A Review paper on Development of Autonomous Vehicle

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Abstract - *The field of autonomous automation is of interest to researchers, and much has been accomplished in this Area, of which this paper presents a detailed chronology. This paper can help one understand the trends in autonomous vehicle technology for the past, present, and future. We see a drastic change in autonomous vehicle technology since 1920s, when the first radio controlled vehicles were designed. In the subsequent decades, we see fairly autonomous electric cars powered by embedded circuits in the roads. By 1960s, autonomous cars having similar electronic guide systems came into picture. 1980s saw vision guided autonomous vehicles, which was a major milestone in technology and till date we use similar or modified forms of vision and radio guided technologies. Various semi-autonomous features introduced in modern cars such as lane keeping, automatic braking and adaptive cruise control are based on such systems. Extensive network guided systems in conjunction with vision guided features is the future of autonomous vehicles. It is predicted that most companies will launch fully autonomous vehicles by the advent of next decade. The future of autonomous vehicles is an ambitious era of safe and comfortable transportation.*

Key Words: *Autonomous car, Autonomous vehicle, Algorithm, Intelligent Transportation, Automotive radar, Automation system*.

INTRODUCTION

Consumers all around the whole world are enthusiastic about the advent of autonomous cars for public. An autonomous car can operate without human control and does not require any human intervention. The timeline of autonomous cars begins in1926 with world's first radio controlled car-Linriccan Wonder'. Significant advances in autonomous car technology has been made after the advent of the vision guided Mercedes-Benz robotic Van in 1980, since when the main focus has been on vision guided systems using LIDAR, radar, GPS and computer vision. This developed into the autonomous technologies present in modern cars like adaptive cruise control, lane parking, steer assist etc. And, in the future, we will be part of a future where fully autonomous cars will be a reality, based on official forecasts by various automobile companies. Transportation accidents is one of the major causes of death in the world. By 2020, this world could prevent 5 million human fatalities and 50million serious injuries by introduction of newer and innovative methodologies and investments in road safety, from regional to international levels. The Commission for Global Road Safety believes that it is very crucial to stop this avoidable and horrendous rise in road injuries, and initiate year on year reductions (Campbell, 2010). Deshpande et al. gave a figure of nearly 3000 deaths because of road accidents daily, with more than half of the people not travelling in a car. Also, it has been reported by Deshpande et al. that if a paramount and efficacious action is not taken, transportation injuries are set to rise to 2.4 million per year, becoming the fifth leading cause of death in the world. So, number of traffic collisions will drastically decrease, due to an autonomous system's increased reliability and faster reaction time compared to humans. This would also reduce traffic congestion, and thus increase roadway capacity since autonomous vehicles would lead to a reduced need of safety gaps and better traffic flow management. Parking scarcity will become a historic phenomenon with the advent of autonomous cars, as cars could drop off passengers, and park at any suitable space, and then return back to pick up the passengers. Thus, there would be a reduction in parking space. Need of physical road signage will decrease, as autonomous cars will receive necessary information via network. There would be a reduction in the need of traffic police. Thus, autonomous cars can reduce government spending on things like traffic police. The need for vehicle insurance will also decrease, along with a decrease in the incidents of car theft. Efficient car sharing and goods transport systems (as in case of taxis and trucks respectively) can be implemented, with total elimination of redundant passengers. Not everyone is suitable driving, so, autonomous cars provide a relief from driving and navigation chores. Also, commute time will decrease, as autonomous vehicles can travel at higher speeds with minimum chances of error. The car's occupants will appreciate the smoother ride experience as compared to non-autonomous cars. Autonomous cars provide excellent benefits, but, some challenges do exist. Although the notion has been rejected, but, it is believed that an advent of autonomous cars would lead to a decrease of driving related jobs. Also, situations like inability of drivers to regain control of their cars due to inexperience of drivers, etc. is an important challenge. Lots of people love driving, and it would be difficult for them to forfeit control of their cars. Autonomous cars also pose challenges interacting with human-driven vehicles on the same route. Another challenge to autonomous cars is that who is to be held liable for damage- the car manufacturing company, the car's occupants/owner, or the government. Thus, implementation of a legal framework and Establishment of government regulations for autonomous vehicles is a major problem. Software reliability is also a major issue. Also, there is a risk of a car's computer or communication system being potentially compromised. There is a risk of an increase in terrorist and criminal activities, for instance, cars could potentially be loaded with explosives by terrorist organizations and miscreants. They could also be used as getaway vehicles and various other criminal activities. Thus, autonomous cars have both pros and cons. In the following review paper you will find various researches which have already been done in development of autonomous vehicle.

