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University Of East London (UEL)

Master of Science

An Analysis of the challenges of developing intelligent vehicles

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Contents

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Abstract

Most of people use cars daily as a major source of transportation. In fact there are over 800 million cars on the road worldwide. Today cars are grossly inefficient when it comes to basic resources such as human health energy and productivity. In the busiest environment there are lots of traffic jams and many people die in traffic accident. Intelligent vehicles will critically enhance driver safety. They will help driver and let the driver know if there is any danger ahead, traffic jam. Intelligent vehicles help to keep a smoother traffic on the roads.

The intelligent vehicle uses advanced technologies which will help driver to identify and respond to any inconvenience and danger in advance more potentially. With this technology cars on the road will be able to communicate each other by sending and receiving messages. This is helpful for the driver to know about their locations and in which direction they are moving. Cars will be able to receive this information, and if there is any kind of risk of crash, it warns the driver and or vehicle take some actions, to help the driver to avoid accident.

The first step is to research and design a system that is capable of controlling vehicles. System should also be able to communicate with other vehicles, road signals, and with a centralized control system. To enhance the safety, intelligent system should be able to install on the existing vehicles. There is need to design smart lanes in congested areas and major intersections. The future of this technology is very bright but all these systems required more research and depth of knowledge. These systems are very expansive, for the fully implement of these features.

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Acknowledgement

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Chapter 1. Introduction

Intelligent vehicles are the machines which consist of number of technologies. These machines are consists of embedded Artificial Intelligence systems. Artificial intelligence makes the machine enable to learn the environment around the machine and adjust itself according to the surroundings.

These robotic machines are able to perform some tasks that cannot be achieved by the human machine or any other machine. This is even impossible to perform some task even by humans working with conventional tools.

We use mobile vehicles in our daily routine. Driving is an important element in our daily life. We daily use vehicles to go to work, transportation of the goods, going to holidays. Safety is the main issue when we are on the road. Other problems while we are travelling is driving congestion and hence environment pollution. According to Reding (European Commissioner for information society and media) around 1.3 million accident incident are happening on European roads every year, and 410000 deaths took places in average.

The designing of intelligent vehicles is a step towards safety on road. It also leads to less congestion. It is an effort where there are no car accidents, no crashes and no congestion of traffic. Intelligent systems are a solution for the driver and transport system. It helps the driver to make decision while driving. Intelligent systems warn the drivers to avoid accident, and can suggest the driver if there is any congestion in the route.

The intelligent systems are the key to make a car intelligent. These systems are embedded in the cars and alert the driver in case of any emergency. These systems are also used in traffic management systems. In the event of crash the intelligent system have the ability to make an emergency call and send the location of the incident of the vehicle. Cars can communicate each other using the intelligent systems. Intelligent systems provide the real time information to the drivers about the surroundings using global positioning systems. (http://www.interactive-ip.eu)

Safety is the most serious impact among the all transport problems. There should be no risk of human injury and death due to the automation error and there must be not any possibility of accident. Research of Europe's information society describes the safety measures and states the 90% human error involved in road accident in Europe. An example describes that at 50 miles per hour speed if there is an accident and we apply the brakes half a second before then we can reduce the damage and energy by 50%. The further research states that 26% of the heavy vehicle drivers and 39% of

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normal vehicle driver do not activate brakes, and 40% are the one who does not apply brakes efficiently. http://ec.europa.eu/information_society/activities/intelligentcar/docs/right_column/intelligent_car_brochure.pdf

Intelligent vehicle systems interact between the driver and vehicle, vehicle to vehicle and vehicle to the global infrastructure systems. These systems work in an integrated approach, where all systems communicate to each other, and then provide the latest information to the driver and used for the in vehicle intelligent systems.

The ability of a machine to move by itself, that is, "autonomously," is one such capability that opens up an enormous range of applications that are uniquely suited to robotic systems. (Sanderson et al 2006)

An interface is provided for to operate the vehicles remotely. These remotely operated vehicles are linked by wired or wireless communications to provide higher bandwidth communications of the input.

In the evolution of robotic vehicle technology, it is clear that a higher level of autonomy is an important trend of emerging technologies, and the remotely operated vehicles mode of operation is gradually being replaced by supervisory control of autonomous operations.

Robotic vehicles are machines that moves autonomously any where, on the surface, in the sea and air. These vehicles are move themselves with their own power, with sensors and computational resources on board to guide their motion.

1.1 Importance of Robotic vehicles

Robotic vehicles are capable of approaching any where its difficult for human to approach. For human being it is difficult to travel high up in the space or to approach deep in the sea. To discover these places Robotic vehicles are used to travel. The National Aeronautics and Space Administration (NASA) Mars rover is a robotic vehicle that has successfully achieved these goals, becoming a remote scientific laboratory for exploration of the Martian surface. The Mars rover is an example of a robotic vehicle under supervisory control from the earth, and capable of local autonomous operation for segments of motion and defined scientific tasks.

Another example of a hostile and hazardous environment where robotic vehicles are necessary tools of work and discovery is the undersea world. Human divers may dive to a hundred meters or more, but light, pressure currents and other factors limit such human exploration of the vast volume of the earth's oceans.

Apart from space and oceans, there are many other applications where human presence is unsafe. Nuclear and biological contamination sites must often be explored and mapped to determine the types and extent of contamination, and provide the basis for remediation. Military operations incorporate many different autonomous and remotely operated technologies for air, sea, and ground vehicles. Increasingly, security and defence systems may use networks of advanced mobile sensors that observe and detect potential events that may pose threats to populations.

Robotic technology may also be leveraged to move un occupied cars. At airport, rental cars may pick up their customer on the curb side, so no more waiting at the rental car counter. But the real potential lies in the car sharing. If we could on the click of a button, order a rental car straight to us. And once at our destination, instead of wasting no time to park the car we can just let the car rive away to pick up the next customer. Such a vision can reduce a number of cars needed. (Thrun 2010)

Robotic vehicles are used in usual everyday jobs that occur over spaces and environments where machine mobility can effectively replace human presence. For example, large Arthur Sanderson, George Bekey, Brian Wilcox 9 scale agriculture requires machines to cultivate, seed, irrigate, and harvest very large areas of terrain. The ability to track an autonomous vehicle using global positioning systems, sensing the soil and plant conditions in the field, encourages the implementation of robotic vehicles for agricultural or “field” applications.

Intelligent vehicles have ability to drive very closely and at very high speed, which reduces the rush on the roads. As they can communicate each other and the global traffic system so they can re route the route for the smoother traffic. (William et al ,2000)

1.2 Research Question:

The main objective of this study is to analyze the simulations application software and other hurdles in this technology.

What are the challenges that present at the time in intelligent vehicles?

What are simulation algorithms that are used to control the intelligent vehicles?

1.1 Aim and objectives

The aims of this research are

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What is intelligent and artificial intelligence, and how it works.

How artificial intelligence is used in the vehicles and technology is used to make a vehicle intelligent.

To study about the intelligent systems, and what type of intelligent systems are used.

How these intelligent systems assist the driver’s driving.

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Chapter 2. Literature Review

An intelligent car is an autonomous which uses an Artificial Intelligence. It has an ability to move by its own. Intelligent cars uses advanced electrical, microprocessors. GPS (Global positioning system) navigation systems are used in the cars for enhance its information orientation. Sensors are used to sense the environment around the vehicle. Since last decade adoption of the smart cards, voice controlled sensors, vision cameras and infrared based devices are the technologies are being used to keep the vehicle safe in the environment. Data is collected from all the input through sensors. Input is then processed and the output results are passed to the actual controls. All aspects are processed through a set of rules to choose the right move for the vehicle to move in the right direction or to stop if there is any possibility of crash.

