GPS RECEIVER BASED ACCIDENTAL PREVENTION SPEED CONTROL SYSTEM

Mr. Samyakkumar Jain
Institute of Technology, Nirma University

Mr. Zeal Patel
Advanced Robotics Group, Houston, Texas, US

Ms. Ritu Bansal
Symbiosis Centre of Information and Tech. Pune

Ms. Priyanka Thakkar
Technical University Darmstadt, Germany

Abstract

This work proposes designing and implementation of the speed control system to prevent over-speeding, as it is increasingly one of the major concerns for some countries. Major causes of the accidents that occur in day-to-day cycles are either due to over-speeding or being ignorant of the speed limit sign-boards. Considering these facts, the proposed design and work is to achieve speed control, based on vehicle location and form sensor networks in overall cities with the use of public transport or personal vehicles. In the proposed design, speed can be reduced with the help of the Speed Control Unit (which consists of motor/actuator or pneumatic cylinders or by directly accessing the ECU (Engine Control Unit)), according to location-specific pre-defined speed limits that have been stored into the database. Based on the information collected by sensors, the proposed mathematical model will take the decision and generate a control system to perform certain actions such as warning alarm indication or reduction of the speed slowly or gradually based on the safety parameters. The proposed design has been implemented and verified using the test runs around the college campus with virtually mapped real-world maps & speed limits parameters.

Keywords: ECU (Engine Control Unit), GPS (Global Positing System) receiver, Processing Unit, Speed Control Unit

1. INTRODUCTION

In day-to-day life, it is common that we hear news regarding the occurrence of deaths due to over-speeding, be it, students rammed over by vehicles in school zones or buses falling into mountain gorges. Over-speeding has become one of the increasing concerns of any nation. Statistics show that over 67% of accidents occur due to over speeding, accounting for around 61% of deaths every year. As many as 1000 school-going children get injured and have become victims of speeding in school zones where the speed limit is not observed and maintained. These data should not come as a surprise, considering 73% of drivers maintain their usual speed while driving through these areas and about 7% ignore the stop signs. India loses around 8 billion $ annually due to road accidents, clearly affecting the GDP of the country.

Keeping these data in mind, the main objective of this proposed design is to reduce and limit the speed of vehicles whenever they cross sensitive areas like school zones and mountain ranges, which in return will lead to a decrease in the number of accident cases.

The speed limits for particular roads, highways are decided based on global parameters like Nature, Engineering, and Humans. The high-way and traffic researchers collect a huge amount of data through different methods from the real world and create a cost-based model to analyze/research these data. Researchers also consider the parameters like weather, visibility, terrain, and location while working on some roads, hills, or high-way places to decide speed limits. These data can also be used for several other purposes such as road, crash risk, traffic [1], road material, shoulder space, and maintenance schedules. Generally, human-related data is the main focus taken into consideration while deciding the speed limits, for which researchers follow the 85^{th} percentile rule.

The speed limit is not only a technical/technological thing, but it is also a combination of Physics and Biology overall, because the faster the speed, the less time for the human brain to react when something goes wrong. According to the data, the faster a person is moving, the more is the kinetic energy in the vehicle which increases the chance of a worse crash and is also indirectly proportional to the speed of the vehicle. Due to the amalgamation of data collected through various sources and human efforts involved to analyze these data, it may result in small deviation while constructing roads depending on location and infrastructure, leading to accidents.

The proceeding sections of this article are organized as follows: Section 2 introduces vehicle speed control/limiting methods and literature review. Section 3 describes the research work for the proposed accident prevention speed control system. Section 4 evaluates the proposed techniques in terms of reliability, area, and performance overheads.

