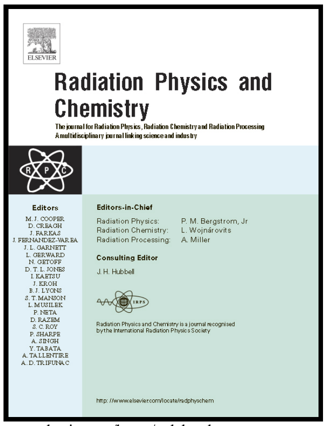

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A Simulation Study of Fast Neutron Interrogation for Standoff Detection of Improvised Explosive Devices

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Abstract

The signature-based radiation-scanning technique utilizes radiation detector responses, called "signatures," and compares these to "templates" in order to differentiate targets that contain certain materials, such as explosives or drugs, from those that do not. Our investigations are aimed at the detection of nitrogen-rich explosives contained in improvised explosive devices. We use the term "clutter" to refer to any non-explosive materials with which the interrogating radiation may interact between source and detector. To deal with the many target types and clutter configurations that may be encountered in the field, the use of "artificial templates" is proposed. The MCNP code was used to simulate 14.1 MeV neutron source beams incident on one type of target containing various clutter and sample materials. Signatures due to inelastic-scatter and prompt-capture gamma rays from hydrogen, carbon, nitrogen, and oxygen and two scattered neutron signatures were considered. Targets containing explosive materials in the presence of clutter were able to be identified from targets that contained only non-explosive ("inert") materials. This study demonstrates that a finite number of artificial templates is sufficient for IED detection with fairly good sensitivity and specificity.

Highlights

Signature-based radiation scanning for detecting explosives was studied
A Monte Carlo simulation study of neutron-based interrogation was conducted
Artificial materials were simulated in order to reduce the number of templates
Use of artificial templates and a density filter can lead to excellent results
We obtained 90% sensitivity and 71% specificity in this limited study

Keywords

Explosives; Detection; Neutrons; Signature analysis; Template Matching

1. Introduction

The improvised explosive device (IED) has become a tool commonly used by terrorists. New and improved methods to detect IEDs, which can masquerade as ordinary objects but contain lethal explosives, are needed. The National Research Council has identified 26 common nitrogen-rich high explosives whose average compositions (by weight) are about 3% H, 20% C, 31% N, and 46% O with standard deviations of 11% or less (NRC, 2004). The densities of these explosives tend to be higher than those of inert compounds that contain only hydrogen, carbon, nitrogen, and oxygen (HCNO). Active interrogation of unknown targets by photons and neutrons can be used to characterize density and composition variables of the contents of the targets (e.g., Gozani, 1994; Brown and Gozani, 1995; Womble, et al. 1995; Singh and Singh, 2003; Buffler and Tickner, 2010). In the signature-based radiation scanning (SBRS) technique considered here, radiation detector responses due to radiation interacting in the targets are called "signatures." These signatures may consist of detector responses due to radiation that is scattered from the target or is generated within the target by mechanisms such as inelastic neutron scattering and thermal neutron capture. In this investigation, only neutron interrogation is simulated and the signatures of interest come from gamma rays produced in neutron interactions with HCNO only (those from other elements are ignored) and also from two detector responses due to backscattered neutrons of energies above the cadmium cutoff of 0.4 eV and below 0.4 eV.