Self-Driving Car - Design and Implementation

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Abstract– In a number of countries around the world, road safety is a big concern. To reduce road risks, advanced technologies are in operation. As part of intelligent transportation infrastructure, innovations include automated vehicles (AV) as a whole. They are a form of safety device that is active. But the questions we still have to answer are, how can we make self-automated vehicles safe enough for the driver and the road; and most importantly how much the level of safety would be designed and implemented. By 2050, these "five revolutions in urban transportation" could: 1. Reduced traffic congestion (30% fewer vehicles on the road), 2. Cut transportation costs by 40% (in terms of vehicles, fuel, and infrastructure), 3. Improve walkability and livability, 4. Free up parking lots for other uses (schools, parks, community centers), 5. Reduce urban CO2 emissions by 80% worldwide. This project is to design and implement a self-driving car that is powered by batteries and a Photovoltaics energy system. The principles of Artificial intelligence have been applied with the aid of suitable sensors and actuators.

Keywords—Smart Car, Machine learning, self-driving car.

I. Introduction

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to the natural intelligence displayed by humans or animals. Leading AI textbooks define the field as the study of "intelligent agents": any system that perceives its environment and takes actions that maximize its chance of achieving its goals. Some popular accounts use the term "artificial intelligence" to describe machines that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving" [1-4].

The Internet of things (IoT) describes the network of physical objects—a.k.a. "things"—that are embedded with sensors, software, and other technologies that is used for the purpose of connecting and exchanging data with other devices and systems over the Internet.

An embedded system is a microprocessor-based computer hardware system with software that is designed to perform a dedicated function, either as an independent system or as a part of a large system. At the core is an integrated circuit designed to carry out computation for real-time operations.

1.1 Self-Driving Car

An autonomous car is a vehicle capable of sensing its environment and operating without human involvement. A human passenger is not required to take control of the vehicle at any time, nor is a human passenger required to be present in the vehicle at all. An autonomous car can go anywhere a traditional car goes and do everything that an experienced human driver does [5-6].

1.2 Society of Automotive Engineers and its levels

The Society of Automotive Engineers (SAE) defines 6 levels of driving automation ranging from 0 (fully manual) to 5 (fully autonomous). These levels have been adopted by the U.S. Department of Transportation. These levels have been adopted by the U.S. Department of Transportation. The 6 Levels of Vehicle Autonomy is explained. Researchers forecast that by 2025 we'll see approximately 8 million autonomous or semi-autonomous vehicles on the road. Before merging onto roadways, self-driving cars will first have to progress through 6 levels of driver assistance technology advancements [1-7].

A. Level 0 (No Driving Automation)

Most vehicles on the road today are Level 0: manually controlled. The human provides the "dynamic driving task" although there may be systems in place to help the driver. An example would be the emergency braking system—since it technically doesn't "drive" the vehicle, it does not qualify as automation.

B. Level 1 (Driver Assistance)

This is the lowest level of automation. The vehicle features a single automated system for driver assistance, such as steering or accelerating (cruise control). Adaptive cruise control, where the vehicle can be kept at a safe distance behind the next car, qualifies as Level 1 because the human driver monitors the other aspects of driving such as steering and braking.

C. Level 2 (Partial Driving Automation)

This means advanced driver assistance systems or ADAS. The vehicle can control both steering and accelerating/decelerating. Here the automation falls short of self-driving because a human sits in the driver's seat and can take control of the car at any time. Tesla Autopilot and Cadillac (General Motors) are super cruise systems both qualify as Level 2.

D. Level 3 (Conditional Driving Automation)

The jump from Level 2 to Level 3 is substantial from a technological perspective, but subtle if not negligible from a human perspective.

Level 3 vehicles have "environmental detection" capabilities and can make informed decisions for themselves, such as accelerating past a slow-moving vehicle. But they still require human override. The driver must remain alert and ready to take control if the system is unable to execute the task.

Almost two years ago, Audi (Volkswagen) announced that the next generation of the A8; their flagship sedan would be the world's first production Level 3 vehicle. And they delivered. The 2019 Audi A8L arrives in commercial dealerships this Fall. It features Traffic Jam Pilot, which combines a lidar scanner with advanced sensor fusion and processing power (plus built-in redundancies should a component fail). However, while Audi was developing their marvel of engineering, the regulatory process in the U.S. shifted from federal guidance to state-by-state mandates for autonomous vehicles. So, for the time being, the A8L is still classified as a Level 2 vehicle in the United States and will ship without key hardware and software required to achieve Level 3 functionality. In Europe, however, Audi will roll out the full Level 3 A8L with Traffic Jam Pilot (in Germany first).

