In this digital era of our world, huge amount of digital image data are being collected on a daily basis. The collected image data is being stored for subsequent processing and use in a wide variety of applications. An image contains descriptive information about the object it represents. A photograph displays this information in a manner that allows the viewer to visualize the subject itself. Images can be classified into several types based upon their form or their method of generation. For surveillance applications for instance, the amount of remotely sensed imagery collected daily by space-borne or airborne systems is on the order of terra bytes. It is often important to accurately and precisely extract relevant information out of this data for a variety of applications. It is, however, impossible
to manually carry out this processing and analysis wholly by human operators. The acquired image data is often noisy, and target objects and background bear significant textural variations. It may also be desirable to track features or objects in an image through time to obtain a dynamic analysis of the scene. In computer vision applications, for instance, an important goal is to understand the contents of an image and be able to automatically gain an understanding of the scene and the surroundings, implying an extraction and recognition of an object. As a result, there is a strong demand for reliable and automated image processing algorithms, for image smoothing, textured image segmentation, object tracking in video sequences, and object extraction and recognition.

The broad objective of this thesis is that of developing image processing algorithms which are efficient, in the sense of ease of computations, fast, statistically robust, in the sense of being resilient to noise, statistically significant and meaningful, in the sense of accounting for textural variations in images, with an ability to extract and provide best edge of target objects in images, for object recognition and tracking purposes.

We next give the motivations for the image processing algorithm we developed, which constitute the core contributions of this thesis, and then the description about the basic concepts of image processing.

1.1 Thesis Motivation and Contributions

This thesis discusses work-in-progress on the application of swarm intelligence ideas to Feature Extraction, such as extracting boundaries or edges of
objects. Feature selection and feature extraction are the most important step to a number of disciplines such as pattern recognition, knowledge discovery and also in classification systems. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. When performing analysis of complex data one of the major problems stems from the number of variables involved.

Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which over fits the training sample and generalizes poorly to new samples.

Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy. At present there are many methods to deal with feature selection. In our research we propose to present a novel feature selection algorithm that is based on swarm intelligence.

Swarm intelligence methods are computational methods inspired by animals such as social insects acting together to solve complex problems. Ants exhibit complex social behaviours that have long since attracted the attention of human beings. Probably one of the most noticeable behaviours visible to us is the formation of so-called ant streets. One of the most surprising behavioural patterns exhibited by ants is the ability of certain ant species to find what computer scientists call shortest paths. Biologists have shown experimentally that this is possible by exploiting communication based only on pheromones, an odorous chemical
substance that ants may deposit and smell. It is this behavioural pattern that inspired computer scientists to develop algorithms for the solution of optimization problems. The first attempts in this direction appeared in the early ’90s and can be considered as rather “toy” demonstrations, though important for indicating the general validity of the approach. Since then, these and similar ideas have attracted a steadily increasing amount of research and Ant Colony Optimization (ACO) is one outcome of these research efforts. In fact, ACO algorithms are the most successful and widely recognized algorithmic techniques based on ant behaviours. Their success is evidenced by the extensive array of different problems to which they have been applied, and moreover by the fact that ACO algorithms are for many problems among the currently top-performing algorithms.

Swarm Intelligence approach in solving complicated optimization problems is relatively new. The main advantage of swarm intelligence approach is that system of simple communicating agents is capable of solving complex problems. An Ant Colony Optimization – ACO is a branch of swarm intelligence which is useful for designing effective combinatorial optimization solution algorithms. Ant Colonies are able to organize their foraging behaviour in an efficient way without any centralized control. This self-organizing structure is carried out via stigmergic communication which is a communication by changing the environment by laying down a chemical substance on the ground called pheromone. The pheromone encourages the following ants to stay close to previous moves.
The Ant Colony Algorithm can be used on data sets with large numbers of features. It is an optimization algorithm capable of incorporating prior information, allowing it to search the sample space more efficiently than other optimization methods. When applied to several high-dimensional data sets, the Ant Colony Optimization was able to identify small subsets of highly predictive features. Since Ant Colony Optimization is an effective combinatorial optimization solution algorithm the same concept is used in extracting features in images. We propose to study the various dimensions of swarm intelligence approach including ant colony optimization. Also we propose to study about extracting features in images with ant colony algorithm.

