Smarter Cities: Transportation

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CS 487

Smart Cities

Most of the world's population resides in urban areas that will keep growing and growing. As more people are born, the more people that will want to move to the most populated and advanced places such as cities. These cities are high density areas that are significantly more efficient in energy consumption, resource, and more compared to other less populated counterparts. Smart cities essentially connect the physical, information technology (IT), social and business infrastructure to overall make a better and more efficient city. These are the most important things to look at for environmental sustainability and longevity of the city.

Smart cities have 3 dimensions, technology, humans and institutional. A city needs to have advanced enough technology for it to function and be as efficient as possible. Not only does it need technology, it also needs to be able to maintain and innovate new technologies. As such, the city's people also need to be creative and knowledgeable for the city to keep growing and advancing (Nam & Pardo, 2011). With this, the education and the city's treatment of its citizens need to be a higher priority. The more options one has and the happier they are, the more they can contribute to society and the city. Then, the institution, government and overall community needs to work together to help the city become "smarter" (Harrison et al., 2010). There are many automated systems or technology that helps make a city to be smart. This paper will be focusing on smart transportation and the possibility of autonomous vehicles and a driverless city.

Smart Transportation

Currently, there are many automated systems in smart cities with regards to smart transportation. One that is most known are how easy it is to use public transportation. Either you pay with cash or coins, or you use a card or phone to pay. You simply deposit money or authorize the system to make a payment in your behalf. Public transportation is now easier to pay and manage. Another simple automated system that might not be on your mind are traffic lights and speed/traffic cameras. They are very well automated as they manage the traffic and automatically captures any vehicles that aren't following the rules. These automated transportation systems increase the traffic safety in the city.

Recently, there have been a rise of "automated" vehicles roaming around the streets, and the question is its impact and how it will continue to grow. Initially, one might say there is no downsides for automated vehicles. However, there are when you look closely and in addition to that, the process of making and integrating automated vehicles in the city can be hard. There's also the risks and ethics of automated vehicles and in the far future, driverless city. This paper aims to talk about the software engineering approaches of forms of smart transportation from data collection, artificial intelligence (AI), and computer to computer interaction (CCI) and human to computer interaction (HCI) as well as all the risk management.

It is estimated that 4/10 of vehicles will be autonomous by 2040 and Australia, Rio Tino is already using driverless trucks and is set to make 30% of trucks autonomous by 2019 (Porter, 2018). While this seems promising, the challenges are the technology and societal structure and thus, the feasibility of this coming into fruition without any hiccups. The safety and efficiency is the number one priority and at the current moment, the safety and costs of autonomous vehicles are one thing that needs to be researched and discussed. The ethics and possible push back from society is one that delays the transition from manual to autonomous vehicles. (Hancock et al., 2019). An example of ethics of autonomous vehicles is the trolley problem. Should a car swerve and kill one pedestrian or instead crash

and kill its passengers. Does the age, and number of pedestrians or passengers killed matters? Does the occupation and identity of the people matter? Should an autonomous vehicle even make these kinds of decisions? Most importantly, are autonomous vehicles safer than humans driving, at least in this current time. These myriads of issues sway the acceptance of the implementation of a high-level smart transportation such as automated vehicles and a possible driverless city. Maybe, it's too soon to come into a conclusion about these kinds of things, but the sooner we start and discuss, the faster it can come into fruition.

The transition to smarter transportation and automated vehicles is coming, the question is how and what can we do to support and make sure it doesn't fail and result in a more dangerous city. Rather than higher ups or the government solely taking charge, it's society as a whole that should determine whether the push for automated vehicles will happen in the near or far future.

