# An Efficient Bleeding Detection Technique in Wireless Capsule Endoscopy from Region of Interest

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**ABSTRACT**

One of the significant challenges in Capsule Endoscopy (CE) is to precisely determine the pathologies location. The localization process is primarily estimated using the received signal strength from sensors in the capsule system through its movement in the gastrointestinal (GI) tract. Consequently, the wireless capsule endoscope (WCE) system requires improvement to handle the lack of the capsule instantaneous localization information and to solve the relatively low transmission data rate challenges. Capsule localization and tracking are considered to be the most important features of the WCE system, thus the current article emphasizes the most common localization systems generally, highlighting the DOA-based localization systems and discusses the required significant research challenges to be addressed. In the proposed method, first region of interest (ROI) is identified and then that ROI is used for feature extraction followed by bleeding image classification. One major advantage in ROI selection is that the computational cost involved in feature extraction and classification will be drastically reduced. An efficient scheme for bleeding detection from WCE images in YIQ domain. Instead of directly using all four spaces of YIQ color model, a new composite color space Y.I/Q is proposed. Our experiments have shown that our computer-assisted diagnostic-procedure algorithm can be used for extracting gastritis and gastrointestinal bleedings in WCE.
**Keywords:** Wireless Capsule Endoscopy, Radio Frequency, Deep Neural Network, Region of Interest, Direction of Arrival.

## 1. INTRODUCTION

Digital Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. Digital image processing is the use of computer algorithms to perform image processing on digital images as shown in Figure 1 [2]. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing.

Digital Image Processing makes use of more complex algorithms and thus attempts to render more refined results in simple way as compared to the analog means. This yields a high possibility of applying advanced algorithms with the input data. The major advantageous characteristic of digital image processing is the abundance of methods to avoid noise factor while processing the input signals. In a broader view, digital image feature processing is one technology that can be implemented for:

- Object Recognition
- Pattern Classification
- Motion Tracking
- 3D Reconstruction
- Robot Navigation

