ACQUISITION AND ANALYSIS OF THE ENDOSCOPIC IMAGES

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Abstract- High incidence of cancer cases in Asia has triggered a need to develop an effective automated screening method for early detection. Currently a computer-based analysis for endoscopic diagnosis of suspected malignancies is not employed. The only method that is used is to take a tissue invasively from the infected parts (biopsy) for the confirmation of pathology which is expensive and time consuming.
Therefore the objective of this paper is to develop a new technique for automated analysis of the endoscopic images based on color and texture information for stomach abnormalities. The proposed method involves endoscopic image processing for characterization using texture-associated features. It is used to classify endoscopic images to normal and potentially abnormal categories. This work proposes an automated way to differentiate between the images to compensate for invasive diagnostic measures. In this method the affected area is segmented and the features are found out from the segmented image that differentiate the abnormal image from the normal and then categorized into Tumour, Ulcer, Cancer or Polyp as individual classes.
A computer-assisted method for automated endoscopic image analysis based on texture feature has been proposed. Initial results suggest the feasibility of the proposed method for stomach abnormalities. The proposed new computer-assisted endoscopic analysis method is devised to be beneficial for automatic classification of the images.
Keywords- Automation, Texture Segmentation, Image analysis, Image classification

Introduction

Stomach cancer is one of the deadliest but preventable malignancies. It often strikes without warning and has been one of the major killer diseases in the world for the past twenty years. Cancer of the stomach and rectum accounts for 15% of cancer deaths; only lung cancer causes more deaths as a single type of cancer apart from the stomach cancer. The annual incidence is 2 out of 1000 people [1].

Stomach cancer can be prevented if polyps that lead to the cancer are detected and removed. The colon cancer is up to 90% curable if it is detected in its early stages. Starting from 50 years of age screening tests should be used for early detection and improved survival. If a close (first degree) relative has had colon cancer, screening should start 10 years prior to the age of onset for possible removal of pre-cancerous Polyps.

The four common screening tests and recommended frequency of use are

- faecal occult blood test (annually);
- sigmoidoscopy (every 5 years);
- double barium contrast enema (every 5 years);
- Endoscopy (every 10 years).

Endoscopy is the most useful, but most invasive test. Endoscope is a clinical endoscopic instrument that is used by physicians to view the interior of a stomach to diagnose possible stomach diseases. Colonoscopy imaging has been an important tool in clinical medicine for diagnostic purposes and the data acquired can also be transferred to a computer to be processed.

Computerized processing of medical images offers a powerful tool that can enhance images and make them easier for the physician to analyse. It can also ease the search of the representative features in the images or provide automatic diagnosis of an image in order to remind or alert the physician for diagnosis as well as to construct a simulator system for teaching trainee-doctors. With the aid of software that is capable of image analysis, an intelligent and automated clinical diagnosis and navigation can be carried out.

This research is motivated by the fact that the operation and diagnosis of the endoscopic procedure requires expert knowledge and is still mostly manual in nature. In addition, manual diagnosis is influenced by the variability of the human observation that leads to differences in diagnosis. Ideally, a computer-based assistant system could help eliminate the variability during the diagnosis. It is hoped that the computer-based system can provide a training system for teaching trainee doctors and thus also possibly assist in the training of intern/resident endoscopists.