The main contributions of this thesis are, first the development of a new algorithm based on Ant Colony Optimization to extract boundary of an ordinary image. Secondly, the algorithm is applied to Medical Images. The reason behind this is, Medical image, such as CT, MRI, shows the information inside the patient body by non-invasive method, so that it is much helpful for doctor’s diagnoses and less painful for patients.

However the raw data can only give the material to doctor, the doctor as to decide by himself which is important which is not. The computer-aided diagnoses is to use computer to process the medical image to extract the useful information so that the doctor can make a diagnoses decision easier and quicker.
In our thesis we want to do medical image feature extraction so the algorithm is applied to medical images for identifying the edges, further more to perform analysis of interested object. Experimental results indicate that the proposed method is more efficient than the Gradient based edge detection techniques.

1.2 Preliminaries

This section focuses on the background of techniques and concepts that are of relevance throughout this thesis. The basic definitions and the concepts are referred from various references like Milan Sonka [18], Gonzalez [25], and Anil Jain [5]. Image Processing is a technique to enhance raw images received from cameras/sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications. Various techniques have been developed in Image Processing during the last four to five decades. Most of the techniques are developed for enhancing images obtained from unmanned spacecrafts, space probes and military reconnaissance flights.

Image Processing systems are becoming popular due to easy availability of powerful personnel computers, large size memory devices, graphics software etc. Image Processing is used in various applications such as, Remote Sensing, Medical Imaging, Non-destructive Evaluation, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Graphic arts and Printing Industry.
1.3 Methods of Image Processing

Basically there are two methods available in Image Processing namely analog and digital image processing. The following section contains explanation about these methods.

1.3.1 Analog Image Processing

Analog Image Processing refers to the alteration of image through electrical means. The most common example is the television image. The television signal is a voltage level which varies in amplitude to represent brightness through the image. By electrically varying the signal, the displayed image appearance is altered. The brightness and contrast controls on a TV set serve to adjust the amplitude and reference of the video signal, resulting in the brightening, darkening and alteration of the brightness range of the displayed image.

1.3.2 Digital Image Processing

In Digital Image Processing, digital computers are used to process the image. The image will be converted to digital form using a scanner, digitizer [5, 25] and then process it. The term digital image processing generally refers to processing of a two-dimensional picture by a digital computer [5, 17, 18, 25]. In a broader context, it implies digital processing of any two-dimensional data. A digital image is an array of real numbers represented by a finite number of bits.
Fig 1.1: Image Formation stages

The principle advantage of Digital Image Processing methods is its versatility, repeatability and the preservation of original data precision.

The various Image Processing techniques are:

- Image representation
- Image preprocessing
- Image enhancement
- Image restoration
- Image analysis
- Image reconstruction
- Image data compression

1.4 Image Representation

An image defined in the real world is considered to be a function of two real variables, $f(x, y)$ with $f$ as the amplitude (e.g. brightness) of the image at the real coordinate position $(x, y)$. The 2D continuous image $f(x, y)$ is divided into $M$ rows and $N$ columns. The intersection of a row and a column is called as pixel.
The value assigned to the integer coordinates \([m, n]\) with \(\{m=0,1,2,\ldots,M-1\}\) and \(\{n=0,1,2,\ldots,N-1\}\) is \(f[m, n]\). In fact, in most cases \(f(x, y)\) which we might consider to be the physical signal that impinges on the face of a sensor. Typically an image file such as BMP, JPEG, TIFF etc., has some header and picture information. A header usually includes details like format identifier typically first information, resolution, number of bits/pixel, compression type, etc.

### 1.5 Image Preprocessing

The function of preprocessing is to improve the image in ways that increases the chances for success of the other processes. Preprocessing typically deals with techniques for enhancing contrast, removing noise and isolating regions whose texture indicate a likelihood of alphanumeric information.

#### 1.5.1 Scaling

Two important techniques are used here. The theme of the technique of magnification is to have a closer view by magnifying or zooming the interested part in the imagery. This is usually done to improve the scale of display for visual interpretation or sometimes to match the scale of one image to another. To magnify an image by a factor of 2, each pixel of the original image is replaced by a block of 2x2 pixels, all with the same brightness value as the original pixel.

By reduction, we can bring the unmanageable size of data to a manageable limit. To reduce a digital image to the original data, every \(m^{th}\) row and \(n^{th}\) column of the original imagery is selected and displayed. Another way of
accomplishing the same is by taking the average in 'm x m' block and displaying this average after proper rounding of the resultant value.

