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Have We Underestimated the Challenges With Automation?

Human Error and Accidents

The research shows that over 90% of all accidents are due to human error. Automated vehicle technologies hold the promise of decreasing the number of accidents. However, accidents are complex and usually there is a chain of events leading up to an accident. For example, take a signalized intersection, where a pedestrian enters the crosswalk against a red light when the traffic light turns green for vehicles. Vehicle A (across the intersection) detects the pedestrian and it drives slowly, crossing the intersection. Vehicle B behind Vehicle A changes lanes due to the unprecedented low speed of Vehicle A, and in the new lane Vehicle C coming with higher speed from behind cannot avoid hitting Vehicle B. The root cause of this accident is due to a pedestrian not following the traffic rules. A chain of unfortunate events takes place due to this. The root cause of an accident is in many cases just like in the example. Vehicle B does not know why Vehicle A is driving slowly (e.g., it could be due to a faulty vehicle). When the police arrive at the scene, only Vehicle B and Vehicle C will be left, and Vehicle C will be held responsible for the accident due to the rear-end hitting of Vehicle B.

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THERE IS AN INTERPLAY BETWEEN HUMAN DRIVERS AND VULNERABLE ROAD USERS IN URBAN SCENARIOS THAT IS CHALLENGING FOR AUTONOMOUS VEHICLES TO CAPTURE.

Vulnerable road users are downright vulnerable in all types of road traffic situations. They are unpredictable in their behaviors for onboard sensors such as cameras, radar, and lidar. In crowded places with many pedestrians and bicyclists, automated vehicles are struggling to make decisions without being too conservative, annoying passengers. There is an interplay between human drivers and vulnerable road users in urban scenarios that is challenging for autonomous vehicles to capture. There are also many situations when a human driver avoids accidents. The research is poor on the noncollision rate for human drivers. How skilled is the human driver in reality? And how many accidents are avoided because of the interplay between drivers and other road users?

There is one technology that is very underutilized in the context of autonomous driving: vehicle-to-everything (V2X) communication. V2X communication entails vehicle-to-vehicle and vehicle-to-smart-road infrastructure communication but also vehicle-to-pedestrian. Onboard sensors such as radar, lidar, and camera are line-of-sight sensors unable to see beyond physical barriers and they are affected by heavy rain and snowfall. Furthermore, they cannot predict the intentions of other road traffic participants. V2X, on the other hand, can "see" beyond physical barriers and provide the intention of others, which is very powerful in the context of autonomous driving. It complements and extends the range of the onboard line-of-sight sensors. V2X is pivotal for automated vehicles, but despite this, none of the major companies working on self-driving technologies is using or promoting it. There is a chicken-and-egg problem with V2X communication; benefits will increase with technology penetration. However, this sensor is cheap compared to other onboard sensors with their advanced signal processing.

There was a notification for proposed rulemaking (NPRM) for V2X communication in the United States, which did not make it through the legislative process before Donald Trump entered the White House. When Trump exercised the two-for-one rule, the NPRM was stalled. The legislation proposed that all passenger cars (<3500 kg) were to be equipped with V2X communication. A similar legislative

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proposal was present in Europe but was stopped due to heavy lobbying during the summer of 2019. There was a made-up narrative that V2X threatened the rollout of 5G networks, which could not be further from the truth since V2X and 5G complement each other. The major difference between the legislative proposals in the United States and Europe was that in the latter case it was an opt-in.

Tesla has experienced three road deaths when customers have used the autopilot functionality where at least two of them could have been avoided if V2X communication had been in place. These two accidents are similar; a truck makes a left turn and crosses the lane where the Tesla is coming, which in turn misinterprets the situation, crashing into the truck-trailer combination. If V2X had been used by the involved vehicles, the Tesla cars would have "detected" the truck in front of it and slowed down or, alternatively, the truck–trailer combination would have received information about the speed of the oncoming Tesla and could have waited with the left turn.

Ad hoc V2X communication is essential for automated vehicles and 4G/5G connectivity is important. V2X communication solves tricky traffic situations, complementing the onboard line-of-sight sensors. The first patent on V2X communication was filed in 1923 by Harry Flurscheim:

> The present invention relates to radio warning systems for use on vehicles intended to permit a vehicle to signal its presence by means of electric waves to all other vehicles in its more or less immediate vicinity.

If Flurscheim's invention had been commercialized a century ago, then V2X would be as common as the steering wheel, brakes, and gear box.

