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RESEARCH ARTICLE

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AUTOMATED SPEED ADAPTATION

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ABSTRACT: As automotive technology is improving day by day new technologies are being implemented in our cars/vehicles. Recently there is a trend of sports/exotic cars having huge engine power and top speed touching almost 400km/h. But, due to these unlimited access to engine power results in breaking of traffic rules, state laws and mainly the speed limit posted.

Speed limits are imposed by the government authorities which depends on many factors viz. traffic condition, road condition, terrain etc. Overshooting the posted speed limit is an offence but hardly people stick to these.

So, automated speed adaptation (ASA) is a technique based on simple radio transmitter & receiver system, which initially gives a warning to the driver, if no action is taken by the driver to reduce the speed the car automatically, reduces the speed to the required speed limit posted. If the automated speed adaptation program is adopted and implemented the risk of road accidents and the number of people dying because of road accidents will be severely reduced, thus saving both human lives and properties.

Keywords—Speed, Radio, Car, Traffic Rules

INTRODUCTION

Generally, in India people hardly follow the traffic rules while driving. It's a very common scenario where it is seen that the posted speed limit is not followed by any of the cars. There is no such law enforcement that can stop this issue and stop people from over speeding. Over speeding kills thousands of people in India. So, what is the present scenario in terms of speed control in India.

Speed Limit Boards

Government of India and other nations also posted boards sideways the roads to indicate the speed limit of the area [1]. These boards were sanctioned in viewing in mind that people driving cars/vehicles will follow rule and stick to the prescribed speed limit. But, it is sorry to say hardly 10% of people comply with this. It's very hard to accept , but it's reality. Even it is seen that people are driving at more than 100km/h in some zones where the speed limit is 50km/h at nights. Driving at such tremendous speed might lead to

severe accident causing both losses to humans and properties. So, in my opinion the speed limit boards don't have any effect. There is a need of something new and strict rules.

Police and law enforcement units uses various equipment to catch and penalise the defaulters like radar guns, road side cameras, high speed vehicles, etc. [2] But using these kind of techniques required huge expenditure of fund as well as labour. What, if there would have been a technique of automatic reduction of speed depending on the speed limit without the involvement of human? Well, research is being carried out on many such aspects. One of the famous one is INTELLIGENT SPEED ADAPTATION.

DISADVANTAGES OF SOME OF THE IMPLEMENTED TECHNIQUES:

- Hardly 5-10% of people follow the speed limits.
- Over speeding leads to severe accident causing huge losses to human life and damage to property.
- Law enforcement finds it very difficult to contain people to follow the rules, presently a very difficult situation in third world countries.

The disadvantages can be overcome by the technique discussed in details below taking each case separately.