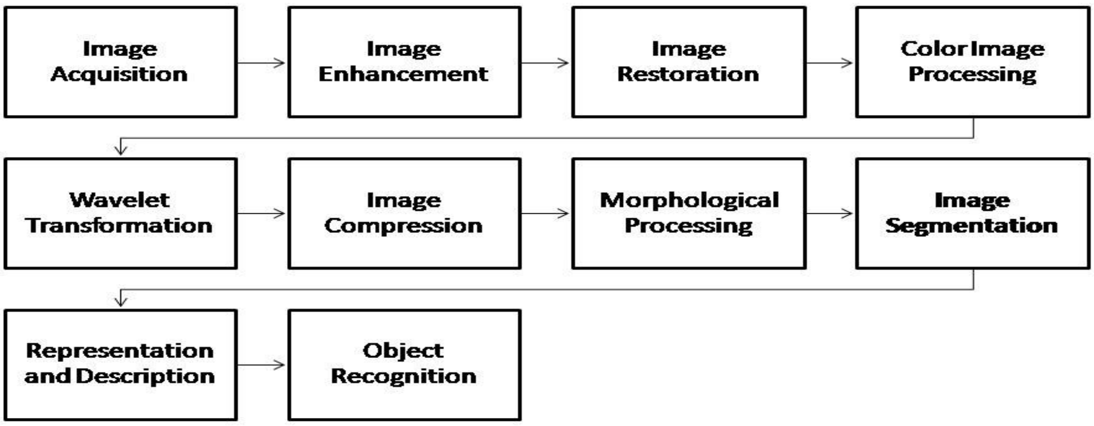


**Figure 1.1: Sequence of Stages in Digital Image Processing**

### 1.1 Endoscopy

Endoscopy is a nonsurgical solid tube for visual examination of the digestion tract, for example the Colonoscopy and Gastroscopy can scope part of the Gastrointestinal (GI) tract. Patients feel very uncomfortable due to the long time of the endoscopy examination process. Additionally, several side effects can occur, such as intestinal wall perforation, breathing difficulty and infection during the inspection time [1]. Consequently, in order to avoid the traditional endoscopy drawbacks, Iddan *et al*. [2] presented Wireless Capsule Endoscopy (WCE) in order to diagnose GI conditions without the need for any sedation [3]. The WCE provides gains for both the physician and patient since it is precise, portable and noninvasive for the inspection of the human body's GI tract. The WCE is a capsule size medical device that captures internal images of the human intestine during its movement. It is equipped with a Radio Frequency (RF) transmitter, camera and a battery to transmit wirelessly the captured image to an exterior receiver that is placed outside the human body. WCE non-invasively assesses the entire small bowel with superior ability to detect the significant mucosal diseases, including polyps, ulcers and angiodysplasia compared to traditional endoscopy [4]. In order to link the captured images from certain region within the patient body with the WEC location, the localization processes becomes essential. Predominantly, in the WCE, the localization process depends on the emitted signal from the equipped sensors within the capsule and the detected signal strength through its movement in the GI tract.

## 2. RELATED WORK

**Philip W. Mewes et al. [2011]** present a novel two step computer-assisted diagnostic-procedure (CADP) algorithm for indicating gastritis and gastrointestinal bleedings in the stomach during the examination. First, identify and exclude sub regions of bubbles which can interfere with further processing. Then address the challenge of lesion localization in an environment with changing contrast and lighting conditions. After a contrast-normalized filtering, feature extraction is performed [5].

**Tonmoy Ghosh et al. [2015]** YIQ (luminance-Y, chrominance-IQ: in phase-I and quadrature-Q) color scheme is used for analyzing WCE video frames, which corresponds better to human color response characteristics. Analyzing the behavior of each of the four YIQ spaces, first, a region of interest is determined depending on the Q value of the pixels and some morphological operations. Next, instead of considering three spaces of YIQ color model separately, a new composite space Y.I/Q is proposed to capture intrinsic information about the luminance and chrominance of images [6].

**Ravi Shrestha et al. [2016]** propose a low-power and efficient illumination system that is based on an automated brightness algorithm. The scheme is adaptive in nature, i.e., the brightness level is controlled automatically in real-time while the images are being captured. The captured images are segmented into four equal regions and the brightness level of each region is calculated. Then an adaptive sigmoid function is used to find the optimized brightness level and accordingly a new value of duty cycle of the modulated pulse is generated to capture future images. The algorithm is fully implemented in a capsule prototype and tested with endoscopic images [7].

**Yixuan Yuan et al. [2016]** proposal is based on a twofold system. First, we make full use of the color information of WCE images and utilize K-means clustering method on the pixel represented images to obtain the cluster centers, with which we characterize WCE images as words-based color histograms. Then, judge the status of a WCE frame by applying the support vector machine (SVM) and K-nearest neighbor methods [8].

**Yishuang Geng et al. [2016]** using 3D Posterior Cramer-Rao Lower Bound (PCRLB) as a framework for performance evaluation, demonstrated that mill metric accuracy can be achieved using hybrid RF and image processing localization technique. This level of accuracy enables precise simultaneous localization and mapping of the WCE movement path inside the small intestine. Using the PCRLB framework, provide in-depth analysis on hybrid localization performance regarding the effects of WCE movement estimation, the effects of system bandwidth as well as the effects of on-body sensor numbers and placements [9].

**Yixuan Yuan et al. [2016]** propose an improved bag of feature (BoF) method to assist classification of polyps in WCE images. Instead of utilizing a single scale-invariant feature transform (SIFT) feature in the traditional BoF method, extract different textural features from the neighborhoods of the key points and integrate them together as synthetic descriptors to carry out classification tasks. Specifically, study influence of the number of visual words, the patch size and different classification methods in terms of classification performance [10].

**Xingying Wang et al. [2017]** present a mechanical scanning device incorporating a high-frequency transducer specifically as a proof of concept for US capsule endoscopy (USCE), providing information that may usefully assist future research. A rotary solenoid-coil-based motor was employed to rotate the US transducer with sectional electronic control. A set of gears was used to convert the sectional rotation to circular rotation. A single-element focused US transducer with 39-MHz center frequency was used for high-resolution US imaging, connected to an imaging platform for pulse [11].

