Building a High Performance, Flexible Multi-Modality Millimeter-Wave Imaging Radar Person-Screening Testbed

Spiros Mantzavinos, Kathryn Williams, Borja Gonzalez Valdes, Galia Ghazi, Yuri Alvarez, James Rooney, Justin Rooney
Professor Carey Rappaport, Professor Jose Martinez, Richard Moore

Abstract

The AIT group is developing a new hardware platform consisting of mechanical and electrical subcomponents for capturing imaging data in a multi-static radar environment.

With the proposed architecture approach along with innovative algorithms the result will have highly improved resolution compared to leading edge systems available on the market today.

Relevance

- Bridging the gap between high-performance, commercially available technology components and security requirements
- Improved technology platform and algorithms will reduce detection errors and decrease false positive results
- Developed infrastructure is modular, expandable, and scalable. It can be used for a variety of applications relevant to Homeland Security

Impact

- Resulting platform will be available to validate a multitude of software and mathematical algorithms
- Future advancements in industrial and commercial electronics will be leveraged directly into new revisions of the hardware platform
- The mechanical and electrical platform will advance state-of-the art; expand field of knowledge through graduate student research, conferences, journals
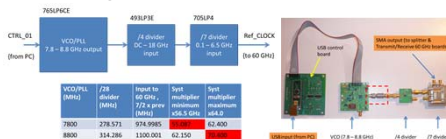
Electrical

Background

- Using 60 GHz technology for high-performance, wide bandwidth, short range unlicensed operation
- Wide bandwidth allows for high resolution

Concept

- 60 GHz integrated chips are available for WirelessHD, Wireless Gigabit standards
- Use transmitter/receiver system as core building block


Concept architecture and prototype source

Architecture and Current Status

- Lab hardware in process of being debugged for system validation
- Software integration to decrease mechanical and electrical scanning time
- Algorithm debugging

FMCW SAR

- Received access to 2D (planar) FMCW radar at Reveal Imaging Technologies as part of a DHS sponsored summer internship.
- Replaced non-functioning hardware and wrote code to control hardware and collect data in monostatic and multistatic configurations
- Wrote matched filter SAR imaging algorithms that convolve the theoretical response from a point source with the received signal to generate a target image at the specified depth.

The data to the right shows the image from a 1D horizontal scan in a multi-static configuration using the matched filter imaging algorithm
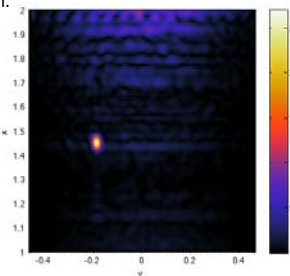
Software

- Ties the gap between electrical and mechanical components
- Provides controls from multiple software modules into a single interface

Program used to create automated tests

Program capable of executing automated tests

Design Advantages

- Provides the ability to create and run tests that would otherwise have to be run manually, therefore reducing debug time
- Written from the lowest level register settings allowing rapid revisions to accommodate the changing needs as the project progresses
- Written primarily using LabVIEW to leverage its rapid development time and advanced data acquisition capabilities

Mechanical

- Aluminum structures provide predictable responses that can be easily accounted for in the imaging algorithms.
- Electrical equipment located on top of the gantry simplifies hardware integration and allows shorter signal cables.


Transmitter Geometry

Novel transmitting antenna is a doubly curved offset reflector with vertical parabolic variation and elliptical horizontal variation, with common focal point

- "Blade Beam" gives 1cm horizontal illumination stripe on body
- Switched planar receiver array arc for fast multistatic 2D inversion
- Translation in height for stacked 3D reconstruction

3D model -> physical build

Measurement, evaluation, fine tuning
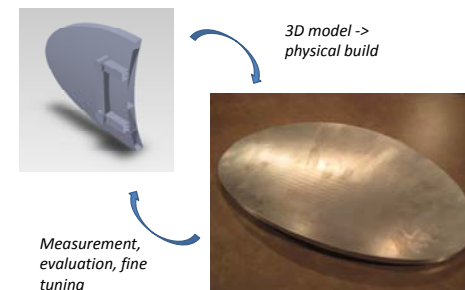
Collected Data

A sample of some data collected with the radar is shown below. This test shows the linear phase change with motion for a given frequency. It also shows that the rate of phase change varies with the final output frequency. This is a crucial requirement to prove that the radar is working as intended and is capable of collecting data that can be used for imaging.
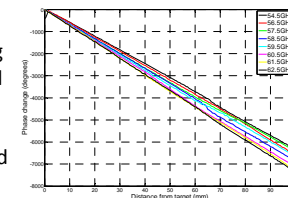
Other References

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