Content Based Image Retrieval using Hexagonal Resampling and Detection of Ailments in MRI scans of Brain

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Abstract—Image processing is an expanding field with its applications spreading across several domains. There is extensive use of digital images for medical purposes which involves critical decisions to be made based on the elucidation of medical images such as MRI scan, CT scan, X-ray etc., and calls for substantial research. This paper is based on the project aimed at processing of MRI scans of brain. The proposed system performs content based retrieval of cases similar to the MRI scan loaded as query using Gabor wavelet based edge detection on hexagonal resampled grid, and proposes an algorithm for identification of ailment, if present. The work is restricted to identification of three brain pathologies viz. tumour, bleed and infarction. The project intends to assist doctors in identifying the abnormalities.

Keywords: Paper format, publish, template, sample

1. Introduction

Content based image retrieval, CBIR, involves looking for similar images based on the content of the images rather than the metadata as in text based image retrieval. Features such as colour, shape and texture are extracted from the image and these serve as basis for further processing. Normal images are found to be in rectangular lattice, transforming them to hexagonal grid using re-sampling delivers improved feature parameters which in turn enhances the retrieval performance. Supporting factor being the resemblance of retina of human eye with the hexagonal grid space helps in replicating natural behaviour in computer vision. Feature extraction starts with detection of edges which provides shape parameters. Gabor wavelet based edge detection technique is used in this work. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination [1]. Gabor filter has the unique property of orientation selectivity that differentiates it from other edge detection techniques that can be represented as summation of different filters. In this work, Gabor filter is applied along three orientations 00, 600 and 1200 and the individual responses are superimposed to get the final edge map. This resulting edge map is used to obtain the shape features using moment invariants. Moments can provide characteristics of an object that uniquely represents its shape [2]. In this work Hu set of invariant moments [3] is used which comprises of seven simple properties such as moment of inertia, skew invariant etc., of an image. To extract the texture parameters Gray Level Co-occurrence Matrix (GLCM) method is used. Summarily, GLCM is a second order statistical texture features extraction technique followed in this work. Based on the generated GLCM matrix, texture features – energy, entropy, correlation and homogeneity are calculated.

To get the detailed images of inner parts of the body, Magnetic Resonance Imaging (MRI) can be used. It employs radiology techniques involving radio waves and magnetism to generate the images. MRI scan has proven to be an extremely precise method for defect detection throughout the body. This work is concerned with following three brain pathologies – tumour, bleed and infarction. A brain tumour is an abnormal growth of tissue in the brain. Since there is limited space in intracranial cavity, growth of tumour is intrusive causing it to be essentially critical and has a high probability of being fatal. Bleed is the condition where there is leakage of blood through the break in the tissue walls over the brain surface. It can cause disastrous cerebral haemorrhage causing paralysis or even death. Infarction refers to death of tissues due to blockage of blood supply to that part thereby causing deficiency of oxygen. The project aims at detection of the above explained abnormalities related to brain and giving visual indications of the same. Thus finds significant role in assisting medical practitioners. This work is divided into two parts, first, content based image retrieval and second, detection of ailments, if any, in the given MRI scan of brain.

1. Content Based Image Retrieval

As explained in the previous section CBIR can be considered as searching through a database of images not based on keywords but on image content. Image content refers to features such as colour, shape and texture. As all the MRI scans are in gray scale this project only uses shape and texture parameters for retrieval purpose. The methods applied for extracting these features have been explained in the following subsections.

1. Hexagonal Resampling

The process of feature extraction is preceded by resampling. It involves transforming images present in rectangular lattice to hexagonal grid space based on the half pixel shift method [4]. For each odd row, retain the pixel values of each odd column and discard the pixel values of each even column. Also for each even row, discard each odd column value and each even column value is set as the average of the left and right pixel values. The hexagonal sampling reduces mean sampling density in spatial domain [5] as compared to the rectangular sampling. In the steps described above, some pixel values have been discarded. However, the improved efficiency accounts for the loss of data.

