COMPARISON OF LINEAR DECOMPOSITIONAL TECHNIQUES WITH ROBUST FITTING ANALYSIS FOR APPLICATIONS TO DETECTION OF ILLICIT TRAFFICKING OF SPECIAL NUCLEAR MATERIALS

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In a companion paper [1], the limits of detection for a special nuclear material of particular concern, ^{239}Pu, using an advanced high pressure xenon detector (HPXe) and robust fitting analysis (RFA) are experimentally determined for a set of spectra with two different source strengths relative to the background and for collection times ranging from 8 minutes to 7.5 seconds. In this paper, the advantages and disadvantages of the application of another newly-developed technique, Linear Decomposition (LD), are experimentally investigated and compared using the same set of data. It is found that while RFA, described in [2], clearly has the potential of the most sensitive detection capabilities, LD may be better suited to applications in first-line customs applications due to its relative simplicity, speed, and small demand on processor and memory. RFA, on the other hand, appears to be the better choice of methods where at the level of higher echelons of response, time, specialized training, and greater computational resources are less of a concern compared to the need for the best possible analytical results.

The technique of Linear Decomposition is best described as a process that finds the best linear combination of the spectra from a reference library that combine together in relative proportions to compose the spectrum of interest (the "sample spectrum"). Linear Decomposition is based on well-known methods of least-squares analysis described, for example, in [3]. As implemented in this paper, Linear Decomposition relies on Cholesky matrix reduction using the methods already developed for the core of RFA analysis for least squares best fits, in which the most fundamental problems of computational inversion of sparse matrices already have been successfully overcome. The matrix inversion, which is required to find the best set of linear coefficients of the library spectra to compose the sample spectrum, also yields the uncertainties in those coefficients in precise and well-understood mathematical terms. Thus, not only is the inspector informed of the most probable composition of the sample spectrum in terms of the spectra in the reference library, but also he is informed of the estimated uncertainty of the results for each of the constituents. The ratio of the coefficient to the uncertainty for each constituent is used as a figure of merit to determine whether to decide that a particular isotope is present, whether it is not present, or whether its presence cannot be determined without a longer collection time than was used for the sample. Finally, the linear combination of all reference spectra is reconstructed and compared to the sample spectrum to determine how well the sample is or is not composed of the reference spectra in terms of chi-square. If chi-square is too large, the analysis is declared invalid. Such invalidity can be due, for example, to the presence of an isotope in the sample but not present in the reference library, or due to an energy calibration that is not within specification. The result is that the inspector is informed whether or not the analysis is valid and, if so, of the confidence he may have in how much of each of the reference library isotopes is present in the sample spectrum. While LD is not able to take advantage of the extremely sensitive non-linear capabilities of RFA, it offers the advantages of speed (less than 2 seconds for analysis), simplicity (well-understood mathematics), and ease of use (a single, automated, non-interactive step). Like RFA, LD is capable of detecting the presence of multiple isotopes in a sample, each having very different activities, and, by the inclusion in the library of shielded spectra, of detecting the presence of shielded isotopes.

HPXe detectors of the type used in this experiment are attractive candidates for portal monitoring systems because of their relative insensitivity to temperature changes and rough treatment, their full-energy peak efficiency over a wide range of energies, and their excellent energy resolution (1.9% at 662 keV with 3.0% efficiency and 1.3% at 1332 keV with 0.7% efficiency) without the need for cryocooling [4,5,6]. A disadvantage of HPXe detectors for field use has been their susceptibility to degraded resolution when subjected to acoustic influences, but significant progress recently has been made with HPXe vibrostability showing negligible degradation in resolution with acoustic noise up to 70 dB [6].

As in the companion paper, the spectra used for analysis were collected at CEA/Saclay with an HPXe unit from MEPhI, described in [7]. These spectra were combined using random sampling of a probability distribution constructed from the original spectra to generate a series of test spectra for a range of conditions typical of portal monitoring operations. These spectra were then analyzed with LD methodology to determine detection sensitivity as a function of source strength and sampling time, and the results were compared to the same results using RFA.

The plutonium source contained 1 gram of ^{239}Pu at a distance of 73 cm from the detector. Additional spectra were included in the reference library to test the ability of the LD method to discriminate between mixed sources and to allow investigation for false positive results. These included ^{137}Cs, ^{133}Ba, ^{60}Co, ^{235}U. The uranium source consisted of 8 grams of ^{235}U at a distance of 42 cm from the detector. To evaluate the LD ability to detect shielded sources, five spectra were included for both ^{235}U and ^{239}Pu with attenuating thicknesses of lead ranging from zero to four millimeters

In summary, analyses of ^{239}Pu spectra using the method of Linear Decomposition were compared with results using the method of Robust Fitting Analysis. Additional spectra were added to the library to test multisource discrimination and false positive rates. All spectra were taken at CEA/Saclay spectra with an HPXe detector from MEPhI. Based on these analyses, the technique of Linear Decomposition appears to be well-suited for applications to the first-line detection and classification of illicit nuclear materials in the field, due to its simplicity, speed, and ease of use, while retaining not only excellent sensitivity but also well-understood results in terms of probabilities and statistics. RFA, on the other hand, is generally more sensitive and comprehensive, but requires greater expertise and more time to take advantage of its full potential, making it more suitable for use by more sophisticated analysts once initial detection and classification has been accomplished.

