Future of Autonomous Vehicles

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Abstract

Automobiles have revolutionized transportation over the course of 20th century. Autonomous vehicle technology has the potential to similarly revolutionize transportation of 21st century. Widespread adoption of autonomous vehicles can significantly reduce the number of car accidents. Automakers should embrace, develop, and manufacture autonomous vehicles for public use because safety, productivity, and environmental benefits of doing so are enormous and clearly evident, while the employment, ethical, and security drawbacks are limited. Use of autonomous vehicles on public roads is currently permitted in parts of US, United Kingdom, Japan, and several other countries. These vehicles use a variety of sensors to perceive their environment and employ deep learning in order to interpret the incoming sensory data in real time. The autonomous vehicle technology has proven to be safe so far. To date, Google’s self-driving cars have caused a single crash – a minor fender bender – while logging over million miles. There are some concerns and challenges regarding development, production, and adoption of autonomous vehicles. While, the challenges to the use of autonomous vehicles are valid they can be and are already being addressed. The potential for safer, environmentally friendly, and more productive future justifies the effort being put in development of autonomous vehicles. Aside from Google, several prominent automakers such as BMW, Ford, and Toyota are on target to develop self-driving cars by 2020. This technology could take years, decades, or even centuries to become commonplace either through drastic push for fully autonomous cars or incremental vehicle automation. However, it will happen, and it is up to everyone to make sure that this technology will benefit as many people as possible.

Automobiles have revolutionized transportation over the course of 20th century. They have given us unprecedented freedom of travel, increased our productivity, and expanded our economy. However, automobiles have also polluted our air. And automobile accidents are one of the leading causes of death in United States. There are multiple solutions to these issues in various stages of implementation such as catalytic converters, non-gasoline powered automobiles, carpool lanes, and autonomous vehicles (AVs). The latter technology holds the most promise and could have immense safety, productivity, and environmental benefits. A multitude of technology firms, research institutions, and automakers are currently testing autonomous cars, busses, and trucks on specially build tracks and city streets throughout the world. There are some drawbacks to autonomous vehicles such as job loss amongst professional drivers, possibility of car hacking, and need for new regulations. However, these concerns can be properly addressed. Moreover, the benefits of autonomous car use are of significantly greater importance than the drawbacks. According to National Highway Traffic Safety Administration (NHTSA) overwhelming majority of automobile accidents are caused by human error [1]. Therefore, widespread adoption of autonomous vehicles can significantly reduce the number of car accidents. Moreover, the owners of autonomous cars would be able to better utilize time previously spent driving. Additionally, adoption of autonomous vehicles would likely lead to a decline in number of cars. This would decrease the total amount of pollution generated by automobiles. Automakers should embrace, develop, and manufacture autonomous vehicles for public use because safety, productivity, and environmental benefits of doing so are enormous and clearly evident, while the employment, ethical, and security drawbacks are limited.

Autonomous vehicle research has started to gain attention in early 2010s. In United States, Google has been primarily responsible for championing and pioneering the development of fully autonomous cars. In 2011, use of autonomous vehicles was authorized by state of Nevada [2, 3]. Florida, California, Michigan, and several other states have authorized use of autonomous vehicles within the following years [4]. Additionally, autonomous car use has been authorized in United Kingdom, Japan, and several other countries [5, 6]. Besides Google, several prominent automakers have engaged in autonomous vehicle research. [5, 6, 7]. Most of autonomous vehicle research is conducted with a driver. The driver is present in case the vehicle acts hazardously. Therefore, these vehicles must have steering wheel, pedals, and etc. However, recently, California has permitted testing of fully autonomous vehicles without a driver in 2016 [8]. Fully autonomous cars, also known as self-driving cars, do not require presence of a driver. Self-driving cars are classified to be level 4 (L4) autonomous vehicles by NHTSA. Autonomous vehicles that require a driver are classified to be level 3 (L3) autonomous vehicles (conditional autonomy) [9, 10]. This is an important distinction because different benefits and concerns are associated with L3 and L4 autonomous vehicles [8]. There are proponents of both L3 and L4 vehicles [8]. Nonetheless, the technology behind L3 and L4 vehicles is identical. All autonomous vehicles use a variety of sensors to perceive their environment and employ deep learning in order to interpret the incoming sensory data in real time.

