Smart Vehicles and Transportation System

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Abstract - This paper describes the design and implementations of an ideal transport mechanism based on vehicle platooning, more efficient use of the existing road network using advanced technology. This view of automation consists of better highways and more intelligent and judgmental cars. Intelligent cars provide a better and more efficient way of transport and the designing of these are based on considering the roads to be ideal and without any breaks. The idea is to develop a magnetic reference sensor system for lateral control, an electronic throttle actuation system, a communication protocol for vehicle-to-vehicle communication. PATH researchers also integrated all the in-vehicle software, and debugged and tested the complete vehicle control system.

Keywords - platooning, automation, magnetic reference sensor system, electronic throttle actuation system, communication protocol.

I. INTRODUCTION

Growing traffic congestion is choking world’s overloaded roads. Intelligent vehicles and automated highways could solve the problem. Anyone who drives to work in one of the metropolitan areas knows that highway traffic congestion is getting worse. Average travel speeds on the crowded commuter corridors near large U.S. cities drop to about 36 mph at rush hour, leading annually to some 5 billion collective hours of delay and estimated productivity loss of $50 billion nationwide. Meanwhile, the cars, trucks, and buses caught in chronic traffic jams waste vast amounts of fuel as they emit enormous quantities of exhaust. This leads to the pollution of the environment.

II. THE TRAFFIC PROBLEM OVERVIEW

The traditional solution has been to construct more and larger roadways, but that is no longer seen as a viable option by transportation planners due to the high financial, social, and environmental costs of such giant projects.

More efficient use of the existing road network using advanced technology seems to be the answer, but exactly what form that system should take is the subject of intense debate among the diverse groups that comprise the transportation community--central, state, and local government agencies, trade associations, and consumer and public-interest groups.

Somehow we need to meet the unsatisfied demand for the freedom and mobility of cars and other vehicles and find ways to operate the existing system more efficiently and effectively.

Fig 1. “TRAFFIC JAM”, where the whole traffic network comes to a standstill.

III. THE APPROACH TO THE PROBLEM

A. Development Overview

The important points that should be followed before approaching problem are Evaluating Impact, Developing capacity and informing policy.

One approach would be to develop automated highways that feature a lane or set of lanes on which vehicles equipped with specialized sensors and wireless communications systems could travel under computer control at closely spaced intervals, perhaps in small convoys or “platoons.” Vehicles could be temporarily linked together in communications networks, which could allow the continuous exchange of information about speed, acceleration, braking, obstacles, and so forth [1]. Small networks of computers installed in vehicles and along selected roadways, could closely coordinate vehicles and harmonize traffic flow. [1], [2]
B. Automatic Driving

A driver electing to use such an automated highway might first pass through a validation lane, similar to today's high-occupancy-vehicle (HOV). These lanes are also known as carpool lanes, commuter lanes, diamond lanes, express lanes, and transit lanes.

The system would then determine if the car will function correctly in an automated mode, establish its destination etc. [3]

Improperly operating vehicles would be diverted to manual lanes. The driver would then steer into a merging area, and the car would be guided through a gate onto an automated lane. An automatic control system would coordinate the movement of newly entering and existing traffic. Once traveling in automated mode, the driver could relax until the turnoff. The reverse process would take the vehicle off the highway. At this point, the system would need to check whether the driver could retake control, then take appropriate action if the driver were asleep, sick, or even dead. [5]

The alternative to this kind of dedicated lane system is a mixed traffic system, in which automated and non-automated vehicles would share the roadway. This approach requires more-extensive modifications to the highway infrastructure, but would provide the biggest payoff in terms of capacity increase.

In fact, a spectrum of approaches can be envisioned for highway automation systems in which the degree of each vehicle's autonomy varies. On one end of the range would be fully independent or "free-agent" vehicles with their own proximity sensors that would enable vehicles to stop safely even if the vehicle ahead were to apply the brakes suddenly.

In the middle would be vehicles that could adapt to various levels of cooperation with other vehicles (platooning). Platoons would resemble like electrically coupled railroad trains.

At the other end would be systems that rely to a lesser or greater degree on the highway infrastructure for automated support. In general, however, most of the technology would be installed in the car.

C. Sensing The Environment

A vehicle might use several approaches to sense its environment. To keep lanes, steer, and find location, magnetometers might be used to sense magnets buried in the roadbed. Alternatively, visual sensors might monitor highway marking tapes installed on the roadway, or intelligent video-imaging systems could track painted lane-boundary stripes.

Obstacle detection and collision avoidance could be handled by millimeter-wavelength radar or infrared laser-ranging systems, or perhaps advanced video-imaging systems.

Accelerometers coupled to various actuators in a vehicle could manage steering, braking, and throttle systems to maintain its proper velocity and position. The choice of wireless communication system would depend on the type of automation. Of course, all this extra equipment would raise vehicle costs, which is one of the controversies surrounding automated highways. [1], [2].
Fig 6. Vehicle installed with various sensors and actuators that help in managing braking, steering and the throttle system of the vehicle.

We need to develop compatible, interoperable system architecture, which is not there today. We need to set some goals and develop some national standards.

D. Traffic Modelling

Basic to these automated-highway schemes are computer simulations to indicate that such systems may be the least expensive way to increase highway throughput. Automation could double or even triple highway capacity. For example, a typical highway lane can accommodate approximately 2,000 vehicles per hour. With automation, that capacity could be expanded to 6,000 per hour, depending on the spacing of entrances and exits.

Fig 7. Drilling done to insert magnets at regular intervals.

