Research Interests

My early research work concentrated on shape recognition. I published several articles in the late 80’s and early 90’s mainly in the area of pattern recognition. The most noted publication is; the comparative study about the moment invariants. This article is the most cited article among all of my publications. The article also won the prestigious most honorable mention award given by the international pattern recognition society for the year 1990.

My publications have been cited in several books and more than 900 refereed international journals and conference proceedings.
Most of my publications cover many aspects of research dealing with image segmentation, image enhancement, image description, and biomedical image processing and pattern analysis.

The following sections highlight some of my research interests and goals:

1- Efficient computation of moments and moment invariants

Many researchers have used moments to compute wide range of functions particularly those that can be represented by series expansions. The moments are widely used in many areas. They have been used successfully to classify, recognize and segment objects in many pattern recognition and image processing applications.
The moments gained popularity in pattern recognition for their suitability to be normalized and become invariant against many parameters such as scale, shift, rotation, contrast, and blur. The regular moments can be considered the building block of all other related forms of moments such as orthogonal moments. This means that any gain or efficiency in computing the regular moments can be passed on to the other forms of moments. In fact the efficiency of computing the moments has been already used to improve the computation of other transforms such as DST and DCT.

We have introduced a new transformation procedure. This transformation is guaranteed to reduce the number of operations needed to compute a particular moment order of a one dimensional signal to at least one half and one fourth for computing a particular order of two dimensional signal or image.

2- Image compression and retrieval

The discrete cosine transform (DCT) is often used in signal and image processing, especially for data compression. The excellent energy compaction property of the DCT is the main reason for its popularity. We introduced a new pre-processing approach for the removal of the blocking effect, associated with the standard 2D-DCT. In this method, the processing of the image is started from the top corners by zigzagging rows and columns of an image into horizontal, vertical or diagonal streams of pixels. These pixel streams are transformed into one-dimensional line arrays. The one-dimensional DCT transform is applied to each array. The experimental results revealed the effectiveness of this method in reducing the blocking effect associated with the standard DCT. The zigzag line method produces very good subjective as well as PSNR results.
Image retrieval plays an important role in a broad spectrum of applications. Content-based retrieval (CBR) is one of the popular choices in many biomedical and industrial applications. Discrete image transforms have been widely studied and suggested for many image retrieval applications. The Discrete Wavelet Transform (DWT) can be used to form the basis for extracting features for retrieving images based on the description of a particular object within the scene. In our research we highlight the common features between compression and retrieval. Several examples have been used to test the DWT retrieval system. A comparison between DWT and Discrete Cosine Transform (DCT) has also been made. The retrieval system using DWT requires preprocessing and normalization of images, which might slow down the retrieval process. The accuracy of the retrieval using DWT has been significantly improved by incorporating efficient K-Neighbor Nearest Distance (KNND) measure in our system.

3- Image segmentation and its application in bioinformatics

Biofilms are biological microorganisms attached to surfaces and develop a complex heterogeneous three-dimensional structure. Understanding interactions in multispecies biofilms may contribute to treatment of polymicrobial biofilm infections as well as rational design of engineered biofilms. Analysis of microbial biofilms by confocal laser scanning microscopy (CLSM) yields a stack of digital images that can be combined to give a three-dimensional view of the biofilm. Information on the relationships among bacteria in multispecies biofilms can be obtained from CLSM image stacks by combining pattern recognition and image processing techniques such as clustering and segmentation.

A multi resolution image analysis utilizing image segmentation of image contours as boundaries for extracting objects at multi resolution levels has been successfully implemented by our biofilm research group (Collaboration effort with Biology dept.). The scheme reduced the complexity of the segmentation problem considerably and simplified the clustering process.

4- Real time image processing

One particular new area that is emerging in the last few years is digital image processing on GPU (Graphical Processing Unit). GPU image processing appears to be a promising platform to increase the capabilities of our image processing algorithms and achieve real time image processing. Development and application of new algorithms to take advantage of the immense processing power of GPUs is a major focus of this research, particularly applications that utilize GPUs in other fields such as biology and medicine.

5- Pattern discovery and trend analysis in health disparity data

The automation of the process of summarizing documents plays a major role in pattern discovery and trend analysis for many areas and in particular for health disparity data. Automatic Text Summarization has been focused on retaining the essential information without affecting the document quality. New multi-document summarization methods that combine topic and fuzzy logic models are more suitable for this kind of application. These methods extract the most relevant topic words from source documents to form
elements of fuzzy sets for the fuzzy logic model. Meanwhile, each sentence on the source
document is used to generate a fuzzy relevance rule that measures the importance of each
sentence. A fuzzy inference system is used to generate the final summarization.

6- The automatic rating of internet postings

The Internet Postings and Personal Freedom
The uncontrolled use of the internet: the good and the bad
Things that may seem good for someone are probably hurting someone else.
Can we accept a wild internet? Anyone could do anything even if it meant destroying
another person by spreading false information.
History shows an endless number of examples of crimes that thrive in lawless
environments. The need to have a global internet constitution and some sort of internet
rating system to at least warn users about the intentions or the contents of a posting is
very essential. The postings may include images, videos, text and audio. A
transformation of all of these postings to a common rule based platform that can be used
to categorize them is essential to the success of such a rating system.
All of the above mentioned categories can be semantically segmented and analyzed to
conform to a set of semantically defined rules. The semantic rules can be used to set the
conditions for rating each category.