

Discrimination Between Normal And Diseased Stomach Using Speckle Imaging

A.M. Hamed

Physics Department, Faculty of Science,
Ain Shams University, Cairo, 11566, Egypt

ABSTRACT

We investigate the Gastroesophageal reflux disease (GERD) using the speckle imaging. The speckle images are computed from the convolution product of Fourier transform of the diffuser and Fourier spectrum of the original image. In addition, contour and digital images are given. This study is made since this disease is still affect a great cluster of peoples in the developed countries. The Mat- Lab code is used for the computation of speckle and other images.

Keywords

Speckle imaging, FFT algorithm, Mat- Lab code, digital images, Gastro esophageal reflux disease (GERD)

1. INTRODUCTION

Electronic video endoscopy is commonly performed for a wide variety of diagnostic and therapeutic procedures due to the advent of miniature CCD cameras and associated microelectronics. In minimally invasive surgical procedures, endoscopes that are inserted through natural orifices of the body, or small incisions, illuminate the surgical region of interest and transmit camera images to a video monitor. Computerized image processing techniques are gaining popularity to assist the clinician in diagnosing the related disease conditions [1].

Gastroesophageal reflux disease (GERD) commonly known as acid reflux disease affects nearly 20 % and more people in US and all over the world [2]. It is a condition wherein the contents of stomach escape into the esophagus causing erosion of esophageal mucosa. It manifests as a burning sensation also referred to as heart burn [3]. The cause of heart burn may be due to laxity of the LES (Lower Esophageal Sphincter) a valve between the stomach and the esophagus, which normally does not allow contents of the stomach to escape in the esophagus. The contents of the stomach, which are at a low pH of 1-3, escape into the esophagus with a much higher pH 5-7. This causes inflammation [4,5] and ultimately erosion of the esophageal mucosa which is termed as Esophagitis. In recent publications, esophagitis and diagnosis of cancer stomach using image processing techniques are investigated as in [6, 7]. A combination of image processing algorithms, local binary pattern algorithm, and support vector machine is considered in [7].

In this study, we investigate the images of diseased, normal stomach, and GERD using speckle imaging technique. Contour and digital images of the inflamed stomach are obtained compared with the normal stomach images. In addition the contour and digital GERD image is made. Results and discussion are given.

2. ANALYSIS

The RGB color images are transformed to gray scale and resized images using the following Mat- Lab codes:

$$\text{Gray scale image} = \text{Rgb2gray}(\text{color image}); \quad (1)$$

$$\text{Resized image}(512, 512) = \text{imresize}(\text{gray scale image}, [512, 512]). \quad (2)$$

The contour of the image is given by the code:

$$\text{Contour} = \text{contour}(\text{gray scale image}) \quad (3)$$

The difference between the two images is given by the code:

$$\text{Difference} = \text{image}(A) - \text{image}(B). \quad (4)$$

The ordinary speckle image can be computed by operating the Fourier transform upon the complex amplitude of the diffuser limited by a circular aperture. The diffuser function represented as follows:

$$d(x, y) = a(x, y) \exp[i\Phi(x, y)] \quad (5)$$

Where $a(x, y)$ is the amplitude of the diffuser, and $\Phi(x, y)$ is its phase which has randomly distributed function.

In matrix form, the diffuser function is represented as follows:

$$d(m\Delta x, n\Delta y) = a(m\Delta x, n\Delta y) \exp[i(m\Delta x, n\Delta y)] \quad (6)$$

The $\text{cir}(x, y)$ is defined as:

$$\text{cir}(x, y) = \begin{cases} 1 & \text{for } \left| \frac{\rho}{\rho_0} \right| \leq 1 \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

The Fourier transform of the diffuser function which is limited by the circular aperture gives the ordinary complex amplitude of speckle. It is computed from the following analytical function:

$$s(u, v) = \iint_{-\infty}^{\infty} \text{cir}(x, y) \cdot d(x, y) \exp\left[\left(\frac{2\pi i}{\lambda f}\right)(xu + yv)\right] dx dy \quad (8)$$

In symbolic form, equation (8) is rewritten as the convolution product of the Fourier transform of the diffuser and the Fourier spectrum of the diffuser as:

$$s(u, v) = \text{F.T.}[\text{cir}(x, y) \cdot d(x, y)] = \left[\frac{2J_1(\alpha r)}{\alpha r} \right] * \tilde{d}(u, v) \quad (8')$$

$\tilde{d}(u, v)$: Fourier transformation of the diffuser, and $\left[\frac{2J_1(\alpha r)}{\alpha r} \right]$ is the F.T. of the circle.

