Advocates and Critics of Autonomous Vehicles

An STS Research Paper
presented to the faculty of the
School of Engineering and Applied Science
University of Virginia

by

Niti Paudyal

May 5, 2016

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: ____

Approved: _______________________________________ Date _________________________
Peter Norton, Department of Engineering and Society

Introduction

Automated software systems operate with minimal or no human intervention. A common example is online language learning platforms such as Rosetta Stone that eliminate teachers by replicating their expertise through computer-assisted language learning. These substitutes can displace teachers and degrade the quality of education offered to students (Clardy, 2009). Yet automation of education has proven economical and the number of users engaged in it is growing. The trend has major social implications.

Automation has extended to the realm of automobiles: Tesla and Google (among others) are developing autonomous vehicles (AVs). Semi-autonomous vehicles are now in service. Levels of vehicle autonomy are defined by the National High Traffic and Safety Administration, from level 0 (no-automation) where the "driver is in complete and sole control," to level 4 (full self-driving automation) where "the vehicle is designed to preform all safety-critical driving functions and conditions for an entire trip" and drivers are "not expected to be available for control at anytime during the trip" (NHTSA, 2013). These companies seek to produce a completely autonomous car (level 4). This goal, however, is socially, legally, and economically disruptive. It implicates insurance and manufacturing companies and the job market for taxi and truck drivers, and raises problems of safety, privacy, and security of the artificial intelligence agent in AVs. AVs are therefore controversial. How can the disagreement between advocates and critics of autonomous vehicles be explained?

AVs will appear on public roads by the 2020's. Before AVs become common, however, they must overcome legal obstacles, which are major barriers to entry for level-4 autonomous cars. Advocates and critics disagree because they do not recognize the two-fold situation regarding reduction of risk and cost as participant groups have different interests and values.

Review of Research

Researchers have examined the inevitable disruptions AVs will bring without considering how participant groups collide while supporting their causes.

Haggemans and Thierer (2014) contend that ethical issues in high-stake situations will be worked out over time through a trial-and-error processes. Hagemann and Thierer (2014) and Fagnant and Kockelman (2013) acknowledge that AVs will disrupt labor markets.

While most AV advocates claim that AVs will eliminate human error in road accidents, and thus eliminate 90% of crashes, Schoettle and Sivak (2014) disagree, claiming that AVs may preform no better than an experienced human driver. They contend that during the transition period, when AVs and conventional cars coexist, safety might worsen. Fagnant and Kockelman (2013) claim that AVs would reduce private car ownership and thus improve environmental conditions. Schoettle and Sivak (2014), however, contend that people may spend more time in cars, negating AVs benefits.

Fagnant and Kockelman (2013) and Haggemans and Thierer (2014) contend that the responsibility for insurance and liability not yet unknown at this time and will be a matter of policy.

Policy, Ethics and Artificial Intelligence

Public perceptions of autonomous cars are mixed, and include unfavorable views (Schoettle & Sivak, 2014). The University of Michigan's Transportation Institute surveyed public opinion in the U.S., U.K., and Australia with a sample of 1,533 people, and concluded that 54 % were apprehensive about partially autonomous cars; 60% were apprehensive about fully autonomous cars. But autonomous systems in other modes of travel may raise expectations. Stephanie Brinley of HIS Automotive claims that autonomous trucks will likely resemble passenger airplanes at first, where the driver becomes “less of a driver and more of a decision maker,” and with time the public will ease into AVs.

However, experts disagree about how AVs should manage decisions in rare, high-stakes situations. Fagant and Kockelman (2014) raise such philosophical questions, such as how should AVs prioritize the safety of their own occupants relative to those of other vehicles or to pedestrians. This is commonly known as the Trolley Problem posed by philosopher Philippa Foot (Thomson, 1985). The introduction of AVs makes personal ethics a matter of public concern as those ethical issues will manifest in legal and policy choices.

Haggemans and Thierer (2014) contend that for “life-and-death” situations, there will be “thorny ethical questions” but that they will be worked out over time through trial and error. Representative Tom Petri (R-WI), chairman of the Subcommittee on Highways and Transit of the House Transportation and Infrastructure Committee, agrees, claiming that there are “many issues with driverless vehicles, and it’s impossible to anticipate all — or even most — of them,” and notes Congress should instead “maintain a flexible system that deals with real problems rather than anticipate problems that don’t exist yet” (Ali, 2014). Organizations such as Technology Liberation Front and the Competitive Enterprise Institute that espouse principles of limited government warn against the precautionary principle or the “natural fear of the unknown to translate into policies,” citing its consequences (Scribner, 2014 & Thierer, 2012). AV critics thrive on natural fear and pose a “serious threat to technological progression” as “hypothetical worst-case scenarios trump all other considerations” (Thierer, 2012). Both organizations argue that policy makers should maximize the potential for “permission less innovation”, the idea that experimentation with new technologies should generally be allowed by default, to permit ongoing experimentation to produce the best product, before public policy applies ethical standards.

