to simulate and optimize traffic control. This paper proposes the use of computer vision technology to develop a traffic control system that is based on periodic still photo feeds and compares different object detection models to find the best model for vehicle detection in our system . The system aims to enhance traffic flow by dynamically adjusting the traffic light cycles based on real-time traffic conditions.

Keywords- Vehicle detection, Traffic Management, Computer Vision, Lane management.

I. INTRODUCTION

The traditional traffic control system in India is inefficient due to predefined specific times for each lane's traffic, which might result in unproductive results as traffic density changes from moment to moment. This leads to traffic congestion, loss of productive time, traffic rage issues, delayed deliveries, etc.

Therefore, to solve this problem, the method proposed in this paper suggests designing a traffic signal timer that can dictate and/or manipulate the time for green lights depending on the changing traffic density. This will significantly reduce traffic congestion, improve the productivity of people and create a safer environment overall. The paper presents an alternate cheap and reliable system to tackle this problem using advancements in computer vision and processing systems.

By implementing such a system, the problem of traffic congestion can be solved or at least significantly reduced, leading to decreased traffic, fewer traffic rage issues, improved delivery times, and potentially reduced air pollution due to fewer idling vehicles. The use of advanced computer vision and processing systems makes this idea a feasible and practical solution in specific areas and conditions.

II. RELATED WORK

In [1] A comparison of various deep-learning image identification methods was done by the authors.

The study's goal was to assess and contrast the efficacy of several deep learning algorithms for image detection tasks. The researchers concentrated on well-known deep learning architectures such as RetinaNet, SSD, YOLOv3, and Faster R-CNN.

For the purpose of developing and testing the algorithms, the authors gathered and produced datasets. They made use of widely utilized benchmark datasets, such as COCO and VOC, to guarantee the accuracy of their findings.

Precision, recall, and mean average precision (mAP), among other performance criteria, were used to evaluate the

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7s
DOI: https://doi.org/10.17762/ijritcc.v11i7s.7014
***Article Received:** 05 April 2023 **Revised:** 26 May 2023 **Accepted:** 04 June 2023*

algorithms. The researchers also took into account things like training duration and computing efficiency.

In [2] the author describes a real-time traffic monitoring system that utilizes an intelligent transportation system and computer vision techniques to address challenges such as vehicle counting, speed estimation, accident detection, and traffic surveillance. Deep learning algorithms, specifically YOLOv3 and YOLOv4, are employed for vehicle detection and classification. The system combines a virtual detection zone, Gaussian mixture model (GMM), and YOLO to enhance vehicle counting and classification efficiency. Additionally, the distance and time traveled by vehicles are used to estimate their speed. The study presents a flowchart outlining the vehicle counting and classification process. The materials and methods section discusses data set preparation, vehicle counting using GMM and virtual detection zone, and vehicle detection and classification using YOLO. The YOLOv3 and YOLOv4 architectures are described, along with their loss functions. The text also mentions speed estimation and provides a diagram illustrating the calculation process. Overall, the system aims to achieve real-time computation, accurate vehicle detection, and efficient traffic monitoring.

In [3] the author describes a proposed research work that aims to analyze traffic density using Python OpenCV and YOLOv3 (You Only Look Once) algorithm. The research work involves recording real-time videos from Sony HD IP cameras in a designated area and using image frames from the video sequence to detect moving vehicles.

The author introduces the use of the YOLOv3 algorithm for vehicle detection and counting without the need for additional hardware. It mentions that YOLOv3 provides better results for rotating and small objects. The section also discusses the experimental setup, including inputs, outputs, anchor boxes, and the encoding process in YOLOv3. It highlights the computation of class scores and explains how the algorithm assigns classes and scores to each box based on the probability of object presence and class probability.

Overall, the research work aims to develop an efficient and accurate system for real-time vehicle detection, classification, and counting using computer vision techniques and deep learning algorithms.

In [5] the author discusses the achievements achieved using convolutional neural networks (CNNs) since 2012 in the field of computer vision's object identification models. Before deep learning became popular, object recognition was carried out using manually created machine learning features like SHIFT and HOG. On the PASCAL VOC Challenge dataset, these models performed only moderately, with the top model achieving about 35% mean average precision (mAP).

