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Identification Of Acute Appendicitis Using Euclidean Distance On Sonographic Image

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Abstract: **Acute Abdomen is defined as a syndrome induced by a wide variety of pathological conditions that require emergent medical or more often surgical management. The cardinal presenting symptom is abdominal pain which has many underlying causes. Over the past 10 years, sonography has gained acceptance for examining patients with acute abdominal pain. Sonography is dynamic, noninvasive, rapid, inexpensive, and readily accessible. It is very tedious and time consuming to analyze the sonographic images manually. The authors propose a novel method for diagnosing acute appendicitis using Euclidean distance measures. This paper details the image mining system that automates the diagnosis of acute appendicitis with significant speed up, experimentation methods, real data used for testing and the result.**

Keywords: Image Mining, Euclidean Distance, Data Mining, Appendicitis, Abdomen

I. Introduction

Appendicitis is the most common cause of acute abdominal pain that requires surgical intervention in the Western world [1]. Patients with the disease may present with a wide variety of clinical manifestations, and the diagnosis may elude even the most experienced clinicians [2]. Reginald H. Fitz presented his landmark article in 1886, in which he coined the term ‘‘appendicitis’’ and correctly classified this disease by describing the appendix as the primary source of inflammation in acute typhlitis [3]. Acute Abdomen is defined as a syndrome induced by a wide variety of pathological conditions that require emergent medical or more often surgical management [4].

The cardinal presenting symptom is abdominal pain which has many underlying causes [5-8]. Over the past 10 years, sonography has gained acceptance for examining patients with acute abdominal pain. Sonography is dynamic, noninvasive, rapid, inexpensive, and readily accessible. The impact of sonography on clinical management of patients with an acute abdomen is impressive. Although data can be processed by manual means, it is extremely time consuming and tedious where huge databases and high throughput experiments are involved. Moreover, unlike textual data, images are multidimensional signals, and are communicated to users via 2-D (sometimes 3-D) projections, which may not be straightforward [6]. Image Mining systems can perform these highly valuable tasks after suitable training and testing.

In this work, the authorsdiscuss how Image Mining can aid in diagnosis acute appendicitis in patients who were referred with acute abdominal pain. Retrospective analysis of sonographic imaging features was done.

II. Image mining

Image mining is more than just an extension of data mining to image domain. It is an interdisciplinary endeavor that draws upon expertise in computer vision, image processing, image retrieval, data mining, machine learning, database, and artificial intelligence. Advances in image acquisition and storage technology have led to tremendous growth in very large and detailed image databases [9]. These images, if analyzed, can reveal useful information to the human users. Image mining deals with the extraction of implicit knowledge, image data relationship, or other patterns not explicitly stored in the images. Much knowledge can be obtained from images. This process can be done in the mind by a human, and implementation of this mind processing by a system is very difficult [9].

Image mining has led to tremendous growth in significantly large and detailed image databases. The most important areas belonging to image mining are: image knowledge extraction, content-based image retrieval, video retrieval, video sequence analysis, change detection, model learning, as well as object recognition. Two different types of input data for knowledge extraction from an image collection are original image and symbolic description of the image [10].

III. Appendicitis

Introduction of new imaging technology in particular, graded compression ultrasound andhas changed ‘‘the rules of the game.’’ The adult appendix is a long diverticulum averaging 10 cm in length that arises from the posteromedial wall of the cecum, approximately 3 cm below the ileocecal valve [11]. The appendix may lie in a retrocecal, subcecal, retroileal, preileal, or pelvic site which influences the clinical presentation [12,13].The maximum incidence of the disease occurs in the 2nd decade; thereafter, disease incidence declines with age [14,15]. The primary pathogenic event in the majority of patients with acute appendicitis is luminal obstruction [16-18]. Fecoliths, which result from the inspissations of fecal material and inorganic salts within the appendiceal lumen, are the most common cause of obstruction and are present in 11% – 52% of patients with acute appendicitis [19-21].

Ultrasound is a widely available and inexpensive modality with the potential for highly accurate imaging in the patient suspected to have acute appendicitis. Although operator skill is an important factor in all ultrasound examinations, it has particular importance in the examination of the patient with right-lower-quadrant pain. Nonetheless, the criteria for the US-based diagnosis of acute appendicitis are well established and reliable [22-24]. Ultrasound is also highly useful in identifying an alternate diagnosis [25]. Symptoms of appendicitis usually include pain in the lower right abdomen, loss of appetite, nausea and or vomiting, with or without fever. There may be mild diarrhea or constipation. The site of this pain could be higher in appendicitis in pregnancy, or even lower in those with very long appendix. Early symptoms of appendicitis are those symptoms that most people with this condition may recognize and complain of. They include lower right sided abdominal pain of gradual onset, feeling sick (or nausea), and loss of appetite. Any one with these three symptoms can be assumed to have appendicitis until proven otherwise [26].

