Using Machine Learning to Estimate Some Anisotropy Indices, Application to Brownian Textures and Breast Images

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Abstract

In this paper, we analyze image textures with help of anisotropic fractional Brownian fields. We also use some anisotropy indices characterizing the anisotropy of these textures. Multi-oriented quadratic variations form the basis of mentioned indices. Anisotropy indices are invariant to some image transforms. Furthermore they can be estimated from the observed data. An application of these indices, combining with a measure of texture roughness, is in lesion detection in mammograms.

Keywords

Texture Analysis, Machine Learning, Anisotropy, Breast Cancer, Fractional Brownian Fields, Lesion Detection.

1- Introduction

Medical imaging techniques have widely improved and revolutionized health care delivery all around the world. Melding the medical imaging and the power of Mathematics and Statistics offers highly personalized and targeted means of diagnosis or prognosis generation and is fostering higher quality and efficiency in health care.

One important aspect of a medical image is its texture which delivers information about the spatial arrangement of intensities in that image and is essential for processing the image. From a study to another, the definition of texture varies, depending mainly on analysis approaches. In such approaches, texture features are usually derived from the estimation of model parameters.

Brownian textures refer to a large class of irregular and non-stationary image textures described by Gaussian random field models. Kolmogorov(1940), Mandelbrot and Van Ness (1968) defined Fractional Brownian field (FBf) as the unique Statistical Tests of Anisotropy for Fractional

Brownian Textures centered Gaussian field, with stationary increments, isotropic and self-similar of an order H, changing in the range of (0,1). Elements of the textures are satisfied in Fractional Brownian Field having the so-called Hurst index, H, which is directly related to a degree of texture roughness.

However, according to Richard (2016), this index is not always sufficient to characterize the texture aspect. In another words, since it is orientation independent, it does not account for directional properties of textures. To explain this shortcoming, consider Figure 1 as an example with two different holder indices. If we consider this issue from a regularity viewpoint, textures of the two different rows can be distinguished while those of a same row cannot. Differences between textures of a same row are only due to variations of their directional properties.
We define some new indices in order to overcome this problem. By the way, there are some requirements for defining them:

1. Indices should be an intrinsic quantity: These quantities are invariant to some image transforms such as rotations, rescaling, or linear changes of intensities.
2. We should be able to estimate these indices from an observed image: This second requirement is probably rigid. In the sense that their related Hurst index should be efficiently estimated using quadratic variations.

The rest of this paper is organized as follows. In section 2, there is a brief overview of application of anisotropy indices in mammograms. In the last section, we share the conclusion and the results.

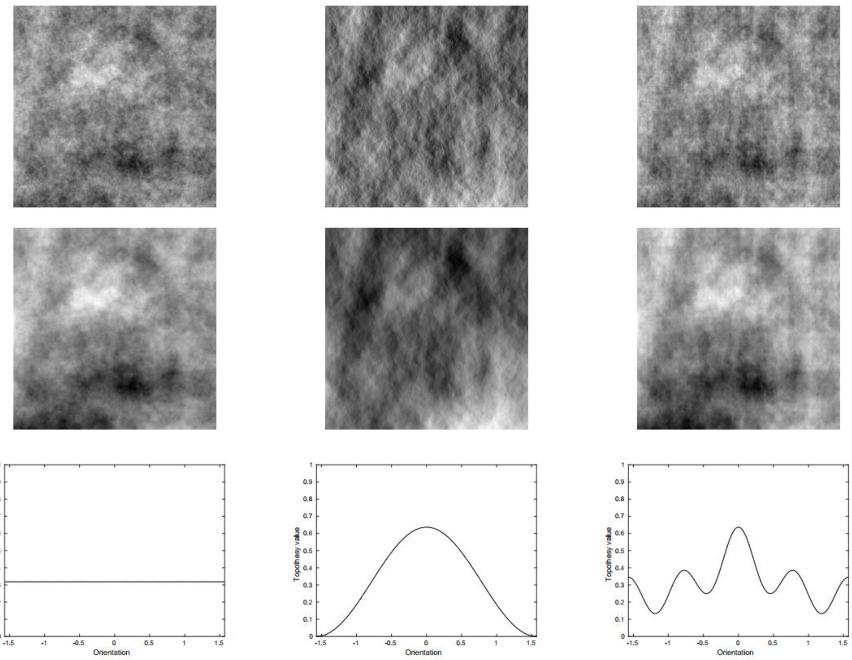

Figure1. In first row, three different ROIs with Holder indices of 0.3 are illustrated and in the second row, you can see the demonstration of three ROIs with Holder indices of 0.6. Each column has its own topothesy function which is represented in the bottom of that column.

2- Application to Mammograms

Breast cancer is one of three first reasons of women mortality all around the world. The early detection of this disease, raises the possibility of remedy and survival rate. Richard (2016) claims that today, mammography acts as the most efficient imaging for early detection and it has become a contractual tool of imaging.

We applied our methodology on a set of data. ROIs of size 100*100 are extracted from the dataset. These data contains 92 pathological mammograms. We also included 358 random ROIs from normal cases. To build our method, we computed increments, resolved the trend by fitting a polynomial of order 1, and finally we computed the anisotropy indices H and A, where H stands for the Hurst index and A is the Anisotropy index respectively. Values of H and A are illustrated in Figure 2.

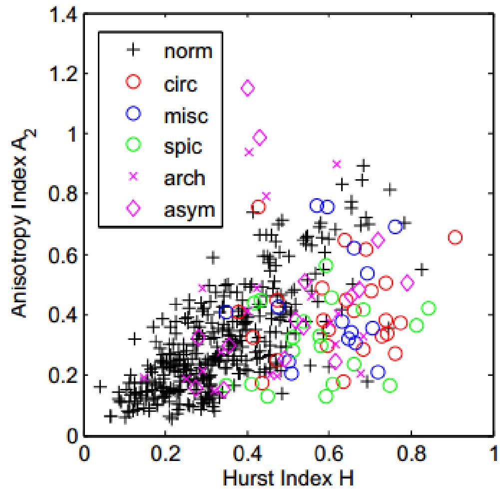

Figure2. Values of Hurst index and Anisotropy index of each ROI (for p=2).

On average, abnormal ROIs seems to be smoother and have higher values of H, which can be explained with the density of the mammogram in the regions with presence of malignancy (pathology). Furthermore, the Anisotropy of these ROIs are lower than the normal ones. This fact confirms the reflection of orientation of the tissues into the nipple, in other words, a normal breast mammogram texture would rather to be anisotropic.

3- Discussion

We applied some indices to characterize the anisotropy of an image texture. The calculations show that these indices are intrinsic and invariant to number of image transforms such as rotation and linearity. Results shows that the estimation mean square error is lower than 2% for selected indices.

Combining anisotropy indices with the Hurst index, made us able to describe irregularity and anisotropy of mammogram textures at the same time. And this lead us to detect lesions in the regions of interests. The most important advantage of anisotropy indices is detecting lesions that were the most difficult to detect.

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