RISE:2013
RESEARCH, INNOVATION AND SCHOLARSHIP EXPO

Graduate
Category: Engineering and Technology
Degree Level: Master of Science in Electrical Engineering
Abstract ID#205

Northeastern University

ALERT
AWARENESS AND LOCALIZATION OF EXPLOSIVES-RELATED THREATS

Low-Cost, Fused Millimeter-Wave and 3D Point Cloud Imaging for Concealed Threat Detection

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Abstract

The growing need to detect non-metallic, concealed threats at venues ranging from airports to sports arenas has created a demand for low-cost, close-range whole-body imaging systems. The adaptation of low-cost wireless communication hardware for millimeter-wave imaging has made possible to design a system that satisfies this demand. The integration of 3D point cloud data has created a multi-modal, fused system that leverages both imaging technologies.

Introduction

The millimeter-wave imaging system is designed to provide imaging performance greater than the current state-of-the-art whole-body imaging systems using lower cost hardware. The addition of 3D point cloud imaging provides data to reduce millimeter-wave imaging time as well as advanced opportunities for concealed threat detection.

Technical Approach

Millimeter-Wave Radar System Configuration

The millimeter-wave imaging system uses a parabolic ellipsoid reflector that focuses the transmitted energy to a thin strip along the body. The reflected signal is sampled by an array of receivers along an arc above and below the reflector. This allows for 2D images that are then stacked to produce a 3D reconstruction.

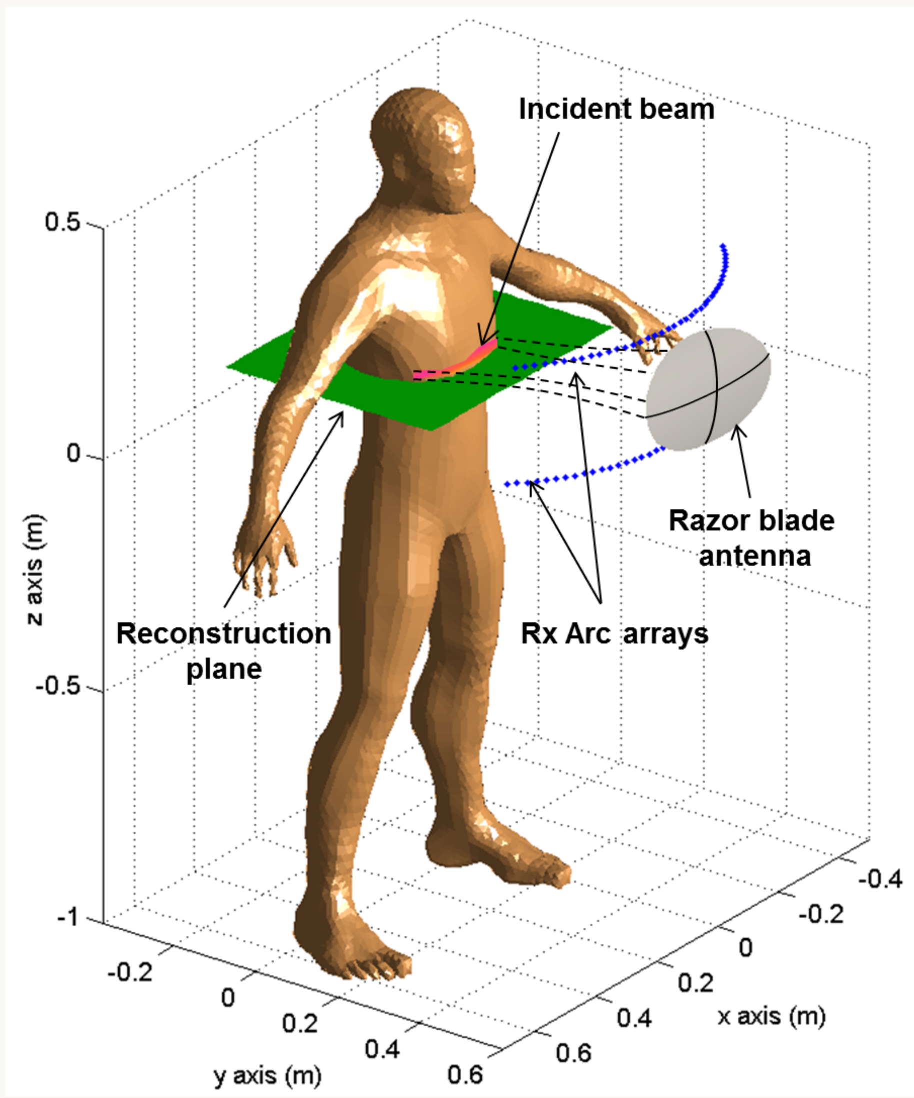

Fig. 1 - Proposed mm-wave system configuration

The reflector and receiver arcs are vertically actuated to generate a 2D image every 1 cm because the reflector creates a 1 cm wide illumination on the surface of the body.