Stomach Abnormalities

The upper digestive tract includes the oesophagus, stomach, and upper portion of the small intestine, also called duodenum [Fig-1]. The lower digestive tract includes the lower portion of the small intestine; large intestine which includes the colon and rectum; and anus. The digestive system processes food for energy and rids the body of solid waste matter. After food is chewed and swallowed, it travels through the oesophagus to the stomach. There it is partly broken down and then sent to the small intestine, also called the small bowel. The small intestine continues breaking down the food and absorbs most of the nutrients [2].
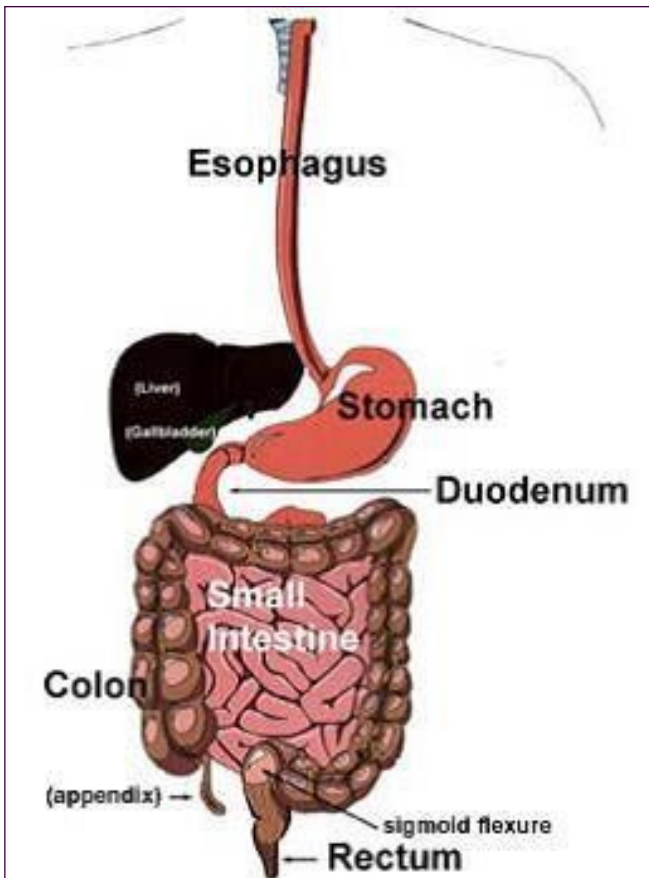
Fig. 1- Organs of gastrointestinal tract.

Stomach cancer usually begins in cells in the inner layer of the stomach. Over time, the cancer may invade more deeply into the stomach wall. A stomach tumour can grow through the stomach's outer layer into nearby organs, such as the liver, pancreas, oesophagus, or intestine.

Stomach cancer cells can spread by breaking away from the original tumour. They enter blood vessels or lymph vessels, which branch into all the tissues of the body. The cancer cells may be found in lymph nodes near the stomach. The cancer cells may attach to other tissues and grow to form new tumours that may damage those tissues. Normally, cells grow and divide to form new cells as the body needs them. When cells grow old, they die, and new cells take their place.

Sometimes, this process goes wrong. New cells form when the body does not need them, and old or damaged cells do not die as they should. The build up of extra cells often forms a mass of tissue called a growth, polyp, or tumour.

Tumours in the stomach can be benign (non cancerous) or malignant (cancerous). Benign tumours are not as harmful as malignant tumours. A stomach ulcer (also called a peptic ulcer) is small erosion (hole) in the gastrointestinal tract. The most common type, duodenal, occurs in the first 12 inches of small intestine beyond the stomach. Ulcers that form in the stomach are called gastric ulcers. An ulcer is not contagious or cancerous. Duodenal ulcers are almost always benign, while stomach ulcers may become malignant.

Endoscopic images are obtained by viewing the mucosal layer and they are helpful in detecting abnormalities in the GI-tract.

If cancer cells have multiplied in the lymph nodes, they are more likely to have spread to other organs of the body as well.

Existing Methodology

In the case of cancer, abnormal cell growth takes place in the stomach resulting in the formation of tumours. The detection of any abnormal growth in the stomach at an early stage will increase the patient's chance of survival. A few methods, such as sigmoidoscopy, barium x-ray, etc., are available for examination of the abnormality, but endoscopy is considered to be the best procedure at present for the detection of abnormalities in the stomach. Despite the usefulness of endoscopic methods, an expert endoscopist is needed to detect stomach cancer or tumour. The endoscopist uses an endoscope to detect the presence of abnormalities in the stomach. The analysis of the endoscopic images is usually performed visually and qualitatively. Consequently, there are constraints such as time-consuming procedures, subjective diagnosis by the expert. A computer-assisted scheme will help considerably in the quantitative characterization of abnormalities and image analysis, thereby improving overall efficiency in managing the patient.