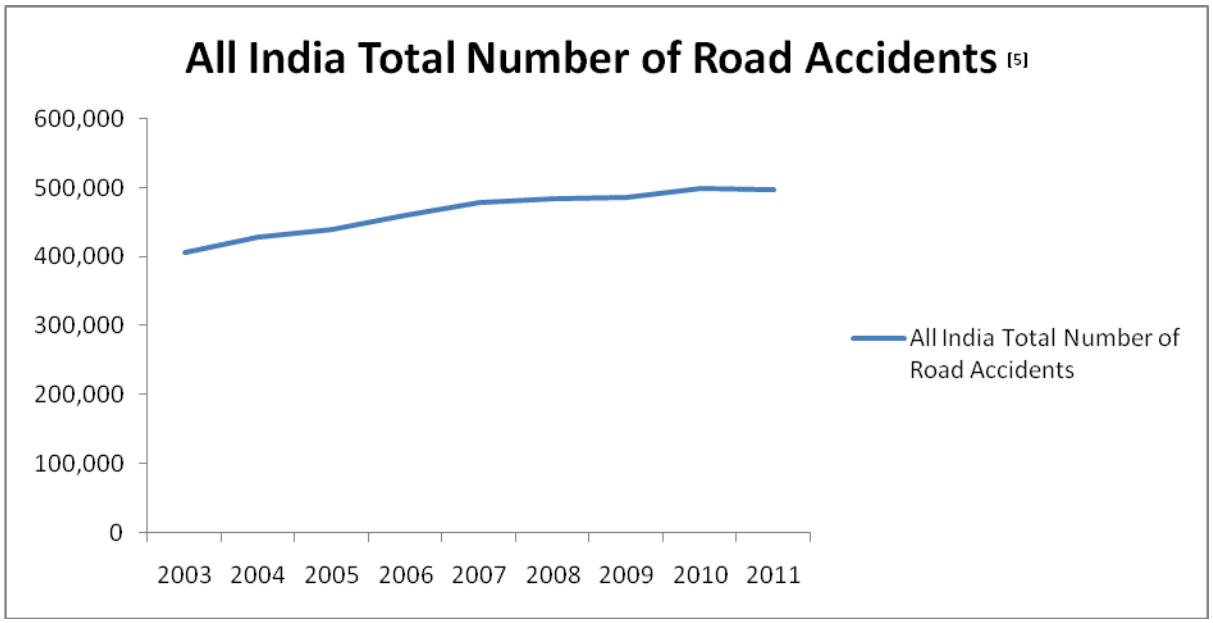
INTELLIGENT SPEED ADAPTATION

Intelligent Speed Adaptation (ISA), [3] is a system that constantly monitors vehicle speed and the local speed limit on a road and implements an action when the vehicle is detected to be exceeding the posted speed limit. This is done through an advisory system, where the driver is warned, or through an intervention system where the driving systems of the vehicle are controlled automatically to reduce the vehicle's speed. It uses information about the road on which the vehicle travels to make decisions about what the correct speed should be. This information can be obtained through use of digital maps incorporating roadway coordinates as well as data on the speed zoning for that roadway at that location, through general speed zoning information for a defined geographical area or through feature recognition technology that detects and interprets speed limit signage. ISA systems are designed to detect and alert a driver when a vehicle has entered a new speed zone, when variable speed zones are in force (e.g., variable speed limits in school zones that apply at certain times of the day and only on certain days), and when temporary speed zones are imposed (such as speed limit changes in adverse weather or during traffic congestion, at accident scenes, or near road works). Many ISA systems will also provide information about locations where hazards may occur (e.g., in high pedestrian movement areas, railway level crossings or railroad grade crossings, schools, hospitals, etc.) or where enforcement actions is indicated (e.g., speed camera and red light camera locations). The purpose of ISA is to assist the driver in keeping to the lawful speed limit at all times, particularly as they pass through different speed 'zones'. This is particularly useful when drivers are in unfamiliar areas or when they pass through areas where variable speed limits are used.

Research has found that, in urban areas, the risk of a casualty crash is doubled for each 5 km/h over the limit. So travelling at 70 km/h in a 60 km/h zone quadruples the risk of a crash in which someone is hospitalised. As a result, it is estimated that about 10% of casualties could be prevented if the large group of motorists who routinely travel at up to 10 km/h over the limit were encouraged to obey the speed limits. About 20% of casualties could be prevented if all vehicles complied with the speed limits. Savings in fatal crashes would be larger.

Number of Road Accidents in India (2003-2011) [4]

2003	2004	2005	2006	2007	2008	2009	2010	2011
4,06,726	4,29,910	4,39,255	4,60,920	4,79,216	4,84,704	4,86,384	4,99,628	4,97,686



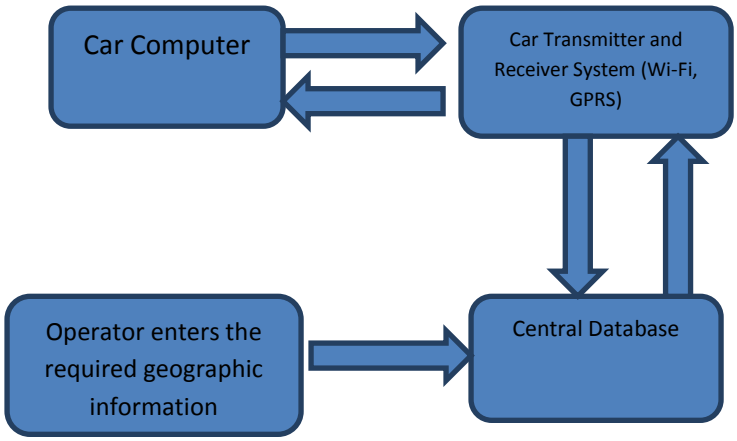
ANALYSIS

(INTELLIGENT SPEED ADAPTATION)

