Intelligent Speed Management System

Prototyping and Testing Report by T60

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1 Motivation

The primary reason for creating this system is to increase traffic safety. We can make sure that drivers are moving at a safe speed limit based on the road conditions by putting in place a dynamic speed restriction system. The system determines the proper speed restriction by taking into account a number of variables, including the weather, traffic, and kind of route.

Our system aims to display speed limit signboards by dynamically setting the speed limit based on the current state of the roads. By doing this, the speed limit is consistently at its best and is safe for everyone on the road. The system's objective is to locate the line of visibility using image processing algorithms, instead of typical visibility sensors, to save cost, or the spot where the road and the sky meet, and use this data to determine the speed limit.

The frequency of accidents on the road can be greatly decreased by creating a system that can automatically limit the speed of cars based on the circumstances of the road. By ensuring that cars are moving at the proper speed limit, the technology can also aid in easing traffic congestion, especially in crowded regions.

2 Literature Survey

- The concept of speed limiters has been around for quite some time, and there have been some attempts to develop dynamic speed limiter systems. Some of the existing systems use GPS and map data to set the speed limit, while others use sensors to detect the road conditions. However, most of these systems are too expensive

- Lately, the popularity of machine learning techniques, computer vision and image processing techniques has increased in all fields. Using all these fields, a study was conducted by Li et al. (2018), where they developed a dynamic speed limiter system that used a camera and deep learning algorithms to detect the road conditions. The system was tested on a highway, and the results showed that it was highly accurate in setting the speed limit based on the road conditions.

- Another study by Dadios et al. (2019) used a similar approach, where they used Object detection using convolutional neural networks to detect the road and traffic conditions and set the speed limit accordingly. The system was tested on a busy road, and the results showed that it was highly effective in reducing the number of accidents.

- Several other studies have used various techniques such as fuzzy logic, neural networks, and decision trees to develop dynamic speed limiter systems. However, most of these systems are still in the experimental stage and have not been implemented in real-world scenarios.

3 Project Scope

The scope of our prototype was to design and implement a minimum viable product(MVP) that could detect the line of visibility if given an input image/video and also detect the traffic passing through the system and adjust the display with the appropriate speed limit for the vehicle so that the traffic congestion is avoided and accidents are prevented. The system was designed to be mounted on the side of the road where camera's already exist for integration for traffic detection. The following is a detailed description of the scope of our work:

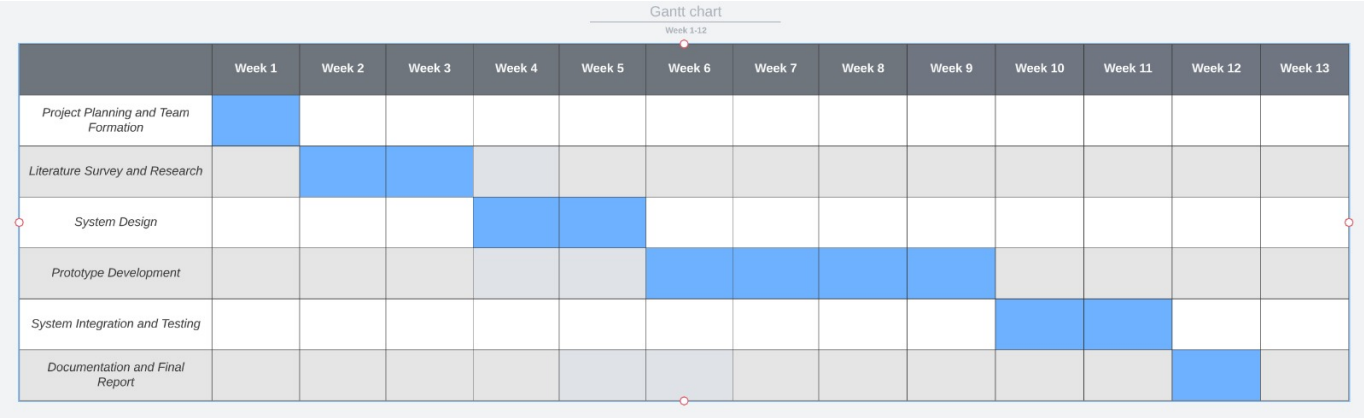
1. **Image Processing**
   Our image processing algorithm was designed to identify the line of visibility on an input image, which would be used to determine the appropriate speed limit for the vehicle. The algorithm was designed to work with a range of input images, including those taken from different angles, distances, and lighting conditions. The algorithm is tested and proved to work in fairly good lighting conditions, even during night with street lights