Object detection in computer vision involves identifying the class and location of objects within an image. Before deep learning became popular, handcrafted features were used for object detection, but they had limited performance. The introduction of convolutional neural networks (CNNs) revolutionized object detection. Models like R-CNN, SPP-net, Fast R-CNN, and Faster R-CNN improved the accuracy and speed of object detection. Additionally, the use of techniques like region proposal networks (RPN) and feature pyramid networks (FPN) further enhanced object detection performance. These advancements in CNN-based object detection models have significantly improved the accuracy and efficiency of object detection tasks.

Gaps in the literature that the implementation aims to fill

This research paper aims to enhance existing traffic management approaches by addressing the limitations found in both traditional methods and reviewed methodologies. The inefficiencies observed in these approaches primarily stem from either the nature of traffic flow in the conventional management of four traffic lanes or the non-dynamic time allocation of green lights. To optimize traffic management, this study integrates the favorable aspects of the reviewed literature while introducing novel formulas for calculating green and yellow light durations. This paper seeks to present an improved solution to the current state of traffic management.

III. METHODOLOGY

The proposed lane management system aims to divide the movement of vehicles based on their intended direction of travel rather than the traditional lane-based system. The system divides each lane into three groups:

Straight

Right-hand turn

Left-hand turn.

Only the straight or right-hand turn movement of vehicles is allowed at a time for a lane. The system also includes a proposed traffic light switching algorithm that uses cameras and YOLO-V7 software to analyze the number of vehicles on the road and provide the relative time for the green light to switch on.

The proposed system aims to manage the flow of traffic more efficiently while also ensuring pedestrian safety.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7s
DOI: https://doi.org/10.17762/ijritcc.v11i7s.7014
***Article Received:** 05 April 2023 **Revised:** 26 May 2023 **Accepted:** 04 June 2023*

The approach taken to implement the system:

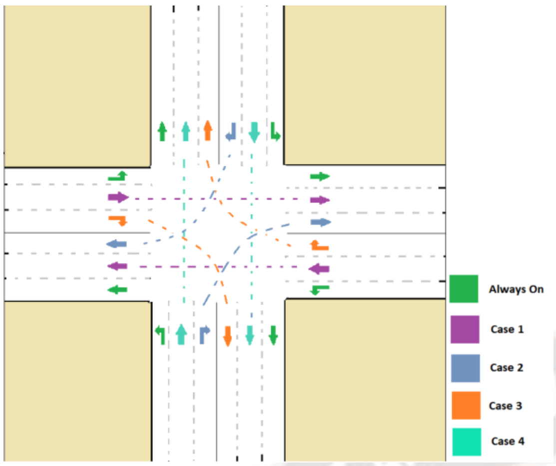

Figure 1 - Proposed Lane Distribution System

The proposed traffic management system involves the use of four cameras, positioned to capture the traffic on each lane. These cameras periodically capture images of the incoming traffic, which are then transmitted to a processing unit located near the intersection. The processing unit can be a compact computer or a custom-designed chip that processes the data and computes the optimal green light timing for each lane group, as determined by the lane management system. These timings are then sequentially implemented to ensure efficient and safe traffic flow at the intersection.

Requirements of the implementation of the system

The software requirements include YOLO-V7, python programming, file management, open cv library, and Raspbian Raspberry Pi operating system.

The hardware requirements include Raspberry Pi 4, breadboard, connecting wires, four RGB LEDs, and resistors.

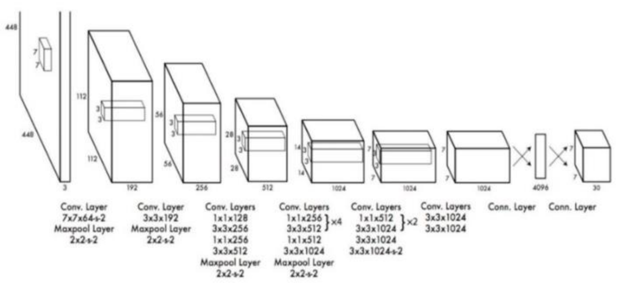

Figure 2 - Yolo V7 Architecture

The design and development process:

The development of this solution follows the following steps

A. Setting up of the raspberry pi:

The Raspberry Pi setup process entails several steps for successfully configuring the device. Firstly, RasBin needs to be loaded onto the Raspberry Pi, followed by the installation of cooling fans to ensure optimal temperature regulation. Furthermore, the setup requires securing the components within a protective case to enhance portability and ensure safety. Additionally, integrating a Raspberry Pi camera into the system for image input, along with the installation of all the relevant packages essential for the project's functionality.