Software

In terms of software in autonomous vehicles, there are three major things to look at, data collection, algorithms, and HCI. There needs to be many advanced sensors in car for it to be autonomous. Radar, lidar, and cameras detects cars and moving objects and also lanes and motionless objects. Ultrasonic sensors can also be used to detect nearby cars, and is especially useful when changing lanes. Satellite imagery is also being used to identify the road being driven as well as traffic and possible issues. The data collection with these sensors is vital in making sure the autonomous vehicle is safe and does what its supposed to do (Ingle & Phute, 2016). Algorithms also need to be verified and not biased as the system is directly in control of human lives with such a vehicle. Algorithms include using the data collected and detecting cars, people, movement, lanes, as well as path finding. It must also somehow make a choice, similar to the trolley problem if it happens to encounter a similar situation. I will talk about the ethics of that situation in another section. One of the major algorithms are object detection/tracking as well as localization. The car must be able to detect objects and humans as well as the location, speed, and direction. Localization is the ability to pinpoint the vehicle's location in a map. This involves taking satellite imagery, GPS, and cameras to extract features like landmarks and roads. This way, the system fully understands its surroundings and sense of the road, lanes and structures.

There are various levels of automation in cars, from level one to level five. Level five is essentially full automation and the car takes full control of all driving tasks under all driving conditions. However, most current autonomous vehicles today are level one, which requires driver assistance, and level two which is partial automation. Some vehicles are level three in which there is conditional automation. Level one is just helpful systems in car that still requires human interaction, such as the speed limiter, which allows the car to drive at a specific speed automatically and all the driver has to do is control the steering wheel. An example of level two automation is automated parking and such. Level three is when an autonomous car can drive on a specific highway or condition. Most systems only handles driving tasks under limited driving conditions and expects the driver to always be aware if need be (Lin et al, 2018). For example, an autonomous vehicle can only drive on highways that it has on the database and requires the human driver to have their hands on the steering wheel. In that case, HCI communication is key and very important and critical for the safety of the driver and everyone in the road.

Aside from sensors and humans communication with the system, there's a possibility that other cars may also. In the case where each nearby cars are communicating with each other, then the result is

a more cohesive and unified traffic which results in higher safety overall more efficiency (Furda & Vlacic, 2009). Other systems may also be communicating with the autonomous cars such as traffic signals, emergency services, and such. Doing so will require more testing and verification, but if all these systems work in harmony, then the better autonomous vehicles will be and the more possible a driverless city can be.

Risk Management

Autonomous vehicles have many benefits but it also has many challenges and risks. One of the ways to combat the challenges is to introduce a more hands on HCI and make sure the awareness of its human partner is always at a high point. In a perfect world, autonomous vehicles can handle all sorts of situations and conditions. However, there will always be crashes and conditions that the system may not be able to handle. It is the humans job to take control at that moment, and hopefully the human was aware and does the appropriate action. With this in mind, its very hard to test and make sure the system of the autonomous vehicle is safe and can handle any situation. Testing and experimenting will be very expensive and possibly result in more expensive cars. This can make it hard to make the car available to most people. So, there's a tradeoff between really expensive autonomous vehicles with high autonomous functions and not so expensive vehicles but more required human to computer interaction. Not only that, this is a fairly recent field and there's not much research done on it, so there is large costs to be had for research.

There's also the litigation and liability of autonomous vehicles. Security is an important part in a system that can possibly harm a human's life. The ability to hack or disrupt the system should be top priority as it not only endangers the passengers but also endangers everyone in the vicinity. Also, there will always be crashes and situations where there is not always a "correct" answer. Should an autonomous vehicle value itself more than an animal or person? What dictates the decision that it makes and how should we handle the result of such actions? If an accident occurs and it goes to court, then the algorithms, sensors, and the decisions the vehicle made will be put in to question (Fagnant et al, 2015). These will be a major part of risk management in autonomous vehicles. These situations and ethics will be discussed more in later sections. With all these problems and risks, the designs and system should be as complete and verified as much as possible to minimize the extra costs that may come from testing or the future.

