IMPROVING THE QUALITY OF IMAGES OBTAINED WITH A GAMMA-RAY BACKSCATTERING DEVICE

MEJORANDO LA CALIDAD DE LAS IMÁGENES OBTENIDAS CON UN DISPOSITIVO DE RETRODISPERSIÓN DE RAYOS-GAMMA

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Abstract

In order to extract more useful information from images obtained with a Gamma-ray Backscattering imaging device some methods of standard imaging treatment were implemented. Three very simple methods, subtract a reference image, smoothing and edge-detection, were implemented with a clear improvement on the image quality.

Keywords: Gamma backscattering, imaging device, image processing.

Resumen

Se han implementado algunos procedimientos estándar de tratamiento digital de imágenes con el fin de aumentar la información obtenida de las imágenes generadas con un dispositivo de retrodispersión de rayos-gamma. Se implementaron tres métodos simples, restar una imagen de referencia, suavizado de la imagen y detección de bordes, y se observó una notable mejoría en la calidad de las imágenes.

Palabras clave: Retrodispersión gamma, dispositivo de imágenes, procesamiento de imágenes.

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Introduction

Due to the capabilities of γ–rays to penetrate some thickness of dense matter they are suitable for direct observation of concealed objects through non-invasive and non-destructive procedures. γ–Backscattering imaging techniques present an advantage when the access to both sides of the sample is not possible.
The Compton Camera is a γ–backscattering imaging device based on the Gamma-ray Compton Backscattering (GCB) technique whose working principle is described in Ref. [1]. The Compton Camera has been successfully tested in thickness measurements, in the location of buried high-density objects in sand, and in the inspection of hidden objects behind metallic walls and in the diagnosis of metallic surfaces [1–3].
The aim of any imaging device is to distinguish dissimilar regions in the field-of-view of the instrument, a goal that refers to the determination of contrast. Different features of any image can be enhanced through standard imaging techniques. In order to increase the contrast of images taken with the Compton Camera some digital imaging treatment methods, explained briefly here, were implemented. First, a reference image is subtracted from every image. The reference image ideally contains only the matrix in which the test object is placed. Second, the resulting image is smoothed using a Gaussian filter and finally, an edge-identification is performed.

Results and discussion

Taking into account that each image contains the contribution of both random coincidences and non interesting objects, it is useful to compare the images which may contain information on the object of interest, called "total image", with the image which contains only information on the material matrix within which the object of interest is placed named "reference image". Obviously, each type of sample defines a different reference image.
In order to illustrate this procedure, a case in which the Compton Camera can be useful, e.g. locating a concealed object, is proposed. A pair of stainless steel pliers is placed behind a 1 cm

thickness aluminum plate. In this specific case, the reference image is defined as that of the aluminum plate alone and the total image is defined as that of the pliers behind the aluminum plate. Figure 1 illustrates this procedure. The total and the reference

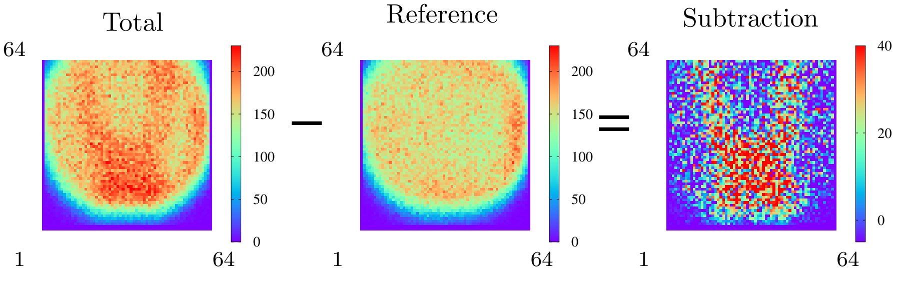

FIGURE 1. *Experimental image of a steel pliers behind an aluminum plate with 1 cm thickness. The subtraction between the total and the reference image is the contribution to the total image from the pliers.*

images are taken with the same acquisition time. The reference image is subtracted from the total image pixel by pixel. The subtraction procedure is intended to eliminate the contribution of non interesting environment and random coincidences from the total image, therefore producing, ideally, an image produced exclusively by the object.