The classic trolley problem can be adapted to AVs, as a utilitarian, consequentialist, deontological or duty-based problem. Bonnefon, Sharriff, and Rahwan (2015) conducted a survey through Amazon's Mechanical Turk, an online crowdsourcing tool, concluding participants were "generally comfortable with utilitarian AVs, programmed to minimize an accident's death tool." However, people were much more resistant to take the utilitarian course for the car to swerve and kill its owner when they were the driver. MIT *Technology Review* (2015) notes that if AVs are "programmed to sacrifice their owners, then more people are likely to die because ordinary cars are involved in so many more accidents" – thus a Catch-22 situation which could then affect consumer adoption. Which model will be adapted and who chooses? Will cars follow different rules or one standard? Will individuals who are used to making their own ethics judgment resist these standards? These questions remain unanswered but are critical to the development of artificial intelligent systems behind AVs.

All artificial intelligence (AI) driven systems face ethical questions. Similarly, movements against autonomous weapons has already begun, spearheaded by Apple's co-founder Steve Wozniak and Tesla's Elon Musk, with over 14,000 signatures (Autonomous Weapons, 2015). The open letter notes though AI has potential for good, it warns that autonomous machines are detached from their actions and thus their consequences. AVs face the same backlash, and a similar standard could be claimed. AI driven risk analysis lies at the core of the problem for critics. In traditional cars, humans are held responsible for decisions. Neuroscientist Antonio Damasio, and most theories claim human decisions are a mix of logic and emotions (Pontin, 2014). The question then becomes can AI replicate human emotions? Would emotions take away from the power of the AI? Alan Turing, the father of theoretical artificial intelligence, claims in his "polite convention" that if a machine behaves like a human, then it is as intelligent as the human being itself (Turing, 1950). AV advocates counter, claiming the use of computing power in AVs is in effect to do what humans cannot. Policy for AVs must answer a long debated question in the artificial intelligence community, to include or exclude emotions in AI.

Safety and Savings

Bob Joop Goos, Chairman of the International Organization of Road Accident Prevention, states human error accounts for 90% of road accidents (Abkowitz, 2014). AV advocates claim that AVs could prevent all such crashes. However, they fail to consider that AVs could introduce new risks, such as system failures, cyber attacks, and risk compensation or "the tendency of road users to make additional risks when they feel safer" (Litman, 2015).

A 2016 Morning Consult poll surveying about 2,000 people revealed that 43% of respondents thought AVs are not safe; only 32% believed they are safe (Johnson, 2016). The poll "hinted that people are unlikely to change their minds any time soon." Almost two-thirds reported they are unlikely to buy a AV car in the next 10 years. Consumers 30 and older are more resistant, citing fear in letting go of control. Manufacturers address the resistance with "semi autonomous" cars. However, such control raises concern for manufacturers. In fully autonomous cars, Google warns of "human element" risks (Shepardson, 2016). Google claims that providing human occupants "with mechanisms to control things like steering, acceleration, braking… could be detrimental to safety because the human occupants could attempt to override the (self-driving system's) decisions." Tesla Model S owner Bill Nelson claims he activated automatic steering because “as we approached the concrete wall, my instincts could not resist. I grabbed the wheel” (USA Today, 2016). Google fears risk compensation effects like this.

As a connected vehicle, AVs are prone to cyber attacks. Advocates fail to mention the safety risk associated with cyber attacks with AVs as they shift their focus to net savings for AVs. A reduction of 1,000 lives are savings but the details of those savings prove critical to the consumers. If AVs eliminate all current accidents but introduce new ones due to cyber attacks, even with net savings, critics may argue that the introduction of new types of incidents are not justified. To justify the tradeoff, a consequentialist may now require twice as many savings rather than a strict comparison on net savings (Lin, 2013). However, Lin argues that in a given year an “arbitrarily and unpredictably doomed to be victims” thus “there’s no issue with replacing some or most of them with a new set of unlucky victims.”