While the speckle image under study considers the multiplication of the following object function located behind the diffuser and limited by a circular aperture. Hence, the diffuser limited by the circular aperture, equation (5), is multiplied by the object

function. The transmitted complex amplitude is represented by the following product:

$$b(x, y) = g(x, y).d(x, y).cir(x, y) \quad (9)$$

Consequently, the Fourier transform of equation (9) gives the modulated speckle by the object information. It is represented by the following convolution product:

$$\begin{aligned} s_{mod}(u, v) &= F.T.[b(x, y)] = F.T.[g(x, y).d(x, y).cir(x, y)] \\ &= F.T.[g(x, y)] * F.T.[d(x, y)] * F.T.[cir(x, y)] \\ &= \tilde{g}(u, v) * \tilde{d}(u, v) * \left[\frac{2J_1(\alpha r)}{\alpha r} \right] \end{aligned} \quad (10)$$

$\tilde{g}(u, v)$, is the Fourier transformation of the object.

3. RESULTS AND DISCUSSION

The images shown in the figures (1- 3) are processed using speckle technique. Normal and Gastritis stomach RGB image of dimensions 186×254 pixels is shown as in the figure (1) while Stomach ulcers in the RGB image of dimensions 213×221 pixels is shown as in the figure (2). GERD compressed RGB image of dimensions 161×157 pixels is plotted as in the figure (3). In the image shown in the figure (1), the horizontal resolution = the vertical resolution = 72 dpi while in the images shown in the figures (2, 3), the horizontal resolution = the vertical resolution = 96 dpi. The bit depth = 24 for all images shown in the figures (1- 3).



Figure (1): Normal and Gastritis stomach color image of dimensions 186×254 pixels. Bit depth = 24, horizontal resolution = vertical resolution = 72 dpi, and resolution unit = 2.

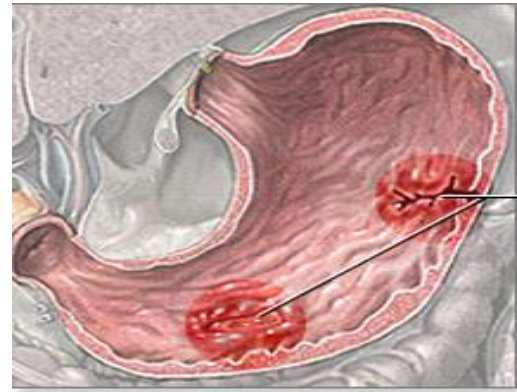


Figure (2): Stomach ulcers in the image of dimensions 213×221 pixels. Bit depth = 24, horizontal resolution = vertical resolution = 96 dpi.

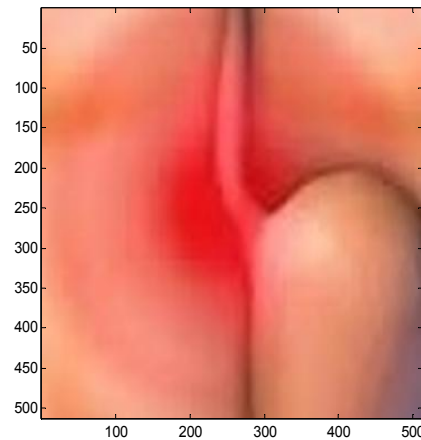


Figure (3): GERD compressed image of dimensions 512×512 pixels. Bit depth = 24, horizontal resolution = vertical resolution = 96 dpi, and the resolution unit = 2.

The normal and gastritis gray scale stomach images of dimensions 512×512 pixels is shown as in the figure (4). The transformation from color image to resized gray scale image is governed by the codes represented in equations (1, 2). The Plot of the normal and gastritis images at horizontal line at 256 and at 400 pixels is represented as shown in the figure (5 a, b). It shows a remarkable difference in profiles between the normal and the gastritis stomach images.

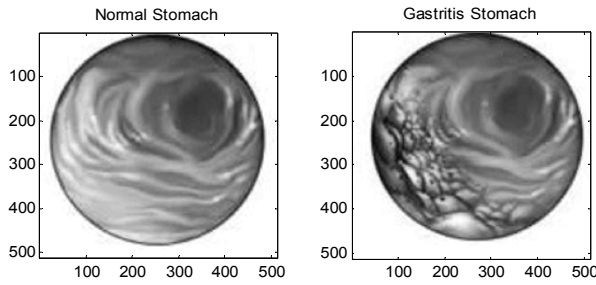


Figure (4): Normal and Gastritis gray scale stomach images of dimensions 512 ×512 pixels.