The acquisition and analysis is done by the doctors in real time at the time of diagnosis and there was no option of storing the acquired videos and images.

The only method used for analysis of the image is to take some tissue from the infected area (biopsy) and get the pathological investigations made for the confirmation of whether it is a cancer, tumour, polyps or ulcer. It takes a lot of time and money [3]. The patient also has to wait for a long period of time.The automation of the analysis for detection of abnormality/malignancy through image processing thus is an ideal proposal.

Endoscopy

Endoscopy is one of the most exciting techniques with expanding applications in clinical medicine. It provides accurate diagnostic information and is being used increasingly to provide therapy for intestinal disorders. Endoscopy means looking inside and typically refers to looking inside the body for medical reasons using an endoscope an instrument used to examine the interior of a hollow organ or cavity of the body. Unlike most other medical imaging devices, endoscopes are inserted directly into the organ. Endoscopy can also refer to using a bore scope in technical situations where direct line of-sight observation is not feasible.

An endoscope is passed through a natural body opening or a small incision. For example, a laparoscope is inserted through small surgical cuts in the pelvic or belly area. In men, a urinary tract endoscope is passed through the opening of the urethra. A gastrointestinal endoscope may be inserted through the mouth or anus. An ultrasound probe can be added to a gastrointestinal endoscope. This is called an endoscopic ultrasound. Depending on the area of interest, this device can also be passed through the mouth or anus. Small instruments can be inserted through an endoscope and used to take samples of suspicious tissue.

A clinical video endoscope system was used in the present work [Fig-2].

Components

An endoscope can consist of

- A rigid or flexible tube.
- A light delivery system to illuminate the organ or object under

inspection. The light source is normally outside the body and the light is typically directed via an optical fibre system.

- A lens system transmitting the image to the viewer from the objective lens to the viewer, typically a relay lenses system in the case of rigid endoscopes or a bundle of fiberoptics in the case of a fiberscope.

- An eyepiece.

- An additional channel to allow entry of medical instruments or manipulators.

Uses

- Endoscopy can involve
- The gastrointestinal tract (GI tract).
- The ear (otoscope).
- The urinary tract (cystoscopy).
- The female reproductive system (gynoscopy)
- Normally closed body cavities (through a small incision):

Non-medical Uses for Endoscopy

- The planning and architectural community have found the endoscope useful for pre-visualization of scale models of proposed buildings and cities (architectural endoscopy)

- Internal inspection of complex technical systems.

- Endoscopes are also a tool helpful in the examination of improvised explosive devices by disposal personnel.

- The FBI uses endoscopes for conducting surveillance via tight spaces.

Fig. 2- Video Endoscope systems

Acquisition of Endoscopic Image

The endoscope has a flexible shaft, which contains an air and water supply channel, an illumination channel and an operating channel to allow the passage of flexible instruments such as biopsy forceps.

