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Ambient Technology in Vehicles: The Risks and Benefits

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Abstract

This paper is aimed towards studying, compiling, and analyzing the recent advances and risks of the current ambient technology that is present in modern day cars. The progression of sophisticated technologies inside cars make them an even more comfortable and entertaining place to be in especially during commutes to work, but recent security threats and distractions have been uncovered with the upsurge usage of new technologies. The future of car's interfaces is an issue since driverless cars are taking the scene by storm. This study also includes a survey that senses the people's use of car technologies when driving.

Keywords: *Ambient Intelligence, Car Interface, Voice Recognition, Driving Distractions, Vehicle Cyber Security, Internet of Things.*

1. Introduction

Since the introduction of automatic air-conditioning in cars in 1954 when the Nash Ambassador rolled out of the manufacturing line [1], automated car systems have been on the rise to cope up with the various demands that the consumer fancies. After all automated air conditioning saves the consumer the hassle of raising and lowering the air conditioning fan when he feels hot or cold. That is what the idea of ambient intelligence is all about, making a connection between machine and mankind, where the machine understands the person's need with minimum effort required from the user.

Nowadays, voice recognition features in cars are widely available especially in the high-end ones, but only a handful of the models produced are efficient enough to entice users into relying on them. Imagine if the user did not have to actually tell the system what to do as in the voice recognition system, but the system knows what the user wants through other means. For example, if you are stuck during rush hour in a traffic jam and you are really agitated, the car's system should sense that and turn on soothing music to calm you down (or whatever calms you down.) Another example, is that if a person is experiencing a stroke, the car should also detect that and self-drive to the nearest hospital or call the emergency line. Vehicles are our main mean of transportation and if we can make it a more intelligent vessel, it will greatly serve us in the future.

Car companies have tried to solve the voice recognition problem in multiple approaches, but they are still not able to reach the point where the system knows what the user means. However, there is an increasing trend towards using online cloud voice analyzer instead of the embedded chips that are currently used [2]. Online voice recognition systems have the advantage of being more sophisticated and efficient, but they still require internet connection and are a bit slower than their onboard counterparts. Both methods of voice recognition (onboard and online) are being researched by various companies and they seem to encounter the same problem of filtering out the background noise that cars are mostly known for, such as the AC fan and outside street noise. Street background noise is especially tricky thing to deal with since the car window can let in or out noises that may interfere with the noise filter.

Other than that, there have been advances in ambient intelligence when it comes to aiding the people drive better and avoid collisions. That is a subject that we will lightly touch on, but not in detail due to its connection with the outside environment rather than the inside of the car.

The nature of the car's interface is also changing; touch screens and displays are getting bigger and more numerous. Good examples would be the Tesla S or the Volvo XC90 of 2016. This is all is no secret, but what we are interested in is that in an era where even the speedometer is displayed on a screen rather than gauge needles, new information can be shown to the driver just by moving eyeballs instead of the whole head. There are still lots of unexplored functions that could be implemented with this advancement. Integrating your smartphone with your car's computer interface is also an increasing trend that is snowballing. This is allowing drivers to carry on their personal material and include it even more in

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their journey to provide a feel at home type of sensation. However, this boon is not without its own dangers.

The security of cars these days is becoming a hot topic since they are becoming increasingly interconnected with everything. Many vulnerabilities have been exposed and are utterly dangerous if not life threatening. Gaining access to the car's driving system is a danger that could be noted as soon as the driver loses control, but what about stealthily gaining access to the car microphone without the user's permissions? This is a hidden security breach that many people overlook.

Section 2 will briefly touch on the ambient intelligence milestones that we have reached until now. Section 3 will analyze and discuss the voice recognition issue in modern day car systems and its potential position when it comes to ambient intelligence. Section 4 will examine a questionnaire that we conducted to examine how prevalent certain voice operated technologies are used in our society. Section 5 will talk about car interfaces that are changing and keep changing with newer technologies emerging. Section 6 is all about the security/privacy issues that we are facing and we will likely to face in the near future. While section 7 will briefly talk about the changing state of the car's interface especially with the emergence of autonomous cars. Finally, section 8 will close this study with a conclusion.

2. Ambient Technology in Cars Through Time

The invention of automatic gear transmission was patented as early as 1923 by the Canadian inventor Alfred Munro [3]. This invention makes the car recognize when the gear needs to be shifted and did it by itself, by doing so it eliminated the need for the driver to have both hands busy with driving, making the other hand free. The car recognized the driver's need and makes the correct decision, which is the essence of ambient intelligence.

Moving on forward in time, as mentioned above the automated air-conditioning system also made a significant contribution when it comes to giving the car more power of pleasing the driver as well as the passengers. Small inclusions to ambient car intelligence have also been added. Good examples would be: the lowering of rear sunshades when the gear is on reverse, self-tightening seat belts when first strapping it, and many others. Those were developed around the beginning of the 21st century. After the first decade of the 21st century the cars ambient intelligence has been on a rapid rise [4]. This is due to the massive immersion of computers into the vehicle industry, not only that but a competition of who is more tech-savvy between the different car companies began to act as a catalyst for even more innovation.

