A Gesture-Driven Robotic Vehicle

A Study of the Social and Political Divide Caused by the Implementation of 5G Wireless Communication in Virginia

A Thesis Prospectus
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By
Nima Razavi

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Technical Team Members: Ruhul Quddus, Ian Le, Goutham Mittadhoddi, Kenny Zhang

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

Joshua Earle, Department of Engineering and Society

Adam Barnes, Department of Electrical and Computer Engineering

Introduction

The topic of the thesis is 5G and I want to ask this question: how do conspiracy theories and public disbelief in science affect the usage and security of 5G cellular communications. Overall, I think this is an important question to ask because creating an interconnected world requires belief in the structures that create and control cellular communications. However, with policy decisions changing frequently with evolving leaders in power (and public perception that influences policy) in all countries, it's important to investigate the possible sources of division within the people who are governing 5G policy. I will be investigating the politics and science behind 5G and how the current climate of disbelief in authority and science (especially in response to the COVID-19 pandemic) has shifted how people interact with 5G. I want to see how the politics governing the implementation and release of 5G impacted how the public's perception of telecommunications has changed over time. The method in which most cell phones in the world communicate with the wider network is through the 5th generation of the broadband cellular network, known as 5G. The actual technology of 5G comes in many forms all aimed to increase throughput, or how fast information is being sent and received. The technology used in this 5G protocol has politics embedded in both its creation and the public's response to its release.

My technical project is the creation of a gesture driven robotic vehicle. My STS project looks at the social response to 5G technology in Virginia and how conspiracy theories and pseudoscience have affected this response. The research topic for my prospectus relates to my technical project because we will be utilizing forms of wireless communication and manipulating their structure for safety purposes within the scope of our project. As our technical project could be scaled up, the 5G infrastructure will be leveraged to improve our product. I want to see how

5G and how policy decisions affect the implementation and compliance with 5G. Essentially throughout my research, I want to see how policy guides the implementation of 5G and how public perception shapes the policies made about 5G. I also need to look into the literature and press releases on how different administrations are governing 5G. Overall, I would like to write my prospectus on this topic because the future of the internet and communications relies on how we implement 5G and I think it is an intriguing topic.

Technical Project

Over the past decade, interest in human-robot collaboration has grown drastically. Rapid advancements in hardware design and firmware platforms, such as ROS, have enabled the creation of advanced robotic systems able to cooperate with humans in both home and industrial environments. In fact, interest in applied robotics has especially increased among middle and high school populations. Currently, many high-school robotics competitions revolve around solving real world problems by having students design complex robotic systems while acting as robot operators. Thus, our project will dive into this growing interest by creating a gesture-driven robotic vehicle marketed towards STEM-interested teenagers. Although this project does not tackle any obvious real-world problems, it enables teenagers to explore applied robotics by providing a fun and approachable entry point for developing interest. Fostering the next generation of young engineers is critical for advancing society and technology.

My technical capstone project will create a gesture driven toy car for use by teenage tech enthusiasts. There are two components to this project: a glove that tracks the hand gestures of the user and a toy car which the user is controlling. The glove takes in gyroscope and accelerometer data from two MPU6050 sensors placed on the glove on the back of the palm and thumb. A Raspberry Pi Pico W transmits sensor information wirelessly using the Pico's built in IEEE

802.11 and Bluetooth capabilities. This project is designed to have all components on the glove fit comfortably in the limited surface area of the hand. The toy car's motors will be driven by a motor controller through ROS commands from another Raspberry Pi Pico W. The glove and the car will be powered by 9V batteries. All components are readily available and easy to manufacture, making the project fit for mass production. The low cost of components will allow the car to be sold for reasonable prices to similar toys. Additional components can be integrated to enhance user experience. An example of this would be a mounted camera on the car allowing a user to have a live view from the car's front facing view.

This fundamental design for gesture-driven control is also present in more involved projects. In one project presented at the International Conference on Nascent Technologies in Engineering (ICNTE), engineers presented a similar hand-motion controlled robotic car that could additionally be toggled between automatic movement and gesture-driven movement (A. Sultana et. al). Moreover, engineers at the ISL Engineering College applied this idea further by designing a gesture-driven grass cutting vehicle powered by solar energy (Pabarekar et. al). All these adjacent projects feature a similar fundamental design: mounting an accelerometer or gyroscope on the user's hand and transmitting the data over the Raspberry Pico's built in Bluetooth transmitter to be translated by the vehicle.

