CS5020 Report

Matriculation number: 170015148

Chosen chapter/technology:
I decided to present a rough guide of driverless cars in a set of webpages. Because the notion of driverless cars appears much more often than before and it is related with many different fields, such as transportation, urban design and future internet. A website is chosen because there are the most number of users who use a web browser to look up the information, compared with other technologies.

The local version of the rough guide can be found in the folder. The online version can be accessed by the URL ***https://sky6842.github.io./***. It is recommended to use Google Chrome to access the website. Because the website is not tested on other web browsers.

Specification:
The completed work for this practical can categorized into two types:

1. Develop the a set of web pages and use different types of medias for the exhibition
2. Research and present the notion of driverless cars

Each type of work will be discussed in detail.

- **Development of the platform**

There are a number of ways to develop a website, such as using a web editor to purely design a website such as wordpress, or to write HTML to define the structure of a website and CSS to define the design of a website and JavaScript to specify the interaction of the website. One of my key decisions made here is to use a combination of technologies HTML/CSS/JavaScript to develop my website for the exhibition. The reasons are that I have complete control on how the website looks and it would be convenient to add up any feature to the website if needed. In addition, the web is very closely related to the network, and HTML/CSS/JS are the essential technologies of the web, it would be valuable to learn these technologies by practising.

Files are organized into different folders. They are:

- Css folder saves all the css files
- Images folder saves all the images displayed on the website(including the icons). The icons and logo are designed using the app Inkscape and Gimp.

- Js folder saves all the javascript files, most of them are library or open-source code such as JQuery. Only html5.js(To access HTML5 function) and script.js are manually written.
- Videos folder stores all 6 videos displayed on the Video section of the website. All the videos are a few minutes long and downloaded from Youtube.

Also all the HTML files are in the parent folder.

The website mainly consisted of 4 web pages, they are index.html, News.html, Papers.html and Videos.html.

Index.html

This is the main page of the website. There are some basic guides shown for navigating the website. The chapter is split into 4 parts, they are:

1. State of the Art - By clicking the 'Read' link the browser will direct to the content of explaining the current state of the art of driverless cars(In a new HTML page).
2. Opportunity - Directs to the HTML page that identifies the likely future direction and what opportunities will be provided for innovation.
3. Benefits - Directs to the HTML page describes the potential benefits of driverless cars and how these benefits can be realised.
4. Risks - Directs to the HTML page describes the potential risks of driverless cars and how these risks can be mitigated.

As I considered each section of the chapter to be independent, therefore there is no link between these chapter pages. But users can easily go back to the main page by pressing the home icon and navigate to the page they want.

I have designed a picture slider(It can automatically slide) on the main page, it consists of 4 different images that are related to driverless cars. These images are found online, the references can be found at the end of the report. The images aimed to be informative. Each image shows a different aspect of the notion of driverless cars.
Images:

1. The first image is aiming to give users some understanding on approximately how much data an autonomous car requires to operate. The equation can give the users a simple concept of the data usage of a driverless car, instead of a list of statistics.
2. The second image is to inform users that, in the development of driverless cars is more than just manual and automatic. A fully autonomous vehicle would be developed along with the stages, each stage would increase some automation to the vehicle.

3. The third one is more a simplified visualisation of the design of a driverless car. It only describes each component in simple terms, therefore it would be easier for users to remember than description in pure text.
4. The last one represents a social problem rather than an engineering problem. It shows the trust on safety of driverless cars in different age groups. The trend is that the younger generation shows better trust on driverless vehicles. The likely reason could be that the younger group of generation has more exposure to different types of technology. However, the data also show there are more people who do not trust driverless cars no matter which age group they are in. This implies a problem that autonomous vehicles are facing, lack of public trust.

There are also some quotes from the famous people displayed on the main page of the website to give them an idea how other groups of people view driverless cars and it also enhances the users' engagement.

News.html / Papers.html

These two pages have almost the same design. I have put some useful articles/news I have read during research into the news page. Each article/news has a date that shows its publish time. Every article in News.html is fresh, all of them are published the second half of 2020. There it means those articles could give the most recent information to interested users, and it will be valuable for them to understand the current development/market to make any decision. In Paper's section, the sources are more formal and traditional. They are the academic papers I found useful to produce my chapter and to understand the notion of driverless cars.

Videos.html

The last HTML file here is to show multiple short videos to users. As the videos are stored locally, the users can play it directly on the website. But it also links to the original address. These short videos can give users the understanding of different aspects of driverless cars in a more visual and auditory way.

