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Will robots be good drivers?

Abstract

The race for driverless vehicles has already begun. We see them in industrial facilities: trucks in Australian open-pit mines, for example. Tested on roads open to traffic, they run on roads and streets in many countries. The brains of experimental vehicles are becoming much more clever and far-sighted, thanks to amazing advances in *deep learning*. Some believe the era of truly autonomous vehicles will start in 2020 or earlier. Some experts do not, as the problems to be solved are daunting. The main issue is safety. How to ensure a level of safety close to that of public transport? How to prove it?

People have been dreaming about motor vehicles without drivers for a long time and they have witnessed many initiatives for more than half a century. Alphabet Inc. and its subsidiary Google X (now X) were the first to shake the worldwide automotive industry with their project for cars without steering wheels or pedals. Google X hastened to obtain the first licence for tests in Nevada in May 2012. Today, X is still ahead of the international competition when measuring the distances travelled each year by autonomous cars. This is not taking into account the Tesla Motors Model S and X,as they have not passed the threshold of true autonomy.

Meanwhile in 2012, after having been set aside by computer scientists for a decade, neural networks suddenly demonstrated, through brilliant discoveries, their surprising ability to learn how to recognize objects and bodies through *deep learning*. In addition, there were more and more remarkable *advanced driver assistance systems* (ADAS). At the same time, the progress of information and communications technology (ICT) opened the way to interconnected vehicles and infrastructures. Within months the automotive industry was shaken by this revolution. All original equipment manufacturers (OEM) threw themselves into the battle: Germans, Americans, British, Chinese, Korean, French, Japanese, etc. Everyone understood this future was at stake.

How to get rid of such dangerous running machines

Governments are closely following technological advances. Of course their primary concern is how to support their domestic industry. However, many hope to stop the exponential growth of the number of accidents. The rapid decline in road accidents since the last world war seems to be over. According to a report published by the World Health Organization (WHO) in September 2016, about 1.25 million people are killed by car

accidents. Half are vulnerable people: pedestrians, cyclists and especially motorcyclists. Tens of millions more are injured. The cost to society is high: between 3% and 5% of the gross national product. In many nations, the numbers of accidents and victims are no longer declining, or only slowly. Hence the importance of technologies that could approach the level of safety in public transport. In Europe, there is about 0.35 deaths per billion passenger kilometres in air transport, 0.5 in rail transport, 0.7 in bus and coach transport but 7 deaths when traveling by car and 140 when riding a two-wheeler! On the roads and streets of France in 2014, there were 3,557 people killed (3,616 in 2015). Compare and conclude: there were only 530 deaths due to professional accidents that very year.

But many do not believe the new technologies can quickly solve the problem of road accidents. They assert that during, let us say the next two decades, safety may only improve through the policies known best everywhere: roads better managed and maintained, vehicles better equipped and reconditioned, drivers better trained, monitored and sanctioned. Such is the opinion of the International Transport Forum (under the Organisation for Economic Co-operation and Development) in a 2016 report: "*Zero Road Deaths and Serious Injuries*". At the very least the Forum is right on this point: the autonomous vehicle cannot dramatically change road safety quickly, as new cars will have to share the road with old cars.

Revolution has already started

There is no more lively debate in the mainstream media than the advent of autonomous vehicles. A catchphrase: will we soon see them on roads or not?

The answer is : they are already circulating…

In Western Australia since 2012, the mining company Rio Tinto already uses driverless trucks, each carrying up to 320 tons. They operate three open pit mines. They are remotely monitored, 1,200 kilometres away in Perth. The fleet will soon comprise one hundred and fifty trucks, built by the Japanese company Komatsu.

Autonomous vehicles are also beginning to be used in agriculture: tractors designed by Autonomous Tractor Corporation (ATC), etc.

Autonomous handling equipment is gradually spreading in the industry. For example, the Canadian company Clearpath Robotics produces and sells OTTO vehicles for moving loads inside factories.

In France, with six autonomous shuttles ARMA from Navya, the transport company Transdev operates a line three kilometres long inside the Civaux Nuclear Power Plant (Vienne).

But these are transports out of open roads.

Training robots

Since the first tests in Nevada four years ago, experimental autonomous vehicles are running in many countries: the United States which ranked first, but also Germany, China, South Korea, Spain, France, Japan, United Kingdom, Singapore, etc.

Why the United States first? Because regulation is favourable. Because the industrial environment is attractive: research centres in Silicon Valley south of San Francisco, universities, etc. Because enthusiasm is high. Because the government and the Safety Authority (NHTSA) strengthen hopes.

Asia and Europe are not left out,but US is still ahead.

When the first driving license for robots?

Autonomy strictly begins once the driver can handle tasks other than driving. The best standard is from SAE International. There are six levels, from 0 to 5. At level 3, the first for true autonomy, the driver must be ready to steer, accelerate and brake at any request of the system. At level 4, the driver-operator knows in advance when to drive. At level 5, the *automotive nirvana…* Driving is cleared of all dangerous human passions. The system never needs the driver-passenger after he enters his destination in the computer.

