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Feature Extraction of Medical Images Using Moment Invariants

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***Abstract*—** Automatic shape recognition and feature extraction from images has become very significant in today's digital word as the use of digital images has grown exponentially over the last few decades. Image processing is a method which uses computer algorithms to extract various useful information from the digital images. Image processing mainly involves visualization, pattern recognition, feature extraction, classification etc. Moment invariants have been used as features for image processing. Moments can provide features of an object that uniquely represent its shape. These features are independent of translation, scale and rotation. The aim of this paper was to investigate the usefulness of moment invariants for the feature extraction from digital images. Two experiments were conducted to test the moment invariant for rotation invariance and scale invariance. The study found that most of the seven features had minor fluctuations when rotating or scaling the image.

***Keywords*—**Moment Invariant, Image processing, Pattern recognition, Feature extraction

I. INTRODUCTION

Digital computers have evolved tremendously in the last few decades, so data from almost all fields is available in digital format. This is multimedia data in the forms such as text, images, videos, audios etc. Digital images are a potential source of information which needs to be analyzed; digital image processing techniques are used to process it. Digital image processing widely used in applications such as satellite images, military and weaponry, meteorology, astronomy, text images and medical technology. Digital image processing speedily substituting optical image processing [1], as it is more flexible and provides much wider range of algorithms to be applied to the digitally stored data.

Digital image processing usage computer algorithms to perform various operations on digital images, the fundamental steps in the processing includes image acquisition, image enhancement, image restoration, color image processing, image Compression, Morphological processing, Segmentation, Recognition, feature extractions, classification etc. Any digital images contain huge amount of information. This is why automated and sophisticated image analysis tools are truly needed. Several methods of digital image processing were developed at the Jet Propulsion Laboratory, MIT, Bell Labs, University of Maryland, and a few other places around the 1960s but the image processing cost was very high at that era. With the advent of affordable computers and dedicated hardware in the 1970s, digital image processing was reproduced [2].
Because of its invariant properties on image translation, scaling, and rotation, moment invariants have been widely used in image pattern recognition in a number of applications. For the continuous function, the moments are strictly invariant. Images, on the other hand, are discrete in practical applications. As a result, image geometric transformations may modify the moment invariants [3].

Rest of the paper is organized as follows, Section I contains the introduction of digital image processing, Section II contain the related work of moment invariants in image processing, Section III contain the some measures of moment invariants, Section IV contain the application of moment invariants in digital images and experimental background, section V describes results and discussion and Section VI concludes research work.

II. RELATED WORK

We started our literature review since moment invariant was introduced and we then reviewed the application of moment invariants in various areas of image processing. The history of moment invariants began many years before the first computer, in the nineteenth century, within the scope of algebraic invariants theory. The idea of algebraic invariants is said to have originated with David Hilbert, a notable German mathematician [4]. Hu [5], who used the conclusions of the theory of algebraic invariants to construct his seven renowned invariants to rotation of 2-D objects, was the first to propose moment invariants to the pattern recognition area in 1962. Since then, many papers have been dedicated to different refinements and generalisations of Hu's invariants, as well as their application in a variety of fields. Wong and Hall in [6] used moment invariants with satellite images for matching templates and also several researchers used moment invariants for character recognition [7, 8]. By revising the fundamental theorem and deriving invariants to general affine transforms, Flusser and Suk [7] and Reiss [9] made major contributions to the theory of moment invariants.

In [10] Van Gool et al. introduced affine-photometric invariants for gray level and color images. These characteristics are unaffected by the affine transform as well as simultaneous changes in picture contrast and brightness. Invariant Moments can be applied to many different aspects of image processing, including invariant pattern recognition, image normalization, image registration, focus/defocus measurement, and watermarking [11]. Recognition of human facial expression has turned into a growing research field. Feature extraction is one amongst the vital step within the recognition of facial expressions, in [12] Geometric Moment Invariants was used as a feature extraction method to recognize human facial expression. Hu's moment invariants were also used for the extraction of shape and texture features [13].