Now driving is also enhanced and aided by computers and cameras. Systems such as the Distronic Plus and Infiniti's auto drive mode can drive by themselves staying inside the lane and maintaining a distance between the cars in front of them. Moreover, Infiniti has developed a system called Predictive Forward Collision Warning that detects the speed of the car that is in front, but also the car that is ahead of it [5].

Those are all great advances that make the driver experience much safer and easier, but our focus in this paper is about what the driver gets while he is inside the car that is not directly linked to the road. Voice recognition is a big issue at the moment and it is still evolving. The next section will talk about voice recognition in car systems and will also have some statistics based on a questionnaire performed in a non-English speaking nation.

3. Voice Recognition in car systems

Voice recognition in cars is indeed a hot topic these days since voice commands in cars are becoming prevalent yet rarely used since most are not natural language systems and the user has to go through the voice commands and memorize the steps/commands in order for it to function in an efficient manner. As J.D. Power announced during their recent conference on voice recognition systems in cars "Any way you slice it, that's a failing grade," [6]. Conversely they also highlighted that it is not easy to develop a car friendly voice recognition system for cars: "The environment of a vehicle is brutal," [6].

Things such as the engine noise and street clamor (especially when the windows are open) are hectic things that have to be filtered and diagnosed. Not to mention the state that the driver has to be always on alert and driving itself can be strenuous at times particularity if the journey is filled with traffic. Filtering the noise has been subject to numerous research [7][8] and is improving at an increasingly steady rate. The use of the current voice recognition systems nowadays is reported to be unsafe by several sources, including the American Automobile Association [9][10]. However, there are also other sources who take the opposite view regarding the matter of safety of the car recognition system [11].

Another change in the voice recognition domain is that car companies are trying to shift from normal voice recognition systems to natural language systems [12]. A parallel idea that is slowly gaining popularity is to integrate smartphones even further by involving them in the cars interface. This idea got materialized in Apples CarPlay and Googles Android Auto applications [13][14]. While Apple has the famed Siri natural voice recognition system, Android is lagging behind with its Google Now when it comes to popularity. This is mainly due to Android's flexible nature, because of its flexibility each company would install their own voice recognition system in the phone's firmware. A good example would be Samsung's S Voice.

That is why we have conducted a questionnaire to sense the extent in which the public use voice recognition systems and other uses of car technologies. This questionnaire had very interesting results that we will discuss in the upcoming part of this section.

4. The Questionnaire

The purpose of this questionnaire is to find out how often people use technologies that may distract them while driving. The statistics should give us an insight on the direction that ambient car technologies should advance in.

4.1. Method

The questionnaire was performed on a total of 418 people. While the majority of people who participated in the questionnaire had English as a second language, the vast majority see their English language skills as "Good" or "Excellent". The age group that participated the most ranged from 25 to 64 years old, specifically the 45 to 54 years old age group had the most participation from the group that was previously specified. Most of the participants reported that they had some sort of education that spanned beyond just high school. Most of the participants are Kuwaiti nationals that live in Kuwait and live in a large city.