Millimeter-Wave Radar System Implementation

The first implementation of the millimeter-wave radar uses a single receiver that is rotated to simulate the arc of receivers. The vertical motion is applied to imaging target for mechanical simplicity.

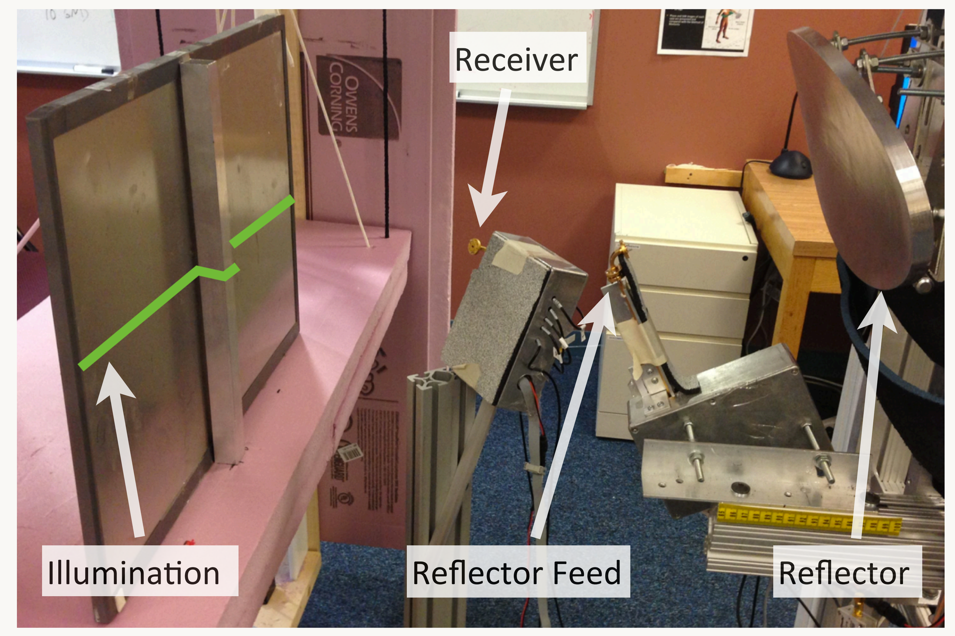

Fig. 2 - mm-wave system implementation

The system was tested using a metal plate with a 1" by 1" square cylinder section placed in the center shown in Fig. 3a. The reconstructed image clearly shows the location and size of the object on the plate.