2. **Speed Limit Calculation**
   Our speed limit calculation algorithm was designed to calculate the appropriate speed limit for the vehicle based on the line of visibility identified by the image processing algorithm and the density/count of vehicles passing through that point per . The algorithm was designed to take into account the distance between the vehicle and the line of visibility, the angle between the line of visibility and the vehicle's direction of travel and density of the traffic. Under our testing the algorithm was working efficiently in different cases and gave out very safe speed limits.

3. **Display**
   Our display system was designed to display the calculated speed limit on an LCD screen using Arduino code. Since this is just a prototype we used the LCD screen to display the speed limit in large, clear letters with high contrast. We also added a warning message to the code that would alert the driver if they exceeded the speed limit, this is implemented,again, by integrating already existing cameras. No new cameras are required to be setup .

4. **Integration**
   Our prototype finally is a integration of all the various components mentioned which is a fully functioning dynamic speed limiter system. The integration process involved ensuring that the MATLAB algorithm, the Arduino code, and the LCD screen were all working seamlessly together.

4 Project Roadmap/Timeline



Project Roadmap

5 Roles and Responsibilities

Our team of five members worked collaboratively to complete the dynamic speed limiter system project. Each member was assigned specific roles and responsibilities based on their areas of expertise and interest. The following are the details of each member's responsibilities:

1. **Image processing and line of visibility detection using MATLAB**
   Sasank(CS20B1005) was responsible for developing the image processing algorithm using MATLAB. This included identifying the line of visibility on the input image, using various image processing techniques, which would be used to determine the appropriate speed limit for the vehicle. Sasank had prior experience in image processing and so was able to implement this alternative to visibility sensor using image processing which is cost effective and fairly accurate as seen from the results. He was also responsible for making CAD model in the initial stages

2. **Speed limit calculation using Python**
   Sravanth(CS20B1006) was responsible for calculating the speed limit using Python. This involved taking the line of visibility identified by Sasank by sending his MATLAB Code the image of the road and using it to determine the maximum allowable speed for the vehicles. Sravanth is well-versed in python and mathematical calculations, so he developed dynamic speed limit calculation algorithm using the Visibility calculated by Sasank previously And finally fed the speed limit to ardiuno's serial monitor for further display in the LCD Screen .

3. **Display using Arduino code and LCD screen**
   Avinash(CS20B1044) was responsible for designing and implementing the code to display the speed limit on an LCD screen using Arduino. This included learning all the details about Arduino, installing the environment and learning about the necessary hardware and writing the code to receive the speed limit data from the python algorithm and display it on the LCD screen. Avinash(CS20B1044) had experience in programming and was able to complete this task effectively. He was also responsible for drafting bill of materials.

4. **Integration of all components together**
   Gaurav(CS20B1021) was responsible for integrating all the individual components of the system together. He connected all the components we bought from web and connected them and ensured they were working properly. Gaurav(CS20B1021) had experience in project management and was able to ensure that the integration was done smoothly and on time.

5. **Worked on a video-based object and traffic detection algorithm**
   Saketh Ram(CS20B1042) was responsible for researching and implementing a video-based object and traffic detection algorithm to enhance the system's functionality. This included identifying the appropriate algorithm for object detection, testing it, and integrating it into the existing system. Saketh(CS20B1042) has experience in computer vision in python and so was able to implement an object detection feature to add to the decision of calculating the speed limit.

Overall, each member of the team had a critical role in the project's success, and all team members worked collaboratively to ensure that the project was completed on time and within budget.

6 Methodology

Our methodology in making a MVP that could display appropriate speed limits on the roads depending upon the weather, road conditions and the traffic density.

1. **Getting the weather conditions on the road**
   The main focus was on weather condition detection, it is rarely present on the roads albeit being a major concern for road accidents. Weather condition detection was done by measuring the visibility. This visibility was tough to measure using regular methods like back-propagation technology because they are expensive. So we decided to use an out of the box solution of using cameras and doing image processing on that to get the visibility line for further calculations.

