COMPACT AND FAST-SCANNING PASSIVE mmWAVE IMAGING TESTBED

Furdeen Hasan, (BCpE)[1,2], Gregg Marella, (BEE)[1,2], Thomas Dillon, (Ph.D)[2], Mark Mirotznik, Ph.D[2], Vishal Saxena, Ph.D[2]
University of Delaware | Center for Composite Materials¹ | Department of Electrical & Computer Engineering²

Introduction

- **Passive millimeter wave (mmWave)** imaging technology can detect ambient radiation in millimeter wavelengths (30-300 GHz) on the electromagnetic (EM) spectrum.
- This technology is used to detect differences in thermal emissions from a distance, useful in applications such as airport security or medial diagnostics.
- The equipment used in the experimental setup, is a COTS Radiometer from Farran, operating in the W-band of the EM spectrum (75-110 GHz).

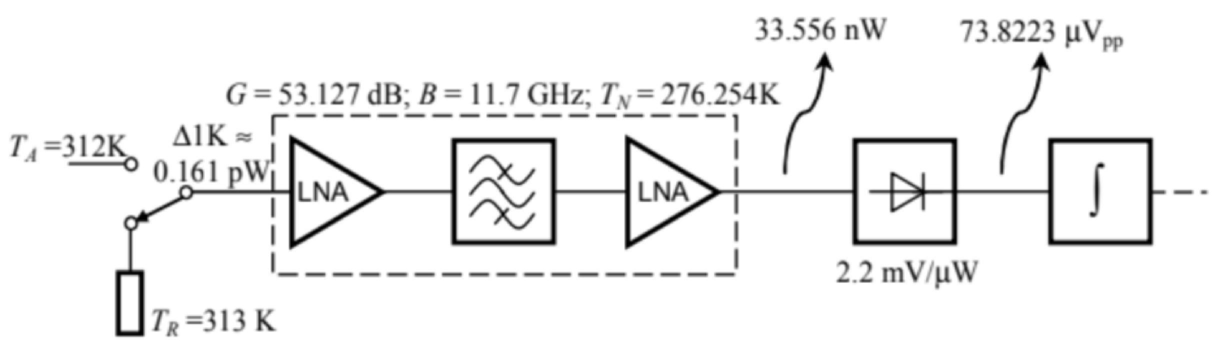
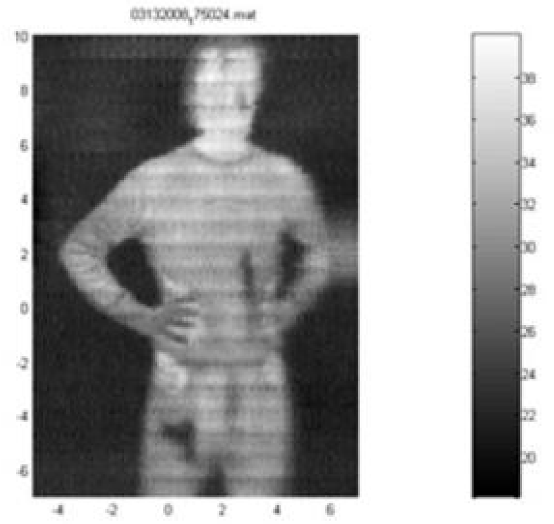


Fig. 1 Farran Radiometer block diagram

[1] M. Sostronek, R. Beresik, and M. Matejcek, "A W-band Imaging Radiometer measurement in near field of antenna," 2018 New Trends in Signal Processing (NTSP), Oct. 2018. doi:10.23919/ntsp.2018.8524067

- ***Fig. 1*** illustrates the COTS Radiometer's low noise amplification (LNA) circuitry to detect small voltage differences.



- ***Fig. 2*** displays a passive mmWave image of a person with a concealed handgun and ceramic knife.

Fig. 2 NIST PmmWI image
https://www.nist.gov/programs-projects/terahertz-imaging-and-sources

Project Objective

- Current mmWave imagers are expensive, immobile, and oftentimes time-consuming.
- **Objective:** create a cost-efficient, mobile, passive mmWave imager to produce high-quality and efficient scans.

Methodology

- Incorporated a Raspberry Pi single board computer (SBC) for system control.
- Utilized a three axis linear stage to create a continuous, back-and-forth, square-plane motion, comprehensively capturing mmWave data.
- Converted the analog output from the Farran Radiometer to a digital signal using an analog to digital converter (ADC), creating discrete data points that aligned with real-time scanning positions.
- Included a Rexolite, aspherical lens designed for W-band operation, as seen in ***Fig. 3***.

