A Mini-Project Report on

Machine Learning Based Autonomous Riding System (M.A.R.S)

Submitted in fulfilment of Mini-Project (ITM605) of

Semester VI

in

Information Technology

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CERTIFICATE

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We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic with honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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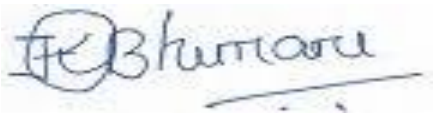

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Abstract

Vision begins in eyes, but truly takes place in the brain. So, in today's world with the best high-definition cameras, high-speed computers, and artificial intelligence computer vision was introduced. Computer vision is one of the latest advancements in technology that helps on giving the abilities of vision and understanding of the environment to computers so that they can extract high-level understanding from digital images and videos. Computer vision can today achieve goals that seemed impossible some decades ago.

One of that goal is autonomous driving. Driving a motor-vehicle is one of the basic tasks that takes place at some point in every person's life. Driving a car requires judgement, control over body, and constant observation of the things happening in the surrounding to traverse through the roads safely, not only for the driver but everyone around. This task seems easy but a lot of human error takes place around us causing accidents.

In several industries machines are being trained using artificial intelligence to reduce human errors and perform high-precision tasks with accuracy. Self-driving cars is an application of computer vision with main motive of eliminating human errors and drive the vehicles with high precision and remove the efforts taken by a person to drive and take advantage of the technology to travel around safely and securely.

This is the main motivation behind the project. To create a completely autonomous system capable of navigating around on its own. Detect, identify and follow traffic signs, signals and rules. Take appropriate actions for dynamic conditions and avoid any sort of loss. Provide user with an application interface to experience a safe journey to selected destination.

1. Introduction

This is the main motivation behind the selected topic is the fast-moving progress of applied artificial intelligence (AI) and the predicted importance of autonomous vehicles on the future, from independent mobility for non-drivers and low-income individuals, reduced pollution, traffic and parking congestion to increased safety on the roads. Autonomous vehicles are also predicted to be relied on in some of the most complex human planned endeavours, such as space exploration. The meteoric rise of AI along with deep learning (DL) methods and frameworks, have made possible the creation of such an autonomous vehicle without expensive laboratories and years of research.
The goal of the project is to create and implement an autonomous driving system that navigates autonomously through the map created and takes dynamic action for different environment conditions.

The system which we are going to build is an autonomous vehicle and more specifically, a self-driving RC car. The goal of the project is to build a model capable of navigating through the map autonomously, while demonstrating the capability to perform behaviours such as lane following, dynamic actions with respect to environment changes. The project will go through the entire process of building such a vehicle, starting from the RC car model and the embedded hardware platform, to the orchestration end-to-end machine learning algorithms and a user application.

Aside from the technological obstacles that are yet to be surmounted, one big barrier precluding autonomous vehicles on roads are of an ethical and legislative nature. [3]As mentioned, Uber, Tesla and others have already had fatal accidents involving autonomous vehicles, which prompted investigations and a long overdue discussion concerning the liabilities that come with allowing vehicles to autonomously navigate real streets with real humans on them, focusing specifically on impossible situations in which a fatal collision may be unavoidable in which the vehicle will have to decide what course of action to take, from self-sacrifice which would mean sacrificing the passengers the car is transporting to intentionally fatally injuring other traffic participants. Other issues include the cost and scalability of self-driving technology and the standardisation of safety assurance in such vehicles, for which models and frameworks have been proposed just in the recent years. The advantages and quality of life improvements autonomous vehicles offer range from safer and less congested roads, reduced parking and fewer vehicles per capita to up to several thousands of dollars saved per year in travel time reduction, fuel efficiency, parking benefits and crash costs.

2. Literature Review

1) Title - BUILDING A SELF-DRIVING RC CAR MASTER'S THESIS
Publication – Master's thesis to University of Zagreb, 2020
Author Name – Ivan Oršolic

Conclusion –
In the thesis the author created a self driving RC car using Embedded Systems, OpenCV, DonkeyCar, Keras methodologies. The paper showed detailed desription regarding the hardware and the software used in the project. It included comparisons, setting up of the environment and connections for the components used. It introduced to the DonkeyCar library that is developed for creating self driving cars similar to that of the scope of our project. The entire project was quite similar to the ideas that we had and implemented some of the objectives that we used. Overall, the thesis paper solved a few doubts and discrepancies regarding the hardware selection and gave a new light on DonkeyCar.

