Content based medical image retrieval based on pyramid structure wavelet

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Abstract

As technology continues to increase the various formats in which medical images are created, transmitted, and analyzed, it has become more necessary to restrict the different ways in which this data is stored and formatted between the conflicting modalities. There is a significant increase in the use of medical images in clinical medicine, disease research, and education. While the literature lists several successful systems for content-based image retrieval and image management methods, they have been unable to make significant inroads in routine medical informatics. This paper presents a new approach to image retrieval based on color, texture, and shape by using pyramid structure wavelet. The major advantage of such an approach is that little human intervention is required. However, most of these systems only allow a user to query using a complete image with multiple regions and are unable to retrieve similar looking images based on a single region. Experimental results of the query system on different test image databases are given. This paper introduces a comparative study between color, texture, shape and the pyramid structure wavelet technique and generates the receiving operating characteristic curve (ROC) to assess the results. The area under the curve when use color is 0.58, when use shape is 0.68, when use texture 0.74 and when use the wavelet technique is 0.8.

Key words:

Image Retrieval, Content based image retrieval, Wavelet transform, and Medical image

1. Introduction

In the last few years, several research groups have been investigating content based image retrieval. A popular approach is querying by example and computing relevance based on visual similarity using low-level image features like color histograms, textures and shapes. Image retrieval (IR) is one of the most exciting and fastest growing research areas in the field of medical imaging. There are two techniques for image retrieval. The first one uses manual annotation (Text-Based Image Retrieval) and the second one uses automatic features extracted from image larger and larger. Furthermore, it is subjective to the culture, the knowledge and the feeling of each person. The second approach uses features extracted from the image such as color, texture, shape it is independent of people. Reasons for its development are that large image databases, traditional methods of image indexing have proven to be insufficient, laborious, and extremely time consuming. These old methods of image indexing, ranging from storing an image in the database and associating it with a keyword or number, to associating it a categorized description, have become obsolete. This is not CBIR. In CBIR, each image that is stored in the database has its features extracted and compared to the features of the query image.

This paper is concerned with a comparative study between retrieval image by using content-based image retrieval using color method or texture or shape and retrieval image with combination between three techniques.

The goals of medical information systems have often been defined to deliver the needed information at the right time, the right place to the right persons in order to improve the quality and efficiency of care processes.

Need more than a query by patient name, series ID or study ID for images. For the clinical decision-making process, it can be beneficial or even important to find other images of the same modality, the same anatomic region of the same disease. [1- 2]

Image Retrieval aims to provide an effective and efficient tool for managing large image databases. With the ever-growing volume of digital image generated, stored, accessed and analyzed. The initial image retrieval is based on keyword annotation, which is a natural extension of text retrieval. There are several fundamental problems commonly associated with this approach such as Text search is language-specific and context-specific.

Text search is highly error-prone, and Text is cumbersome. To eliminate problems of text-based approach, Content-based image retrieval system is proposed in which query result depend on the visual features of the image (color, texture, shape).

The paper is divided into three main sections. Section one is devoted to general introduction to CBIR. The second one concerns the background of the features employed in CBIR. The third is concerned with the experimental part of the paper, which is a full explanation of the algorithms used, and how they worked, and we make comparative study between retrieval image by using content-based image retrieval using method color or texture or shape and retrieval image with combination between three techniques.

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2. Previous work

Recently visual information retrieval systems images are linked in a database, and can be searched by text strings. These text strings can be related either to a feature in the image itself, or to the image (e.g., suspect's name, place and date of crime). These strings are stored and can be searched in a structured way, as in classical SQL-databases. Text strings are often subject to classification into one of a limited number of allowed strings. This approach is taken because free text is susceptible to spelling errors and allows the use of several strings with the same meaning.
Text descriptors have several limitations:

- Text descriptors depend on what the user enters into the database.
- Several image features, for example texture and color distribution, are difficult to describe unambiguously using text descriptors.
- Entering text strings in a database requires much effort from the user, and any changes to the classification rules will make the reclassification of images necessary.

However, at this moment visual information systems provide different ways of searching the database, enabling searches based on features such as texture, shape, and color.
Such feature-based searches can be combined with searches for textual information. This system is based on a similarity search that ranks the images in the database based on a computable measure for their similarity to a chosen image. Similarity searches often involve user interaction, whereby the user provides feedback on the relevance of the search results by selecting a different feature, or modifying the weight of certain features. [3-5]

2.1 Information Retrieval

A lot of information about the content of an image can come from other sources than the image itself.
In the last years, image-processing techniques have been developed that allow the indexing of images based on their visual content (content-based image retrieval). This section describes these two different approaches to image retrieval. In the next subsections, the basic methods and problems of respectively content-based image retrieval will be discussed.