The tip of the shaft can be deflected by two control wheels providing up-down and left right movements. The shaft also accommodates a charged couple device (CCD) camera system to capture the images. This CCD camera is connected to a monitor, allowing the doctor to clearly see any masses in the wall of the stomach [Fig-3].
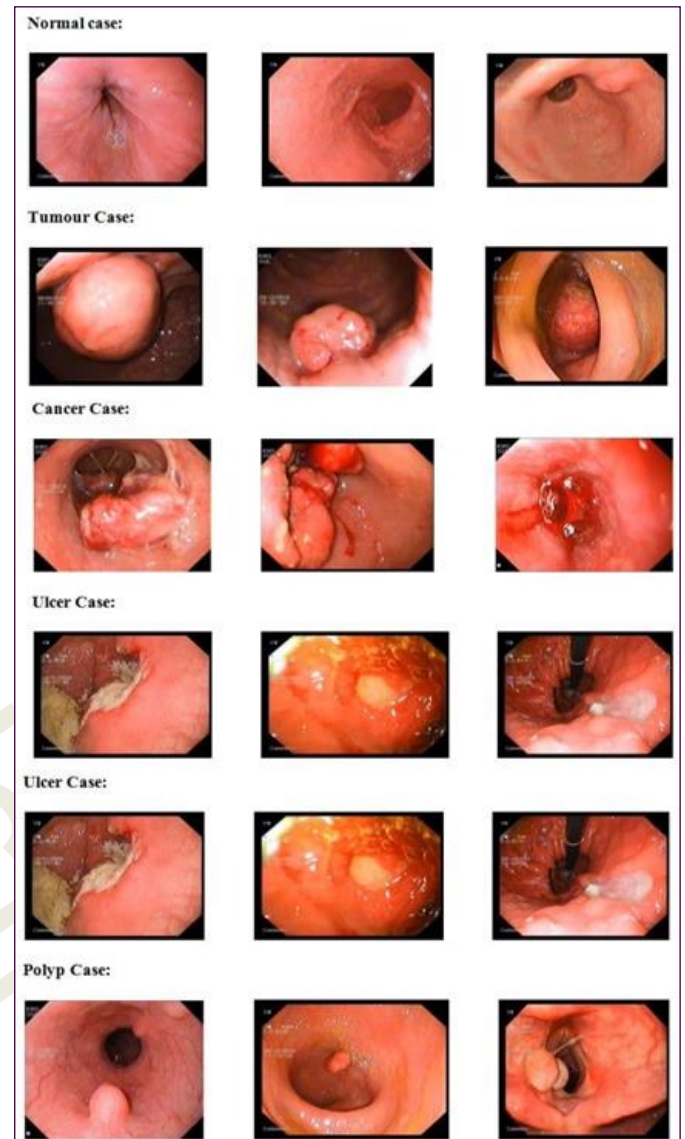

Fig. 3- Acquired image

Methodology

Endoscopic imaging methods have been used to examine the condition of the abnormality in stomach. The development of an intelligent method for the identification of the abnormality status is being explored as a computer-aided tool for the early detection of stomach cancer, tumour. It is important to extract the quantitative parameters representing the characteristic properties of the abnormality from an endoscopic image. The quantitative features are used for detecting the normal or abnormal condition of the stomach from the endoscopic images. Endoscopic images contain texture[5] and colour information. Features from texture and colour are extracted from the endoscopic image to identify a normal image from an abnormal image. Four statistical measures are derived from the image namely mean, standard deviation, root mean square value, and entropy.

For the calculation of the parameters the region of interest is segmented from the original image.

An interactive polygon tool, associated with the image is displayed in the [Fig-4], called the target image. With the polygon tool active, the pointer changes to cross hairs when one moves the pointer over the image in [Fig-4]. Using the mouse, the region is specified by selecting vertices of the polygon. The polygon can be moved or resized using the mouse [6].

Image Classification

The proposed approaches was evaluated using 100 clinically endoscopic images (20 normal and 80 abnormal).In abnormal images there are tumours, cancers, ulcers and polyps. Mean, standard deviation, root mean square, entropy was calculated for both the normal and abnormal image and a comparison is made.