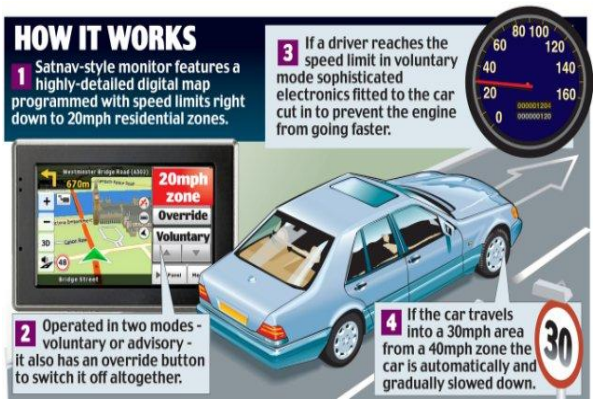
In case of Intelligent Speed Adaptation, there are many ways of speed control. One system is that the car computer and display monitor is connected to a common database which stores various information about the road condition, posted speed limit and other geographic information about various places. The car computer can fetch the required information from the database and analyze it and automatically reduce the speed.

There are two types of ISA system [6]:

1. Active System → It automatically intervenes and correct the vehicle's speed according to the posted speed limit of the zone.
2. Passive System →It simply warns the driver of the vehicle travelling at a speed excess of the speed limit posted.



Working principle of ISA [7]



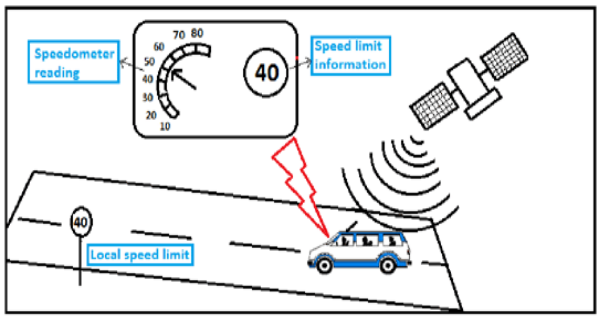
RESULT ANALYSIS

It's under analysis and in proposal phase.

GPS BASED SYSTEM

GPS is based on a network of satellites that constantly transmit radio signals. GPS receivers pick up these transmissions and compare the signals from several satellites in order to pinpoint the receiver's location to within a few meters. This is done by comparing the time at which the signal was sent from the satellite to when it was picked up by the receiver. Because the orbital paths of the satellites are known very accurately, the receiver can perform a calculation based on it's distance to several of the orbiting satellites and therefore obtain its position. There are currently 24 satellites making up the GPS network, and their orbits are configured so that a minimum of five satellites are available at any one time for terrestrial users. Four satellites is the minimum number of satellites required to determine a precise three-dimensional position.

Working principle of GPS based system [8]



Visual displays in vehicles for Intelligent Speed Adaptation showing speed limit information and non-adherence with the local speed limit