B. Implementing YOLO image recognition software:

The implementation of YOLO v7 software facilitates the recognition of various vehicles, including cars, buses, trucks, vans, and others. Before implementing YOLO v7 we split the images detected into two halves, one for straight-going vehicles and one for vehicles turning right. YOLO was specifically designed to improve the speed of slower two-stage object detectors like Faster R-CNN. The process of implementing YOLO v7 involves several key steps. Firstly, dependencies such as NumPy and OpenCV need to be installed. Next, the YOLO v7 software is downloaded from a GitHub repository. Subsequently, YOLO v7 is built to ensure proper functionality. Pre-trained weights for YOLO v7 are then obtained and integrated into the system. By following these steps, successful integration of YOLO v7 can be achieved for vehicle recognition purposes. After detecting the number of vehicles in the images we insert the number of vehicles in every image into an array.

C. Switching traffic lights based on the number of vehicles detected:

After we get an array of the number of vehicles in each lane, we use different formulae to calculate the time for vehicles going straight. After getting the times we turn the signal green for each lane for the time allocated to it using GPIO pins on a raspberry pi to turn on the LEDs.

For the Opposite Straight Road 1 and Opposite Straight Road 2, the time duration for the green light, for vehicles to cross the intersection is determined by the formula

$$[(\sqrt{s})n/l + A1]\ s \qquad (1)$$

s represents the distance, n is the number of vehicles, and l denotes the number of lanes. Additionally, a fixed time delay of A_1 seconds is added for Opposite Straight roads , and A_2 seconds for Right turn roads

Similarly, for Right turn road 1 and Right turn road 2, the green light time for vehicles is calculated using the formulae

$$[(v_1/4)*(0.27)] \qquad (2)$$

$$[(v_2/4)*(0.27)] \qquad (3)$$

respectively, where v_1 and v_2 are speed limits on the road

The Green light is always on for the left-hand turns.

ISSN: 2321-8169 Volume: 11 Issue: 7s
DOI: https://doi.org/10.17762/ijritcc.v11i7s.7014
***Article Received:** 05 April 2023 **Revised:** 26 May 2023 **Accepted:** 04 June 2023*

Table 1 - Traffic lights timing calculations formulae

	Time green (T_g) in seconds	Time yellow (T_y) in seconds	Time red (T_r) in seconds
Opposite Straight road 1	$\sqrt{s} \cdot \frac{n}{l} + A_1$	$\frac{v_1}{4} \cdot (0.27)$ sec	Rest of the wait time
Opposite Straight road 2	$\sqrt{s} \cdot \frac{n}{l} + A_1$	$\frac{v_2}{4} \cdot (0.27)$ sec	Rest of the wait time
Right turn road 1	$\sqrt{s} \cdot \frac{n}{l} + A_2$	$\frac{v_1}{4} \cdot (0.27)$ sec	Rest of the wait time
Right turn road 2	$\sqrt{s} \cdot \frac{n}{l} + A_2$	$\frac{v_2}{4} \cdot (0.27)$ sec	Rest of the wait time
Pedestrian group 1	Same as OS1	NA	Rest of the wait time
Pedestrian group 2	Same as OS2	NA	Rest of the wait time