[Fig-4] the selected endoscopic images of normal and abnormal case of stomach. Features based on texture and colour are defined and extracted from those images for diagnosis of the abnormality status.
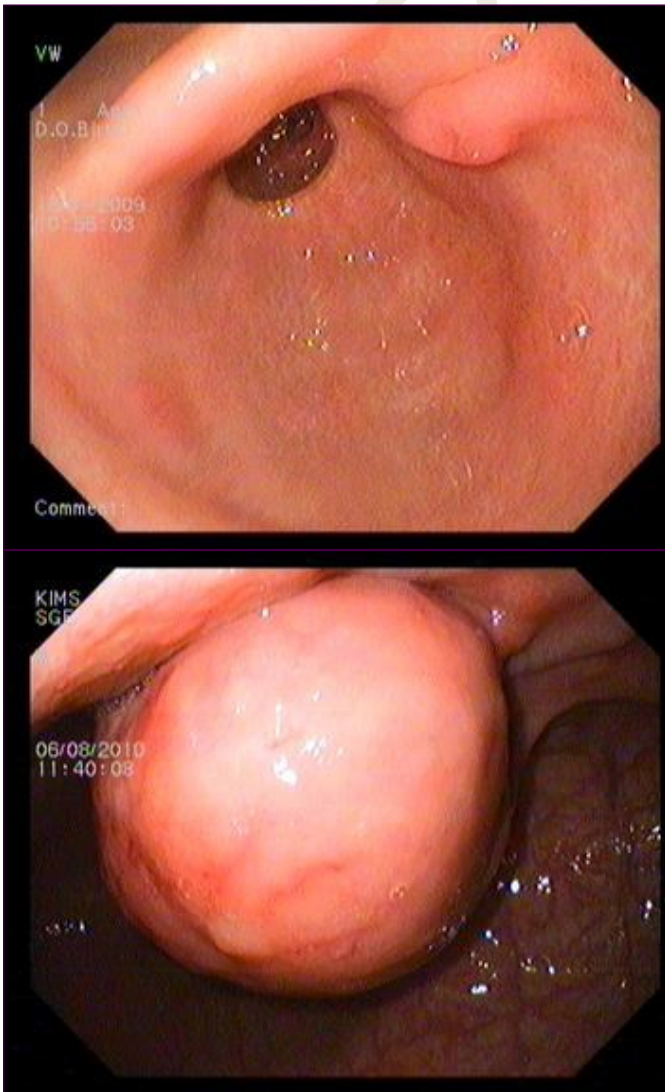

Fig. 4- Selected image for testing

Segmentation Procedure of a Single Image

Various steps of segmentation are followed [Fig-5]. Image A is the original image. Image B is gray image. Image C is the masking over the gray image. This is called Binary Masking. This Binary mask is superimposed on the original image. Image E is the superimposed image. Finally the cropped Image G is obtained which is the region of interest [7].
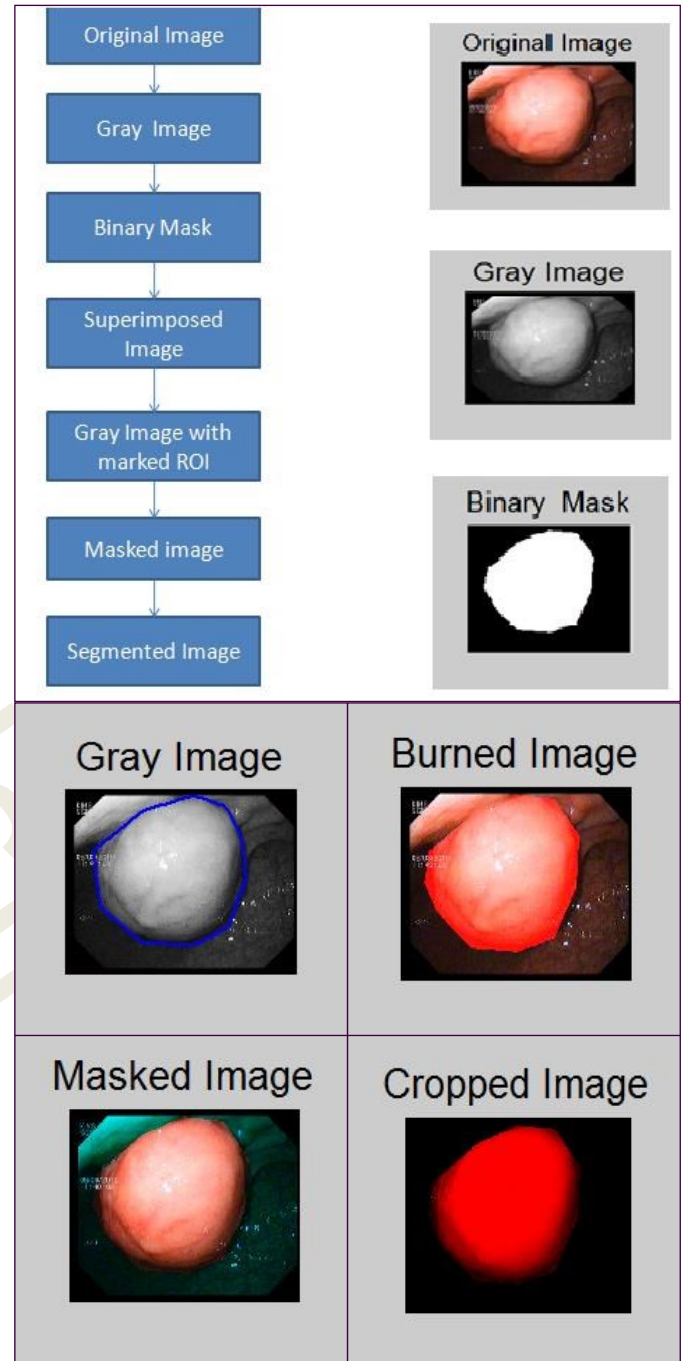