2) Title - A Comparative Study on Machine Learning Algorithms for the Control of a Wall Following Robot
Publication – IEEE International Conference on Robotics and Biomimetics (ROBIO) – 2019
Author Name - Issam Hammad, Kamal El-Sankary, and Jason Gu

Conclusion –
The methodologies used by in paper were Keras, Scikit-learn, Monte-Carlo cross-validation, Machine learning algorithms – Decision tree, Gradient Boost Classifier, Support Vector Machines, KNN, Gausian Naive Bayes.
The understanding from the paper included that according to the popular No Free Lunch Theorem, there is no golden machine learning algorithm that can outperform all the other machine learning algorithms in solving all possible problems. Identifying correct algorithm based on application is important. The paper provided comparison between the algorithms

with different data-sets and showed the results for the best performing algorithm for the given application i.e. wall following robot.

3) Title - Comparative Analysis of Machine Learning Algorithms on Different Datasets
Publication – International Conference on Innovations in Computing (ICIC), 2017
Author Name - Kapil Sethi, Ankit Gupta, Gaurav Gupta, Varun Jaiswal

Conclusion –
In the paper the authors used MATLAB to simulate the working of different algorithms for varying datasets. The sensitivity and accuracy of NN, SVM and KNN are determined from the simulations. The schema used by the authors for the experiment was identified and as per the examination, SVM classifier contrasted better than KNN and NN with accuracy of close to 99.38%

4) Title - Autonomous Vehicles and Embedded Artificial Intelligence: The Challenges of Framing Machine Driving Decisions
Publication – XIII Conference on Transport Engineering, CIT2018
Author Name - Martin Cunneen, Martin Mullins, and Finbarr Murphy

Conclusion –
The paper covered the moral decisioning problems faced by algorithms while driving. How not having an emotional quotient may affect the weighted inputs and their corresponding outputs. This paper focused more on ethical challenges as well as the social dilemma that can revolve around autnomous cars and how over-fitting of data while training can make the AI model biased to certain aspects and how this problem is solved by having appropriate diversified datasets and suffiicient training of the model.

3. Existing System Architecture

Google Self Driving Car – (WAYMO)

[8] The Google self-driving car project is now called as WAYMO. WAYMO stands for a new way forward in mobility. We are a self-driving technology company with a mission to make it safe and easy for people and things to move around. The Google Self-Driving Car is a project by Google that involves developing technology for autonomous cars, mainly electric cars. The software powering the cars is called Google Chauffeur. The Google Self-Driving Car Project begun way back in 2009, with only one goal in sight - building a completely autonomous car by 2020. The idea was to build one prototype that would be able to successfully drive itself across real-life scenarios.

Architecture-

[7] These cars have about $150,000 in equipment including a $70.000 LiDAR system. The range finder mounted on the top is a Velodyne 64-beam laser This laser allows the vehicle to generate a detailed 3D map of its environment. The car then takes these generated maps and combines them with high resolution maps of the world, producing different types of data models that allow it to drive itself. As of June 2014, the system works with a very high-definition inch-precision map of the area the vehicle is expected to use. Equipment's and Sensors used are -

