Spatial Relationship Based Approach for Detection of Hookworm

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Abstract:- **Wireless capsule endoscopy (WCE) has become a widely used diagnostic technique to examine inflammatory bowel diseases and disorders. As one of the most common human worm infections, hookworm is a type of a small tubular structure with grayish white or pinkish translucent body. Automatic hookworm detection is quite a challenging task due to low quality images, presence of additional intestinal matters, complex structure of intestinal tract and varied features in terms of color and texture. Hookworm infection seriously threatens human health, causing intestinal inflammation, progressive iron/protein-deficiency anemia, mucosa damage, and malnutrition of human. This proposed paper demonstrates the detection of hookworm in human, automatically, by using GLCM, guided filter and later applying morphological processing in order to detect its presence in the intestines.**

Keywords:- *Hookworm detection, WCE, Texture.*

I. INTRODUCTION

Hookworm infection is an infection caused by intestinal parasite which mainly affects the gastro intestinal tract of humans and animals. Hookworm eggs are usually found in the faeces of an infected person or animal and they develop into immature worms in the environment, When a person walks on bare feet or come in contact with these worms which are mostly present on the beach or garden areas, they get attached into the skin and penetrate get situated in various parts of the body like eyes, hands, legs but most probable in the intestines. This results in itching and rashes in the affected part and then causes fever, vomiting, and coughing, abdominal pain, loss of appetite, diarrhoea and mainly result in anaemia which may also lead to a person's death.
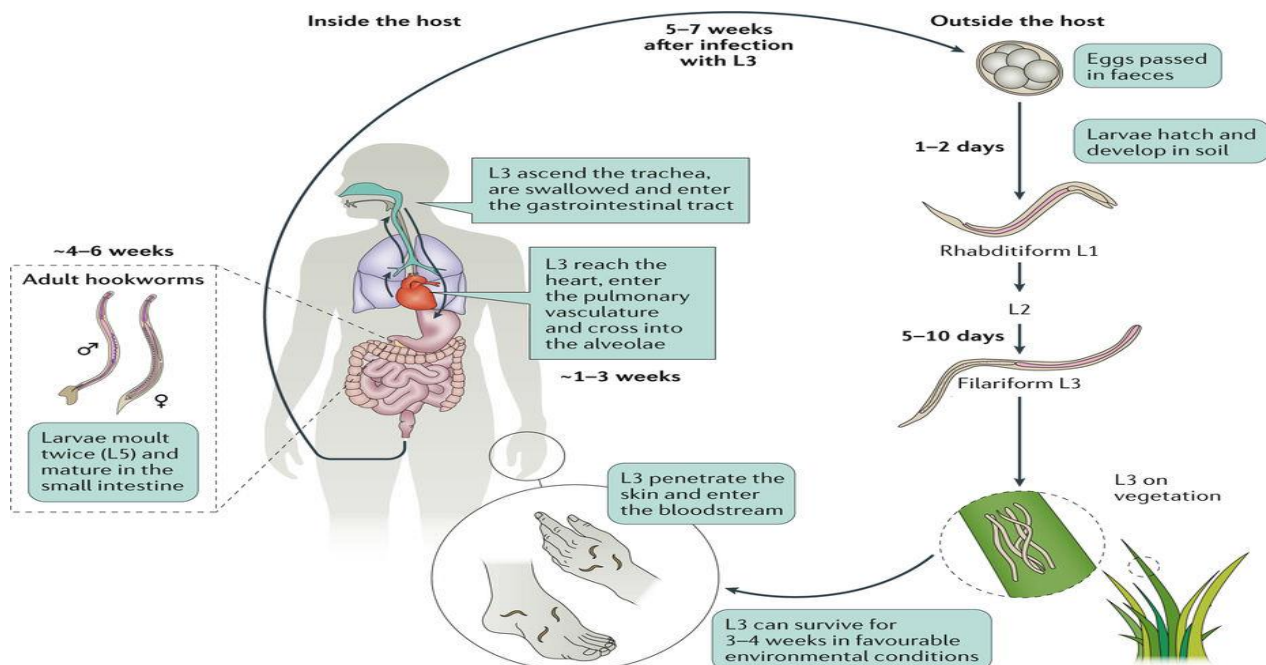

Fig. 1:- The lifecycle of a Hookworm

Hookworm infection when present on the outer parts of the body can be easily viewed through naked eyes. But they mostly occur in the intestines which cannot be viewed directly. So in-order to find its presence we obtain the images of the intestines using Wireless Capsule Endoscopy (WCE).