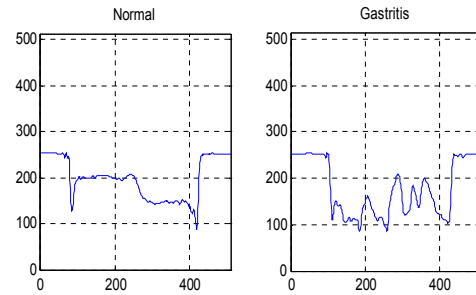


Figure (5- b): Plot of the normal and gastritis images at horizontal line at 400 pixels.

The Contour of normal and gastritis stomach images is shown in the figure (6) using the code in equation (3) and the difference between the normal and the gastritis images is given in figure (7) using the code in equation (4). The Speckle images of dimensions 128× 128 pixels for the normal and gastritis stomach given in the figure (8) is computed by operating the Fourier transform algorithm represented as in the equations (5- 10). The plot of the speckle images for the normal and gastritis stomach at horizontal lines at 32, 64, and 96 pixels is shown as in the figure (9 a, b, c). A remarkable difference is shown between the normal stomach and the gastritis stomach plots. This difference is shown for the three plots at horizontal line at 32, 64, and 96 pixels. Hence, the two speckle images are different.

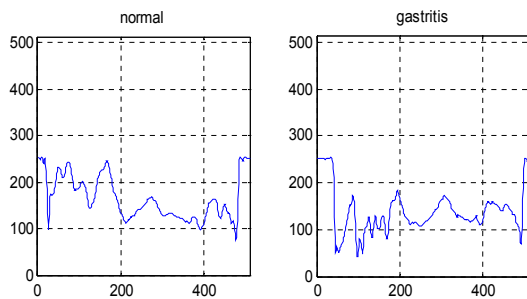


Figure (5- a): Plot of the normal and gastritis images at horizontal line at 256 pixels

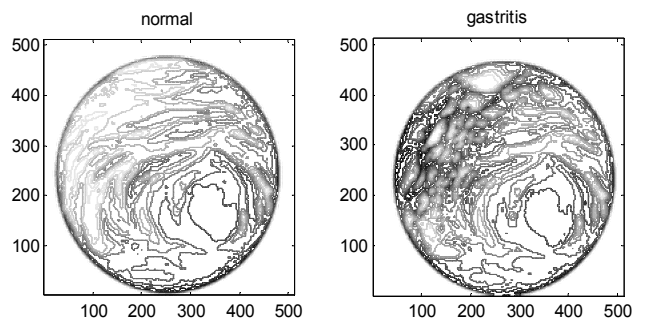


Figure (6): Contour of normal and gastritis stomach shown in the figure (4)

Discrimination Between Normal And Diseased Stomach Using Speckle Imaging

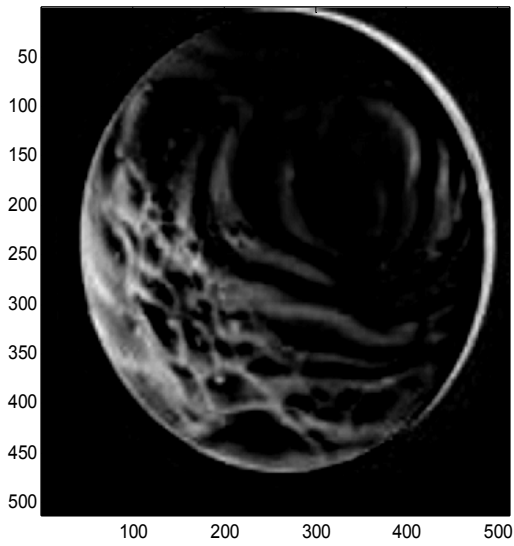


Figure (7): The Difference between normal and gastritis stomach images

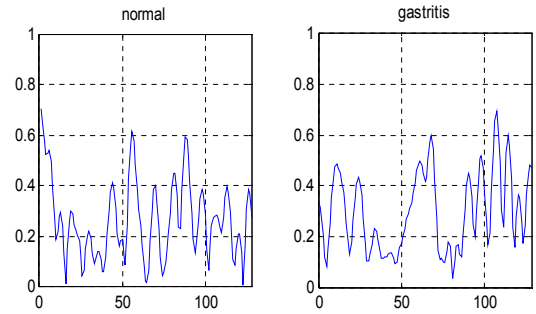


Figure (9- a): plot of the speckle images for the normal and gastritis stomach shown in the figure (4) at horizontal line at 32 pixels

