ALTAIR: Automatic Light Tailoring Apparatus Instructing Radiance
(Technical Paper)

The Ethical Question of New Technology in Vehicles: Is It Worth the Trade-Off?
(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Engineering

By
Steven Peng

November 1, 2021

Technical Team Members:
Peter Morris
Mason Notz
Alexander Tomiak

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.

ADVISORS

Harry Powell, Department of Electrical and Computer Engineering

Bryn E. Seabrook, Department of Engineering and Society

Introduction

As time progresses, new innovations in technology aim to benefit society by improving peoples' quality of life (QOL), which is defined by the World Health Organization (WHO) as "individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHO, 2012). The first proposed project is the technical project, which focuses on improving the QOL of individuals working constantly at home with a system called the Automatic Light Tailoring Apparatus Instructing Radiance, or ALTAIR for short. ALTAIR is a system that will control the interior light levels of a room to help reduce eye strain and improve the user's overall health. ALTAIR will work by actuating the blinds on a window to let in a certain amount of natural light, as well as utilizing light-emitting diode (LED) smart lights when needed in the case that there is not enough natural light outside. By focusing on improving the QOL of the end user, ALTAIR can either focus on the overall energy efficiency of a room by strategically opening and closing the blinds as needed to help regulate the temperature, or primarily focus on the light level of the room with a bias to natural light for the added health benefits. QOL improvements is currently happening in nearly every industry, including the automotive industry, although there may be unforeseen downsides to the implementation of QOL improvements within modern vehicles.

The second proposed project is a Science, Technology, and Society (STS) research paper that will focus on major technical innovations within the automotive industry in everyday road cars. Every year, car manufacturers design and develop new technologies and features that improve the occupant's convenience, comfort, and safety. One primary downside that becomes apparent as automotive manufacturers add more technology to cars is that more vulnerable endpoints are created, allowing malicious entities to compromise the vehicle, putting both the occupants and the

general public in danger (SAE, 2018). Another downside is that most modern "smart" cars have a variety of sensors and data that is relayed back to the manufacturer for analytical purposes, but a driver's personal driving habits can then be sold off to a third-party entity without the driver's consent, such as to insurance companies. By looking at the rapid innovation of technological features of modern "smart" cars with the risk analysis framework and the technological fix framework, the cybersecurity implications of these new features will be analyzed to determine if they are worth the added cost and risk to consumers that they bring, along with determining if the new features are solving a true problem to begin with. A research paper on the cybersecurity implications of modern vehicles will be the final product of this analysis.

ALTAIR: Automatic Light Tailoring Apparatus Instructing Radiance

With the ongoing COVID-19 pandemic, many companies and educational institutions have transitioned from full-time in-person work to either a fully remote or hybrid work option. While many employees and students see the transition to remote work as a positive benefit as they do not have to wake up early to make the commute, they do not consider the health implications of staying home at a desk all the time. By working remotely in a room at home all day, it is very likely that workers are not receiving adequate light, especially natural light, at any given time. According to Zee and Cheung from Northwestern Medicine, "…exposure to light, especially during the day… is beneficial to your health via its effects on mood, alertness, and metabolism" (Paul, 2014). A lack of natural light can lead to a variety of health issues, such as a deficiency of vitamin D, an increased chance of seasonal depression, and increased eye strain (Garone, 2020). While artificial light from fluorescent or LED bulbs can increase the rooms brightness at any given time of day, they still lack the benefits that natural light provides and can even cause more harm to a person's health if the light bulbs are not the proper light temperature for the given time of day, which can lead to an

undesirable increase in activity in one's central nervous system, which can increase stress and prohibit sleep at night (Noguchi & Sakaguchi, 1999). Additionally, there is evidence that a lack of natural light can hinder eye development in children, which is a major factor in the myopia epidemic (Sánchez-Tocino et. al, 2019). Another issue that many homeowners face is high electricity bills from insufficient insulation within their house. For example, if a homeowner were to leave their blinds open on a sunny day with the air conditioning (AC) on, the heat from the sunlight would enter the house and warm up the interior, all while the AC is trying to fight the heat and cool down the house.

