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A Review on Autonomous Car

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Abstract: An autonomous car is a self-driving vehicle that has the capability to perceive the surrounding environment and navigate itself without human intervention. For autonomous driving, complex autonomous driving algorithms, including perception, localization, planning, and control, are required with many heterogeneous sensors, actuators, and computers. To manage the complexity of the driving algorithms and the heterogeneity of the system components, this paper applies distributed system architecture to the autonomous driving system, and proposes a development process and a system platform for the distributed system of an autonomous car. The development process provides the guidelines to design and develop the distributed system of an autonomous vehicle. For the heterogeneous computing system of the distributed system, a system platform is presented, which provides a common development environment by minimizing the dependence between the software and the computing hardware. A time-triggered network protocol, Flex Ray, is applied as the main network of the software platform to improve the network bandwidth, fault tolerance, and system performance.

Keywords: localization, planning, control, driving algorithms, Flex Ray, network protocol.

I. INTRODUCTION

The overview of this paper is to explain a driverless car is an autonomous vehicle that can drive itself from one point to another without assistance from a driver. One of the main impetuses behind the call for driverless cars is safety. An autonomous vehicle is fundamentally defined as a passenger vehicle. An autonomous vehicle is also referred to as an autopilot, driverless car, auto-drive car, or automated guided vehicle (AGV).Most prototypes that have been built so far performed automatic steering that were based on sensing the painted lines in the road or magnetic monorails embedded in the road. Purpose of the current work is to study and analyse the driverless car technology. This mobility is usually taken for granted by most people and they realize that transportation forms the basis of our civilization. The need for a more efficient, balanced and safer transportation system is obvious. This need can be best met by the implementation of autonomous transportation systems. Current work focuses on how to use the Future Car Technology That's On the Road Today. In the future, automated system will help to avoid accidents and reduce congestion. The future vehicles will be capable of determining the best route and warn each other about the ahead. Many companies and institutions working together in countless projects in order to implement the intelligent vehicles and transportation networks of the future The development of these autonomous driving technologies, the Defensive Advanced Research Projects Agency opened the Grand Challenge and Urban Challenge competitions in the U.S. The Grand Challenge competition focused on the development of autonomous cars that can traverse off-road terrain by themselves. Based on the results of the Grand Challenge, the Urban Challenge competition aimed at the advancement of autonomous cars with urban driving technology. Through both of these competitions, the feasibility of the autonomous car realization has been confirmed. As a result, global automakers and information technology companies such as General Motors, Volkswagen, Toyota, and Google have made an enormous investment in the commercialization of autonomous cars. In Korea, in order to stimulate autonomous car research, two autonomous vehicle competitions (AVCs) were held in2010 and 2012 by the Hyundai Motor Group. The purpose of the 2010 AVC was to establish the foundation of autonomous driving technology in Korea. The missions of the 2010 AVC concentrated on waypoint tracking and static obstacle avoidance .Based on the fundamental technology, the 2012 AVC tried to develop techniques for urban driving environments; the missions were related to urban driving such as traffic signal detection, overtaking, crosswalk stops, and passenger detection. This paper is based on the results of the 2012 AVC. Developing an autonomous car refers to the integration of technologies from two industry fields: the automotive industry and the mobile robot industry. The robust and reliable mechanical and electrical platform for the autonomous car can be achieved from the automotive industry. Many autonomous driving algorithms have been researched for a long time in the robot industry, and they can be applied to the autonomous car [10][11]

II. STRUCTURE OF THE AUTONOMOUS DRIVING CAR

A. Basics of Autonomous Cars

An autonomous car is a self-driving car that has the ability to drive by itself without human intervention. There are five basic functions that drive the autonomous car:

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perception, localization, planning, control, and system management. The conceptual description of each function is shown in Fig. 1. Perception is a process that senses the surrounding environment of the autonomous car using various types of sensor techniques such as RADAR, LIDAR, and computer vision. The localization finds the position of the autonomous car using the techniques of a Global Positioning System, dead reckoning, and roadway maps.