The links in News.html/Papers.html/Videos.html can allow the users to explore more of driverless cars.

- **Exhibition content**

The content of the website has been categorized into 4: state-of-the-art, opportunities for innovation, benefits and risks. A summary would be provided for each of them and I will explain my vision for how driverless cars will move forward at the end of the section.

1. State-of-the-Art

Driverless cars also have other similar names, such as autonomous vehicles, self-driving cars. They have the same goal, allowing vehicles to be controlled by computers instead of humans.

There are a number of technologies to achieve self-driving cars, this includes sensors, which can collect the information from the vehicle's environment , computers that can process the sensory data and send warning/control signals and actuators that are doing lateral and longitudinal control.

Vehicle-to-Vehicle(V2V) and Vehicle-to-Infrastructure(V2I) are the essential parts of a driverless system. V2V allows vehicles to share the data to each other for route-planning and spot the blind spots of a vehicle. V2I allows the vehicles to communicate with road infrastructure to increase the safety of vehicle's systems

The current available sensors and AI algorithms cannot fully understand a vehicle's surrounding. There are still improvements that need to be made on both hardware and software to achieve driverless cars, Such as the accuracy of sensors and complexity of relevant algorithms.

In the current state-of-the-art of driverless systems, there are 3 types of systems used for driverless systems.

1. Ego-only systems - Most common system design at the moment, all the necessary driving operations are carried on each single self-sufficient vehicle at all times. It is easier to develop a self-sufficient system than a connected system therefore more practical, but it may have other issues like it can never spot the blind spots of its camera.
2. Modular Systems - It consists of separate components linking the sensory inputs to actuator outputs. It allows a complex problem to break down into a set of easier problems, but it is being prone to error propagation.
3. End-to-End systems - This design has 3 common approaches, they are direct supervised deep learning, Neuroevolution, Deep reinforcement learning. Supervised learning is a more practical way at the moment, but its generalization performance is poor. Both Neuroevolution and Deep reinforcement learning offer better generalization performance but they need to interact online to learn the driving behaviour, so cost could be high.

Localization is another crucial part of a self-driving system. It allows the vehicle to find ego-position relative to a reference frame in an environment. 3 common types of localization

- Global Positioning System and Inertial Measurement Unit(GPS-IMU) - IMU part would measure the changes in position and orientation, and the information is used for localizing the vehicle with dead reckoning.
- Simultaneous localization and mapping(SLAM) - It makes an online map and localizes the car in the map simultaneously. It can be used in anywhere as it does not require priori information of a map.
- A priori map-based localization - The main method used for the localization task currently. The idea is to compare a pre-built map to the online reading to find the best possible locations.

2. Opportunities for innovation

V2X development is likely to happen to achieve a mature driverless system. There are two ways suggested to be the core technologies of V2X. They are the wireless based network(DSRC) and cellular network(usually referred as 5G). Cellular network is used by more recent V2X development as it offers much faster transmitting speed and lower latency. But DSRC has been tested and vetted for more than a decade, so we may be more confident with DSRC.

There are number of opportunities provided, they are:
Urban planning - To get the full benefit of connected and automated vehicles, the environment of vehicles has to be updated correspondingly. It will give the opportunity to redesign the infrastructure of the city. The new infrastructure should be able carry and share data about events, such as crashes, traffic jams and more.
Cyber security - V2X means that there would be much more data transmitted over the network and quality of the data could be private and crucial. New innovations in cyber security are expected before V2X is fully achieved. This means that there will be more people working in cyber security and more new cyber security technologies to be innovated in future.

3. Benefits

The potential benefits of driverless cars including:

- Safer roads - Statistics from many sources showed that traffic accidents caused by human errors. The computers have the potential to eliminate all driver errors. Rigorous and formal test and verification methods, appropriate regulations and appropriate infrastructures are needed to achieve such benefit.
- Emission reduction - If every And if every driverless car in a city can share the real-time data and find their way to destination in the shortest/safest way then it would reduce the total amount of emissions by a large margin. This requires that the algorithm find the route is efficient and the data sharing strategy needs to be reliable and fast.

- Accessibility - Driverless cars allow people who are currently unable to drive and therefore struggle to get around easily. The system designer in both hardware and software need to always keep different types of users in mind, such as elders and disables.