2.2Text-Based Image Retrieval (TBIR)

The text-based technique first annotates with text, and then uses text-based database management system to perform image retrieval. The use of text-based image retrieval was very popular in the early days of computer vision, but its usage has been less dominant in recent years.

2.2 .1Uncontrolled Vocabulary

The most common method for image retrieval is to annotate image with associated text. The human indexer can describe image according to content, the caption of the image, or the background information such as time, place, or photographer. To access the desired image data, the seeker can construct queries using homogenous description, such as keyword, to match the annotation. Since this method does not limit the indexer and the seeker to use specific textual information to describe images, the term," uncontrolled vocabulary" , is used to distinguish this method from other systematic methods.

Free Text or Additional Keywords

Van den Berg classified the use of uncontrolled vocabulary into two main methods:
The use of free text, and of additional keywords. About the former method, van den Berg stated that:"Description of images in natural language comes closest to our natural way of communication but bears in them the ambiguity of prose. Retrieval is based on exact string matching and success is unpredictable science it depends entirely on the concurrence between the vocabularies of the people who have built the descriptions and those formulating the search terms"[6].

2.2.2 Controlled Vocabulary

In an attempt to introduce a measure of control to the vast number of descriptive word, which might be used when, indexing images, and considerable attention has been paid to the development of thesaurus-based indexing system [6].

3 Content based image retrieval

CBIR or Content Based Image Retrieval is the retrieval of images based on visual features such as color, texture and shape [7]. Reasons for its development are that in many large image databases, traditional methods of image indexing have proven to be insufficient, laborious, and extremely time consuming. These old methods of image indexing, ranging from storing an image in the database and associating it with a keyword or number, to associating it with a categorized description, have become obsolete. This is not CBIR. In CBIR, each image that is stored in the database has its features extracted and compared to the features of the query image. It involves two steps [8]:

- Feature Extraction: The first step in the process is extracting image features to a distinguishable extent.

- Matching: The second step involves matching these features to yield a result that is visually similar.

4. Feature Extraction

This is describing common methods for extracting content from images so that they can be easily compared. The methods outlined are not specific to any particular application domain

4.1 Color Features

One of the most important features that makes the recognition of images possible by humans is color. Color is a property that depends on the reflection of light to the eye and the processing of that information in the brain. The color is used everyday to tell the difference between objects, places, and the time of day [9-10]. Usually colors are defined in three dimensional color spaces. These could be RGB (Red, Green, and Blue), HSV (Hue, Saturation, and Value) or HSB (Hue, Saturation, and Brightness). The last two are dependent on the human perception of hue, saturation, and brightness. Color searches will usually involve comparing color histograms, though this is not the only technique in practice. Color represents the distribution of colors within the entire image. This distribution includes the amounts of each color, but not the locations of colors.

4.2 Texture Features

Texture is that innate property of all surfaces that describes visual patterns, each having properties of homogeneity. It contains important information about the structural arrangement of the surface, such as; clouds, leaves, bricks, fabric, etc. It also describes the relationship of the surface to the surrounding environment [7]. In short, it is a feature that describes the distinctive physical composition of a surface.

Texture properties include: (Coarseness, Contrast, Directionality, Line-likeness, Regularity, and Roughness).Texture is one of the most important defining features of an image. It is characterized by the spatial distribution of gray levels in a neighborhood [10]. In order to capture the spatial dependence of gray-level values, which contribute to the perception of texture, a two-dimensional dependence texture analysis matrix is taken into consideration. This two-dimensional matrix is obtained by decoding the image file; jpeg, bmp, etc.