WCE is a procedure used to obtain the images of the internal parts of the body primarily the intestines. It is designed the GLCM is used to detect the presence of hookworm, which is followed by a segmentation process of first smoothening unwanted portion using guided filter and then segmenting the hookworm portion out by morphological processing.

like a normal medical capsule consisting of a battery source, tiny camera surrounded by LEDs to provide light source to capture numerous images per second with accuracy. The obtained images are first color converted into agray scaleimage and

The color converted image is then processed using a GLCM matrix algorithm to detect for the presence of the hookworm infection in that image.
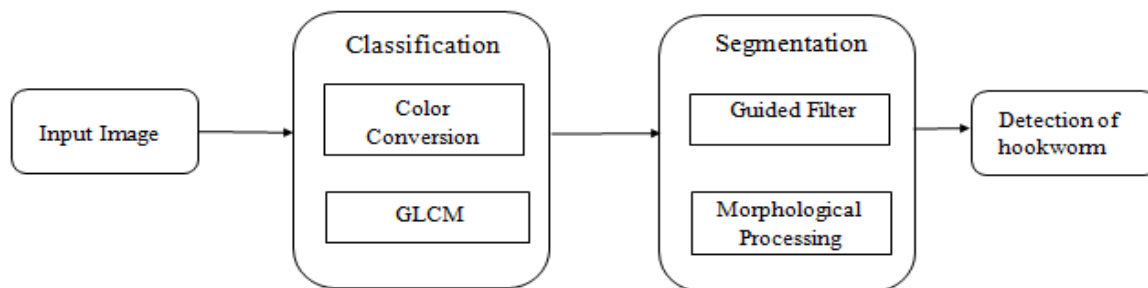

Fig 2:- Block Diagram for the detection of hookworm using spatial relationship.

II. CLASSIFICATION

The classification stage is further divided in to two stages. The process starts with the color conversion of the input image followed by detection hookworm through its features.

A. Color Conversion

The input image is first converted to a black and white image and then inversion operation is applied to it. The input image also undergoes a rgb to gray conversion as in any image processing grayscale images have only black and white and shades of gray .So using a grayscale image(8 bit) is less complex rather than processing the color image (24 bit). Finally the edge detection process is done by using a Canny Edge Detector. Canny edge detection occurs in the following steps

- Application of a Gaussian filter to smoothen the edges and noise removal
- Finding intensity gradients
- Non-maximal suppression to produce thin edges
- Hysteresis thresholding

The output of canny is a perfect extraction of edges of the hookworm image and it is widely preferred among all the other edge detection techniques as it provides low error rates, better localization and the hysteresis process helps in removing false edges. Once the required output is obtained the final image can again be converted to a color image.

B. Gray Level Co-Occurrence Matrix

The Gray Level Co-occurrence Matrix (GLCM) is an image analysis technique to calculate the texture features of hookworm image. It is a tabulation which consists of how frequently combinations of gray levels co-occur in the image section by measuring the variations in intensity of the pixels. It is a statistical approach which considers the spatial relationships of the pixels in the GLCM and eventually also known as Gray Level Spatial Dependency Matrix. It calculates how often pixel pairs with particular values occur in the image and their specified spatial relationship between them to extract the texture features.

The Texture features of the hookworm are obtained by extracting the contrast, correlation, energy and homogeneity values of the grayscale image.

By using the below table, the texture features are calculated and the presence of hookworm in the image is detected and is classified from the other images obtained from the WCE images.

Property	Description	Formula
Contrast	It is a measure of local variations in the GLCM matrix.. Range = [0 (size(GLCM,1)-1)^2] It is the variance value and has a value 0 for a constant image.	$\sum_{i,j} |i-j|^2 p(i,j)$
Correlation	It is a measure of the joint probability occurance of the particular pixel pairs. Range = [-1 1] Its value is 1 for a positively correlated image and -1 for a negatively correlated image and NaN for a constant valued image.	$\sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j}$
Energy	It returns the sum of squared elements of the GLCM. Range = [0 1] It gives the uniformity within pixels.	$\sum_{i,j} p(i,j)^2$
Homogeneity	It is the measure of closeness of distribution of elements of GLCM to the GLCM diagonal. Range = [0 1] GLCM diagonal = 1	$\sum_{i,j} \frac{p(i,j)}{1+|i-j|}$

Table 1.