2.1 Autonomy

Autonomy refers to the system capable of operating in the real world environment without any form of external control for extended period of time. All living systems are the examples of the autonomous systems. These systems are capable of surviving in dynamic environment. Real systems maintain their internal structures exhibits a variety of behaviours. The autonomous systems are capable of adapting the environment changes. (Bekey 2005)

As real world systems are more complex they are likely to exhibit of more and more unexpected behaviours. Bekey(2005) explains the Asimov's law as follow :

1. A robotic machine should never hurt a human
2. Robot should follow the human, unless it deny the first law
3. Robotic machine should never hurt any other and also follows the first and second law

   A high level control is required to achieve the above laws stated that implies the Asimov's Law. There are other controlled at low level which make sure that the motor driving robots used in a stable configuration and do not oscillate at the next level of control. It makes sure that they do not collide with one another or any obstacle.

   The high level control provides the input to the lower levels, there is always a feedback from low level control to the upper level controls. Sensors are the inputs at low level.

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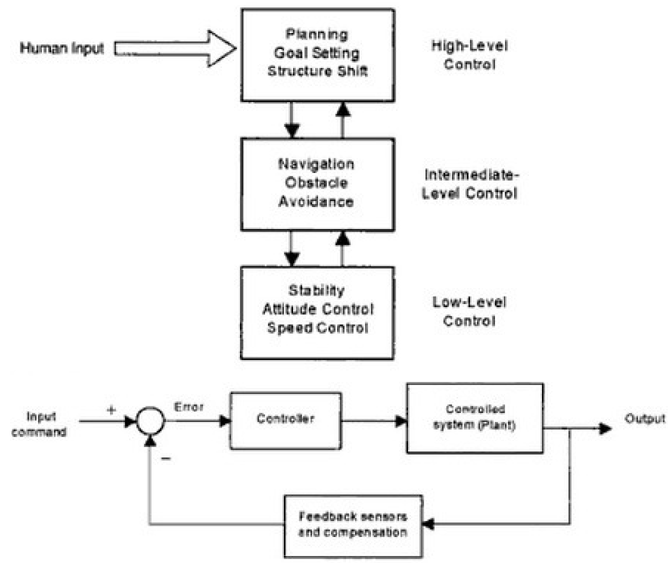

Figure 1 Basic control system

A Human input involved in high level control. Middle level control is generally autonomous in contemporary mobile robots, but it still involves some human input.

2.2 Software architecture

Software is the primary contribution of intelligent vehicles. The software is the key to robotic driving. Autonomous driving software is generally divided in to three main categories.

Perception addresses the problem of mapping sensor data into internal systems and prediction about the environment.

1. Planning refers to analyse the data and making driving decisions.
2. Control is the actual controls of the vehicle, controls the steering wheel, hitting the brakes, accelerates; turn left or right and emergency stops in the case of emergency
3. Additional software modules interface to the vehicles and its sensors.

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2.3 Localization and path planning

Navigation and localization is very important the problem of simulation and mapping is a research field with significant outcomes that have directly influenced the reliability and practicality. The principle of the Simultaneous Localization and Mapping (SLAM) algorithms is a refined and elegant mathematical formulation that represents the detected features of the environment by probability distributions. By moving a vehicle, or using several vehicles, to observe the same features, the consistency of these probability distributions is resolved into a small number of feasible maps that describe the world being explored. Currently these methods are able to efficiently and reliably resolve two-dimensional domains of modest size. (Sanderson et al)

SLAM algorithms provide an example of the importance of basic systematic research that stimulates great advances in practical applications. In military applications the integration of ground, air, and water sensors and vehicles is essential to fully understand the activities in a theatre of operations. The complexity of dynamic coordination of large-scale operations using sensor feedback and real-time assessment is extremely complex. Algorithms such as SLAM define fundamental principles that underlie the consistent interpretation of such complex activities, and support the development of reliable implementations. (Kumar, 2002)

2.4 Mechanisms and Mobility

Basic studies of kinematics and dynamics of motion in all domains (ground, air, and water) continue to examine fundamental issues of devices that contact and interact with the forces around them. A primary example of this work is the study of bipedal locomotion and the distinction between "quasi-static" walking and "dynamic" walking. Algorithms used in recent full humanoid prototypes exhibit very sophisticated motion and balance, but still do not achieve all of the characteristics of human Dynamic balance.

2.5 Power and Propulsion

The long-term autonomy of vehicles is directly impacted by the available power and the energy efficiency of motion. These considerations are of additional importance in remote domains, such as planetary and undersea deployments, where recovery or refuelling is impractical. While battery technologies are of primary interest for all such vehicles, from vacuum cleaners to spacecraft, there are premiums obtained by efficient motion and even sharing of tasks among multiple vehicles. In addition, there are several strategies for energy storage, as well as strategies for energy harvesting in many forms.

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2.6 Computation and Control

Micro computation has enabled the use of embedded computer systems that are small, light, and energy efficient. Such embedded computational systems have been helpful in the development of robotic vehicles with sophisticated computer architectures that organize sensor-based feedback and control actions on board. Much of the current research internationally is focused on advanced computer architectures and implementations that coordinate these tasks.(Kanellakopoulos et al 2003)

In the intelligent transportation system, information about the moving things around the vehicles helps the assistant system to process and warn the driver if there any chance of collision. The system can execute the routines to hit the brakes automatically and alert the driver about this situation.

2.7 Sensors and Navigation

Sensors are used for input the information from the real world, and to monitor the internal environment.(Bekey 2005)

Sensors monitor the environment and are used to control the vehicles. It is essential for the navigation of the robotic vehicle. Sensors are used to sense the surroundings and utilized the relative locations of events.

2.7.1 Exteroceptive sensors

Exteroceptive sensors are used to get the information from the external environment in the real world. In real world environment we used five types of senses (vision, hearing, smell, touch, taste). For a robot to design a sense of vision an artificial 'Eye' is required for the robot to see through intelligent eye. It does not require only the light sensitivity but requires more aspects of vision based contexts. Robot sensors are very limited as compared to the natural sensitivity.

2.7.2 Proprioceptive sensors

Proprioceptive sensors monitor the organism of robot's internal environment, for example for a robotic vehicle and a software architecture communicating each other the system has to monitor the internal behaviour of the vehicle such as wheel rotation, battery status, any short circuit, engine and heating status of the vehicle. (Bekey 2005)

The commonly used "Proprioceptive sensors" systems are (http://www.robots.com/robot-education.php?page=proprioceptive+sensors)

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- Global positioning systems (GPS) are the systems which decode the signals from the satellite and calculate the global position on the earth.

- Internal navigation system (INS) is a navigation system which uses computers, sensors and radar to calculate the position, velocity of the moving object.

- Shaft Encoders is an electromagnetic device that works as a transducer which converts the angular position of a shaft to an analogue/digital code.

- Compass used to detect direction and accurately correct motion.

- Inclinometer measures the angle of the axis.

Advanced robotic vehicle technologies for ground, air, and water have been tied to the development of improved sensors and sensor networks. Ever more, security and defence systems may use networks of advanced mobile sensors that observe and detect potential events that may pose threats to populations. One area of technology advancement is the development of microelectronics and micro-electromechanical systems technologies for specific sensors used in water and air. There are number of sensors which are designed to measure different tasks. (Sanderson et al).

Different types of sensors are used in autonomous vehicle. The commonly used are infra-red, sonar, radar and laser sensors. Emitter sensor is used to locate objects in a fixed field of view from a vehicle.(Jia et al 2008)

Infrared sensors are used to see objects as hot spot in which heat is emitted. These kinds of sensors are used to sense the human body emitting heat, and some time vehicles on the road, which releases heat from engine.

Heat vision cameras are used to see in the dark, used in the wars to target the enemy efficiently. It is very effective weapon used against enemy.

There has been a lot of search in autonomous vehicles and many algorithms have been proposed for the navigation of the vehicle. The basic purpose of these algorithms is to make a vehicle intelligent, which can sense the environment and interpret the vision based information. If the vehicle has to move from one location to another coordinate, it should be able to travel efficiently avoiding all the obstacles in the way with the help of an expert algorithm of path finding.

In vision based target tracking charged coupled devices are used as sensors for the navigation of autonomous vehicles. Another feature of using these cameras can also provide the 3 dimension analysis of the object. Navigation, map building and robot localization, obstacle avoidance can be the ideal application fusing visual target tracking system.