4.3 Shape Features

Shape may be defined as the characteristic surface configuration of an object; an outline or contour. It permits an object to be distinguished from its surroundings by its outline [12]. Shape representations can be generally divided into two categories [7]:

1. Boundary-based, and
2. Region-based.

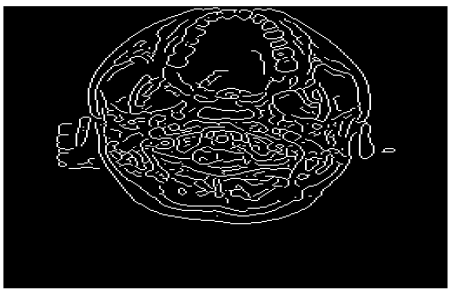


Fig. 1 Boundary-based

Boundary-based shape representation only uses the outer boundary of the shape as shown in fig.1. This is done by describing the considered region using its external characteristics; i.e., the pixels along the object boundary. Region-based shape representation uses the entire shape region by describing the considered region using its internal characteristics; i.e., the pixels contained in that region [13].

5. Proposed work

Work implemented in Matlab and the database software used is SQL, with different training sets (263 images) can be constructed. This research use DICOM image, in DICOM image pixel has not limited pixel so it can not be stored in database to solve this problem DICOM image must convert to normal image (jbg, tif, bmp)

First, find maximum pixel in DICOM image then divided max of DICOM over 255.Finally the result multiply in max DICOM.

5.1 Digital Imaging and Communications in Medicine (DICOM)

The DICOM file that is created that represents some variable that could be attributes such as; patient name, date of the study, image modality and pixel information. To create an image from the DICOM information the tags, which correspond to the image, are extracted out of the file information. The image is then formed as a .jpg or .bmp image as shown in section 5. There are many advantages to using the DICOM format there are standard way to store

information safe that any transfer of the data will be brief and exact.

The database can be described as show in table 1

Class	No. of image
Brain	88 brain tumor 20 normal brain
Head	100 head tumor
Spin	55 normal spin
Total image	263 images

Retrieve image in database by using three techniques (color, texture, shape) and a combination between them.

5.2Color

5.2.1 Quadratic Distance Metric

This equation is used in deriving the distance between two color histograms is the quadratic distance metric:

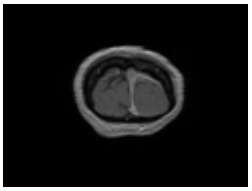
$$d^2(Q,I) = (H_Q - H_I)^T A (H_Q - H_I) \quad (1)$$

Where HQ: histogram of query image, HI: histogram of image in database and A: similarity matrix.

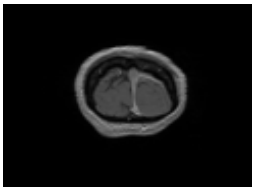
5.2.2 Histograms

This paper used Global color histograms in extracting the color features of images. In analyzing, the histograms there were a few issues that had to be dealt with. First, there was the issue of how much we would quantize the number of bins in a histogram. By default the number of bins represented in an image's color histogram.

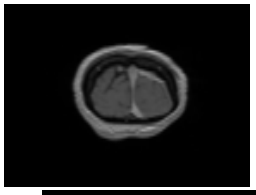
Therefore, when retrieve query image by using content based image retrieval using color method from head tumor category the result is shown in fig2:



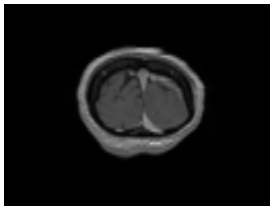
Query image

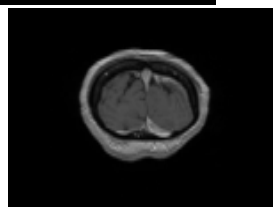


Diff=0



Diff=0.08228





Diff=0.23612 Diff=0.416

Fig. 2 show example of head tumor query

5.3 Texture

5.3.1 Pyramid-Structured Wavelet Transform

Another technique has been examined called the pyramid-structured wavelet transform for texture classification. Its name comes from the fact that it recursively decomposes sub signals in the low frequency channels. It is mostly significant for textures with dominant frequency channels. For this reason, it is mostly suitable for signals consisting of components with information concentrated in lower frequency channels [7].

Due to the innate image properties that allows for most information to exist in lower sub-bands, the pyramid-structured wavelet transform is highly sufficient.

Using the pyramid-structured wavelet transform, the texture image is decomposed into four sub images, in low-low, low-high, high-low and high-high sub-bands. At this point, the energy level of each sub-band is calculated. This is first level decomposition. Using the low-low sub-band for further decomposition, This paper is reached third level decomposition. The reason for this is the basic assumption that the energy of an image is concentrated in the low-low band.