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THREATS AND RISKS NEW THREATS IN TERRORISM

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INTRODUCTION

The topics to be studied are the types of attacks that we can expect from the terrorists of the future, the methods they may apply. Among these methods the weapons of mass destruction and the cyber-terrorism are included.
Try to give an idea under a police perspective of what kind of attacks we may expect and the possibility of these attacks.

THE THREAT OF WEAPONS OF MASS DESTRUCTION

How to obtain the materials, technical expertise and type of terrorist groups that can be interested in using WMD.
These groups are the apocalyptic groups or sects, the neo-fascist groups and the so called fringe-terrorists.

THE NUCLEAR THREAT

To obtain the material terrorists have to turn to illicit trafficking.
Interpol project nuclear in 1994 revealed that none of the offenders belonged to a terrorist organization.

Interpol is involved in co-operation programs along with international organisations having an interest in prevention, detection and response to illicit practices involving radioactive materials, like the IAEA and the WCO

Interpol is participating in training courses, seminars and other initiatives tending to train officers.

THE CHEMICAL THREAT

Co-operation with the Organisation for the Prohibition of the Chemical Weapons (OPCW)

Two examples of the use of chemicals in the history of terrorism. The use of gas sarin by members of the sect Aum in Matsumoto and Tokyo in 1994 and 1995.

Aum complex organization with ramified structure.

THE BIOLOGICAL THREAT

The biological weapons have been described as the nuke of the poor.Three categories of weapons. Only one example at Interpol. Again members of one sect in 1984 trying to incapacitate voters through the poisoning of meals in several restaurants in the USA.

CYBER-TERRORISM

Some organizations engaged in terrorist activities are inclined to use the internet in pursuit of political goals

They have been using internet for two main purposes, propaganda for their cause and communication to their own members and sympathisers.

CONCLUSION

Need for intelligence gathering, technical training for police officers and co-operation among international organisations with information exchange and common programs.

The likelihood of an attack using WMD by terrorists is low, but the consequences are severe. A program for response should be in place.

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"NUCLEAR REGULATORY MEASURES TO PREVENT ILLICIT USE OF NUCLEAR MATERIALS AND RADIOACTIVE SOURCES"

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Synopsis

The events related with the illicit use of nuclear materials and radioactive sources has sparked off several initiatives, at a national and international level, in order to prevent their occurrence, and in the case of the event taking place, to rapidly adopt the measures to recover these materials and mitigate the consequences. The countries and international organizations are increasingly aware of the derivations that illicit use might generate. These events lead to several consequences, being the most important one the risk and damage to persons. The illicit acts that involve nuclear materials also generate derivations associated with the non-proliferation of weapons of massive destruction. For all these reasons, the different national and international organizations involved with the control of such materials have decided to adopt or strengthen the mechanisms that help decrease the probability of these illicit acts happening.

In some cases, the existence of illicit use and its increase have highlighted the need to strengthen the organizations devoted to the regulation and control of nuclear activities. This is so because adequate legislation and national authorities that have the faculties, capacity and proper resources to track and control nuclear materials and radioactive sources constitute the fundamental column to effectively prevent and react to this matter. These organizations should be also responsible for the co-ordination with the other institutions involved in the prevention and response of these illicit uses.

As regards the regulatory infrastructure of the countries, one central topic refers to the design of control measures assuring the continuity of knowledge about use and movements of nuclear materials and radioactive sources. These systems are defined considering, among others, the risk related, vulnerabilities, strategic value or dangerousness of the materials, their inventories and significance in radiological terms.

Summing up, in the area of the illegal use of nuclear material or radioactive sources, the existence of competent regulatory authorities that set up adequate control measures and take due account of synergies in safeguards, physical protection and radiological protection, and other measures, such as the export-import control of sensitive materials, lowers the probability of occurrence of illicit use.

Internationally, the different forms of co-operation and the issuing of recommendations and guidelines also constitute fundamental elements for the prevention of illegal movements of nuclear materials and radioactive sources between boundaries.

The aim of this paper is to briefly describe the different nuclear regulatory measures, which in their specific area serve the objective of prevention and response to the illicit use of nuclear materials and radioactive sources.