Charged Coupled Device cameras are in operation to capture the images of the environment in three dimensions. These cameras take pictures in am continuous stream. This information is then processed by a centralized System, which is then used to navigate the vehicle. For the development of the intelligent, tracking is and tracing are the area of development. These systems also provide assistance to human drivers. (Jia et al 2008)

2.8 Driver Assistance systems

Driver assistance system is to help the driver to avoid accident and any crash. It alerts the driver in advance by sensing the environment using the sensors and other technologies. Advanced driving assistance systems alerts the drivers in advance and wait for the driver reaction in a limited time frame. If there is no reaction from the driver it executes the suitable action according to the situation. (Bishop, 2002)

Driver assistance systems are supporting systems in vehicles that are proposed to improve the driver performance while driving the vehicle by helping the driver in different situations. These systems are designed and adapted in order to improve the driving safety and comfort for a driver. (Peter 2008)

These are the electronic systems as compare to the old monitoring systems where all the speedometers, heat detection, rare and side mirror views were available on the dash board.

Modern technology has overcome the manual systems and gives the opportunity to install the advanced assistance systems in the modern vehicles.

The use of advanced driving assistance systems in the car increases the driving safely by decreasing the driving risks. Safety is crucial when designing an intelligent vehicle. Number of intelligent systems have been developed and tested. As Intelligent vehicles are controlled by the driver where as robots are self controlled, when designing an intelligent system, the human factors of the driving behaviours are to be considered, observing the conditions, avoiding obstacles and manoeuvring the vehicle according to the environment and interpreting the situation and response.(Malik & Rakotonirainy 2008)

In most crashed the human mistake is the major factor. Response time is very important from the driver in case of abnormal situation. Most of the crashes are

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involved human mistakes in the result or the driving intention is diverted. FaceLAB is an tool used to monitor the driver's face. It provides the information about the eye blinking rate and face moment which helpful to warn the driver if there is any abnormality. It also records the wait on the steering. The sleepy drivers are warns if the system analyse and detect that driver feels sleepy.

There are number of driver assistance systems available such as:

2.8.1 Vehicle Navigation Systems

Vehicle Navigation system utilizes map data and spot the vehicle's co-ordinates in the global system. These systems are useful to the driver because they are allow then to more aware of driving conditions since there intension split between navigation and the driving moment where the roads are un known.

"Telematics" technology is used in these navigation systems, which allows the driver updated in the real time.

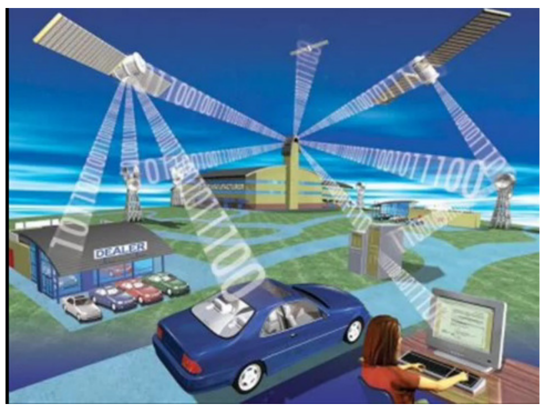

Figure 2 Telematic Technology

"Telematic" Technology includes a system that receives, send and store the information between the real world and the vehicle such technology is use full to such systems that start emergency signalling service that tells the exact location of the vehicle for the emergency purpose in the case of an accident. Another main advantage of this technology can be an emergency warning systems that alerts the driver for the advance road conditions that can alert the driver be sending the data to the vehicle. http://searchnetworking.techtarget.com/definition/telematics

2.8.2 Rear view cameras

Rear view cameras are used to display the rear of the vehicle, these cameras sends the pictures to the monitor that is visible to the driver facing forward. These views are

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available used when driver puts the vehicle in the reverse mode. It improves the ability of the driver to reverse the car safely, park the car and to reduce the park lane accidents.

2.8.3 Automatic Parallel Parking

These systems are available in the modern vehicle, which executes the function for the parallel parking for the driver. This requires the driver to properly adjust the vehicle near the parking space.

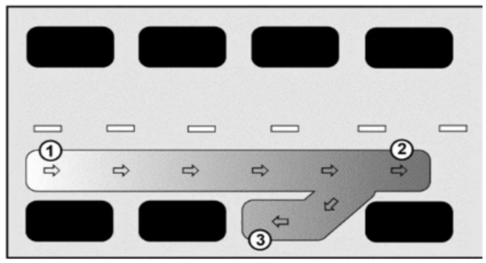


Figure 3 Parallel parking

It help the driver to locate the appropriate space for parking , indicate the driver where to stop the vehicle parallel to the car and then assist the driver while car is in reverse mode between the two vehicle and gives indication to stop at the safe distance from both the front and rare vehicle.

2.8.4 Collision warning system

Collision warning system uses radar or a laser to detect the possibility of collision with any other object or a vehicle. For a moving vehicle comes closer to any obstacle it alert the driver to hit the brakes, if it exceed the time frame of the response time the it activates the internal function to stop. These systems have ability to set up a brakes applying function in case if the collision is predicted.

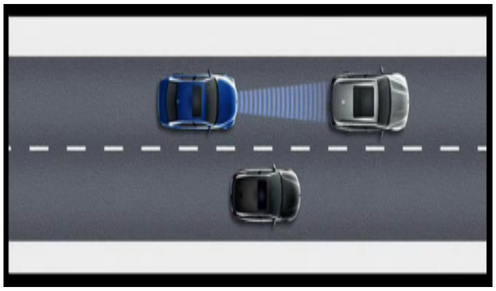


Figure 4 Collision Warning (a)

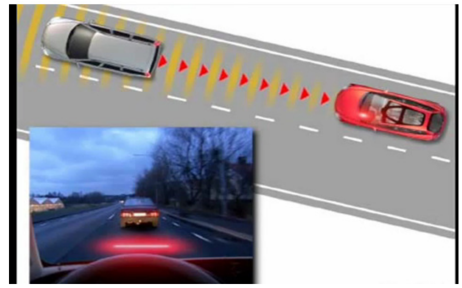
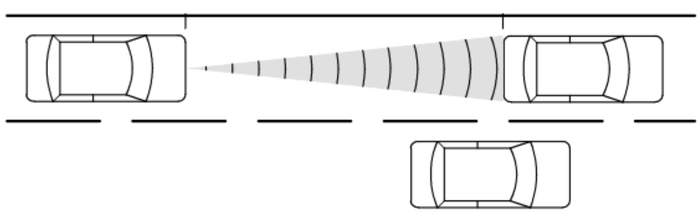


Figure 5 Collision Warning (b)

2.8.5 Autonomous cruise control system (ACC)

Autonomous cruise control system is being used in some vehicles. This system used a laser or radar setup, attached to the front of the vehicle is used to detect the vehicle in front. If a slower moving vehicle is detected, the system slow down the vehicle and control the clearance or time gap between the ACC vehicle and the vehicle in front. If the system detects that the forward vehicle is no more in front it again accelerate the vehicle to the set speed.



This operation allows the ACC vehicle to autonomously slow down and speed up with traffic without any interference from the driver. The main function of the ACC module is to process the information from the radar sensors and check if there is any is any car ahead. As far as the vehicle is in the safe distance within the time gap it passes the information to the engine control module to control the distance between the two vehicles. http://sunnyday.mit.edu/safety-club/workshop5/Adaptive_Cruise_Control_Sys_Overview.pdf

2.8.6 Lane change assistance systems

Vehicle lane change system is to notify the driver when the vehicle changes the lane. Lane change assistance systems are useful to avoid collision. This system is use full

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when at blind spot, if there is a vehicle which is not visible by the driver. Lane change assists the driver to change the lane when there is a possibility.

