Implementation of numerical method based on Artificial Intelligence for Identifying Behavioral Patterns in Dosimetry Measurements

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Introduction

This contribution is developed through collaboration between the Department of Physics at the University of Cordoba (UCO) and the Ionizing Radiation Dosimetry Unit into the Energetic, Environmental and Technological Research Center (CIEMAT) in Spain. The main objective of this work is to implement unsupervised artificial intelligence (AI) algorithms methods in order to find behavior patter in both thermoluminiscence (TL) glow curves and gamma spectra measurements of germanium detector.

Methods

Several algorithms methods, in order to identifies clusters of data points, based on their proximity to each other and their density within the dataset (DBSCAN algorithms) and/or AutoEncoders, that are an artificial neural networks that learns to compress and then reconstruct data. These AI methods are widely used because have shown high capability for managing a large volume of data that are implemented in the following two areas:

1. TL glow curves obtain from dosimetry services and TL material characterization and analysis laboratories.

2. Gamma spectra of environmental samples measurements of Cinderella Germanium detector, measured in the particle station of Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) placed in Portugal, (PTP53).

Results

Finally, an automated tool, developed in Python codes based on AI, is implemented that takes experimental data, learns from it, and is capable of classifying these measurements to clusters, without the need for prior technical supervision.

Conclusions

So that, this work presents an automated quality control system capable of grouping measurements without prior supervision and of differentiating y analyzing the intrinsic information of the TL curve and gamma spectra themselves.

How to select a dosimeter?

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Introduction

This work proposes a new TLD selection method. When analyzing the TLD 100 dosimeter, due to small size and ease of "cracking", the range of use must be considered in selection, as an internal crack means that light resulting from radiation interactions with the dosimeter is not transferred to the TLD Dosimeter reader proportionally and must be discarded.

Methods

142 TLD-100 crystals were irradiated with a dose of 5 Gy and evanescence time of 15 hours. The spectra of the crystals were obtained individually in Victoreen model 2800 reader. The irradiation was repeated three times, using a styrene plate, which has 288 TLD-100 irradiation positions with space for 72 seeds (Figure 1). The error of the CNC, the equipment used to manufacture the irradiation plate, is of the order of 0.1%. Only the peak range of iodine-125 irradiation was chosen, formed in the temperature range of 100°C and 200°C.

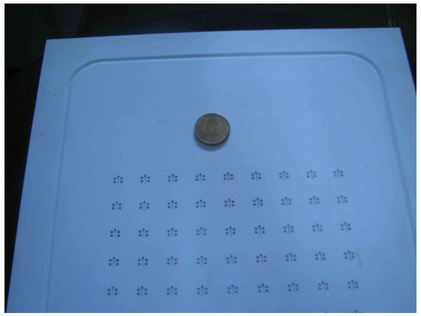

Figure 1 – Styrene plate used to irradiate the crystals

Source: ZEITUNI, C.A, 2005

Results

Dosimeters that simultaneously presented a maximum of 15% of standard deviation and 15% of deviation from the mean were considered acceptable. The values of 15% were arbitrarily chosen, just to guarantee a pre-selection of the crystals to minimize the number of crystals to be used, guaranteeing the use of the considered best of lot acquired by the Institute. The dosimeters that were within the acceptable range's uncertainty values were placed in a plastic box, separating them individually for tracking.

Conclusions

The proposed methodology using a cutting parameter and an automatic reader, such as the Harshaw 5500, the pre-selection of crystals can be reduced to just over 4 measurements of 1 hour each. And considering the thermal "burning" time of the crystal, plus its irradiation, the complete measurement takes just over four working days.