Comparative analysis of edge detection methods on beaker glass

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Abstract. Digital image processing in the form of edge detection using the Sobel, Robert, Prewitt, Canny, and LoG algorithms, in addition to the binarization algorithm, can determine the edges of an object so that it is expected to improve accuracy. In this study, edge detection analysis will be performed on RGB (Red, Green, Blue) images from image capture using a Digital Single-lens Reflex Camera (DSLR) camera. Image processing of the DSLR image uses algorithm design that is made systematically, structured, and neat so that the results of the program can be strived to run following what is expected.

1. Introduction
Graduated beakers, beakers, Erlenmeyer flasks, dropping funnel, and other the glassware like are not volumetric instruments. They are not precisely calibrated, and the scale serves only as an approximate guide. Calibration of glassware is commonly using a liquid of known, specific density, and an analytical balance.

Image is a picture, similarity, or imitation of an object. The image is divided into two, namely analogue and digital images. Analogue images are continuous images such as images on television monitors, X-rays, CT scan results, whereas digital images are images that can be processed by computers [1]. The image processing using computers has two objectives: first, create more suitable images in observing and identifying, and second, automatically, the computer can recognise and understand images [2]. An image may be considered to contain sub-images, sometimes referred to as Region of Interest (ROI) or only regions. In a revolutionary image processing system, it should be possible to apply specific image processing operations to selected regions [3].

The object contours play a crucial role in human vision, and their composition presents some meaningful concepts, so people can effectively and widely identify various objects [4]. Edge detection is the primary method used to recognise the contour of objects. It is the process of classifying and placing sharp discontinuities of an image. Three different types of discontinuities in the grey level are point, line, and edges [5]. The edge detection algorithm consists of a sequence of steps to get a digital image, calculate intensity, highlight the border of regions [6]. The most common edge detection techniques are Roberts, Sobel, Prewitt, Kirsh, Robinson, Marr-Hildreth, LoG, and Canny edge detection.

The recognition plays an essential role in analysing properties such as liquid-level and volume of transparent containers made by glass. Glassware is quickly inspected using computer vision because there are no patterns, monochrome, and transparency [7]. Recognition of the liquid level based on the combination of computer vision with external additives, which are easily identified in the image. Edge
detection of the liquid level is perhaps the most efficient nonadditive computer vision approach when dealing with transparent fluids [8]. The edge image or intensity gradient is used for the approach to identify the liquid line in the image.

The observed shape of the ellipse depends on the angle of view. If the line of sight is the exact height of the surface, it will appear as a straight line (Figure 1.a). A full circle appearance of the liquid surface if the vessel is viewed directly from above (Figure 1.c). Mostly, the identification of the liquid level in transparent containers performed from the side (Figure 1.b). The subtract between empty glassware, and filled glassware could be analysed of its pixel to recognise the meniscus of volumetric glassware.

Numerous researchers designed useful edge operators and their evaluation. In the year of 2009, Pithadiya et al. compared a few optimal edge detections to inspect the over and underfill liquid level of a bottle in the bottle. The results of different optimal edge detection algorithms such as Marr-Hilderth, LoG, Canny, and Shen Castan algorithm were much better than Sobel and Kirsch operators [9].

In 2011, Muthukrishnan and Radha attempted to study the performance of edge detection techniques for image segmentation, and also, the comparison of these techniques is carried out with an experiment by using MATLAB software. Their study resulted in Marr-Hilderth, LoG, and Canny edge detectors produce almost the same edge map. Since different edge detections work better under different conditions, Canny is a superior one when compared to all for a selected image [5].

In 2015, Şaban Öztürk and Bayram Akdemir proposed Roberts, Prewitt, Sobel, LoG, and Canny edge detection algorithm method to improve the production of glass. Glass is a difficult material to examine with cameras due to its reflection and the transparency features. The study showed that the LoG edge detection algorithm is better than other edge detection algorithms in determining texture analysis [10]. Idowu et al., in 2015, applied a Sobel filter to obtain a binary image to extract the level gradient, and ellipsoidal fitting helps to estimate the size of the cup. The images are processed in MATLAB. They attempted to infer volumetric measurements using a camera on a conically shaped glass. Through these methods, fluid non-adherence can be better estimated [11].

