REDUCED ORDER MODELLING FOR RADIATION DETECTION

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Radiation detection plays an important role in many fields, such as nuclear physics, radiation transport and medical radiation physics. There are several types of instruments, such as radiation portal monitors (RPM), currently available to detect and identify radioactive materials. RPMs are currently used at ports for screening vehicles. These instruments analyse the gamma-ray spectrum and/or the neutron flux emitted by passing vehicles to detect radioactive materials. One of the biggest challenges with these monitors and/or methods is managing false alarm rates. In this work, a reduced order model is developed in such a way that the location of radioactive sources to be identified from the noisy sparse sensor data. Reduced order models are computationally inexpensive numerical techniques, which can be used to simulate stochastic problems rapidly. The fundamental idea of this work is to develop a ROM that estimates an entire radiation spatial field (including the source location and the emission spectrum) given the measurements from a few sensors. The ROM approach consists of an 'offline' and 'online' procedure. In the 'offline' step, detailed Monte Carlo (MC) simulations are performed to generate a radiation field. The "online step" is used to localize and detect energy spectra of radiation sources given sparse trial data, obtained from a Monte Carlo simulation at a few sensors. Bayesian parameter estimation with a Gaussian prior is used to estimate the latent variables associated with noisy sparse data. Thereafter, a noise-free estimate for the measured data is obtained and radiation sources are identified. The results are validated using a terrestrial radiation detection scenario. The approach developed in this research is shown to be a promising method for radiation detection problems.

Keywords: Bayesian parameter estimation, Monte Carlo simulation, Noisy sparse data, Radiation source detection, Reduced order model