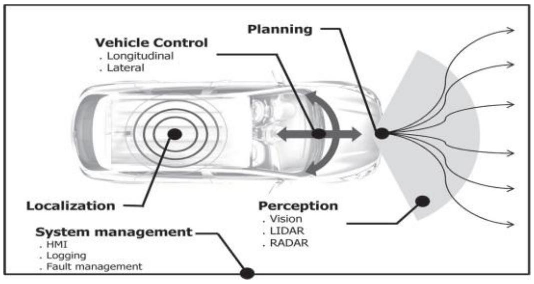

Fig. 1. Basic functions of autonomous cars.

The planning function determines the behaviour and motion of the autonomous car based on the information from perception and localization The planning function determines the behaviour and motion of the autonomous car based on the information from perception and localization.

The control function follows the desired command from the planning function by steering, accelerating, and braking the autonomous car. Finally, the system management supervises the overall autonomous driving system. The example functions of the system management are the fault management system, logging system, and human–machine interface (HMI).Almost all autonomous cars have the five basic functions, and each function has different functional subcomponents according to the purpose and complexity of the autonomous car. The functional subcomponent represents the actual implementation of autonomous driving functions, as shown in Fig.1 In order to implement the functional components on the computing units of the autonomous car [10]

B. System Overview of Autonomous Car

Describes autonomous car A1 and its sensor configuration .The vehicle platform was equipped with an electronics stability control (ESC) system. ESC is used to improve the vehicle dynamic stability by detecting the abnormal vehicle motion and controlling the vehicle motion using a brake system. In order to detect the abnormal vehicle motion, many types of onboard sensors are used for ESC, including wheel-speed sensors, a steering-wheel-angle sensor, and a yaw-rate sensor. The onboard ESC sensor information is shared through the in-vehicle network, i.e., the controller area network (CAN). Therefore, we can access the onboard sensor information of the ESC by connecting to the CAN. A motor-driven power steering system is used to control the steering, and the acceleration pedal signal is emulated for the acceleration. A direct-current motor that is mechanically connected to the brake pedal is used for braking. The gear shift lever is controlled by a motor to determine the direction of the vehicle. Eight laser scanners are installed on A1, as shown in Fig. 2(b). Two multilayer laser scanners (Ibeo LUX) that measure obstacles up to 200 m away in an optimal environment

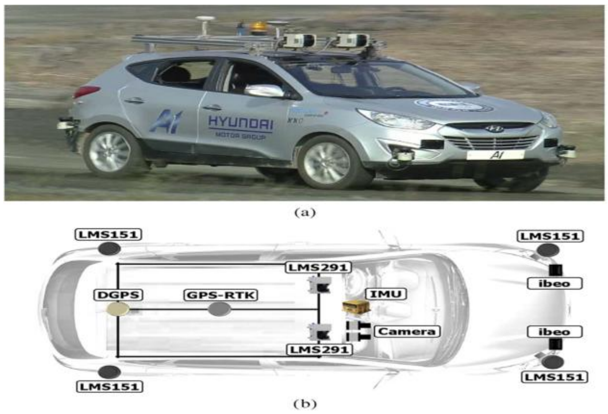

Fig 2. Vehicle platform and sensor configuration

are mounted on the front bumper to detect distant objects. To detect the adjacent objects around the ego vehicle, four single layer laser scanners (LMS 151) are installed on each corner .Two single-layer laser scanners (LMS 291) that scan vertically to the ground are installed on the roof to detect barriers, which To detect and classify the mission objects, one colour camera and three mono cameras are installed on the inside of the windshield. The two types of GPS receivers, i.e., a Real-Time Kinematics GPS (RTK-GPS) and a Differential GPS (DGPS),are equipped in the vehicle to measure the position of the ego vehicle in a global coordinate frame. An inertial measurement unit (IMU) that is located at the center of the vehicle is used to estimate the vehicle’s dynamic motion.[1][3]

C. Autonomous Driving Algorithm

In order to autonomously drive without human intervention, an autonomous car requires five basic functions, i.e., localization, perception, planning, vehicle control, and system management (see Fig. 3).