E. Level 4 (High Driving Automation)

The key difference between Level 3 and Level 4 automation is that Level 4 vehicles can intervene if things go wrong or there is a system failure. In this sense, these cars do not require human interaction in most circumstances. However, a human still has the option to manually override. Level 4 vehicles can operate in self-driving mode. But until legislation and infrastructure evolves, they can only do so within a limited area (usually an urban environment where top speeds reach an average of 30mph). This is known as geofencing.

F. Level 5 (Full Driving Automation)

Level 5 vehicles do not require human attention―the "dynamic driving task" is eliminated. Level 5 cars won't even have steering wheels or acceleration/braking pedals. They will be free from geofencing, able to go anywhere and do anything that an experienced human driver can do. Fully autonomous cars are undergoing testing in several pockets of the world, but none are yet available to the public.

1.3 Methodology and Work Operation

The methodology and work operation as the following:

1. Frist, we started by making a complete design of prototype of the electric car and designing the mechanical part of the car. Programs SOLID and Matlab/Simulink and python Language have been used.
2. Then, the artificial intelligence part, Image processing using ARM and Embedded Linux have been applied and used.
3. Technical part and the whole project have been finished.
5. We aim to benefit humanity by bringing our idea to reality.

II. Key Physical Components of Autonomous Vehicles

In this section the key physical components of autonomous vehicles have been presentted.

A. Artificial Intelligence (AI)

In order for the AV to operate in a full range of environments with millions of changing aspects that will need to be accounted for, it will require AI, which will allow the base level software to be developed and tested with a self-learning capability.

B. Cameras

They provide real-time obstacle detection to facilitate lane departure and track roadway information (like road signs).

C. LIDAR

It is a radar system that emits a laser in a pattern similar to a rotating radar, only in more discrete and densely spaced increments. The reflected laser light is used to provide the AV information on the distance for each discrete laser emission.

It can be implemented to Measure distance by illuminating target with pulsed laser light and measuring reflected pulses with sensors to create 3-D map of area.

D. GPS

These global positioning systems will be a critical link for AV to determine their location as they move. It helps to Triangulate position of car using satellites. Current GPS technology is limited to a certain distance. Advanced GPS is in development.

III. Computer Vision

The computer vision is the subfield of artificial intelligence which tries to imitate the human vision capabilities. And by "human vision", we do not merely mean the eyes or the ability to see images – it is not as trivial as simply taking a picture with your phone. The purpose is not to imitate just sight, but actually to imitate perception – the ability of humans to make sense of what they see.

If we parallelize the human and computer vision systems, we can say that both consist of a sensor and an interpreter. When it comes to sensors, cameras are most often considered the equivalent of the eyes for a computer vision system. In reality, cameras are only a part of a wide range of hardware that are used to capture information about the real world. Just to name a few, there are RGB, monochrome or even hyperspectral cameras but also distance sensors, laser scanners, radars, etc.

Depending on the application, different combinations of these sensors can be selected. In the case of interpreters, a combination of hardware (computers, CPUs etc) and software (algorithms) is used to imitate the human brain and interpret the input data from the sensor. In this article, we will focus not so much on the hardware part of computer vision, but rather on the methods that are used to extract information from images.

IV. SOLAR VEHICLE

Solar electric vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions.

Looking at how the level of technology is improving every day, most inventors are doing their best to come up with the best inventions that will wow the world. When solar-powered cars were first introduced to the world, they let to significant relief to many consumers, especially those that were buying readily available gas-electric hybrid vehicles. The level at which solar-powered car works, makes them a better and attractive option, especially for those looking for more ecologically friendly personal transportation. Therefore, the researchers are continuing to develop affordable, reliable solar-powered vehicles. Even though solar-powered vehicles, for example, solar boats are widespread and available commercially, they have not become transportation devices yet.

Therefore, such vehicles are mostly manufactured for the main reason for racing competitions and doing engineering exercises, and often, they’re sponsored by government agencies.