IV. Existing Methods for Appendicitis Diagonosis

The diagnosis of appendicitis begins with a thorough history and physical examination. Patients often have an elevated temperature, and there usually will be moderate to severe tenderness in the right lower abdomen when the doctor pushes there. If inflammation has spread to the peritoneum, there is frequently rebound tenderness. Rebound tenderness is pain that is worse when the doctor quickly releases his hand after gently pressing on the abdomen over the area of tenderness[32].

4.1 Leukocytes Count

The white blood cell count in the blood usually becomes elevated with infection. In early appendicitis, before infection sets in, it can be normal, but most often there is at least a mild elevation even early. Unfortunately, appendicitis is not the only condition that causes elevated white blood cell counts. Almost any infection or inflammation can cause this count to be abnormally high. Therefore, an elevated white blood cell count alone cannot be used as a sign of appendicitis[33].

4.2 Urinalysis

Urinalysis is a microscopic examination of the urine that detects red blood cells, white blood cells and bacteria in the urine. Urinalysis usually is abnormal when there is inflammation or stones in the kidneys or bladder. The urinalysis also may be abnormal with appendicitis because the appendix lies near the ureter and bladder. If the inflammation of appendicitis is great enough, it can spread to the ureter and bladder leading to an abnormal urinalysis. Most patients with appendicitis, however, have a normal urinalysis. Therefore, a normal urinalysis suggests appendicitis more than a urinary tract problem.

4.3 Abdominal X-Ray

An abdominal x-ray may detect the fecalith (the hardened and calcified, pea-sized piece of stool that blocks the appendiceal opening) that may be the cause of appendicitis, which is obvious in case of children.

4.4 Ultrasound

An ultrasound is a painless procedure that uses sound waves to identify organs within the body. Ultrasound can identify an enlarged appendix or an abscess. Nevertheless, during appendicitis, the appendix can be seen in only 50% of patients. Therefore, not seeing the appendix during an ultrasound does not exclude appendicitis. Ultrasound also is helpful in women because it can exclude the presence of conditions involving the ovaries, Fallopian tubes and uterus that can mimic appendicitis.

4.5 Barium Enema

A barium enema is an X-ray test where liquid barium is inserted into the colon from the anus to fill the colon. This test can, at times, show an impression on the colon in the area of the appendix where the inflammation from the adjacent inflammation impinges on the colon. Barium enema also can exclude other intestinal problems that mimic appendicitis, for example Crohn's disease.

4.6 Computerized tomography (CT) Scan

In patients who are not pregnant, a CT scan of the area of the appendix is useful in diagnosing appendicitis and peri-appendiceal abscesses as well as in excluding other diseases inside the abdomen and pelvis that can mimic appendicitis [33].

4.7 Laparoscopy

Laparoscopy is a surgical procedure in which a small fiberoptic tube with a camera is inserted into the abdomen through a small puncture made on the abdominal wall. Laparoscopy allows a direct view of the appendix as well as other abdominal and pelvic organs. If appendicitis is found, the inflamed appendix can be removed with the laparoscope. The disadvantage of laparoscopy compared to ultrasound and CT is that it requires a general anesthetic.

There is no one test that will diagnose appendicitis with certainty. Therefore, the approach to suspected appendicitis may include a period of observation, tests as previously discussed, or surgery[33]..

V. Distance Measure

Image processing tools provides various distance transform a metric or measure of the separation of points in the image. Distance Metrics are City Block distance, Chessboard distance and Quasi-Euclidean distance. The city block distance metric measures the path between the pixels based on a 4-connected neighborhood. Pixels whose edges touch are 1 unit apart; pixels diagonally touching are 2 units apart.The chessboard distance metric measures the path between the pixels based on an 8-connected neighborhood. Pixels whose edges or corners touch are 1 unit apart. The quasi-Euclidean metric measures the total Euclidean distance along a set of horizontal, vertical, and diagonal line segments.Image mining tools provides Euclidean distance. The Euclidean distance is the straight-line distance between two pixels. Acute appendicitis is mesure only straight line distance between two pixels.

