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Riding to the Future

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I. Introduction

There used to be a time when autonomous cars existed only in science fiction novels. Now, fully-functioning autonomous vehicles are nearing widescale availability, with estimates as early as 2020 ("The Road to Self-Driving Cars"). Within three years, about 10 million driverless cars will hit the road (Johnson). While these cars will improve society in many ways, numerous ethical questions must be answered before fully-autonomous cars can responsibly share the roads.

II. Semi-Autonomous Vehicles

Currently, several vehicles offer driverless features in the United States. These features are just a taste of the future. Cars available on the market are close to, but not, fully autonomous. Today’s cars can monitor blind-spots, give forward collision warnings, detect pedestrians, and adaptive cruise control.

Semi-autonomous vehicles can detect cars in the rear blind zones and warn drivers of their presence. When a vehicle is present in the other lane, a warning light in or on the rear-side mirror will illuminate. If the driver activates a turn signal while the warning light is on, the car will activate a blinking light or an audible warning to tell the drive it is unsafe to move over. This feature is also beneficial when people back out of parking spots by detecting approaching vehicles crossing behind the backing vehicle ("The Road to Self-Driving Cars").

Forward-collision warning uses sensors or cameras to monitor the distance between your car and the one in front. If the system calculates that you are in danger of hitting the car in front of you, it alerts you with audible and visual warnings. It can also pre-charge the brakes to provide maximum braking power to the driver. Some systems even tighten the seat belts in preparation for a collision. A few cars go a step further by automatically braking the car if the driver does not respond quick enough. The Insurance Institute for Highway Safety (IIHS) has seen a 7 percent reduction in crashes for vehicles with a basic forward-collision warning system. IIHS estimates a 14 to 15 percent reduction for cars with automatic braking. Even if the crash is not avoided, the severity of the crash is lessened with these automatic features. Forward-collision warnings are available for many luxury vehicles and it is beginning to be more accessible to the mainstream models like the Chevrolet Traverse, Ford Edge, and Honda Accord. Automatic brakes will be an option in the redesigned Mazda 3 and Subaru Forester ("The Road to Self-Driving Cars").

New systems can also recognize pedestrians in front of a car and automatically apply the brakes. In 2012, pedestrian deaths from motor vehicle accidents accounted for 14 percent of all fatalities. Lane departure warnings alert sleepy or distracted drivers when they are drifting to another lane. This feature uses cameras and radar to detect lane markings and triggers a warning if the car starts to leave the lane without a turn signal. Advanced systems can take corrective steering action to keep the vehicle in its lane. There are limitations to this system because it relies on well-marked lanes that cameras and sensors can see. If it’s dark or snowy, the sensors will not be able to detect lane markings. Also, it does not consider moving to avoid roadkill or narrow roads. Parallel parking is a challenge for many drivers but semi-autonomous cars can parallel park with a park assist feature ("The Road to Self-Driving Cars").

The Society of Automotive Engineers developed a 5-level breakdown of autonomous vehicles. Level 0 is no autonomous features which are most cars currently on the road. Level 1 has some autonomous features like automatic braking and cruise control. Level 2 has automated steering, braking and acceleration, but requires human oversight. Examples of this level are the

Tesla Model S and Mercedes-Benz 2017 E Class. Level 3 cars can monitor their environment and drive autonomously, but may request human intervention at any time. These vehicles will be released in the next few years. This level includes the Audi A8 (2018), Nissan ProPILOT 2.0 (2020), and the Kia DRIVEWISE (2020). Level 4 cars can drive independently but may request human intervention in unusual conditions like extreme weather. Tesla and Volvo both have a model that falls into this level. Ford and BMW are set to release models in 2021. Level 5 is a vehicle that drives completely independent in all conditions. There are no cars available in this level yet but manufacturers are not far off (Ong).