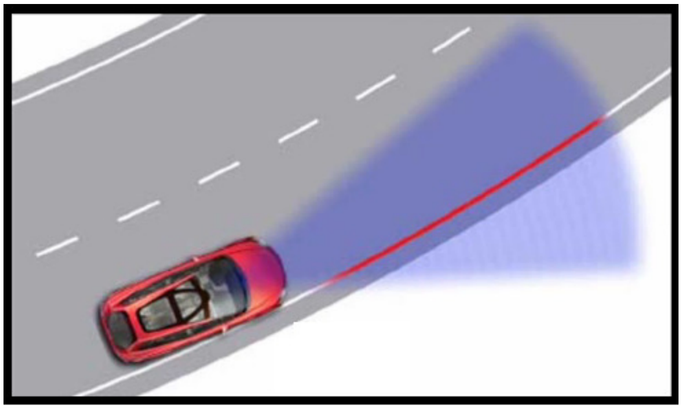

Figure 6 Lane change system

Similarly the lane departure warning system is introduced. It provides a safety benefits if by chance or unknowingly the driver shifted to the lane and also indicates on the curved turning roads.

According to Thomas (1997), in 1991 4% of the accidents were reported due to line changing in United States. The common cause of these crashes is that t when the driver perform the manoeuvre of changing the lane, driver did not aware of the other vehicle of the target lane. This is commonly happen when the other vehicle is in the blind spot of the driver. If the driver is being alerted about the vehicle at the blind spot then there is most likely the crash is avoided.

Lane change models normally involved two steps. First step in the selection of the lane that is target lane and in second step is the lane change execution process (Ramanujam, 2007). The need of line changing can be in two situations. Situation one is where it is mandatory to change the line this can be by the reason the lane ahead is finished or merging to another lane. This is the condition when we join the main highway from the small roads. It can also be due to an accident ahead and driver is forced to leave the current lane. Second condition when it is not mandatory to change the lane, but the driver changes the lane for his or her ease to avoid a slow moving vehicle ahead which is blocking all the line and causing congestion. http://www.fhwa.dot.gov/publications/research/operations/06136/index.cfm

The Lane change execution process uses different models to manoeuvre the vehicle. A gap acceptance model is one in use for change the lane.

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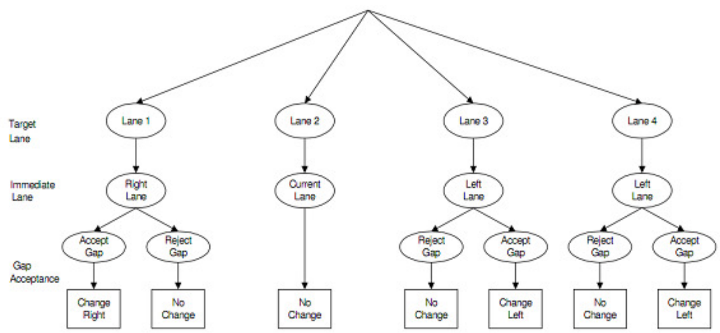
According to Ramanujam (2007), earlier research in 1997 by Yang and Koutsopoulos driver can start the lane change in mandatory condition depend on distance from the exit point and flow of the traffic and where no mandatory condition involved, is when the driver is driving the car below the maximum speed limit on the particular motorway. The lane selection is responsible to choose the best lane according to the situation and smoothness of traffic flow. In 1997 Ahmed amended the old lane changing model. He introduced a three level decision model for lane change. Level one is to decide where there is a need to change the ling considering both conditions i.e. mandatory or un-mandatory. Once there is a situation to change the lane the level two is to choose the lane left lane or the right lane. Level three is to consider the gap acceptance in the target lanes. Gap acceptance is the critical gap the driver needs to execute the safe lane change.

In 2005 Choudhary introduced an extended version of the lane change model named the target lane selection model. He included all lanes in a cross section of the choice set of the driver. The model diagram is as below.



2.8.7 Head up Displayed system

Head-up display system projects the driving information on the vehicle front screen. This is a newly designed technology where wind screen is used as a transparent display medium. Information such as the driving speed, navigation system, rear views from the cameras, fuel & engine information, temperature and road hazards are displayed.

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Figure 7 Head up Display

This information can be customized be the driver according to the requirement. These display screens can also be used to utilize the night visions. Viewing objects in night vision are much easier to identify. Heat emitted objects can be displayed to alert the driver.

2.9 The Google Driverless Car

The Google driverless car is a project by Google that involves developing technology for driverless cars. The project is currently being led by Google engineer of the Stanford Artificial Intelligence Laboratory and co-inventor of Google Street View.

It has been working in secret but in plain view on vehicles that can drive themselves, using artificial-intelligence software that can sense anything near the car and mimic the decisions made by a human driver. (Markoff 2010)

“The technology is ahead of the law in many areas,” said Bernard Lu, senior staff counsel for the California Department of Motor Vehicles. “If you look at the vehicle code, there are dozens of laws pertaining to the driver of a vehicle, and they all presume to have a human being operating the vehicle.” (Markoff 2010)

There is even the farther-off prospect of cars that do not need anyone behind the wheel. That would allow the cars to be summoned electronically, so that people could share them. Fewer cars would then be needed, reducing the need for parking spaces, which consume valuable land.

2.10 A driverless car on the road ahead

Successful tests of vehicles were carried out by EU research project in this test a car was driven behind a lorry on Volvo’s test track in Sweden. The driver handed over the

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control to the truck and took his hands off the wheel. Accelerating, slowing down, left and right were all controlled by the driver of truck. Systems in the car behind adjusted its speed, direction and distance in between to keep it in tandem.

According to Smith H (Jan 2011 Metro Newspaper) Researchers believes that technology for vehicles trains could become a reality with is a decade.

2.11 Defence Advanced Research Project Agency (DARPA)

Defence Advanced Research Projects Agency (DARPA) organized a number of competitions, the urban challenges. DARPA explains the technology to make the intelligent into reality in intelligent vehicles. Thrun explains the way the technology can be utilized to make the robotic vehicles effective.(Urmson, 2008)

DARPA organize challenges in the field of intelligent vehicles during decade. The first competition was held in 2004. The competition was to drive the car in Mojave Desert for 142 miles. There was a winning prize for the amount 12 Million Dollars. The total time for the competition was ten hours. The result of this challenge was not effective. All the competitors were failed to continue during the first few miles. It was a bad impact in the progress of the robotic technology that the intelligent cars are not safer fir the human use. The results showed that there is much more need to develop in the field of artificial technology.

In 2005 DARPA arrange another competition. This time the challenge was to drive the cars through mountain, lake side and flats. The total distance was to travel was 132 miles. Twenty three finalists were selected out of total 195 competitors. Stanford's intelligent vehicle named "Stanley" wins this first prize in 2005. Only for vehicles were able to finish in the time. Only Four cars that finished the challenge were the hope in the intelligent technology in future. (Siciliano B. etal, 2008)

In 2007 another competition was took place by DARPA, the urban challenge. In the Mock city the competition was held. In this competition about 36 self drive vehicles were announced, from which only 11 were selected. All the vehicles are to be followed the traffic rules of California. During the run "Boss" by Carnegie Mellon University claims the first prize. The "Junior" by Stanford win the second position.

All these competitions by DARPA were a great effort towards the robotic technology used in intelligent cars. All the technology used in these intelligent vehicles has to be more advanced in order to make safer drive for human use without any risk of any danger. New roads need to be build and all the hardware and software used in the cars must be reliable to meet the safety requirements. New user friendly interfaces need to be designed that are simple and easy to user for the human (Darms et al, 2009)

A competition took place with paved roads. Numbers of robotics cars with other conventional cars took part in this competition. All the cars had to obey the traffic rules like crossings, signals and speed limits. The results of the DARPA challenges were very limited in many aspects there are still a number of challenges which have to be improved to become where these intelligent cars will be safer for human use.(Thrun 2010)

2.12 Coupled layered architecture

Developing intelligent capabilities for robotic systems requires the integration of various technologies from different disciplines. It also requires the interaction of various software components within a real-time system, and the management of uncertainties resulting from the interaction of the robot with its environment. There are number of algorithms which are developed for number of robotics systems. Couples layer architecture for robotic is provide a domain specific robotic architecture. Coupled layer architecture has to layers, functional layer and the decision layer. Functional layer has four main features. It provides system level decomposition; secondly it separates the system capabilities and algorithmic capabilities. Algorithms are defined in most general terms.