In order to reduce noise and any other fine-scale phenomena a smoothing procedure has been implemented. In the image obtained after smoothing, the number of counts in each individual pixel are re-calculated as the average of the contents in neighbour pixels. The neighbour pixels are defined by a two-dimensional Gaussian function centered at the interesting pixel. The standard deviation of the Gaussian, σ, defines the number of pixels involved in the average calculation, whereas the weight of each pixel in the average calculation is defined by the value of the Gaussian function at the given pixel. Distances between pixels are measured from the center of each one. Figure 2 displays the final image obtained when the Gaussian smoothing is executed with standard deviation $\sigma = 1.3$ pixel. The input image is the result of the subtraction procedure in Fig. 1 (right). In order to reduce the noise as much as possible the optimal σ value is defined by the largest value such

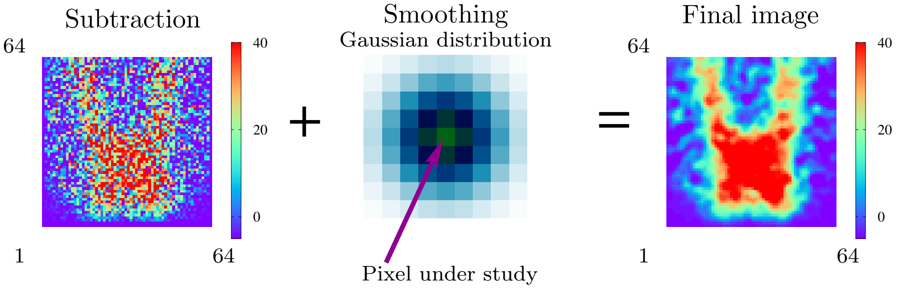

FIGURE 2. *The final image is result of smooth the subtracted image using a Gaussian filter with* $\sigma = 1.3$ *pixels.*

that the size of the object in the image and the edge resolution are not compromised.

Finally, a basic edge detection method is applied. The location of the edge is performed using the gradient method. The gradient of the image is calculated using the Sobel operator [4] because it has shown good noise-suppression [5]. Before applying the edge detection algorithm, a median filter is applied because adds noise reduction while preserving the edges. The right side of Figure 3 shows the edge identification of images generated by pliers behind an aluminum plate and a steel coupler behind polystyrene sheets, in both cases 1 cm thickness. Dark blue regions represent the edges of the original images. We found out that in most cases two very simple procedures, reference-subtraction and smoothing, already achieve a clear improvement of the original image. The simple edge-detection algorith, together with the median filter, proved successful in images generated by the Compton Camera and can be used in a future shape-size identification algorithm.

Summary

Two very simple procedures, reference-subtraction and smoothing, already achieve a clear improvement in the quality of the images taken with the Compton Camera. Conventional edge-detection algorithm based on gradient calculation, and Sobel operator, are successful in the edge-detection in spite of the high noise of the raw experimental images.

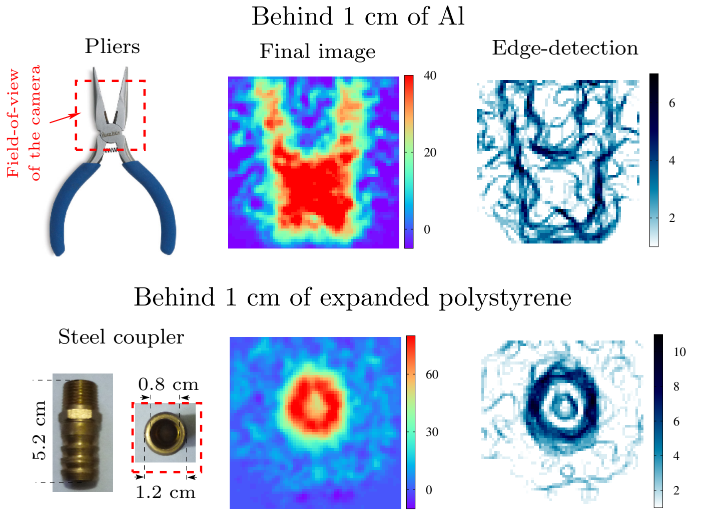

FIGURE 3. *Edge detection applied on final resulting images.*

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