Smart cars on sensible roads information technology essay

Technology, Information Technology

Abstract—This paper presents a brief study of cars as an autonomous intelligent agents by considering information from the surrounding environment (highways, road) determining its position, detecting the movement and detecting the behavioural patterns of the surrounding vehicle and negotiating its travel while moving with other moving objects. It also proposes for the development of intelligent vehicle highway system which will help in co-ordination and automatic control of the cars in its environmentKeywords— safe zone, free space, travel corridor, travel path, PROMETHUS, VORAD, IR, EMPIRICAL

Introduction

Travel and traffic today has become a hectic part, humans have difficulty in tracking continuously moving objects near their vehicles for any length of time. In addition it also leads to accidents thus the development of intelligent vehicles to inform the driver about its surrounding environmental objects becomes a necessity today. In regards to the problems faced by the humans, in 1980 a EUROPEAN project " PROMETHUS"[1] was launched which significantly contributed to the development of autonomous intelligent vehicles. Since then many projects have been developed for highway traffic safety. The majority of these projects explore vision issues such as lane detection, segmentation, object detection, tracking etc. Currently robotics and AI technologies available today are being employed to assist the driver and also to help the car know about the traffic rules and negotiate safety by co-ordinating with its surrounding vehiclesThe paper is divided into seven parts. Part one gives the introduction, part two describes the various zones around a car, its detection and imaging. part3 puts all these layers and imaging in real time traffic , part four imbibes these real time zones and imaging in the car, part five explains about smart highway in short, part six describes the hardware requirement part seven is reference, conclusion and acknowledgement

THE ZONES AROUND A CAR

The space around a car is divided into four zones: free space, travel corridor, travel path and safe zone, as shown in figure 1Free space: The free spce is the space around a car in which no moving objects of importance is detectedTravel corridor: The travel corridor is the space in which the car is free to move and considers any invasion of this space to be cautionary. The travel corridor extents as far as edge of free space and atleast as large as safe zoneTravel path: The travel path is the actual path the car uses to travel and it comes within the travel corridor. Safe zone: The safe zone is the immediate space surrounding the car. A simple relationship connects these space zones $SZ \subseteq TC \subseteq FS$Using the cameras mounted on all the sides of the car will provide an idea of the travel corridor, travel path safe zones and free space around a car. Laser scanners are used to detect the moving objects so that no " blind spots" are there. The positioning of the cameras as shown in the right image of fig2 overlaps the images formed by them. This is helpful as well as useful in case any of the cameras malfunction, other cameras will still cover the full image. Laser scanners are mounted in groups of three and then mounted on each sides of the car. Each camera has a 60 degree field of view and this assumes to eliminate the blind spots. The arrows indicate the direction of the view. The twelve cameras are solely used for providing an overall idea of lane width, road curvature, road surface, surrounding space. The figure below shows the laser scanningDetermining the free space around a car is a two step process. The first process is processing of raw data by laser camers and sensors and then generating a " 2D image". The second process is the formation of " 3D contour shell " by processing the lost information. Looking in fig3 the corridor is created by scanning and processing, notice that there are some lost information. Next the exterior shell is generated as shown in figure 4The Figure 4. I is a top view of a car with the twelve laser range finders, the Figure 4. II image is a top view of a car with the Free-Space surrounding the car, and the Figure 4. III image is just the necessary contour information generated by the range finders. CALCULATING TRAVEL PATH: The travel path is well within the travel corridor and if the travel path intersects the travel corridor the path is considered as unsafe. The travel path is limited by several extraneous controls-road width, weather conditions, and current carload. Note that vision and IR cameras can be used to track the edges of roads. The safe-zone is graphically illustrated and can be mathematically described by the equations: 1) Distance left= Car-Size – Ex2) Distance right = Car-Size + Ex3) Distance from t = Car-Size – Ey4) Distance back = Car-Size + EyWhere E is empirically determined for each car. The right image shows that the safe-zone of a car at rest is symmetrical about the vertical and horizontal axis; this is why we can use Ex or Ey. When a car is moving, shape is no longer symmetric (the front part is longer to the rear one), but E will increase with speed and be limited by lane width and travel conditions. So once again we need to look at what the Safe-

Zone within its two possibilities: 1) The vehicle at rest 2) The vehicle in motion.