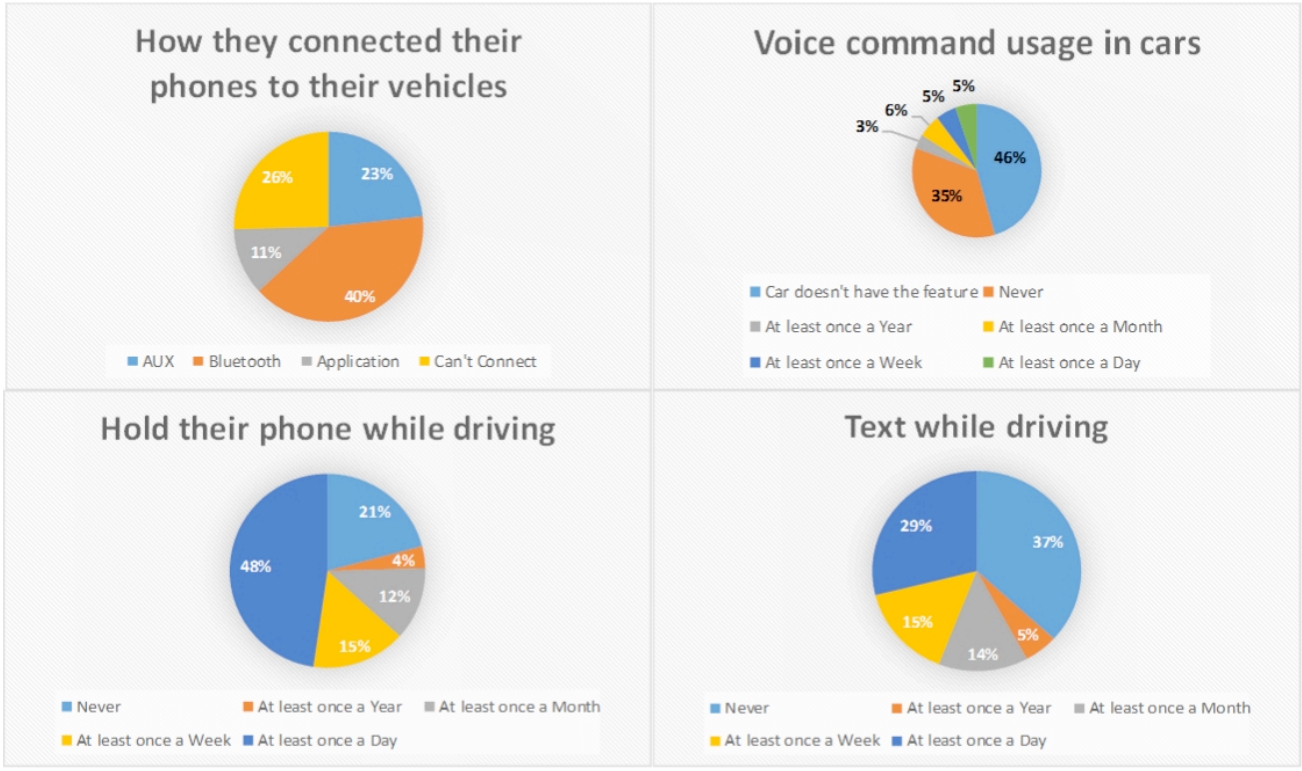

Figure 1 shows some of the survey's results

While there were previous studies on using smart phones while driving and what kind of applications that kept the driver busy, none to our knowledge asked specifically what kind of connection that most used with their cars [15][16]. Moreover, the frequency of smart phone usage was an important part in the questions asked.

The questions asked are related to the frequency of mobile usage during driving, the voice recognition related features usage when driving, how do they connect with the car, and other stuff as well. There were only 13 questions in the questionnaire; it was made short so that more participants would complete it without leaving midway.

The 400 of the people participated in the survey via a link that was spread in numerous social media platforms. While 18 of the participants filled in a paper survey. The links in the social media had two versions: An Arabic and an English one. The participants chose which one was the better option for them.

The questionnaire was designed using SurveyMonkey®, which is a well-known and secure surveying website.

4.2. Results

Surprisingly, people who were surveyed that reported that they hold their phones while driving (52%) are an exact match to the percentage of people that answer calls while driving in the USA [16]. There was a substantial difference when it comes to the number of people who text while driving with the NHTSA survey (20%) [16], but the percentage was very close when compared to the AT&T survey (61%) [15]. Of the people surveyed, 63% reported that they text when driving. 44% of the total surveyed reported that they do it as common as at least once a week.

Other interesting findings include:

- The majority of the people who have a voice command feature in their cars do not actually use it (64%).
- People tend to use the Voice-to-Text feature more often than the Text-to-Voice feature in their smart phones (38% and 25% respectively).
- Almost half of the people that can connect their phones with their cars chose Bluetooth (54%). The rest were people who used their cars application (15%) and people who used AUX (31%).
- Interestingly people who either never used a personal smart phone assistance, such as Siri, made up 69% of the people surveyed. The majority knew of their existence but never bothered using it (63%).
- People who used the cars voice command feature at least once a month are 7% less likely to text on a daily basis while driving. Although overall, they are more likely to text while driving.
- Most of the people surveyed either text while driving at least once a day (29%) or do not text while driving at all (37%). The rest text while driving but less frequently.
- Education degrees and English fluency did not play a role in the likeliness of a person using the phone while driving.
- 59% of the people who never held their phone at all while driving used Bluetooth, while 36% didn't connect their phones with any medium.

It is worth mentioning that people with applications installed in their car systems were only 4% less likely to text when driving. There also seems to be a general trend that signifies that the older the person seems to get, the less likely he is to text while driving with the exception of a slight increase in the 18-24 age range.

4.3. Implications

The first thing that we can see is that voice commands in car systems and applications had only a minor effect on the driver to leave the phone alone while driving. The biggest factor when it comes to not texting while driving is age. The results are not a big surprise after all that is what other sources have also found out [17], but what was indeed disappointing is that current car technologies had minor or no effect at all.
Even the results of the people who use personal smart phone assistants (such as Siri or Google Now) at least once a week did not differ significantly to the rest of the people who did not use them as much. These results only signify that our current level of ambient intelligence in cars is severely lagging behind when it comes to understanding the driver, hence the point where the driver does not even have to touch his smart phone while driving seems a bit of a far cry. Some of the research regarding this matter looked for a more humanistic solution by persuading the driver through technological means rather than develop new technologies that enable the driver to stay connected when driving [18]. They also have encouraging results when putting their concept into testing.
We should take the results of this survey with a grain of salt, since almost all vehicles in Kuwait operate with automatic transmission. The similarity of the results with the American surveys may also be the result of automatic gear transmission usage. The previously mentioned British survey [18] could add credit to this claim since it has much lower percentages of phone usage than the American surveys. Moreover, a survey executed by the World Health Organization(WHO) [19] had lower percentages of phone usage when driving in countries that had manual gear transmission. Nevertheless, this claim is a bit not solid since it needs a proper study to prove and none exist that we know of at the moment.