1. LiDAR
2. Video Cameras
3. Radar Sensors
4. Orientation Sensors
5. Central Computer

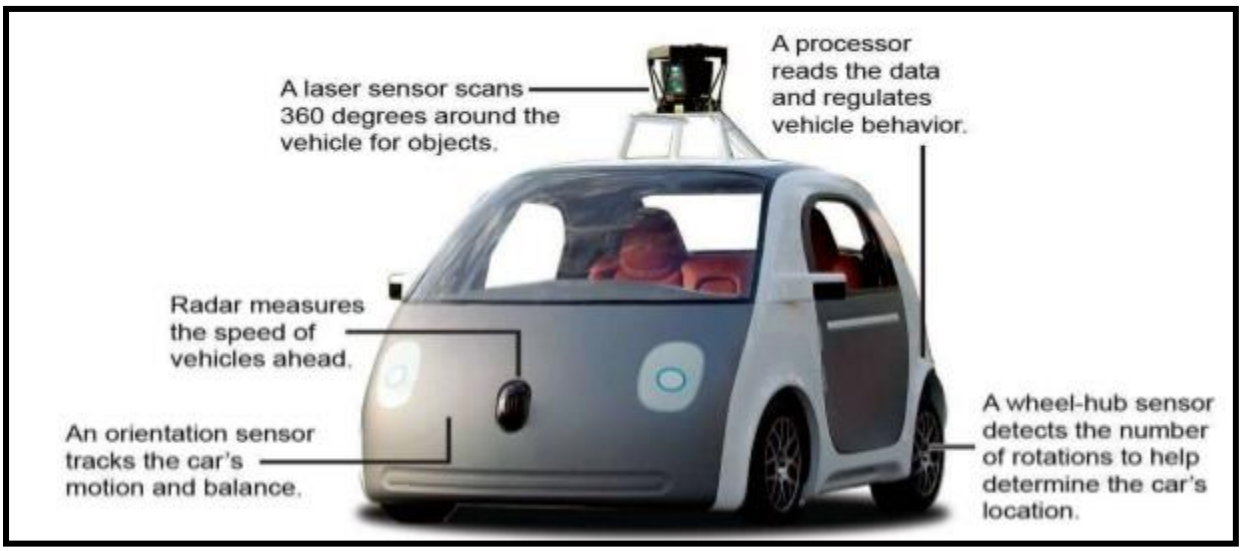


Figure 3.1- Architecture and components of Car

Working-

Algorithm Used-

1. Regression
2. Ada Boosting
3. K-Means
4. Neural Network Regression

These vehicles have sensors and software that are designed to detect pedestrians, cyclists. vehicles, road work and more from up to three football fields away in all 360 degrees. Powered by an electric motor with around a 100-mile range, the car uses a combination of sensors and software to locate itself in the real world combined with highly accurate digital maps. A GPS is used, just like the satellite navigation systems in most cars, to get a rough location of the car, at which point radar, lasers and cameras take over to monitor the world around the car, 360-degrees. The software can recognise objects, people, cars, road marking, signs and traffic lights, obeying the rules of the road and allowing for multiple unpredictable hazards, including cyclists. It can even detect road works and safely navigate around them. The main head behind the detecting, recognizing and categorizing the objects is the Google Chauffeur. This software is included within the Car's computer system. The LIDAR system in the car is an active laser sensor system that illuminates the car's surroundings, creating what are known as point clouds, we have to take those images and provide 3D annotations. This LiDAR data is annotated to

provide accurate georeferenced coordinates that are used to replicate the reality of a car's surroundings, creating the Al that makes the technology safer and more reliable. For semantic understanding, the car takes image understanding from low-level image features to high level semantics by identifying objects and events providing situational understanding, in this autonomous car, one of the major tasks of a machine learning algorithm is continuous rendering of surrounding environment and forecasting the changes that are possible to these surroundings.

These tasks are classified into 4 sub-tasks:

1. The detection of an object
2. The identification of an object or recognition object classification
3. The object localization
4. Prediction of movement

4. Problem Definition

Driving a motor-vehicle is one of the basic tasks that takes place at some point in every person's life. Driving a car requires judgement, control over body, and constant observation of the things happening in the surrounding to traverse through the roads safely, not only for the driver but everyone around. This task seems easy but a lot of human error takes place around us causing accidents.

[9] Every year, traffic accidents account for 2.2% of global deaths. That stacks up to roughly 1.3 million a year — 3,287 a day. On top of this, some 20–50 million people are seriously injured in auto-related accidents each year. The root of these accidents? Human error.

Humans are prone to errors may it be drivers or pedestrians there are many examples that we have faced personally that are caused due to over-confidence, lack of judgement and other distractions.

Unintentional or foolish interruptions caused by the pedestrians, domestic animals and other drivers on road results in accidents and loss of both health and wealth.

Lack of road sense, taking the traffic rules lightly, and disregard to the authorities also results in traffic or vehicle environment difficult to travel in. [10] In 2020, 10,010 four-wheelers were towed away for wrong parking and a fine of Rs 85,73,642 was recovered.

Specially abled people who are physically unable to travel alone, require drivers to carry them around or have to modify their cars with attachments which costs them a lot of money.

