Prospectus

Design and Construction of a Kinetic Art Weather Display
(Technical Topic)

Potential Negative Effects of the Expansion of Smart Home Technology on Psychology and Human Behavior
(STS Topic)

By

Adam Lenox

November 5, 2020

Technical Project Team Members:

Lisa Accolla, Jack Davis, Katherine Ellis, Joshua Rigby

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

Signed: Adam Lenox
Technical Advisor: Gavin Garner, Ph.D.
STS Advisor: Sean Ferguson

Introduction

For nearly 50 years, the Mechanical and Aerospace Engineering (MEC) building at the University of Virginia has provided space for professors and students to learn, teach, and experiment (UVA Engineering, 2018). However, the basement of this building lacks windows and thus a convenient, visual representation of the time of day and weather. Our capstone project attempts to change that by introducing a piece of kinetic art mounted to the wall of the basement to present an accurate, visually appealing depiction of the time of day and weather. This project will hopefully lead to a happier and more productive workspace for those working in the basement of the MEC building. However, as with any introduction of new technology, one must analyze the unintended consequences such a technology may initiate. Such an analysis would not necessarily serve to prevent the adoption and implementation of this technology completely. Rather, it would seek out what is causing these issues and provide a framework to adjust the design or implementation to prevent or counteract negative consequences.

Smart home technology has been expanding across the world in recent years, adding many devices to the ever-expanding Internet of Things (IoT). These webs of sensors, algorithms, and technologies combine to create a convenient, efficient, connected home. However, these benefits may come with associated risks to human cognition and behavior. These risks include overdependence, unhealthy social habits, manipulation of the subconscious mind, loss of the feeling of privacy in the home, and perhaps even psychological and mood disorders. The STS research thesis proposed attempts to analyze the negative effects on psychology and human behavior that may result from the expansion of these smart home technologies.

Technical Topic

The objective of the capstone project is to develop a functional piece of wall art that uses mechanical movements and electronics to display various outdoor/weather conditions. It will further be referred to as a kinetic art weather display or weather display. This idea was inspired by the conditions that students and researchers are under when they are working in the labs of the University of Virginia's Mechanical and Aerospace Engineering department, which are located in the basement of the MEC Building at UVA. These labs have no windows and one can easily lose track of time, especially when personal protective equipment is being worn, making it difficult to check one's phone. Further, studies have shown that there is a significant and stable relationship between working environment, overall job satisfaction and productivity (Edwards et al., 2002; Schneider et al., 2003). Thus, the weather display will serve the purpose of informing users of the current conditions outdoors (rain, snow, clear, daytime, nighttime, etc) through pictorial means that are quick and easy to process with just a glance, while also being aesthetically pleasing. It will also demonstrate important engineering concepts such as the modern-day synthesis of electronics and mechanical devices, as well as advanced manufacturing techniques such as 3D-printing, CNC machining, and laser cutting that allow for the construction of complex products with relatively low monetary and time costs.

A literature review yielded one product that is of a similar concept to the one developed by the capstone group. The "Weather Clock" by Bramwell Brown is primarily an analog clock, but it has a small display in the bottom portion that depicts various weather conditions with moving parts and what weather condition is displayed is dependent upon the information from an internal barometric pressure sensor (Bramwell Brown, 2020). From the following description, it can be discerned that the capstone group's weather display will differ significantly.

The display will be a circular design fashioned from wood using a CNC Mill, where the top half is a visible window for weather and the bottom will be space to store the mechanics that operate the weather changing devices. It will feature two transparent, semicircular acrylic sheets that are engraved with rain and snow patterns. These sheets, when illuminated by strips of LED lights, provide an artistic simulation of the current weather pattern. The design will also involve sun and moon figures that rotate around the display to indicate the day and night. Smaller features that will be included are a backlight that can vary brightness within the window, a UVA-themed background, an LED matrix display indicating time, date, and temperature, as well as interactive buttons that will allow manual control of the settings. The goal is for all these movements and displays to be dictated by a Parallax Propeller microcontroller chip that is connected to a Raspberry Pi single-board computer that will relay weather and time data from an open-source application programming interface (API).