Third it separates the behavioural definition and implementation, for example controlled motor which separates the specialization to hardware controller.

Fourth the functional layer provides models. These models are flexible at run time. This is a part of the abstraction model, whose one part is associated with the generic functionality and the other is adaptation.

The decision layer interacts with the functional layer using. A client - server architecture is implemented to communicate between the two layers. It also monitors the execution plan as if there is any modification in the sequence of the activities to be executed. It also checks about the availability of the system resources for the different operations to be execute

2.13 Path Planning using a Genetic Algorithm

One of the most difficult problems in robotic is developing robust automatic motion planning. In order to travel a robot successfully, it must be able to efficiently and reliably plan a route between two points. It requires to be aware of the environment around the autonomous vehicles (Jia et al). The route should be in such a pattern that

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it does not cause the robot to collide with obstacles. Path planning algorithms is the one tries to connect the initial and final configurations by specifying a series of intermediate configurations through which the robot can safely traverse.

This complexity of the path planning problem increases exponentially with the dimension of the configuration space. The configuration space is the space of all complete specifications of the position of every point of a robot system. (Candido, 2005)
Many global path planning methods suppose a complete representation of the configuration space. Potential field and bug approaches are local methods that do not make this assumption but are not complete methods. Local minima or loops will often cause this class of path planners to fail.

A local planner considers two points start and destination and commands the robot to move between the two points. The most common assumption is the straight line planner which operates by moving in a straight line between the two points.

In 2005 Naso and Turchiano proposed a genetic algorithm. To each decision they adjust a weight in the algorithm and get good results that genetic algorithm can be used for intelligent vehicles. Norman in 2002 proposed another approach to simulation model to direct the vehicle where more than one path is available. The selection of the right path is selected by avoiding the traffic congestion to the same destination. A recursive approach is used to find the best least congested path among the available options.

The disadvantage of this algorithm is that the vehicle has to choose the long route to avoid traffic congestion to reach the destination. The advantage of approach is that as the vehicles chooses the least congested path among the available options, so on each route there are balanced numbers of vehicles.

‘Simulated highways for the intelligent vehicle highway’ (Shiva) is a simulated environment of kinematics that describes of the motion of the objects. It is expansive to test an intelligent algorithm on the road in the real system. Shiva allows simulate the sensors vehicles and human operated vehicles. To move the car in simulation environment interrupts are fired such as break, accelerate etc. It is a customised system vehicles can be tested by assigning different attributes to the objects. (Sukthankar et al., 2002)

2.14 The fitness function

Fitness function is the one algorithm that determines that which solution with in the choices is best when there is more than one choice, and less distance to cover. In order

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to perform complex tasks successfully to evolve autonomous robot controllers, the fitness function is the one which eliminate the available possibilities to minimum and chooses the best to perform better result (Nelson et al., 2009).

In order to avoiding obstacles and minimizing distance between start and end points, the fitness function of the genetic algorithm had to have a term to draw path endpoints towards the goal.

Making clever use of the parameters of the fitness function and lengths of the paths in the initial population it was possible to overcome these shortcomings.

To fix these shortcomings a second path representation scheme is used. Each path is represented as an ordered set of angles. The angles are then stored in a binary tree structure. For the two dimensional case one needs only one angle per waypoint on the path for a unique representation of a path. Each node in the binary tree represents the angle that two path segments make at a specific point in the path. Varying the value of the angle at the node corresponding to middle node we can move it to anywhere equidistant from the previous waypoint, and the next waypoint. The left node then can modify the path segment between other two, while the right node modifies the path segment between left node and the parent node.

2.15 Common control Architecture

In the Fuzzy interface it focuses on the handling reactive and reflective cases. It either follows the behavioural or classical paradigm. Fuzzy navigation schema follows the classical paradigm. It consists of

1. Set of control rules, which contains the different situation which are possible to arise? All the rules are operated ever time to generate to control law

2. Behaviour based acknowledges that autonomous vehicle must exhibits; these behaviours are exhibit in different situations. Set of rule are used in each behaviour, and a interface is used to determined which one should be invoked. It is possible that more than one behaviours are invoked according with the situation.

3. Sensor readings provide information about the environment. The data received directly from the sensor is normally in complete. This then further processed to make valid and meaningful information it is furthered processed.

4. The information gathered from the sensors is very important for the vehicle to change its position and move in a safe manner so it will not collide with any other obstacle

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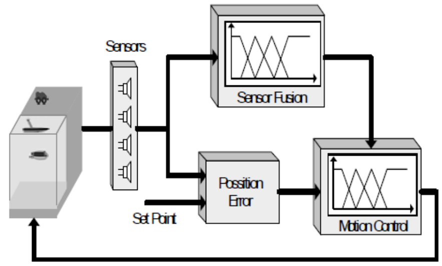

Figure 8 Common control architecture

The sensor fusion block takes input and date which is provided by the sensors of the vehicle and output the information for eventual obstacles is respect to vehicle position. The interpreted obstacle information forms a collision possibility, which send this to the motion control system. Sensors, position error and sensor fusion are the inputs for the motion control. Motion control is the one generated the command to move forward, stop, turn left and turn right.

2.16 What is Prolog

Prolog is computer language based on logic. It is mainly based on the defining the logical rules and then solve the problem according to that predefined rules. It can be used to write any kind of program. Prolog is commonly used to program the large amount of data held in database. These systems are called Knowledge base systems. Prolog is often used to develop the programs in the areas such as artificial intelligences natural language processing and databases.

2.17 Programming in Prolog

Prolog is called a declarative language or rule based language. Facts are the simple set of data used in Prolog. A fact is consists of two things, predicate and an argument. For example

action (stop), action (accelerate), action (proceed).

In the above example “action” is a predicate and “stop”, “accelerate”, “proceed” are the arguments. The arguments are knows as atoms, it is similar to the string that are used in other procedural language.

A predicate is always a string or atom An argument can be of different types. We can use more than one argument with one predicate, for example

Action (accelerate, 50).

In this example above predicate “action” has two arguments, accelerate and 50. The arguments can be of different tope.

Integer: integer argument consist of only digit eg, 50, 100

Real: consist of digit with decimal points

Atoms: An atom is a string, can have digits or underscore. It is always start with lower case. Capital letters can be used in the middle. No space is allowed in the atoms.

String: A string is a combination of characters enclosed in double codes eg “string”. Can contain a space, full stop or underscore etc.

Variables: always start with CAPITAL letter; it can contain different values as used in other non declarative languages.

A rule is the extended fact which added the sub goal. The sub goal has to be satisfied for it to be true. A clause is a combination of rules and the face. It is a fact or a rule, like an item in the database.(David 1994)

A Rule has to parts; a head and a body. The head is similar as the fact. The body consist of a sub goal normally clauses. Rules of facts both should be true for the rule it self to be true. “:-” is used to separate the head from the body when defining a rule.

Action (stop) :- traffic_light_is_ red; no_obstacle_ahead_onthe_ Road_ahead.

This is a rule which has two sub goals. In this case action(stop) is true if “traffic_light_is_red” or “no_obstacle_ahead_onthe_ Road_ahead”. It cas be read as:

The car will stop if the traffic signal lights are red or there is an obstacle ahead on the road.

2.18 Why prolog for intelligent vehicles

Prolog language can be used to design the expert systems. To design Expert systems for the intelligent vehicles are consists of set of rules. In this case the rules cannot be defined in the term of data. There has to be an database which contain all the rules. Procedural language on the other hand can be used to design the expert systems, this can be achieved by the use of set of selection statements commonly used if… then…else construct but the largely data base systems are very complex so the rules

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are to be nested and it become very difficult to track the bug if there is any and also its very difficult to add new rules to the expert systems in further development.

Defining rules for autonomous expert systems is an is to design a database with all the facts and set of instructions, that can then be used in different situation as to be required according to the environment. Rules show the relation between data element. Attributes are used to expresses the data. Parameter can be an expression or set of expressions has to be satisfied to perform an action. For example for an driver assistance system there can be an condition to check the traffic light. – [http://www.amzi.com/articles/rule_engines.htm]

If the traffic light is red then

Execute Stop process.