2. **Getting the information regarding the traffic**
   Now that we had weather conditions, we next moved to getting traffic conditions, specifically the number of vehicles passing the junction per hour. Getting this count is challenging. We had to use some high level computational object detection models to get this information. Since our resources are limited we chose to do all the computation on the cloud and send back the result to the system to display.

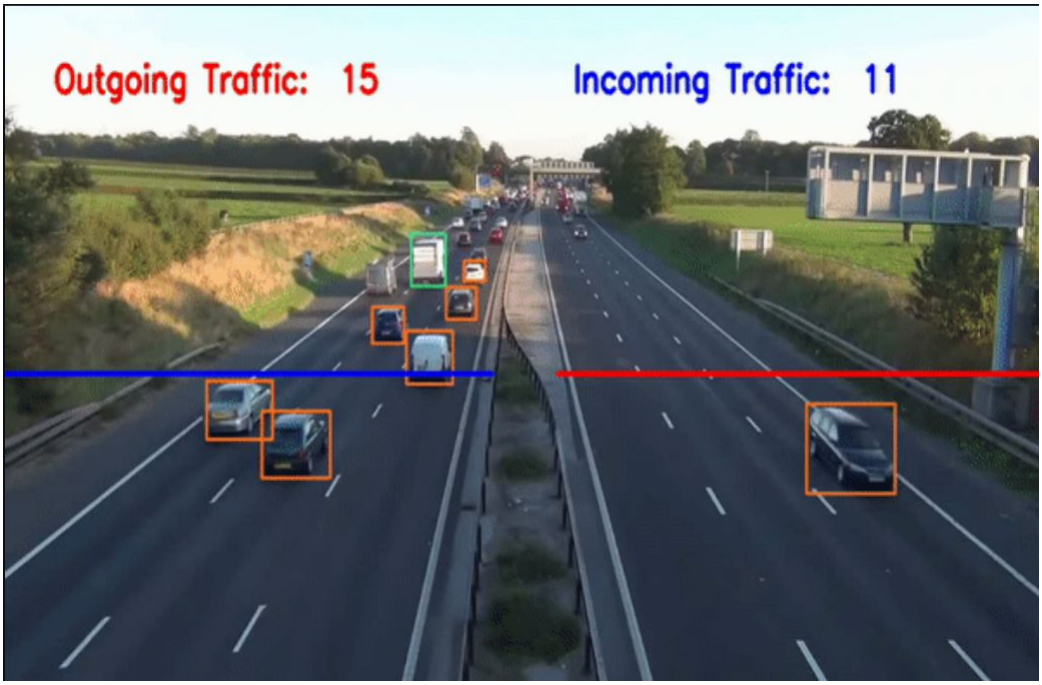
3. **Display**
   Now we had the input data for our system we had to make a algorithm that uses these inputs in accordingly and calculates the speed limit for the users to follow. We have also taken into account the data given out by weather APIs and google maps APIs and used them to make a decision. The algorithmic design part was more research intensive than the others. Various government organisations have published works regarding the acceptable speed limits under various conditions. We made a note of all these conditions and designed an algorithm to produce a speed limit that helps people travel safe and fast without congestion.

4. **Integration** The final step in our methodology was to integrate all the individual components of the system together. This involved ensuring that the algorithm, the Arduino code, and the LCD screen were all working seamlessly together.

```
1
2  ser = serial.Serial("COM7", 9600)
3  # speed_limit = min_speed + (max_speed - min_speed) * (max_vis -
   ↪  data_dict["test0"]["vis"]) / (max_vis - min_vis)
4  # print(speed_limit)
5  while 1:
6      print("Enter the index of the test image: (Enter -1 to exit): ")
7      index = int(input())
8      if index == -1:
9          break
10     if index <= 5:
11         speed_limit = min_speed + (max_speed - min_speed) * (max_vis -
           ↪  vis_list[index]) / (max_vis - min_vis)
12         # round off to 2 decimal
13         speed_limit = round(speed_limit, 3)
14         speed_limit = str(speed_limit)
15         ser.write(speed_limit.encode())
16     else:
17         ser.write("Error Getting Image!".encode())
```

