Millimeter wave standoff radar detection system with motion compensation and 3D imaging capabilities

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Introduction

The mm-waves radar is the ideal modality for standoff detection because it can work at distances from 20 to 50 meters. In addition mm-waves can penetrate clothing, and have high resolving capability reacting to the dielectric contrast of interest (explosives). In this poster we present our latest results in the area of standoff detection of potential suicide bombers using millimeter wave radar. We have collected experimental data using a mm-wave radar, with a multiple bistatic configuration. The data has been processed, by using a Synthetic Aperture Radar (SAR) technique, in order to create two dimensional images on the target region. Then, a feature algorithm based on entropy level has been applied to the SAR images in order to distinguish between threat and no threat cases. This SAR has a moving rail over a linear aperture of 1.85m and has Frequency Modulated Continuous Wave (FMCW) signal. In this work we have implemented a new motion compensation algorithm in order to improve the SAR images generated from the measured data with different threat objects. The algorithm corrects for the relative movement existing between the target and the radar system by using a corner cube reference to the target region. This method improves the imaging accuracy and the capability for distinguishing threat from innocent cases. This poster also presents simulated results for a possible extended version of mm-wave standoff radar configuration which would have the potential for 3D imaging capabilities. For this purpose, the system consists of a two-dimensional aperture array of receivers, which ultimately improves the detection performance of potential hazards.

Radar Configuration

We use the SAR image processing of the measurements from a FMCW radar. The Radar has the following parameters: center frequency—94GHz, bandwidth—3GHz and pulse burst duration—83.36µs.

Motion compensation algorithm

• The relative movement of the target produces distortions in the final images. For compensating for these errors, three steps are used in the correction algorithm:
  1. Correction of the slight phase fluctuation occurring during the measurement in successive pulses.
  2. Optimize the measurement parameters using the bistatic data. Parameters are the corner cube position and the monostatic receiver position in Fig. 1(b).
  3. Compensate for the random phase error in the bistatic measured data with the phase of the monostatic measured data.

The configuration of the measurement consists of a person, who is the target and a corner cube in the target region Fig. 1(b).

Results

• The entropy for the innocent case is 4.14, while for the threat cases it is (5.59,5.21,5.48) which shows that the entropy method gives acceptable foreign object distinguishing results.

3D imaging simulation

The SAR processing is also used to simulate the 3D images of the targets using a planar array of static antennas.

• Fig. 4 presents the baseline configuration used in this work. It consists of a rectangular antenna array located at R=20m from the target. The transmitting array is made of a single transmitter located at the center of the antenna. The receiver array consists of 36 line receivers uniformly distributed along a 0.7m x-aperture. Each line receiver is comprised of 46 single receivers uniformly distributed along a 1.85m y-aperture.

References


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Figure 1: (a) picture of the real radar (b) measurement configuration

Figure 2: image of the target with different threats (a) with a metallic object on the chest (b) with metallic pipes on the chest. (c) with a silicon pipes on the chest

Figure 3. The entropy calculated for each of the images is depicted at its title.

Figure 4: Antenna array and target configuration

Figure 5: Target geometry used in the simulation: (a) body without metal pipes, and (b) body with metal pipes

Figure 6: Image reconstruction: (a) Reflectivity and isocontours of body without metallic pipes (b) reflectivity and isocontours of body with 5 cylindrical metallic pipes (c) reflectivity and isocontours of body with 5 cylindrical metallic pipes with higher threshold

Figure 7: image of the target (a) without threat (b) with a silicon metallic object on the chest (c) with metallic pipes on the chest. (d) with a silicon pipes on the chest