**Xiaohan Xing et al. [2018]** present an automatic bleeding detection algorithm that consists of three stages. The first stage is the preprocessing, including key frame extraction and edge removal. In the second stage, discriminate the bleeding frames using a novel super pixel color histogram (SPCH) feature based on the principle color spectrum, and then the decision is made by a subspace KNN classifier. Thirdly, further segment the bleeding regions by extracting a 9-D color feature vector from the multiple color spaces at the super pixel level [12].

## 3. PROPOSED WORK

**Step-1** Take an image and apply gamma correction
**Step-2** Apply edge detection on gamma corrected image and remove edges
**Step-3** Edge removed image should be converted to YIQ
**Step-4** Separate Q plane which is having bleeding part
**Step-5** Extract this bleeding part (which should be entire bleeding area in an image) from original image

### 3.1Gama Correction

Gamma correction function is used to correct image's luminance. Like this: output_luminance = gammaCorrectionFunction [input_luminance]

The luminance is a value between 0 to 1.

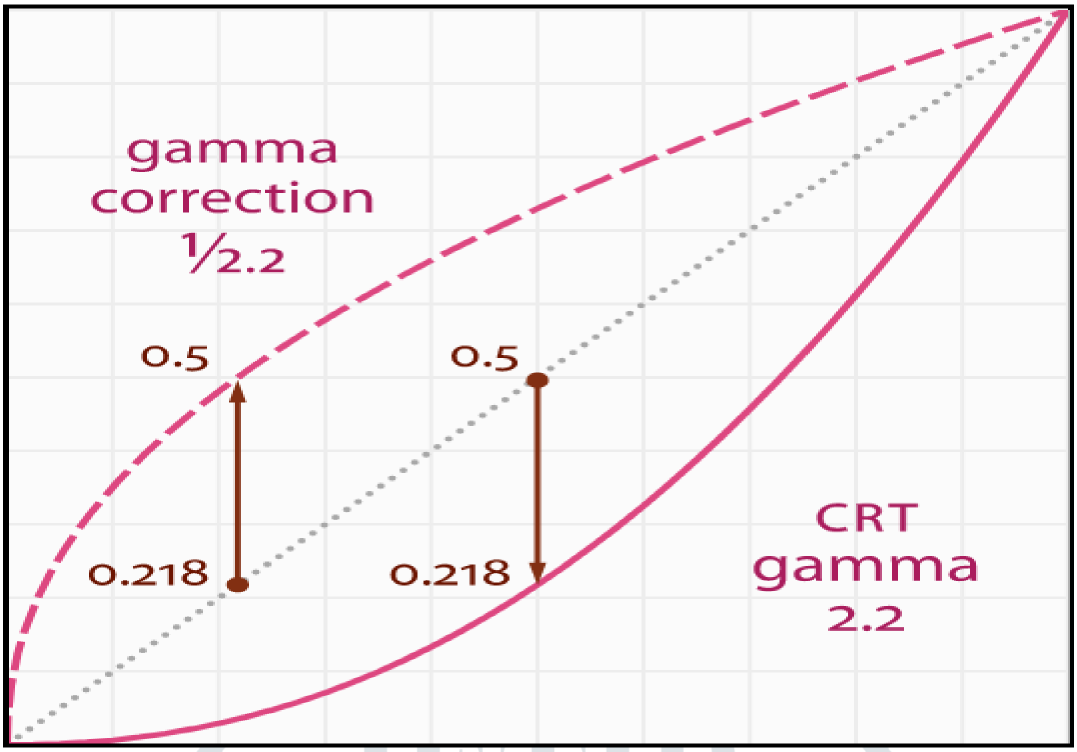


**Figure 3.1: Gamma Correction**

x-axis is voltage. y-axis is brightness. The solid red curve is typical CRT monitor's voltage and brightness ratio. The dashed red curve is its inverse function, the gamma correction function. The gray dotted line is the corrected result.

Gamma correction function is a function that maps luminance levels to compensate the non-linear luminance effect of display devices (or sync it to human perceptive bias on brightness).

"Gamma correction function" is defined by:

gammaCorrectionFunction[x] = x^γ

where γ is a constant, and "^" is the power operator. The value γ is said to be the gamma.

