Application of Radar Techniques in Human Body Scanning at Security Checkpoints

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SICA-LAB

ALERT — Awareness and Localization of Explosives-Related Threats

Abstract

A radar system using Compressive Reflector Antennas (CRAs), multiple-input-multiple-output (MIMO) feeding arrays, and millimeter waves was created to detect biological matter and generate images based on radar feedback. The primary objective of this project was assisting with mechanical support for ongoing testing involving millimeter wave scanning through the development of prototype 3D models. 3D printed parts will be used to house or mount hardware. They are instrumental to the experimentation and continuation of research involving this radar system because they are an inexpensive option during the prototyping phase. These parts are modeled in SolidWorks after extensive planning, measuring, sketching, and designing. After printing and testing, the parts undergo additional refining to improve their design and functionality. This process results in parts that can be used in furthering the research because of their inexpensive cost and flexibility in solving problems. Becoming comfortable using and navigating the SolidWorks program is a major aspect of creating prototype parts.

Background

The possibility of assessing a large area of space with millimeter waves allows for numerous applications for the use of these waves in detecting biological material. In the Martinez lab, one of the main focuses is on the use of millimeter waves in security checkpoints at public and private buildings or events.

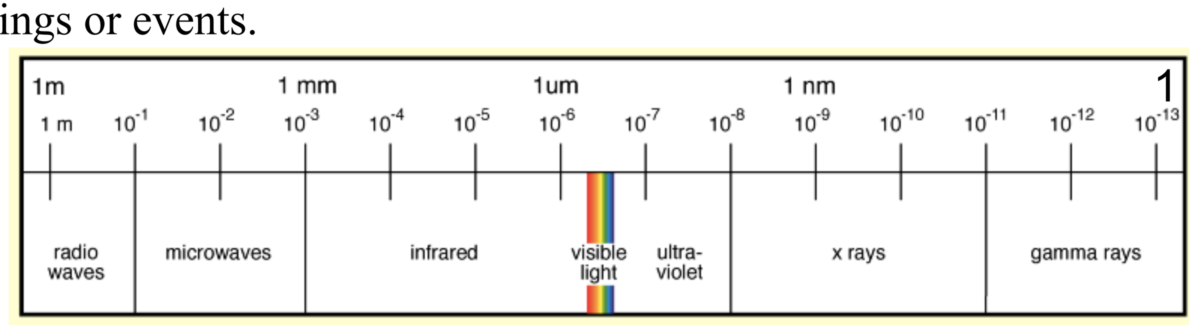


Figure 1. Millimeter waves have shorter wavelengths and a higher information capacity than wifi waves. In addition, they are impeded by biological matter, making them ideal for radar.

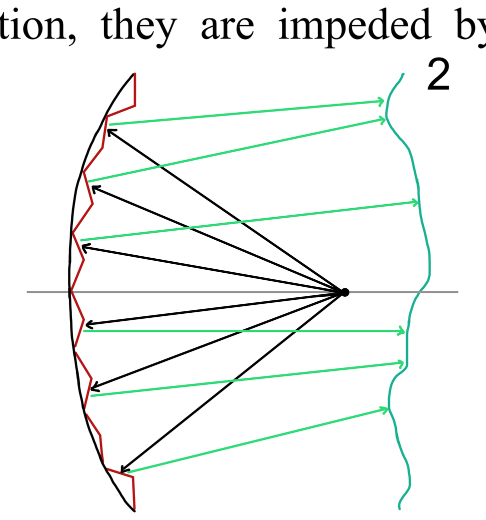


Figure 2. MIMO feeding arrays are a series of transmitters that emit millimeter waves and receivers that collect them. The transmitters shoot the millimeter waves in a conical shape at the parabolic antennas, or CRAs, which reflect the waves and create a wider beam width so the waves cover a larger area of space.

Project Objective

Assist with mechanical support for ongoing testing involving millimeter wave scanning through the development of prototype 3D models with the intention to support, conceal, or protect hardware used in the research.

