Superintelligent Self-Driving Vehicles

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***Abstract*— The concept of a completely automated self-driving vehicle is nowadays a riveting notion. Automobile and tech companies have been perfecting their autonomous solutions, but there are some significant concerns present. It will be required to achieve higher levels of machine intelligence to enable self-driving vehicles to function correctly and be an improvement over the current state of the traffic system. Machine superintelligence and technological singularity will affect humanity, but not necessarily negatively, as some critics tend to claim. Superintelligent self-driving vehicles could eliminate, or at least mitigate, human errors, which would result in increased safety, efficiency, and equity. This paper will be inspecting the new possibilities brought with the acceptance of such machines.**

***Keywords*— Artificial Intelligence, Singularity, Self-Driving Vehicles**

I. Introduction

Even though the field of artificial intelligence has seen exceptional advances in the past decades, it has, nevertheless, remained largely unexplored. The possibility of achieving even higher levels of machine intelligence draws the profession's attention, as well as the attention of the broader public. Artificial intelligence is ubiquitous, it has pervaded science, industries, and day-to-day lives, but it has probably made more impact on the automobile world than it has on any other.

The car industry has evolved tremendously since its beginnings in the late 19th century, resulting in the modern car becoming more of a sophisticated and advanced mobile computer. Technological progress has helped make vehicles safer, faster, affordable, accessible, and smarter - especially with the rise of artificial intelligence. The next anticipated breakthrough in the fruitful relationship between vehicles and thinking machines, is the emergence of completely autonomous vehicles.

Yet, the problem is that present-time self-driving cars' prototypes are experiencing too many challenges to be allowed to operate unsupervised. Machine intelligence, that controls these cars, requires further improvements to be able to fulfill the task, but, on the other hand, its ascent may come with many 'unknown unknowns'. The question of how will the occurrence of machine superintelligence affect the transportation system and life in general, has been tackled by many - computer scientists, sociologists, philosophers, automotive enthusiasts. From all points of view, it will surely change human lives from the ground up.

II. Machine Intelligence

The term artificial intelligence (AI) describes machines able to execute actions resembling human intellectual and cognitive capabilities. There are a plethora of examples of AI in everyday life – digital assistants (Apple's Siri or Amazon's Alexa), e-mail filters, predictive searches on search engines, product recommendations, et cetera. People have gotten so used to utilizing these in their everyday life that they are generally not considered fascinating, or even intelligent anymore. Silicon Valley computer scientist Larry Tesler explained this phenomenon with what is now publicly acknowledged as Larry Tesler's Theorem: „Artificial intelligence is whatever hasn't been done yet" [1].

Currently, all of the commercially applied AI falls under the label of Artificial Narrow Intelligence (ANI). ANI describes a machine that is capable of performing one certain task, possibly even better than a human would, but essentially nothing more than that specific task. These machines are extremely successful in terms of learning or analyzing big data, but are practically useless outside of the context that they were developed for [2].

The next significant breakthrough in the field of AI is the development of Artificial General Intelligence or AGI. The concept of AGI describes a machine with human-like intelligence and the ability to solve problems in a broader range of domains. What differs AGI from the present ANI, is the capability of contextual adaptation and explaining the reasoning of the decision-making process. The key feature of AGI is its ability to deal with many different domains and master new skills that it has not been confronted with before. However, not all AGIs will necessarily be built as general-purpose systems. Just as it is a case with humans, some machines might have tendencies towards mathematics, while others might develop better verbal communication skills [3].

Since machines powered by AI have already surpassed human abilities in an ever-increasing number of different fields, the notion that one of them will be better at developing artificial intelligence than humans are, is based on justified grounds. This could result in a machine bettering its own intelligence, causing the emergence of the Artificial Superintelligence, which would far exceed human intelligence [4]. This phenomenon has first been described by British statistician Irving John Good:

> Let an ultra-intelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultra-intelligent machine could design even better

> machines; there would then unquestionably be an 'intelligence explosion,' and the intelligence of man would be left far behind. Thus, the first ultra-intelligent machine is the last invention that man need ever make, provided that the machine is docile enough to tell us how to keep it under control. [5]

III. Machine Superintelligence

The moment when machines gain superintelligence is known as the technological singularity. Singularity is originally a mathematical term defining a point (singularity point) where the function of a variable is not analytic. In this context, it describes a point beyond which no prediction can be made with confidence. Artificial intelligence cognoscenti define singularity as "phenomena whereby ever-more-rapid technological change leads to unpredictable consequences [6]". The idea of technological singularity was announced by science fiction author Vernor Vinge in 1993 where he stated that achieving technological singularity is 'comparable to the rise of human life on Earth [7].' Since then, the definition of singularity and singularity itself have been both practical and philosophical questions.