### 3.2 Canny Edge Detector

Canny operator is one of the most extensively used detectors that utilizes associated edge detection algorithm. The three major factors supporting the high speed performance of canny edge detector [12] are mentioned as under:

- Degree of good detection
- Extent of good localization
- Unique response to one edge

Canny detector is named after the research scientist who developed the optimal filter to extract edges of an image by enhancing the product of two expressions corresponding to the two criteria of precise detection and localization. This optimal filter is approximated using first derivative of Gaussian function that transforms a window of pixels into a set of binary pattern.

The calculation is based on the value of specific local threshold followed by application of mask to find the existence of edge at a point. Canny edge detector initially levels the image smoothing to remove the effective noise component and scans the window view for the image gradient that shows the regions with high value of differential in spatial domain. The algorithm then outdoes those pixels which are not a component of maximum. [14] Canny Edge Detection Algorithm is described in the following steps.

1. The input image is first convolved using Gaussian filter. A less blurred image is formed in contrast to original. The blur effect is reduced by using Gaussian filters and noise component is removed from the image before defining the location of an edge. The width of Gaussian filter is kept lower and is applied as a sliding mask.
2. The variation in the intensity of edge is calculated by applying gradient measurement in spatial pattern, followed by estimation of gradient vector.
3. Based on the value of gradient in x and y directions of an image function, the criteria follows procedure to depict the edge direction in $0^o$ or $90^o$ plane. The direction of the edge is given by the formula [73].

$$\Theta = \tan^{-1} (G_x/G_y) \qquad - (i)$$

### 3.3 Convert to YIQ

The YIQ (luminance-inphase-quadrature) model is a recording of RGB for colour television, and is a very important model for colour image processing.

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} . \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The luminance (Y) component contains all the information required for black and white television, and captures our perception of the relative brightness of particular colours. That we perceive green as much lighter than red, and red lighter than blue, is indicated by their respective weights of 0.587, 0.299 and 0.114 in the first row of the conversion matrix above. These weights should be used when converting a colour image to greyscale if you want the perception of brightness to remain the same.

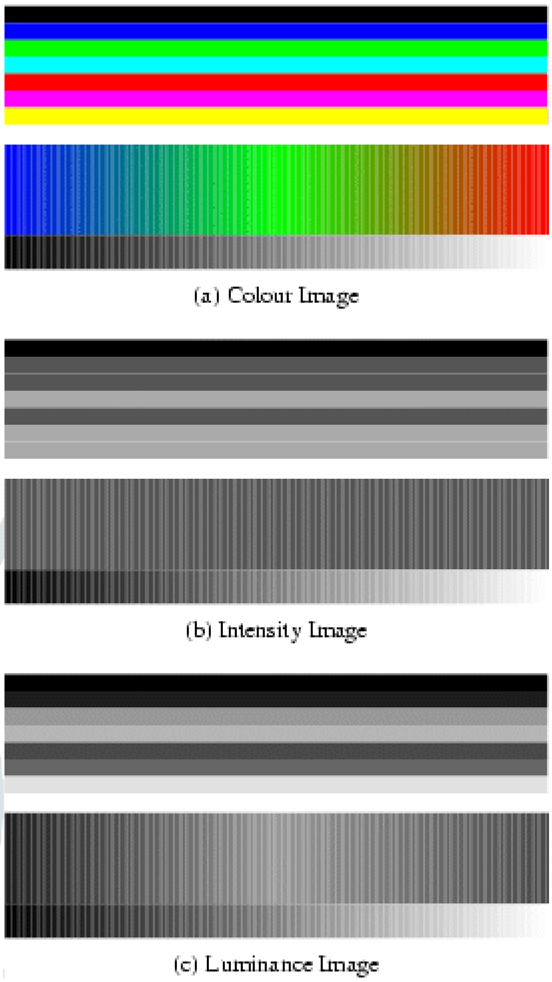


**Figure 3.2: YIQ Conversion**

Image 3.2 (a) shows a colour test pattern, consisting of horizontal stripes of black, blue, green, cyan, red, magenta and yellow, a colour ramp with constant intensity, maximal saturation, and hue changing linearly from red through green to blue, and a greyscale ramp from black to white. Image (b) shows the intensity for image (a). Note how much detail is lost. Image (c) shows the luminance. This third image accurately reflects the brightness variations perceived in the original image.