5. Car Interface

5.1 Display

Touch screen displays are replacing head units that have physical buttons and knobs, which is a trend that all car companies are trying to catch up on. Like all things, this trend has advantages and disadvantages.
Advantages of touch screens are:

1- Multilayer Menus are organized and well labeled, allowing even a person who is not familiar with the car to master it in no time.
2- Software updates allow car interface problems to be solved even if they were discovered after production and distribution.
3- Touch screens allow flexibility when it comes to the installation of applications by third parties. This makes the car more integrated with other products (i.e. smart phones and smart watches).
4- Has the potential to even replace smart phone interaction by using CarPlay or Google Auto.

The disadvantages are:

1- You can no longer do anything without looking at the screen as in the case with buttons and knobs.
2- Touch sensitivity and accuracy may be an issue with low quality touch displays. Moreover, it will severely distract the driver.
3- Wet fingers may interfere with the touch mechanism.

While there are lots of car companies that prefer to stay away from touch displays even with big screens present in the head unit of their cars, many provide a hybrid option of having a touch display that can also be controlled using knobs and buttons.
The head unit's interface is a big distraction for the driver, that is why there is a study [20] that decided to take into account the helping hand of the front seat passenger by morphing the head unit into a shared area instead of keeping it most suitable for the driver only. The designs are demonstrated to tremendously increase the driver's attention to the road and involve the passenger even more with the decision making process. Their design required an extra touch screen to be installed on the front passenger's side, which will in real life cost the car manufacturer more. There is a slight disadvantage to this configuration, which is that it requires the presence of a passenger and an extra display (which will cost more). The car company Tesla already has the shared area interface that they proposed, but not the front passenger seat display.
In addition, there is a study that experimented to see which type of interface interaction was better; touch screen only, speech only, or speech and touch screen [21]. expectedly, speech and touch screen interactions got the best scores in almost every category making it the method with least eyes off the road time, least mentally demanding, least number of lane deviations, and required the least time. This study also noted that the speech only option was far better than the touch screen only option. Similar results can verify the dangers of car touch screen fiddling by another executed study [22] that found that texting while the phone is on a phone holder (which is mimics the case of a car's touch screen) is more dangerous than holding it by hand.
Dashboard displays and HUD (heads-up display) are also on the rise with the technology becoming more mature, cheaper, and reliable. The ways in which HUDs can be deployed are either by being built-in by the car manufacturer, or acquiring an autonomous HUD display (i.e. Navdy), or using your phone with a transparent reflective sticker on the windshield. When we mention HUD we also have to mention AR (augmented reality) especially when it comes to driving. A paper was published [23] highlighting the direction that AR is to going to and it also mentioned all of the complications that this ripening concept has to take care of. HUDs in windshields can block or distort important details that could result in terrible accidents. The paper also stressed that HUD screens are not going to replace dashboard screens since each part has to display certain information.

5.2 Body Accessories

Products such as google glass have had large positive reaction from developers, but a less than an enthusiastic response from consumers. Many papers have not only suggested AR applications to be developed for google glass, but also tested what it would be like for the driver to text using google glass while driving. At least three independent papers [24][25][26] have tested that concept and the results were rather encouraging. All of the paper's results verified that using Google Glass is better than using the phone to text message even when voice recognition/commands were used while driving. Although they also concluded that no texting at all is better than texting using Google Glass. This could potentially have further implications on activities other than just texting,

say receiving a call or reading short notifications that are related to the car.
The emergence of the smartwatch came in to the commercial market by storm. Research in the area of smartwatch applications is an increasingly flourishing one, though not numerous at the moment. A group of researchers previously laid out the concept and foundations to design a smartwatch application that can sense if a driver is drowsy [27]. It should also be mentioned that the concept is tested and its formulas exhibited. Another group managed to invent a fully functional system that uses either a smartwatch or a sensor-embroiled steering wheel to detect the drowsiness of drivers with more than 97% accuracy [28]. If car manufacturers apply this application, countless accidents could be avoided especially if the car would automatically park on the side of the driving lane and turn off if a drowsy or a drunk driver is detected. Another possible application of the smartwatch is to detect if the driver has any pulse anomaly and drive him automatically to the nearest hospital, but let us be realistic for now; we do not live in an age of driverless cars just yet. Instead, the car can honk the horn or give an alarm to the nearby cars that the driver of this car is having a medical emergency.
However, enticing as it is to use a smartwatch when driving, active interaction with it should be avoided as much as possible. A study [29] completed by a group from MIT and Harvard concluded that interacting with a smartwatch when driving can be even more dangerous than smartphone interaction. This leaves smartwatches with the role of the passive sensor that relays pulse and hand movement when possible when driving.