AV advocates contend they will be greener. The mission of SAFE’s (Securing America’s Future Energy) Autonomous Vehicle Task Force is to encourage the “widespread deployment” of AVs while serving the group’s interest in a cleaner environment. Fagnant and Kockelman (2013) claim that AVs will reduce vehicle ownership, while self-driving taxis would replace personal vehicles. However, Schoettle and Sivak (2014) contend that AVs would enhance the mobility of the blind, the disabled, underage children, and the elderly, increasing the overall travel per vehicle up to 75%. The environmental claims may be unrealistic (Litman, 2015). Though SAFE’s task force envisions AVs as a means to a cleaner environment, they may prove detrimental.

Productivity, fuel and across the board savings from AVs may be massive. Platooning, where trucks cut wind resistance is a component of autonomous trucks that can cut fuel costs by travelling in close processions (Kaye & Sterling, 2016). Costs savings in wages and fuel bills may be massive. The American Trucking Association (2015) reports the freight business alone is worth $700 billion in 2014. Gerald Waldron, managing director of Australian Road Research, says AVs provide "a huge benefit, and that's before you start looking at the impacts on road safety" citing AV testing estimates savings of 40 percent. Given these savings, pricing of AVs also does not seem to be an issue either as Morgan Stanley (2015) reports "full autonomous capability will add only about $10,000 to the cost of a car, at today's prices, which we expect will fall significantly by the time technology is ready to be commercialized." Morgan Stanley notes with negligible costs, AVs overall could contribute $1.3 trillion in savings for the US economy, and over $5.6 million globally. These savings translate to 8% of the US annual GDP where the reallocation of these savings may have major implications itself. The productivity gains are estimated to be $507 billion. The savings are hard to decipher, as consumers instead of driving may devote time to other activities such as sleep, phone calls, work, etc. The possibilities for consumers are endless. AVs bring across the board savings, however, it is unknown if those savings will implicate the all groups in economy positively.

Many of the safety and fuel or environment benefits are overstated as they neglect the potential for new risks or costs. AVs mitigate risks by eliminating human error but can introduce new ones. AVs may seem to decrease emissions of greenhouse gases as car ownership declines in favor of car sharing, but AVs may increase ridership with new passengers and increased mobility. AVs may yield net savings in lives but they may be prone to new incidents due to cyber attacks. The estimated savings AVs provide is massive but fail to recognize how those savings would translate in the economy.

Disruptions to Labor Markets

Driverless cars will cause major disruptions in labor markets as they may replace the 240,000 taxi drivers or 1.6 million truck drivers in the U.S., claims Fagnant of the Eno Center for Transportation (Pulmer 2013). As AVs replace humans, disruptions to job markets will bring scrutiny to them.

Hagemann and Thierer (2014) predict that AVs will have “similar disruptive impacts” on various industries that will result in “short-term economic perturbations and employment dislocations.” They draw parallels to computers for comparison, quoting Peter Singer: “For hundreds of years, there was a highly skilled profession of men who did mathematics for hire. They were well paid, many making the equivalent of $200,000 a year. They were called ‘calculators.’” Hagemann and Thierer (2014) claim just like computers, professions have been consistently reshaped by technology, and intelligent vehicles will follow suit. AVs may bring radical disruption or complete extinction to some professions, such as cabbies, truck drivers, and truckers, but as with all technological advances they occur incrementally. With the automation of dispatching and the luxury of using unlicensed drivers, conventional taxi drivers are already feeling disruptions through ride sharing applications like Uber, and Lyft. This disruption has caused organizations like the New York Taxi Workers Alliance (2015), a union for the 50,000 taxi drivers in NYC, cry out for driver unity against ride sharing apps like Uber noting this new paradigm is a situation in which only Uber profits, claiming that Uber threatens drivers as they are “rushing to bring out the first ‘Driverless Car’ so that they don’t have to ‘lose’ the fare to the driver.” The Taxi Alliance resists technological innovations that may disrupt their work.

Though changes such as ride sharing applications are incremental, Hagemann and Thierer (2014) cautions not to “discount the possibility that a new technology will kill off a large sector;

nor can we assume away the possibility that all industries will adapt to new advances in technology." However, they also argue that this disruption could create different types of jobs, where the traditional mechanic has to gain a few more skills now to fix an AV. Automation may reshape more jobs than it destroys.