Although our project is similar in concept, it differs in a few key areas. For one, we will focus much more attention on the user-control side of the project. Rather than using a single, rigid device, we will design a controller glove that is both modular and visually appealing. Specifically, the glove will feature two separate sensors for controlling the speed and rotation of the car, as well as a vibrational motor for haptic feedback. Furthermore, one of the sensors, mounted on the thumb, will be responsible for toggling the car into precision mode, whereby the

user can control the vehicular motion more tightly. Another key distinction is the data transmission protocol. Rather than using unencoded custom RF signals, we will be transmitting data via a Bluetooth socket between two Raspberry Pi Pico W's using the connection handshake and packet structure of the Bluetooth protocol.

My technical capstone project relates to my STS research topic through the possible implementation of 5G into the larger upscaling and realization of my technical project. As the world of connected devices, an Internet of Things can provide faster communication and interconnectedness of all devices. My technical project incorporates a wireless communication component. A large-scale mass production of my technical project will most likely incorporate 5G technology.

STS Project

As seen in the technical project, it is evident that 5G technology can be a powerful force. However, just as telecommunications has been regulated since its conception, 5G will be impacted by political forces. The government controls telecommunications through several government agencies. The roll out of 5G has also been used by some to spread misinformation. A cellular protocol with the intention of simply providing information in a faster method has led to some using pseudoscience to manipulate the reality of 5G to further conspiracy theories about COVID-19. This misinformation has seeped into the politics of how 5G is regulated through politicians who choose to believe those conspiracy theories.

Key Texts

My sources are going to be representative of public opinions on 5G and how fear of 5G fuels policy implementations of 5G. For instance, the city of Mill Valley, located a few miles

North of San Francisco, severely restricted the placement of cell towers over “cancer concerns” because of the “29 to 1” ratio of letters in support of the restriction even though the new 5G antennas have reduced radiation emissions compared to 4G antennas (Crichton). The focus of my thesis will be on Virginia and concerns about 5G in Virginia are very present. In Virginia Beach the local government is attempting to gain control of regulations on where small cell towers are deployed on the oceanfront (Bonessi, 2022). In Montgomery county, Maryland, a county bordering northern Virginia, Bonessi describes the turbulence during a council meeting concerning 5G. When discussing a commission which was tasked with the rollout of 5G, Bonessi notes:

> “The county governments also accused the commission of failing to update its radio frequency safety standards […] ‘I do not consent to radiofrequency microwave radiation,’ Anne Pritchard, a former registered nurse and longtime resident of Silver Spring, told the council last month” (Bonessi, 2022).

The use of 5G by conspiracy theorists to weaponize 5G has caused some to believe in this pseudoscience and the fear of “cancer concerns” is just one way this fear has manifested and propagated. By shrouding the fears of 5G in half truths about radiation, conspiracy theorists spread a false message believed by individuals who accept the logic of the conspiracies without conducting more research which can easily disprove the conspiracy claims. Conspiracy theorists used 5G after it has been released to attempt to sway politics by sewing in pseudoscience to the truth of what 5G actually is. The fight over 5G in Virginia is a particularly challenging problem to tackle because of how culturally diverse the area is. With farmlands in southwest Virginia and industry and military contractors in northern Virginia, it is a uniquely situated state that requires taking into account all parties involved in making 5G policy. For instance, there has already been

push back from the Department of Defense in northern Virginia on companies establishing 5G networks for private residential areas (Alleven, 2022). The sensitive nature of work near northern Virginia has forced Ligado, a company tasked with implementing the new 5G infrastructure, to completely end its 5G trial in northern Virginia. The concerns of 5G from Department of Defense officials, whether founded on truth or on speculation prompted by conspiracy theorists, is now preventing 5G access in northern Virginia. The proximity of northern Virginia to Washington DC and the secure government installations in northern Virginia like the CIA limits the ability to deploy 5G in Virginia. On the polar opposite side of the 5G battle in Virginia is Craig County, a small southwest Virginia county looking to implement 5G despite being in a rural, sparsely populated area of Virginia. Yancey of the Cardinal News (Yancey, 2022) notes that because of the efforts of a local council member who reached out personally to the CEO of T-Mobile, the county has welcomed expanded access to 5G by building a substantial 5G infrastructure in Craig County (Yancey). Compared to neighboring Giles county with broadband access to 30.4% of residents, Craig county has 92.6% access, higher than affluent Loudoun County and above the state average for Virginia (Yancey, 2022). Yancey notes that Craig county has seen "a veritable flood of new residents" with "local businesses [and farmers] now able to sell their goods online" (Yancey, 2022). Yancey's article gives another perspective in the 5G battle with problems specifically in Virginia. Craig County is a prime example of how the implementation of 5G is uniquely being shaped by the geography and demographics of Virginia.