Moment Invariant has been used by different researchers in different areas of image processing. Over the past few decades, the use of Moment Invariant in medical image processing has grown significantly. S. Sharma et al. in [14] used Zernike moments along with support vector machine (SVM) to detect abnormalities or suspicious areas in digital mammograms. They used Zernike moments with order 20 and got better results among other studies. S. Urooj et al. in [15] were presented a complete framework for geometric invariant feature extraction using Hu's moment, and utilized Hu' seven moment invariants to extract the invariant features from medical images. The proposed method tested against scale invariance and rotation invariance. Y. M. Vaidya et al. in [16] presented an algorithm using different moment invariants for feature extraction of blood vessels of retinal fundus images and variety of moment invariants such as geometric and Zernike moment invariants were employed in the algorithm. A further study was employed on radiographic images of four dental caries in [17] and features were extracted by using Hu's moment invariants.

III. MOMENT INVARIANTS

Moments can provide features of an object that uniquely represent its shape and hence moment invariants used to extract features of images. Several strategies for obtaining invariant features from moments for object recognition and representation have been developed [18]. Hu [5] provided the mathematical basis for two-dimensional moment invariants and exhibited their applications for shape recognition. Hu's moment invariant values are invariant to translation, scale and rotation of the shape.

Hu [5] defines seven of these shape descriptor values computed from central moments through order up to three that are independent to object translation, scale and orientation. Translation invariance moments are derived by calculating central moments, size invariance moments are achieved from algebraic invariants and a set of seven invariant moments can be calculated from the second and third order values of the normalized central moments which are independent of rotation.

Moment invariants are usually calculated based on the information provided by both the shape boundary and its interior region [5]. Given a function *f(x,y)*, these regular moments are defined by:

$$M_{pq} = \iint x^p\, y^q f(x,y)dxdy \qquad (1)$$

Where, *Mpq* is the two-dimensional moment of the function *f(x, y)* for *p*, *q* = 0,1, 2, …. The order of the moment is *(p+q)* where *p* and *q* are both natural numbers. For implementation in digital form this becomes:

$$M_{pq} = \sum_X \sum_Y x^p\, y^q f(x,y) \qquad (2)$$

Image centroids are used to define the central moment and to normalise the image for translation. The equation (2) further used to calculate the co-ordinates of the centre of gravity of the image and is shown by:

$$\mu_{pq} = \sum_X \sum_Y (x-\bar{x})^p\, (y-\bar{y})^q \qquad (3)$$

Where, $\bar{x} = \frac{M_{10}}{M_{00}}$ and $\bar{y} = \frac{M_{01}}{M_{00}}$

The central moments do not change; therefore, the central moments are invariants under translation. From (3), it is easy to express the central moments of order up to 3 are as follows in expression (4).

$$\eta_{pq} = {}^{\mu_{pq}}/_{\mu_{00}}\gamma \qquad (4)$$

Where the normalization factor: γ = (p+q/2)+1. A set of seven values can be determined from normalized central moments and they are described by:

$$\begin{aligned}
\phi_1 &= \eta_{20} + \eta_{02} \\
\phi_2 &= (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 \\
\phi_3 &= (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \\
\phi_4 &= (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \\
\phi_5 &= (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] \\
&\quad + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\
\phi_6 &= (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\
&\quad + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \\
\phi_7 &= (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] \\
&\quad - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]
\end{aligned} \qquad (5)$$

All the seven Hu's [5] invariant moments, ϕ_I, $1 \le I \le 7$, computed on the shape boundary and its interior region and also shown to independent to scale and rotation.

IV. MOMENT INVARIANTS APPLIED TO DIGITAL IMAGES

Mainly the image processing systems based on: Image acquisition, Preprocessing of the images, Feature extraction, and Classification. Common example is the reading of alphabetic characters in text [19]. Pattern recognition is a crucial measure of any image processing systems. Many applications employing moment invariant for shape recognition for the classification of such definite shapes and it is one of the most primary and common problems in pattern recognition.