The subject of debate is the attainability of the singularity and, in case it is attainable, how would machines with greater-than-human intelligence act towards the human race. Furthermore, another often posed question is how high is the bar set for a machine to be considered singular. If the ultimate artificial intelligence must utterly mimic the human mind, besides its ability to resonate, it needs to embody consciousness as well. Since "consciousness has less to do with pure intelligence and more to do with our human nature as living and breathing organisms [8]", instilling the sense of awareness into machines remains a complex problem. However, it is debatable whether resolving it is indeed required to reach singularity. Luciano Floridi, Professor of Philosophy and Ethics of Information at the University of Oxford, stated that computers are essentially Turing machines and that Turing machines cannot be conscious [9]. Even Alan Turing, in the paper where he introduced the test for machine intelligence (Turing test), stated that the question of whether the machines can think is meaningless [10]. Therefore, if the machine need not be conscious, but merely effective, to be a world-changing event, there are significantly higher chances of achieving technological singularity. In this context, the term 'effective' implies a machine that is better than humans in solving various problems in unpredicted environments.

IV. The Singularity And The Future of humanity

The remaining impediment to the emergence of technological singularity, besides the development of the necessary hardware and software, is the human factor. Predictions for coexistence between ASI and humanity are diverse and numerous, ranging from 'Friendly AI' to apocalyptic scenarios. The rise of technology could undoubtedly bring as many new possibilities for humans, as the perils [11].

Luddites (umbrella term describing people who dislike new technologies) fear most of the machine takeover denouement. The most radical, dystopian scenario was presented by Theodore Kaczynski in his now-infamous manifesto named Industrial Society and Its Future:

> If the machines are permitted to make all their own decisions, we can't make any conjectures as to the results, because it is impossible to guess how such machines might behave (...) What we do suggest is that the human race might easily permit itself to drift into a position of such dependence on the machines that it would have no practical choice but to accept all of the machines' decisions. As society and the problems that face it become more and more complex and as machines become more and more intelligent, people will let machines make more and more of their decisions for them, simply because machine-made decisions will bring better results than man-made ones. Eventually a stage may be reached at which the decisions necessary to keep the system running will be so complex that human beings will be incapable of making them intelligently. At that stage the machines will be in effective control. People won't be able to just turn the machine off, because they will be so dependent on them that turning them off would amount to suicide. [12]

However extreme Kaczynski's predictions were, several other recognized academics and scholars have agreed with him, including Stephen Hawking, who expressed his fears regarding machine superintelligence in an interview: "The development of full artificial intelligence could spell the end of the human race [13]." The argument supporting the possible machines' malevolence lies in the fact that even though machines would initially be programmed to be docile, they would still be bettering themselves and re-writing their own software, hence those original instructions could easily be overwritten.

On the contrary, Eliezer Yudkowsky, a recognized AI researcher, claims those presumptions are a misjudgment because even if the machines had the hypothetical ability to eradicate humanity, they would not necessarily do it. He further elaborated this at the 2006 Singularity Summit at Stanford University: "When technology advances far enough we'll be able to build minds far surpassing human intelligence. Now, it's obvious that how large a cheesecake you can make depends on your intelligence. A superintelligence could build enormous cheesecakes—cheesecakes the size of cities—by golly, the future will be full of giant cheesecakes! [14] " What Yudkowsky's example highlights is that there is a significant disparity between the machine's capability to do something and what it will do in reality. What bridges the gap between the two, is the motive. Essential motives a singular machine might exhibit are directly related to tendencies towards self-improvement, rationality, and protecting itself, which fundamentally do not pose a danger for the human race [11].

But how would people adapt to the presence of superior intelligence? Technology is nowadays ubiquitous in the human world. Devices became a part of everyday lives in pervasive but subtle ways. They were tailored for people, to serve all of their likely needs by becoming more helpful and reliable. The saying

'We shape our buildings and afterwards our buildings shape us' can appositely be applied to the relationship between man and his technological devices. Technology is designed in such a way to fit into human lives optimally, adjusted to benefit its user. But at one point in time, people began changing their ways of living as a consequence of digitization. Technology has been given control over a large number of actions both in industry, as well as private lives. Therefore, the concept of accepting superior artificial intelligence as a part of the ordinary world is perfectly plausible.