The California Partners for Advanced Transit and Highways (PATH) Program has developed the technology whereby magnets buried at intervals in the roadbed would be sensed by magnetometers in vehicles, providing a way to monitor their location and velocity. This approach could cost around $10,000 per mile to install, far less than the millions of dollars to build each mile of new highway.

Fig 8. Drilling should be made properly so that the magnets don’t get displaced later.

The fuel consumption and exhaust emission of a motor vehicle is related directly to its specific driving cycle.

If you can smooth out the traffic flow, vehicles can run at constant speed, which increases mileage and reduces air pollution. Furthermore, with platoon spacing set at a half a car length, cars can draft off each other, reducing drag by half. This arrangement could result in a 20-percent boost in fuel economy.

Fig 9. Magnets being buried into the holes made by drilling.

Many members of the transportation community doubt these claims. The computer models and studies that indicate that automation could double or even triple traffic capacity are not accurate. On paper, an automated highway system looks like a solution to future traffic problems, but technical feasibility has not been proven beyond a few lab and controlled test track demonstrations. These technologies have to be pretty much proved otherwise, there's no way to avoid the legal liabilities involved. [4]

The demonstrations are certainly useful, but as yet there's no consensus: "All the stakeholders need to sit down, find common ground, and then go on from there."

IV. THE FEATURE AND EXECUTION EXAMPLE OF AHS

A. Functional Requirements Of Automated Vehicle Operation
**B. Automated Demonstration**

The origin of research on AHS was done by a team from ‘The Ohio State University’ led by Dr. Robert E. Fenton. Their first automated vehicle was built in 1962, and is believed to be the first vehicle to contain a computer. Steering, braking and speed were controlled through the onboard electronics, which filled the trunk, back seat and most of the front of the passenger side of the car.

The most celebrated demonstration of traffic automation took place last August on a stretch of California freeway near San Diego. The experiment was conducted by the National Automated Highway System Consortium (NAHSC), a public/private partnership authorized by Congress in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 to perform long-term research on automated highway systems (AHS) for approximately seven-and-a-half years. In late 1994, the U.S. Department of Transportation (DOT) awarded the contract for this work to the NAHSC.

The PATH project, a prototype automated highway system, was tested in San Diego County, California in 1991 along Interstate 15. However, despite the technical success of the program, investment has moved more toward autonomous intelligent vehicles rather than building specialized infrastructure. The AHS system places sensory technology in cars that can read passive road markings, and use radar and inter-car communications to make the cars organize themselves without the intervention of drivers. Such an autonomous cruise control system is being developed by Mercedes-Benz, BMW, Volkswagen and Toyota.

The AHS technical-feasibility demonstration also witnessed other similar automated feats by trucks/buses using video system to keep lanes and detect obstacles.

This part of the demonstration was conducted by Eaton VORAD Technologies in Southfield, Mich. Toyota and Honda also showed their versions of intelligent vehicles. The Toyota automobile, for example, featured a lane-departure warning system that alerts the driver when the vehicle leaves the lane unintentionally and corrects the vehicle path if the driver fails to respond. It also had an adaptive-cruise-control system that automatically sets the following distance to the preceding vehicle. At the heart of the Toyota system is an advanced image-processing system and several laser-ranging sensors.

**C. Driver Assistance System**

The different Driver Assistance Systems are as follows:

- Night Vision
- Adaptive Cruise Control
- Collision Warning
- Collision Avoidance
- Driver Impairment Monitoring
- Advanced Driver Assistance
- Cooperative Infrastructure
- Automated Driving

**Cruise control:** Cruise control (sometimes known as speed control or autocruise) is a system that automatically controls the rate of motion of a motor vehicle. The driver sets the speed and the system will take over the throttle of the car to maintain the same speed. The cruise control system actually has a lot of functions other than controlling the speed of your car. For instance, the cruise control pictured below can accelerate or decelerate the car by 1 mph with the tap of a button. Hit the button five times to go 5 mph faster. The cruise control will disengage as soon as you hit the brake pedal, and it won’t engage at speeds less than 25 mph (40 kmph).

**D. Advantages And Disadvantages Of AHS**

Some of the advantages include:

1. Its usefulness for long drives across sparsely populated roads. This usually results in better fuel efficiency.
2. Some drivers unconsciously violate speed limits. In this situation the cruise control may control the speed thus avoiding accidents. For example, it may go over its setting on a downhill which is steep enough to accelerate with an idling engine.
However, cruise control can also lead to accidents due to several factors, such as:

1. The lack of need to maintain constant pedal pressure, which can help lead to accidents caused by highway hypnosis or incapacitated drivers; future systems may include a “dead man's switch” to avoid this.

2. While driving on wet/ice covered roads, the vehicle not equipped with “Electronic Stability Control” could go into a skid. Stepping on the brake such as to disengage the cruise control often results in the driver losing control of the vehicle.

Fig 12. Both automated highway lanes and intelligent vehicles will require special sensors, controllers, and communications devices to coordinate traffic flow.

V. CONCLUSION

Looking back on a century inundated by technology, the motor vehicle stands out as a singularly dynamic invention. In the next century, this dynamism will be driven by advances in information and computer technology. Our challenge is to ensure that new information, safety, and automation technologies are integrated to create human-centered intelligent vehicles that can advance safety, surface transportation efficiency, and economic competitiveness.

Hence, implementation of this system would be achieved by the 3 E's namely,

- Education
- Engineering
- Enforcement

The vision of a human-centered intelligent vehicle, therefore, is not fixed but will continuously evolve in the wake of continuing technological breakthroughs.

REFERENCES