End if
If the traffic light is Green then

Execute accelerate process.

End if
If the traffic light is yellow then

Execute wait process and then accelerate

End if

In Prolog attributes and their values are easy to express. Its very simple and easy to define rather than using the nested if statements.

Action (stop) :- signalLight (red).

Action (proceed) :- signalLight (green).

Action (accelerate) :- signalLight (yellow).

signalLight (Color) :- inputFromSensor (signalLight, Color).

2.19 Traffic sign Recognition

Traffic sign are very important on the roads. Traffic signs regulates, alerts, warn the driver about the coming up head situation and might force to do some action. They

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assist the driver about the speed, the roads directions, giving distance to any town and city etc.

Traffic sign recognition is very important for the intelligent systems. Fast and robust recognition is very important and helpful for the driver, and hence increase safe driving. Automatic sign recognition is challenging, due to the different shapes of sign boards, different colour of background apart from that weather conditions, amount of light, shadow and fog etc.

Traffic sign recognition is a two phase task. The first phase is to detect the traffic sign, and the second phase is to read the traffic sign. The traffic sign is detected from the sequence of video stream or from the continuous pictures normally from a video camera. Algorithms used for the detection are usually use colour and shape of the sign. The more efficient and quick recognition is very important in intelligent systems. Pacheco (2004) recommends special barcode on the road signs. These bar codes were coloured, and easy to read. Aoyagi and Asakura (1996) proposed a genetic algorithm for the detection of traffic signs.

Traffic sign recognition using Neural Networks (Lorsakul etal) is the system are pre processed images taken from the video stream is used as an input into the system. These images are then read in different coloured and black & white mode. Black & white image is then smothers and canny edge detection used to improve the picture to find the required area of the sign. This image in then converted in to binary image. In all this process the image is reduced to the smallest area of the traffic sign called blob. This blob section is used as an input to the neural network. Neural network is then performed some tasks to read this input blob. The system is trained and validated to find the best network architecture. The results are very accurate when reading the traffic signs with different backgrounds.

In autonomous vehicle a fuzzy logic is implementer to navigate the vehicle. The aim of this is a successful application to move a vehicle collision free on the ground (Xiaopeng et al 2003). The wide applicability of this in autonomous navigation is based on the representation of inherently vague notation. This can be achieved by the simple if…then statements. All of these rules consist in the form of language information describing the problem in a very simple manner.eg.

If (velocity of vehicle ahead is decreasing and the distance between the vehicles is less than the set distance) then
{

`

stop accelerating and apply breaks to stop the vehicle at the safe distance from the vehicle ahead

}

Fuzzy logic is an appropriate tool for the representation of the sensors reading more accurately .The response time of this logic is very quick and low computation time of hardware implementation. (Tsourveloudis, 2008)

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Chapter 3. Research Methods

The research is required to analyse challenges that present at the time in towards the intelligent systems for vehicles, there are a number of intelligent systems are available as discussed in chapter 2, systems should be installed efficiently and accurately. All the sensors used to get input information for automation, computers to process that data, processors, Operating systems and intelligence software systems must be reliable for the safety of the human.

To determine the autonomous software a quasi-experiment approach is used as primary research method.

3.1 Quasi Experiment:

The main purpose is to design an algorithm for the intelligent vehicles. A set of rules are to be defined for the intelligent vehicles for the driver assistance systems. Quasi experiment is a method of research in which there is no random assignment of subject to condition. It is a natural experiment approach. Independent variables used are assigned the values are real values, but not assumed values

The quasi experiments evaluate the population on which the experiment is being done. They also results weather the output of the program is correct. The logical model used in the development of program, weather the changes which are to be expected are occurring. If the required changes are not occurring, it means the logic is not correct and requires an analysis of the model. The use of quasi experiment as a research approach evaluate that the results from a particular program are very powerful for that particular sub-system and the programs that are designed to improve a particular area are very help full. This may not be helpful for all the regions.

3.1.1 Dependant and independent variables

Casual relational is the relation between the dependent and independent variable. It is a relation that how much effect will on the dependent variable when there is a change in independent variables. For examples when we move the steering to turn the vehicle, how much the tyres should be moved, and the car should turn. It is possible the on the full turning of the steering there is not much moment in tyres motion and in contrast a half turning of steering could result a full bend of tyres motion.

3.1.2 Experimental phases

An experimental approach is divided into five phases

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1. Identifying the problem
2. Planning
3. Conducting experiment
4. Analyzing the data
5. Results and findings

Identifying the problem

The first step is to identify the problem. Once the problem is clearly stated then there is need to find the alternative solution of the problem. Choose the best approach among the possibilities to find the solution and formulate the hypothesis.

Planning

The next step is to test the hypothesis. When testing hypothesis we make sure how generalised or complex the result is required. There is a need to identify the population size needed to perform the experiment. This will result how simple and complex results are to be. If we choosing the entire population there results are more complex. If there is need to develop an application, we analyse the type of the application and decide which programming is best to develop the application, in this research a declarative language prolog is used to define the rules for the intelligent vehicles.

Conducting experiment

The next step is the practical experiment. In this phase the real models are designed. If the research is base on the development of an application, code is written using the editor or integrated development environment and compiled. Testing is also part of this stage. Code is being test and should be error free and the application is in running condition to and yielding the results.

Analyzing the data

Forth step is analyzing the data. After the development, there is need to test the data or the application. The finding yields from the experiments are analyzed by comparing or contrasting. Applications are tested in real time environment, it is very important to analyse the application in the real environment because sometimes the

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results vary when a real time application is experimented in actual environment rather than in development environment.

Results and findings

Once the research has been completed and all experiments are conducted in real systems results are released based on the adopted experiment approach. The results can be positive or negative depend on the adopted method. This is normally a documented paper which illustrated the history during the development of the application and concluded with an analysis of all the steps taken during the development.

3.2 Secondary search

Secondary Search is based on the collection of through external resources. To carry out this research the main recourses are the journals and the research works. Books are also available but there are not enough details about the intelligent systems for the robotic vehicles. Web sites are another external source of information with statistical data and the current search articles about intelligent systems.

3.3 Interviews

Interviews are the guided set of questions. Interviews are used to collect facts. Interviews are the best way to find out about the people opinions, what they think about. A structured approach is used while interview. Semi-structured approach is used when the study is about to find the common factor among different contributors. In this approach almost the same questioned are asked to all participants where as an unstructured approach is useful when exploring people awareness.

This document is about the study of intelligent vehicles and the technology used in it, interviews cannot be conducted to carry out this research. Interview can be bias, if the interviewee is from the company about which the information is collected

3.4 Questioners

Questioners are another way of research. These are used when doing any survey, for example a survey about any manufacturer, or supplier can involves a questionnaire approach about the quality of the products.

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3.4.1 Questionnaire types

There are two types of questionnaire structured and non-structured. Structure approach is one where the questions are in a pre ordered list, the population choose to respond already know the purpose of the information. These types of questionnaire are called non-disguised. The only difference between non disguised and disguised approach is that in disguised questionnaire respondents have no idea about why the information is being collected.

Non structured approach is the one where there is no sequence of the question and researchers can ask random questions without any sequence. Closed ended questions are multiple choice questions, where respondent are bound in the domain of answers and they have to answer one option for each question. This approach is helpful to quantify the answer. The advantage of closed ended questionnaire is that the respondent does not need to think a lot to answer the question because the answering options are provided as a domain of each question.
http://www.scribd.com/doc/18132256/Types-of-Questionnaires

Open ended questions are the approach where the respondents can answer in their own words. A blank space or a text box is provided to answer the question. Answers can be very descriptive and then analysed towards the results. The problem about the questionnaire is that the respondent should be aware of the technology about which the questions are about.

3.5 Primary search

Primary search method used in this search is quasi experiments which involve the development of expert system for the intelligent vehicles. This is a set of rules to follow during driving. A driver assistance system used sensors to learn the environment and this information is used as an input to the expert systems.