5. 1 Pre-Processing

The cropping operation and image enhancement can be done to increase the dynamic range of chosen features so that they can be detected easily. The histogram equalization can be used to enhance the contrast within the diognosis of the sonographic images and also hybrid median filtering technique can be used to improve the image quality. Good texture feature extraction can be done by increasing the dynamic range of gray-levels [27].

5.1.1 Texture feature extraction

Though many texture features have been used in the medical image classification, Spatial Gray Level

Dependent Features (SGLDF) can be used to calculate the intersample distance for better diagnosis [28, 29]. In order to detect the abnormalities in medical images association rule mining is built using texture information [30, 31]. This information can be categorized by the spatial arrangement of pixel intensities. In order to capture the spatial distribution of the gray levels within the neighborhood, two dimensional co-occurrence matrices can be applied to calculate the global level features and pixel level features.

5.2 Euclidean distance

In this paper the Appendicitis is found out using the Distance measure in order to confirm the patient is diagnosis with Appendices. The distance is the predominant one to bring out the diagnosis. The Euclidean distance is used here to find out the measure of the acute appendicitis.

Euclidean distance is the distance between two points in Euclidean space. Take two points P and Q in two dimensional Euclidean spaces. This describes P with the coordinates (p1,p2) and Q with the coordinates (q1,q2). Now construct a line segment with the endpoints of P and Q. This line segment will form the hypotenuse of a right angled triangle. The distance between two points p and q is defined as the square root of the sum of the squares of the differences between the corresponding coordinates of the points; for example, in two-dimensional Euclidean geometry, the Euclidean distance between two points a = (ax, ay) and b = (bx, by) is defined as:

$$d(a,b) = \sqrt{(p_1 - q_1)^2 + (p_2 - p_2)^2}$$

This algorithm computes the minimum Euclidean distance between a column vector x and a collection of column vectors in the codebook matrix cb. The algorithm computes the minimum distance to x and finds the column vector in cb that is closest to x. It outputs this column vector, y, its index, idx, in cb, and distance, the distance between x and y.

Step1: load the column vector x;
Step2: load the code book;
Step3: minimum distance is initially set to the first element of cb.
Step4: i.e. set idx=1;
Step5: compute distance by normalized values of (x-cb) for all cb;
Step6: if d is lessthan distance set distance is equal to d;
Step7: set idx=index;
Step8; end

Fig 1: Proposed method

$$d(a,b) = |p - q|$$

$$\sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_n - q_n)^2}$$

$$= \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}$$

In one dimension, the distance between two points, x1 and x2, on a line is simply the absolute value of the difference between the two points: [32]

$$\sqrt{(X_2 - X_1)^2} = |X_2 - X_1|$$

In two dimensions, the distance between

P = (p_1,p_2) and q = (q_1,q_2) is:

$$\sqrt{(p_1 - q_1)^2 + (p_2 - p_2)^2}$$

The example for this tutorial computes the minimum Euclidean distance between a column vector x and a collection of column vectors in the codebook matrix cb. The function has three output variables:

- y, the vector in cb with the minimum distance to x
- idx, the index of the column vector in cb corresponding to the closest vector
- distance, the distance between x and y

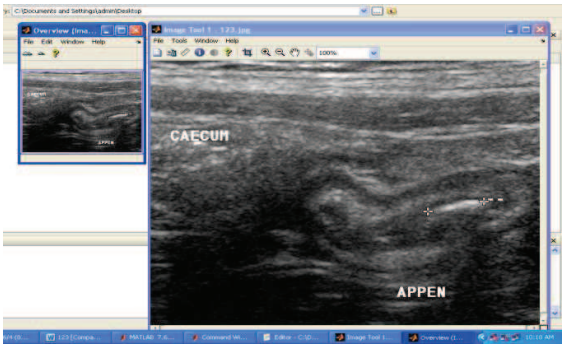


Fig 2: Sonographic image of Appendicitis

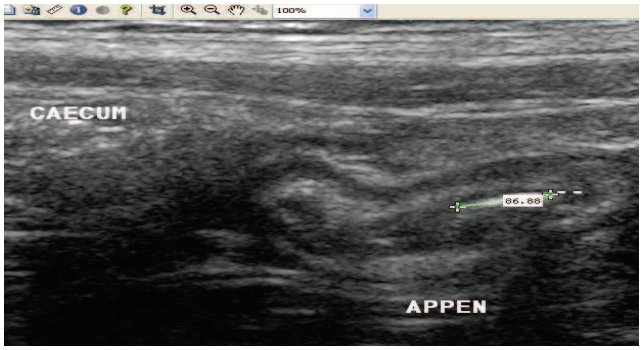


Fig 3: Distance Measure

Table1: Variables for Distance Measure.