The localization is responsible for the estimation of the vehicle position, and the perception derives a model of the driving environment from multi sensor fusion based information. Based on the localization and perception information, the planning function determines the maneuvers of the autonomous car for safe vehicle navigation. The vehicle control function follows the desired command from the planning function by steering, accelerating, and braking the autonomous car. Finally, the system management supervises the overall autonomous driving system. Detailed description of the autonomous driving algorithm are shown in the fig.3 [7]

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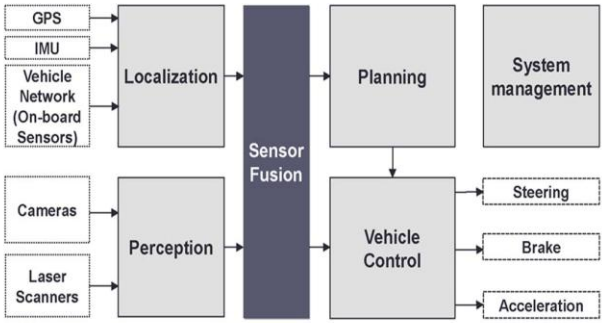

Fig. 3. Structure of the autonomous driving car

1) Localization: A localization system is an essential component of an autonomous car since autonomous cars find optimal paths and control the vehicle motion only if the ego vehicle position from the localization system is available. A GPS is widely used for localization systems because it directly provides a global position and the ego vehicle's velocity. However, the raw data position of the GPS cannot be used for an autonomous driving system since the quality of the GPS position is significantly affected by satellite signal conditions. The accuracy, reliability, and continuity of the measured GPS position data will rapidly deteriorate when GPS satellite signal conditions are unstable due to blockage and multi paths. A lot of previous research focused on the fusion of a GPS with additional information such as vehicle motion sensors (wheel-speed sensors, gyros, accelerometers, and magnetic sensors environment perception data, and digital maps in order to compensate for GPS vulnerabilities. The basic principle of an information fusion-based localization system is that GPS position errors are corrected by another information source such as vehicle motion constraints and correction data from matching the perceived landmark with a digital map. In this paper, in order to cover the various driving conditions, fusion system is used for the localization system. The localization system can adapt to changing vehicle dynamic characteristics under various driving conditions since the IMM filter selects the kinematics and dynamics model according to driving conditions. A GPS-bias correction algorithm was also applied to the localization system in order to improve the accuracy and reliability of the localization system

2) Perception: The perception system offers information non surrounding environments using several types of sensor components such as cameras, radars, and laser scanners. A range-sensor-based (a radar and a laser scanner) perception system detects and tracks static and dynamic obstacles whereas a vision-based perception system recognizes various visual objects The data of the detected and recognized objects are used for the situation assessment of the autonomous driving system. The perception system of A1 consists of a laser-scanner based moving object tracking algorithm and a vision-based object detection and classification algorithm. The object tracking system of A1 uses four LMS151s and two LUXs to track moving vehicles around the ego vehicle. In particular, an integrated-probabilistic-data-association-filter-