References

Figure 1 - The Electromagnetic Spectrum. (2018, August 25). Retrieved from http://www.columbia.edu/~vjd1/electromag_spectrum.htm

Figure 2 - Molaei, A., Juesas, J.H., Allan, G., & Martinez-Lorenzo, J.A. (2016). Active imaging using a metamaterial-based compressive reflector antenna. *2016 IEEE International Symposium on Antennas and Propagation (APSURSI)*, 1933-1934.

Methods

Drafting
- Initial brainstorm to discuss ways of supporting, concealing, and protecting hardware
- Develop ideas without definitively choosing a prototype design

Designing
- Determine the constraints of the part
- Conduct measurements with a caliper
- Sketch design based on previous ideas and redesign to fit observed constraints as seen in Figure 3

Modeling
- Model design in SolidWorks program after further brainstorming
- Conduct design review with members of the design team who did not participate in design process

Printing
- 3D print part on a Fused Deposition Modeling (FDM) printer using Acrylonitrile Butadiene Styrene (ABS) plastic as seen in Figure 4

Refining
- Evaluate for efficacy and compatibility with its environment
- Further revisions to computer model based on observations
- If possible, manipulate the prototype to work temporarily

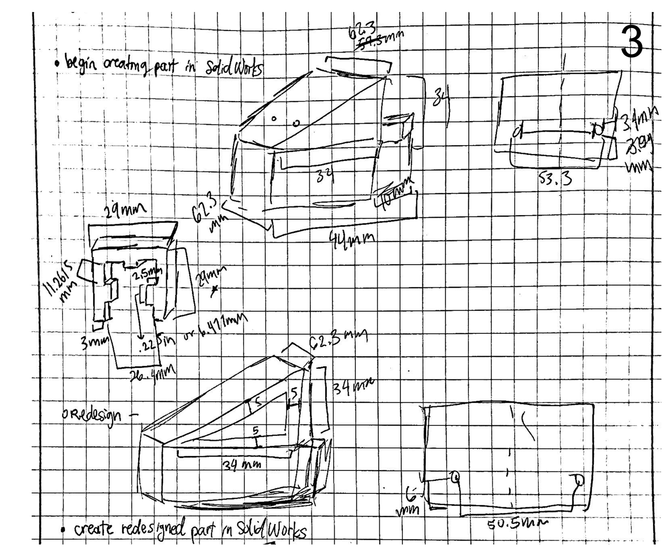


Figure 3. Several sketches are made when designing T-slot mount.

Figure 4. The printed piece will be redesigned if necessary.

Results

One part is designed with a few variations with the intention of being mass produced for the research purposes of the lab. Another model is created with three parts to house delicate hardware and conceal interior elements.

Figure 5. This T-slot mount secures a transmitter to be used for test evaluation. It is designed so the transmitter is resting against the triangular protrusion. There are screw holes to secure the transmitter and mount.

