radiology images,
quantitative analysis,
fractal dimension

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REMARKS ON QUANTITATIVE ANALYSIS OF MEDICAL RADIOLOGY IMAGES

An attempt to assess algorithms potentially supporting quantitative analysis of radiology images has been undertaken. The computer tools designed for this purpose basicly refer to the idea of the fractal dimension estimations and implement various algorithms. Preliminary results for sample PET images are presented and conlcusions for further investigations are formulated.

1. INTRODUCTION

It is commonly accepted that the visual inspections of digital images by radiologists and assessments of the likelihood of malignancy or benignity cases are often non-reliable when referring merely to imaging data. With the development of new imaging technologies providing better resolution, it is essential to be able to extract additional parameters quantitatively evaluating digital image data for screening procedures. The notion of the fractal dimension as a quantitative parameter is frequently used to analyze different textures of medical images in various modalities (see e.g. [2],[5],[7],[9],[10],[11]). There are several alternative definitions of the fractal dimension, all assuming the basic idea of power law behaviour, and consequently many algorithms have been proposed to evaluate its value for different types of digital images. The algorithms proposed previously for opthalmology images [1] together with other approaches described in the literature for CT and MR modalities [12] are both extended and combined here to asses their possible use in supporting medical diagnosis procedures. Section 2. briefly presents the applied algorithms and the designed application. In Section 3. preliminary results of calculations performed for sample PET[8] images are discussed.

2. METHODS AND TOOLS

2.1. ALGORITHMS

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The implemented algorithms for fractal dimension (FD) estimations refer to space and frequency domains, respectively. Both the approaches have been described and applied earlier [12],[1]. The basic idea of their difference in the treatment of the image data is schematically represented in Figures 1 and 2, below.

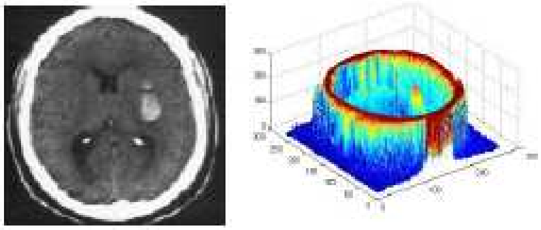

Fig.1. A sample medical image and its gray scale representation in 3D as applied in fractal dimensions estimations in space domain (space FD)

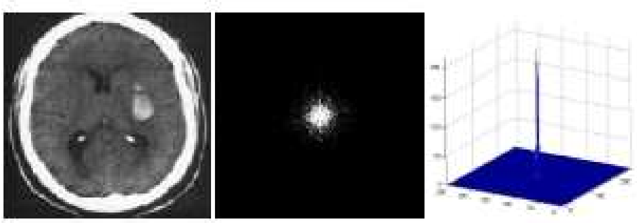

Fig.2. A sample medical image, its power spectrum projection with appropriate gray scale representation in 3D as applied in fractal dimensions estimations in frequency domain (spectral FD)

The following algorithms have been implemented: Spectral Fractal Dimension (SFD) [1] and Piecewise Modified Box Counting (PMBC) and Piecewise Triangular Prism Surface Area (PTPSA) for space domain [12]. The crucial difference between all the approaches is related to different divisions of the gray scale 3D surface. The first algorithm provides the value of spectral fractal dimension. The next two (PMBC and PTPSA) generate (on the basis of the original image data) new images – representing special mappings of the fractal dimension values, where each pixel is described by the local fractal dimension value of the appropriate sub-image considered in the calculation procedure. Sample data of this type are presented in Fig.3. For each such image some additional statistical properties may be estimated.