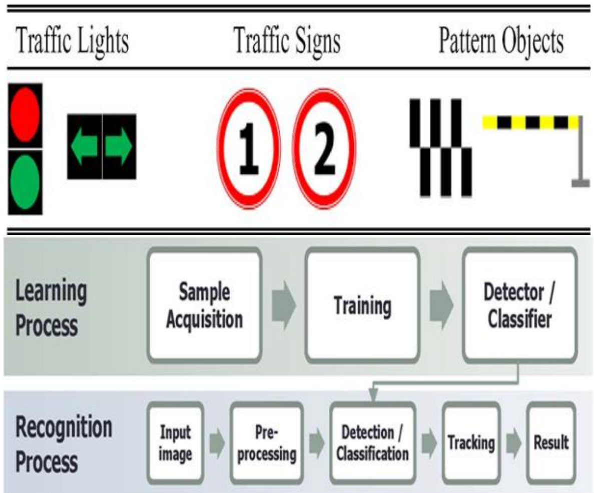

Fig.4.Machine-learning-basedscheme for object recognitio

Tracking algorithm is implemented using raw data. Tracked dynamic objects are integrated using a covariance-based track to-track fusion algorithm to reduce the conflict detection from the six laser scanners [There are several visual objects that should be detected and classified by the vision system, i.e., two types of traffic signs, two types of traffic lights, and the pattern objects,. A machine-learning-based scheme is employed to perceive the visual objects. The scheme consists of two main parts (see Fig. 4). We construct large training samples for each object at first in the learning process. The diversity of the training samples should be satisfied to establish the high performance of the detector or the classifier; therefore, the training samples are obtained from various illuminations, poses, and background conditions. Representative features are selected for each object in the training step; for instance, Haar-like features are used for traffic-sign detection, and a histogram of oriented gradients (HOG) is employed for the traffic-sign classification. Finally, machine learning algorithms are conducted, such as Adaboost and support vector machines (SVMs), to build detectors and classifiers]. The input image is pre processed for noise reduction and feature extraction in the recognition process. Next, the detector finds the location of the object in the image. The classifier identifies what types of objects are detected based on the detected image. Finally, the object tracking method is applied to filter out false positives and integrate temporal recognition results. For instance, the boost-based traffic-sign detector finds where the circular traffic sign is in the image, and then, the circular traffic sign is categorized as the number one, the number two, or others, which are false positives by the SVM classifier with then HOG feature. The traffic sign is tracked by the nearest neighbour filter, which estimates the position, width, and height of the traffic sign in the image. The performance of the traffic sign recognition is over

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95% under various lighting and weather conditions. From over 30 000 sample images, we evaluate that the recognition system performed well as long as the traffic-sign image is not occluded with rain or saturated with direct light.

3) Planning: The planning system determines the man for autonomous cars. Planning algorithms for autonomous

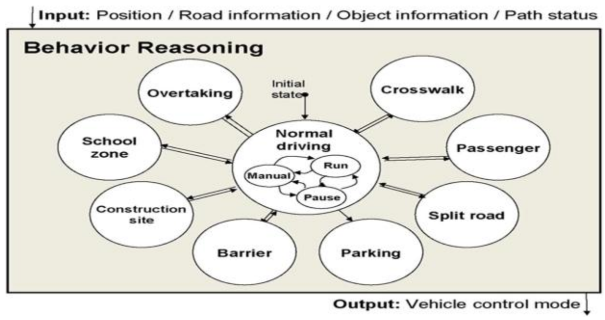

Fig. 5. FSM for behaviour reasoning.

cars can be divided into three stages in order to provide safe and reliable maneuvers under various driving situations i.e., global routing, behaviour reasoning, and local motion planning. Global routing finds the fastest and safest way to get from the initial position to the goal position. In this stage, a digital map management system and a data searching algorithm are essential for fast routing behaviour reasoning assesses the driving situation and determines the overall behaviour of the autonomous car based on the global route and perception information (see Fig. 5) The local motion can be then generated in the local motion planning stage based on the global route and the determined behaviour. In the last stage, the generated local motion should avoid static and dynamic obstacle collisions for safe autonomous driving The planning system of A1 focused on behaviour reasoning and local motion planning since the road map contains the global route of the track provided by the competition organizers. The map data represent the road geometry based on WGS84-type information with centimetre -level accuracy. The objectives of A1's behaviour reasoning and local motion planning are to perform autonomous driving and to accomplish various missions in real time. behaviour reasoning executes a rule-based decision process based on finite-state machines (FSMs) for an overall driving strategy based on the localization and perception information (see Fig. 5). Incorporated in the decision process, the rule is predefined to follow traffic regulations (e.g., lane keeping, obeying traffic lights, and keeping under speed limits) and to accomplish various tasks. In order to drive in various driving environments, local motion planning is composed of two types of path planning algorithms, i.e., road-map-based path planning and free-form path planning Road-map-based path planning mainly works in normal situations such as lane driving, whereas free-form path planning generates a complex path in unstructured environments such as roads under construction. The selected path planning algorithm with the behaviour planner iteratively generates a safe and feasible path.