III. Benefits of Driverless Vehicles

Fully driverless cars will change society as we know it. Imagine being able to hop out of your car at your front door and have the car park itself. Envision being able to maintain independence as you age. Autonomous vehicles will remove human error completely, increase mobility for elderly and disabled persons, and improve efficiency for supply chain processes.

Car accidents are one of the leading causes of death and human error is the cause of 90 percent of accidents (Fikes). Human errors include speeding, driving drunk, drowsiness, and being distracted. Motor vehicle safety ranks among one of the past decade's "ten great public health achievements" in the United States. This would save 29,000 lives in the United States alone and 10 million lives per decade (Fleetwood). Driverless cars could also alleviate traffic jams and parking issues. Cars would be able to detect busy routes and choose a different course. Street parking in urban areas will be lessened because it will not matter if your car is parked far away if it can come pick you up from your house.

Self-driving cars will be life-altering for the disabled and elderly. Blind and paralyzed people would gain independence and freedom with autonomous vehicles. Google's demonstration video of a driverless car featured a legally blind man riding to Taco Bell. A third of the population does not have drivers' licenses and a tenth of the population do not have access to cars due to age, disability, low income, or preference (Guerra). About 36 million older drivers still hold valid licenses in the United States. Eighty percent of them live in car-dependent suburbs or rural areas, not cities with public transportation. By 2030, the number of Americans over 65 is expected to reach 72 million (Johnson).

Brian David Johnson, a Professor of Practice at Arizona State University's School for the Future of Innovation in Society, argues that new hobbies may emerge for the elderly. Nightclubs or afternoon clubs may develop with the elderlies' newfound freedom. Volunteering or paid work could increase with new mobility. Johnson theorizes that a new market will be created for autonomous golf carts as many elderlies live in retirement communities. He believes the impact on the senior community will be profound and that they may be the first people to fully adopt autonomous cars (Johnson).

The business world will be radically changed by autonomous vehicles with a better supply chain process. Companies will do less warehousing and implement more just-in-time delivery systems. Each truck currently requires a human driver rather than the handful of people needed to manage a warehouse. Drivers' wages represent 30-40 percent of a long-distance hauler's operating costs. Trucks will no longer be bound by human limitations like hour limits. Eliminating these restrictions will result in more goods moved per day, making for faster deliveries to retailers and consumers. In 2012, 330,000 large trucks were involved in crashes that killed 4,000 people. Reduced accidents will lead to lower insurance costs and less damage to vehicles. One study published on the Quantum Run website, "Prediction-The Job-Eating, Economy-Boosting, Social Impact of Driverless Vehicles: Future of Transportation P5," estimates the savings from the reduction of vehicle crashes at more than $500 billion annually in the United States alone (Crandall).

Surprisingly, driverless trucks will use less fuel because of platooning. Platooning is where two or three trucks travel in tandem, one after the other, in closely spaced intervals. This configuration reduces drag like what happens when racecars line up behind each other while wheeling around NASCAR tracks. According to the National Renewable Energy Laboratory, platooning will result in up to 5 percent fuel savings for the lead truck and 10 percent for the trailing trucks. The lower fuel consumption also helps the environment by reducing carbon dioxide emissions (Crandall).

IV. Ethical Dilemmas

While there are many benefits to self-driving cars, there are ethical issues that must be addressed. Some of these issues are operational while some are more general social policy issues. On the operational side, manufacturers are creating crash algorithms to decide how the vehicle will balance competing safety issues for the occupants and third parties. For example, who will have better chances of survival in a crash? Should these decisions be left up to the owner, manufacturer, or legislation? Currently, these issues are being regulated on a state basis but there is increasing pressure for the federal government to make universal standards.

Allocating algorithm development responsibility necessarily implicates accident liability issues. Most people would probably agree that crash algorithms should favor the vehicle's passengers over other vehicles but not jeopardize innocent pedestrians who are simply in the wrong place at the wrong time. But when driver error and driver choice in an accident situation are eliminated, the question will remain, "Who is ultimately liable in a driverless crash?"