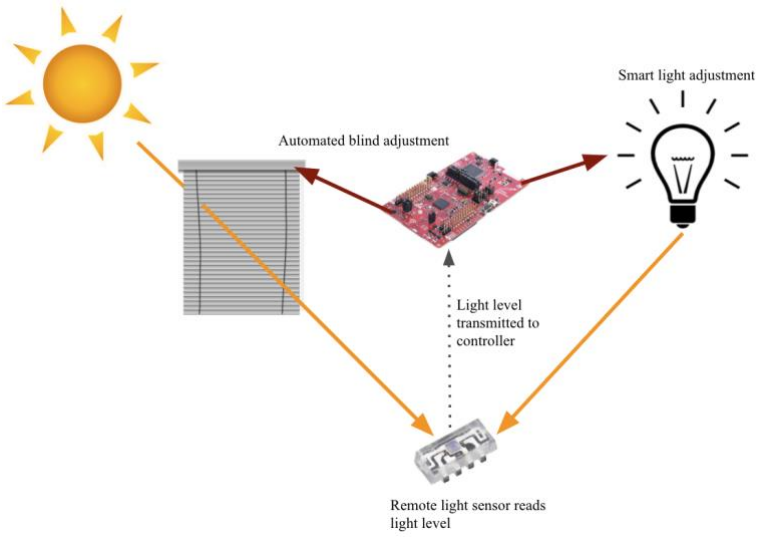

Figure 1: ALTAIR System Overview. By A. Tomiak, 2021.

To solve these issues, a system called "Automatic Light Tailoring Apparatus Instructing Radiance," or ALTAIR for short, is being developed by a team of four electrical and computer engineers: Peter Morris, Mason Notz, Steven Peng, and Alexander Tomiak. ALTAIR will automatically actuate the room's blinds and smart lights to obtain and maintain a set light level within the room through the help of a wireless remote light sensor. The system will prioritize natural light over artificial light whenever possible to achieve the health benefits of natural light.

The system will be controllable through the web application that is hosted on a Raspberry Pi embedded within the remote light sensor.

To use the device, the user will first set a desired light level through the web application, then the system will automatically adjust the blinds first to attempt to reach the desired light levels through natural light alone. If the system does not achieve the desired light level through the blinds, the system will then turn on the smart lights and gradually increase the brightness until the desired light level is reached. The blinds will automatically close after sunset for privacy and energy saving purposes, and the smart lights will also adjust the color temperature to properly suit the time of day to reduce eye strain and optimize the user's physiological activity to improve their QOL. A simplified flowchart of the system at work can be seen in Figure 1: ALTAIR System Overview. The system may also feature options to improve or maximize energy efficiency within the room by closing the blinds on a bright, sunny day to prevent extra heat from entering the room and controlling the brightness solely from the LED smart lights, which would reduce the load on the home's AC unit. The final deliverables for ALTAIR will be a video and a live demonstration of a working prototype with functional hardware that actuates a set of blinds through commands sent from the user interface, as well as a closed-feedback algorithm that will automatically adjust the blinds and smart lights until the desired light level is reached. A final report will also be written that will delve into the entire design process of the system as well as addressing various concerns such as safety and the environmental impact of the system, and discussion potential future plans of the system.

The Ethical Question of New Technology in Vehicles: Is It Worth the Trade-Off?

Every year, automotive manufacturers implement new technological features into their vehicles to improve the occupants' QOL to entice them to upgrade their old vehicle to a new one,

but by doing so the manufacturers can unintentionally introduce vulnerabilities that malicious entities can use to hack into the vehicle and control it. From a broader standpoint, QOL in a vehicle primarily focus on the comfort and convenience of the vehicle's occupants, such as satellite radio or a remote start feature to warm up the vehicle ahead of time (Zoepf, 2011). Another factor that encourages manufacturers to install new technology in vehicles is to improve safety for those both inside and outside of the car. For example, the United States government introduced the Cameron Gulbransen Kids Transportation Safety Act of 2007 that required all automotive manufacturers to have backup cameras as a mandatory feature in all light vehicles made after May 1st, 2018, rather than being an optional paid feature as it was before. This law came to be as a two-year-old child, Cameron Gulbransen, was killed when he was hit by an SUV that could not see him behind the vehicle while backing up into a driveway (Kids And Cars).

