Autonomous Vehicles

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Yair Wiseman
https://orcid.org/0000-0002-4221-1549
Bar-Ilan University, Israel

INTRODUCTION

The first car was invented in 1870 by Siegfried Marcus (Guarnieri, 2011). Actually it was just a wagon with an engine but without a steering wheel and without brakes. Instead, it was controlled by the legs of the driver.

Converting traditional vehicles into autonomous vehicles was not just one step. The first step was just 28 years after the invention of cars that is to say 1898. This step's concept was moving a vehicle by a remote controller (Nikola, 1898). Since this first step and as computers have been becoming advanced and sophisticated, many functions of modern vehicles have been converted to be entirely automatic with no need of even remote controlling.

Changing gears was one of the first actions that could be done automatically without an involvement of the driver (Anthony, 1908), so such cars got the title of "automatic cars"; however, nowadays there are vehicles that can completely travel by themselves although they are not yet allowed to travel on public roads in most of the world. Such vehicles are called "autonomous vehicles" or "driverless cars".

BACKGROUND

Autonomous vehicles will noticeably change the worldwide transport market. Autonomous vehicles will improve our quality of life and road safety. The number of traffic accidents will be significantly reduced. In Addition, autonomous vehicles can improve on the parking issues like the ability to park in a remote location in a rural fringe of the city. These vehicles will be more fuel efficient and their insurance will be cheaper. Also, people with disabilities can greatly benefit from this technology and military autonomous vehicles can prevent injuries and deaths in combat.

There are many practical obstacles and law difficulties that should be discussed. There were several car accidents where autonomous vehicles were involved (Wiseman & Grinberg, 2016a), (Wiseman & Grinberg, 2016b), (Wiseman & Grinberg, 2016c), (Wiseman & Grinberg, 2018). Until now two of these accidents were very tragic resulting in the death of a person.

There are several companies along with several government branches (especially military branches) that develop autonomous vehicles. Many of their products will be available for use in the coming years.

There is a need for more research until a car will be able to safely take us to our destination, without being involved in an accident and without having to drive or be there at all. Where is our car on the scale of autonomy and advanced safety? The international automotive organization SAE International (Society of Automotive Engineers) has defined six different levels of autonomous driving, or independent, in vehicles (SAE, 2014). This scale is quite acceptable in the autonomous vehicle industry. These six levels are divided into two groups: The three low levels require the driver to be active at least in part. In

DOI: 10.4018/978-1-7998-3479-3.ch001

the high three levels, there may be situations where the driver is not required to drive at all. These six levels are listed herein below:

Level 0: No Driving Automation. The driver is in charge of all driving activities in other words a vehicle which is not autonomic at all.

Level 1: Driver Assistance. One autonomic system is operating in the vehicle. For example, Electronic Stability Control (ESC) (Lie, Tingvall, Krafft & Kullgren, 2006), Adaptive Cruise Control (ACC) (Van Arem, Van Driel & Visser, 2006), Emergency Brake Assist (EBA) (Page, Foret-Bruno & Cuny, 2005). The autonomic system acts by itself as a help for the driver. However, the autonomic system is not used for driving, but only helps the driver when necessary, as an emergency device.

Level 2: Partial Driving Automation. A vehicle in which two or more autonomic systems work together, capable of simultaneously handling two tasks. For example both steers the vehicle and operate the braking system. The main limitation of this level is that in any given moment, the driver must analyze the conditions of the road and respond accordingly. Thus, even if the car is of level 2, the technology still needs the driver to be aware of the circumstances and to respond immediately to any scenario because the autonomic system cannot prevent some of the potential accidents.

Level 3: Conditional Driving Automation. In some conditions the driver is not required to monitor the driving; however, there are limitations in this level; in other words the car cannot be driven without human intervention under any conditions. For example it can be automatically driven only on highways. Accordingly, when the vehicle goes, a human driver must supervisor it, because if emergency circumstances come about, the human driver will intervene so as to avoid any potential accident if the car cannot handle the circumstances.

Level 4: High Driving Automation. The vehicle will be able under certain circumstances to operate fully autonomously and to protect its passengers from accidents. An autonomous vehicle at this level does not require a human driver to be ready to respond in an emergency, but only if the defined circumstances are kept.

Level 5: Full Driving Automation. There is no restriction to certain circumstances, nor is there a need for a human driver for supervision in emergency circumstances.

MOTIVATION

Approximately 94-95 percent of road accidents are caused by human errors (NHTSA, 2015), (Freeman, 2016). These errors are usually taken place because of smartphone use, fatigue or distraction because of any other reason (Kaplan, Guvensan, Yavuz & Karalurt, 2015). An autonomous vehicle will prevent the vast majority of them. In addition, an autonomous vehicle will always conduct itself as it has been programmed. Therefore, if a programming failure is detected that has not been occurred in all tests, it will be possible to issue an update how to correct this failure. This update will instruct all autonomous cars how to conduct themselves in a similar case (Koopman & Wagner, 2016). In this way, every autonomous car will be trained by the experience of all autonomous cars as opposed to a human driver trained only by his own experience.

Autonomous cars will be of great help for people with disabilities (Bradshaw-Martin, & Easton, 2014). For example, people with severe visual impairments can safely travel in an autonomous car. In addition, people with an exhausting job or drunk people will be able to travel in such a car without driving. Moreover, autonomous vehicles will release also people in good physical shape from the burden