5.3.2 Energy Level

Energy Level Algorithm:

1. Decompose the image into four sub-images
2. Calculate the energy of all decomposed images at the same scale, using [7]:

$$E = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{n} |X(i,j)| \quad (2)$$

Where M and N are the dimensions of the image, and X is the intensity of the pixel located at row i and column j in the image map.

3. Repeat from step 1 for the low-low sub-band image, until index is equal to 3.

Using the above algorithm, the energy levels of the sub-bands were calculated and further decomposition of the low-low sub-band image. This is repeated three times, to reach third level decomposition. These energy level values are stored to be used in the Euclidean distance algorithm.

5.3.3 Euclidean Distance

Euclidean Distance Algorithm:

1. Decompose query image.
2. Get the energies of the first dominant k channels.

3. For image i in the database obtain the k energies.
4. Calculate the Euclidean distance between the two sets of energies, using [7]:

$$D = \sum_{k=1}^{K} (x_k - y_{i,k})^2 \quad \text{Note take k=6} \qquad (3)$$

Increment. Repeat from step 3.

Using the above algorithm, the query image is searched for in the image database. The Euclidean distance is calculated between the query image and every image in the database. This process is repeated until all the images in the database have been compared with the query image. Upon completion of the Euclidean distance algorithm, we have an array of Euclidean distances, which is then sorted. The three topmost images are then displayed as a result of the texture search.

So when retrieve query image by using content based image retrieval using texture method from brain tumor category the result is shown in fig3:

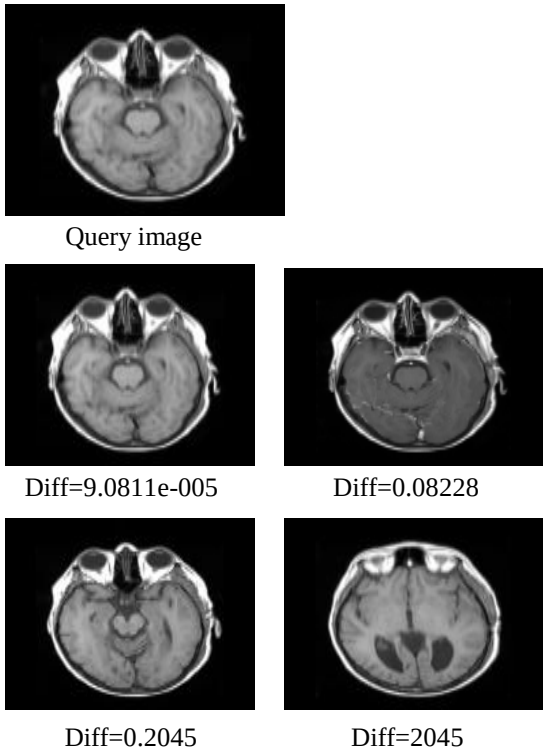


Fig. 3 show example of brain tumor query

5.4 Shape

Shape extraction, the process goes through several steps. The image is first transformed into a gray level image, and then it is transformed into a binary one. Further, the binary image suffers a de noise process in order to eliminate those isolated pixels or small isolated regions because very often the shape obtained from the binary image has noise around the shape boundary. Then, the boundary is finally traced using a 8-connectivity contour tracing technique [15].

Fourier Descriptor C_k is defined as the k-th discrete Fourier transform coefficient:

$$C_k = \sum_{n=0}^{k-1} Zn \cdot e^{-2\pi ikn/N} \qquad (4)$$

Where z_0, $z_1 \ldots z_{N-1}$ represents the boundary coordinates in a counter-clockwise order.

Next, we apply the following theoretical results proven in [15]. For rotational invariance and invariance with respect to the starting point, we use only the absolute values of the descriptors C_k. For translational invariance we discard the Fourier Descriptor C_0 and for scale invariance we divide the Fourier Descriptors by $| C_1 |$. The number of coefficients generated from the transform is usually large. As we are interested in minimizing as much as possible the size of the feature vectors, but at the same time achieve a good representation of shape, we finally use only a limited number of 20 Fourier Descriptors, more precisely those that describe the lowest frequencies and that contain information about the general features of the shape.