DISADVANTAGES OF GPS BASED SYSTEM

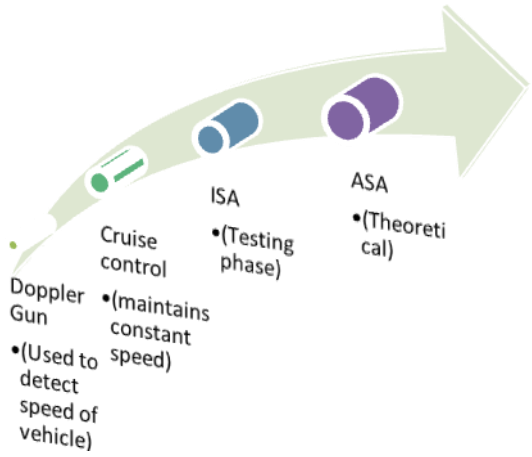
The popularity of GPS in current ISA and in car navigation systems may give the impression that GPS is flawless, but this is not the case. GPS is subject to a number of fundamental problems. Many of these problems relate to the accuracy of the determined position. The receiver still gets the signal from the satellites, but due to satellites' ephemeris uncertainties, propagation errors, timing errors, multiple signal propagation path, and receiver noises, the position given can be inaccurate. Usually these inaccuracies are small and range from five to ten meters for most systems, but they can be up to hundreds of meters. In most situations this may not matter, but these inaccuracies can be important in circumstances where a high speed road is located immediately adjacent to roads with much lower speed limits (e.g., residential streets). Furthermore, because GPS relies upon a signal transmitted from a satellite in orbit, it does not function when the receiver is underground or in a tunnel, and the signal can become weak if tall buildings, trees, or heavy clouds come between the receiver and the satellites. Current improvements being made to the GPS satellite network will help to increase GPS reliability and accuracy in the future but will not completely overcome the fundamental shortcomings of GPS. In order to be used for ISA systems, GPS must be linked to a detailed digital map containing information such as local speed limits and the location of known variable speed zones, e.g., schools. Advanced digital maps have the capacity for real-time updating to include information on areas where speed limits should be reduced due to adverse weather conditions or around accident scenes and road works.

RADIO FREQUENCY BASED SPEED CONTROL PROPOSAL

- Like the technical data transmitted in radio beacon, so instead of transmitting data if we can use fixed radio frequency for individual speed limit.
- For example, for 40km/h limit, 400 kHz

frequency can be used. There will be a Universal fixed range of frequency for different speed limit.

TIMELINE



- The car computer will be programmed according to the universally accepted frequency band.
- Car receiver after receiving the signal sends the feed to the car computer which then analyses the signal.
- After analysing the data, it compares the vehicle speed with the posted speed limit, if it is within the limit no action is taken.
- If the speed of the vehicle is above the posted limit initially it gives a verbal warning of over speeding to the driver for 2-3 seconds.
- If no action is taken by the driver it automatically reduces the vehicle speed by reducing the fuel flow to the engine.
- There will be a small range transmitter installed along with the car which will continuously transmit the range of frequencies to the receiver .
- If the driver installs jammer to stop the use of system from operating, the signal flow will be stopped and sensed by the receiver which will instruct the car computer to stop the engine and bring the vehicle to a halt.
- There will be a National ASA helpline system.
- If in any case the driver or someone tries to tamper with the system, it will automatically with all the vehicle details send a shortwave signal to the National ASA helpline system.
- Later, police can track the vehicle down.
- In any case, if the driver has to over speed the limit for a short period of time.
- It can be done by pressing the gas pedal after the resisting point (up to the floor) which will then temporarily disable the system and unlock the full power of the engine.
- Once the driver releases the gas pedal, it will again reactivate.
- This method can further be implemented on traffic signals.
- Used by Western Railway and Central Railway of India known as Auxiliary Warning System (AWS) which works on the same principle of radio frequency transmission .
- A receiver receives the signal which warns the driver about the signal state, if no action is taken it automatically takes the necessary action.
- To enhance more security against tampering the frequency bands used has to be confidential.
- The range of the transmitter will be of the road width because if range is more it can cause interference with other electronic objects.
- The by-default speed limit will be country specific. For e.g. in India, where there will not be any specific speed limit posted, the default speed limit will be 40km/h. The vehicle will not exceed this speed until it enters a specific speed zone. (The default speed will vary according to the country and it's laws).

ANALYSIS

Receiver – Transmitter System: *(The devices proposed here are just for sample demonstration)*

Transmitter –

RF Link Transmitter -315MHz (WRL08945)

This is only the 315MHz transmitter. This wireless data is the easiest to use, lowest cost RF link.We can use these components to transmit position data, temperature data, even current program register values wirelessly to the receiver. These modules have up to **500 ft range** in open space. The transmitter operates from 2-12V. The higher the Voltage, the greater the range - see range test data in the documents section.