2. LITERATURE REVIEW

Viorel Stoian. (2017)[1]: He Presented a fuzzy control algorithms for autonomous electric vehicles which are moving next to the obstacle boundaries, avoiding the collisions with them. Four motion cycles (programs depending on the proximity levels and used by the autonomous vehicle on the trajectory (C-1, C-2, C-3, and C-4) are shown. The directions of the movements corresponding to every cycle and for every reached proximity level are presented. The sequence of the programs depending on the reached proximity levels is indicated. The motion control algorithm presents the evolution of the C-1 C-2 C-3 C-4 C-1 C- 2 functional cycles (programs) by a schematic program code. The fuzzy rules for evolution (transition) of the programs and for the motion on X-axis and Y-axis respectively are described by 3 tables. The fuzzy controller for the electric vehicle based on the algorithm presented above is simple. Finally, some simulations are presented. RRR If the object is like a circle, every program is proper for a quarter of the circle. If the object is like an irregular geometrical figure, the trajectory follows the concave or convex segments of the boundary. The small imperfections of the proximity sensor's reading and of movement directions are resolved by fuzzy logic controller.

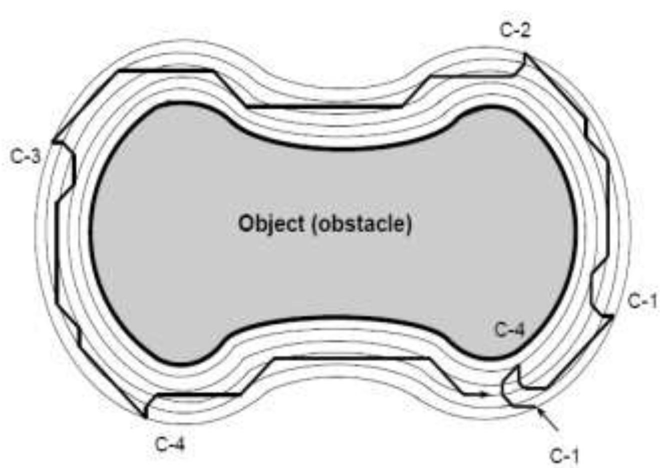

Fig.1 - The trajectory of the autonomous electric vehicle around an irregular obstacle.

Campbell, Mark (2010)[2] : They presented an overview of the current state of the art in autonomous vehicles and described some of the upcoming technical challenges and opportunities as they develop the next generation of robotic navigation systems. Their perspective has been motivated by our participation in the DUC, where numerous technologies had to be integrated to develop vehicles capable of driving in realistic urban environments. They believe that the chances for future research provide many opportunities for exciting work in robotics, controls, artificial intelligence and many other systems disciplines.

Jian-Gang Wang (2016)[3]: They proposed a real-time two-stage appearance-based brake-lights recognition approach from a single image. An eight-layer convolutional neural network, BVLC Alex Net model, is trained on a rear-vehicle database obtained by a fast vehicle detection algorithm, in which road segmentation and vanishing point are used to improve the accuracy and speed up the processing. Finally, lidar and vision are fused at the detection level. Two-stage approach prevents the brake-light recognition from taillight pairing problems caused by the image noise. The algorithm can recognize brake-lights regardless of whether the target vehicle and the autonomous vehicle are in the same lane.

Kyungbok Sung, Kyoungwook Min, and Jeongdan Choi (2018) [4] : They described in detail the driving information logging use in developing an autonomous vehicle. Driving information logging can be used in many areas such as analysis of problems in the study of autonomous driving system and analysis of accident risk. The contents of this paper was based on the information stored for the permission to operate the autonomous vehicle on public roads in Korea, but it is expected to be applicable to other countries and other studies.