The capstone group's general plan is to prototype the various mechanical movements to see if they are viable. Then, the entire project will be modeled in a computer-aided design (CAD) software to determine the placement of all the components and overall size of the project. Once the modeling is complete, the weather display will be constructed with traditional techniques as well as new, advanced manufacturing techniques such as 3D-printing, wood CNC milling, and laser cutting acrylic. The project is set to be completed working alongside fellow undergraduate students Lisa Accolla, Jack Davis, Katherine Ellis, and Joshua Rigby under the guidance of Professor Gavin Garner, Ph.D. It should be finalized in November of 2020.

STS Topic

Smart home technology refers to devices used within the home to digitally monitor, assist, and/or provide automated or connected services to residents (M. R. Alam et al., 2012; Sovacool & Furszyfer Del Rio, 2020). Though the idea of technology introducing more convenience into the home is not new, this market has grown rapidly in recent years. The smart homes market was valued at approximately USD 64.60 billion in 2019 and is projected to grow at a compound annual growth rate of 25% to USD 246.42 billion by 2026 (Mordorintelligence, 2019). Surveys indicate that much of this growth is due to the convenience, monetary savings, and energy efficiency associated with smart homes (Wilson et al., 2017). With this rapid expansion, the potential mental health risks this technology poses, from depression to overdependence to manipulation of the subconscious mind, should be analyzed now so they may be taken into consideration when developing smart home technologies in the future. After all, it can be argued that the spaces in which we live shape us as much as we shape them (Easthope, 2004).

The idea that the expansion of the technologies meant to connect people and technologies could cause negative mental effects has been around for many years now. In 2013, Rosen, Whaling, Rab, Carrier, and Cheever research this link between clinical symptoms of psychiatric disorders and technology use. This research concluded that technology use, and especially use of social media, could be used as a predictor for at least six personality disorders and three mood disorders. A similar study found that television watching and computer use were associated with anxiety and depressive disorders (de Wit et al., 2011). Smart home technology, by entrenching users deeper into the world of social media, would thus further this issue. Worst of all, many of the individuals studied had a positive view of these technologies and likely did not even consider the negative aspects they hold.

Beyond these psychiatric disorders, social media also poses a threat in the spread of misinformation and directing people to think certain ways. Some of this stems from numerous political disinformation campaigns which have been increasing in recent years (Exposure Labs, 2020). However, as Renee DiResta (2018) explains, much of this spread of misinformation is the responsibility of algorithms designed to show relevant information. These algorithms are unable to sift through what information *should* be given to the user and are so complex that even those who create such algorithms do not always know why they act they do. Similar algorithms are implemented in smart home technologies that may give daily news updates or social media updates to users. Algorithms with this much power and influence should thus be further analyzed before implementing in homes.

With the use of machine learning, algorithms have become so powerful that they could in fact be too dangerous in how helpful they are. In a representative survey of 1025 people, over half of respondents believed it could make household members lazy and, more notably, 77% of those surveyed agreed or strongly agreed that smart technologies risked increasing dependence on technology (Wilson et al., 2017). Over the years, this dependence would not only dull the ability to perform small tasks like cleaning but could lead to issues in routine. Algorithms present the dangers of creating bad habits but also creating reliance on technology for healthy routines. For example, a complex smart home system that adjusts lighting, sounds, and devices around the house to direct a user on to a healthy sleep schedule is great until the user travels or moves and is unable to stay on a healthy sleep schedule on their own. On the other hand, an algorithm that only seeks to please the user may recommend videos the user likes until late in the night, causing the user to binge television every night before bed, which is listed as one of the top five behaviors that ruins chances at getting good sleep (The Better Sleep Council, 2019).