Artificial superintelligence could resolve problems where humans have reached the dead-end, complex problems where the human brain's processing speed and ingenuity were not enough, such as eliminate famine, illnesses, poverty, ignorance, financial crises, war – all to enable humans to have longer and better lives.

V. Self-Driving Vehicles

One of the fields where AI has the highest potential is the automotive industry. Nowadays, mentioning driverless vehicles tends to spark the discussion in both business and scientific circles. They are also a very present idea in the media - they have never been so keen in the eye of the public – which comes as no surprise considering that their emergence could revolutionize the way people travel, work and live.

Understanding what is considered a fully autonomous vehicle requires learning the standards those cars must meet. SAE (Society of Automotive Engineers) International has declared six levels of driving automation for on-road vehicles, where level 0 represents zero automation and human's absolute control, while level 5 represents full automation where the system performs all aspects of driving under all environmental and roadway conditions without any human assistance whatsoever [15]. Having a true self-driving vehicle means achieving level 5 autonomy. Self-driving vehicles must de facto perform the driving task on its own at least as well as humans.

A. History

While the concept of an entirely driverless vehicle seems futuristic and distant even in 2020, the idea itself dates back to the Middle Ages. The first design – 'The Self-Propelled Cart' was created by Leonardo da Vinci in the 1500s. This vehicle was relatively simple - it was powered by springs under tension, while its path had to be programmed in advance, before setting it to go. 'The Self-Propelled Cart' is now considered a precursor to the cars and robots [16][17].

Significant progress in the development of driverless vehicles was achieved in a series of projects sponsored by DARPA, The U.S. Department of Defense's research agency. Their first project named 'Autonomous Land Vehicle'(ALV) began in 1984. ALV was an all-terrain vehicle built for military purposes that could navigate a route without human assistance using a video camera and laser scanners for spatial orientation. ALV has accomplished some of the defined objectives, but its performance was drastically influenced by weather conditions, time of day, time of year and other circumstances. Thus, it was not reliable enough for military purposes [18].

A major leap forward was accomplished in 1995 by Ernst Dickmann and his team from the Bundeswehr University of Munich. They developed a vehicle named VaMP, which was a re-engineered Mercedes SEL 500 with autonomous capabilities. VaMP had achieved the team's expectations after it had managed to drive itself from Munich to Odense (roughly 1000km) and back almost entirely autonomously [18].

Another project that yielded big success were three challenges sponsored by DARPA, held between 2002 and 2007. These challenges included competitions that required teams to develop autonomous vehicles that would race on predefined routes, including both on- and off-road stages, for a large monetary reward. The latest of the three, 'The Urban Challenge', took place in a mock city environment. Accordingly, besides all the previous, vehicles also had to meet the new demands – obeying traffic rules, detecting other vehicles, parking, and others. These challenges showcased many new capabilities of AI-powered vehicles, raising interest of the general public and industry. Numerous carmakers and tech companies have been perfecting their prototypes for years, but they are inclined to believe they are in the home stretch now [18].

At this time, there are not any legally allowed driverless vehicles on the roads. However, a large number of vehicles produced in the past few years do have autonomous capabilities or artificial intelligence-powered driver-assistance systems. All these still require a human driver to intervene when the vehicle comes across unpredicted situations. For example, Tesla offers the Smart Summon feature, which enables the car to drive from its location - garage or parking spot - to its driver. But this feature comes with Tesla's admonishment that the driver is still responsible for all possible unforeseen events, even without him being behind the wheel at the time [19] [20].

B. Current Challenges

Despite the tremendous efforts of automobile and tech companies, autonomous vehicles still have numerous challenges to overcome before being allowed on the roads. The problem that raises the most concern is security. There have already been fatalities in accidents involving autonomous vehicles during road tests as a consequence of the vehicle's inability to detect humans [21]. However, road accidents are sometimes inescapable. In a world where all cars are still driven by humans, 1.25 million people die on the roads [22]. Moreover, making vehicles intelligent and giving them control could potentially reduce the number and severity of collisions. The argument supporting that claim lies in the fact that humans react instinctively in emergencies, while artificial intelligence could analyze all possible outcomes, choose the most optimal one, and act accordingly. However, autonomous vehicles must be pre-programmed, and therefore, the decisions they make could potentially be biased and influenced by the developer's personal beliefs. A sense of ethics differs greatly amongst people, which makes the goal of creating a system that everybody agrees on utterly unattainable.