Google’s self-driving cars are some of the most advanced autonomous vehicles. These cars use and integrate data collected from many different sensors such as “sonar devices, stereo cameras, lasers, and radar” [11]. The most important of these sensors is “the LIDAR laser remote sensing system” [11]. This system can accurately detect objects up to 100 meters in all directions and take up to 1.3 million readings per second [11]. LIDAR is used in combination with stereo cameras in order to map the vehicle’s surroundings [11]. Additionally, radars installed on front and back bumper of the driverless car monitor the speed of nearby vehicles [11]. Google’s software integrates data received from the sensors in order to build an accurate representation of the self-driving car’s environment [11]. Deep learning algorithms use the generated environment map along with the GPS in order to maintain appropriate speed and direction of the vehicle [8]. Technologies such as electric cars and car-to-car communication are well suited for use in autonomous vehicles. Car to car communication is highly effective at preventing accidents and can be used in a vehicle with any level of automation (L0 - L4) [12]. Electric car technology is especially well suited for autonomous vehicles because a driverless car could travel to and use a charging station whenever not in use [8]. Self-driving car’s ability to perform useful tasks when not in use by primary owner(s) makes it highly efficient. This is one amongst many potential benefits of using autonomous vehicles.

There is a multitude of powerful benefits to widespread use of self-driving cars. Use of self-driving vehicles would eliminate the human element from driving and drastically reduce number of accidents. To date, Google’s self-driving cars have caused a single crash – a minor fender bender – while logging over million miles [13, 14]. The autonomous technology still requires a great deal of improvement. However, machines are inherently more reliable drivers than humans because they do not become distracted, fatigued, and drunk [8]. Moreover, self-driving cars would provide mobility to people that cannot safely drive due to disability, old age, or lack of experience [15]. Widespread use of a self-driving vehicles could also undercut personal car ownership, free commute time, decrease fuel consumption, transform auto insurance, and save US citizens 1.3 trillion dollars a year [16, 17, 18, 19, 20]. The financial benefits of autonomous vehicles result from accident, time, and fuel savings combined with productivity gains [21]. Diminished fuel consumption in autonomous vehicles is a result of smoother driving exhibited by driverless cars, proliferation of electric autonomous vehicles, and traffic flow optimization [22, 23]. Lower fuel consumption would also lead to a decrease in amount of vehicle generated pollution. Thus, adoption of autonomous vehicles would directly benefit the environment.

There are some concerns and challenges regarding development, production, and adoption of autonomous vehicles. Adoption of self-driving vehicles would put millions of professional drivers in US out of work [24]. However, the savings generated by use of autonomous vehicles will help to offset the negative effects of employment loss. Moreover, the millions of people that will be saved from death and injury should take priority over jobs [25]. Additionally, there are some regulatory and ethical challenges to autonomous vehicles [26]. The regulatory challenges are being addressed on federal and state level in United States [5, 27]. The ethical considerations largely exist in form of highly contrived scenarios such as the infamous Trolley Problem [28]. In Trolley Problem a person must either willfully kill a single person or let five people die [29]. It will be up to scientists, philosophers, lawyers, and politicians to come up with a satisfactory course of action to be taken by the autonomous vehicles in complex scenarios such as the Trolley Problem. Another potential concern is the possibility of an autonomous vehicle being hacked [30]. The solution is simple. Autonomous vehicle developers will have to focus heavily on the cyber security of their products. While, the challenges to the use of autonomous vehicles are valid they can be and are already being addressed. The potential for safer, environmentally friendly, and more productive future justifies the effort being put in development of autonomous vehicles.

Aside from Google, several prominent automakers such as BMW, Ford, and Toyota are on target to develop self-driving cars by 2020 [31, 32, 33]. People are interested in purchasing autonomous vehicles and find them trustworthy [34, 35]. Some, however, caution that car and technology companies are being overly optimistic. The technology to produce autonomous vehicles that are reliable and safer than human drivers might take decades of development and research [36]. Pursuit of autonomous vehicles is a worthy goal. Self-driving cars can give mobility to disabled people, save lives, and grant people more time. This technology could take years, decades, or even centuries to become commonplace either through drastic push for fully autonomous cars or incremental vehicle automation. However, it will happen, and it is up to everyone to make sure that this technology will benefit as many people as possible.

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