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Radioactive source localization using a Data Driven MVA method

In the new era of homeland security there is a growing concern regarding the possession and the potential use of radiological materials by terrorist groups usually in the form of a radiological dispersion device (RDD), also known as "dirty bomb". Since the defended areas from such a threat may not have specific entrance and exit points, the problem of how to localize a radioactive source in an open area should be investigated.
We present a small form factor (0.5cm3) CZT sensor network consisted of a number of five (5) Non-Directional Detectors (NDD) in a planar cruciform topology capable to localize a stationary radiation source in 3D. The localization was performed with fusion algorithms based on MVA techniques. The algorithms make use of Multilayer Perseptron Neural Network (MLP) and Gradient Boosted Decision Trees (BDTG). The training of the MVA methods has been done using a set of experimental data (defined as the response of the sensors in different 3D radiation source positions) collected with the sensor network and exploiting the symmetry of its topology. The initial small set of experimental data points was increased to a few thousand points by utilizing both the symmetry of the network topology and the fact that the response of the sensors is proportional to Ae-μr/r2, where A represents the source activity and the sensor efficiency and r is the distance in 3D between each sensor and the radiation source and the term e-μr corresponds to the absorption term.
Using the above data driven method thousands of data points have been generated and subsequently used for the training of the MVA algorithms. The benefit of this approach is that without any significant computational cost the effects of both the radiation absorption and scattering can be taken into account, which in other circumstances would require a detailed description of the surrounding materials in order to produce reliable simulated data of the experimental setup. When the effect of the radiation absorption and scattering is not taken into account the source localization especially in the depth direction (source transverse distance from the sensor plain) could be biased towards higher values[1].
The localization efficiency of the algorithms has been estimated using a set of experimental data that was not used during the training phase. The data have been gathered in our laboratory using a 137Cs source of 180μCi. A localization resolution (standard deviation of the accuracy distribution, where accuracy is defined as the difference between the estimated and the true coordinate) of the order of 10cm and 12cm has been archived for the Horizontal (Figure 1) and Vertical (Figure 2) directions respectively. In addition a resolution of the order of 15cm has been obtained for the depth (Figure 3) direction without significant bias in the position estimation when the radiation source was located in a monitored volume of 5m x 2.8m x 2m.

Primary author: Dr KYRIAKIS, Aristoteles (Nat. Cent. for Sci. Res. Demokritos (GR))

Co-author: Dr KARAFASOULIS, Konstantinos (.Hellenic Army Academy)

Presenter: Dr KYRIAKIS, Aristoteles (Nat. Cent. for Sci. Res. Demokritos (GR))

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