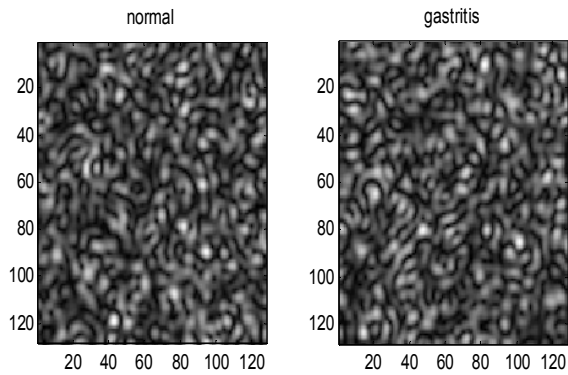


Figure (8): Speckle images of dimensions 128×128 pixels for the normal and gastritis stomach shown in the figure (4)

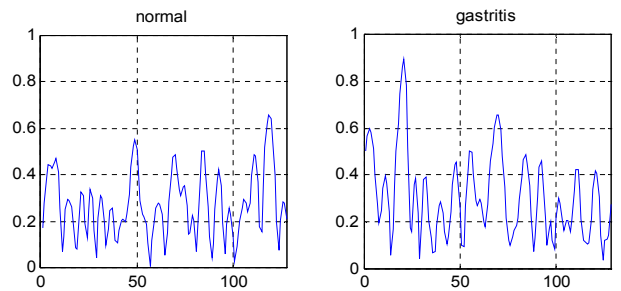


Figure (9- b): plot of the speckle images for the normal and gastritis stomach shown in the figure (4) at horizontal line at 64 pixels

9999999999986444555665557655665654334444444566555544434799999999
 999999999999864445655665665555665544444444444444433479999999999
 999999999999997544445655655555566766556554434568999999999999
 999999999999998765444444445554456655554445789999999999999999
 999999999999999877655444444445556788999999999999999999999999
 99

Figure (13- b): Digital image of the gastritis stomach, the values range is from 1 up to 9 pixels

4. CONCLUSION

Firstly, discrimination between the normal and gastritis images is shown based on the comparison of their digital images. The normal image showed agglomeration of transparent pixel values as compared with the gastritis image which has random values of pixels for the whole image. In addition, the GERD image has moderate pixel value for the inflamed part of the esophagus at 4 pixels while the transparent part of the stomach has fixed value at 7 pixels.

Secondly, the discrimination between the speckle images of normal and gastritis stomach are investigated comparing the plots of both images at three different horizontal sections. It shows a remarkable difference between the two plots corresponding to the normal and gastritis stomach images of speckles.

Finally, discrimination is realized based on the comparison of the digital B/W speckle images of the normal and gastritis stomach.

REFERENCES

[1] D. Carmella, C. Bartolozzi - 2012 - Medical, 3D Image Processing: Techniques and Clinical Applications. <https://books.google.com.eg/books?isbn=3642594387>.

[2]Source: National Digestive Diseases, Information Clearinghouse (NDDIC) (<http://digestive.niddk.nih.gov/statistics/statistics.aspx#speckle>)

[3] R. Fass, G. Tougas,51 (2002) 885-892, Functional heartburn: the stimulus, the pain, and the brain, Gut.

[4] A.P. Hungin, S. Raghunath, A. S, Wiklund, I., FAM Pract., 22 (2005) 591-603, beyond heartburn: A Systematic review of the extra- esophageal spectrum of reflux-induced disease.

[5] T. Kaltenbach, S. Crockett, L.B. Gerson, Arch. Intern Med, 166 (2006) 965-971, Are lifestyle measures effective in patients with gastroesophageal reflux disease? an evidence-based approach,

[6] S. Santos, G.R. Udipi, and D. Santosh, International Journal of Computer Applications 42(2012)45, Los Angeles Classification of Esophagitis using Image Processing Techniques.

[7] D. Ahmadzadch, M. Fiuzy, and J. Haddadnia, J. Basic Appl. Sci. 3(2013) 243-251, Stomach cancer diagnosis, by using a combination of image processing algorithms, local binary pattern algorithm, and support vector machine.