2. VEHICLE SPEED CONTROL/LIMITING METHODS

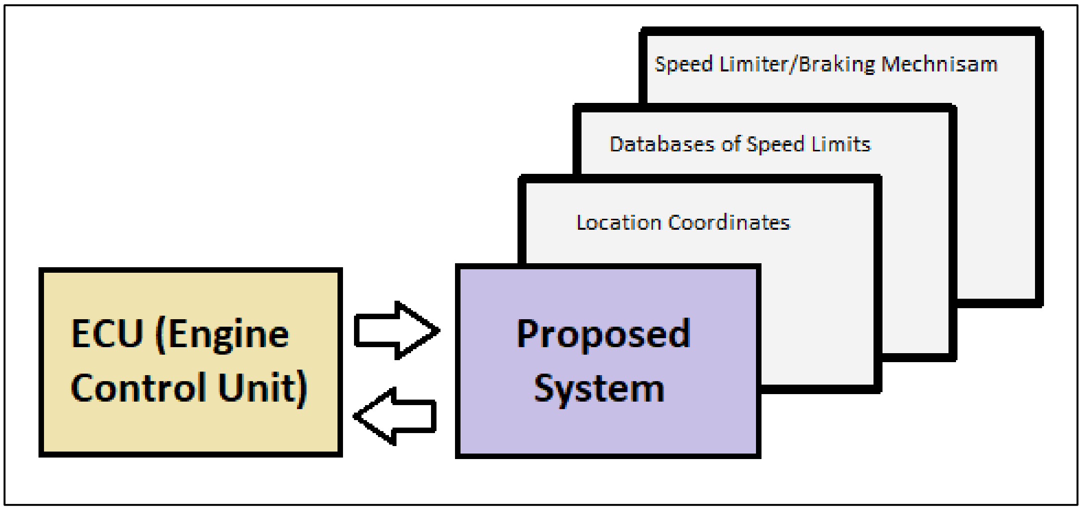
By controlling the vehicle speed, it gives benefits like reduction in traffic noise, Pollution, Green House Gases, Average Fuel Consumption, and its Barrier effects. Many devices and methods [2] [3] [4] are available in the market for the same but as such, no official rules [5] have been created. To control the speed of vehicles there are 2 possible ways, the first is infrastructure changes in roads, Landmarks, Humps, Platforms and the second is Vehicle Technology and Enforcement. The infrastructure changes include (1) Adaptions for speed reduction at high-risk locations using speed hump and raising platforms for pedestrians [6][7], (2) Gateway infrastructure treatments by indicating new speed regime, (3) Roundabouts slow traffic at intersections via positively change the potential impact angle, provide better visibility and clarity about traffic flow and right-of-way [8], (4) Pavement narrowness and optical treatments which present a feeling or even illusion that the driver is going too fast [1].

The infrastructure changes may require proper planning and a picture of long-term execution. The Vehicle Technology includes external supportive active and passive systems where active systems will automatically intervene and correct the speed and confirm with safe speed limit and passive systems will only warn the driver of the vehicle traveling at an unsafe speed [5]. This Vehicle Technology can be implemented with the Enforcement to improve the awareness and compliance of Traffic Rules and Road-Signs which can be integrated with Spot Cameras and Automated in-vehicle enforcement devices/systems.

3. RESEARCH WORK

As over speeding is a major issue in the normal vehicle in the market, the proposed design consists of a Location-specific database, speed measurement, location coordinates, and speed limiter/braking mechanism as shown in Fig. 1 which will be communicated with the existing ECU of the Vehicle.

Fig 1: Block Diagram of the proposed technique



The processor has an inbuilt mathematical model that uses the current speed and location which will be compared with the location-specific defined speed limit from the database. Based on the result from a mathematical model, the action needs to be taken against the over/instantaneous speed with measuring parameters like effective speed difference, force, and timing details. The system will perform the event of reducing the speed of the vehicle as per the specified parameters by a mathematical model.

3.1 Location Specific Speed Limit Database

As per the rules and regulations of the government, every road, landmark, the highway has some speed limit based on the geographic or nearby landmark locations which need to be followed by every vehicle based on its weight and vehicle category. During the construction of the road or any infrastructure, location-specific details and the traffic/road laws are applied as per the guidelines mentioned in the rule/section. Vehicles should be instructed to follow speed limit guidelines, considering the safety of children & other public near hospitals, schools/colleges, accident-prone areas, etc. These all speed-related data is put on the banner/signs so that drivers can follow the same. The author has proposed a safety system in which these data will be stored and recorded for the use of Electronic Safety System to fetch the information about the road, landmarks, and traffic rules related data.

