# EDGE DETECTION IN FICUS CARICA TREE IMAGES USING FUZZY LOGIC

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**Abstract**
Edge detection is an essential part of image processing, computer and machine vision. Numerous edge detection methods have been developed in the last years that can be summarized into two basic categories: gradient based and zero-crossing. All classical operators identify a pixel as a particular class by carrying out some series of operations within a mask centered on the pixel under observation. Recent researches have concentrated on the most accurate classification methods that include fuzzy logic, artificial neural networks, etc. This study shows how to detect edges in ficuscarica tree images based on fuzzy set theory. The fuzzy logic for edge detection using membership functions define the degree to which a pixel belongs to an edge or uniform region. The results are compared to classical operators. The proposed fuzzy image-processing algorithm has shown greater accuracy compared to other edge detection techniques, and avoids obtaining double edges.

**Key words:** fuzzy logic, edge detection, image processing, ficuscarica tree.

## INTRODUCTION

Edge detection is an essential part of image processing, computer and machine vision. Edges are changes in intensity values of neighboring pixels in an image that occur on the boundary between different regions (MAINI AND AGGARWAL, 2009). If an image is composed of objects and contrasting background, an edge is a transition from background to object or vice versa (GOSE ET AL., 1996).

Many edge detection methods have been developed in the last years and can be summarized into two basic categories: gradient based and zero-crossing. The gradient based methods detect edges by computing the maximum and minimum in the first derivative expression of an image. The zero-crossing methods search for zero crossings in the second derivative computed from the image. This is the basis for the gradient and zero-crossing edge detectors used to locate sharp changes in the intensity functions (SONKA ET AL., 1993). Here we will discuss some commonly used edge detectors. One of the early edge operators is the Roberts operator. It uses two 2x2 masks to compute the gradient across the edge in two diagonal directions. The disadvantage of the Roberts operator is its high sensitivity to noise. The Sobel operator is a discrete differential operator that utilizes two 3x3 masks, the first one estimates the gradient in the x-direction while the other estimates the gradient in the y-direction. It is less sensitive to noise but its smoothing affects the accuracy of edge detection. The Prewitt operator, similarly to the Sobel operator, uses the same equations except the constant, which is equal to 1 (HARALICK AND SHAPIRO, 1992).

The Laplacian operator searches for zero crossing in the second derivative of the image to find edges. As a second derivative, the Laplacian is unacceptably sensitive to noise. Its magnitude produces double edges and it is unable to detect the edge direction (GONZALEZ AND WOODS, 1992). Therefore an operator that combines both smoothing and differentiating in the same operator is desirable. This could be done in separate steps. Firstly, it may smooth an image with a binomial operator in order to reduce the noise, and then a discrete Laplacian operator can be applied to this smoothing image so as to detect the edges. A combination consisting of a Gaussian operator followed by a discrete Laplacian operator is called Laplacian of Gaussian operator (LOG operator) (SOLOMON AND BRECKON, 2010).

The Canny edge detector is an operator that can be implemented in the following steps: smooth image with a Gaussian filter, compute the gradient magnitude using partial derivative, remove pixels that are not part of an edge by applying non-maxima suppression to the gradient magnitude, and detect edges by double thresholding (CANNY, 1986). The Canny edge detector is generally acknowledged as the best edge detection method developed to date.

All the above classical operators identify a pixel as a particular class by carrying out a series of operations within a mask centered on the pixel under observation. The classic operators work well in circumstances where the area of the image is in high contrast. However, classic edge detectors tend to give poor results for labeling edge pixels, when an edge represents a small grayscale jump (ALSHENNAWY AND ALY, 2009).

Recent research projects have concentrated to the most accurate classification methods that include fuzzy logic, artificial neural networks, support vector machines, etc. Image information is a very complex process, so fuzzy set theory used in image analysis can give us better effect compared to other computing methods (HU AND TIAN, 2006). Fuzzy image processing has three main steps: image fuzzification, modification of membership values, and if necessary, image defuzzification. The fuzzification (coding of image data) and defuzzification (decoding of results) are steps that make it possible to process images with fuzzy techniques. The main power of fuzzy image processing is in the middle step (modification of membership values) (MONDAL ET AL., 2012). LIU ET AL. (2016) describe a fuzzy inference engine for detecting image edges. Some membership functions (Gaussian and triangle) were used for designing the fuzzy inference system. By applying fuzzification and defuzzification, the relationship between input and output values was identified.

This paper shows how to detect edges in ficuscarica tree images based on fuzzy set theory. It has created a fuzzy inference engine to detect image edges. On the inference engine step, two Gaussian membership functions in two directions (horizontal and vertical) are used for input signals. Triangular membership functions, white and black, are used for the defuzzification step. Finally, the results are compared to classical operators.

## MATERIALS AND METHODS

Ficuscarica tree images were acquired in plantation at MarkopouloMesogaias (Attiki, Greece). For image acquisition, a digital camera (Canon Power Shot SX530 HS) was used. The digital camera was mounted on a tripod to maintain stability. Images were acquired during the daytime from August to September for a total of 250 images. Two of the original images are shown in Fig. 1.