Many articles discuss the trolley problem to describe the ethical dilemma of driverless cars: imagine a trolley car out of control and 5 people are on the track ahead. They will die if you do nothing. Or you can flip a switch and divert the car to a different track where it will only kill one person. What should you do? Now imagine a pedestrian who suddenly steps off a curb, should an autonomous vehicle serve into another lane to avoid hitting the pedestrian? In a different variation of the trolley problem, the only way to stop the trolley is to push a bystander onto the tracks. People often answer that is alright to stop the trolley by pulling the lever but not to push the person in front of the tracks. This is called the doctrine of the double effect, meaning that deliberately inflicting harm is wrong, even if it leads to good. However, inflicting harm may be acceptable if it is not deliberate, but a consequence of doing good. The double effect logic is hard to program in a vehicle algorithm. The program must constantly change and predict what the outcome of change would be (Deng). Thus, it is remarkably hard to implement the will of the majority of people who want their cars to prioritize them but are not willing to deliberately harm other humans like a pedestrian on a sidewalk.

Noah J Goodall, a member of the Virginia Transportation Research Council, a partnership between the Virginia Department of Transportation and the University of Virginia, cautions against the overreliance of the trolley problem in designing vehicle algorithms. He claims that these trolley-type dilemmas have "clear consequences whereas in real driving there may be subtle choices, uncertain outcomes, and often an obviously superior course of action, for example, apply the brakes" (Goodall). The trolley problem should be considered for rare collisions.

A practical difficulty to engineers is even ensuring the vehicles recognize a hazard before deciding on a course of action. Raúl Rojas of the Free University of Berlin, who heads

AutoNOMOS labs, an autonomous vehicles research effort funded by the German government says, “One of the things AutoNOMOS cars have struggled with is someone walking behind a parked bus.” A human mind would expect them to reappear and be able to estimate when and where but for a driverless car, that is an inference too far. Being able to notice a bus is one thing but realizing that the bus is full of children is another (Ong).

Alan Winfield, a roboticist at the Bristol Robotics Laboratory, UK performed an experiment with 3 robots. Initially, there was one robot being the “human” (H-robot) and the other had to recognize danger and save the “human” (A-robot). They ran the test dozens of times and A-robot was able rescue H-robot every time. Next, he added another H-robot that was also in danger. The A-robot frequently saved the nearest H-robot and sometimes could save both. However, in almost half the trials, the A-robot faltered and let both H-robots perish (Deng). Engineers will need to establish more rules for self-driving cars to make decisions in crashes but these rules are a challenge when not all humans agree on the “right” choice.

The consequentialist perspective would favor saving the most lives even if the number of others were greater than the number of passengers. Deontologists would condemn the active sacrificing of the car’s passengers ("Self-Driving Cars: An Ethical Perspective"). Researchers have found that peoples’ results varied. An algorithm that told the car to kill one person to save 10 bystanders was popular, with 76 percent of 182 approving. But when the person killed was a passenger, the favorable response rate dropped by a third (Fikes). Most said they would not buy an autonomous vehicle if it were programmed to sacrifice its occupants (Brant). A Mercedes-Benz executive said all of Mercedes-Benz’s future Level 4 and Level 5 autonomous cars will prioritize saving the people they carry (Sarich).

It is impossible to anticipate all possible scenarios. However, Nick Bostrom, a philosopher at the University of Oxford and director of its Future of Humanity Institute, argues that people should accept that lives will be lost from autonomous vehicles, but the future fatalities will be far less that the amount of people that currently die every year from crashes. The important part is building a better system than we have now (Ong).

Insurance may shift from the driver to the manufacturer. One theory is to have liability be governed by the same principles as in other product liability (Luetge). Manufacturers will likely have to apply a "one-size-fits-all set of behaviors that may be inconsistent with those of the user." The driver would be liable for the decisions of the manufacturer but share no role in determining the ethical values of those decisions. In a poll by the Open Roboethics Initiative, 44 percent of respondents said the passengers in the vehicle should control how it responds in ethical situations. Moreover, passengers would feel more comfortable holding end liability. Yet, allowing the vehicle owners to determine the level of protection their vehicle's programming will apply based on whether the owners or passengers will accept financial responsibility presents elitist considerations beyond the ethical concerns.