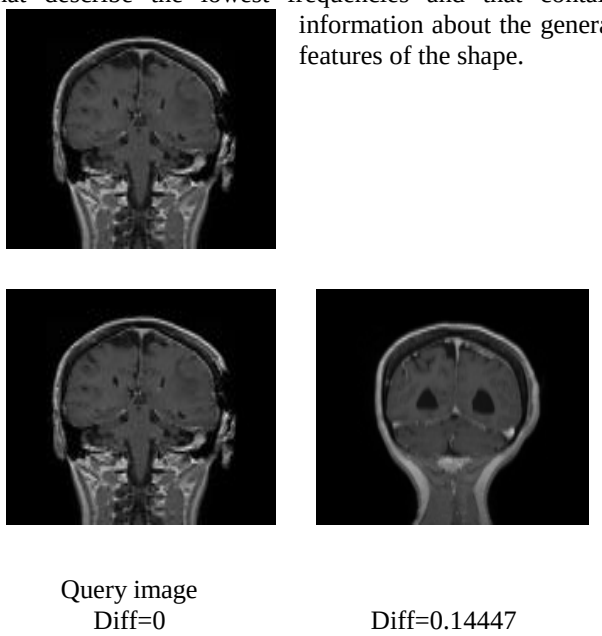


Fig.4 show example of head tumor query

As an example retriever query images by using content based image retrieval using shape method from head tumor category give about 90%:

5.5 The Hybrid technique based on pyramid structure wavelet:

In this technique, we retrieve image by using color, texture and shape as the following algorithm:

1. Take query image.
2. Select technique assumes hybrid active technique.
3. Calculate HSV by using quadratic distance equation (color), energies by using pyramid structure wavelet (texture) and Fourier (shape) for query image.
4. Loop on database images for each database image:
   4.1 compare HSV of query with HSV database images
   4.2 compare energies of query with energies database images
   4.3 compare Fourier of query with Fourier database images
5. Sort each feature list ascending
6. Combine 3-sorted list in 1-sorted list contain indices of sorted images and their differences.

An example retriever query images by using hybrid technique from brain tumor category give the result shown in fig5:

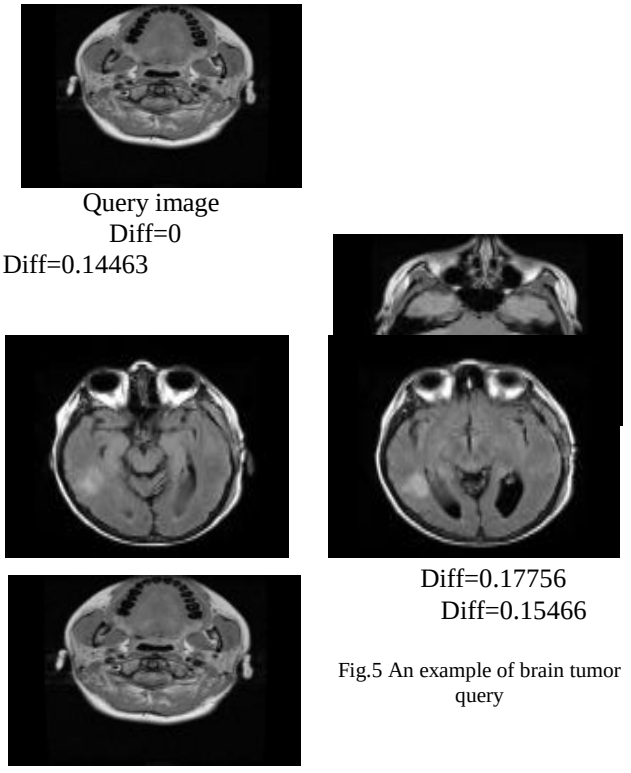


Fig.5 An example of brain tumor query

6 Experimental results

The hybrid technique based on pyramid structure wavelet was implemented in MATLAB programming language on a PC with Pentium 4CPU under Windows XP. To compare the performance of hybrid technique with other techniques (color, texture, shape), the experiments were done on the same database which contain 263 images are classified as the following:

88 images brain tumor, 20images normal brain, 100 images head tumor and 55 normal spin.

It can assess result of retrieval image by using color, texture and shape and combination between them by using Receiver-operating characteristic curve (ROC) Then we can conclude that the combination between them gave the best result where it has a few false negative, the second which gave result very good is texture, the third which gave result good is shape finally the color technique gave a resnable result as shown in fig. 6 where the area under the curve when use color is 0.58, when use shape is 0.68, when use texture 0.74 and when use the hybrid technique is 0.8. Although hybrid technique was gave the best result with the other technique it take the longest time for calculation comparison with the other techniques.