RF Link Transmitter [9]

The theory of operation is very simple. What the transmitter 'sees' on its data pin is what the receiver outputs on its data pin. If one can configure the UART module on a PIC, you have an instant wireless data connection. The typical range is 500ft for open area. This is an ASK transmitter module with an output of up to 8mW depending on power supply voltage. The transmitter is based on SAW resonator and accepts digital inputs, can operate from 2 to 12 Volts-DC, and makes building RF enabled products very easy.

Features:

- 315 MHz Transmitter Operation
- 500 Ft. Range - Dependent on Transmitter Power Supply
- 2400 or 4800bps transfer rate
- Low cost
- Extremely small and light weight

Now, suppose for a particular speed limit for a particular zone the frequency mapped is 315 MHz, so the transmitter considered above will continuously transmit 315MHz. The radio receiver installed within the car will be pre mapped to the frequencies allotted for speed limits by the Government. The receiver will receive the 315MHz signal (for this sample case) and will send the signal to the car ECU, which will then compare the detected frequency with the preprogrammed set of frequencies and will take the steps for speed controlled discussed below.

Speed Reduction Mechanism and Method[10]

Modern ECU –These use a microprocessor which can process the inputs from the various engine sensors in real-time. ECU consists of mainly hardware and software in which various codes and logic are programmed. The hardware consists of electronic components on a printed circuit board (PCB), ceramic substrate or a thin laminate substrate. The main component on this circuit board is a Central Processing Unit (CPU) which is a microcontroller device. The software is stored in the microcontroller or other chips on the PCB, typically in EPROMs or flash memory so the CPU can be re-programmed by uploading updated code. This type of system is also referred to as an Engine Management System (EMS).

High end engine management systems receive inputs from other sources, and control other parts of the engine. For example, some variable valve timing systems are electronically controlled, and turbocharger waste gates are also controlled. They communicate with the transmission control units, directly interface electronically controlled automatic transmissions, traction control systems and many more. The Controller Area Network or CAN bus automotive network is often used to achieve communication between these devices.

Modern ECUs include features such as cruise control, transmission control, ABS (Anti-locking Braking System), and anti-theft control, Engine Immobiliser and many more.

Programmable ECU –These are those types of ECUs which are programmable. These units do not have a

fixed behaviour and can be reprogrammed by the user.

Application of programmable ECU include adding or changing of a turbocharger, adding or changing of an intercooler, changing of the exhaust system or a conversion to run on alternative fuel and many more. As a result of these changes, the old ECU may not provide appropriate control for the new configuration. In these situations, a programmable ECU can be wired in. These can be programmed/mapped with a workstation connected using a serial or USB cable, while the engine is running.

The programmable ECU may control the amount of fuel to be injected into each cylinder. This varies depending on the engine's RPM and the position of the accelerator pedal (or the manifold air pressure). The engine tuner can adjust this by programming the ECU for a particular frequency band as required for frequency based speed control and by bringing up a spreadsheet-like page on the laptop where each cell represents an intersection between a specific RPM value, an accelerator pedal position and frequency band for speed control. In this cell a number corresponding to the amount of fuel to be injected is entered.

By modifying these values while monitoring the exhausts using a wide band lambda probe to see if the engine runs rich or lean, the tuner can find the optimal amount of fuel to inject to the engine at every different combination of RPM and pre-programmed frequency bands..

