Implementation of Canny and Isotropic Operator with Power Law Transformation to Identify Cervical Cancer

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Abstract. Colposcopy has been used primarily to diagnose pre-cancer and cancerous lesions because this procedure gives an exaggerated view of the tissues of the vagina and the cervix. But, the poor quality of colposcopy image sometimes makes physician challenging to recognize and analyze it. Generally, implementation of image processing to identify cervical cancer have to implement a complex classification or clustering method. In this study, we wanted to prove that by only applying the identification of edge detection in the colposcopy image, identification of cervical cancer can be determined. In this study, we implement and comparing two edge detection operator which are isotropic and canny operator. Research methodology in this paper composed by image processing, training, and testing stages. In the image processing step, colposcopy image transformed by nth root power transformation to get better detection result and continued with edge detection process. Training is a process of labelling all dataset image with cervical cancer stage. This process involved pathology doctor as an expert in diagnosing the colposcopy image as a reference. Testing is a process of deciding cancer stage classification by comparing the similarity image of colposcopy results in the testing stage with the image of the results of the training process. We used 30 images as a dataset. The result gets same accuracy which is 80% for both Canny or Isotropic operator. Average running time for Canny operator implementation is 0.3619206 ms while Isotropic get 1.49136262 ms. The result showed that Canny operator is better than isotropic operator because Canny operator generates a more precise edge with a fast time instead.

1. Introduction
Cervical cancer is the second most maglina ncy among women [1]. Cervical cancer is an abnormal growth cell occurring in the uterine cervix that usually detected when cancer enters an advanced stage. Therefore women are recommended to undertake precancer examination such as colposcopy. Colposcopy is the examination to see the surface of the cervix by inserting a tool called colposcope into the vagina. The cervical surface image can be documented with a small camera on the colposcope. Colposcopy has been used primarily to diagnose pre-cancer and cancerous lesions because this procedure gives an exaggerated view of the tissues of the vagina and the cervix [2]. Furthermore, the colposcopy can directly visualize the quality and location of lesions of the cervix [3]. One of the challenge factors is difficulties in training the physicians to recognize the pathology of colposcopy image [4]. The poor quality of colposcopy image sometimes makes physician challenging to analyze it. Identification of cancer should be identified more accurate if the colposcopy images are transformed into edge detection forms. Edge detection is the process to characterize the intensity changes in the image [5]. This process aims to simplify the analysis of images by reducing the amount of data from the image but still preserving useful information about boundaries of the object [6].
Lesions are an area of abnormal tissue on the cervix. Every stage of cervical cancer has different broad and lesion location on cervix [7]. Every colposcopy with abnormal cell will generate different edge detection pattern because it corresponds to lesion boundaries. This model depends on wide and position of lesions on the cervix.

This work is experimental research to identify and classify cervical cancer stage based on colposcopy image processing. In this study, we implemented two edge detection algorithms which are Canny and Isotropic operator. The Canny algorithm is an optimal edge detection that already applied noise reduction in its step. On the other hand, Isotropic is one of gradient edge detection with more straightforward action. Classification of cancer stage identified by comparing edge detection result with edge detection of reference images. The parameters in this research are the accuracy of stadium cancer classification, quality of edge detection and the running time. The benefit of this study this method could be a choice to transform colposcopy image into edge detection form that easier to identify the cancer lesions.

2. Related Works
Previous research which implemented image processing in health field had been done by [1,4,7,8]. Research by [1] proposes to develop an automated diagnostic system for cervical pre-cancerous. The study by [4] describes a texture image analysis technique for characterizing and recognizing typical vascular patterns relating to cervical lesions from colposcopy image. The investigation by [8] has developed a prototype digital imaging colposcopy system for use in clinical, research and teaching environments. The previous research about edge detection algorithm had done by [5, 6, 9, 10]. From all the previous research declared that edge detection is a useful method to represent a clear image while still preserving useful information about object boundaries.

3. Methodology
The Methodology of this research can be described in Figure 1.

![Figure 1. Methodology.](image)

3.1 Colposcopy Image
Colposcopy Images are dataset for training and testing stage. The dataset is from a health official government sites at URL www.pptm.depkes.go.id. These colposcopy images are 30 png images with 200 x 200 pixels containing vascular pattern lesions from different stages of cervical cancer.