While the implementation of these new technologies achieves all their desired goals of improving the comfort, convenience, and safety of the occupants of the vehicle and the general public alike, there can be unintended consequences embedded within the technology that consumers may not be aware of. For example, some insurance companies offer a device that tracks the driver's driving habits, such as how hard the driver uses the brakes or if the driver speeds often, and by using that data can ideally offer a lower, or even potentially higher in some cases, insurance rates (State Farm). While this may sound like a win-win scenario for the safe driver who can save money by not driving recklessly, it is very likely that the data being collected is being sold off to other companies indirectly related to the insurance company for a profit. Another disadvantage is that some newly implemented convenience features in vehicles, such as built in Wi-Fi that the occupants can use anywhere, can introduce vulnerabilities that malicious entities can use to take control over portions of vehicle against the driver's will. For example, in 2015 security researchers

Charlie Miller and Chris Valasek were able to hack into a 2014 Jeep Cherokee through a vulnerability in the vehicle's custom Uconnect infotainment system that had a built-in Wi-Fi hotspot, enabling them to control nearly every aspect of the vehicle remotely, such as the engine, the steering wheel, and even the brakes (Sorokanich, 2015). These examples bring up the ethical question of new technologies in vehicle, along with the implications in the security of the vehicle and the use of the data collected from new innovations.

To analyze the potential tradeoffs and dangers of new technologies in modern vehicles, the risk analysis framework and the technological fix framework will be utilized. Risk analysis is defined as identifying the ramifications of a situation based on the information available at the time, determining the scale of the risk in terms of who is impacted, and determining if there are any potential solutions to the aforementioned risks (Mythen, 2004). While many modern vehicles on the road offer a variety of convenient "smart" features such as built-in Wi-Fi, Bluetooth connectivity to mobile phones for music and calls, and remote start capabilities, from a cybersecurity standpoint each feature has a risk associated with it as it could be providing a potential entry point for malicious entities to take advantage of. On the other hand, a technological fix is defined by Newberry as "the use of technology to respond to certain types of human social problems that are more traditionally addressed via political, legal, organizational, or other social processes" (Newberry, 2005). An example of a technological fix in modern vehicles would be the "driver awareness" feature that some manufacturers implement to ensure that drivers are staying attentive to the road instead of their mobile phones. Rather than tackling the issue of mobile phone addiction where people are reliant on using their cellphones at any given time, companies are developing eye-tracking solutions that would signify to the driver to pay attention to the road if they look away from the road for an extended period of time (Cvahte & Topolsek, 2019). While

this solution can indeed curve distracted driving, one unseen risk is whether the data used to track the driver's eyes is localized to the vehicle or sent elsewhere for processing, and if the data is sent elsewhere then what happens to the data after being processed? There is a potential that the data could be shared with insurance companies, who can then determine if a certain driver is prone to use their cellphones while driving and increase their insurance rate as they are more of a liability in comparison to someone who is fully attentive to the road.

As for the acquisition and analysis of data, the primary methods of doing so will be with political and discourse analysis. A political analysis will provide insights on how governments worldwide handle data privacy issues along with the regulation of new technological features in vehicles. For example, the United States government implemented a data regulation law named the Health Insurance Portability and Accountability Act that protects the sharing of a patient's data without their consent within the healthcare industry (Health Insurance Portability and Accountability Act). Discourse analysis will provide an understanding of the general public opinions on such issues through outlets such as Twitter, YouTube, and Reddit, as many claims of data privacy concerns with new technology can be found on those three platforms. To obtain relevant data a variety of sources will be utilized, primarily those from Google as a search engine for news articles along with Google Scholar for scholarly research papers, Twitter, and Reddit for public opinion on related topics. Keywords that will be used on these sites to find relevant posts and papers would be "cybersecurity," "smart cars," "technology in cars," "smart car dangers," "vehicle vulnerabilities," and "data ethics," to name a few. By analyzing the safety, security, and privacy concerns of modern and future technologies used in the automotive industry, both manufacturers and the consumer can gain a better understanding of the risks associated with such technologies from malicious entities abusing vulnerabilities that allows them to control a vehicle

remotely to ethical concerns of who and where the data collected from the vehicle systems get sent to.

