How to delete the collimator influence on the gamma camera image: HURRA Filter

In this work we describe an easy method to eliminate the high energy collimator artifacts in the planar image of a gamma camera.

A Gamma camera is an instrument widely used in nuclear medicine. This is nothing more than a radiation detector with a collimator of lead, which allows to create an image of the radiation map of any radiation object or a patient (whom has previously injected a radioactive drug) as if it were a picture of the radiation rather than light. Unfortunately, when the thickest collimator is needed (the radiation is more energetic), an undesired patron is created in the image due to the collimator. This patron blurs the image and is known as an “artifact” in the image.

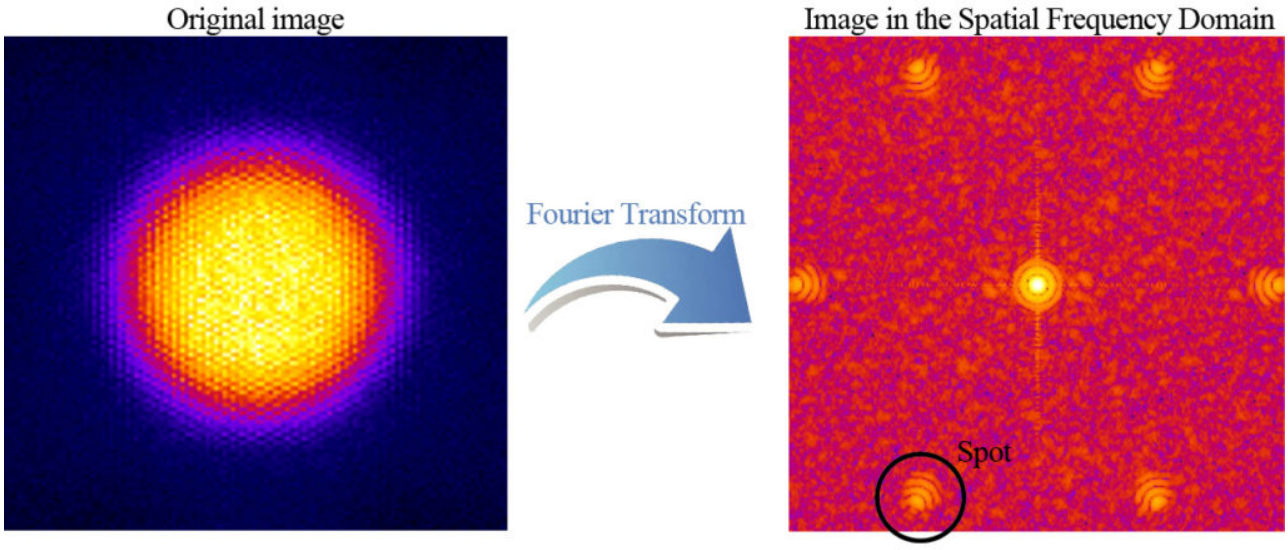

Fig. 1. (Left) Image of a petri dish filled with a solution of I-131 acquired in a gamma camera with High Energy Collimator. (Right) The same image after applying the Fourier Transform. Apparently it is very different, but contains the same information as the original image. Note that some spots appear in the shape of a hexagon.

We have developed a method to eliminate this artifacts by using a simple math tool called “Fourier Analysis”. The advantage of this method is that requires low computing power and we get a cleaned image without artifacts in a few steps. This fact is very important because a cleaner image means that the illness would be view better by physicians and then they could make a more exactly diagnostic.

The idea behind this method is that the collimator have a very characteristic form. The collimator is a lead sheet with a set of holes that allow radiation to pass through them. These holes form a hexagonal network. Then, if the collimator affects to the image, it will do it with a hexagonal pattern. Thanks to Fourier Transform, we can study any existing periodicity in an image, and of course, a hexagonal net produces periodicities that are very easy to detect. In mathematical terms, this periodicities means that there are some predominant spatial frequencies. By applying a Fourier Transform in two dimension, we can transform any image to the same image but in the space of spatial frequencies. Apparently, the image in the spatial frequency domain is very different from the original image, but both of them have the same information. In Figure 1 we can see an image which has been transformed into the spatial frequency domain by Fourier Transform in 2D. If we see this image carefully, we will see that there are some spot which form a hexagon. This spots are the responsible to create the artifacts in the original image, so to clean the image, we only have to delete this spots. This is exactly the few steps that we do: We take an image acquired in a gamma camera (it could be any image), then we apply the Fourier Transform and delete the spot which form the hexagon, and finally, we have to undo the Fourier Transform by applying the Inverse Fourier Transform. In this way, we recover the original image out of artifacts due to the collimator. We have called this three steps as “HURRA Filter”.

Despite you can do it manually with image processing software, what really is powerful is to program it to do it automatically. And this is very easy because theses spot in the special frequency domain always appears in the same position because is always due to the same collimator (all gamma camera model have one different to others). In fact, the position of these spots could be calculated only by knowing the geometric characteristic of the collimator and employing basic trigonometry.

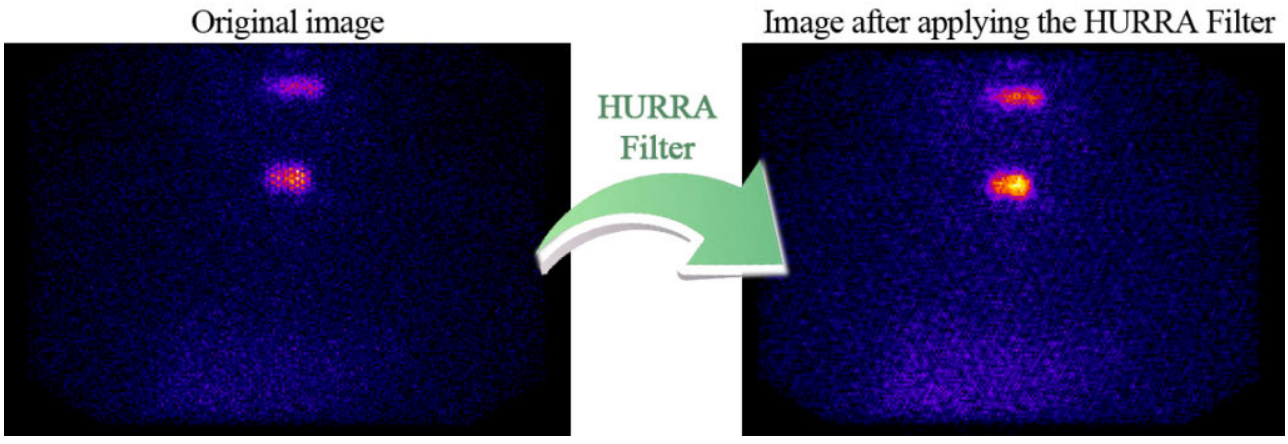

Fig. 2. (Left) Gammagraphy of a patient treated for thyroid cancer with I-131. If the image is enlarged in the maximum intensity zone, you can see that the image is grainy due to the collimator artifact. (Right) The same image after applying the three steps of the HURRA Filter. The hexagonal patron disappears and the contrast improves. The image quality is better, which improves the accuracy of the diagnosis.

On the Figure 2, you can see the result to use the HURRA Filter over the image of a real patient. By deleting the collimator artifacts, the image quality improves because the hexagonal patron disappear and the signal to noise ratio is better.

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Publication

The HURRA filter: An easy method to eliminate collimator artifacts in high-energy gamma camera images.
Perez-Garcia H, Barquero R
Rev Esp Med Nucl Imagen Mol. 2017 Jan - Feb