Other parameters that need to be mapped are:

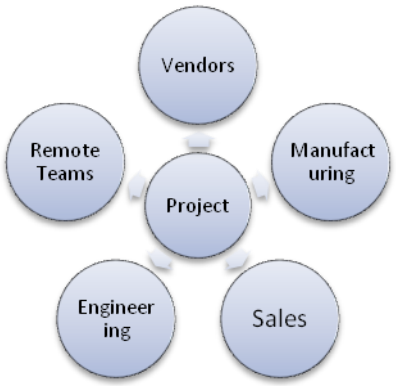
- **Revolution limit:** Defines the maximum RPM that the engine is allowed to reach. After this fuel and/or ignition is cut. Some vehicles have a "soft" cut-off before the "hard" cut-off. This "soft cut" generally functions by retarding ignition timing to reduce power output and thereby slow the acceleration rate just before the "hard cut" is hit.
- **Ignition Timing:** Defines at what point in the engine cycle the spark plug should fire for each cylinder. Modern systems allow for individual trim on each cylinder for per-cylinder optimization of the ignition timing.
- **Closed loop lambda:** Lets the ECU monitor a permanently installed lambda probe and modify the fueling to achieve the targeted air/fuel ratio desired. This is often the stoichiometric (ideal) air fuel ratio, which on traditional petrol (gasoline) powered vehicles this air: fuel ratio is 14.7:1. This can also be a much richer ratio for when the engine is under high load, or possibly a leaner ratio for when the engine is operating under low load cruise conditions for maximum fuel efficiency.
- **Transient fueling:** Tells the ECU to add a specific amount of fuel when throttle is applied. The is referred to as "acceleration enrichment".
- **Low fuel pressure modifier:** Tells the ECU to increase the injector fire time to compensate for an increase or loss of fuel pressure.
- **Staged injection:** Allows for an additional injector per cylinder, used to get a finer fuel injection control and atomization over a wide RPM range. An example being the use of small injectors for smooth idle and low load conditions, and a second, larger set of injectors that are 'staged in' at higher loads, such as when the turbo boost climbs above a set point.
- **Variable cam timing:** Allows for control variable intake and exhaust cams (VVT), mapping the exact advance/retard curve positioning the camshafts for maximum benefit at all load/rpm positions in the map. This functionality is often used to optimize power output at high load/rpms, and to maximize fuel efficiency and emissions as lower loads/rpms.
- **Waste gate control:** Controls the behavior of a turbocharger's wastegate, controlling boost. This can be mapped to command a specific duty cycle on the valve, or can use a PID based closed-loop control algorithm.
- **Gear control:** Tells the ECU to cut ignition during (sequential gearbox) up shifts or blip the throttle during downshifts.

In order to communicate with the driver, an ECU can be connected to a "data stack", which a simple dash board is presenting the driver with the current RPM, speed limit in that zone and other basic engine data. These data stacks, which are digital, communicates with the ECU using one of several proprietary protocols running over RS232 or CAN bus, connecting to the DLC connector (Data Link Connector) usually located on the underside of the dash, in line with the steering wheel. Thus the ECU can initially give warning to the driver to reduce speed. If the driver doesn't responds to the warning, the ECU automatically reduces the engine speed which in turn reduces the vehicle speed. The ECU analyses the frequency received from the roadside transmitter and matches it with the pre-programmed frequency for a particular speed and in turn reduces the vehicle speed to the posted speed limit.

In case of an emergency or in order to avoid sudden accident, the ECU will be programmed to release full power of the engine for a particular throttle position and a threshold force or speed with which the accelerator pedal is pushed. As soon as the driver pushes the accelerator pedal with a speed and force above the threshold the ECU will detect it and release the full power of the engine overriding the speed limit. As soon as the pedal is released and the pedal crosses the threshold point the ECU will again detect and reduce the power of the engine and speed according to the posted speed limit.

***RESULT ANALYSIS*- Under Analysis**

DEPENDENCIES AND RESOURCES



Looking Ahead

- Practical testing of ASA.
- Surveying of market for cost estimation and management of ASA.
- Finding out faults and flaws of the proposed ASA.
- Testing and physical implementation of ASA in test vehicles and the required testing be done.

CONCLUSION

1. Implementing Automated Speed adaptation will increase road safety.
2. It will reduce the chance of road accident with sufficient margin as of present situation.
3. Cost of installation will be very low compared to other methods of ISA
4. GPS based ISA has limitation such as closed tunnel, overhead obstruction, etc.
5. More effective speed control
6. Less requirement of human labour.
7. More automation and less faults.

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