3.2 Instantaneous Speed and Location Measurement

The other component of the proposed system is that system uses speed and location which needs to be used for querying the road details and to make a comparison for decision making.

Information on potential speeding can be taken from GPS location, road maps, radio beacons, optical recognition, and dead reckoning techniques. As far as the real-time position/tracking is concerned, Satellite-based systems like GPS & NavIC are more reliable compared to other techniques but these rely on the infrastructure of roads/landmarks and vehicle technology used in Dashboard and ECU. As satellite and communication technology has become advanced nowadays, the amount of accuracy for location measurement is increasing significantly. The high-way and traffic researchers use road maps, radio beacons, optical recognition, and speed radars for other purposes.

3.3 Braking System or Speed Limiter

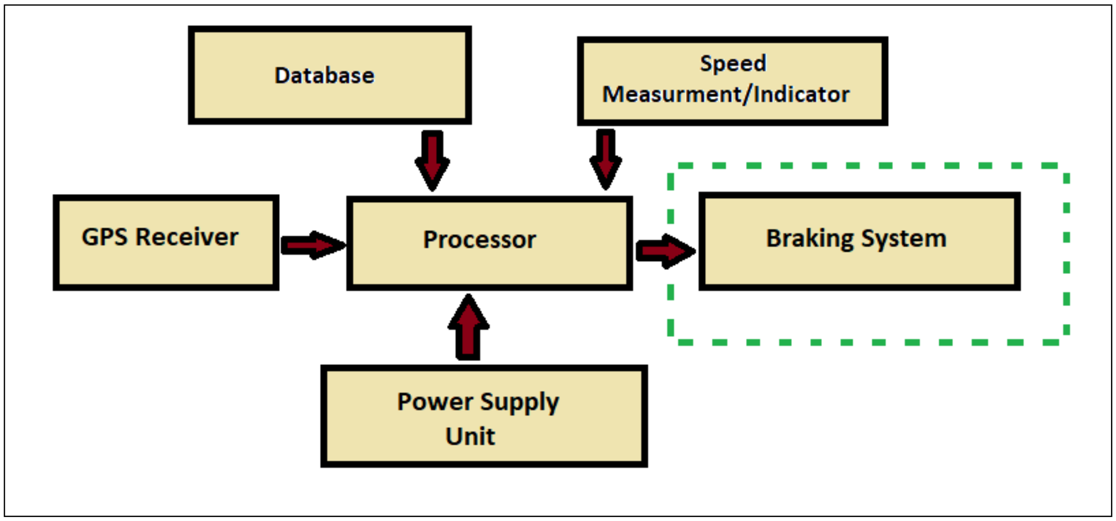
In many vehicles, the adjustable speed limiter or Intelligent Control Systems are equipped, where Adjustable Speed Limiter has freedom/controllability to driver to change or adjust threshold speed. Speed limiters are installed only on some categories of cars/vehicles which are mostly counted in premium categories. Speed limiters work based on the sensors reading from the vehicle dashboard/ECU. These speed limiters will transfer the command and control to ECU to stop the flow of the fuel further, after reaching the threshold limit which has been calculated through differential equations and models set by the manufacturer.

Braking systems are also a crucial part of vehicle technology, as direct brakes cannot be applied via the system for security and safety purposes. The ABS (Anti Braking System) helps the ECU to calculate the amount of force/action needed to be applied to stop at emergencies and prevent a crash. The proposed system will be in the form of an external device that can be installed manually on the vehicle based on the enforcement laws embedded by the government/traffic & road department. The reason behind using the external device is that every vehicle is not equipped with such technology and is not designed based on such criteria. This device can be embedded to increase the amount of road safety and save economic losses.

4. IMPLEMENTATION & SIMULATION RESULTS

The proposed design consists of Speed Measurement, Processing Unit, and Braking System as shown in Fig 2. The processing unit consists of a processor, power supply module, database, and indicators.