4. Risks

The potential risks of driverless cars including:

- Unemployment - The revolution means that there would be some job lost and some new jobs would be created. The people whose job is driving-centric would be adversely affected. Hence it is important to provide the opportunities for them to transfer their skill set to mitigate the adverse effects.
- Cyber crime - Any digital device connected to the internet is vulnerable to hacking. If an attacker can get into the system, the vehicles may be completely controlled by the attacker and put passengers in danger. the cars would also face the theft of private data and the threat of computer virus. System designers need to think carefully on the encryption/decryption of all types of vehicles' communication. It is also useful to add a secure authentication layer, to ensure data is coming from trusted sources.

Vision:

Driverless cars involve many different types of technologies to work expectedly. This includes automatic brake systems, lane-changing systems, use of cameras and sensors for collision avoidance, artificial intelligence to analyze information in real-time, and high performance computing and deep learning systems to adapt to new circumstances. Those technologies are expected to increase its efficiency and reduce its complexity to create a mature driverless system.

autonomous vehicles are expected to be partially autonomous first, and then become fully autonomous in a more distant future. At that time, the appropriate regulations are expected in place to ensure safety of vehicles. In the meantime of developing driverless cars, organisations and governments should provide more evidence of safety to gain more public trust.

Autonomous driving will increasingly demand more and more reliable network-based structures, requiring redundant, real-time architectures. These architectures will organize high performance clusters in functional domains and be connected via a central gateway in a high-speed data backbone structure. Group sensors and actuators will be organized hierarchically.

Driverless cars will have incredibly sophisticated systems, including high performance computers and an increasing number of advanced driver assistance system (ADAS) sensors, such as high-resolution stereo and/or mono cameras, RADAR, and LIDAR.

Vast amounts of data will be generated from these systems, which will require sophisticated electronic support, including high-speed data nodes, links, cables, and assemblies. The inside of the driverless car would be like an information highway, and data streams will run in parallel to increase the transmitting speed. They'll be managed in switched networks with sufficient margin to ensure the operations of vehicles are safe.

TE Connectivity (TE) can provide gigabit-speed networks. It can help automotive leaders to achieve their goals, by providing connectivity solutions that overcome electrical, software protocol and interface compatibility challenges.

V2X communications must continuously collect and understand complete data concerning the surrounding environment. Fully autonomous vehicles require all of this information to correctly execute actions such as braking or changing lanes without assistance.

Both sensor technology and radio-based communication would be used for V2X communications. Car sensors can support vehicle systems interact with their environment. Radio systems enable vehicles to exchange information with other peers and with traffic infrastructure such as lights, signs and tolls. These surroundings actively communicate their state and changing conditions around them to the vehicle. Thus, a light communicates that it is about to change from red to green, a sign indicates that the next turn-off is five miles ahead, and a vehicle a lane over communicates that it is about to signal and turn right. All of these signals make driving safer. Information on driving conditions, such as icy roads ahead, traffic slowdowns, can also enable vehicles to interpret data and make correct decisions

Fully autonomous cars can make decisions instantly. To be safe, fully autonomous driving requires real-time data transmission. Current cellular radio standards such as LTE(4G) have a latency of around 40 milliseconds, which is too slow to be safe for driverless vehicles. 5G mobile communication will provide higher data rates of up to 10

Gbps with considerably lower latency than LTE, making it suitable for real-time safety applications.

References:

Videos:

1 https://www.youtube.com/watch?v=B8R148hFxPw
2 https://www.youtube.com/watch?v=ixIoDYVfKA0&t=25s
3 https://www.youtube.com/watch?v=gEy91PGGLR0
4 https://www.youtube.com/watch?v=G2OU_lzsMdE
5 https://www.youtube.com/watch?v=JC94Y063x58
6 https://www.youtube.com/watch?v=L_YLu7Zb5F8

Papers and articles:

1. https://www.researchgate.net/publication/336579045_State-of-the-Art_Self_Driving_Cars_Comprehensive_Review
2. https://www.researchgate.net/publication/278661090_Autonomous_Driving_Context_and_State-of-the-Art
3. https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/19732/State-of-the-Art-Autonomous-Driving-Technology-as-2019-Comes-to-a-Close.aspx
4. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/401562/pathway-driverless-cars-summary.pdf
5. https://search.proquest.com/openview/a805bcd7922a5dfbbef1f53561606eaf/1?pq-origsite=gscholar&cbl=42116
6. https://search.proquest.com/openview/363b5a1667c50757217edaa2f3eba006/1?pq-origsite=gscholar&cbl=47271

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