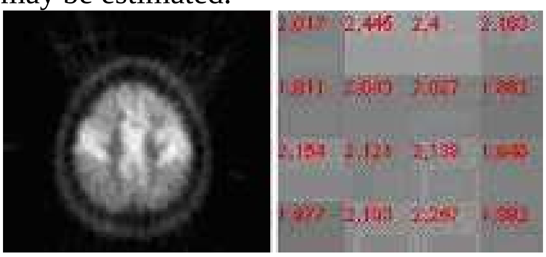

Fig.3. A sample medical image and its fractal mapping image generated by the PTPSA procedure for ROI 32x32 (see the text)

2.2 TOOLS

The application exploited for the study has been prepared in Java with the use of Java Advanced Imaging library (ver. 1.1.2)[6]. It requires Java environment in version 1.4.2 or higher and may be applied both in Windows and Unix systems. A sample screenshot of the application interface is shown in Fig.4., below. All the basic functions available in the application have been tested versus approriate Matlab procedures with sample medical images [3][4].

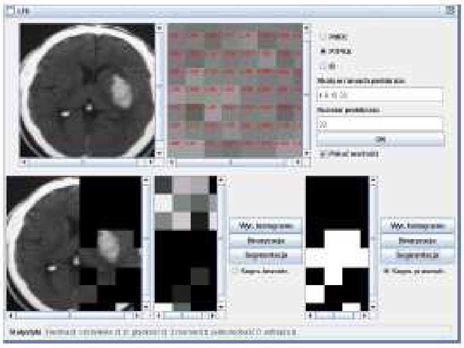

Fig.4. Sample screenshot of the designed application interface

3. RESULTS AND CONCLUSIONS

The preliminary study has been performed for 162 PET images available in the PET Brain Atlas [8]. The set consisted of 102 images collected for various types of dementia, 30 cases of tumor and 30 images diagnosed as normal.
The estimated values of spectral fractal dimensions do not allow reliable differentations of the considerd medical data. The results are presented in Fig. 5, below.

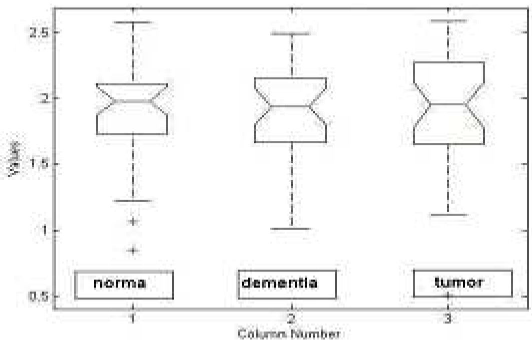

Fig. 5. Estimated spectral fractal dimensions values for PET images for three groups of cases

The generated fractal mapping resulting from the implemented PMCB and PMTSA algorithms also do not enable reasonable classification of the images as it can be seen in Fig.6, below presenting average intensity of the generated fractal images.

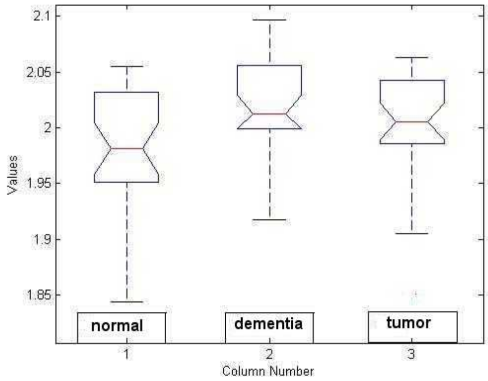

Fig. 6. Average intensity values of the generated fractal mapping images for the three groups of cases

On the one hand the preliminary results seem to show that the algorithms enabling classification of medical images for some other modalities, as described in the literature, are not useful for the brain PET imaging data. On the other hand, however, an inspection of the considered image data [8] reveal their poor technical quality – comparatively law resolution and noisy character. The available diagnostic descriptions are also rather modest. The diagnostics applicability of the investigated algorithms assuming a detailed digital image analysis may appear useful for more refined imaging PET data – it does require further studies. In particular, the elaborated application may be essential for monitoring temporal quantitative changes in digital images registered for the same subject.

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