Fig 2: Block Diagram of the proposed technique



As the proposed Safety System boots up, the processor will invoke the commands to collect the instantaneous location from the GPS receiver and transfer it to the measurement model created by authors which is responsible for the course of action needed to perform by the processor and other supportive components. This model will query the database for safety limits and road details which will be further getting compared with the current speed of the vehicle. According to the difference between current speed and safety limits, the model will transfer data and control to the processor, through which the processor will generate an indicator/alarm at the user Dashboard and instruct him/her to decrease the speed and keep pooling the current speed data. If the driver will not respond to the indicator/alarm, the system will come into action simultaneously pooling data from the location receiver.

Fig 3: Technology Schematic of the proposed technique

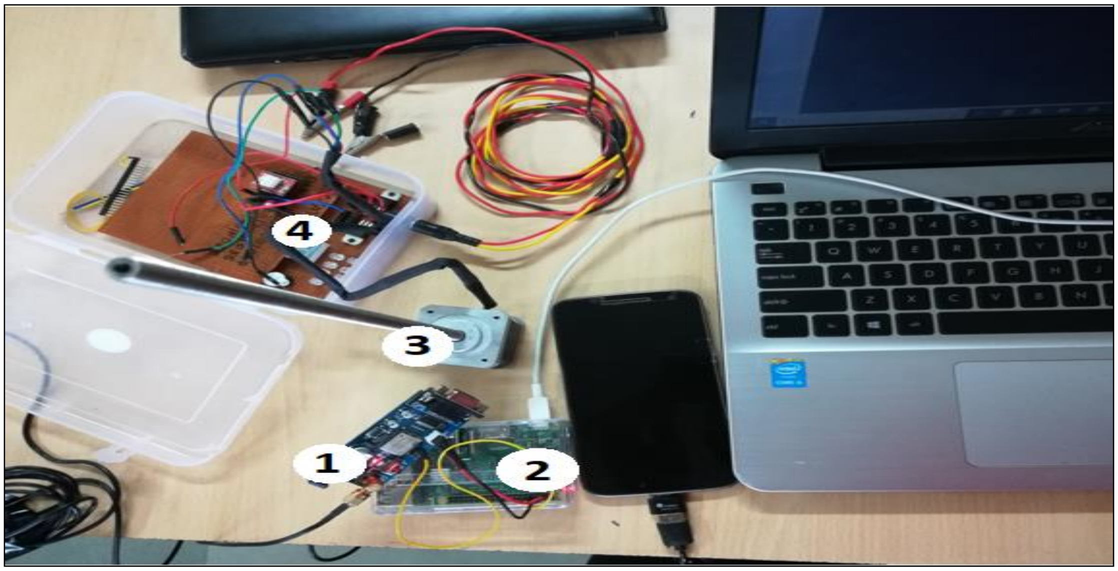
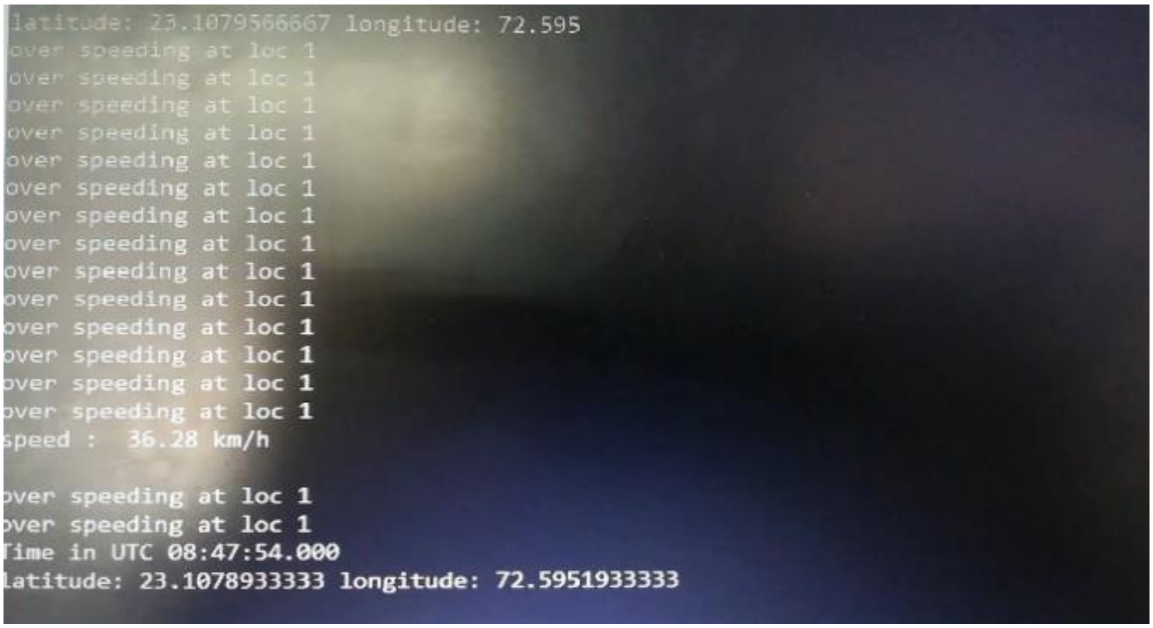