5. Objectives

1. To design, fabricate and develop a completely autonomous scaled down vehicle using latest trends in the field of Computer Vision, AI and Embedded Systems as per the feasibility.
2. To apply an algorithm that can find the shortest path with respect to distance in the scaled down map created.
3. To orchestrate a system that detects, identifies, and follows the traffic signs and rules on the roads.
4. To create a system that morally and ethically takes dynamic action for any implausible condition that occurs.
5. To provide user with an application interface that has an overwrite command with higher priority than the system commands.
6. To understand new technologies, hardware and implement the same in a feasible manner.
7. To manage the entire project in a professional manner by cost management, team management and waste management strategies.

6. Project Scope

Our project:

- Can be useful for development of fully autonomous vehicles.
- Can be implemented as a cab service like Ola, Uber, etc.
- Can be useful to students for understanding and implementing the applications of AI, Computer Vision and Embedded Systems.
- Can be useful for differently-abled people and general population for easier and safer travel.

7. Proposed Technology Stack

Hardware:

- Nvidia Jetson Nano 2GB developer kit
- Environment Sensing (camera + LiDAR)
- DC motor
- Electronic Speed Controller
- Stepper Motor
- PCA9685
- Li-Po Batteries
- GSM Module
- Output Devices (LEDs, Buzzers, etc)

Software:

- JetPack SDK – OS for development board
- TensorFlow
- Keras Framework
- OpenCV2
- Python
- Dijkstra Algorithm
- You Only Look Once Algorithm (YOLO)
- Flutter
- MySQL