NPR reports that in 2014 trucking, delivery, and tractor drivers were the most common jobs in 27 of the 50 US states (Bui, 2015). The International Brotherhood of Teamsters or Teamsters, an American labor union of freight drivers and warehouse workers, has the most to lose from driverless cars (Who Are The Teamsters?, 2015). Unions such as Teamsters and the American Trucking Associations claim that trucks will continue to need human operators, much like passenger airplanes (Davies, 2015). Teamsters' resistance can be explained as a defense of their members' livelihoods.

Truckers like Kevin Baxter, former Australian truck driver, continually downplay concerns stating "the whole time I've been trucking, the railways have been going to replace me, but that hasn't happened" (Kaye & Sterling, 2016). The trucking industry has seen shortages worldwide; the number of drivers is expected to stall while demand is forecasted to jump to 80% by 2031. The American Trucking Association aware of AV technology discounts the magnitude of the impact AV may have on truckers (Costello & Suarez, 2015). Truckers tenaciously compare the effect of AVs to the impact older transportation systems like railroads and air transport disregarding that AV technology does not introduce a competitor rather it reduces the human operator, the truckers themselves.

Though AVs may disrupt the labor market, even destroying some sectors, the impact of technological innovation is familiar and inevitable.

Insurance and Liability

AVs raise complex liability issues for insurance and manufacturing companies. In California and Nevada, where self-driving cars are legal, insurance companies want stricter regulations (Cohen, 2013). Current regulations from National Highway Traffic Association fail to outline which party will be responsible for incidents. Consumers, manufacturers, and insurance companies remain torn.

Fagnant and Kockelman (2014) of the Eno Center for Transportation claim that even with near-perfect autonomous driving, instances where crashes are unavoidable exists. In real-time decision making, human drivers are not held responsible "to circumstances beyond their control, regardless of whether their decision was the best" while AVs are equipped with sensors, and predictive algorithms that lead to more informed decisions. This raises problems of responsibility. Consumer Reports notes that it will be answered over time, and may depend on the situation (Monticello, 2016).

Insurance companies collect 157 million in auto premiums annually where 90% of accidents are caused by human error (Abkowitz, 2014). Will AVs eliminate auto insurance companies? AVs may cause "significant reduction in insurance premiums" according to RAND Corp, as the average auto insurance in the U.S. is $1,029 for sedans (AAA, 2015). While personal auto insurance liability will decrease, RAND predicts manufacturers liability will increase (Anderson et al., 2014). KPMG's insurance task force concludes that current safety technology for crash prevention already accounts for a 7-15% decline in claim frequency while insurance companies have yet to respond with new insurance policies (KPMG, 2015). Frank Diana of TCS Global Consulting predicts that AVS will bring massive reductions in accidents, commute time, and the overall the number of cars on the road creating a ripple effect disrupting established industries where such as 90% of insurance premiums could disappear (Diana, 2014). AVs result in lower claim volume with a $200 billion impact in personal and commercial auto insurance each year as of most of the claims are a direct function of the frequency and severity of accidents. With accidents curtailed by AVs, those premiums go away. Cutts (2014) claims that the "human element" to driving was the major monkey maker for automobile insurers and with AVs eliminating 90% of claims, AVs could see heavy resistance. However, liability could shift to manufacturers as they handle data of vehicle operation and can correct risks. This additional liability runs risk for manufacturers to bankruptcy should something fail, a clear indicator to resist AVs. Yeomans of Llyods (2014) notes that AVs could later draw parallels to product liability insurance where, unlike traditional cars, insurers are more concerned with the model of the car than the user. However, If AVs became more of a service than a good, liability would transfer to who ever owns the fleet. Many unknowns for insurance and liability remain but Cutts (2014) claims product laws for AVs will gradually evolve through a body of case law. The impact of liability, Cutts (2014) says, will depend on the situation, and information known to the AVs to the ethical model chosen will determine how it implicates the parties involved.

Conclusion

Autonomous Vehicles will be mainstream in the 2020's and many questions remain unresolved. Many of the issues are all ethical. It is not an issue particular to AVs but to all artificial intelligent systems which in the future will become norm. Policy regarding a universal standard of norms for the public will have to established, and AVs are the just the beginning of this process. Participant groups will continue to advance their causes with advocacy and litigation as more issues are brought into the judicial process, and more will rise as they foresee more disruptions cross industry sectors similar to other technological disruptions like internet provided.

References

AAA. (2015). Cost of Owning and Operating Vehicle in U.S. Increases Nearly Two Percent According to AAA's 2013 'Your Driving Costs' Study. www.newsroom.aaa.com

Abkowitz, A. (2014, September 10). Do Self-Driving Cars Spell Doom for Auto Insurers? Bloomberg. www.bloomberg.com

Ali, A. (2014, March 20). Government Hitting The Breaks On Driverless Cars. OZY.