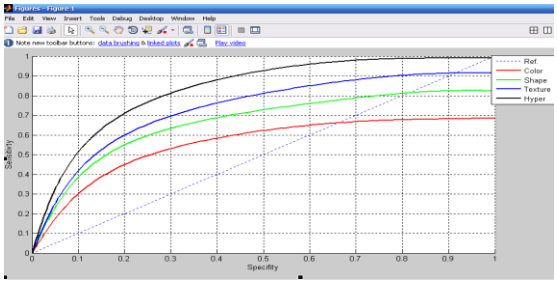


Fig. 6 Comparison of retrieval image using color, texture, shape and hybrid techniques

7. Conclusion

This paper performs a simple color-based search in an image database for an input query image, using color histograms. It then compares the color histograms of different images using the Quadratic Distance Equation. Further enhancing the search, the paper performs a texture-based search in the color results, using wavelet decomposition and energy level calculation. It then compares the texture features obtained using the Euclidean Distance Equation. A more detailed step would

further enhance these texture results, using a shape-based search.

This paper introduced a hybrid technique based on pyramid structure wavelet and compares the results with other techniques based on color, texture, shape. Generate the receiving operating characteristic curve (ROC) to assess the results. The area under the curve when use color is 0.58, when use shape is 0.68, when use texture 0.74 and when use the wavelet technique is 0.8.

8. Future work

These systems are envisaged as working in an "intelligent" manner, similar to the functioning of the human visual system. Such systems would learn and draw conclusions based on experience. These systems remain yet hypothetical because knowledge of human visual system is limited.

References

[1] KP.Andriole, "The Society for Computer Applications in Radiology Transforming the Radiological Interpretation Process (TRIP) Inititative", White Paper (http://www.siimweb.org). November 2005. Last Accessed: March 26, 2007.

[2] A.Smeulders, M.Worring, S.Santini, A.Gupta, R.Jain, "Content-based image retrieval at the end of the early years", IEEE Trans Pattern Rec. & Machine Intel., 22(12):1349-80, 2000.

[3] SK.Chang, A.Hsu, "Image information systems: Where do we go from here?", IEEE Transactions on Knowledge and Information Engineering, 4(5), pp.644- 658, 1994.

[4] P.Agrain, H.Zhang, D.Petkovic, "Content-based representation and retrieval of visual media: a state of the art review", Multimedia Tools and Applications, 3(3), pp. 179-202, 1997.

[5] J.P. Eakins, M.E. Graham, "Content-based image retrieval", Tech. Rep. JTAP-039, JISC Technology Application Program, Newcastle upon Tyne, 2000.

[6] Lai.Tring-Sheng, "A Photographic Image Retrieval System", School of Computing, Engineering and Technology University of Sunderland Sunderland, United Kingdom January 2000,

[7] Siddiqu Sharmin, "A Wavelet Based Technique for Analysis and Classification of Texture Images", Carleton University, Ottawa, Canada, Proj. Rep. 70.593, April 2002.

[8] Seidl Thomas and Kriegel Hans-Peter, "Efficient User-Adaptable Similarity Search in Large Multimedia Databases", in Proceedings of the 23rd International Conference on Very Large Data Bases VLDB'97, Athens, Greece, August 1997.

[9] HD. Tagare, CC. Jaffe, J. Duncan, "a content-based retrieval approach", 4(3):184-98, J Am Med Inform Assoc. May-Jun 1997.

[10] Wang Shengjiu, "A Robust CBIR Approach Using Local Color Histograms", Tech. Rep. TR 01-13, October 2001.

[11] R. Jain, R. Kasturi, and B. G. Schunck, Machine Vision, McGraw Hill International Editions, 1995.

[12] Lexico Publishing Group, LLC, "shape", [Online Document], Available at: http://www.dictionary.reference.com/search?q=shape

[13] [13]- B. Kimia Benjamin, "Symmetry-Based Shape Representations", October 1999, Found at: http://www.lems.brown.edu/vision/Presentations/Kimia/BM-Oct-99/talk.html

[14] Bouet Marinette, Khenchaf Ali, and Henri Briand, "Shape Representation for Image Retrieval", 1999, [Online Document], Available at: http://www.kom.etechnik.tudarmstadt.de/acmmm99/ep/marinette/

[15] T. Petkovic, J. Krapac, Technical Report. "Shape Description with Fourier Descriptors", 2002.

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