Prolog is a high-level programming language based on formal logic. Unlike traditional programming languages that are based on performing sequences of commands, Prolog is based on defining and then solving logical formulas.

Prolog is called a declarative language or a rule-based language. Programming in declarative language consists of a list of facts and rules. It means that the data related to the problems is declared in a database. After declaring the facts and data, rules are then defined to get the required information from the database as compared to procedural language where for every type of search a routine has to be typed in. parsed queries are used to find the solutions of the problems.

Declarative languages are used to define the problems as compare to procedural languages that are used to solve the problem. Like Any other procedural language, prolog does not use constructs, any counter or conditional loops, not and conditional (if…else, switch) statement. There is no data type deceleration in prolog. Prolog is widely used for knowledge base systems particularly for programming related to artificial intelligence applications and expert systems. (Mano 2010)

One of the main reasons to use Prolog is that you do not have to tell the computer how to solve a problem. Prolog programs consist of a carefully ordered set of rules. The research is bias to choose the prolog programming, because logical programming is easy as compare to structured languages.

3.6 Limitations

Limitation in the developing of expert systems is, we assume the input is coming from the installed sensors and the vehicle has installed with the input devices. The internal processes that how sensors sense the environment and how this input is processed internally by the expert systems will not be discussed in this document. Limitations in this study are that as this is a growing technology and it is not implemented fully anywhere in the world, so the information available is not complete. It is hard to find the deep knowledge in artificial intelligence field.

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Chapter 4. Results and findings

An application is built for the intelligent vehicle systems. This application consists of the set of rules for intelligent vehicles using prolog a declarative approach. The rules states explain the conditions in which the driver has to take some actions.

Driver assistance systems make a vehicle intelligent. Safety is the critical issue for driving. The important assistance systems which are really helpful for drivers are the collision warning systems, lane changing systems.

4.1 Lane changing system

Lane changing system is a system helps driver to change the lane. Numbers of parameters are to be checked before the activation of the manoeuvre.

- Car hazard light activated (left / right)
- Position of car in Lane
- Total time to change the lane (left / right)
- Blind spot status
- Time to fill the space by another car
- Distance between the front vehicle and rare vehicle in the target lane. This distance should be more than the vehicle length

4.1.1 Rules to change the Lane of an intelligent vehicle

```
/* Dimension of the vehicle */

car(length,6).          /* length of the vehicle */

car(width,4).           /* width of the vehicle */

car_hazard_light(right, inactive).      /*predicate for car hazard light on the right side, the status is inactive mean
                                        that the right hazard light is NOT turned on*/

car_hazard_light(right,active).         /*predicate for car hazard light on the right side, the status is active mean that
                                        the right hazard light is ON */

car_hazard_light(left, inactive).       /*predicate for car hazard light on the left side, the status is inactive mean that
                                        the right hazard light is NOT turned on*/

car_hazard_light(left, active).         /*predicate for car hazard light on the left side, the status is active mean that
                                        the left hazard light is ON */
```

`

blind_spot_status_right(empty). /* predicate outputs the status of the blind spot on the right side of the vehicle. Lasers, sensors, radars are used as an input and then images or video streaming systems are used to monitor the area if any vehicle , cycle or bike entered in blind spot */

blind_spot_status_right(notempty). /*sense the blind spot on the right if it is empty */

blind_spot_status_left(empty). /*status if blind spot on the left of the vehicle*/

blind_spot_status_left(notempty). /*sense the blind spot on the left if it is empty */

The rules changeLaneRight / changeLaneLeft below explain that which parameters are to be true when changing the lane. The firs status is to check if the vehicle hazard left if changing the lane to left and right if changing the lane to right is active. Blind spot status is checked to avoid any possibility of collision. T is a variable which estimate the time needed to change the lane in normal condition. A time check is introduced here for the safety. This time (T) is calculated by algorithm which estimates the time (T) . Tx is the time to fill the targeted gap by another vehicle, this is estimated by reading the behaviours of the vehicle around or vehicle to vehicle communication system. This system checks the velocity and the time reach the target space. For the success of lane change rule the time T should be always greater than that Tx. Here we have 3 extra seconds added in Tx to make sure that it is safe for the vehicle to move to adjacent lane. The required space available for the vehicle to fit is also checked for safety measures. SpaceAvailable variable checks the space available in the adjacent lane which is than compared with the vehicle length with an extra 6 meters on both sides. All the data is gathered by the sensors installed around the vehicle. In this program we will assume that T, Tx and Space variables are calculated by the sensors and input to the software as a parameter.

Driver safety is very important when changing the lane. Data from sensors is interpreted and speed of the car and distance from the front vehicle or obstacle is continuous monitored. To avoid crash in front if the vehicle is at the speed of 60 miles per hour, the rules explain if the distance is less than 100 meters then car must slow down and apply brakes. The reason this is embedded because 100 meters in the minimum distance to stop the vehicle at that speed. Heave vehicle need more distance to cover when apply the brakes.

Cameras are used on the side mirror view to get the information from the rare of the vehicle. It provides the updated information to the driver. Image processing is used to read and fetch the information. The sensors input from both sides of the vehicle used to avoid side crashes. Systems issue a warning if there is any vehicle entering in to

`

the blind spot which results in disable the lane change function. If driver tries to change lane, system sends warning message, hence increase the safety.

```
changeLaneRight:- car_hazard_light(right,active),blind_spot__status_right(empty),

write('Enter the time to change the lane in Seconds: '), read(T),

write('Enter calculated time to be filled by another vehicle in Seconds: '), read(Tx),

T>Tx+3,

write('Enter the space in meters available for the vehicle in the target lane:'), read(SpaceAvailable),

car(length, Len),

SpaceAvailable >(Len +6).

changeLaneLeft:- car_hazard_light(left, active),blind_spot_status_left(empty),

write('Enter the time to change the lane in Seconds: '), read(T),

write('Enter calculated time to be filled by another vehicle in Seconds: '), read(Tx),

T>Tx+3,

write('Enter the space in meters available for the vehicle in the target lane:'), read(SpaceAvailable),

car(length, Len),

SpaceAvailable >(Len +6), nocrash.

nocrash:- obstacle(front), obstacle(left), write ("speed of the car: "), read(Speed), speedlimit(Speed),

write("Distance from the front vehicle in meters: "), read(Distance), (speed >30 , speed < 60, distance<100 ; stop. )
```

4.2 Traffic Light Rules

Intelligent vehicles follow the traffic rules. When a vehicle is approaching at the traffic light shows down and checks the signal lights ahead. Driving straight ahead it checks the status of the traffic signal. A red light indicates that vehicle should stop. A green light indicates Go. A flashing yellow light is a alert that the signal status about to change to red or green. Same rules apply when vehicle turns left or right. An arrow sign right or left indicates that for the control. A green arrow (left/right) shows that the road is available for turn.

If (vehicle A is inside the lane)

{Vehicle A is travelling ahead; No signal is sent

`

}

If (vehicle A is start entering to adjacent lane)

{Vehicle A is trying to change the Lane; turn signal is sent

Vehicle B and C behind the Vehicle A should slowdown, and allow a safe time gap and safe distance.

}

If (vehicle A is entered to adjacent lane)

{Vehicle A changed the Lane; turn signal is sent

Vehicle B can accelerate the speed

Vehicle C behind Vehicle A should slowdown by keeping the safe distance.

}

If (vehicle A is decreasing its speed)

{Vehicle B behind Vehicle A should activate the brake behaviour

}

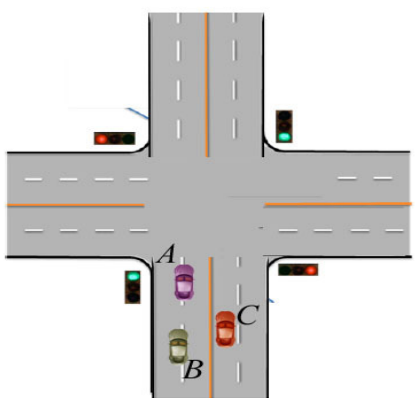

Figure 9 Intelligent system, Traffic light

When vehicle approaches at the traffic junction, it reads the signal light status. Smart cars have ability to communicate with the traffic light. It gets the information from that junction and calculates if there is clear chance to drive through the intersection if the signal is green or a flashing yellow light. It calculates the time to approach to the junction and compare it with the time to change the status of the traffic signal, if there

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is safe time stamp so it adjusts the speed by accelerating or applying brakes with respect to the other vehicles' behaviours and not exceeding the maximum speed limit.