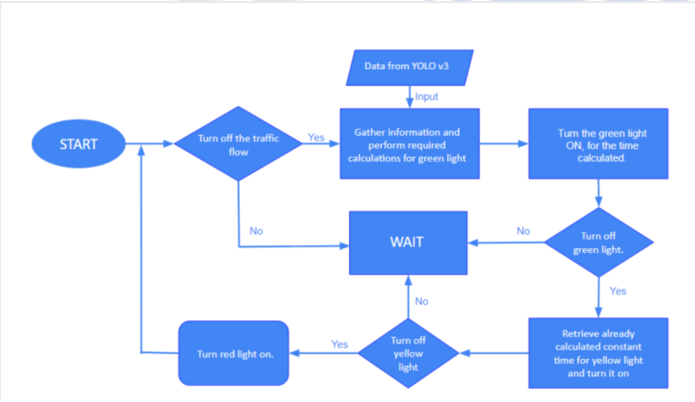

Figure 3 - Traffic light switching flow chart

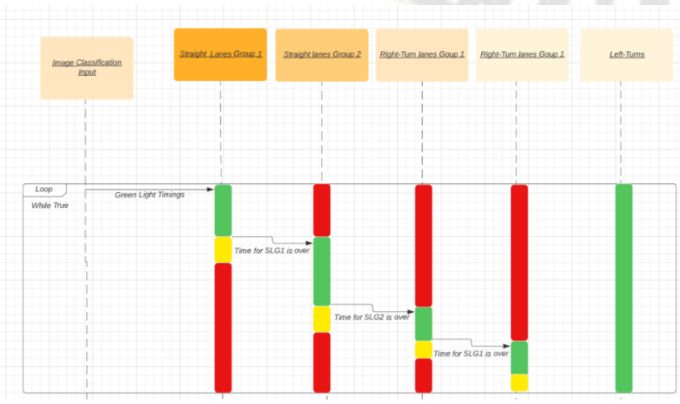

Figure 4 - Time Series Diagram

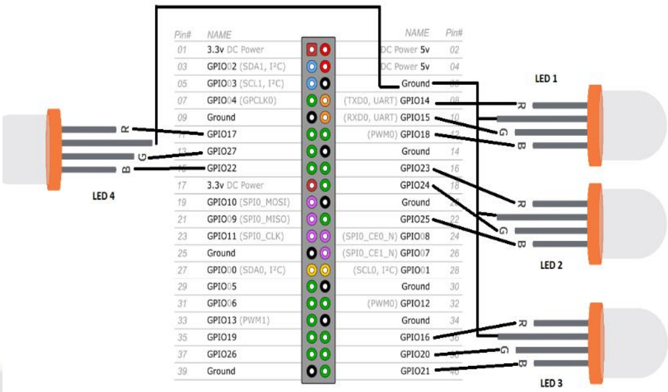

Figure 5 - Pin diagram for connections in the circuit

IV. IMPLEMENTATION AND RESULTS

A. *Algorithm*

Step 1: The initial step involves capturing images to obtain a sample of the real-time traffic scenario under consideration.

Step 2: The captured images are then segmented into distinct lanes, the right-moving, left-moving, and straight-moving lanes.

Step 3: Subsequently, the left-moving lane is disregarded, and the remaining straight-moving and right-moving lanes are grouped based on their parallel movements.

Step 4: To analyze the traffic within the created groups, the YOLO v7 (You Only Look Once) object detection algorithm is employed. This algorithm enables the detection, counting, and storage of the number of vehicles within each group, providing data for subsequent calculations.

Step 5: Leveraging the gathered information and the formulated formulas presented in the provided table 1, the timings for green and yellow lights are calculated using a Raspberry Pi. These calculations incorporate various factors, such as traffic density, number of lanes, speed limit of the road, etc to calculate traffic light timings.

Step 6: The calculated timings are then transmitted to the circuit responsible for controlling the traffic lights. The circuit receives the timing instructions and activates the appropriate lights accordingly, ensuring an efficient traffic management system based on the calculated values.

Step 7: Upon completion of a full cycle involving all the created groups, the process restarts from Step 1, continuously adapting to changing traffic conditions.

B. *Data For Assessment*

The evaluation of the system's functionality involved the utilization of various images obtained from different traffic signals randomly captured from the internet. These images

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7s
DOI: https://doi.org/10.17762/ijritcc.v11i7s.7014
***Article Received:** 05 April 2023 **Revised:** 26 May 2023 **Accepted:** 04 June 2023*

served as representative samples for assessing the proper functioning of the entire system. Additionally, data collected from manually captured images of real traffic intersections were incorporated to evaluate the performance of individual components within the system. This approach allowed for a comprehensive assessment of the system's capabilities and ensured a thorough evaluation of its effectiveness in real-world scenarios.