STS Methodologies

STS methodologies can be incorporated to justify upgrading to 5G in the first place and explain the social reasons for its resistance. To understand the utilitarian need for 5G, Bijker in *The Social Construction of Technology* examines the reason it is vital to continue to evolve

systems. The book focuses on the very broad interaction between technology and humans. The specific section I have focused on for my thesis is on "The Evolution of Large Technological Systems" (Douglas, page 54, 2012). Bijker succinctly summarizes the struggle between humans and large technological systems as messy and complex (Douglas, page 52, 2012) and thus enveloping the relationship between humans and 5G (as one of those large technological systems). Bijker notes that a system should be considered to be outdated when the load factor of the technology can not supply the expected output of a system. The load factor according to SCoT is "the ratio of average output to the maximum output during a specified period of time" (Douglas, page 66, 2012). Essentially, it is how change is necessary for large technological systems. The load factor is what determines how efficient a technological system can be since over time the system will be obsolete if the curve of the load factor is decreasing over time. This means that compared to what it could be maximally producing, the technological system is not being utilized to its full potential. This downward trend is the indicator for when an old system must be replaced. If it is no longer matching the maximum potential it once had, either through lack of demand by consumers or physical stressors, the system must be replaced. Bijker says this is an imperative improvement that needs to be made: "the load curve that indicates the load factor, or the utilization of investment and related unit cost, is a much relied on indicator of return on investment. [When the load factor is low] the managers of a technological system try to expand the system in order to acquire a more desirable load or diversity" (Douglas, page 66, 2012). The load factor is the bridge from determining if the current status of a technological system is a more economic solution compared to newer or better options. Studying the load curve gives a quantitative measure of the success of the system. By placing numerical values on the average and maximum outputs of a system, a quantitative approach can determine if the

system is outdated. This framework of quantitatively describing a system through its performance is the best utilitarian way to determine if a system should be implemented or not and the implementation of 5G should mirror this approach as opposed to an approach based on pseudoscience. Bijker's use of the load factor favors a quantitative approach to the pros or cons. Through the SCoT framework, Bijker explains why the best approach to determining the safety or effectiveness of a technological system is through quantitative measure as opposed to a vague fear of change.

From the SCoT framework, the social groups that are addressed in my thesis will be civilians who utilize or are prevented from using 5G technologies for personal or business uses, civilians who live near 5G towers, and government entities such as the FCC. The government entities are responsible for the allocation of 5G spectrum and 5G implementation rules. As noted in the Yancey article, civilians rely on 5G technologies for their livelihoods and the introduction of 5G technology to an area can be vital for the economic growth and prosperity of a group. As seen in the Crichton and Bonessi reading, the people near 5G towers required for the distribution of 5G capabilities play an important role as well and are a group that needs to be accounted for when conducting research about 5G deployment.

Conclusion

Overall, the next steps are to look for more primary sources on my more narrow topic of 5G in Virginia. In looking to differentiate my thesis from others, I reviewed the prospectus of Richard Zhou (Zhou, 2022). I chose to review this prospectus because it also investigates the controversies and politics behind 5G deployment (Zhou, 2022, page 1). After reading Zhou's prospectus, I think that considering the whole world for the focus of my prospectus and thesis

would be too broad to tackle and provide meaningful explanations. Each region of the world has different degrees of 5G deployment and is administered by very different governments and officials. Focusing on Virginia, and maybe even more within the Charlottesville area, would focus my paper and be more digestible to the audience without trying to provide very wide reaching claims. For this, I need to conduct a more thorough search of articles and papers focusing on 5G deployment in Virginia.

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