3.2 Colposcopy Image Processing
Colposcopy image processing is a stage to convert colposcopy image into edge detection form. The detail from this step can be seen in Figure 2.
3.2.1 Image Enhancement
Image enhancement is a process to convert an image into suitable form than the original image. In this research, we implemented n\textsuperscript{th} Root Power law transformation method. The principal objective of this process is to improve the detail of edge detection. This technique is a spatial transformation that operates directly on pixels. The advantage of spatial-based domain technique is easier to understand and easier to implement in a real-time implementation because the complexity of these methods is low [11].

The n\textsuperscript{th} root power law is defined by equation 1.

\[ G = c \cdot F^\gamma \]  

where:

\( G = \) Image Result, \( F = \) Original Image, \( c = \) Constant, \( \gamma = \) gamma value.

In this research we implemented \( c = 1 \) and gamma value = 0.53. The result of this transformation process becomes input for the next process.

3.2.2 Edge Detection with Canny Operator
There are several processes in determining edge detection by the canny method. The process includes a Gaussian filter, gradient magnitude calculation, non-maximum suppression and determination of thresholding and edge direction. Analysis of Gaussian filter process is to eliminate noise on the image before trying to locate and detect any edges. Gaussian filtering is convolution operation of multiplication of kernel matrix with an original image. This kernel matrix helpful for functions of Gaussian computation. In this study, we implemented 3 x 3 kernel matrix.

\[ G_x = \begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & -1 \end{bmatrix} \]  

The next step is to get the edge strength by taking the gradient of the image. The approximate of edge strength at each point can be calculated with convolution mask of 3 x 3 Sobel operator. One estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows). They are shown below:

\[ G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \]  

The magnitude of the gradient is then approximated using the equation 4:

\[ |G| = |G_x| + |G_y| \]  

Edge direction can be calculated by inverse tangent of \( G_x / G_y \).
The next process is Non-maximum suppression. This stage is used to trace along the edge in the edge direction. This process will eliminate the non-maximum edges into 0

3.2.3 Edge Detection With Isotropic

We implemented Isotropic as one of the gradient operators. Process stages in this operator contain isotropic mask determination, gradient magnitude calculation, and thresholding determination. Isotropic applies the nearer pixels to the corner kernel with value $\sqrt{2}$.

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -\sqrt{2} & 0 & \sqrt{2} \\ -1 & 0 & 1 \end{bmatrix} \quad G_y = \begin{bmatrix} 1 & \sqrt{2} & 1 \\ 0 & 0 & 0 \\ -1 & -\sqrt{2} & -1 \end{bmatrix}$$

The magnitude of the gradient can be calculated with equation 6:

$$G = \sqrt{G_x^2 + G_y^2}$$

3.3 Learning / Training and Cancer Stadium Labeling

Training or learning process is a process of labeling all dataset image with cervical cancer stage. This labeling process involved pathology doctor as an expert in diagnosing the colposcopy image as a reference. The Four stadiums are normal, stage 1, stage 2, stage 3 and stage 4. We provided 15 datasets to the training stage or 3 dataset image reference for each cancer stadium.

3.4 Testing Stage and Cancer Stadium Classification

Testing stage is a stage to determine the cancer stage classification of colposcopy image input. The process of deciding cancer stage classification is done by comparing the similarity image of colposcopy results in the testing stage with the image of the results of the training process. Classification of each colposcopy in a testing stage will follow the classification colposcopy in training stage with has the closest similarity value. In this study, the similarity distance is calculated by using Euclidean distance method. Euclidean Distance has a high accuracy so it is suitable to be used as a method to calculate the similarity or dissimilarity of some images. Euclidean distance from two vector $x$ and $y$ with $n$ training data can be seen in equation 7.

$$d(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

The smaller value of $d(x, y)$ means objects are more similar conversely the bigger value of $d(x, y)$ means objects are more dissimilar.

3.5 Classification Accuracy and Running Time Analysis

Classification Accuracy and running time analysis are processes to measure the accuracy of classification and running time process. In this research we implemented percentage of correct predictions with a formula:

$$\text{Percentage Accuracy} = \frac{\text{Number of Correct Classification}}{\text{Total number of samples}} \times 100\%$$
4. Results and Discussion
The result of stage cancer classification can be seen in Table 1.