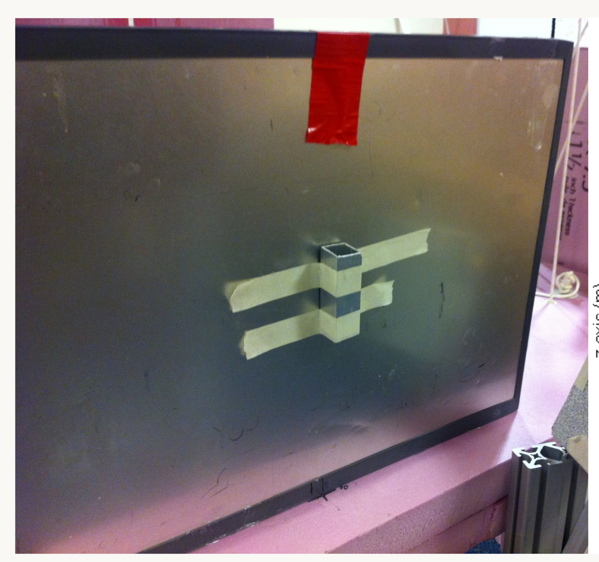

Fig 3a - Imaging target

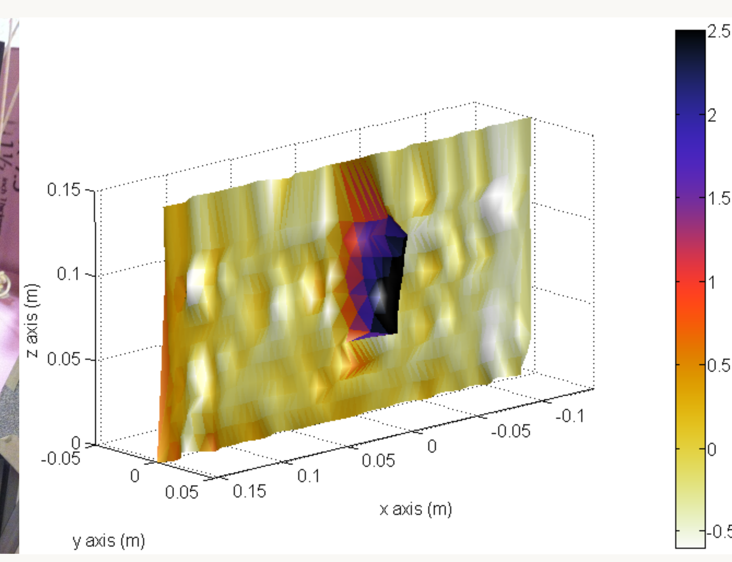

Fig 3b - mm-wave image

3D Point Cloud Integration

The point cloud data was collected using an off-the-shelf Microsoft Kinect. It was positioned just above the reflector to have the same imaging perspective as the millimeter-wave images. The imaging target from Fig. 3a was covered with a shirt, as shown in Fig. 4, and the test was repeated using the millimeter-wave and the point cloud imaging.

Fig 4 - Imaging target covered with a shirt

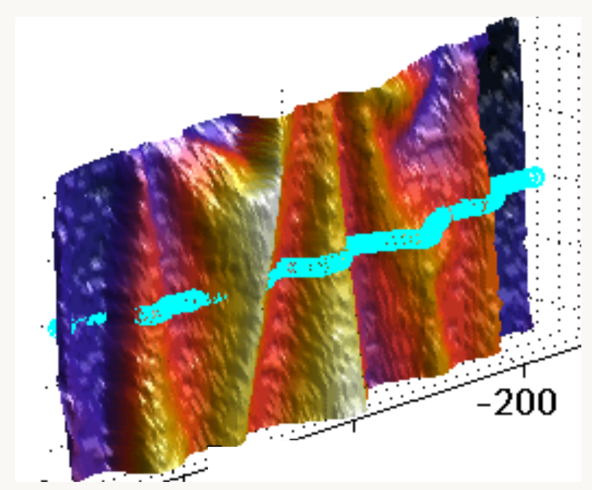

Fig 5 - Point cloud image

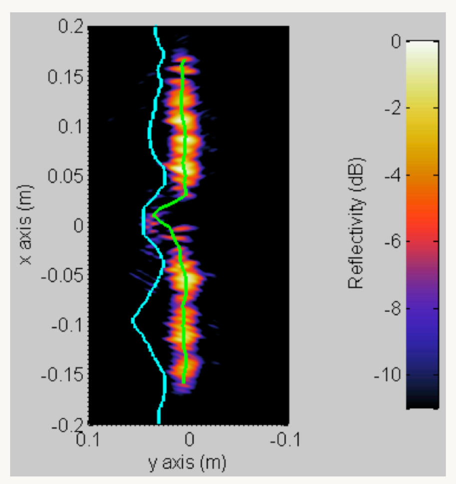

Fig 6 - Point cloud and mm-wave image

The point cloud image is shown in Fig. 5 and the combined image is shown in Fig. 6. The point cloud data provides additional information about the imaging region and the relationship between the body and clothing that can be used for threat detection.

Opportunities for Transition to Customer

The proposed imaging system was designed from initial concept to solve a real problem with a customer friendly solution. Actions were taken in all design areas to solve customer needs such as cost, imaging speed, footprint size, and most importantly image quality. This system is designed for easy transition to the field.

Conclusions

The proposed architecture demonstrated the capabilities of combining two low-cost sensors to produce a fused imaging system that provides more information about the target than anything commercially available. This will allow for better threat detection through more advanced threat recognition algorithms.

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This work is supported by the Science and Tech. Directorate, U.S. Dept. of Homeland Security, Award No. 2008-ST-061-ED0001; and by the Ministerio de Ciencia e Innovación of Spain / FEDER under CSD2008-00068 and TEC2011-24492/TEC.