There is a domain where industry is now close to autonomy: shuttles for public transportation. Such vehicles are tested in many cities. They are designed by two French companies (Navya and EasyMile), but also by Local Motors from Arizona and Hi-Tech Robotic Systemz from India. Within two or three years, such shuttles will probably run on restricted traffic lanes at low speed (20 to 25 km/h) without an on-board agent. In France, perhaps in Paris and Lyon. Human intelligence of the automatic system will only be present in the control center, which will remotely monitor traffic.

And what about trucks? To reduce the drag force, will platooning of traffic with partially autonomous trucks soon be allowed in some European countries? It would be a first phase before more complete autonomy. Trucks would be joined one to another by radio. The smart system would replace drivers behind the lead vehicle for part of their tasks: control of the safe distance between trucks, acceleration and braking when necessary. Even in the first phase, benefits would be significant as it was shown by the French Institute Ifsttar and under the European experiment which ended in Rotterdam in early April 2016: lower fuel consumption, lower carbon dioxide emissions as a result, lower danger.

As to private cars, statements by OEMs are increasingly optimistic. Most of them predict driving at level 3 or 4 as soon as 2020 or 2021. The company Tesla Motors has even proclaimed that it would sell cars completely autonomous around the end of 2017, whether new regulations will allow them or not. The new economy is also confident: Alibaba, Alphabet, Baidu, Grab, Mobileye, LeEco, Nvidia, Tencent, Uber, etc.

Around 80 % of the media is optimistic. The way William Arthur Ward did, they argue that « *Optimists enrich the present, enhance the future, challenge the improbable and attain the impossible* » ! But the pessimists will struggle to have the last word …

Success or failure? And so what?

Many engineers, economists and planners are trying to imagine our future world, especially its ever-growing cities, under the reign of fully autonomous vehicles. They are all basing their studies on this irrefutable argument: private cars are expensive machines, nevertheless almost all idle all day long! In Île-de-France, a car is parked more than 95%

of the time, it is driven only three times every two days, it only runs six kilometres each journey. Hence the high added value of shared cars. It is easy to prove that the organization of sharing is easier if cars belong to fleets managed by a central platform. Secondly the organization is much easier when many cars are autonomous, because far less expensive at least when they run empty. Current experiments in Pittsburgh (by Uber), Singapore (by nuTonomy), Tokyo (by Robot Taxi), etc. will tell us before 2020 whether such projects are feasible in a near future. If answer is yes, great and quick changes would certainly ensue.

What could be the causes of failure? Notably two.

The main reason is the difficulty obtaining a high improvement of safety. One can believe these four obstacles are surmountable: adaptation of the law (about liability and insurance), social acceptance, improvement of road equipment, even cyber security.

Through international standards such as ISO 26262 about functional safety of road vehicles, it is generally required that machines commit less than one fatal error per billion operating hours. But what is true for automatism does not apply to intelligent robot. A robot is generally considered safe if it works much better than human behaviour. But not one thousand or one million times better! An autonomous vehicle is a robot that adapts its behaviour to circumstances, not an automatism that repeats identically what was taught.

If the rule of 10^{-9} factor is not applicable, to what level should the safety of autonomous vehicles climb? On 8 June 2016, the administrator of the American agency for road safety (NHTSA) publicly stated that he could start with a factor 2. On 19 October, the CEO of Tesla Motors also put forward this coefficient. It would suffice, they said, to prove the social benefit of self-driving. Would halving the mortality rate actually be satisfactory? Many doubt it. The French company Valeo think the goal must be less than one major accident per billion passenger kilometres. The factor 2 of NHTSA and Tesla would mean the number of people killed in or by car per billion passenger kilometres decrease from 7 to 3.5 in Europe, although other modes of public transport would remain at a level below 0.7 in the future. Is this simple comparison enough to prove that safety gain should be at least 10 to 20 times better? Many other arguments and conclusions are possible.

Still unresolved, the second challenge is the certification of systems. How to certify the safety of running robots even when the circumstances of an accident are of infinite variety? Which beam of simulation, testing and experimentation could lead to the certification of a new model? Even the improbable often occurs on the road: a badly damaged floor, roadwork that has not been announced, sudden fog, a violent snowstorm, a reckless driver, an unclear sign from a maintenance worker. In addition, artificial intelligence (AI) already uses powerful neural networks (*deep learning*), but their wonderful talented brain is partly inexplicable.

The best bet?

Most States have pledged that research would soon be successful. In this fighting spirit, France published an ambitious roadmap on 12 September 2013, part of its New Industrial France (NFI) program. In doing so, are all governments acting wisely? Are they right to trust idealists who want to vanquish at once and forever the anarchy of the road?

Mary Shelley wrote in Frankenstein: « *Invention, it must be humbly admitted, does not consist in creating out of void, but out of chaos.* ».

In any case, the States should never forget that the success or failure also depends on the laws and regulations they will enact. Some rules will define what is precisely the functional safety of autonomous vehicles, others rules will define what evidence the industry will have to submit.

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