8. Proposed System Architecture

Block Diagram –

A small draft that will depict our RC-Car structure

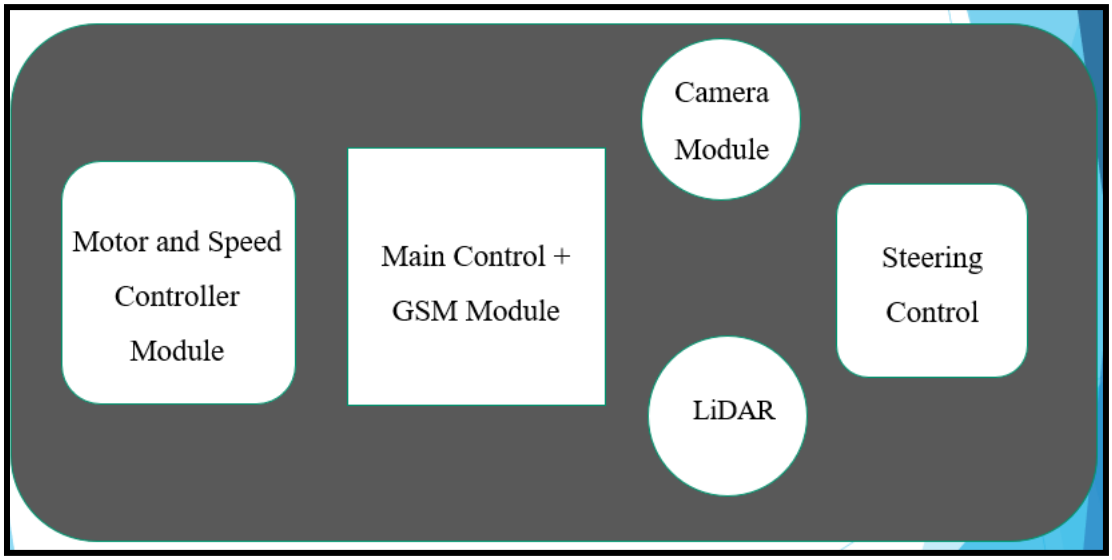


Figure 8.3- Block Diagram of Car

Flow Diagram –

1- Application Flow

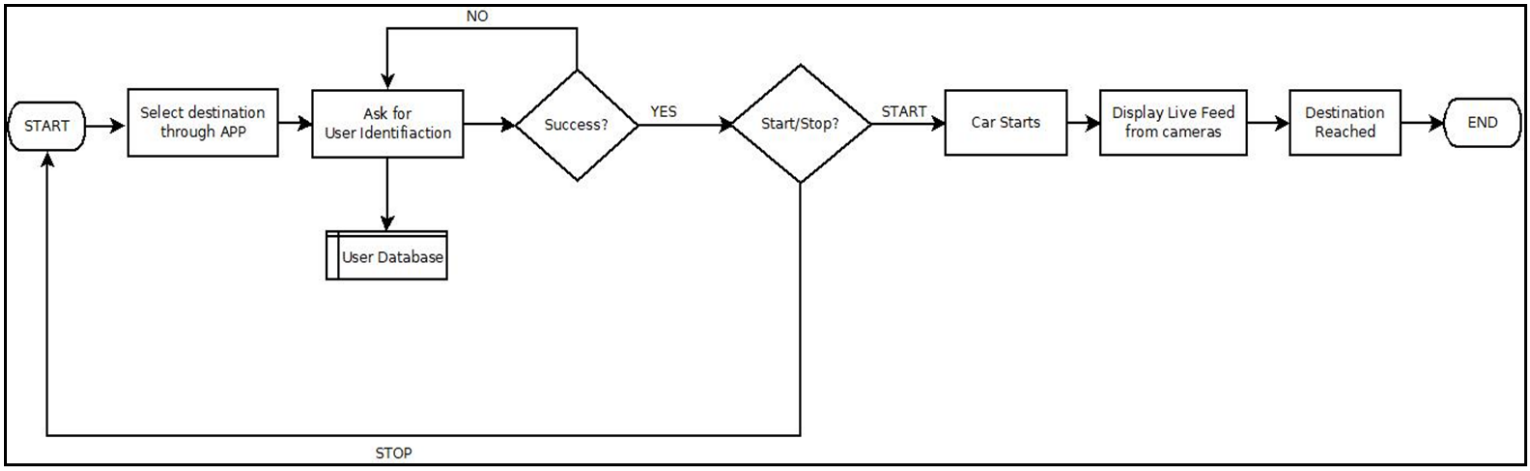
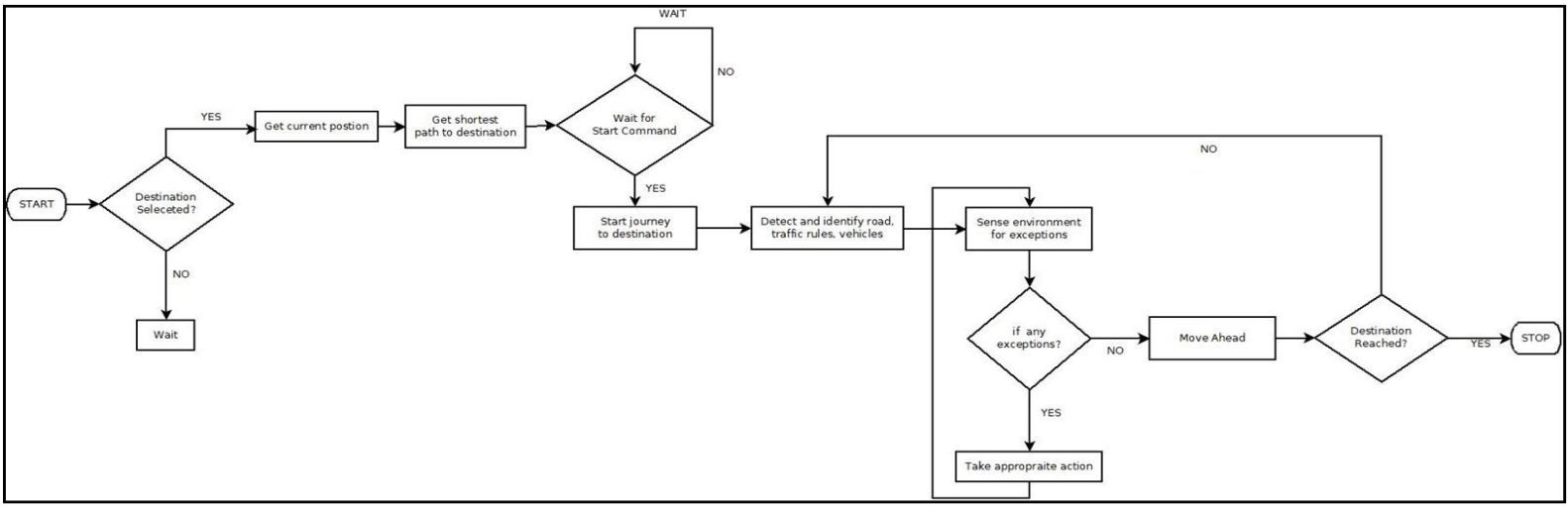