Name	Size	Bytes	Class
Distance	1x1	8	double
Point1	1x2	16	double
Point2	1x2	16	double

VI. Experimental Study

An experiment has been conducted on sonography data set based on the proposed algorithm is shown in fig1.The original input image is shown in Fig2. The result for finding acute appendicitis by distance measure is shown in fig3.The proposed algorithm has been used to determine the acute appendicitis using the distance measure as shown in fig3.

The study period was from Jan 2010 – May 2010. Ultrasound imaging was done in all patients. Patients were followed up until the discharge diagnosis was made. Acute appendicitis of sonographic imaging findings in 148 patients was done in patients. In the experimental study total number of 148 instances has been studied in the range of 16 – 51 years. It is noted that mean age of these referel instances are the range 33 – 34. Male and female sex ratio is in the range of 2 : 1. The column chart clearly shows the sex distribution for 148 instances.

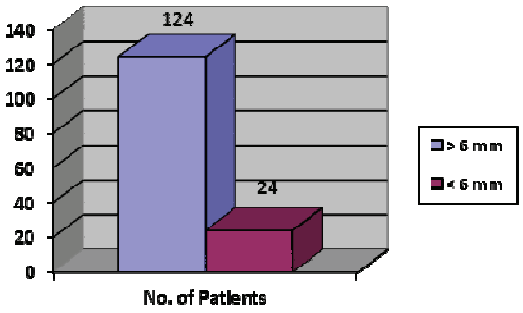
6.1 Results

The images are classified in two different sizes based on the thickness of appendicitis with *greater than 6 mm* and *less than 6 mm*. The proposed system is tested with 148 instances and the results obtained are: out of 148 instances, 124 instances show thickness measured as greater than 6 mm. Table 2 shows the results out of the the experimental study conducted for finding acute appendicitis using sonographic images from 148 patients.

Table 2 : Thickness of Appendix

Size	No. of Patients	Percentage
≥ 6 mm	124	83.78%
< 6 mm	24	16.22%

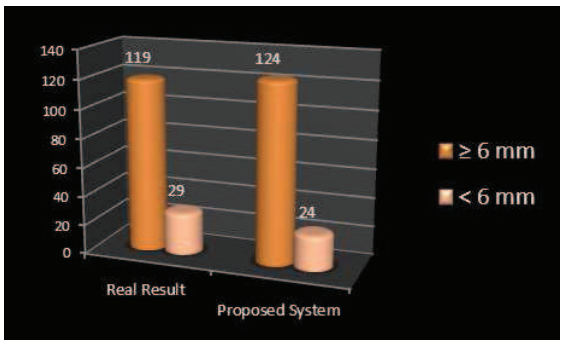
Graph 1 : Thickness of Appendix



A sonologist has been consultated and the results obtained from the sonologist on the same 148 samples reveal that 119 patients are affected by appendicitis. A comparison of the results obtained from the proposed system with the results obtained from the sonologist has been done and the results are as shown in table 3 and the graph corresponding to this is shown in graph 2.

Table3: Comparison of Proposed Method and Real Result

Size	Results from Proposed method	Results from Sonologist
≥ 6 mm	124	119
< 6 mm	24	29



Graph 2 : Comparison of Real Result and Proposed Method

6.2 Validation of Results

The results are validated by calculating the deviation of the results obtained through the proposed method and the real results obtained from the sonologist. The calculations are shown in table 4.

Table4: Difference between the results

N = 148	Results from Proposed method	Results from Sonologist	Difference
Mean	0.84	0.80	0.03
Varience	103.89	95.68	8.21
Std Dev	10.19	9.78	0.41
Std Err	0.26	0.26	0.00

The standard deviation and standard error clearly show that the proposed method yields nearly good results.

VII. Conclusion

In this paper, a new algorithm has been proposed to measure the distance for finding the aucte appendicitis. The quasi-euclidean metric measures the total euclidean distance along a set of horizontal, vertical and diagonal line segments. The existence of appendicitis is found out using the distance measure on the sonographic image of the patient who is diagnosed for appendicitis. Out of the 148 patients considered for experimental study, 124 sonographic images showed a length of above 6 mm implying the existence of appendicitis. The euclidean distance is used here to find out the measure of the acute appendicitis. This work can be further extended to include the module on automatic identification of the start and end points of measurement using image processing and automation techniques.

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