The autonomous vehicle's movement is regulated by its actuator, which principally relies on sensory inputs - the data it acquires from cameras, radars, lidars, et cetera. Therefore, if the

inputs are erroneous, the vehicle will undoubtedly make the wrong decisions. This becomes worrisome if sensors can be tricked by false signals, which turned out to be possible- even the most sophisticated systems are prone to hacking by a simple laser pointer. It has been shown that it is both possible to trick the car into thinking there are objects in its environment that do not exist in reality, and on the other hand, prevent them from noticing real objects by overwhelming the sensors with false signals. These insights highlight that self-driving vehicles, at least in their present form, are accompanied by great dangers [23].

The issue of liability in case of accidents, critical moral dilemmas AI could potentially face, and an extensive and lengthy process of governments passing laws regulating the use of self-driving vehicles in addition to mentioned difficulties postpone the potential revolution of transportation. The root of the problem is that the artificial intelligence systems applied in existing autonomous vehicles belong to the spectrum of narrow intelligence while driving a vehicle is not a simple action in the slightest. Automated cars are undeniably better at managing distance, speed and time, because of their ability to calculate these values in a matter of seconds, while the best humans can do is estimate. Spatial orientation, reaction time, resistance to distractions also give artificial intelligence advantage, but human experience, perspicacity, and shrewdness still make humans the ultimate driving machines.

A rising number of companies began testing their autonomous prototypes in real-life conditions. But candidly speaking, these conditions are different from actual human experiences. Vehicles in question are pre-programmed for all possible and anticipated situations, geo-fenced (possess virtual models of real-world areas) and are familiar with the surroundings before the drive itself [24], while on the other hand, human drivers have an unquestionably more challenging task figuring all of these out on the go. So, can these vehicles truly be labeled as fully autonomous?

Present-day driverless vehicles work well in a vacuum but have proven unsatisfactory in realistic conditions. They lack common-sense reasoning, adaptability to new situations, versatility – innate human abilities. Artificial Narrow Intelligence is obviously not up to the task. Automated driving requires higher levels of machine intelligence to become fully functional and widely-adopted. Will it be actualized with AGI; or may achieving ASI, or even singularity, be necessary?

C. Opportunities of Superintelligent Vehicles

If the implementation issues and philosophical questions are put aside, and the hypothesis of technological singularity is presumed as possible, or even probable in the next couple of decades, how would it impact the automobile industry and life in general? Surely, widespread adoption of automated vehicles would primarily transmute the transportation system, but the ramifications could significantly affect the whole society in terms of safety, environmental sustainability, sociability, and jobs.

The leading cause of road accidents is human error – distractions, driving under influence of various prohibited substances, drowsiness, aggressiveness, stress, et cetera. AI-powered machines are, reasonably, immune to those and doubtlessly better in terms of alertness and responsiveness, hence their takeover of the driver's seat could virtually eliminate human error. As a result of fewer road incidents, there would be fewer traffic disruptions altogether [25] [26].

Fossil fuel cars impact the environment extremely negatively, mostly by causing air pollution by the emission of exhaust gases and particles. Improving fuel efficiency would significantly benefit the biosphere. However, that is not a simple task for human drivers - they tend to drive impulsively, frequently accelerating and braking, which is much less efficient than driving at a constant speed. On the contrary, vehicles can be programmed to follow certain rules. Another opportunity brought by AI-powered vehicles is vehicle-to-vehicle (V2V) connectivity, predicted to live up to its maximum potential at the moment when the majority of the vehicles on the roads become intelligent. It will enable them to communicate and share data on their status, road conditions, their planned path – all to improve traffic flow. An example of the previous is platooning [27] – vehicles that are headed in the same direction, drive in groups, at a shorter distance between them than human drivers could safely realize, where all included vehicles accelerate and brake simultaneously. Platooning improves road capacity, fuel efficiency, aerodynamic drag, and safety. It makes the most notable difference when applied to trucks, which are prone to wind resistance because of their brick-like shape. An even more advanced concept is vehicle-to-everything (V2X) connectivity, where 'everything' includes traffic signs, infrastructure, Internet of Things, devices… [28] [26]

Self-driving cars will obviate the need for a human in the driver's seat and thus could also reduce the need for owning a car. Private car ownership could be replaced with the 'Taxi model' [29] – there would be fleets of self-driving vehicles in the cities available for ride-sharing, emulating a taxi-like system.