This STS thesis will build upon previous research that analyzes effects of technologies on human psychology and behavior to attempt find the link between such negative effects to smart home technologies. Though much of the research on the unintended effects of smart homes currently stems from survey data, this thesis will examine the concrete data from studies linking psychological and behavioral changes to technology. This can then be used to draw conclusions on the negative effects that the expansion of smart home technology may have on psychology and human behavior.

Next Steps

Overall, though much research has been done to analyze the general effects of technology on psychology, the connection has yet to be made clear between the expansion of smart technology in the home and human behavior. There are two main connections that must be made in further researching this topic: the connection between technology and changes in psychology and behavior and how these technologies are ultimately being embedded in homes through the expansion of smart home technology. In the coming months, I will be working to locate scientific papers and studies that analyze psychological effects of the use of specific technologies as well as technology use in general. Further, I will study specific examples of smart home technologies to better understand and be able to explain how the aforementioned technologies are implemented within them.

References

de Wit, L., van Straten, A., Lamers, F., Cuijpers, P., & Penninx, B. (2011). Are sedentary television watching and computer use behaviors associated with anxiety and depressive disorders? *Psychiatry Research*, *186*(2), 239–243. https://doi.org/10.1016/j.psychres.2010.07.003

DiResta, R. (2018, August 30). Free Speech Is Not the Same As Free Reach. *Wired*. https://www.wired.com/story/free-speech-is-not-the-same-as-free-reach/

Easthope, H. (2004). A place called home. *Housing, Theory and Society*, *21*(3), 128–138. https://doi.org/10.1080/14036090410021360

Edwards, L., Torcellini, P., & Laboratory, N. R. E. (2002). A Literature Review of the Effects of Natural Light on Building Occupants. *National Renewable Energy Laboratory*, 58.

Exposure Labs. (2020). *'The Social Dilemma'—What is the social dilemma?* The Social Dilemma. https://www.thesocialdilemma.com/the-dilemma/

M. R. Alam, M. B. I. Reaz, & M. A. M. Ali. (2012). A Review of Smart Homes—Past, Present, and Future. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, *42*(6), 1190–1203. https://doi.org/10.1109/TSMCC.2012.2189204

Mordorintelligence. (2019). *Smart Homes Market | Growth, Trends, Forecast (2020—2025)*. Mordorintelligence. https://www.mordorintelligence.com/industry-reports/global-smart-homes-market-industry?gclid=CIjd6MXjydYCFYYDKgod4ZQFaw

Rosen, L. D., Whaling, K., Rab, S., Carrier, L. M., & Cheever, N. A. (2013). Is Facebook creating "iDisorders"? The link between clinical symptoms of psychiatric disorders and technology use, attitudes and anxiety. *Computers in Human Behavior*, *29*(3), 1243–1254. https://doi.org/10.1016/j.chb.2012.11.012

Schneider, B., Hanges, P. J., Smith, D. B., & Salvaggio, A. N. (2003). Which comes first: Employee attitudes or organizational financial and market performance? *Journal of Applied Psychology*, *88*(5), 836–851. https://doi.org/10.1037/0021-9010.88.5.836

Sovacool, B. K., & Furszyfer Del Rio, D. D. (2020). Smart home technologies in Europe: A critical review of concepts, benefits, risks and policies. *Renewable and Sustainable Energy Reviews*, *120*, 109663. https://doi.org/10.1016/j.rser.2019.109663

The Better Sleep Council. (2019, July 23). *Break Your Bad Bedtime Behaviors*. Better Sleep Council | Start Every Day with a Good Night's Sleep. https://bettersleep.org/blog/5-bad-sleeping-habits-to-break-immediately/

Weather Clock. (n.d.). Bramwell Brown Clocks. Retrieved October 25, 2020, from https://www.bramwellbrown.com/products/weather-clock-small

Wilson, C., Hargreaves, T., & Hauxwell-Baldwin, R. (2017). Benefits and risks of smart home technologies. *Energy Policy*, *103*, 72–83. https://doi.org/10.1016/j.enpol.2016.12.047