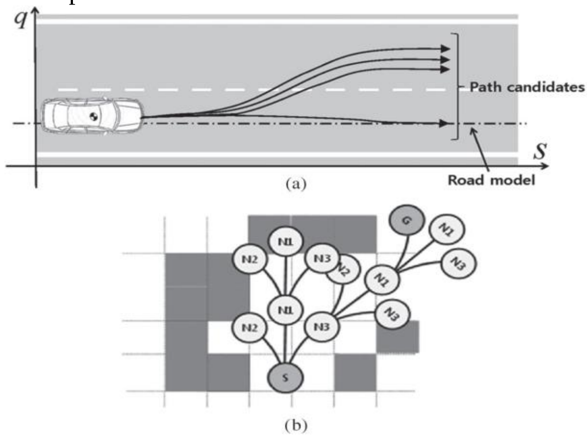

Fig. 6. (a) Lane-keeping and changing-path candidates in the roadmap-based path planning algorithm. (b) Graph-structure-based path candidates in the free-form path planning algorithm

4) Vehicle Control: Vehicle control is an essential function for guiding the autonomous vehicle along the planned trajectory. The vehicle control should be accurate for safe driving and should be robust under various driving conditions In order to meet these requirement , the control system should be able to deal with several vehicle characteristics, such as non constraints vehicle dynamics and physical limitations (e.g., constraints on the steering system and maximum allowable tire forces). In addition, a controller is required to solve the trade off problem between the tracking performance and the ride comfort To deal with these vehicle characteristics in a practical way, the vehicle control system of A1 is divided into a lateral controller and a longitudinal controller (see Fig. 7). The lateral control algorithm assumes that the vehicle moves along the Ackermann steering geometry Base on this assumption, the target steering angle is obtained from a lateral error of the preview points in the generated path. In order to accurately track the path, the preview points and the feedback gains are scheduled according to the vehicle speed and the path curvature information. The longitudinal control algorithm derives the target position of the acceleration and brake pedals from reference inputs. In order to cope with various driving situations, the longitudinal controller is composed of three modes, i.e., speed control, distance control, and emergency stop. The speed control mode, which is based on the proportional–integral–derivative-control law- based feedback controller and the vehicle-power train model- based feed forward controller, derives the target acceleration from the target and current vehicle velocities. Based on the target acceleration, the desired wheel torque is converted to manipulate the acceleration and brake pedals. In the distance The function generates the desired velocity using a position error between the current and target locations. When the autonomous car meets unexpected situations

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such as system faults and sudden obstacles, the emergency stop mode produces maximum deceleration for accident avoidance.

5) System Management: For the development and operation of an autonomous car, the system manager is essential for supervising the entire autonomous driving system. Basically, the system manager of A1 performs the following functions: as a human–machine interface (HMI), driving mode management, and fault management. The HMI consists of an operating interface (a remote controller and an e-stop switch) and a display system that indicates the health status of the car, the position, the path, and the surrounding object information. For the operation of A1, the driving mode is divided into three states, i.e., manual, run, and pause. In the manual mode, A1 is manipulated by the human; in the run mode, A1 drives by itself. If the operator pushes the emergency stop switch or a system fault occurs, the system mode is converted to the pause mode. The fault management system monitors the health status of all modules for safe driving. If the health status of the critical module for autonomous driving fails or does not update for a certain period of time, fail management algorithms, which are embedded in each module, determine the state of the system health as failed and convert the autonomous mode to the pause mode [7] [8][9]