Stationary (Default) Safe-Zone

When the car is at rest it can mean the vehicle is at the stop sign and running or it is parked, in such a case the safe zone would have to include space needed to open a door etc. The parameter E is used while we are driving and are essentially constrained by width of the lanes and the context in which we are driving. In this case the context is stopping on/off ramp or traffic signal. The true meaning of the stationary safe zone is to create an absolute minimum buffer zone around the car. A car is free to travel anywhere within the Free-Space. If a Travel-Corridor intersects the Free-Space then the Travel-Corridor is rejected as unsafe. This will be assumed to be true with other cars, too. A Travel-Corridor must in turn be fully encompassed by the Safe-Zone. In other words, Free Space ≥ Travel-Corridor ≥ Travel-Path ≥ Safe-Zone. III TRAFFIC PATTERNSAny two cars can be said to be in one of the eight different positions relative to each other. The left image illustrates the eight possible relative positions using the centre car as the target car. The right hand image shows four of the relative positions (red= 2, blue= 4, green= 5, orange= 7). The symmetry lets us consider just the positions involved with the centre car. If there are eight surrounding cars, they can be viewed as pairs of cars and concatenate the individual pairs into a worldview of all the cars. (This gives us a total of 28 = 256 possible patterns. For the study of the traffic priority of each car, each car is essentially interested in the relative positions of any other car, by considering their velocity as well. The velocity will allow us to predict the position of car A plus the car B. IV A Car as an Autonomous AgentWhat is proposed here is not a car without a driver but rather a car assisting its driver to reach its destination safely. The driver still needs to do the driving and other core important controls, but the car might offer suggestion or " nudge" the course to amore safer and efficient path. To achieve this the car has to become rather smart defining its present status. As stated the car will process information with the help of today's technologies, making use of satellite communication along with range finding equipment. The car would store its present status information, also the car would observe drivers driving style and offer suggestion to improve its driving. Not only must the car able to predict its present status but also must be able to predict future status solely on its observation. . Assistance may be as extreme as taking over the control of the car and bringing the car to a safe stop in a rest area because of erratic driving on the owner's part, to as little as slowing the car down because an ambulance is trying to pass. In addition, the car will be able to negotiate its current position and velocity with another car that shows an irregular or dangerous travelling behavioural pattern.

Learning patterns of behaviours for other cars

One obviously knows that an 18 wheel hard truck would behave differently than a sedan than a subcompact. The smart car would categorize different travelling behaviour. Smart cars from different manufactures " hold" different traffic rules and traffic patterns. Based on the range-finding information, the category of vehicle can be assessed and the Safe Zone and Travel-Corridor can be modified.

Exchanging information with other cars

The smart car will be able to exchange information with other surrounding cars via internet, central routing system etcThe purpose of communication is to inform the car with irregular behaviour about its travelling pattern and seek for possible answers. The major problem with the central system is privacy. Many people would probably not like their locations and driving behaviour available in a central database. V Smart Cars on Smart Roads: Along with the development of smart vehicles, there has been a considerable development of intelligent vehicle highway system (IVHS). IVHS proponents claim that a proper combination of control, communication and computing technologies, placed on the highway and on the vehicle, can assist driver decisions in ways that will increase highway capacity and safety without building more roads. IVHS FUNCTIONSLet us imagine an automated network of interconnected highways. Appropriately equipped vehicles may enter and exit this network at various ' gates' and travel through this network under control authority distributed between the highway and vehicle. The network is embedded in a larger transportation system containing several inhomogeneous networks." For example, a vehicle leaving the automated network may enter an unautomated network of urban arterials. Upon entering a gate, the vehicle announces its destination. The (IVHS) system responds by assigning to it a route through the network. A route R is a sequence likeThe interpretation is that the route consists of a sequence of segments. The first segment of the route is on the highway named H, starting at gate s, and finishing at gate f l ; the second segment is on highway H, from gate s, to f2; and so on. It is understood that an interchange lane connects f1 on HI to s, on H,, etc., as illustrated in figureVI. HARDWARE REQUIREMENTSImplementation of the control design will require significant hardware on the roadside and in the vehicle to collect or communicate information. Roadside Monitors: They measure traffic conditions such as flow and speed. Based on these data the link layer calculates a path for each vehicle and the target platoon size and speed, and communicates them to the vehicle. Traffic measurements may be made by loop detectors, ultrasonic sensors (used in Japan), or vision systems. Sensors: Vehicles must be equipped with a longitudinal sensor that measures the relative distance and speed between itself and the vehicle in front of it. Such sensors may be based on radar, ultrasonics (as in a Polaroid camera), or vision. In order to change lanes the vehicle must be equipped with sensors that locate vehicles on the side within a range of about 30 m. Inter-Vehicle Communication: The planning layer requires the ability to communicate with neighbouring vehicles within a range of about 60 m. Such communication links need to be reliable, and incur very small delay (about 20 ms) Again, various solutions may be proposed including broadcast or cellular radio, infrared beacons, communication through a roadside stationEXPERIMENTAL RESULTS AT BERKELEYA very simple two vehicle platoon control system has been implemented. Details are available. The control system components include: 1) A radar system made by VORAD [1] to measure relative distance and speed; 2) Throttle and brake actuation system; 3) A 80386-based PC equipped with a data acquisition board to interface with the sensors and actuators and a communication board to interface with the radio; 4) Digital radio transceiver made by PROXIM operating at 122 kbps.

Reference

[1]VORAD: Vehicle Onboard RadarCONCLUSIONIn this paper some navigation ideas from the robotics research and autonomous agents' areas were transferred into smart cars navigation domain. In particular, traffic rules and navigation issues were discussed and learning behaviour patterns were addressed as well. This is an ongoing on collaborative effort between ITRI and Ford researchers. The transportation system has a major impact on society. A qualitative change in that system as envisaged by IVHS advocates will, in the long run, significantly affect our daily lives, the spatial organization of work, and the environment. Transportation engineering as traditionally defined cannot by itself meet this challenge. Neither can control theory by itself. A socially responsive approach will require the integration of several disciplines. AcknowledgmentI heartily acknowledge my mentor Ravi sir as also university of California from where I have taken considerable help. I would also like to thank the European development project PROMETHEUS for the great considerable content of information. The ideas here are taken from the various IEEE papers on smart cars and is supported by the various research papers on intelligent vehicle system and smart highway system . The ideas expressed here are a combination of the different ideas read by me as also some formulated by me.