Fig. 5- Region of interest is segmented from the original image

Result Analysis

All the stastical features for both the normal and the abnormal image is calculated using matlab. Line graphs are drawn to note the variations [Fig-6].

From the features it is observed that there are huge differences between normal and abnormal image. So for all the images maximum and minimum is calculated.

Fig. 6- Comparison between normal and abnormal image using texture parameters.

TUMOR ANALYSIS WITH NORMAL CASE

MEAN			RMS			ENTROPY		
	Range			Range			Range	
	Normal	Abnormal		Normal	Abnormal		Normal	Abnormal
MAX	68.56	35	MAX	125.73	80.13	MAX	1.81	1.2
MIN	51	10.6	MIN	83.69	58.12	MIN	1.37	0.19

CANCER ANALYSIS WITH NORMAL CASE

MEAN			RMS			ENTROPY		
	Range			Range			Range	
	Normal	Abnormal		Normal	Abnormal		Normal	Abnormal
MAX	68.56	54.2	MAX	125.73	89	MAX	1.81	1.2
MIN	51	15	MIN	83.69	45.12	MIN	1.37	0.29

Decision Making

The rule-based classification is use to classify Endoscopic images [8]. Here we aim to minimize confusion errors between spectrally similar classes [Fig-7]. The strategy for discriminating between normal and abnormal is to label all images beyond certain value as normal and other as the abnormal. Object classification is then used to differentiate between images.
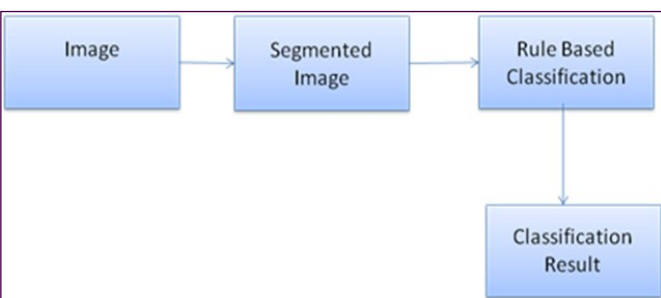

Fig. 7- Block diagram of rule based classification.

Statistical Analysis

The attributes used are the mean, median, RMS value and the entropy of the segmented image. Since the image has already been classified using maximum likelihood classification in a visual approach, image segments can be initially assigned by analyzing classes of images belonging to every segment [9].