According to data gathered in the US, the average person spends about an hour a day driving their vehicle, with an average occupancy rate of around one and a half persons per vehicle [30] [31]. A vast amount of half-empty vehicles on the roads cause bottlenecks and congestions, slowing down the traffic flow, especially during the heaviest commuter traffic. It indirectly leads to significant efficiency loss and a waste of time on a daily basis. Nevertheless, a majority still prefers using a personal vehicle over public transportation systems for the sake of comfort and flexibility [32]. Self-driving vehicles as a mode of public transportation would give the best of both worlds – improving mobility while retaining the benefits of a personal vehicle. The study [33] conducted by Luis Martinez of the International Transport Forum simulated a medium-sized European city in which all personal vehicles are replaced with driverless Shared Taxis and Shared Buses, to assess the effects of such a transportation model. The results showed that there would be ninety percent less vehicles on the roads, but the daily average of vehicle usage would rise to twelve hours, and the average daily mileage would increase from thirty to two

hundred and fifty kilometers. That would naturally shorten the lifespan of a car, demanding a more frequent renewal of the fleet, resulting in more new and environment-friendly vehicles. Greenhouse gas emissions would plummet around forty percent, while traffic fluidity would increase, especially in urban areas. There would be no need for as many parking lots in cities, allowing repurposing of those areas. According to these findings, many transportation issues, especially in urban environments, would be resolved if the taxi model prevails.

On a macro-level, the adoption of driverless vehicles promises many benefits for society as a whole. However, this technological revolution would also significantly affect individual human lives. Even though driving a vehicle is primarily a means of transportation – utilized for transferring things or beings from one place to another, in reality, it has become far more than that. It is both a cultural and social practice. It evokes feelings of joy and excitement, freedom and independence, power. The presence of vehicles has reconfigured everything from little daily habits to the whole structure of cities [34].

The emergence of self-driving vehicles will be life-changing for the ones who are unable to drive and are dependent on others – disabled, elderly, children. So, alongside the option of nobody owning a vehicle, there could be a future where everybody owns one. But, because upfront car payments can be expensive, private ownership will not be an available option for everybody, especially economically and financially disadvantaged populations. Adoption of driverless taxis would, on the other hand, reduce the traveling costs and thus make it a convenient and affordable option for many.

Whether private or shared, vehicles would not require a human driver anymore. Instead of being coerced to navigate the road, the former driver could, together with the other car occupants, undertake alternative work or leisure-related activities [35]. Moreover, the vehicles could become mobile units for work, entertainment or socializing between departing and arriving at their location, allowing people to be connected and on the move, while still offering them privacy and seclusion from the public. They would allow passengers to use travel time productively, making the long-distance commute or travel a more acceptable option.

Vehicles and driving elicit a range of sensations and emotions in people, from anger and annoyance caused by other drivers' recklessness and imprudence, to enjoyment and thrill of the driving experience. While embracing self-driving vehicles could diminish the unpleasantries, it would lessen the positive feelings at the same time. Thus, driving enthusiasts are mainly reluctant to accept the idea of being replaced by AI. Realistically speaking, vehicles without intelligent features will most definitely not entirely disappear in the imminent future - they could become a leisure activity instead, a hobby.

People are and will remain, a driving change in the car industry. Thus, carmakers must have their targeted customers' pleasure in mind while designing and developing new vehicles and, as they promise, driving will remain a pleasurable activity, only enhanced by artificial intelligence features [36].

VI. CONCLUSION

The development of machine superintelligence is crucial for self-driving vehicles. Even cutting-edge autonomous prototypes experience concerning problems, making their broader acceptance less probable. They lack certain abilities that are inherent to humans, which could be instilled in them with the achievement of higher levels of artificial intelligence.

Although singularity is, by definition, unpredictable, it is possible to envision the future of transportation, after more capable machines succeed to resolve all the challenges they currently face. With software taking over the wheel, human errors would virtually be eliminated, resulting in increased safety and efficiency and novel models of transporting, working and living would become the new norm.

This will certainly not happen in the imminent future, since the possibility of achieving higher machine intelligence and singularity is still widely disputed, but if and when it happens, the human world will be revolutionized.

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