Investigation on Control Methods and Development of Intelligent Vehicle Controller for Automated Highway Systems

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Guide
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Introduction

Challenges in Road Transportation:

- Traffic Congestion
- High accident rate
- High Accident mortality
- Increase in Vehicle Population

Government initiatives to tackle surface transportation problems:

- Conversion of 2 lane highways to 4 lane highways
- Building high speed expressways
- Golden Quadrilateral project
- Strict enforcement of traffic regulations

These Initiatives have not been able to solve the problems.
The Single Most Important Factor for Road Accidents is:

**Human Error**

Drivers tend to commit errors when driving at very high speeds due to the following reasons:

- Fatigue
- Poor Visibility
- Deteriorated Road Conditions
- Adverse Weather
- Very small available response times

Intelligent vehicles and Automated Highway Systems (AHS) will help in reducing the number of accidents and thus minimise loss of life and property resulting from accidents.
**History of AHS & Intelligent Vehicles**

1939 – New York World Fair – GM Futurama
first formal introduction to the idea of AHS and autonomous vehicles

1953 – scale model of AHS developed by GM and Radio Corporation of America
1958 – GM tests full size passenger car with in-built guidance system

1960s – Development of road centralised control system (Dr. Valdamir Zworykin from RCA).
Circuits buried in the road to magnetically sense vehicle speed and location.

1980s – a vision-guided Mercedes-Benz robot van, designed by Ernst Dickmanns, Bundeswehr University Munich
DARPA-funded Autonomous Land Vehicle (ALV) in the United States
1987-1995- EUREKA Prometheus Project on autonomous vehicles

1994- twin robot vehicles Vamp and Vita-2 of Daimler-Benz drove semi autonomously
1995-the Carnegie Mellon University Navlab project-semi-autonomous car
1996-Alberto Broggi of the University of Parma launched the ARGO Project – lane following achieved
1997-DEMO 97- Fleet of over 20 vehicles guided on a 7 mile stretch of Interstate 15 Highway north of San Diego, USA

2000-AHSRA Demo 2000 (Japan) - 38 cars, buses and trucks illustrated the ideal system for reducing road traffic accidents using driver information and control assist systems. The automation system made use of magnetic sensors on the road.
2001--the Carnegie Mellon University Navlab project-semi-autonomous car
2001-2003-Chauffeur II –development of truck platooning by DaimlerChrysler, Renault, IVECO and Fiat
2009- SARTRE project-UK, Spain & Sweden- Platooning system with lead vehicle controlled by a professional driver
2010 -VisLab ran VIAC, the VisLab Intercontinental Autonomous challenge, 13000 KM test run of autonomous vehicles.
2011- First successful trial of SARTRE project was in Jan2011 at Volvo Test Track in Sweden-single car was slaved behind a rigid truck.
Intelligent Vehicles (Driverless Cars)

Vehicles equipped with an autopilot system --- capable of driving without input from a human driver.

Advantages of intelligent / autonomous vehicles are:

- Relief from driving and navigating task
- Accident prevention
- Increased roadway capacity
- Traffic congestion reduction
- Increased safety due to elimination of driver error
Intelligent Vehicle Sub-systems

- Master controller
- Steering controller
- Braking controller
- Obstacle avoidance controller
- Engine controller (ECU)
- Lane following controller
- Transmission controller

Fig. 1 Vehicle sub-systems
Perception is an important aspect of any intelligent or autonomous system.

Some of the sensors used in the Intelligent Vehicles are:

**GPS (Global Positioning System)** -
- provides the absolute location and direction of the vehicle on the road
- data is received from satellites orbiting the earth

**Optical Camera** - Eye of the vehicle. Provides it vision capability

**Infra red camera** - Provides night vision capability

**Radar** – Measurement of distances (vehicles - vehicle and Vehicle – obstacles)
Laser Scanner – Known as LIDAR (Light Detection And Ranging) Sensor.

- Most popular sensor, used in most vehicles.
- Very expensive (a typical unit costs more than 3 lakh Rupees)
- Provides 2D and 3D data of the vehicle surrounding environment

Odometry – measurement of changes in position, velocity and acceleration using sensors located in moving parts.

Inertial Measurement Systems – Accelerometers and Gyroscopes

- Measures relative movement of robot in linear or angular direction.

Compass – Determines vehicle direction with respect to earth’s poles.
Sensor fusion – Mechanism or algorithm that combines the data from different sensors into one perception of the environment.

Fig. 2 Vehicle sensor fusion mapping
Intelligent Vehicle Sensor Location

Autonomous Passat by Volkswagen, Germany

(Figure from Robotland Blog article “Pickup an autonomous taxi cab in Berlin with iPad” dated October 18th, 2011)
A general architecture of an intelligent vehicle.

**Fig. 4 Vehicle Architecture**
Replace the Human Driver with an Equivalent Intelligent System:

Develop a **Supervisory / Master** controller that will co-ordinate the functioning of the various sub-system controllers of the intelligent vehicle.

- Development of Vehicle and Driver behavior Models (Finite State Machine – FSM)
- Development of control algorithms: Fuzzy, Neural and Genetic Algorithms
- Simulation and validation of developed control algorithms
- Development of Embedded controller
- Testing with scaled down vehicle model
Actual Implementation – Success Stories

Google’s Autonomous Car project

- Fleet of robotic Toyota Priuses have covered more than 1,90,000 miles (3 lakh kilometers) in all types of road conditions with minimal human input.

University of Berlin’s “MadeinGermany” VW Passat

- Autonomous taxis in Berlin

VisLab (Italy) – VisLab Intercontinental Autonomous Challenge (VIAC)

- Four driverless vehicles -15,000 KM trip - Parma in Italy to Shanghai China - July 26, 2010 - October 28, 2010 with virtually no driver intervention.
References


7. Robotland blog, ‘Pick up an autonomous taxi in Berlin with iPad’, October 18, 2011

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THANK YOU