### 3.4 Separate Q Plane

*Q* stands for *quadrature*, referring to the components used in quadrature amplitude modulation. Some forms of NTSC now use the YUV color space

## 4. RESULTS

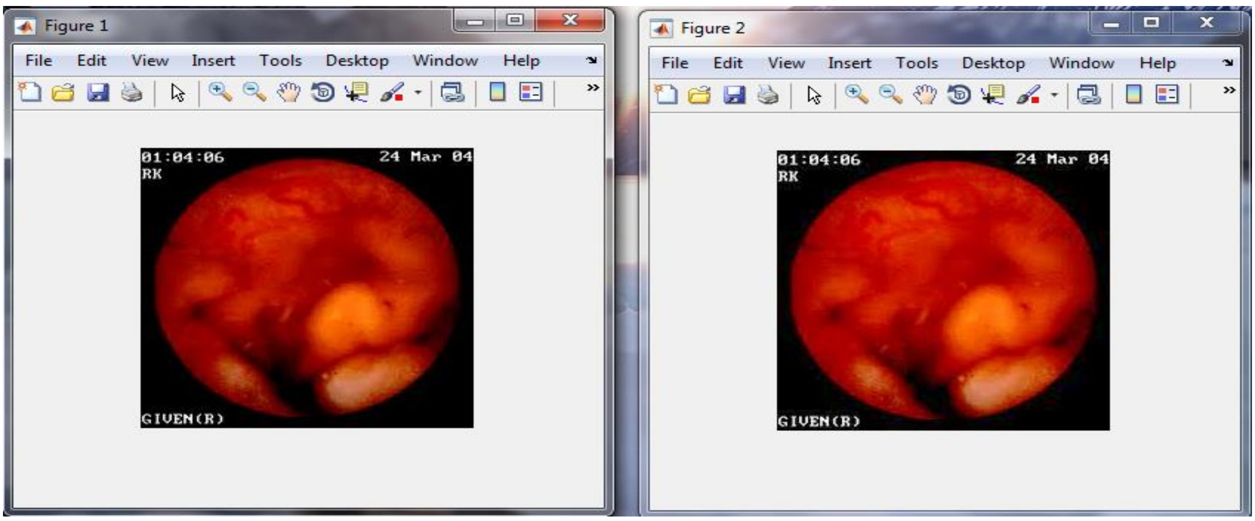


**Figure 4.1: Adaptive Gamma Correction with Weighting Distribution**

Input Image and apply gamma correction. As shown in figure 4.1 Gamma correction is applied to original image and Gamma Corrected image is produced as shown in figure 4.2