5.3 Brain Computer Interface (BCI)

Using brainwaves in a car is not entirely a new concept since it has been used to control with the driving process [30] [31]. These applications are indeed very helpful for handicapped people and could be used in the future for all people, nevertheless it is a long way from industrial scale implementation and will likely die out since driverless cars is the wave that is going to eliminate the need for people to control the car's movements.
Responding to the rise of the autonomous car, there have been research on incorporating brainwave usage in various applications. One study [32] designed and tested a system that enables people to control semi-autonomous cars using brainwaves. The system aids the driver into driving the correct path and helps him remain so.
Let us keep in mind that BCI is still a fairly new when it comes to vehicle applications and that we would most likely encounter new research regarding the matter since the BCI society was only formed in 2013. There is a lot of research regarding patterns in brainwave bands and signals but not a lot of applications when it comes to utilizing it. This field is clearly growing and we are just looking at the tip of the iceberg at the moment.

6. Security and Privacy

The issue of security in cars is the biggest obstacle to achieve a much more technologically integrated car. Car companies are being careful for the right reason, after all, modern cars are filled with exploitable modes of communications such as Bluetooth, data transmitted via radio waves, and telematics/Wi-Fi. In order for a car to be truly technologically advanced, it needs more ECUs (Electrical Control Unit). While an ECU is a very essential part of an integrated electrical system, it is a fairly recent occurrence that they are taking up a major role when it comes to controlling the parts of the vehicle that have a direct effect on the driving experience. ECUs have enabled features such as: Park Assist, Adaptive Cruise Control, Collision Prevention, and Lane Keep Assistance. These impressive features have had a major dent on the security of the car since an attacker can manipulate them [33]. Two hackers managed to break into many car systems; sabotaging breaks, turning off engines, taking control of the accelerator, and numerous other things [34][35]. Not to mention the embarrassing keyless ignition study that revealed how a myriad of cars can be stolen by attacking the cipher design, enabling the attacker to sniff out the key within 30 minutes [36].

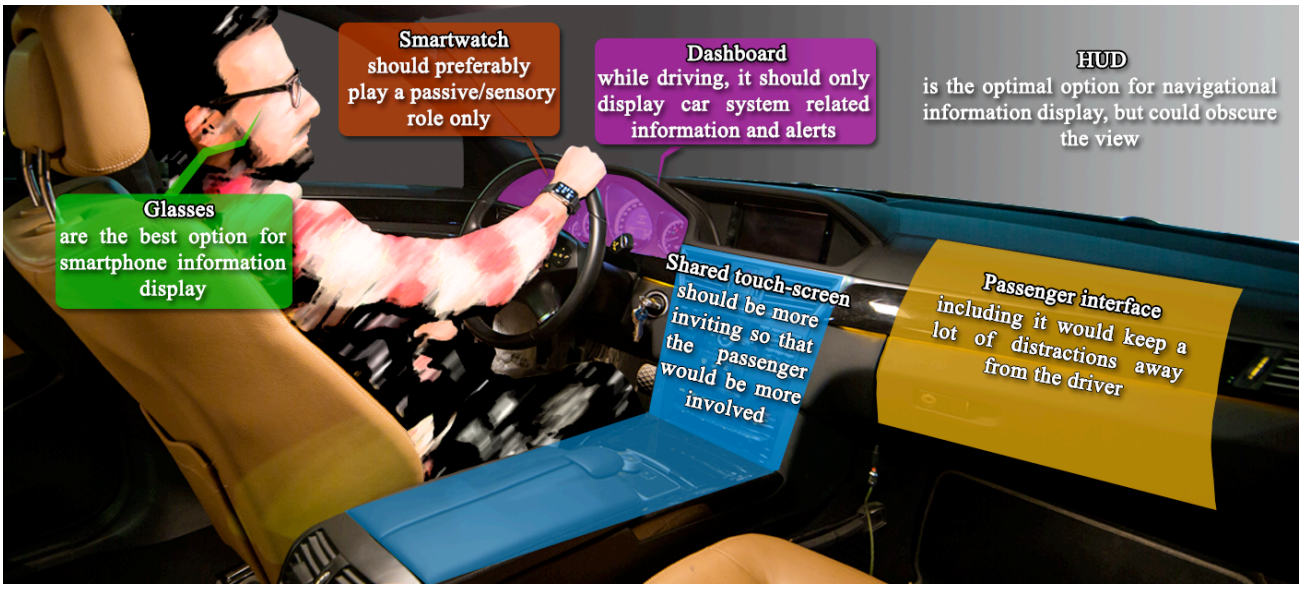

Figure 2 Gives a brief summary of the conclusions that studies have revealed

Volkswagen fought the initial publication of the previously mentioned research in order for it to avoid negative publicity [37]. These vulnerabilities are not without reason, after all, car companies struggle in a competitive market which makes it hard for the transparency of safety to persist [38]. Car manufacturers should follow the aviation culture of safety transparency, in order for the industry to eliminate all ways that a vehicle can be exploited (cyber or physical).