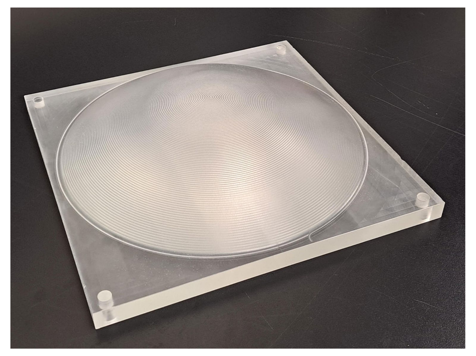


Fig. 3 Focus-enhancing dielectric lens

- The custom designed lens was determined to be in focus at 12 inches in front of the radiometer.

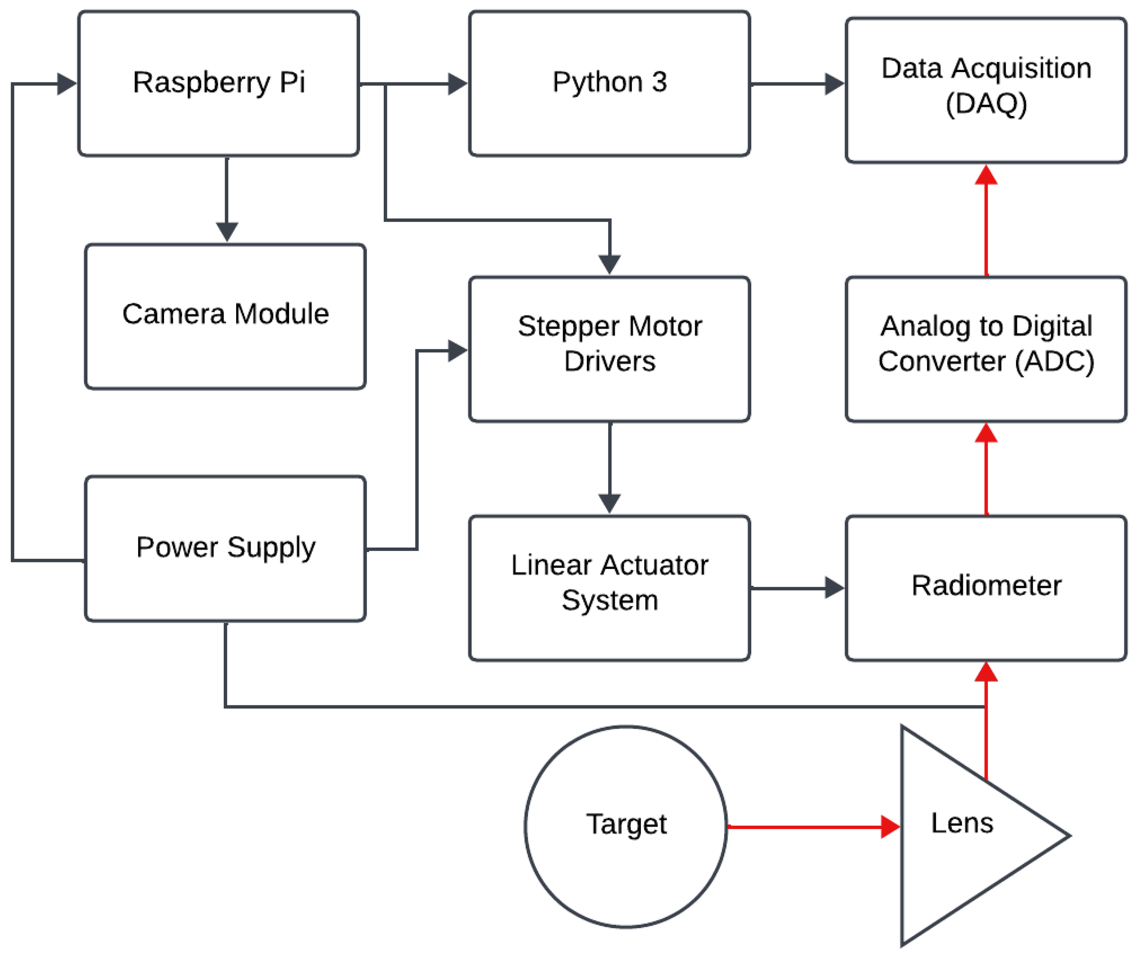


Fig. 4 System diagram of the experimental setup

- Wrote Python scripts to control system operations including the linear actuator movement, data acquisition, and visualization.
- Using CAD software, designed and 3D printed custom mounting components to assemble the experimental setup.