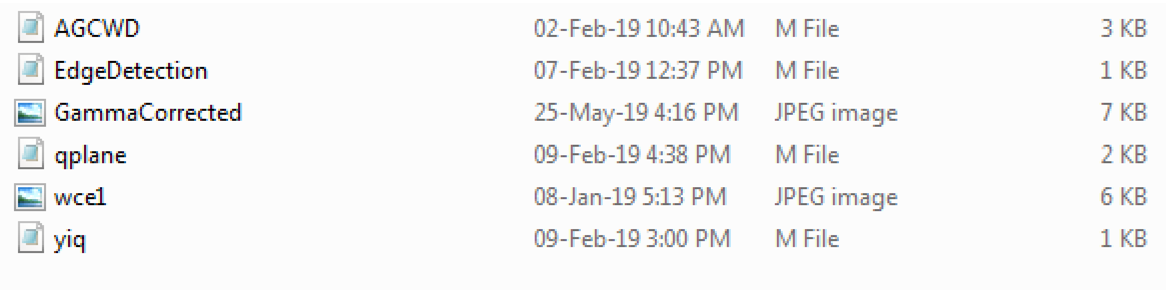


**Figure 4.2: Gamma Corrected Image**

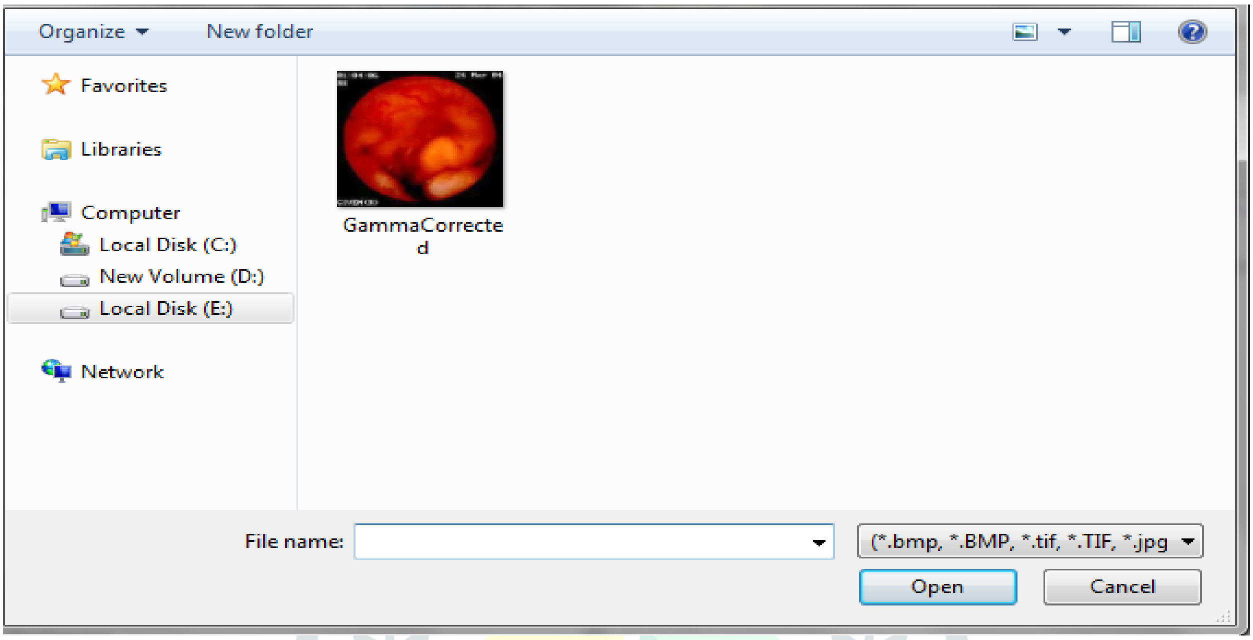


**Figure 4.3 Input gamma corrected image and remove edges**

As shown in figure 4.3 Gamma Corrected image is selected for edge detection.