Basically, a solar-powered car works on the same principle as a house that is powered by solar panels. The solar panels have photovoltaic cells that are made of semiconductors to help to convert sunlight into electricity that is used to power the electric motor. Some types of solar-powered cars convert the electricity directly to an electric motor while others, usually use the obtained power to help in fueling the battery that runs the engine. if solar-powered cars can run during the night. The solar-powered cars can run at night. During the day, the energy from the solar panel is used to charge the battery to be used during the night when there is no sunlight or when there are adverse weather conditions.

V. BENEFITS OF SMART ELECTRIC CARS

The V2V is used for Car-to-Car communication using communication systems and the GPS navigation system. That can receive and transmit 1000 signals per second of surrounding vehicles to determine the speed, location, and destination of surrounding vehicles within a circle of about 1000. The V2V technology will enable cars to sense The Surrounding area, which provide them with enormous Potential. In addition, cars will be able to receive and analyze information beyond the drivers’ visual limits. By equipping more cars with them. Vehicles will be equipped with novel computing, communication, and sensing capabilities and user interfaces. These will support a spectrum of applications that enhance transportation safety and efficiency, but also provide new or integrate existing services for drivers and passengers. A significant role is envisioned for existing or upcoming wireless infrastructure (e.g. cellular), connectivity to the wire-line part of the Internet, and dedicated road-side infrastructure units (RSUs). User-portable devices are also expected to be wirelessly attached to the on-board equipment.

VI. PROPOSED DESIGN OF ELECTRIC CAR AND ITS CONSTRUCTION

Figure 1 shows the operation and the work of a self-driving car. While figures 2-7 show the pictures of the proposed design of Self-Driving car which is designed and implemented by students under supervision of supervisors. The figure shows the following components which are used in the proposed design.

1- Battery (all-electric auxiliary): In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.

2- Charge port: The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.

3- DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

4- Electric traction motor: Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.

5- Power electronics controller: This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.

6- Traction battery pack: Stores electricity for use by the electric traction motor.

7- Transmission (electric): The transmission transfers mechanical power from the electric traction motor to drive the wheels.