III. SEGMENTATION

A. Guided Filter

The guided filter is a filter that does its filtering operationof by means of a guidance image resulting in preservation of the edges. The spatial relationship of the neighborhood pixels are taken into account which may be 4 or 8neighborhood according to the output desired. It is popularly called as smoothing by edge output.

They are greatly applied in the areas where noise reduction, detailed smoothing, detailed enhancement, HDR compression, image matting and feathering, haze removal, and joint up samplings are required. They are usually done by verifying the statistics of the region taking the spatial neighborhood in to account by calculating:

- Mean values of input image and guidance image
- Variance of input image and guidance image
- Covariance of input image and guidance image
- Linear Co-efficient of pixels

If the input image has varied statistics compared to the guidance image then the, the filtered image is computed by,

$$q = mean\_a \cdot * I + mean\_b \qquad (1)$$

where, q – Filtered Image
      I – Guidance Image
a ,b – Linear coefficients of Input Image

The guided filter has a great potential in computer vision & graphics. Due to its simplicity, efficiency, and high-quality it is preferred over other the other existing filtering techniques as it results in an efficient edge smoothening.

B. Morphological operations

Morphological operations denotes the removal of imperfections in an image due to noise and distortion. They are done by imposing a structural element over the input grayscale image which convolutes by the AND (or) OR operation depending on the required output image.

Structuring element plays a major role in Morphological processing . Usually odd dimensions of matrix are used where the origin is usually taken as the center even though the origin can be taken outside the kernel.

The structuring element is said to fit, ifeach of the pixels are already 1 in the input image corresponding to the structuring element and ,they are said to hit ,ifat least one of the images are made 1,so as to make the output pixel as1.

The four major techniques of morphological processing are,

- Dilation
- Erosion
- Opening
- Closure

In this proposed paper, we make use of Dilation and closure techniques to detect the hookworm portion and to provide image enhancement.

A. Dilation

Dilation is a process in image processing where the edge detected boundaries are dilated or in other words the boundaries are thickened so as to perform edge detection.

The dilation process is done by using a structural element which performs an OR operation with the input image to check for a hit to occur which changes the pixel value to 1 otherwise to 0 resulting in thickening of the boundaries.

They are mathematically represented by,

$$g = f \oplus s \ (2)$$

where,

g – dilated binary image,
f –input binary image,
s – structuring element.

B. Closure

Closure is a process wherein the unfilled pixels are filled with white pixels or by implementing OR operation thereby making the image white with the structural element hovering on top.They are usually performed on dilated or eroded binary images.

The closure function is generally idempotent and is mathematically represented by,

$$g = f \bullet s = (f \bullet s) \bullet s \ (3)$$

where,　　　　　g – output image,
f – dilated binary image,
s – structuring element.

They are usually done with the structural element rotated 180º,that is it takes complement of the input image and convolutes with the processed image to get the desired output followed by the complement of the result.

The hit and fit of the resultant image is usually determined by matched pair of structuring element. Then the Ex-OR operationis performed wherein if the input image pixel and structural element that hovers over it is 1, then resultant is Zero (0) and if any one of the image pixel is 1,then the resultant pixel is always one (1).

Fig 3. Examples of WCE images having hookworms .The extra intestinal matters are evident in the images which makes automatic detection quite of hookworm a quite challenging task.