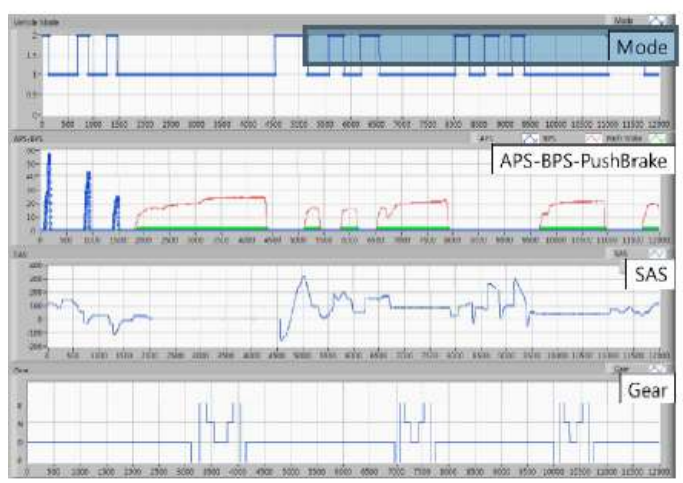

Fig 1. Driving Information Analysis Tool

Flyte, Margaret Galer (1995)[5] : He concluded that There is a need to take human factors into account when designing and implementing advanced technology systems in vehicles in order for the potential safety benefits to be achieved. It is clear that the interaction of users with the technology currently or potentially available in vehicles is complex and safety critical. The poor design of information and support systems could mean that all too easily they move from being of potential safety benefit to becoming major safety hazards. The challenge facing the automotive technology industry now is how to incorporate human factors effectively into the development and design of advanced technology systems so that they deliver the potential benefits to the users without the potential safety costs. The challenges for the human factors practitioners are two-fold. The first is to considerably enhance understanding of the issues critical to safe and effective use of advanced technology systems in automotive applications and to undertake research to provide solutions.

Leighty, Robert D (1986)[6]: He developed a DARPA ALV program. The DARPA ALV program brings a critical mass of effort and talent to bear on key technology issues for evolving autonomous land vehicle capabilities. The Army can then incorporate these capabilities into their plans and requirements for autonomous vehicle systems of the future.

Behringer, Reinhold, and Nikolaus Muller. (1998)[7]: They experimented the behavior of autonomous car. The behavioral capabilities for autonomous lateral guidance by machine vision have been extended to turn-offs. It has been shown that it is possible to guide a road vehicle by a computer vision system not only on rather straight Autobahn, but also on roads with tight curves and turn-offs. The agreement between estimated and actual curvature is good enough to allow their integration into an approximate map of the course (when the course forms a closed loop). The basic algorithms for the turn-off control have been developed in closed-loop simulation and verified on a test track. In connection with a landmark navigation process, which is currently being integrated into the system, this will enable VaMoRs to freely navigate in a known environment.

Wenger, Josef. (2005)[8]: They developed concept of automotive radar. Automotive radar is a key technology improving driving safety in future, especially due to its inherent advantages (weather independence, direct acquisition of range and velocity, ground clutter reflection detection). In this contribution the status and perspectives of automotive long and short range radar sensors has been shown. Novel LRR developments aim to increased system sensitivity, higher range and angular resolution and to a wider FOV. This enhancement over existing automotive radar sensors will allow a new quality of environmental sensing. In combination with UWB SRR new perspectives of comfort and safety features in future automobiles open up. To meet the technological challenges with respect to small size, low weight, easy packaging, and low cost for future UWB SRR a research project funded by the German Ministry of Education and Research (BMBF) has been started exploiting SiGe technology for cost effective “radar on chip” solutions.

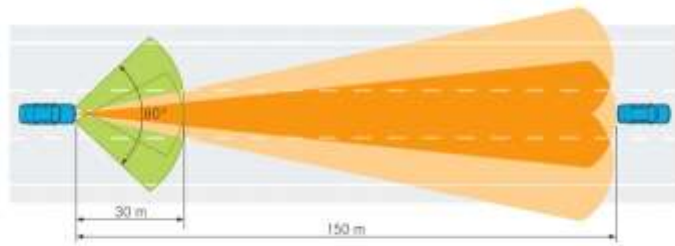

Fig. 1 Combination of LRR and SRR for advanced safety features.