At the Traffic junction; not only the signal lights to be followed. There is also need to check if there is any pedestrian remaining on the road or any other vehicle that might be still in the middle of the junction.

```
        /***************  rules for traffic light *********************/

/* traffic lights red, green and yellow status is stable */

signal_light(red, stable).          /*Traffic light signal red*/

signal_light(yellow, stable).       /*Traffic light signal yellow*/

signal_light(green, stable).        /*Traffic light signal green*/

        /* traffic lights red, green and yellow status is flashing to be changed to another color */

signal_light(red, flashing).        /*Traffic light signal red flashing*/

signal_light(yellow, flashing).     /*Traffic light signal yellow flashing*/

        /* traffic light arrows red, yellow and green for right turn */

signal_light(red_arrow,right, stable).          /*Red arrow signal right */

signal_light(yellow_arrow,right, stable).       /*Yellow arrow signal right */

signal_light(green_arrow, right, stable).       /*Green arrow signal  */

signal_light(red_arrow, right, flashing).       /*Red arrow signal right flashing */

signal_light(yellow_arrow, right, flashing).            /*Yellow arrow signal right flashing */

/* traffic light arrows red, yellow and green for left turn */

signal_light(red_arrow, left,stable).           /*Red arrow signal left */

signal_light(yellow_arrow,left, stable).        /*Yellow arrow signal left */

signal_light(green_arrow, left,stable).         /*Green arrow signal left */

signal_light(red_arrow,left, flashing).         /*Red arrow signal left flashing */

signal_light(yellow_arrow,left, flashing).      /*Yellow arrow signal left flashing */

stop:-  signal_light(red,stable).               /* Stop the vehicle if the signal light is red  */

stop:-  signal_light(yellow, flashing).         /* Stop the vehicle if the signal light is yello and wait for the green light to go or
        red light to Stop */
```

`

stop:- write('any obstacle found in front'), read(O), (O='n'). /* vehicle detects if there is any passenger or obstacle in front of the vehicle route. A stoop command is activated if there is a possibility of crash*/

/* Turn left or turn right rule checks is the traffic signal is green, the system also checks if there is any other vehicle or any pedestrians is still in the way. Once all cleared, then turn manoeuvre performed. Variable 'P' is a input from the input sensors which detects for any obstacle in front and pass the value to the expert system. */

```
turnLeft:- signal_light(green_arrow, left, stable),

        write('Any pedestrian in front of the vehicle detected (y/n): '), read(P),    /*reads P as input from sensors*/

        (not(P='y'); not(P='Y')), (P='N'; P='n').

turnRight:- signal_light(green_arrow,right, stable),

        write('Any pedestrian in fron of the vehicle detected (y/n): '), read(P),    /*reads P as input from sensors*/

                (not(P='y'); not(P='Y')), (P='n'; P='N').
```

4.3 DVI (Driver Vehicle Information) System

DVI system is the one which enables the cars to communicate. The DVI system let the driver know if there is a danger ahead. And instruct the driver to take some action such as hitting the brakes and slowing down the vehicle speed. Intelligent vehicles show great potential and assist the driver in the hazard situation. In the intersection where the view is compromised, did not warn on both directions.

If the vehicles are able to communicate, the vehicle approaching the intersection will be aware of another approaching vehicle and alert the driver.

Figure 10 Road Intersection

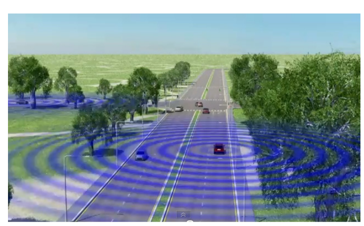

Figure 11 Intelligent vehicle sensation

Traffic situation awareness, Intelligent vehicles could alert the driver to upcoming traffic issues, for example if there is any change in traffic flow pattern like vehicle ahead suddenly brakes, this action is observed by a vehicle behind and the information is intimated to the driver so to take some action or autonomous vehicle could activate the stop or slow down vehicle function.

Blind spot assistance is another feature. Blind spot function help driver to warn if some vehicle is entering their blind spot. With intelligent vehicle sensor technology, they could help driver anticipate vehicle approaching from behind. With intelligent vehicles, the drivers can analyse the un-expected behaviour for example on the blind curve vehicle that is broken down at that place on the road could alert the driver of incoming vehicle.

`

Chapter 5. Analysis

In this chapter the results from the research methods is analyzed. A comparison of primary and secondary search and research questions and literature re will be corresponding.

Intelligent vehicle systems are helpful for the driver's assistance. The primary search is carried out by development algorithm using prolog programming language. The technologies we discussed in chapter 2 are used in intelligent vehicles seems that intelligence is in place but there are still more research is required to make this technology more safer for the human to use without any risk of death.

Secondary research methods were very useful in this study. Journals and books have quite lot information about the intelligent vehicles and new systems.

Smart cars using the intelligence technology can communicate with the roads, maps, and assist the drivers in advance if there is any possibility of abnormal behaviour predicted, to the safer route to their destiny. Communication of the vehicle with the traffic signals and traffic signs is very helpful. Smart cars have ability to make decisions by observing the environment or by communication with other vehicle. Software architecture or Expert system receive input data from the sensors devices and processed this data is then passed to a rule bases system, by analysing the data the decision has been made and implemented.

The lane changing assistance system is very effective, it checks the parameters necessary when change the lane. The rule fails if any of the parameter is false. The weakness of this system is that it activates only if the Hazard light are active. For the success of the rule to change the lane is depend on it. Once the manoeuvre is active the position of the car in the lane is also checked. This is necessary because it contribute in the calculation of the time to change the lane. Delay of few seconds and or an early response can cause damage and results in crash. The information is collected with the help of on lane installed devices which measure the distance of from the lane to the vehicle wheels. Maximum time required to change the lane is calculated. It ranges between six seconds to thirteen seconds. The rules are checked all of these parameters with additional status of the blind spots in the target lane. The rule activates when left or right indicator is active. If driver fails to activate the indicator and start change the lane it would issue warning to driver for the hazard activation.

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Driving the vehicle on congested roads and junction, the system checks the parameters can cause of crash. It checks all the safety issues along with the data about the junction lights. Once all the parameters are true then the rule succeed.

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Chapter 6. Conclusion

For the safety of the peoples and comfort, there is need to develop more interfaces and models. More research is required for the full implementation of this intelligent technology for people. All the components of the vehicles should be installed fully, the response time is very important from any input device. Components of software, sensors, should be functioning fully and reliable.

There is a need to build the new roads, install with the sensors devices. Each lane on the roads is to be marked as a separate section. For the success full adaptation of the intelligent assistance systems for the drivers, existing road needs to be equipped with the same technology. Traffic lights on the roads, at junctions and traffic signals also recommended be equipped with this latest technology. Traffic zones are needed to be marked which are helpful to define speed limits and other constraints. A high budget is required to install this system on the roads. Alternatively in the most congested areas where traffic jams is very often this system is very helpful. For the vehicle manufactures to install the technology is very expansive.

6.1 Learning and outcomes

In this study we have learned about:

- The technologies used to make vehicle intelligent, types of input devices or sensors used to learn the environment.
- Software architectures at present available for the cars
- A detailed knowledge of the driver assistance systems used in vehicles and how they communicate internally or external with other global systems.
- The use of prolog in the designing of the expert systems. It is first time that I have learned a declarative language for logic programming. I found it very interesting and easy to use when using for decision base systems as compared to procedural languages where for each task there is need to define separate procedures. Defining the rules is much easier rather than selection statements used in other languages.

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