| Stage Cancer Classification | Original Image | \( n^{th} \) root power Law Transformation | Canny Operator | Isotropic Operator |
|-----------------------------|----------------|-------------------------------------------|----------------|--------------------|
| Normal Cervix               | ![Normal Cervix](image1) | ![Normal Cervix](image2) | ![Normal Cervix](image3) | ![Normal Cervix](image4) |
| Cervical Cancer Stage 1     | ![Cervical Cancer Stage 1](image1) | ![Cervical Cancer Stage 1](image2) | ![Cervical Cancer Stage 1](image3) | ![Cervical Cancer Stage 1](image4) |
| Cervical Cancer Stage 2     | ![Cervical Cancer Stage 2](image1) | ![Cervical Cancer Stage 2](image2) | ![Cervical Cancer Stage 2](image3) | ![Cervical Cancer Stage 2](image4) |
| Cervical Cancer Stage 3     | ![Cervical Cancer Stage 3](image1) | ![Cervical Cancer Stage 3](image2) | ![Cervical Cancer Stage 3](image3) | ![Cervical Cancer Stage 3](image4) |
| Cervical Cancer Stage 4     | ![Cervical Cancer Stage 4](image1) | ![Cervical Cancer Stage 4](image2) | ![Cervical Cancer Stage 4](image3) | ![Cervical Cancer Stage 4](image4) |

Based on Table 1, the result of edge detection with Canny operator generates better result compared to Isotropic Operator. With Canny operator, the cancer lesions are brighter and sharper.

Running Time of Canny and Isotropic process time (in millisecond) can be seen in Table 2

| Cervix Stage | Canny | Isotropic |
|--------------|-------|-----------|
| Normal       | 0.3744006 | 1.2168022 |
| Stage 1      | 0.3588006 | 1.2012021 |
| Stage 2      | 0.3432006 | 1.2948022 |
| Stage 3      | 0.3588006 | 2.0124035 |
| Stage 4      | 0.3744006 | 1.7316031 |

According to running time process, the Canny operator has better time efficiency comparing to the Isotropic operator. The accuracy of stage cancer classification from this research can be seen in Table 3.
Table 3. Classification Stage Cancer Accuracy.

| No | ID Colposcopy Image | Classification Accuracy |
|----|---------------------|-------------------------|
| 1  | Image 1             | Accurate                |
| 2  | Image 2             | Accurate                |
| 3  | Image 3             | Accurate                |
| 4  | Image 4             | Accurate                |
| 5  | Image 5             | Not Accurate            |
| 6  | Image 6             | Accurate                |
| 7  | Image 7             | Accurate                |
| 8  | Image 8             | Accurate                |
| 9  | Image 9             | Not Accurate            |
| 10 | Image 10            | Accurate                |
| 11 | Image 11            | Not Accurate            |
| 12 | Image 12            | Accurate                |
| 13 | Image 13            | Accurate                |
| 14 | Image 14            | Accurate                |
| 15 | Image 15            | Accurate                |

Based on this result, we can calculated percentage accuracy of this classification is 80%.

5. Conclusion

In this study, we wanted to prove that by only implementing the identification of edge detection in the colposcopy image, identification of cervical cancer can be determined. In this research, we implemented and compared two edge detection algorithms which are Canny and Isotropic operator. The Canny algorithm is an optimal edge detection that already applied noise reduction in its step, in this study, we implement 3 x 3 kernel matrix. On the other hand, Isotropic is one of gradient edge detection with more straightforward action. The methodology of this research is image pre-processing, training and testing stage. The pre-processing step is image enhancement or the process to improve the detail of edge detection. In this research, we implemented n\textsuperscript{th} Root Power law transformation method with Constant\textsuperscript{a} = 1 and gamma value = 0.53. Training or learning process is a process of labelling all dataset image with cervical cancer stage. In this study, this labelling process involved pathology doctor as an expert in diagnosing the colposcopy image as a reference. We provided 15 datasets to the training stage or 3 dataset image reference for each cancer stadium. Testing stage is a stage to determine the cancer stage classification of colposcopy image input. The process of deciding cancer stage classification is done by comparing the similarity image of colposcopy results in the testing stage with the image of the results of the training process. In this study, the similarity distance is calculated by using Euclidean distance method. We use 15 colposcopy images for testing step. The result of edge detection with Canny operator generates better result compared to Isotropic Operator. With Canny operator, the cancer lesions are clearer and sharper. Furthermore, the Canny operator has better time efficiency comparing to the Isotropic operator. Average running time for Canny operator implementation is 0.3619206 ms while Isotropic get 1.49136262 ms. The result showed that Canny operator is better than isotropic operator because Canny operator generates a clearer edge with a fast time instead. The percentage accuracy of cancer stage stadium with this experiment reach 80% for both methods.

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