In this paper, it developed a popular edge detection algorithm such as Sobel, Roberts, Prewitt, Canny, and LoG algorithm to identify a specific liquid level of Beaker glass through GUI MATLAB. They can operate in a shorter time and simpler algorithms. MATLAB is a high-level language in computations that combines calculation, apparition, and programming. The problems and solutions are uttered in recognisable mathematical details [12]. Applying an edge detector to the image obtained may filter out information that may be regarded as less relevant while preserving the important structural properties of an image. The goal of the project is that various edge detectors can
be analysed by using these popular algorithms. We tested five detectors for detecting edges of the glass and liquid inside the glass and compared their results, which detector works better. The data could then be the initial study to calibrate the beaker glass using image processing.

2. Research Method

Beaker glass image capture using a DSLR camera with a specified distance, the background color is different from the color of the beaker glass. Then apply edge detection using the MATLAB GUI to retrieve the edges of the object. Beaker glass image in JPG format with modes (Red, Green, Blue) are converted to grayscale mode to facilitate the process of processing images at a later stage. Edge detection in grayscale images using operators Robert, Sobel, Prewitt, Canny, and LoG. Following are the steps of the operators' algorithm:

```matlab
% --- Executes on button press in btnBrowse.
function btnBrowse_Callback(hObject, eventdata, handles)
% hObject handle to btnBrowse (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
[nama, alamat] = uigetfile(['*.jpg'; '*.bmp'; '*.png'; '*.tif'; '*.png'], 'Pilih Gambar');
img = imread([alamat, nama]);
handles.image = img;
guidata(hObject, handles);
axes(handles.axes1);
imshow(img);
axes(handles.axes2);
imshow(img);

% --- Executes on button press in btnRobert.
function btnRobert_Callback(hObject, eventdata, handles)
% hObject handle to btnRobert (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
citra = handles.image;
citraGray = rgb2gray(citra);
citraRobert = edge(citraGray, 'roberts');
axes(handles.axes2);
imshow(citraRobert);

% --- Executes on button press in btnSobel.
function btnSobel_Callback(hObject, eventdata, handles)
% hObject handle to btnSobel (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
citra = handles.image;
citraGray = rgb2gray(citra);
citraSobel = edge(citraGray, 'sobel');
axes(handles.axes2);
imshow(citraSobel);

% --- Executes on button press in btnPrewit.
function btnPrewit_Callback(hObject, eventdata, handles)
% hObject handle to btnPrewit (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
```
The image segmentation display is shown in Figure 2. Image processing begins with transforming the RGB image into grayscale and binary image.

Figure 2. Image segmentation program
3. Results and Discussion
The segmentation image is displayed in Figure 3. The simulated image is the image of a beaker glass filled with coloured aquades. Image output shows that all of the edge detection methods used cannot show the outline of the image.

![Segmentation Image]

Figure 3. The segmentation image

The Roberts image is close to Sobel one, but it made the degraded of the edge of the pixel quality due to much jerky effect on the edges. The Sobel operator had a larger convolution kernel, which
smooths the input image to a greater extent, so makes the operator less sensitive to noise [13]. Nevertheless, for locating intricate edges, a Sobel operator is not accurate [14].

The performance of the Sobel is relatively similar to Prewitt’s. Sobel and Prewitt are still not able to provide better results because of the poor quality of the beaker glass image, which makes it so difficult to detect the edges of the glass and liquid.

As compared to the other operator, the Canny operator detected that the edges of the object image in Figure 8 are more clearly without any discontinuity. Satbir Kaur and Ishpreet Singh have studied a comparison between edge detection techniques. The features in the image can be extracted without disturbing its features by using the Canny operator [15]. The only disadvantage of Canny is that it needs more time than Sobel [16].

The Robert, Sobel, Prewitt, and LoG operator is less sensitive to noise. The LoG is a great extent in removing noise as differentiates twice if it compares to Canny. However, the Canny one provides edge gradient orientation, while the LoG operator is unable to find edge orientation while. So that, the Canny one provides edge gradient orientation. Li Bin and Mehdi Samiei Yeganeh proposed that the LoG operator is rarely directly used for edge detection because it often produces the edge of twice pixels wide [17]. Overall, image output shows that all of the edge detection methods used cannot show the outer lines of the aquades. So, it cannot be used to compare calculations in terms of calculation and image segmentation.

4. Conclusions
In this study, the various edge detection algorithm for image segmentation was applied to beaker glass image taken by DSLR. The performance of these algorithm used GUI MATLAB. It works well and results that Canny and LoG algorithm almost similar, while Roberts is much closer to Sobel and Prewitt. As compared to the other operator, LoG us better for optimal performance. Overall, image output shows that all of the edge detection methods used cannot show the outer lines of the aquades. So, it cannot be used to compare calculations in terms of calculation and image segmentation.

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