Connectivity

Cooperative Intelligent Transport Systems

Cooperative Intelligent Transport Systems (C-ITS) is the European notion for increasing road traffic safety and road traffic efficiency by means of using wireless communication, both V2X as well as cellular connectivity. C-ITS encompasses Day One scenarios and Day Two scenarios, where the former extends the awareness horizon for the driver and the latter extends the awareness horizon for the automated vehicle. The European Telecommunications Standards Institute (ETSI) standardization for Day One scenarios was finalized in 2014. Large-scale deployment in Europe took off in 2019 when Volkswagen (VW) launched V2X communication and Day One scenarios as a default feature in their new Golf 8. This deployment has now been extended to also cover their full electric ID family. VW is using the dedicated short-range communication technology IEEE 802.11p (also known as ITS-G5 in Europe). By the end of 2021, there will be more than 700,000 V2X-equipped vehicles on European roads.

The current activities in ETSI standardization are addressing the extended awareness horizon for automated vehicles. In Day One applications, vehicles transmit information about the current status of the ego vehicle, such as speed, position, status of sensors, and so on. In Day Two applications, the ego vehicle will, e.g., broadcast information about what the vehicle detects with its onboard sensors using the so-called collective perception message. This will contain an object list of what the ego vehicle detects such as parked cars, bicyclists, pedestrians and other moving objects (which might not be V2X-equipped). Maneuver coordination is another message elaborated on in ETSI standardization currently. This will facilitate negotiation of maneuvers in tricky traffic situation such as left turns in intersections.

Platooning and cooperative adaptive cruise control (CACC) are also categorized as Day Two applications addressing both safety as well as efficiency. One-third of all accidents are rear-end collisions, which are caused crowded road traffic situations. When there are speed changes, the driver or the ACC system does not have time to react. Much research shows how CACC could make traveling in highway scenarios much safer with less jerky driving, reducing CO_2 emissions. In CACC, the vehicle's ACC system receives information about speed changes upstream and can adjust its speed more smoothly. In platooning, vehicles are more tightly connected to each other and can be perceived as one vehicle by the other road traffic participants. Platooning has predominantly been associated with truck operation but who would not appreciate a long journey on a highway in a platoon of cars doing other things than driving.

Linking the Vehicle to the Transport System

The key to unlock the full potential of ITS is to link the vehicle to the transport system, e.g., share data between relevant stakeholders for traffic safety, reduced emissions, and efficiency. For example, a vehicle detects an icy spot and reports this to the cloud. The data in the cloud can be fetched by other vehicles approaching this area but also by authorities who can send ice maintenance machinery to the location. In 2010, the European Commission (EC) brought forward the Directive on ITS [1], a legislation for facilitating a minimum set of ITS actions in the member states of the European Union. Linking the vehicle to the transport systems is one out of four priority

areas found in the directive. This directive is currently being revised by the EC for extending the scope to, e.g., include connected and automated mobility but also to review existing goals and requirements. In hindsight, the ITS directive has not been very successful. A directive sets up goals that need to be achieved to those the directive is addressed and, in the case of the ITS directive, it is the member states who are the recipients. However, how to reach the goals set out are up to every member state with the outcome of varying maturity and quality of the goals. The EC can draft delegated acts under the ITS directive with more detailed requirements, facilitating harmonization between member states, and this has also been performed with varying results.

One central concept in the ITS directive is national access points (NAPs), where data from authorities in each member states is provided to the general public and companies in each member state. The insufficient quality of many NAPs makes them unusable. Vehicles cross member state borders every day and drivers want to experience the same ITS services throughout EU, which is currently not possible. The NAPs are a good start, but to link the vehicle to the transport system requires an IT infrastructure to be in place where authorities can post, e.g., updates on closed roads/lanes, roadworks, accidents, and adverse weather conditions, whereas vehicles can share data on road conditions, and so on. Automated vehicles also need this type of data for planning the drive ahead.

ITS can contribute to reduced emissions, but few legislative proposals regard ITS as one key technology for reducing emissions. The EC has just launched a package of legislative ambitions called the *Fit for 55 Package* that addresses emissions. The purpose is to have reduced net emissions to 55% by 2030 (the former goal was to reduce this to 30%) compared to the levels in 1990 [2]. The package consists of several areas where the EC would like to draft new legislation with more stringent requirements on emissions. One proposal is to have a new emission standard for vehicles. Europe has already the most stringent emission requirements for vehicles and the traditional fuel engine has reached its physical limitation. It cost at least €100 million in development costs for a vehicle manufacturer to decrease emissions with 1% for fuel engines, which is wasted when drivers are not driving in a fuel-efficient manner. This money could be spent on ITS activities to reduce emissions through better planning of the movement of goods and people.

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ENSEMBLE

The European research project ENSEMBLE has fostered the first generation of truck platooning [3]. All European truck brands are part of the project and a live demonstration of the project's outcome is scheduled to take place in September 2021 in Spain. Many reports on different aspects of platooning have been made public [3], ranging from functional safety to communication protocols. The outcome of the project will be brought to ETSI standardization and the EC is eager to see the results, which will form the basis for drafting a delegated regulation under the European type of approval framework for vehicles on public roads.