A preventative measure to hack into the ECU was introduced by the microprocessor manufacturer Intel [39]. Their new ECUs work on a network of trustlets, an advanced system of control unit trustworthiness that is being implemented on embedded devices. It mainly relies on the concept of isolation of computing tasks, which is to isolated each ECU so that the attacker can't mess with the signals that it gives and receives. Intel claims that this new system of ECUs can reportedly give cars "cloud level security".

Small mobile network communication is obviously a key point in the car's synchronous functionality. New improved networks have been designed in studies to accommodate for this need [40]. Naturally, studies to keep this network secure have also been suggested in other studies [41]. The car's network is becoming increasingly similar to the concept of the internet of things (IoT) hence research that has been already been done on IoT has a lot of potential to contribute in a positive way to the car of the future.

7. The Future of Car Interfaces

Concept cars from all, if not all car manufacturers, are being designed with autopilot driving functionality. Rolls Royce takes it a step even further by designing a concept car that is entirely autonomous [42]. Current cars with semi-autonomous driving functionality are in no way 100% safe as there were several accidents that have occurred as reported by car manufacturers such as Tesla [43]. In spite of that, most car manufacturers are held back mostly from the hectic legislation process rather than lagging technology needed to ensure the full secure deployment of such a feature.

With that in mind, how will the interface of the future car look like? The appropriate answer would depend on whether you are looking at the near future or the not so distant future. Semi-autonomous cars are being sold and used nowadays look exactly like regular cars without the semi-autonomy feature. Other than the large screen interface, the Tesla S model interior looks very similar to the other cars. This is because it is still a semi-autonomous and not a fully autonomous car (i.e. Google's self-driving car). A semi-autonomous car has the option of a person taking control over the wheel while a fully autonomous car does not.

There is a reason why there is no wheel in autonomous cars, which is because humans require approximately 17 seconds after taking the wheel to fully comprehend the function of driving according to Google [44]. Google's self-driving car has a small screen at the side and a very wide but small screen facing the passengers in front for information display.

This layout, though very simplistic, offers what the current relaxed commuter wants: Ample space with less screens and buttons intruding on him. The design assumes that most of the car's users will be either looking out of the window or passing time by other means (i.e. Laptop, smartphone). Another layout would to set up a fully integrated entertainment system inside the car to fill in the empty space. Either case, this is very new field that needs more research that will truly be accomplished once autonomous cars are widespread.

There remains the issue of trust that is profoundly required in order for the passenger to completely switch to autonomous cars. According to a survey released by the AAA [45], 75% of drivers fear self-driving cars. The silver lining though was that after experience with self-driving cars, most people tend to trust the machine. Another glimmer of hope is that six out of ten drivers actually want semi-autonomous driving technology in their next car that they would purchase.

It is a bit hard to sway people into buying autonomous cars by endorsing it as the safer option since proving that requires enormous effort and a lot of time. As calculated by a study done by RAND [46], rigorous testing has to be done for hundreds of years in order to compare percentages of accidents of autonomous vehicles to regular ones. Therefore, in order to scientifically prove the safety of autonomous vehicles a new testing method has to be proven.

If autonomous vehicles become the norm, there would be a lot of implications surrounding car usage. According to a study [47] there would be a dip in the actual ownership of autonomous vehicles. This would drastically change the scene when it comes to how the interface is designed no doubt since the car would be a less personalized thing. The autonomous shared car would take the role of the Uber driver rather than totally replace all personalized cars.

Figure 3 displays a concept future car designed by Mercedes-Benz. (Courtesy of Mercedes-Benz)

8. Conclusion

We studied and analyzed the current level of ambient technology that is available in the current market along with its related research. The majority of people don't use current technologies while driving frequently, which highlights the gap that current ambient car technology has to bridge. Some technologies are less likely to distract drivers than others like the Google Glass and HUD, but they all require some mental workload nevertheless.

Displays play a vital role in this debate too since they are becoming more widespread year by year, and that is why research is suggesting to involve the front seat passenger to do more of the work so that the driver doesn't lose concentration. BCI technology show great promise but still remain mainly present only in the research field only.

There are many dangerous faults that still exist in today's car technology. The best way to tackle this problem is by being transparent about it, so that more hands could join in and other companies could avoid making the same mistakes. Autonomous cars will no doubt act as a catalyst for numerous changes to occur on the car interface scene.

References

[1] Nunney M. Light and Heavy Vehicle Technology. 3rd ed., vol. 2. pp.68-73. Oxford: Clarendon (2016).

[2] Halpert J. Cars hear you, but when will they get you? .Automotive News. (March 23rd 2015). pp.22 Vol.89.

[3] Canada Intellectual Property Office. Retrieved from: http://brevets-patents.ic.gc.ca/opic-cipo/cpd/eng/patent/235757/summary.html

[4] Gitlin J. How can cars keep up with gadget innovation?. ARS Technica Website. (June 23rd 2013). Retrieved from: http://arstechnica.com/cars/2014/06/industries-collide-how-automakers-are-adapting-to-consumer-tech-life-cycles/.