Figure 8.1- Application Flow

2- Vehicle Flow

Figure 8.2- Vehicle Flow



Working of Application:

The system proposed by our team will have an application which can control the car. The application will have following features –

1. It will have a GUI interface through which the user can select its destination.
2. As soon as user selects the destination, user needs to be validated. Once user is authenticated, then only user can start its journey. Validation will be done through the database.
3. User can stop the car or can overwrite the system commands; this feature is given by our team so that if any implausible condition occurs and if the machine gets confused on which thing to act-on then the user can take the decision.

Working of Vehicle:

1. The vehicle will first check if the destination is selected by user or not. If not, then the vehicle will wait for the destination to be selected.
2. If yes, then it will first check which destination is selected and it will determine its shortest path using the shortest path algorithm.

3. It will wait for the start command from the user. If the start command is sensed by the vehicle, then it will start its journey.
4. As soon as it starts its journey, it will detect and identify the roads, vehicles and traffic signs.
5. It will continuously sense the environment and will if there any exceptions occurred. If not, then it will continue its journey.
6. If yes, then it will take appropriate actions till the exception is not fully encountered by it.
7. If the destination is reached then it will notify the user that "Destination is Reached".

9. Summary

Summarizing the report, the project is going to be a great way through which machine learning, specifically computer vision can be studied and applied through a hands-on approach. The objectives and scope of the project are decided based on primitive feasibility study. The hardware and software technology stack decided will enable us in achieving the goals and objectives set. The self-driving cars will combine a variety of sensors to perceive their surroundings, such as LiDAR. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage using algorithms and deep learning frameworks namely YOLO (you only look once), keras, TensorFlow and OpenCV respectively. It also proves that working on autonomous vehicles, albeit smaller scale models, does not need to involve a huge financial investment or obligation, but with a savvy building mindset can be made into a great platform which actually performs well in the real world.

References

1. Margarita Martínez-Díaz, Francesc Soriguera “Autonomous vehicles: theoretical and practical challenges”, 2018 Transportation Research Procedia, Volume 33.
2. Martin Cunneen Martin Mullins & Finbarr Murphy ”Autonomous Vehicles and Embedded Artificial Intelligence: The Challenges of Framing Machine Driving Decisions:”, 2019, Applied Artificial Intelligence , An International Journal
3. https://bib.irb.hr/datoteka/1071914.5e4dc43800410_Building_a_Self-Driving_RC_Car_-_Ivan_Orsolic_0016114170_Masters_thesis.pdf
4. https://www.kdnuggets.com/2017/06/machine-learning-algorithms-used-self-driving-cars.html
5. https://iiot-world.com/artificial-intelligence-ml/machine-learning/machine-learning-algorithms-in-autonomous-driving/
6. https://aithority.com/guest-authors/how-to-get-started-as-an-ai-developer-for-self-driving-cars/
7. https://www.slideshare.net/KonapalaKumar/google-self-driving-car?from_action=save
8. https://waymo.com/tech/
9. https://towardsdatascience.com/how-to-train-your-self-driving-car-using-deep-learning-ce8ff76119cb#:~:text=Every%20year%2C%20traffic%20accidents%20account,auto%2Drelated%20accidents%20each%20year.
10. https://www.tribuneindia.com/news/ludhiana/rs7-2-cr-fine-collected-from-1-48l-violators-205340#:~:text=In%202020%2C%20a%20total%20of,away%20and%20Rs%201%2C89%2C
11. https://analyticsindiamag.com/computer-vision-using-tensorflow-keras/
12. https://www.cvfoundation.org/openaccess/content_cvpr_2016/papers/Redmon_You_Only_Look_CVPR_2016_paper.pdf
13. https://www.mygreatlearning.com/blog/yolo-object-detection-using-opencv/#sh3
14. https://www.section.io/engineering-education/introduction-to-yolo-algorithm-for-object-detection/#:~:text=YOLO%20is%20an%20algorithm%20that,%2C%20parking%20meters%2C%20and%20animals.
15. https://machinelearningmastery.com/how-to-perform-object-detection-with-yolov3-in-keras/