From the line graph values a certain range is given for all the types and rule based approach is applied to check that input image belong to which category.

After all the pre-processing method, segmentation was done for the input image [Fig-8] and all the statistical features are calculated using matlab.
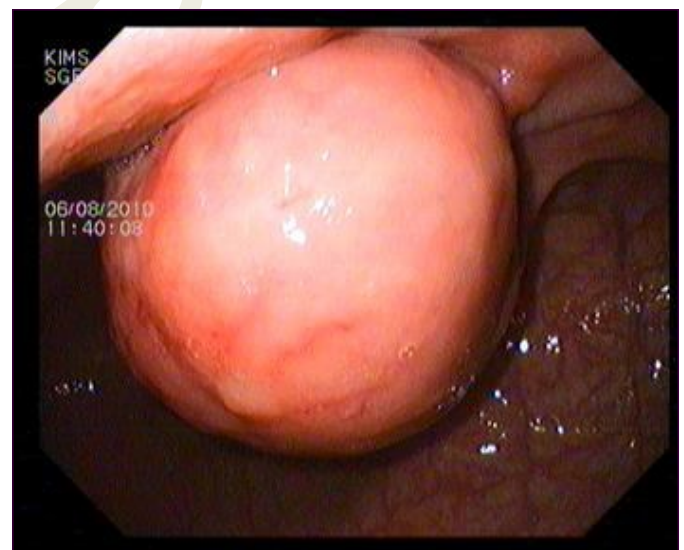

Fig. 8- Input image

Finally the ruled based method is implemented for the segmented image and the result is obtained represented by the statistical features [Fig-9].

The result window displays the final result and it also displays the status of the input image being a tumour in a message box [Fig-10].

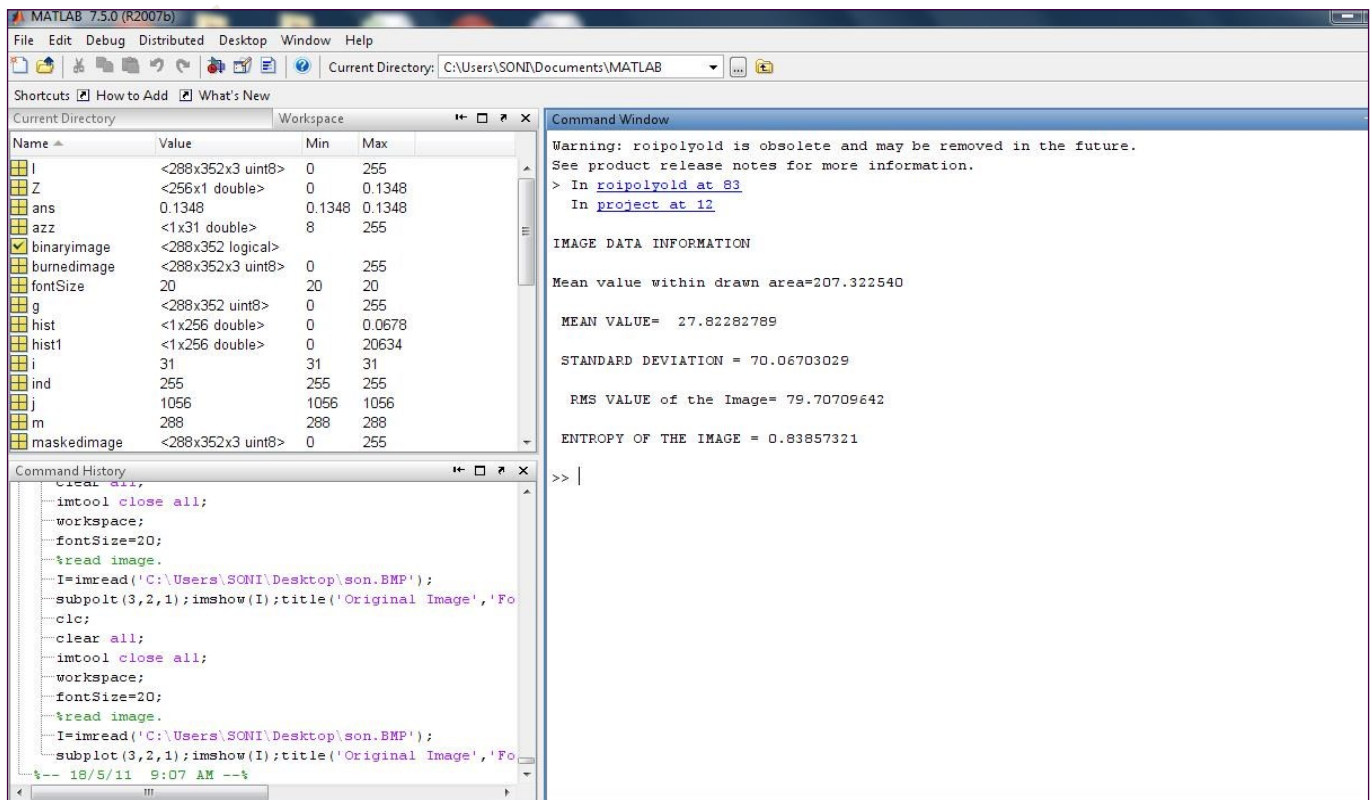The method implemented is therefore capable of classifying images into different categories.