1.5.2 Rotation

Rotation is used in image mosaic, image registration etc. One of the techniques of rotation is 3-pass shear rotation, where rotation matrix can be decomposed into three separable matrices. The following matrix is a rotation matrix

$$R = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix}$$

(1.1)

which can be divided into 3 separable matrices as

$$\begin{bmatrix} 1 & -\tan \theta/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ \sin \theta & 1 \end{bmatrix} \begin{bmatrix} 1 & -\tan \theta/2 \\ 0 & 1 \end{bmatrix}$$

1.6 Image Enhancement Techniques

Some times images obtained from satellites, conventional and digital cameras lack in contrast and brightness because of the limitations of imaging sub systems and illumination conditions while capturing image. Images may have different types of noise. In image enhancement, the goal is to accentuate certain image features for subsequent analysis or for image display [18, 25]. Examples include contrast and edge enhancement, pseudo-coloring, noise filtering, sharpening, and magnifying. Image enhancement is useful in feature extraction, image analysis and an image display. The enhancement process itself does not increase the inherent information content in the data. It simply emphasizes certain specified image characteristics. Enhancement algorithms are generally interactive and application dependent.
Some of the *enhancement techniques* are:

- Contrast Stretching
- Noise Filtering
- Histogram modification

**1.7 Image Restoration**

Image restoration is the removal or reduction of degradations that were incurred while the digital image was being obtained. These degradations include the blurring that can be introduced by optical systems, image motion, as well as noise from electronic and photometric sources. The aim of image restoration is to bring the image toward what it would have been if it had been recorded without degradation. Each element in the imaging chain contributes to the degradation. Partial restoration of the lost image quality can serve as anything from a cosmetic frill to a matter of vital importance depending upon the application. There are several approaches available to image restoration. The task of restoring a degraded image can be approached in one of two basic ways. If little is known about the image, one can attempt to model and characterize the sources of degradation and implement a process designed to remove or reduce their effects. This is an estimation approach, since one attempts to estimate what the image must have been before it was degraded by relatively well-characterized processes. If, on the other hand, a great deal of prior knowledge of the image is available, it might be more fruitful to develop a mathematical model of the original image and fit the model to the observed image.
1.8 Image Analysis

*Image analysis* is concerned with making quantitative measurements from an image to produce a description of it [6]. In the simplest form, this task could be reading a label on a grocery item, sorting different parts on an assembly line, or measuring the size and orientation of blood cells in a medical image. More advanced image analysis systems measure quantitative information and use it to make a sophisticated decision, such as controlling the arm of a robot to move an object after identifying it or navigating an aircraft with the aid of images acquired along its trajectory. Image analysis techniques require extraction of certain features that aid in the identification of the object. Segmentation techniques are used to isolate the desired object from the scene so that measurements can be made on it subsequently. Quantitative measurements of object features allow classification and description of the image.

1.9 Image Reconstruction and Image Data Compression

Digital image processing generally creates significant numbers of large files containing digital image data. Very often, these must be archived or exchanged among different users and systems. Since digital images, by their nature, are quite data intensive, reducing their size can produce solutions and are more ambitious than would otherwise be practical. By eliminating redundant or unnecessary information, image compression is the activity that addresses this aim. Image data files commonly contain a considerable amount of information that is redundant and
much that is irrelevant, making them prime candidates for modern data compression techniques. Data compression techniques exploit inherent redundancy and irrelevance by transforming a data file into a smaller file from which the original image file can later be reconstructed, exactly or approximately. The ratio of the two file sizes specifies the degree of compaction. Some data compression algorithms are lossless, while others are not. A lossless algorithm eliminates only redundant information, so that one can recover the image exactly upon decompression of the file. A lossy compression algorithm eliminates irrelevant information as well, and thus permits only an approximate reconstruction of the original, rather than an exact duplicate.

A general algorithm [18], for data compression and image reconstruction is shown in the following figure 1.2.

Fig 1.2 : Data compression and image reconstruction
The first step removes information redundancy caused by high correlation of image data. The second step is coding of transformed data using a code of fixed or variable length. An advantage of variable length codes is the possibility of coding more frequent data using shorter code words and therefore increasing compression efficiency, while an advantage of fixed length coding is a standard codeword length that offers easy handling and fast processing. Compressed code are decoded after transmission or archiving and reconstructed.