C. Results and Discussion

The proposed lane management system has shown promising results in comparison to the traditional traffic management systems, particularly on smaller roads leading to urban areas intersecting highways, commonly known as collector connections. The approach of dividing the movement of vehicles based on their intended direction of travel, rather than the conventional lane-based approach, has led to a more efficient traffic flow and safer pedestrian crossing. The system optimizes the traffic light timings by analyzing the real-time data obtained from the four cameras installed at the intersection, resulting in a reduced waiting time for vehicles. Additionally, the system adapts to the changing traffic density patterns, ensuring a smooth flow of traffic throughout the day. By utilizing advanced computer vision and processing technologies, this innovative approach offers a reliable and cost-effective solution to the traffic congestion problem, ultimately enhancing the quality of life in urban areas.

On simulating the conditions of a highway intersected by a smaller road coming from the city the results prove that there is a significant reduction in the time the vehicles had to wait at the signal.

There is a significant drop in the waiting times from 27.75 seconds to 10.0 seconds in the simulations

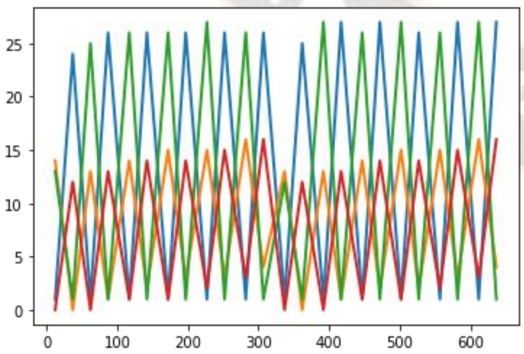

Figure 6 - No of waiting vehicles in a lane vs time graph in the proposed system

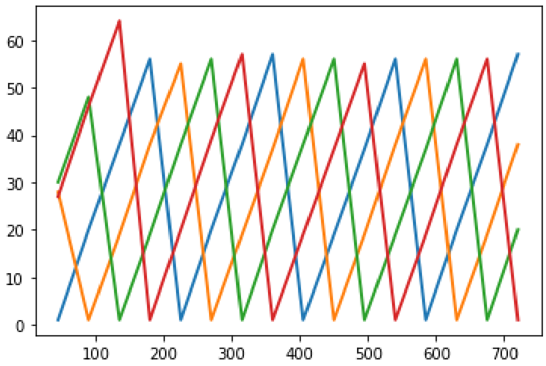

Figure 7 - No of waiting vehicles in a lane vs time graph in the traditional system

The diagrams visually represent the number of vehicles present in a lane at different points in time on the x-axis, with the y-axis indicating the number of vehicles in a color-coded format. The passage of time is represented along the x-axis.

V. RESULTS VISUALIZATION

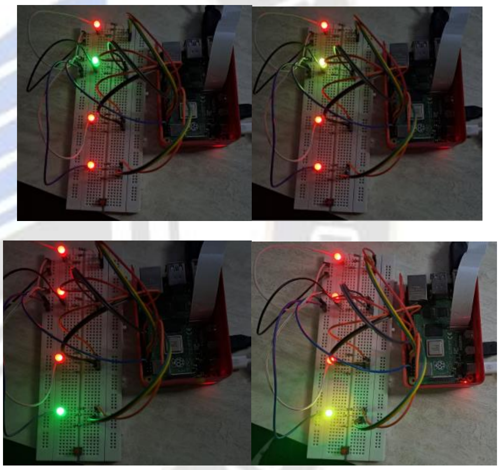

Figure 8.1, 8.2, 8.3, 8.4 Different group's traffic lights changing from green to yellow(group 2 and 4 as an example)

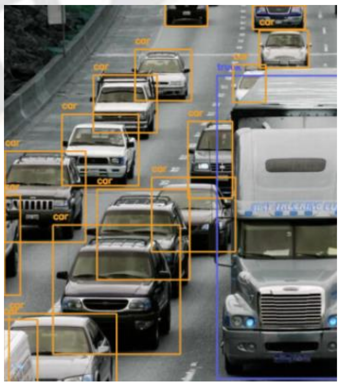

Figure 9 - Sample image 1 traffic detection

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7s
DOI: https://doi.org/10.17762/ijritcc.v11i7s.7014
***Article Received:** 05 April 2023 **Revised:** 26 May 2023 **Accepted:** 04 June 2023*