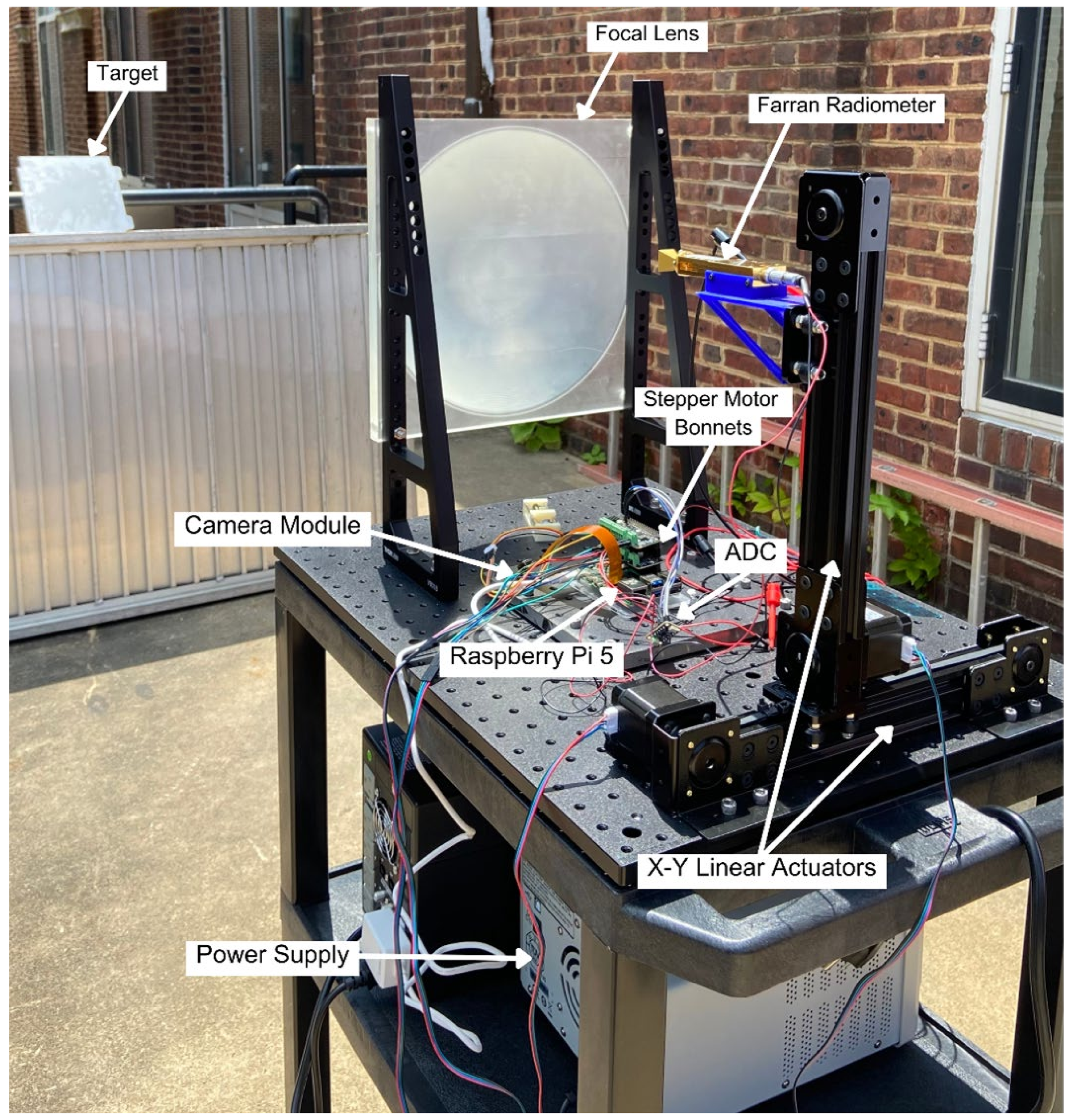


Fig. 5 Experimental setup with a passive mmWave source target

- In ***Fig. 5***, the passive mmWave system is compiled onto a compact, rollable cart for increased mobility.