[5] Infiinite USA's official Website. (December 23rd 2015). Retrieved from: http://www.infinitiusa.com/sedan/q50

[6] Sedgwick D. (2014) J.D. Power pans in-car voice recognition systems. Automotive News. (August 6th 2014).

[7] Chen H, Ruan S. An automotive application of real-time adaptive Wiener filter for non-stationary noise cancellation in a car environment. Conference: Signal Processing, Communication and Computing (ICSPCC). (2012)

[8] Chen H, Ruan S, Jheng H, Qi Z. FPGA implementation of high sampling rate in-car non-stationary noise cancellation based on adaptive Wiener filter. Conference: IEEE/IFIP 19th International Conference on VLSI and System-on-Chip, VLSI-SoC 2011, Kowloon, Hong Kong, China, (October 3rd-5th 2011).

[9] Osswald S, Wurhofer D, Trsterer S, Beck E, Tscheligi M. Predicting Information Technology Usage in the Car: Towards a Car Technology Acceptance Model. International Conference on Automotive User Interfaces and Interactive Vehicular Applications. https://doi.org/10.1145/2390256.2390264

[10] American Automobile Association. (October 22nd 2015). Retrieved from: http://newsroom.aaa.com/2015/10/new-hands-free-technologies-pose-hidden-dangers-for-drivers/

[11] Newcomb D. Voice Recognition in Cars Can Help More Than Hurt. PCmag.com. (October 10th 2014).

[12] Snavely B. Improved systems for vehicle voice recognition coming. Detroit Free Press. (November 8th 2011).

[13] Apple's official Website. (December 23rd 2015). Retrieved from: http://www.apple.com/ios/carplay/

[14] Android's official Website. (December 23rd 2015). Retrieved from: https://www.android.com/auto/

[15] Smart phone Use Behind the Wheel Survey. (May 2015). AT&T.

[16] US Department of Transportation. NHTSA Survey Finds 660,000 Drivers Using Cell Phones or Manipulating Electronic Devices While Driving At Any Given Daylight. (April 23rd 2013). Retrieved from: https://www.transportation.gov/briefing-room/nhtsa-survey-finds-660000-drivers-using-cell-phones-or-manipulating-electronic-device.

[17] Mais D. Seat belt and mobile phone use surveys: England and Scotland, 2014. UK Department for Transport. (February 25th 2015). Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment data/file/406723/seatbelt-and-mobile-use-surveys-2014.pdf

[18] Miranda B, Jere C, Alharbi O, Lakshmi S, Khouja Y, Chatterjee S. Examining the Efficacy of a Persuasive Technology Package in Reducing Texting and Driving Behavior. Persuasive Technology. 8th International Conference, PERSUASIVE 2013, Sydney, NSW, Australia, (April 3rd-5th 2013). Proceedings. pp 137-148. https://doi.org/10.1007/978-3-642-37157-8_17

[19] World Health Organization, NHTSA. Mobile phone use: a growing problem of driver distraction. 2011. ISBN 978 92-4-150089-0

[20] Rumelin S, Seigl P, Butz A. Could You Please? Investigating Cooperation In The Car. Adjunct Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI 13), (October 28th-30th 2013), Eindhoven, The Netherlands. Pp 61-64.

[21] Schalk T, Gibbons L. Toward Natural User Interfaces in the Car: Combining Speech, Sound, Vision, and Touch. Adjunct Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI 13), (October 28th-30th 2013), Eindhoven, The Netherlands. Pp 65-69.

[22] Kujala T, Grahn H, Holmstedt N. Hand-Held texting is less distracting than texting with the phone in a holder: anyway, don't do it. Proceedings of the 19th International Academic Mindtrek Conference. Pp 98-105. (2015). https://doi.org/10.1145/2818187.2818270

[23] Gabbard L J, Fitch M G, Kim H. Behind the Glass: Driver Challenges and Opportunities for AR Automotive Applications. Proceedings of the IEEE, Vol. 102, No. 2, (February 2014). Pp 124-136. https://doi.org/10.1109/JPROC.2013.2294642

[24] He J, Choi W, McCarley J, Chaparro B, Wang C. Texting while driving using Google Glass: Promising but not distraction-free. Accident Analysis and Prevention. pp.

218-229. (2015). https://doi.org/10.1016/j.aap.2015.03.033

[25] Sawyer B, Finomore V, Calvo A, Hankock P. Google Glass: A Driver Distraction Cause or Cure?. Human Factors: The Journal of Human Factors and Ergonomics Society. Pp. 1307 1321. (2014). https://doi.org/10.1177/0018720814555723

[26] Young K, Stephens A, Stephan K, Stuart G. In the eye of the beholder: A simulator study of the impact of Google Glass on driving performance. Accident Analysis and Prevention Volume 86, (January 2016). Pp. 68-75. https://doi.org/10.1016/j.aap.2015.10.010