Conclusion

In summary, an automatic interior light adjusting device named ALTAIR will be created that will automatically actuate the blinds and smart lights within a room to achieve the user's desired light level and will benefit the user's health by introducing more natural light throughout the day while working at home, while also improving the energy efficiency of the home to reduce the cost of the energy bills. By analyzing the potential consequences and security implications of the implementation of new technologies in modern vehicles in the STS research paper, it is hoped that society will be aware of the data privacy concerns that come with new automotive technology, and that manufacturers need to put a process in place to catch such issues before they make it to production, which can then put the general public at risk.

References

Cameron Gulbransen Kids Transportation Safety Act of 2007, Pub. L. No. 110-189.

Cvahte Ojstersek, T., & Topolsek, D. (2019). *Eye tracking use in researching driver distraction: A scientometric and qualitative literature review approach*. Journal of eye movement research. Retrieved October 30, 2021, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7880134.

Garone, S. (2020). *The Health Benefits of Natural Light (and 7 Ways to Get More of It)*. Healthline. Retrieved October 24, 2021, from https://www.healthline.com/health/natural-light-benefits.

Gianforte, K. (2018). *The Danger of An Over-Personalized Insurance Industry.* Retrieved October 23, 2021, from https://krissyg-hub.github.io/docs/Gianforte_InsuranceEthics.pdf.

Health Insurance Portability and Accountability Act. Pub. L. No. 104-191, § 262, 110 Stat.1177.

Mythen, G. (2004). Defining Risk. *Ulrich Beck: A Critical Introduction to the Risk Society*. (pp. 53-73). London, England. Sterling, Virginia. Pluto Press.

Newberry, B. (2005). Technological Fix. In C. Mitcham (Ed.) *Encyclopedia of Science, Technology and Ethics*. (Volume 4., pp. 1901-1903). New York, New York. Macmillan Reference USA.

Noguchi, H., & Sakaguchi, T. (1999). *Effect of illuminance and color temperature on lowering of physiological activity*. Applied Human Science. Retrieved October 31, 2021, from http://www.jstage.jst.go.jp/article/ahs/18/4/18_4_117/_article.

Paul, M. (2014). *Natural Light In The Office Boosts Health*. Retrieved October 28, 2021, from https://news.northwestern.edu/stories/2014/08/natural-light-in-the-office-boosts-health.

SAE, Synopsys. (2018). *Securing the Modern Vehicle: A Study of Automotive Industry Cybersecurity Practices.* Ponemon Institute. https://www.sae.org/binaries/content/assets/cm/content/topics/cybersecurity/securing_the_modern_vehicle.pdf

Sánchez-Tocino, H., Villanueva Gómez, A., Gordon Bolaños, C., Alonso Alonso, I., Vallelado Alvarez, A., García Zamora, M., Francés Caballero, E., Marcos-Fernández, M. Á., Schellini, S., & Galindo-Ferreiro, A. (2019). *The effect of light and outdoor activity in natural lighting on the progression of myopia in children*. Journal Français D'Ophtalmologie, 42(1), 2–10. https://doi.org/10.1016/j.jfo.2018.05.008

Sorokanich, B. (2015). *Why you still shouldn't panic about car hacking*. Road & Track. Retrieved October 4, 2021, from https://www.roadandtrack.com/new-cars/car-technology/a26144/why-you-still-shouldnt-panic-about-car-hacking/.

State Farm. (2021). *Drive Safe & Save™ Mobile - State Farm®*. State Farm. Retrieved October 27, 2021, from https://www.statefarm.com/customer-care/download-mobile-apps/drive-safe-and-save-mobile.

Tomiak, A. (2021). *ALTAIR System Overview*. Retrieved October 30, 2021.

World Health Organization. (2012). *WHOQOL: Measuring Quality of Life*. Retrieved October 31, 2021, from https://apps.who.int/iris/rest/bitstreams/110129/retrieve.

Zoepf, S. M. (2011). *Automotive features: Mass impact and deployment characterization*. Retrieved October 30, 2021, from https://dspace.mit.edu/handle/1721.1/65434.