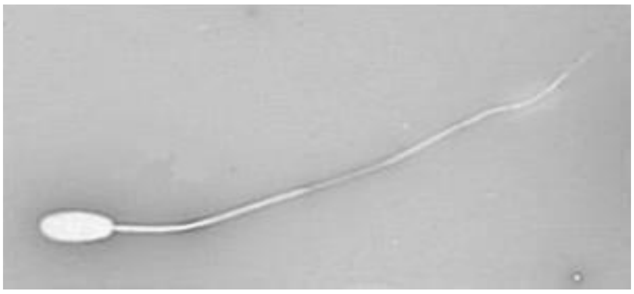

Figure 1. A Digital Image

The digital image shown in Fig.1 is used for the experiment and also the necessary preprocessing steps were carried out on the image [20] to meet the requirement of experiment. All the algorithms were tested on MATLAB version 7 platform.

V. RESULTS AND DISCUSSION

This section shows the results obtained by applying the moment invariants technique to the chosen image in order to calculate the usefulness of shape recognition in digital images. The test image is shown in Fig.-1. All the experiments performed on MatLlab 7. Firstly, we tested the proposed moments for rotation invariance and then for scale invariance.

The first experiment was conducted to examine the invariant moment for rotation invariance. The test image is rotated by 0 to 60 degree with 10 degree increment step and the seven invariant moments are computed for each of the rotation of the test image. The obtained results are summarized in Table 1. It is observed that ϕ_3, ϕ_5 and ϕ_7 shows almost rotational invariance properties.

The second experiment was conducted to examine the invariant moment for scale invariance. The test image is scaled by positive scale factor such as 0.1, 0.2, 0.3, 0.4, and 0.5 with 0.1 increment step and the seven invariant moments are computed for each of the scaled value. The obtained results are summarized in Table 2. It is observed that highest fluctuation occurs for the features ϕ_5 and ϕ_7 and the ϕ_3, ϕ_5 and ϕ_7 shows almost scale invariance properties.

Table 1. Features of Moment Invariant under different rotation angles

Rotation by 10 degrees							
Original	5.7928	11.6573	33.2390	32.8843	66.1683	38.8356	67.4323
10	5.6800	11.4327	33.2442	32.8661	66.1742	38.8097	67.4381
20	5.6361	11.3675	33.2483	32.7145	66.1784	38.9611	67.4139
30	5.6801	11.5024	33.2254	32.4986	66.1711	39.4142	67.4104
40	5.7242	11.6553	33.2022	32.2980	66.1414	40.3256	67.3803
50	5.8633	12.0415	33.2583	32.2116	66.1724	40.9747	67.4348
60	6.0621	12.6120	33.2467	32.2656	66.1574	40.2260	67.4037

Table 2. Features of Moment Invariant under different Scaling factors

Scaling by 0.1 factor							
Original	5.7928	11.6573	33.2390	32.8843	66.1683	38.8356	67.4323
0.1	5.7898	11.6489	31.8850	31.6769	63.6183	37.5829	64.9369
0.2	5.7925	11.6559	33.2941	32.9546	66.3377	38.9109	67.3492
0.3	5.7812	11.6322	33.5909	32.8138	66.3714	38.8729	68.1472
0.4	5.7845	11.6394	33.4326	32.8676	66.3053	38.8645	67.8407
0.5	5.7850	11.6403	33.1024	32.7959	65.9453	38.7248	67.2478

VI. CONCLUSION

In this study, an outline of feature extraction using moment invariant is studied. The seven features of moment invariants are employed to extract the invariant features from the test image. Two experiments were conducted to test the moment invariant for rotation invariance and scale invariance. The study found that most of the seven features had minor fluctuations when rotating or scaling the image.

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