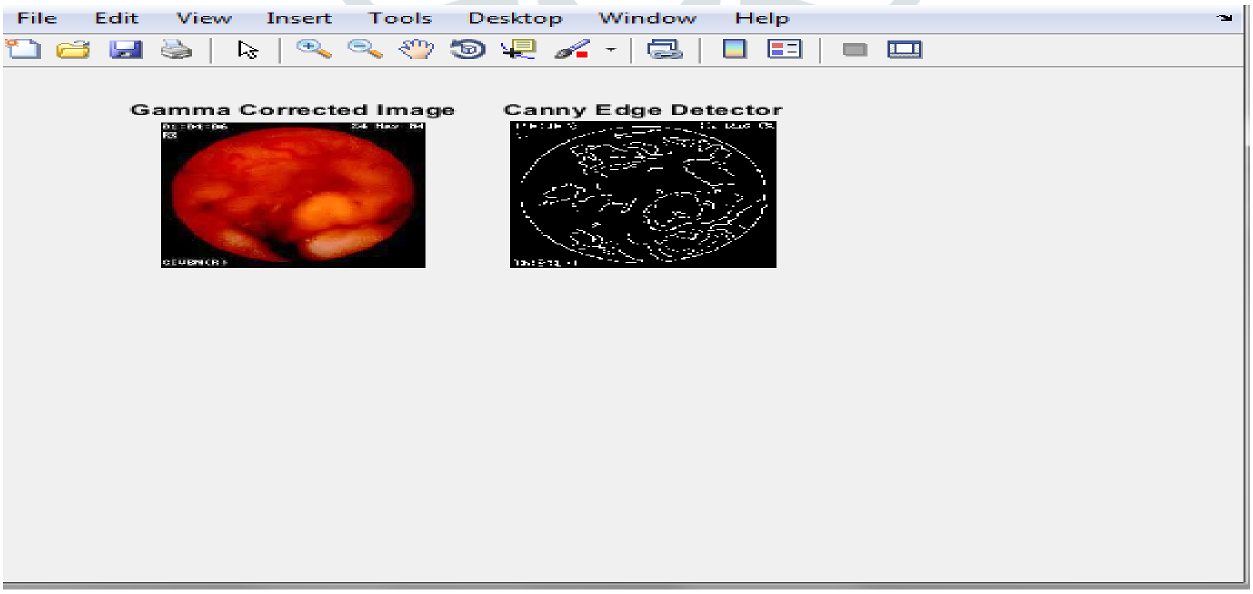


**Figure 4.4 Canny edge detectors to remove edges**

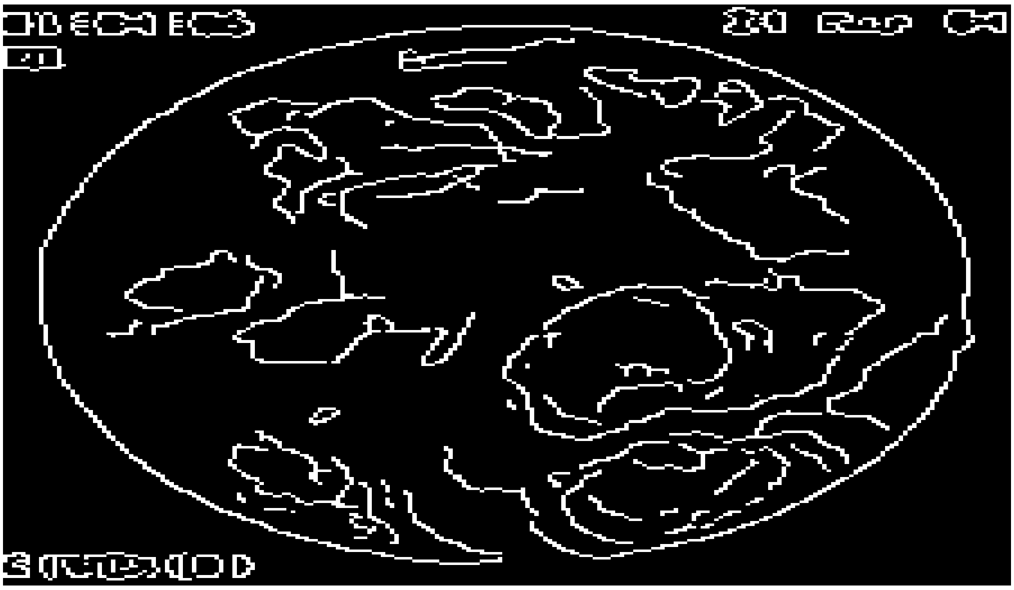

**Figure 4.5 Output of Canny edge Detector**

Figure 4.5 shows edge removed image

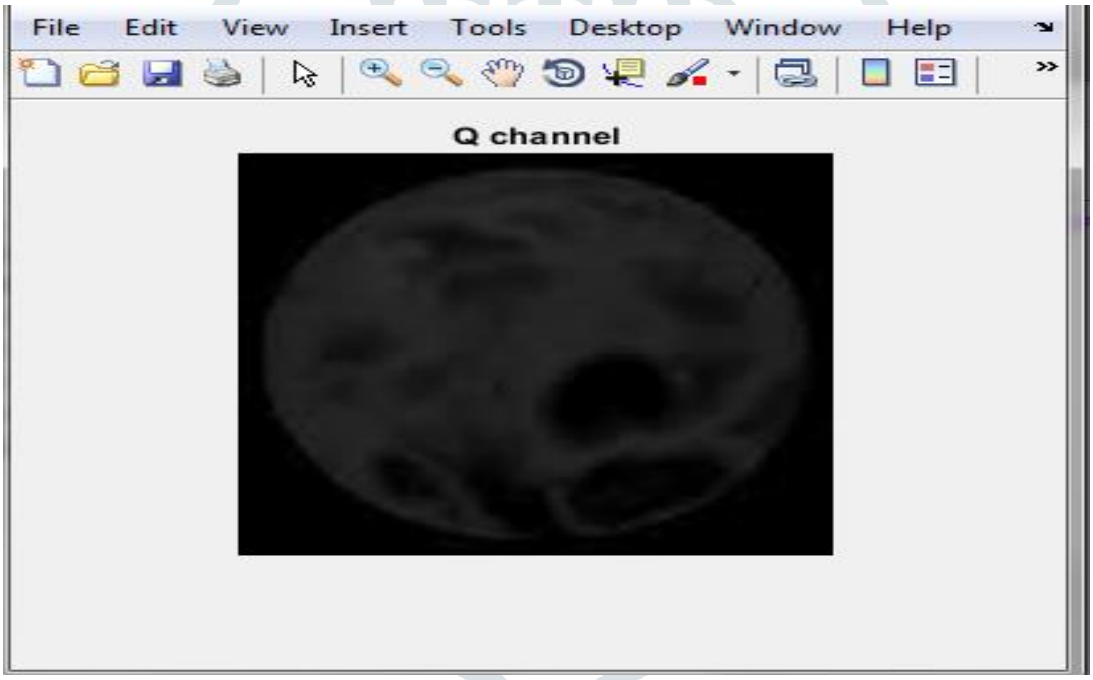


**Figure 4.6 Separate Q plane**

As shown in figure 4.6 Q plane is separated which is having bleeding part.

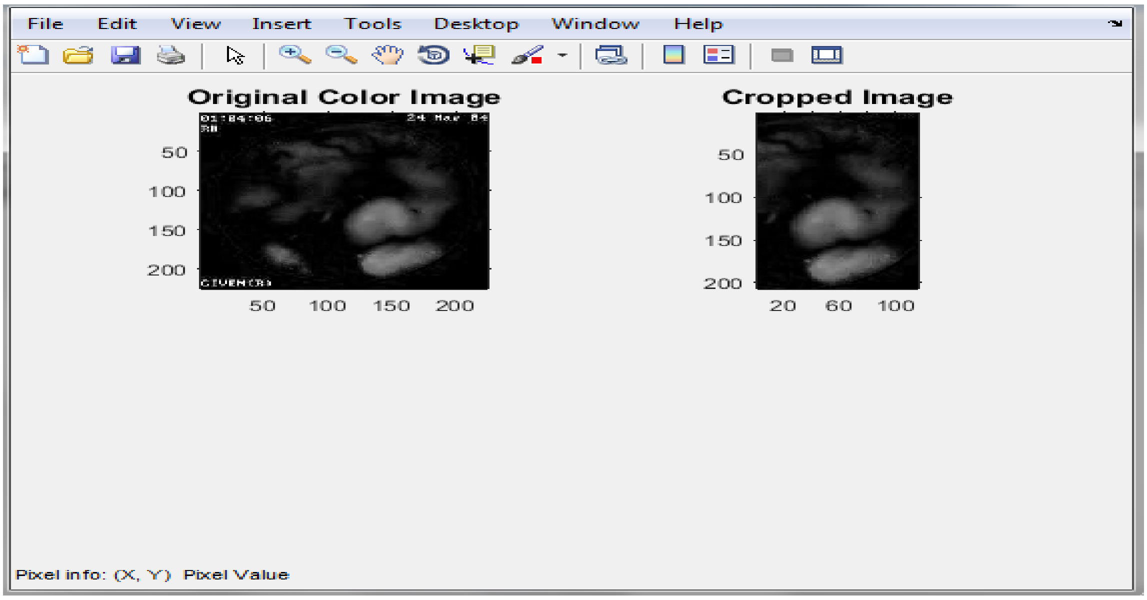


**Figure 4.7 Extract Bleeding part**

As shown in figure 4.7 bleeding part is extracted (which should be entire bleeding area in an image)

**5. CONCLUSION AND FUTURE SCOPE**

An efficient bleeding detection scheme from WCE images in YIQ color domain is implemented. First a method for region of interest (ROI) detection is developed based on Q value and morphological operation to identify possible bleeding zones. Different statistical characteristics of Y, I and Q spaces in discriminating bleeding frames in WCE images are investigated. A composite space using Y, I, and Q spaces is proposed for extracting features from extracted ROI. In order to classify bleeding and non-bleeding WCE images from extracted features, the Deep Neural Network (DNN) classifier is employed. In the future, we will find more suitable features for the bleeding frames classification in order to decrease the mistakes in the localization tasks.

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