American Trucking Association. (2015, May 11). Tracking Revenues $700 Billion for the First Time According to New Report. www.trucking.org

Autonomous Weapons: An Open Letter from AI & Robotics Researchers. (2015, July 28). Future of Life Institute. www.futureoflife.org

Bonnefon J. , Shariff, A. , Rahwan, I. (2015, October 13). Autonomous Vehicles Need Experimental Ethics: Are We Ready for Utilitarian Cars?

Bui, Q. (2015, February 5). The Most Common Job In Every State. NPR. www.npr.org

Bomey, N. (2016, March 15). Self-driving car leaders ask for national laws. USA Today. www.usatoday.com

Clardy, A. (2009, June). Distant, on-line education: Effects, principles and practices. Unpublished manuscript. ERIC.

Cohen, A. (2013, January 14). Will Self-Driving Cars Change the Rules of the Road? Time. www.ideas.time.com

Costello, B., & Suarez R. (2015, October). Truck Drive Shortage Analysis 2015. American Trucking Association. www.trucking.org

Cutts, J. (2014). Technology Trends to Watch: On the Road to Driverless Cars. Consumer Electronics Association.

Davies, A. (2015, May 15). World's First Self Driving Semi Truck Hits the Road. Wired. www.wired.com

Diana, F. (2014, Feb 5). Autonomous Vehicles: A Disruption Case Study.

Fagnant, D., & Kockelman, K. (2014, October 1). Preparing a Nation for Autonomous Vehicles Opportunities, Barriers and Policy Recommendations. Eno Center for Transportation. www.enotrans.org

Kaye, B., & Sterling, T. (2016, Jan 21). Safety, savings fuel push for driverless trucks. Reuters.

KPMG. (2015). Automobile insurance in the era of autonomous vehicles. www.kpmg.com

Lin, P. (2013, July 13). The Ethics of Saving Lives With Autonomous Cars is Far Murkier Than you Think. Wired. www.wired.com

Litman, T. (2015, 10 December). Autonomous Vehicle Implementation Predictions. Victoria Transport Policy Institute.

Monticello, M. (2016, March 31). The State of the Self-Driving Car. Consumer Reports.

Morgan Stanley. (2015, Jan 23). Autonomous Cars: The Future is Now. www.morganstanley.com

NHTSA. (2013, May 20). U.S. Department of Transportation Releases Policy on Automated Vehicle Development. www.nhtsa.gov

Johnson, F. (2016, Feb 8). Voters Aren't Ready for Driverless Cars. Morning Consult.

Pontin, J. (2015, 17 June). The Importance of Feelings. MIT *Technology Review.*

Pulmer, B. (2013, October 23). Here's what it would take for self-driving cars to catch on. Washington Post. www.washingtonpost.com

Schoettle, B., & Sivak, M. (2014). A Survey of Public Opinion About Autonomous and Self-Driving Vehicles in the U.S., the U.K., and Australia. *The University of Michigan Transportation Research Institute*.

Schoettle, B., & Sivak, M. (2015). Potential Impact of Self-Driving Vehicles on Household Vehicle Demand and Usage, Sustainable Worldwide Transportation Program. *The University of Michigan Transportation Research Institute*.

Scribner, M. (2014, April 23). Self-Driving Regulation: Pro-Market Policies Key to Automated Vehicle Innovation. Competitive Enterprise Institute.

Securing America's Future Energy. (2015, 14 October). "SAFE launches Autonomous Vehicle Task Force to Advance U.S. Economic and National Security." www.secureenergy.org

Shepardson D. (2016, Feb 10). In boost to self-driving cars, U.S. tells Google computers can qualify as drivers. Reuters.

The New York Taxi Workers Alliance (2015). Call for Driver Unity! http://www.nytwa.org

Thierer, A. (2012, Feb 4) The Precautionary Principle Meets Driverless Cars in DC. The Technology Liberation Front.

Thomson, J. (1985, May). The Trolley Problem. The Yale Law Journal, 94(2).

Turing, A. (1950). Computing Machinery and Intelligence. Mind.

Who Are The Teamsters? (2015). www.teamster.org/about

“Why Self-Driving Cars Must Be Programmed to Kill” (2015, Oct 22). MIT *Technology Review*

Yeomans, G. (2014). Autonomous Vehicles: Handing Over Control: Opportunities And Risk For Insurance. Llyod’s Exposure Management.