D. Software Component Design

Describes the designed software components and information flow of autonomous car The A1 software architecture is composed of four parts, i.e., a sensor interface, autonomous driving algorithms, an actuator interface, and a development interface. Through the sensor interface, the various types of sensor data are entered into the autonomous driving algorithms. The GPS provides the global position, speed, and heading angle data for the positioning algorithm. The IMU and onboard sensors provide the dynamic information of the ego vehicle to the estimation algorithm of the vehicle motion. The cameras and laser scanners measure the information about the external environment around the ego vehicle. Based on the sensor information, the autonomous driving algorithms generate the control inputs of the vehicle actuators to drive the vehicle autonomously. The vehicle state estimation algorithm estimates the vehicle's dynamic states by integrating the motion sensor information with the vehicle system models. The estimates of the vehicle state are incorporated into the GPS.

Software architecture of autonomous car data to more accurately and reliably estimate the ego vehicle's position. The vision algorithms detect and classify the objects in the driving environment based on the image information from the colour cameras and mono cameras. The road barriers and the static and dynamic obstacles are detected and tracked using the detection and tracking algorithms. The sensor fusion algorithm integrates all of the information from the perception algorithms and improves the accuracy and integrity of the primitive perception data.

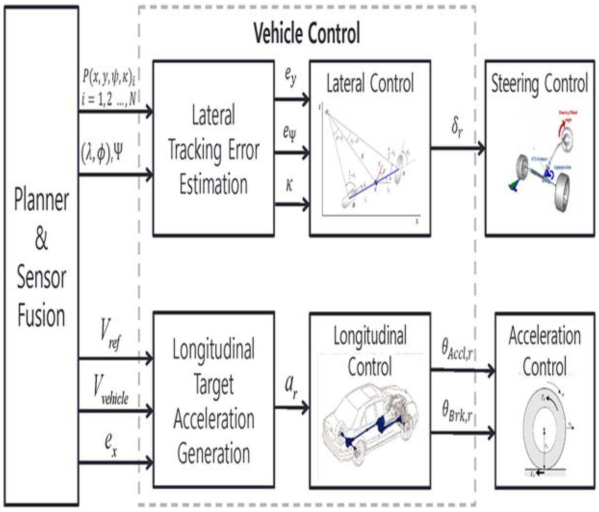
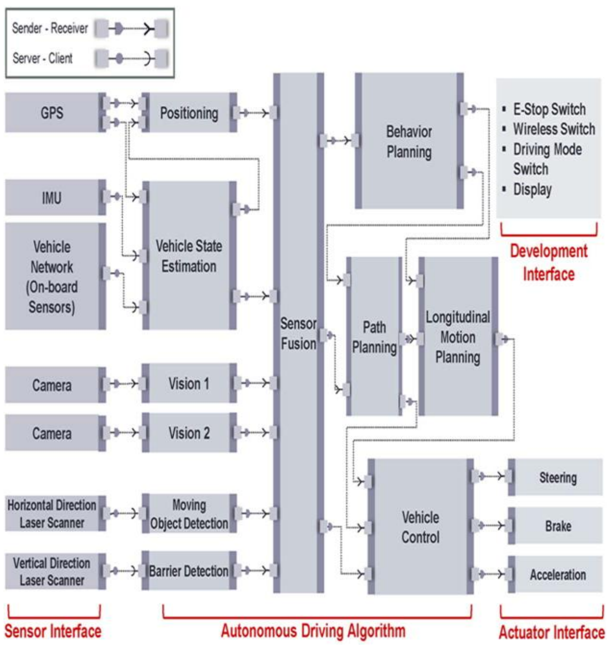


Fig. 7. Structure of the vehicle control system

The planning algorithm uses the integrated perception data to determine the behaviour and motion of the vehicle Software architecture of autonomous car data to more accurately and reliably estimate the ego vehicle's position. The vision algorithms detect and classify the objects in the driving environment based on the image information from the colour cameras and mono cameras. The road barriers and the static and dynamic obstacles are detected and tracked using the detection and tracking algorithms. The sensor fusion algorithm integrates all of the information from the perception algorithms and improves the accuracy and integrity of the primitive perception data. The planning algorithm uses the integrated perception data to determine the behaviour and motion of the vehicle The vehicle control algorithm calculates the control inputs from the vehicle actuator, such as steering, braking, and acceleration, to follow the desired behaviour and motion from the planning algorithm.