Fig. 3 shows the schematic/implementation of the proposed design, in which GPS Receiver is denoted as Tag-1, Processing Module as Tag-2, Braking System as Tag-3, and Power Management System as Tag-4. As Processing Unit an author has taken Raspberry Pi 3 which contributes as Processing Module, Data Base, and Custom Measurement & decision-making model.

Fig 4: Simulation of test run for proposed system integrated with Google Maps on Location 1

The proposed technique and its implementation have been tested around a college campus with the help of virtual/hypothetical points of limit speed restrictions where the driver had to pass through within the speed limit decided in the databases. These hypothetical locations have been denoted as Location 1 and Location 2 in Fig. 4. This image is taken with help of Google Maps. Our system is linked with maps to create, track and analyze the performance. Based on these test run scenarios, the author has found several modifications and scope of improvements in the developed mathematical model for computation of action.

Fig 5: Simulation Logs of test run for proposed system via remote desktop sharing



This test run has been performed to test and validate the working of each component in the system which mainly includes Measurement of Action and Braking actuation/Action as per the requirements. In the test, the driver has over speeded the vehicle (in virtual/hypothetical experiment, the author has scaled down the limits and threshold values with appropriate mapping techniques), for which the system has been completely into action mode from end-to-end. Fig.5 shows the logs for the over-speeding scenario.

Fig. 4 & 5 show the live simulation of the test run performed by the author on the different receiving ends of the system. As noted in Fig. 4, the live location has been shared and combined with Google Maps with the help of a custom interface script. Fig. 5 demonstrates the remote desktop which is connected with the Processing Unit of the System, showing important information displayed on the command line using logs/debug points.

Fig 6: Simulation of test run for proposed system integrated with Google Maps on Location 2

