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Statistical Gaussian Mixed Models Applied to Osteoporosis

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Abstract: *Osteoporosis disease attacks a large number of people, causing fractures of the hip and spine. Strong bones reflect the integration of bone mineral density (BMD) and bone quality. In the present work a method based on statistical methods of bone image treatment is proposed. In particular, quartile vectors, principal components analysis (PCA) and Gaussian Mixed Models (GMM) are shown to be effective in performing computerized statistical diagnoses, determining the presence of osteoporosis.*

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I. Introduction

Hip and spinal fractures are serious clinical conditions, which occur as a result of osteoporosis [1], and they lead to substantial morbidity and mortality. Fractures of the hip and spine are associated with an excess mortality of up to 20 and 4% respectively. The conventional radiographic bone mineral density (BMD) methods include the following: a) Singh indices; b) radiographic geometry of the hip; c) radiographic vertebral morphometry; and d) radiographic absorptiometry (AR) [2]. In this work, it is proposed to perform measurements from grayscale bone images for the detection of osteoporosis, applying quartile vectors and Gaussian Mixed Models (GMM).

II. Methods

A quantile of a random variable qp is defined as the smallest value q such that the cumulative distribution function is greater than or equal to a probability p, where p is "0 <p <1". This can be calculated from a continuous probability density function [3].

One of the purposes of Principal Component Analysis (PCA) is to reduce the dimensionality of p a d, where d <p, while the variance of the original data is conserved. In this project, PCA was applied to obtain a version of feature vectors with a reduced dimension, without diminishing efficiency [4].

A Gaussian Mixed Model (GMM) is represented by a triplet composed of means, covariances and weights; In general, each class is represented by a GMM model Λ. GMM modeling uses the expectation-maximization (EM) algorithm to train the models Λ_i={m_i,(μ_i) ⃗,Σ_i }. This calculation is performed with the quartile vectors extracted from the different bone images (abnormal or normal) [5-8].

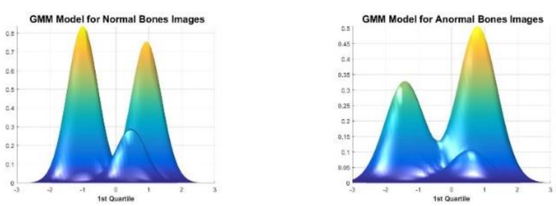

Figure 1. Images generated from the GMM application.

First, the images are transformed from RGB to gray levels; the unnecessary pixels were cleaned until obtaining images of a pixel size 98x112. Then, each image is segmented into 4x4 frames (16 images) as can be seen in Figure 2.

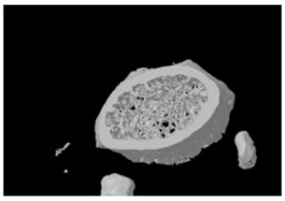 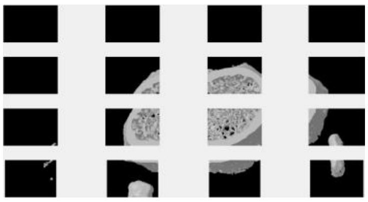

Figure 2.Original grayscale image on the left side and on the right side the segmented image.

From each frame a histogram was calculated and from this a quartile vector was obtained, consequently, 16 quartile vectors were obtained by each original image, and 160 by class. PCA was calculated on all the resultant quartile vectors of each class and on the quartile vectors of each image. With all the abnormal bone imaging vectors, a GMM model composed by 4 Gaussians was computed; the same procedure was followed for the images of normal bones, obtaining two models at the end.

III. Result

According to the pixel histograms obtained from the comparison between abnormal and normal bone images, a different number of pixels could be observed between 70 to 150 values. This tells us how osteoporosis affects bones. The result of the classification was 100% efficiency, which means that each image based on its class, has enough information related to the class itself, this allowed to be classified correctly.

IV. Conclusion

The GMM models showed their potential by efficiently classifying the bone classes, that is, normal and abnormal, or with and without osteoporosis, by reaching the error rate, reaching 100%. In the future, it would be convenient to apply cross validation to obtain classification efficiency in a more exhaustive and reliable way. Also make an analysis of the images with more frames per image at the time of being more segmented.

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