Automatic Characterization of Body-Borne Threats Using Wideband Radar

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Opportunity

In order to reduce pat-down rate at airport radar body scanners we need to discriminate benign objects, such as money belts and belt buckles, from prohibited items. An effective way to do this is to develop an automatic algorithm that can distinguish potentially hazardous foreign objects from the benign ones.

This research proposes a method which can automatically determine permittivity and thickness of body-borne objects by processing wideband radar images. The algorithm can be used to find explosive threats and rule out benign objects. Starting with a reconstructed millimeter-wave radar image of the body with an anomaly attached to it, we extract the nominal body contour using a seven-term Fourier series in circumferential angle, which predicts the body surface in the absence of the object. We then subtract the ideal body response from the image and define the amount of peak body displacement observed in the radar image (this displacement is caused by a signal retardation due to the presence of a weak dielectric object). This and the weak front surface reflection of the attached foreign object let us calculate the permittivity using:

$$\varepsilon\prime = (1 + \frac{3d}{d})^2$$

Approach

1. **Step 1:** The Object, Scanner Image
   - Petroleum Jelly attached to the lower right thigh.

2. **Step 2:** Reconstructed 2D Cross Section Image
   - 3.5 cm thick object is attached here!

3. **Step 3:** Nominal Body Contour
   - Green curve shows nominal body contour generated with a seven-term Fourier series in \( \varphi \).

4. **Step 4:** Ideal Body Response
   - Ideal body response generated by putting amplitude scaled sinc functions on nominal body contour

5. **Step 5:** Finding the Peak Body Displacement
   - Back Surface of the dielectric displaced \( d \) from nominal contour

6. **Step 6:** Dielectric Thickness
   - The red dot shows the body displacement
   - By subtracting the ideal body response from the data, the displaced body pixels become dominant and can be found by thresholding the image. Thresholds = 0.25, 0.4
   - Front Surface of dielectric extending \( d \) from nominal contour

Impact

The unique feature about my research is that it can find threats automatically. This addresses the problem of high false alarm rate in security checkpoints.

References