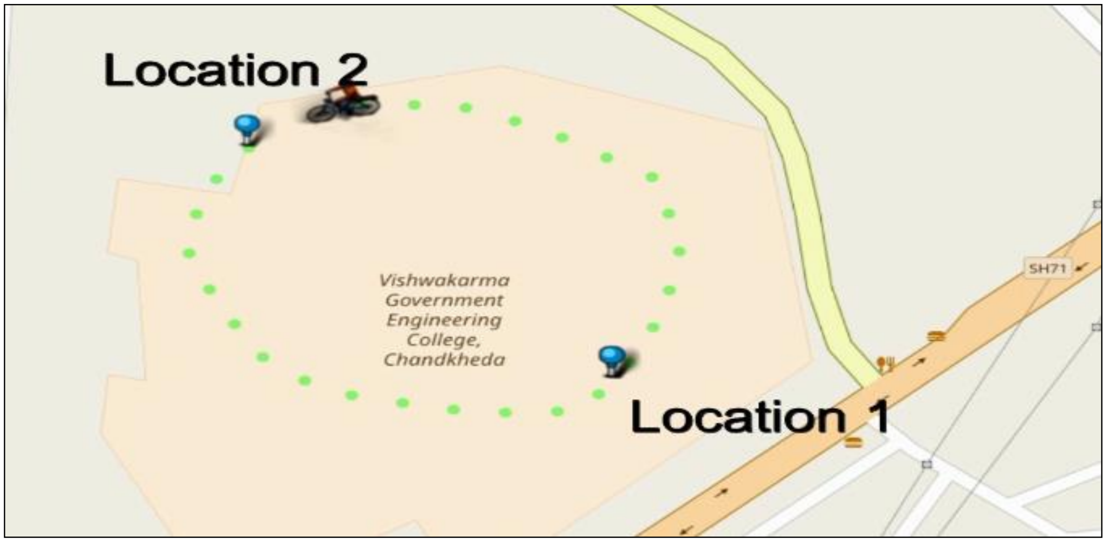


Fig.6 shows the simulation results that have been tested for Location 2 and the author has successfully validated the functionality and correctness of the proposed system.

5. CONCLUSION

Speed Limits, Over-Speeding, and Neglecting Sign Boards have been overcome by Intelligent Autonomous Vehicle System. The demand for an autonomous vehicle with safety, accuracy and reliable design has been on the rise in recent years. Researchers and Scientists are working on Autonomous Vehicle technology with a couple of test runs but safety, reliability, and faith in Autonomous systems are still some issues faced by humans. To overcome the above-mentioned challenges, the proposed design for an accident prevention system is implemented, integrated, and tested into the small real-world field. Implementations like adding extra computing modules, sensors to implement mesh network of multiple devices, and detailed focused design on mechanical/electronic braking system design can be the future scope of the proposed work. The work can be further extended by integrating the system with Traffic Cameras and a real-time ticket issue system for violation of road & traffic enforcement laws. The proposed system can be implemented for better performance and reliable solutions with the intervention of the industries and ECU manufacturing companies.

REFERENCES

[1] Major, R., & Mészáros, G. (2020). Thoughts on Road Traffic Control. Internal Security, 12(2), 54–55. https://doi.org/10.5604/01.3001.0014.6703

[2] Kumar, V. P., Rajesh, K., Ganesh, M., Kumar, I. R. P., & Dubey, S. (2014). Overspeeding and Rash Driving Vehicle Detection System. *2014 Texas Instruments India Educators' Conference (TIIEC)*. https://doi.org/10.1109/tiiec.2014.013

[3] Khan, M. A., & Khan, S. F. (2018). IoT based framework for Vehicle Over-speed detection. *2018 1st International Conference on Computer Applications & Information Security (ICCAIS)*. https://doi.org/10.1109/cais.2018.8441951

[4] A.K., K.J.A., & A.D.R. (2019). A Research For Tracking Overspeeding Vehicles. *International Journal of Recent Technology and Engineering*, *8*(2), 5026–5028. https://doi.org/10.35940/ijrte.b1082.078219

[5] Su, D., Guo, Z., Li, Z., & Zhou, Y. (2016). Operation Risk Model and Monitoring-warning System of Expressway Tunnels. *Transportation Research Procedia*, *14*, 1315–1324. https://doi.org/10.1016/j.trpro.2016.05.204

[6] Bhamrah, R. S. (2016). Variable Density Speed Hump. *International Journal of Students' Research in Technology & Management*, *4*(2), 35–37. https://doi.org/10.18510/ijsrtm.2016.423

[7] Salau, T. A. O., Adeyefa, A. O. O., & Oke, S. A. (2004). VEHICLE SPEED CONTROL USING ROAD BUMPS. *TRANSPORT*, *19*(3), 130–136. https://doi.org/10.3846/16484142.2004.9637965

[8] Rey, G., Clair, D., Fogli, M., & Bernardin, F. (2011). Probabilistic assessment of roadway departure risk in a curve. *Vehicle System Dynamics*, *49*(10), 1649–1671. https://doi.org/10.1080/00423114.2010.532556