California, District of Columbia, Florida, Michigan, Nevada, North Dakota, Tennessee, and Utah have passed legislation allowing autonomous driving. Florida, Michigan, and District of Columbia statutes contain language protecting the original manufacturers from liability for defects introduced on the aftermarket by a third party who converts a non-autonomous vehicle to an autonomous vehicle. Additionally, car manufacturers' liability will be limited if an accident or injury involves an autonomously operating vehicle when the car is equipped with aftermarket parts. Thus, the party who installed the technology is liable. California, Tennessee, Nevada, and North Dakota are silent on liability (Foster).

National legislation may be the best solution. Such uniformity may relieve the manufacturer and consumer from large lawsuits contingent on how their one car behaved (Belay). Currently automated driving is being handled on a state-to-state basis but it is necessary for the federal government to make superseding legislation because driverless vehicles will likely cross state lines. Federal laws will need to be enacted soon as there have already been incidents of autonomous vehicle crashes. In February 2016, a Google driverless car caused a fender-bender with a bus. In May 2016, Tesla's Autopilot mode became the first automated driving fatality in over 130 million miles. The National Highway Traffic Safety Administration (NHTSA) announced in March 2016 a $3.9 billion, 10-year commitment to developing automated driving safety. The NHTSA created an expanded Federal Automated Vehicles Policy, which serves as "guidelines" rather than rulemaking. This policy includes a 15-point safety assessment for design, development, testing, and deployment. The policy contains model state policies, clarified existing rules, and new rules and authorities that the NHTSA may consider seeking in the future (Riehl).

Another issue with autonomous cars is health implications. Vehicles will be easily accessible and may discourage healthier alternatives like biking or walking. This may also divert funding efforts to import mass transit. Further, increased driving will harm the environment with increased carbon dioxide levels (Fleetwood).

Cars have the added risk of hackers. There will need to be cybersecurity on vehicle-vehicle wireless networks. In 2015, hackers stopped a Jeep on a St. Louis highway by wirelessly accessing its braking and steering via the onboard entertainment system. Chrysler was forced to recall 1.4 million vehicles (Kulisch). This incident proved that vehicles are susceptible to hacking and that hacking can cause accidents. Terrorists may use hacking to harm large groups of people. Another risk is hackers disabling someone's car and holding it for ransom until a payment is made (Hamers). Hackers could steal personal information or determine a driver's location (Kulisch).

V. Glimpses of the Future

Despite the ethical issues, driverless vehicles are inevitable and there is evidence for the what the world will look like in the years to come. Just Eat is a company in the United Kingdom that receives takeout orders via an app and sends the food to the customer using a delivery droid (Johnson). John Deere has a plant in Horicon, Wisconsin that has a fully self-driving, autonomous robotic vehicle built by Clearpath that can transport up to 3,000 pounds of goods through congested plant and warehouse areas without the need for drivers, supervision, or guidance infrastructure. Rio Tinto created a fleet of autonomous vehicles that work in Australian mines. There are 50 trucks operating with an additional 150 ordered. The driverless trucks outperform its manned fleet by almost 12 percent. The Rotterdam Port in the Netherlands uses autonomous trucks to unload 10,000 containers a day from the megaships. Self-driving trucks are already being tested on the open highway. Nevada was one of the first states to grant a license for an autonomous commercial truck to operate on an open public highway (Crandall).

VI. Conclusion

Driverless cars are just around the corner. The benefits of self-driving cars are tremendous but there are issues that will need to be addressed. People should be aware of the issues surrounding autonomous vehicles and be involved in public policy. Legislature will need to form rules for crash-algorithms. Self-driving cars should follow a set standard of rules looking for the optimal survival route for its passengers.