Gerla, M., Lee, E.-K., Pau, G., & Lee, U. (2014) [9] : They concluded that the urban fleet of vehicles is evolving from a collection of sensor platforms to the Internet of Autonomous Vehicles. Like other instantiations of the Internet of Things, the Internet of Vehicles will have communications, storage, intelligence and learning capabilities to anticipate the customers' intentions. This article claims that the Vehicular Cloud, the equivalent of Internet Cloud for vehicles, will be the core system environment that makes the evolution possible and that the autonomous driving will be the major beneficiary in the cloud architecture. We showed a vehicular cloud model in detail and discussed potential design perspective with highlights on autonomous vehicle, AUV, for future research.

Funke, Joseph, Paul Theodosis, Rami Hindiyeh, Ganymed

Stanek (2015)[10] : They presented a novel system enabling a vehicle to autonomously operate at the limits of friction, which will have useful implications in future collision avoidance and accident prevention systems. Compared to other research in this area, their system is designed for high speed real-time control at 200 Hz, tracking a pre computed clothoid based optimized trajectory at the limits of the vehicle's capability. The vehicle was tested at and successfully completed the Pikes Peak Hill Climb course, which incorporates a combination of paved and unpaved road surfaces, significant bank and grade, and narrow operating areas. Future work includes runtime modification of the desired path. Paths could be modified to avoid an obstacle, for example, or a new path could be calculated if the vehicle exceeds its limits. Road friction could also be estimated real-time, which would improve the accuracy of the controller.

Fig. 1. Audi TTS research vehicle

Okuda, Ryosuke, Yuki Kajiwara, and Kazuaki Terashima (2014) [11] **:** They surveyed of technical trend of autonomous driving algorithms is shown. The research for autonomous driving are still going on, there should be more advanced algorithms until actual autonomous driving car is introduced into the market.

Fagnant, D. J., & Kockelman, K (2015) [12] **:** In this paper a brief surveyed of opportunities, barriers and policy recommendations for preparing a nation for autonomous vehicles. In addition to the impacts and interactions with other components of the transportation system, as well as implementation details. They research in these areas and gave some suggestion about nationally recognized licensing framework for AVs, determining appropriate standards for liability, security, and data privacy.

Sunwoo, M., K. Jo, Dongchul Kim, J. Kim, and C. Jang. (2014)[13]**:** They presented the development process and system platform for the development of the distributed system of an autonomous car. A distributed system architecture is used for the system platform because it has many benefits for developing an autonomous driving system, such as reduction of the computational complexity of the entire system fault-tolerant characteristics, and modularity of the system. The development process provides the guidelines to design and integrate the distributed systems of an autonomous car. A layered architecture based software platform, which originated from AUTOSAR, is applied to the distributed system in order to improve the reusability, scalability, transferability, and maintainability of the application software. A Flex Ray network is applied for the main network of the software platform in order to improve the network bandwidth, fault tolerance, and system performance.

Junig wei. (2013)[14]**:** They concluded that a new highly integrated autonomous vehicle has been developed and tested in a closed test field and public road for over a year. Experiments show that the platform design proposed in this paper is robust and easy for developers and end-users to operate. The vehicle is equipped with redundant sensors and has the ability to perform everyday driving while maintaining an appealing appearance. The system also has reliability and fault-tolerance features. Future work includes improving the vehicle's intelligence. The vehicle should better understand surrounding vehicles 'intentions / movements to perform socially cooperative behavior. The on-road planner will also be improved to perform more like skillful, socially aware human drivers for better social acceptance. Multiple fault-tolerance modes will be tested in the vehicle to ensure the car can still function even if one or more components fails. Along with these developments, more intensive road tests in different driving situations will be performed to analyze the vehicle's driving performance statistically.

Fig. 1: The CMU autonomous vehicle research platform in Road test

3. CONCLUSION

This paper discusses basic chronology leading to the development of autonomous cars. Autonomous vehicles developed from the basic robotic cars to much efficient and practical vision guided vehicles. The development of Mercedes- Benz vision guided autonomous van by Ernst Dickmanns and his team gave a paradigm shift to the approach followed in autonomous cars. Also, contemporary developments in autonomous cars reflect the vivid future autonomous cars behold. Official future predictions about autonomous cars point out that most automobile companies will launch cars with semi and fully autonomous features by 2020. Most cars are expected to be fully autonomous by 2035, according to official predictions as cited earlier. This paper reviewed the historical antecedents, contemporary advancements and developments, and predictable future of semi and fully autonomous cars for public us.

4. REFRENCES

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