Real Life Examples

An example of such systems, autonomous vehicles, is already out in the world. Tesla is one of the most popular "autonomous" vehicles and is the majority out in the road currently. They use radar, camera and ultrasonic sensors to detect cars, moving objects, and humans. They also have object detection/tracking and localization using satellite imagery, GPS, and all of its sensors. Current and future traffic is also calculated and detected based on prior knowledge or from its sensors. Tesla cars also include automatic steering, lane changes, emergency steering, side collision warning and auto parking (Ingle & Phute, 2016). However, drivers must keep their hands on the steering wheel always. This way the driver is always aware in case the care comes across a condition that they need a human partner to take over. Tesla's autonomous can be viewed as a level three, which is conditional automation. They are only able to autonomously drive in some highways and cities that is dependent on how much data they have on the road and location. They also require a high amount of human awareness. This requirement

of human awareness and interaction is needed for safety however, can you actually call this vehicle autonomous with such requirements?

Another example are delivery drones, specifically autonomous drones that are being used for last mile delivery of small and light items. These drones are prevalent in delivery companies such as Amazon, Google, DHL, and UPS as well as the healthcare industry (Scott & Scott, 2017). In healthcare specifically, delivery drones are used for blood medication, vaccines, and defibrillator deliveries. This greatly reduces freight traffic and car traffic. Rather than huge trucks going around and stopping by to individual locations, it has drones doing that. However, due to the costs and limitations of drones, only small and light items are currently supported. In the future, delivery drones will be essential and have a massive impact on energy consumption, safety, privacy, and pollution (Therese Jones, 2017). It will be much more efficient and more environmentally friendly than trucks and cars for deliveries.

Ethics

Systems will always have some consequences, no less, automated systems. The ethics of autonomous vehicles is a never ending one and one that needs to be addressed. There's laws and a process for when a human driver makes a mistake, how about for an autonomous vehicle? Human drivers may be forgiven for making a bad split-second decision but that's not the case for an autonomous car. The people to blame is much harder to determine. Would the programmers or the company face the consequences of the cars actions that society deems to be illegal and jail worthy. It then becomes a question of where is the line drawn on the actions of inanimate objects. Should a car be able to make a decision to end a human life. If it doesn't, then when it is faced with that decision then what actions will it take. This can possibly lessen the safety benefit of an autonomous vehicle, since it will require more human interaction. Imagine a child running in front of an autonomous vehicle and it can't do anything, so it allows the human driver to take action. However, with such an instant switch to autonomous to human, the human driver now must make a decision in less time than it would have with a manual car. People should be researching and talking about the ethics and morality of autonomous vehicles.

There's also the problem of privacy and ways to make sure an autonomous vehicle is making the "correct decisions". With these smart cars, everything is being recorded from normal driving to crashes. The metadata can include routes, destinations, speed, etc. and some people may not want that to be available and be able to be used against them in court (Bonnefon et al, 2016). That data can be used correctly but it can also be misused by people or even the government. At the same time, having this data be publicly available will result in more efficient transportation systems and products. Also, when an autonomous vehicle crashes, how should it be handled. The actions, results, and the algorithm should be evaluated that it is "correct" by society's standards. Thus, both programmers and ethic researchers should review the algorithm and how the car was designed to make sure it is designed "correctly".

Morals are subjective and differs from people to people. Discussing the morality of algorithms in autonomous vehicles will probably never end and reach a consensus. The only real end is if the result far outweighs the bad. As long as autonomous vehicles are deemed to be safer than human drivers and are more efficient and better for the environment, then the ethics should not be a major roadblock. Nevertheless, the ethics debate of autonomous vehicles will probably never end. However as more and

more debate is done, the closer it is for society to reach a consensus of our morality and how we should view and process these new types of technology.

Future

Technology is advancing fast and autonomous vehicles are already roaming around the streets. Thus, there is no doubt that there would be more and more electric and autonomous vehicles. In 10 years, most car companies will have a significant portion of their products be an autonomous vehicle at some level. 50 years and beyond, the concept of driverless city and cars communicating with one another to make a highly safe transportation system can possibly be a reality. In the far future, all vehicles of some kind, such as drones, will be made autonomous. Laws will be made to encourage and require the use of autonomous vehicles for safety and efficiency. Human interaction will be rarely needed for vehicles as they are far more dangerous than the automated system. Autonomous vehicles are coming whether people like it or not. The question is how fast and how will society adapt to welcome the new age of smart transportation.

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