A Python Code Snippet for Calculating the Speed Limit

Link to the full Code



Traffic Density Counting by detecting and counting vehicles

(a) Maximum speed limit of 20 km/h

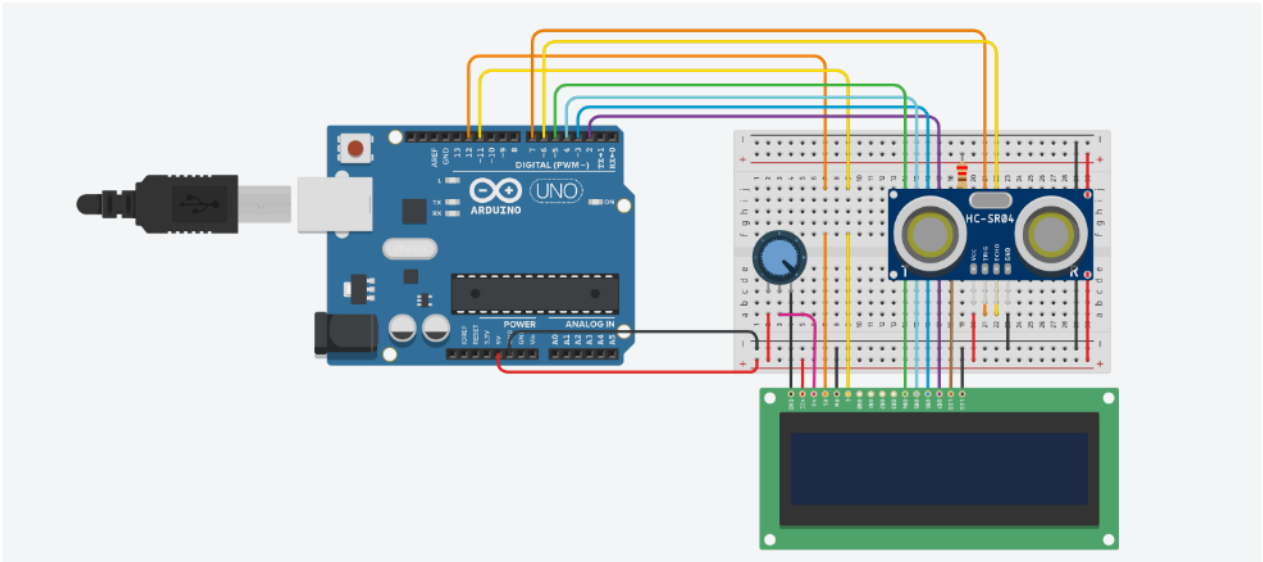
(b) Maximum speed limit of 40 km/h

7 Bill of materials

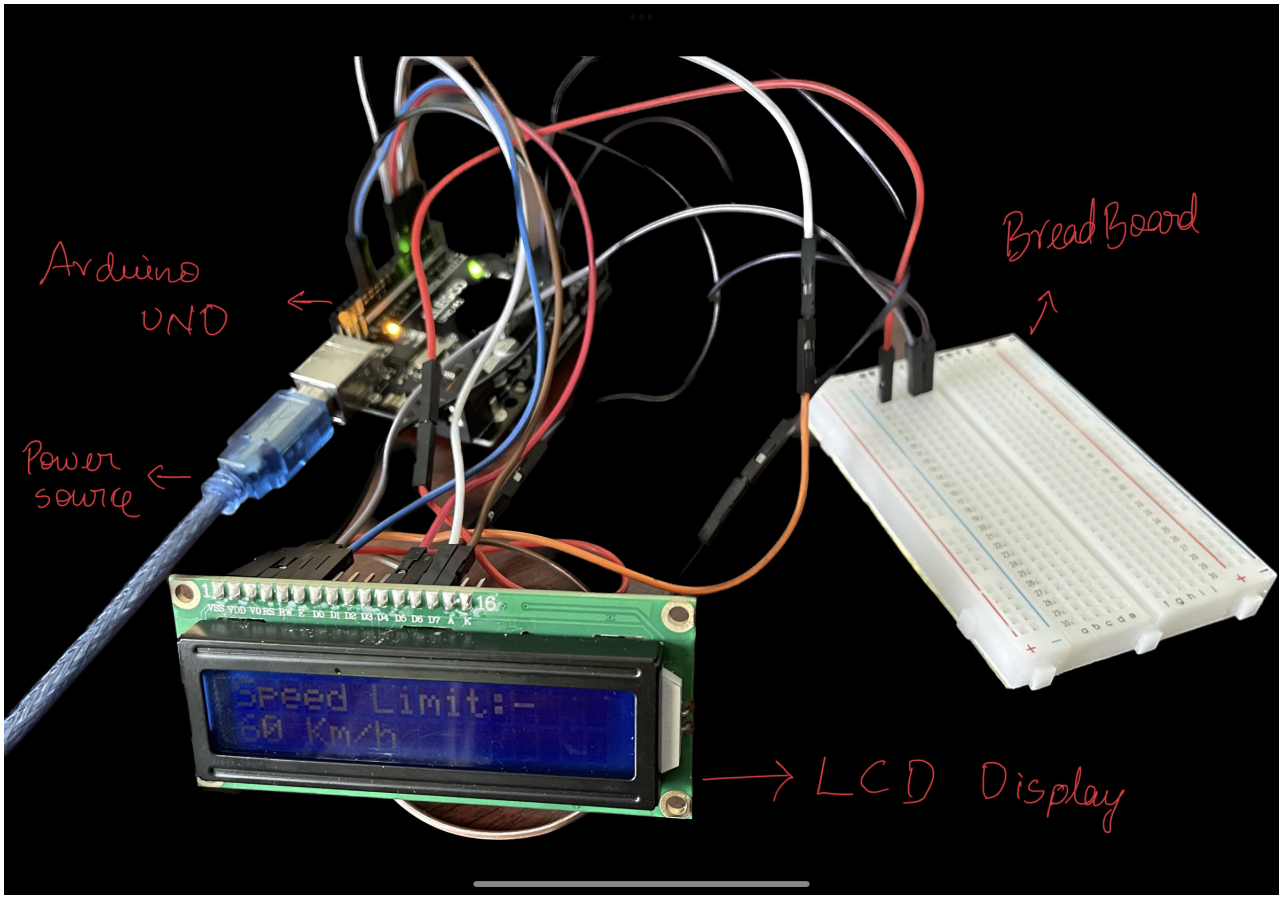
Table 1: Bill of Materials

Name	**Price**	**Qty**
16 x 2 LCD Display	120	1
Arduino Uno board	1000	1
Battery (AA)	–	–
ESP32-CAM Development Board WiFi Bluetooth Module	1100	1
MISC (Cables, Enclosure, wiring etc)	310	1
APIs (Google Maps, weather etc)	NIL	–
Total	**2530**	**4**

8 Prototype/CAD model with labels



Tinker CAD model of the Prototype



Picture of Prototype with Labels

9 Key takeaways/learnings from course

1. **Specific to the project**
   One of the key takeaways from this project was the importance of proper project planning and time management. Creating a detailed roadmap and assigning clear roles and responsibilities to team members was easy but actually sticking to that road map was fairly difficult, nevertheless we ensured that the project stayed on track and met its deadlines. Additionally, working with different hardware and software components required careful attention to detail and problem-solve in order to create a functional system.

2. **General learnings from the course**
   Throughout this course, We gained a deeper understanding of the principles and best practices, from the teachers, for designing and building complex real world systems. Specifically, We also gained a better understanding of the role of testing and validation in ensuring that a system meets its functional requirements and is robust enough to handle unexpected environments. Throughout this project, we learned the importance of value addition in creating a successful and impactful product. Initially, we started with the goal of creating a dynamic speed limiter system that could accurately detect speed limit signs and adjust the speed of a vehicle accordingly. However, as we conducted research and developed our prototype, we

realized that simply detecting speed limit signs was not enough, we had to add new functionalities to provide true value to the customer.

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10 Future scope

Our dynamic speed limiter system prototype has several potential avenues for future development and improvement. Some of the possible future scope for the project are:

1. **Real-time Video Input**
   As of now, our system can only use a single input image for speed limit detection. In the future, we can expand our system to use real-time video input for more accurate and dynamic speed limit detection. This would involve using a video camera instead of what we are using now and bettering the image processing algorithm to work on video streams.