1. Gabor Wavelet Based Edge Detection

For feature representation and discrimination Gabor filters have been found to be predominantly suitable and also their frequency and orientation are similar to those of the human visual system. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave [1]. Integration of time/space and frequency data allows analysis of time frequency, which is termed as Gabor expansion. The filter has real and imaginary component representing orthogonal directions. The two components may be formed into a complex number or used individually. In this project only the real component of the filter has been used.

where,

*x’ = x cosθ + y sinθ*

*y’ = -xsinθ + y cosθ*

In this equation, \lambda represents the wavelength of the sinusoidal factor, \theta represents the orientation of the normal to the parallel stripes of a [Gabor function](http://en.wikipedia.org/wiki/Gabor_function), \psi is the phase offset, \sigma is the sigma of the Gaussian envelope and \gamma is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function.

1. Moment Invariants

For 2D continuous function *f(x,y)* the moment of order *(p + q)* is defined as

For *p,q = 0, 1, 2, . . .* Adapting this to scalar (greyscale) image with pixel intensities I(x,y), raw image Mij are calculated by

A uniqueness theorem (Hu [3]) states that if *f*(*x*,*y*) is piecewise continuous and has nonzero values only in a finite part of the *xy* plane, moments of all orders exist, and the moment sequence (*Mpq*) is uniquely determined by *f*(*x*,*y*). Conversely, (*Mpq*) uniquely determines *f*(*x*,*y*). In practice, the image is summarized with functions of a few lower order moments. Next, central moments are calculated using the following equations

Where and are the components of the centroid. Using these central moments up to the desired order can be calculated. Moments *ηi j* where *i* + *j* ≥ 2 can be constructed to be [invariant](http://en.wikipedia.org/wiki/Invariant_(mathematics)) to both [translation](http://en.wikipedia.org/wiki/Translation_(geometry)) and changes in [scale](http://en.wikipedia.org/wiki/Scale_(ratio)) by dividing the corresponding central moment by the properly scaled (00)th moment, using the following formula

Hu set of moment invariants [3] for moments which are invariant under rotation, scaling and translation, are defined as

*I1 = η20 + η02*

*I2 = (η20 - η02)2 + 4*

*I3 = (η30 - 3η12)2 + (3η21 - η03)2*

*I4 = (η30 + η12)2 + (η21 + η03)2*

*I5 = (η30 - 3η12) (η30 + η12) [(η30 + η12)2 –*

*3(η21 - η03)2] + (3η21 - η03)*

*(η21 + η03)[3(η30 + η12)2 - (η21 + η03)2]*

*I6 = (η20 - η02) [(η30 + η12)2 - (η21 + η03)2]*

*+ 4η11(η30 + η12) (η21 + η03)*

*I7 = (3η21 - η03) (η30 + η12) [(η30 + η12)2 –*

*3(η21 + η03)2] - (η30 - 3η12)*

*(η21 + η03)[3(η30 + η12)2 - (η21 + η03)2]*

1. GLCM Texture Measurements

Gray-Level Co-occurrence matrix is created from the image by calculating how often a pixel with gray-level (grayscale intensity) value *i* occurs horizontally adjacent to a pixel with value *j* [5] [6]. The outcome of GLCM for each element (i , j) is computed by summing the pixel with the value *i* occurred in the particular spatial relationship to a pixel with value *j* in the input series [7] [8] [9]. The co-occurrence probability between gray levels *i* and *j*, *Cij* is defined as

Where, *P (i, j)* represents number of occurrences of gray levels, *i* and *j* varies within the given image window for certain pairs of inter-pixel distance (δ) and orientation (θ). As explained by Haralick, after the computation of Gray-level Co-occurrence Matrix, the desired statistical texture measure can be found using co-occurrence probabilities. This probability measure can be defined as

The texture features can be calculated using the following equations

1. Proposed Methodology

The CBIR system proposed in this work can be illustrated with the help of architectural design of the system, as shown in figure 1.

For feature representation and discrimination Gabor filters have been found to be s:

* Top = 19mm (0.75")
* Bottom = 43mm (1.69")
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Recommended font sizes are shown in Table I.

1. Title and Author Details

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