Results

- Data processing was done using Python libraries including NumPy for numerical computations, SciPy for data smoothing, and Seaborn for data visualization.

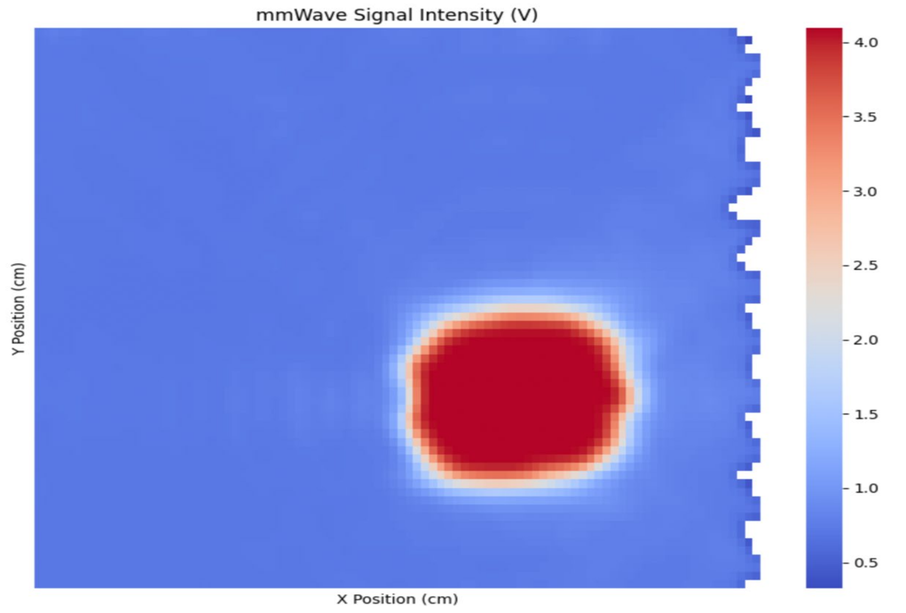


Fig. 6 Active source mmWave experimental image

- Data represented in ***Fig. 6*** illustrates a scan of an active mmWave source, which creates a clear contrast between the source and its surroundings.

- The experimental setup in ***Fig. 5*** yielded the heatmap in ***Fig. 7***.
- ***Fig. 7*** conveys contrasts in ambient temperatures due to the metal sheet, reflecting the sky at a colder temperature.

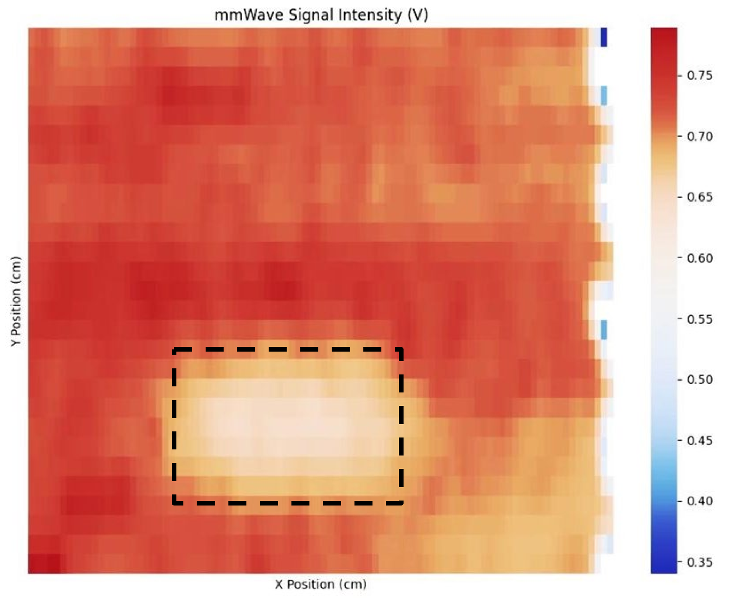


Fig. 7 Passive mmWave source target experimental image

Future Work

- Expand the Passive mmWave Imager's use to image passive targets with more complex designs.
- Incorporate chopping, using a pin-switch, to improve the signal to noise ratio.
- Refine data display by removing invaluable data points.
- Further increase portability by designing a casing and implementing a tripod for mobility.

- ***Fig. 8*** depicts a passive mmWave imager, mounted to a tripod, to create a mobile device capable of operating on different terrains.

Fig. 8 Thruvision Passive TAC16 mmWave Imager
https://thruvision.com/resources/#datasheets/

Acknowledgements

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