IV.　　RESULT

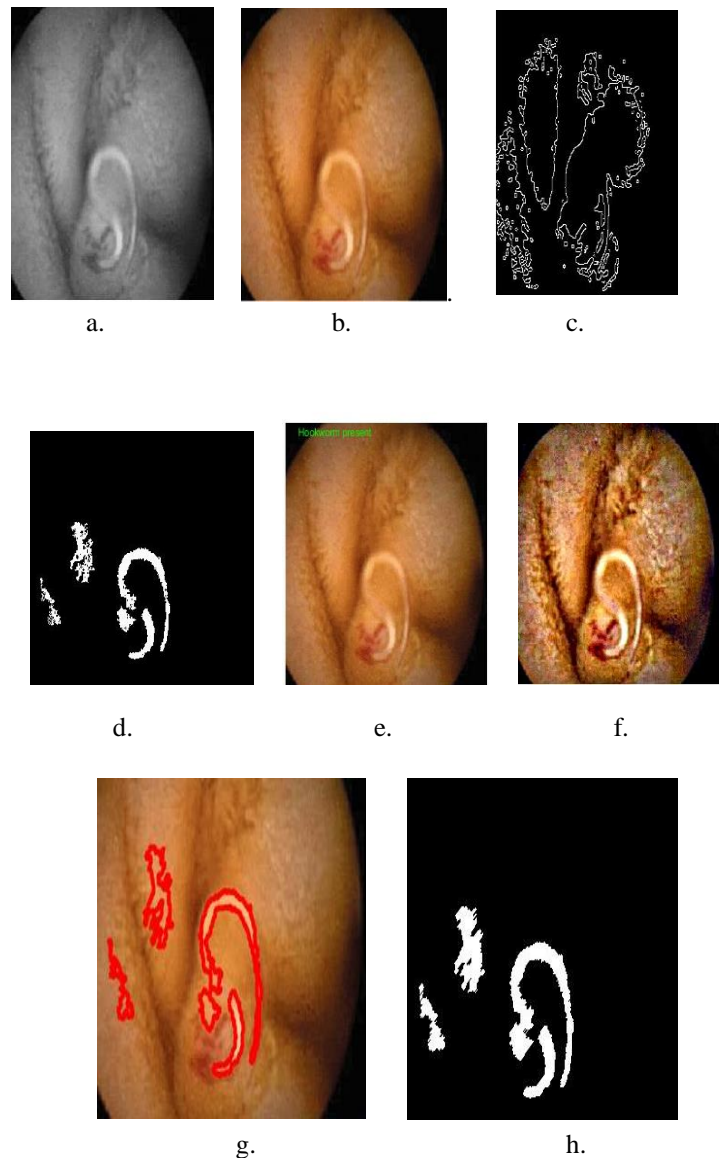a.　　　　　　b.　　　　　　c.

d.　　　　　　e.　　　　　　f.

g.　　　　　　　　h.

Fig4. The resultant output images of the proposed system: a)input image b)color converted image c) canny edge detection d) detection of presence of hookworm e) filtered image using guided filter f) dilated Image g)closure image h) hookworm boundary detection.

The above table depicts the feature values and the number of objects in the connected components of the given example hookworm images in Fig3. This helps in detecting the presence of hookworm in the given images.

S.no	Contrast	Correlation	Homogeneity	Energy	No.of connected objects
1.	0.1789	0.9522	0.9430	0.1912	627
2.	0.1568	0.9561	0.9376	0.1992	495
3.	0.1801	0.9654	0.9570	0.1954	524
4.	0.0515	0.9787	0.9753	0.2266	130
5.	0.0912	0.9770	0.9546	0.1906	412
6.	0.0546	0.9818	0.9738	0.2150	124
7.	0.0865	0.9795	0.9706	0.1938	102
8.	0.0886	0.9856	0.9749	0.2276	90
9.	0.1514	0.9734	0.9486	0.1438	271
10.	0.1362	0.0468	0.9498	0.9498	373
11.	0.1857	0.9542	0.9641	0.2011	130
12.	0.1567	0.9353	0.9436	0.2613	747
13.	0.1024	0.9787	0.9579	0.2451	179
14.	0.1368	0.9775	0.9505	0.1354	287
15.	0.0912	0.9770	0.9546	0.1906	412

Table 2. Comparison Table

V.   CONCLUSION

Detection of hookworms by automation processes is quite a demanding task. Although various methods were previously being adopted ,the percentage of error rates were quite high. By taking in to consideration the previous models and improvised technique is proposed in this paper. This approach uses spatialrelationship based morphological processing to boost the overall performance of detection.

This method proves to provide better results compared to other existing systems by detecting the presence of all the hookworms available in the given image. But there are still 10% error rates of detection of unwanted intestinal matters due to contrast and lightning variations in the WCE images. We further work in rectifying those minimal error rates as eventually we need to propose the best automatic detection to assist endoscopists and helps in detecting the hookworms accurately, in a much simpler way.

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