Autonomous Vehicles

Tesla Abandons Radar

Tesla has once again surprised the industry and the general public, this time by abandoning radar and only relying upon eight camera sensors mounted on the vehicle for its autonomous functionality. In May of this year, the models Tesla X and Tesla 3 were placed on the U.S. market without radar. Tesla has stated that advanced image processing has now made radar obsolete. Several experts in the industry have reacted to this decision as they still believe that radar is a must-have for automation. The response of *Consumer Reports* to this was to remove the "top pick" label for the affected models, and other ratings have also decreased. Some critics say that the radar drop is due to cost-cutting, and by only using a camera system, situations like driving when it's dark, under poor weather conditions, and in sunny glare will for sure be more challenging. On the contrary, radar of course has its drawbacks such as classifying static objects and vehicles that are perpendicular to the driving direction such as truck–trailer combinations. None of the news flashes about this topic mention another very critical piece for fusing data from different sensors in real time, namely time synchronization. Lidar, cameras, and radar need to be very tightly synchronized to make relevant decisions about the surroundings.

Autonomous Transport Service in Challenging Conditions

The Finnish company Sensible4 has developed a full autonomous driving stack (SAE Level 4) with an expected launch in 2022 that can be brought into different car brands. They support transporting people the last mile. The company has received awards for their technology such as the Finnish Engineering Prize in 2020 and first place in the Dubai World Challenge for Self-Driving Transport in 2019. A two-year pilot with electrified and autonomous vehicles has

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just been launched in Switzerland together with Swiss Transit Lab [4]. These vehicles will be part of the public transportation service in Schaffhausen. The autonomous software is designed for coping with both rain and snowfall and was tested in Lapland, Finland, during harsh weather conditions.

New Insurance Broker for Automated Vehicles

Koop Technologies is a newly started business focusing on insurance technology and brokerage for commercial autonomy and robotics with the aim of accelerating the insurance business for autonomous technologies [5]. With the human driver out of the loop, conventional insurance risk models become obsolete. Koop plans to act as an intermediary between traditional insurance companies and companies launching self-driving technologies. They will collect data, calculate on risks, and provide foundations for insurance underwriting.

Gatik Raises US$85 Million

Gatik was founded in 2017 and focuses on electrified autonomous goods transport for the middle mile in the United States using medium-duty trucks. Earlier this year, they initiated goods transports for Walmart in Louisiana between a supercenter in New Orleans to a pickup point in Metairie. At the end of August, Gatik raised US$85 million in Series B funding and in total they have raised US$114 million.

Wrap-Up

Waymo was the first company to announce the intention of bringing self-driving technologies to public roads. They began their journey in 2009 under the notion of Google's self-driving car project. This was over a decade ago. Currently, they are operating a taxi service in Arizona that opened to the public in 2020. It is the first commercial taxi service without a safety driver. The vehicles can travel in speeds up to 45 mph. There are still tricky traffic situations that the taxis have difficulties in handling; this has been reported in the press, such as when there are many pedestrians present or traffic cones. Google is leading the world in the field of data processing, collecting excellent experts, and they have developed taxi service in a predefined area under nice weather conditions during the last decade. This is, of course, a major milestone and should be acknowledged, but this also reveals the challenges inherent with automation.

There is a naiveté in the traditional automotive industry regarding autonomous driving and the time it will take to place Level 4 vehicles on the market. Automakers try to accelerate their plans for bringing automation to the roads by having strategic collaboration with startups developing self-driving technologies. However, automakers have not been working for over a decade on automation like Google.

One of the drivers for automation is the potential reduction in accidents and fatalities, as mentioned earlier. Over 90% of all accidents are caused by human drivers, but what is the noncollision rate for drivers due to the human brain's capability to determine contexts in a split of a second and due to the interplay between drivers and other road users? The enchantment of this number dazzles what new types of accidents that will occur or if really all accidents can be addressed by automation.

Automation will, of course, play a role for the future for moving goods and people in a safer and more secure way, reducing environmental impact. However, the timeline needs to be revised and challenges need to be acknowledged. Connectivity also needs to be accepted as a natural ingredient for facilitating automation. Connectivity is a powerful "sensor," bringing information that cannot be achieved with other onboard sensors, especially ad hoc V2X communication that can within milliseconds "see" beyond physical barriers and receive intentions by other road users, extending the information horizon.

To summarize, the projected launch of autonomous vehicles is years behind because challenges are greater than expected. Are we solving the right problems and pain points with automation, or are we developing technology for technology's sake? Automation is an evolution and not revolution, manually-driven vehicles will be operated alongside automated vehicles for the foreseeable future on public roads. Furthermore, automation is one tool in the toolbox for making the world cleaner and safer, together with electrification and ITS.

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