2. **Object Detection**
   As of now our system does not have efficient any object detection capabilities. In the future, we can expand our system to include object detection to detect and avoid obstacles or traffic. This would involve using object detection algorithms such as Y.O.L.O.(you look only once)which uses an end-to-end neural network that makes predictions of bounding boxes and class probabilities all at once into our system.

3. **Wireless Communication**
   Our system currently uses a wired connection between the Arduino board and the LCD screen. In the future, we could use wireless communication technologies such as Bluetooth or Wi-Fi to improve the flexibility and range of our system by removing limitation caused by wired mode.

4. **User Interface**
   Our system currently displays the detected speed limit on an LCD screen as its only an prototype. In the future, we could develop a more user-friendly interface that displays the speed limit and other relevant information on a smartphone app or a dashboard display to come in notice of the driver.

5. **Automated Speed Control**
   Our system currently only displays the detected speed limit. In the future, we could develop an automated speed control system that controls the speed of a vehicle based on the detected speed limit. This would involve integrating the system with the vehicle's throttle and brake systems.

11 Conclusion

In conclusion, our team T-60 has successfully designed and implemented a dynamic speed limiter system prototype that can detect and display the speed limit using an input image that is taken every 2 minutes on the road. The system uses MATLAB for image processing and speed limit calculation and Arduino code for displaying the speed limit on an LCD screen.

The project has taught us valuable skills in image processing, algorithm design, programming, and teamwork. We were able to leverage our individual strengths and work together towards a common goal, resulting in a functional prototype.

Although our system has limitations such as the use of a single input image and the lack of object detection capabilities, we are proud of the work we have accomplished and believe that this project has real-world applications, particularly in the field of autonomous vehicles.

Video Documentation of Project

Here's the drive folder for the Project: https://drive.google.com/drive/folders/12HBaUTnai8YjT8jaEHbAbNr2kRdspKm1

References

1. Arduino. (2023). Arduino Uno.
   Retrieved from `https://www.arduino.cc/en/Main/ArduinoBoardUno`

2. MATLAB. (2023). MATLAB.
   Retrieved from `https://www.mathworks.com/products/matlab.html`

3. Improving homogeneity by dynamic speed limit systems Nicole van Nes , Stefan Brandenburg, Divera Twisk

4. Dynamic speed limits; effects on homogeneity of driving speed Nicole van Nes, Stefan Brandenburg and Divera Twisk

5. Review of Variable Speed Limits and Advisories: Theory, Algorithms, and Practice Xiao-Yun Lu xiaoyun.lu@berkeley.edu and Steven E. Shladover

6. MAGE processing based intelligent traffic controlling and monitoring system using Arduino

7. Smart Traffic Control System Using Image Processing Rishikesh Mishra,Ganesh Helambe

8. New Vehicle Speed Measurement System with Image Processing Lifeng Zhang

9. Design of an Automatic Vehicle Speed Limit Notification and Warning System Thandiwe E Mashayahanya, Powell Mlambo, Eugenia R Chiweshe, Rumbidzai Muvunzi ,Michael Matingo

10. Intelligent Vehicle Speed Controlling and Pothole Detection System Aditya Anand, Rushiraj Gawande ,Prathamesh Jadhav , Rima Shahapurkar ,Anjali Devi

11. Alcala, F., Campoy, P., Lacroix, S. (2019). Vision-based obstacle detection and avoidance for autonomous driving: a survey. Journal of Field Robotics, 36(2), 393-416. doi: 10.1002/rob.21847

12. Moutarde, F., Stanciulescu, B. (2018). Pedestrian detection: An evaluation of the state-of-the-art. Computer Vision and Image Understanding, 167, 21-51. doi: 10.1016/j.cviu.2018.01.003

13. Park, S., Cho, S., Lee, S. (2020). A study on speed control by detecting speed limit signs using deep learning. Sensors, 20(16), 4618. doi: 10.3390/s20164618

14. Vilaça, J., Viegas, P., Mendonça, R., Santos, V. (2019). Smart speed bumps for traffic calming in smart cities. Sensors, 19(3), 526. doi: 10.3390/s19030526

15. Zhang, J., Fang, Y. (2019). Automatic traffic sign detection and recognition: A survey. IEEE Transactions on Intelligent Transportation Systems, 20(2), 673-679. doi: 10.1109/TITS.2018.2830989