[27] Ros-Aguilar S , Merino J, Snchez A, Valdivieso A. Variation of the Heartbeat and Activity as an Indicator of Drowsiness at the Wheel Using a Smartwatch. International Journal of Artificial Intelligence and Interactive Multimedia, Vol. 3, No. 3. Pp 96-100. (2015). https://doi.org/10.9781/ijimai.2015.3313

[28] Lee B, Park J, Pu C, Chung W. Smartwatch-Based Driver Vigilance Indicator With Kernel-Fuzzy-C-Means-Wavelet Method. IEEE Sensors Journal, Volume 16, No. 1, pp 242-252. (January 1st 2016). https://doi.org/10.1109/JSEN.2015.2475638

[29] Samost A, Perlman D, Domel A, Reimer B, Mehler B, Mehler A, Dobres J, McWilliams T. Comparing the Relative Impact of SmartWatch and Smartphone Use While Driving on Workload, Attention, and Driving Performance. Procedings of the Human Factors and Ergonomics Society 59th Annual Meeting. (2015).

[30] Kim Kyung-hoon. Chinese researchers unveil brain powered car. Reuters. (Dec 7th 2015). Retrieved from: http://www.reuters.com/article/us-china-brainpower-car-idUSKBN0TQ23620151207

[31] Autonomos Labs, Brain Driver Project. Free University of Berlin. Retrieved from: http://autonomos-labs.com/projects/past-projects/braindriver/

[32] Gohring D, Latotzky D, Wang M, Rojas R. Semi-autonomous Car Control Using Brain Computer Interfaces. Advances in Intelligent Systems and Computing. Volume 194, pp. 393-408.

[33] Miller C, Valasek C. A Survey of Remote Automotive Attack Surfaces. Black Hat Security Conference (2014).

[34] Greenberg A. Hackers Reveal Nasty New Car Attacks–With Me Behind The Wheel. (July 24th 2013). Retrieved from: http://www.forbes.com/sites/andygreenberg/2013/07/24/hackers-reveal-nasty-new-car-attacks-with-me-behind-the-wheel- video/#2715e4857a0b3852e2d75bf2

[35] Greenberg A. Hackers Cut a Corvettes Brakes Via a Common Car Gadget. (August 11th 2015). Retrieved from: http://www.wired.com/2015/08/hackers-cut-corvettes-brakes-via-common-car-gadget/

[36] Verdult R, Garcia F, Ege B. Dismantling Megamos Crypto: Wirelessly Lockpicking a Vehicle Immobilizer. USENIX Security Symposium. (August 12th-14th 2015).

[37] Crilly R. Thousands of cars vulnerable to keyless theft, according to researchers. The Telegraph. (August 18th 2015). Retreived from: http://www.telegraph.co.uk/news/uknews/11808814/Thousands-of-cars-vulnerable-to-keyless-theft-according-to-researchers.html

[38] Fisher D. Information Sharing on Threats Seen as a Key for Auto Makers. (September 10th 2014). Retrieved from: https://threatpost.com/information-sharing-on-threats-seen-as-a-key-for-auto-makers/108185/

[39] Brown D, Cooper G, Gilvarry I, Rajan A, Tatourian A, Venugopalan R, Wheeler D, Zhao M. Automotive Security Best Practices. Retrieved from: http://www.intel.com/content/www/us/en/automotive/automotive-security-best-practices-white-paper.html

[40] Kurdi H. Personal Mobile Grids: Ubiquitous Grid Environments For Personal Users. Journal of Ubiquitous Systems & Pervasive Networks. Volume 6, No. 1 (2015) pp. 01-10.

[41] Samani A, Ghenniwa H, Wahaishi A. PRIVACY AWARE SMART OBJECTS IN INTERNET OF THINGS. Journal of Ubiquitous Systems & Pervasive Networks. Volume 6, No. 2 (2015) pp. 01-10.

[42] Official Rolls Royce 103EX webpage. (July 29th 2015). Retrieved from: https://www.rolls-roycemotorcars.com/en-GB/103ex.html

[43] Vlasic, Bill; Boudette, Neal E. (2016-06-30). "Self-Driving Tesla Involved in Fatal Crash". The New York Times.

[44] Paul Lienert, Joseph White. Automakers, Google take different roads to automated cars. (September 4th 2015). Reuters. Retrieved from: http://www.reuters.com/article/autos-selfdriving-gurus-idINKCN0R40CZ20150904

[45] Three-Quarters of Americans "Afraid" to Ride in a Self-Driving Vehicle. AAA News Room. (March 1st 2016). Retrieved from: http://newsroom.aaa.com/2016/03/three-quarters-of-americans-afraid-to-ride-in-a-self-driving-vehicle/

[46] Kalra, Nidhi and Susan M. Paddock. Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?. Santa Monica, CA: RAND Corporation, (2016). http://www.rand.org/pubs/research_reports/RR1478.html. https://doi.org/10.7249/RR1478

[47] Schoettle, B. & Sivak, M., 2001. POTENTIAL IMPACT OF SELF-DRIVING VEHICLES ON HOUSEHOLD VEHICLE DEMAND AND USAGE. Clinical Nutrition, (November), p.1-49.