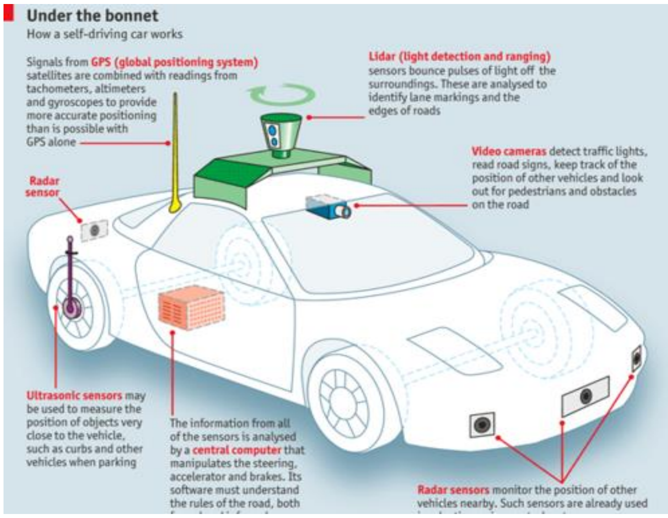

Fig. 1 Self-driving car

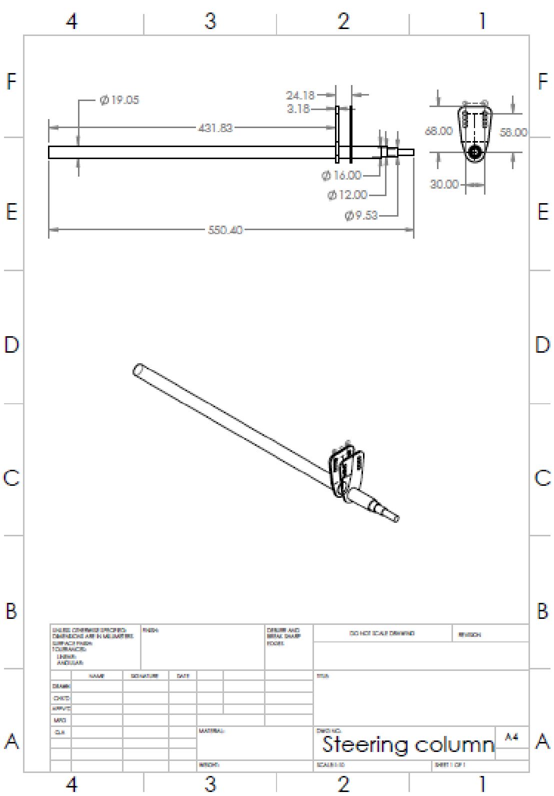

Fig. 2 Steering column

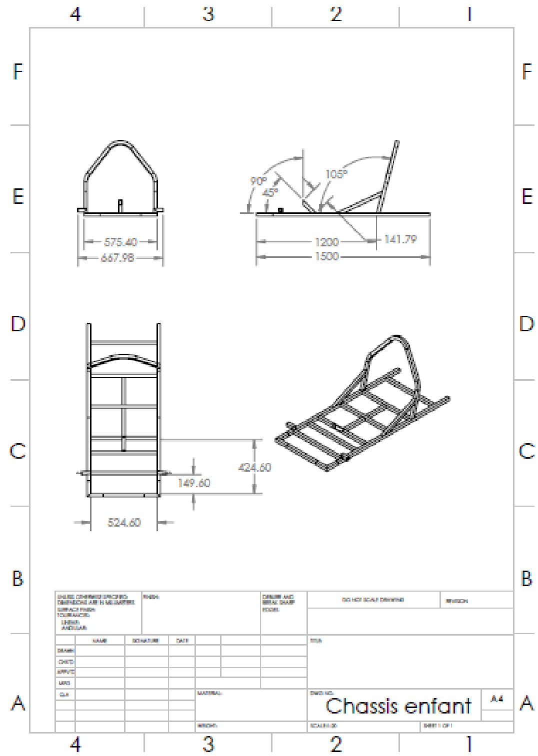

Fig. 3 Chassis

Fig. 4 Solar cell for power the car with the aid of batteries

Fig. 5 Basic stage of the car

Fig. 6 Electrical Motor of car

Fig. 7 The designed and implanted Self-driving car (our project).

Autonomous cars rely on sensors, actuators, complex algorithms, machine learning systems, and powerful processors to execute software.

Autonomous cars create and maintain a map of their surroundings based on a variety of sensors situated in different parts of the vehicle. Radar sensors monitor the position of nearby vehicles. Video cameras detect traffic lights, read road signs, track other vehicles, and look for pedestrians. Lidar (light detection and ranging) sensors bounce pulses of light off the car's surroundings to measure distances, detect road edges, and identify lane markings. Ultrasonic sensors in the wheels detect curbs and other vehicles when parking.

VII. Outcomes and Benefits

The main outcomes of the presented work are as the following:

1. The prototype is a real car with self-driving ability without the need of human interaction.
2. The idea is directed to corporates in order to develop it and bring it to life, as seen in some automotive cars compares that reached the highest profit.
3. Bright skies, the Egyptian company, is an example of how achievable our idea is.

Moreover, Overview of major benefits that we have when applying our project:

1. Keep connected with surrounded cars to take the traffic status rapidly to avoid crowded ways.

2. By processing the gathered data, we can predict accidents, and then we can avoid it.

3. Opening a voice channel between two cars or more than two cars.

4. Speed monitoring and paths histories

5. Internet connected car

VIII. CONCLUSION

With the heights of the technology autonomous car is no more a myth, It’s a reality! We would like to present that there must be further developments in this technology to make autonomous car more common all over the world. This can be happened by making the autonomous easy to operate for the user and the designers should concentrate more in producing autonomous cars, which should not cost a lot, they should in the vicinity of customers’ budget. With this type of vehicles there will be great advantages in the coming feature. Due to speed control technique, accident-free driving is possible and fuel savage is also made possible by the technique, which will make the car to travel through shortest path. In the near future, autonomous car become more common all over the world. Indian efforts in the embedded technology can assure that these autonomous cars will become cheaper and may evolve with many more advantages. So, that we could find ourselves using these autonomous cars in the near feature. Deep sub-micron processing technologies have enabled the implementation of new application-specific embedded architectures that integrate multiple software programmable processors (e.g. DSPs, microcontrollers) and dedicated hardware components together onto a single cost-efficient IC. These application-specific architectures are emerging as a key design solution to today's microelectronics design problems, which are being driven by emerging applications in the areas of wireless communication, broadband networking, and multimedia computing. However, the construction of these customized heterogeneous multiprocessor architectures, while ensuring that the hardware and software parts communicate correctly, is a tremendously difficult and highly error pruned task with little or no tool support.

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