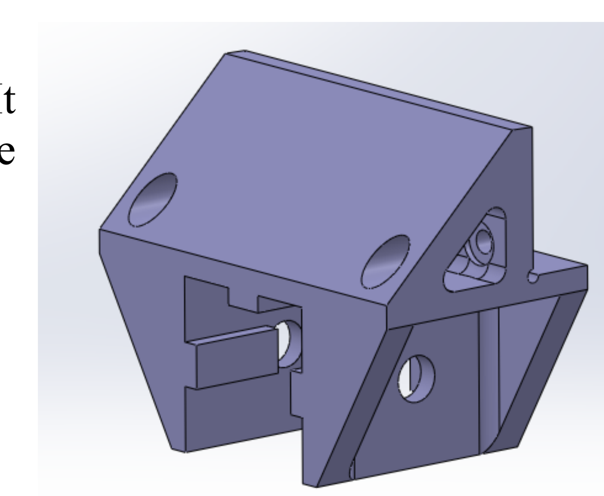
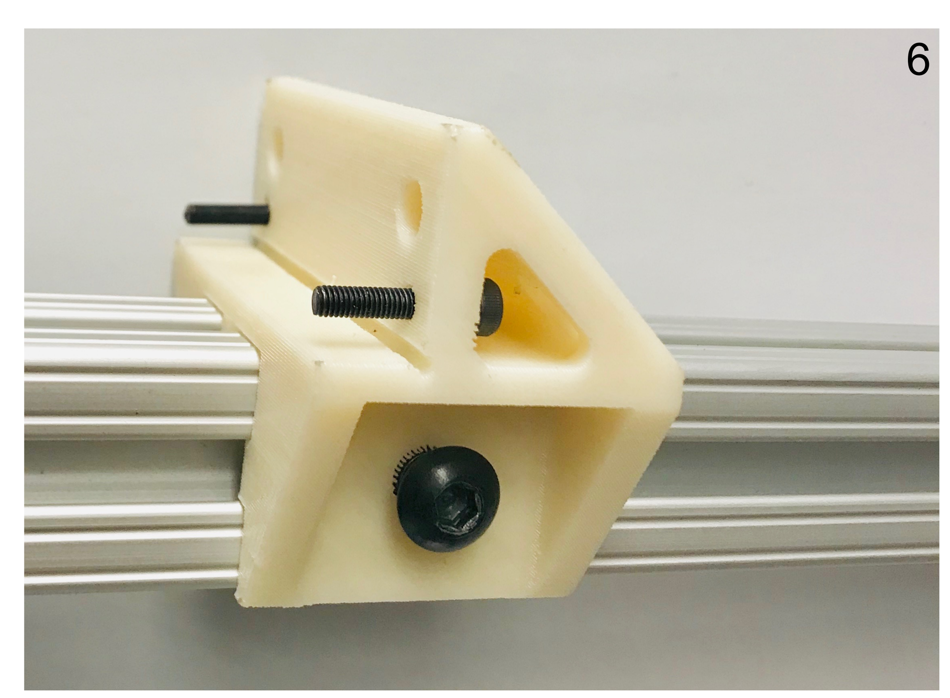


Figure 6. This is the printed prototype of the model above. The circuit board connects to the back of the piece through screws, but is not pictured for confidentiality. The bottom slides onto a 1x1 T-slot rail.



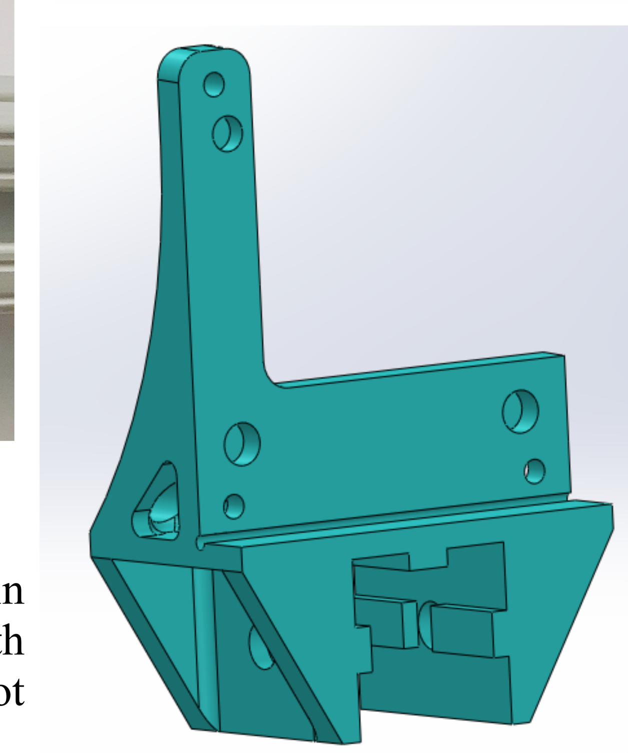
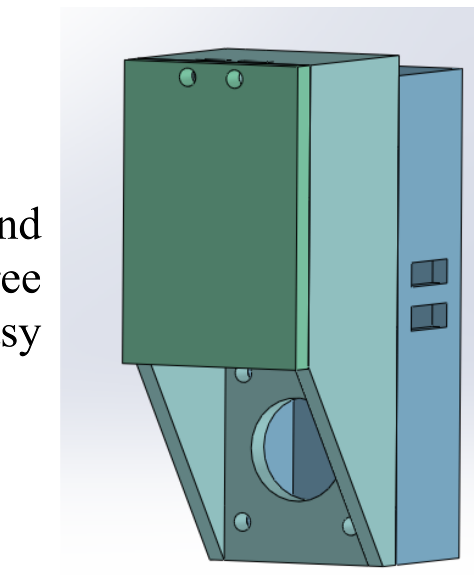