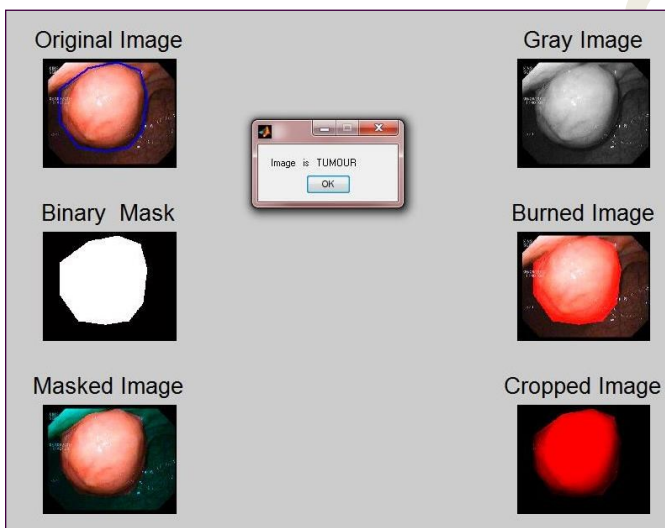**Fig. 9-** Command window display

Fig. 10- Image window display

Conclusion

The advanced image processing techniques can be applied successfully to endoscopic images. New approaches on extracting texture based features from endoscopic images for the analysis of the stomach abnormality have been developed. Texture and colour are important features, in which some features are able to distinguish the normal and abnormal image and also were able to classify the images into four different categories.

Overall, the process showed convincing results and achieved a similar accuracy as in the laboratory case. Further work will go into optimization of the system and into development of further modules to aid the surgeon. It is believe that advanced image processing methods will play an increasingly important role in endoscopic image analysis where the surgeon faces new challenges due to continuing miniaturization.

This paper has been done to fulfil most of the basic needs to investigate the implementation of this algorithm in real time application. Here we have taken care to deal with real time data like Endoscopic image, but still it can be modified to enhance its features which could not be included due to time constraints and in depth knowledge of Matlab. The salient features that might be further added are as follows

- The tool can be made more user friendly making it complete GUI.
- Matlab tools make it works in a real time data with a good hardware support.
- Handling of large file due to insufficient memory management is a problem in Matlab.
- The tool developed can be modified for fast real time output.
- Neural Network can also be implemented for better accuracy.

Conflicts of Interest: None declared.

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