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The actuator interface conveys the actuator control input that is generated from the autonomous driving algorithm to the low-level controllers for steering, braking, and accelerating. The development interface provides the safety and debugging functions for developing the autonomous system, including the emergency stop, the wireless stop, the driving mode selection, and monitoring. The information flows between each software component are described with a VFB, as shown in Fig. 8. There are two types of communication between each software component, i.e. client–server and sender–receiver. At the client–server interface, the server provides the information to clients when the clients request the service. At the sender–receiver interface, the sender provides the information to the receiver without any request. Since the information flows are abstracted with the VFB, the software component designer does not need to be concerned with the constraints of the computing hardware and network. The designer can only concentrate on the design of the functional aspects of the software components.[4][5]

CONCLUSION

Currently, there are many different technologies available that can assist in creating autonomous vehicle systems. Items such as GPS, automated cruise control, and lane keeping assistance are available to consumers on some luxury vehicles. The combination of these technologies and other systems such as video based lane analysis, steering and brake actuation systems, and the programs necessary to control all of the components will become a fully autonomous system. The problem is winning the trust of the people to allow a computer to drive a vehicle for them. Because of this, there must be research and testing done over and over again to assure a near full proof final product. The product will not be accepted instantly, but over time as the systems become more widely used people will realize the benefits of it The implementation of autonomous vehicles will bring up the problem of replacing humans with computers that can do the work for them.

REFERENCES

[1] K. Chu, M. Lee, and M. Sunwoo, “Local path planning for off-road autonomous driving with avoidance of static obstacles,” IEEE Trans. Intel. Transport. Syst., vol. 13, no. 4, pp. 1599–1616, Dec. 2012.

[2] J. Han, D. Kim, M. Lee, and M. Sunwoo, “Enhanced road boundary and obstacle detection using a downward-looking LIDAR sensor,” IEEETrans. Veh. Technol., vol. 61, no. 3, pp. 971–985, Mar. 2012.

[3] N. Dalal and B. Triggs, “Histograms of oriented gradients for human detection,” in Proc. IEEE Comput. Soc. Conf. CVPR, San Diego, CA,USA, 2005, pp. 886–893.

[4] P. Viola and M. J. Jones, “Robust real-time face detection,” Int. J.Comput. Vis., vol. 57, no. 2, pp. 137–154, May 2004

[5] S. Glaser et al., “Maneuver-based trajectory planning for highly autonomous vehicles on real road with traffic and driver interaction,” IEEE Trans. Intel. Transp. Syst., vol. 11, no. 3, pp. 589–606, Sep. 2010

[6] K. Chu, J. Kim, and M. Sunwoo, “Distributed system architecture of autonomous vehicles and real-time path planning based on the curvilinear coordinate system,” SAE int., Warrendale, PA, USA, Tech. Papers, 2012.

[7] R. Rajamani, Vehicle Dynamics and Control. New York, NY, USA :Springer-Verlag, 2012.

[8] Hemami and M. Mehrabi, “On the steering control of automated vehicles,” in Proc. IEEE Int. Conf. ITSC, 1997, pp. 266–271.

[9] G. Bradski, “The Open CV Library,” Dr. Dobb’s J. SW Tools, 2000

[10] Elkady and T. Sobh, “Robotics middleware: A comprehensive literaturesurvey and attribute-based bibliography,” J. Robot., vol. 2012,pp. 959 013-1–959 013-15, 2012

[11] E. de Lellis, V. di Vito, L. Garbarino, C. Lai, and F. Corraro, “Designprocess and real-time validation of an innovative autonomous mid-airflight and landing system,” World Acad. Sci., Eng. Technol., vol. 79,no. 55, pp. 174–184, Jul. 2011.