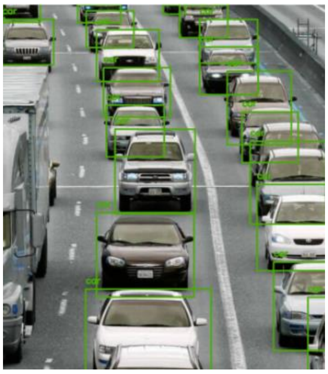

Figure 10 - Sample image 2 traffic detection

VI. CONCLUSION

In conclusion, the proposed lane management system and traffic light switching algorithm discussed in the paper could potentially provide a more efficient and reliable solution to traffic congestion problems on Indian roads. By leveraging advancements in computer vision and processing systems, the proposed system aims to dynamically adjust traffic light timings based on real-time traffic patterns, resulting in a smoother and safer flow of vehicles and pedestrians. While further research and testing are needed to fully assess the feasibility and scalability of this system, it presents a promising avenue for tackling the pressing issue of traffic congestion in urban areas.

REFERENCES

[1] M. Maity, S. Banerjee and S. Sinha Chaudhuri, "Faster R-CNN and YOLO based Vehicle detection: A Survey," 2021 5th International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2021, pp. 1442-1447, doi: 10.1109/ICCMC51019.2021.9418274.

[2] Gadde, S. ., & Chakravarthy, A. S. N. . (2023). Novel and Heuristic MolDoc Scoring Procedure for Identification of Staphylococcus Aureus. International Journal of Intelligent Systems and Applications in Engineering, 11(2s), 125 –. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/2516

[3] Cheng-Jian Lin, Shiou-Yun Jeng, Hong-Wei Lioa, "A Real-Time Vehicle Counting, Speed Estimation, and Classification System Based on Virtual Detection Zone and YOLO", Mathematical Problems in Engineering, vol. 2021, Article ID 1577614, 10 pages, 2021. https://doi.org/10.1155/2021/1577614

[4] CH. Ranga Reddy, Angshuman Roy, Ms. G. Priyanka, Dr. G. Victo Sudha George "VEHICLE DETECTION USING YOLO V3 FOR COUNTING THE VEHICLES AND TRAFFIC ANALYSIS" Dept. of Computer Science & Engineering, Dr. MGR Educational and Research Institute, Chennai, India , International Research Journal of Engineering and Technology (IRJET), 2022

[5] Prof. Shweta Jain. (2017). Design and Analysis of Low Power Hybrid Braun Multiplier using Ladner Fischer Adder. International Journal of New Practices in Management and Engineering, 6(03), 07 - 12. https://doi.org/10.17762/ijnpme.v6i03.59

[6] Prof. Pallavi Hiwarkar; Damini Bambal; Rishabh Roy. "Vehicle Detection System & Counting Of Vehicles In Still Images Using Deep Learning", International Journal of Creative Research Thoughts (IJCRT), 2022

[7] Sultana, F., et al. "A Review of Object Detection Models Based on Convolutional Neural Network." A Review of Object Detection Models Based on Convolutional Neural Network SpringerLink, 9 June 2020, doi:10.1007/978-981-15-4288-6_1.

[8] Syed Sahil Abbas Zaidi, Mohammad Samar Ansari, Asra Aslam, Nadia Kanwal, Mamoona Asghar, and Brian Lee, "A Survey of Modern Deep Learning Based Object Detection Models.", ScienceDirect, 8 Mar. 2022, doi:10.1016/j.dsp.2022.103514.

[9] Thompson, A., Walker, A., Fernández, C., González, J., & Perez, A. Enhancing Engineering Decision Making with Machine Learning Algorithms. Kuwait Journal of Machine Learning, 1(2). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/127

[10] P. Adarsh, P. Rathi, and M. Kumar, "YOLO v3-Tiny: Object Detection and Recognition using one stage improved model" 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2020, pp. 687-694, doi: 10.1109/ICACCS48705.2020.9074315.

[11] Srivastava, S., Divekar, A.V., Anilkumar, "Comparative analysis of deep learning image detection algorithms". J Big Data 8, 66 (2021). https://doi.org/10.1186/s40537-021-00434-w

[12] Shinde, Shubham & Kothari, Ashwin & Gupta, Vikram. (2018). YOLO based Human Action Recognition and Localization. Procedia Computer Science. 133. 831-838. 10.1016/j.procs.2018.07.112.