Thesis Project Portfolio

‘Origami’ Horn Antenna for Contactless Vital Sign Monitoring

(Technical Report)

Government Use of Technology in Surveillance

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

Surveillance technology has become prevalent on a large scale, permeating throughout society and everyday life. Some aspects of this technology are innocuous and helpful, however surveillance has also been used for morally ambiguous purposes. Surveillance can be conducted through a popular type of artificial intelligence called facial recognition technology. Facial recognition technology has a myriad of uses, yet since it is a new technology, there are ongoing debates as to how the government should regulate and use this technology. Governmental regulation and use of this technology, specifically for law enforcement use in the commonwealth of Virginia, is the focus of my STS research project. While this research is important to understand arguments surrounding the regulation of this new technology, its importance can be similarly applied to potential new surveillance uses of technology that I have developed for my technical research project. In my technical research project, I develop affordable, non-contact vital sign measurement systems intended for clinical use. While their initial intent is clinical, there are a number of ways in which my technical project can be used, for example, by law enforcement searching a home for suspects without a warrant. Due to the potential for immoral use of both of these budding technologies, I hope that my research can bring forth novel, quality advancements while still being conscious of how legislation could serve to limit the negative downstream potential uses of such advancements.

The intent of my technical research project was to develop affordable, non-contact vital sign measurement systems. We did this by transmitting and receiving millimeter-wave frequency radio waves through a copper horn antenna, which is a well-known method for determining heart rate or respiration rate by measuring small displacements in the chest. While horns which can be used for this purpose are already available on the market, their costs range from approximately

$1000 to $3000, with little variability in different sizes of horns that can be purchased. By creating a python program which takes in intended horn dimensions and converts them to a 2D geometry, we were able to 3D print flat horns with extremely low-cost printed circuit board bases and thin copper outer layers. Once these flat horns were fabricated, we folded them into their intended 3D shapes and soldered them together. Once the horns were in the 3D shape, we tested them by comparing their waveform to that of commercially available horns of the same shape, determining that our 3D printed models were qualitatively similar to the approximately 400 times more expensive commercial horns. These results led us to believe that our technology can be used to make the horns necessary for non-contact vital sign measurement cheaper and more customizable, allowing for financially feasible use in the clinical setting as well as for increasing innovative scope through customization for other related uses.

The focus of my STS research paper was to determine how far governmental powers can ethically extend their use of facial recognition technology by examining claims made by various groups both in favor of and opposed to Virginia's recent legislation regarding the use of the technology by state and local law enforcement agencies. Using a framework created by the Georgetown Law Center on Privacy and Technology as well as the Virginia bill's official summary, I compared concerns about the bill's impacts to its actual verbiage in the cases of each of the four most common uses of the technology by law enforcement. I found that the bill adequately addressed concerns and provided a good layout for proper use of the technology in two of the four most common use cases. However, I also found that it did not do enough to curtail risk of immoral action in a third case. Furthermore, in the fourth common use case, the bill actually detrimentally affected both law enforcement and interest groups opposed to the technology, resulting in a "lose-lose" situation. I hope that my analysis and these frameworks can

be repeated in other jurisdictions to ensure that future legislation curtails risk of misuse while still helping law enforcement agencies perform their jobs more efficiently.

Overall, my research did achieve its goals by advancing my technical project to a near market-ready state as well as by providing analysis into legislative action that can be used in the future to make better legislation. I am happy with the state of my research this year, and I hope that future groups can advance my antenna design project to market as well as continue to scrutinize, iterate, and improve future legislation that impacts how budding technologies are implemented by law enforcement.