Phenomenological Scattering Analysis of an RF Area Secure Perimeter

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Abstract

Surveillance of perimeters is essential, especially for critical infrastructure such as transportation hubs, power stations, chemical facilities and others. There are many approaches to perimeter surveillance but most of these require large upfront investments. This investigation uses advanced electro-magnetic modeling techniques with real human body geometries to establish the best set of detectable features using the Wireless Area Secure Perimeter (WASP) system geometry. Using the frequency, power level, network configuration, and antennas employed by WASP, predictions on limits to target recognition are presented, along with recommendations for system reconfiguration for improving target characterization.

Relevance

The WASP system consists of an array of low power, self-contained, unattended transceivers. It eliminates the need for costly power and communication infrastructures associated with today's technologies, resulting in overall system design promises to lower cost.

Unburdened by such infrastructure requirements, WASP can dramatically change how and where perimeter and border intrusion and detection will be performed. By considering the scattering from objects moving through the array of sensors, it may be possible to determine body size; whether the individual is carrying or wearing a bag; and whether an individual moving into and then back out of a region has changed, indicating picking up or dropping off of an object.

Technical Approach

Electrical model of the body

Electrically speaking, there are two different kind of body tissues, those with high water content (muscle and skin) and those with low water content (bone and fat). Cut of the body at the height of the hips was chosen because of the higher fat content

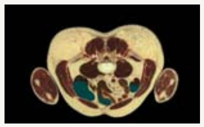


Fig. 1. Human cross section

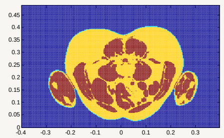


Fig. 2. Electrical representation of Fig. 1

The field out of the body in the simplest model, all skin (Fig. 3.c), is similar to the complete one (Fig. 3.a).

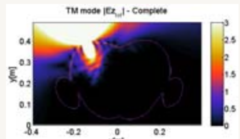


Fig. 3.a Complete model

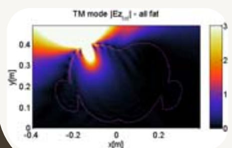


Fig. 3.b All-fat model

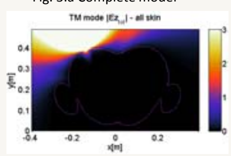


Fig. 3.c All-skin model

2D simulations

We used the full wave finite difference frequency domain (FDFD) [3,4] method to model the scattering of an incident spherical wave. Fig. 4 represents the geometry of the problem.

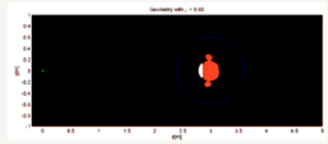


Fig. 4. Problem geometry showing body cross section with backpack and source in (0,0)

We modeled the backpack filled with TNT, water or metal and study field in the nearfield region using FDFD.

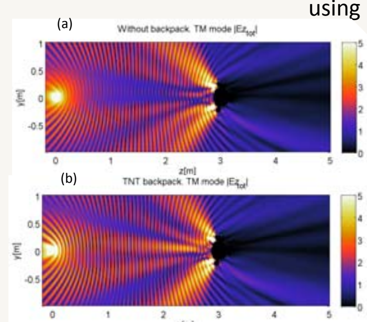
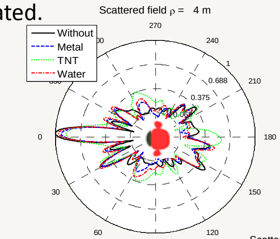
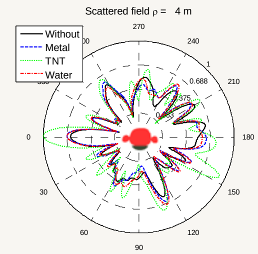


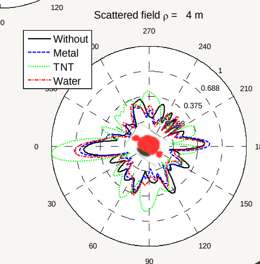
Fig. 5. Fields (a) without backpack and (b) TNT-filled backpack.

We also considered other body orientations respect to the source.

To find the fields in the far zone, equivalent electric and magnetic currents are found on the surface of a box bounding all scattering objects of interest, and these currents are then weighted by the Green's function and integrated.







Opportunities for Transition to Customer

The main objective of this work is to characterize the feasibility of determining additional physical characteristics of traversing individuals using the actual parameters employed by the WASP system developed by Raytheon Inc. This phenomenological analysis will determine the feasibility of extending the capabilities of the existing perimeter detection concept into a target characterization or threat identification system.

Accomplishments Through Current Year

- We demonstrated that a simple model of the body as a complete muscle/skin volume can be used instead of the original model without loosing scattering characteristics.
- Complete 2D cases with different variations in the model were simulated, showing that the TNT-filled backpack produces the most distinctive pattern.

Future Work

- We will continue working on the 3D model to simulate the behavior of the real model.
- On field measurements to validate the theoretical results.

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