Figure 7. This model is an alternative design to the T-slot mount modeled in Figure 5. It has the same base design as Figure 5, but includes a protrusion with the intention of giving extra support to the transmitter. This design is not printed because the prototype in Figure 5 worked sufficiently.

Results Continued

Figure 8. A module is created to house and conceal fragile hardware. The module has three components, one being a cap to allow for easy access and serviceability.



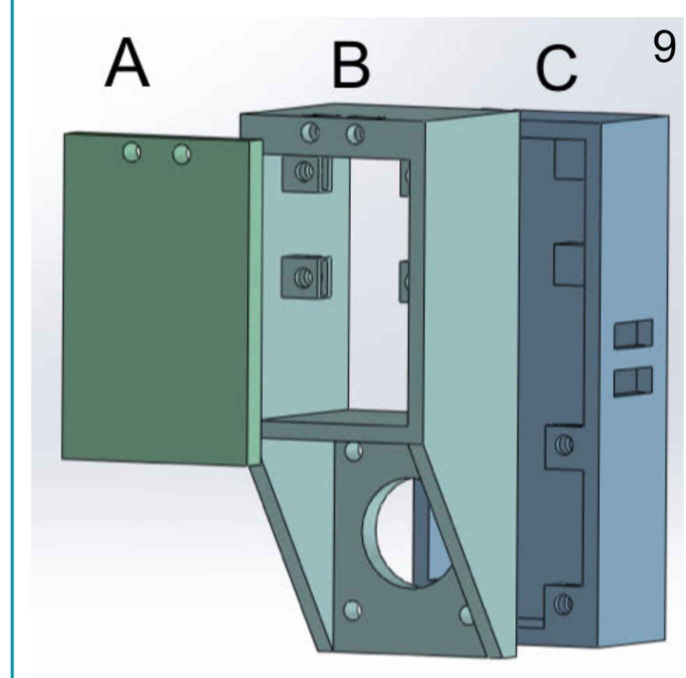


Figure 9. Captive nuts are used to hold together the module and pin a phased array in place. Slots on the side of component C and a circular cutout on component B allow for communication with external hardware.

Conclusions and Future Steps

Becoming comfortable using and navigating the SolidWorks program is a major component of creating these prototype parts. In particular, easily adjustable models are important in allowing for quick changes during the design review process.The limitations of FDM printers and ABS plastic (mainly that the low resolution of the printer makes detailed parts difficult to print with accuracy) are discovered through the creation of multiple prototypes. Problem solving with SolidWorks and 3D printing offers an inexpensive option when prototyping, skills that are useful in solving a multitude of engineering problems. Solving these problems requires an awareness that conditions can change quickly, and the parts must be able to adapt to these changes. The model should be created in a way that anticipates these changes and allows for efficient modifications if necessary. It is also important to make the model user friendly so all members of the research team can use it without knowing the design intent. The design process requires considerable time and effort to create accurate prints that achieve their task in a simple and adaptable way.

Acknowledgments

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