Fuzzy logic image processing was performed in the MATLAB environment (Mathworks, MA, USA). The developed algorithm includes the below steps: a) The original RGB images converted in gray scale for fuzzy analysis, b) The image gradients calculated along the horizontal (x-axis) and vertical (y-axis) directions, c) A fuzzy inference system created for edge detection, d) The image gradients ($I_x$ and $I_y$) specified as inputs of edge of fuzzy inference system, e) The intensity of edge detected image specified as an output of edge of fuzzy inference system, f) The rules for fuzzy inference system specified to make a pixel black or white, and g) The fuzzy inference system was evaluated.

**Fig. 1. –** Ficus Carica tree original images

The fuzzy logic for edge detection allows the use of membership functions to define the degree to which a pixel belongs to an edge or uniform region. A zero-mean Gaussian membership function is specified for each input of the designed edge fuzzy inference system (Fig. 2). If the gradient value for a pixel is '0' then it belongs to the zero membership function with a degree of 1. Standard deviations for the zero membership can be changed to adjust the performance of the edge detector. Increasing the values makes the algorithm less sensitive to edges in the image and decreases the intensity of detected edges (SUDHAVANI ET AL., 2014). Triangular membership functions, 'white' and 'black' are specified for the output of edge of the fuzzy inference system. Membership function plot for outputs of edge of the fuzzy inference system is shown in Fig. 3.

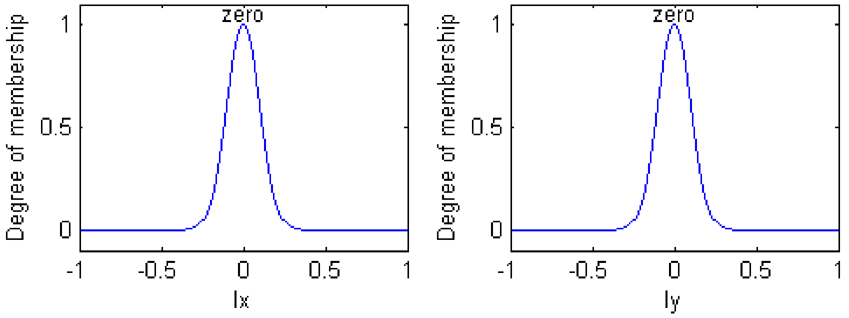



**Fig. 2.** – Gaussian membership functions in horizontal and vertical directions

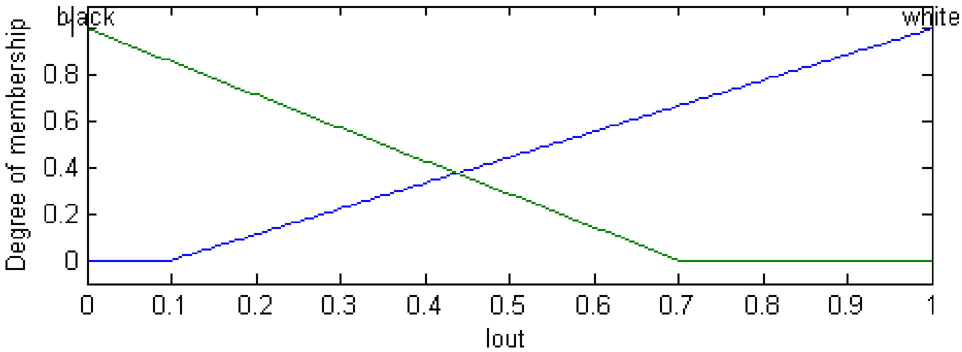



**Fig. 3.** – Output membership functions

The edges are detected using fuzzy inference system, by comparing the gradient of every pixel in horizontal and vertical directions. If the gradient for a pixel is not zero then the pixel belongs to an edge (black). The gradient is defined as zero using Gaussian membership functions for fuzzy inference system inputs. The edge detector performance is adjusted by changing the values of triangular membership functions in 'white' and 'black'. The triplets specify the start, peak, and end of the triangles of the membership functions. These parameters influence the intensity of the detected edges.

## RESULTS AND DISCUSSION

In this study, a simple fuzzy inference system is tested which has two fuzzy sets with Gaussian membership function for each input fuzzy variable and two fuzzy sets with triangular shape membership function as 'white' and 'black' for the output fuzzy variable while two fuzzy rules were simultaneously defined for it. Then according to the described fuzzy inference system, the edges of two ficuscarica tree images were detected.Fig. 4 shows the experiment results of the proposed edge detection algorithm. The input RGB original image converted in gray scale in Matlab (Fig. 4a) for fuzzy analysis. After specifying the image gradient along the horizontal (x-axis) and vertical (y-axis) directions, the fuzzy logic edge detection algorithm relied on the image gradient to find breaks in uniform regions. The outputs of the fuzzy inference system are shown in Fig. 4b and 4c. The fuzzy inference system allows edges to be detected even in the low contrast regions as shown in Fig. 4d. This is due to the different treatment given by the fuzzy rules to the regions with different contrast levels.

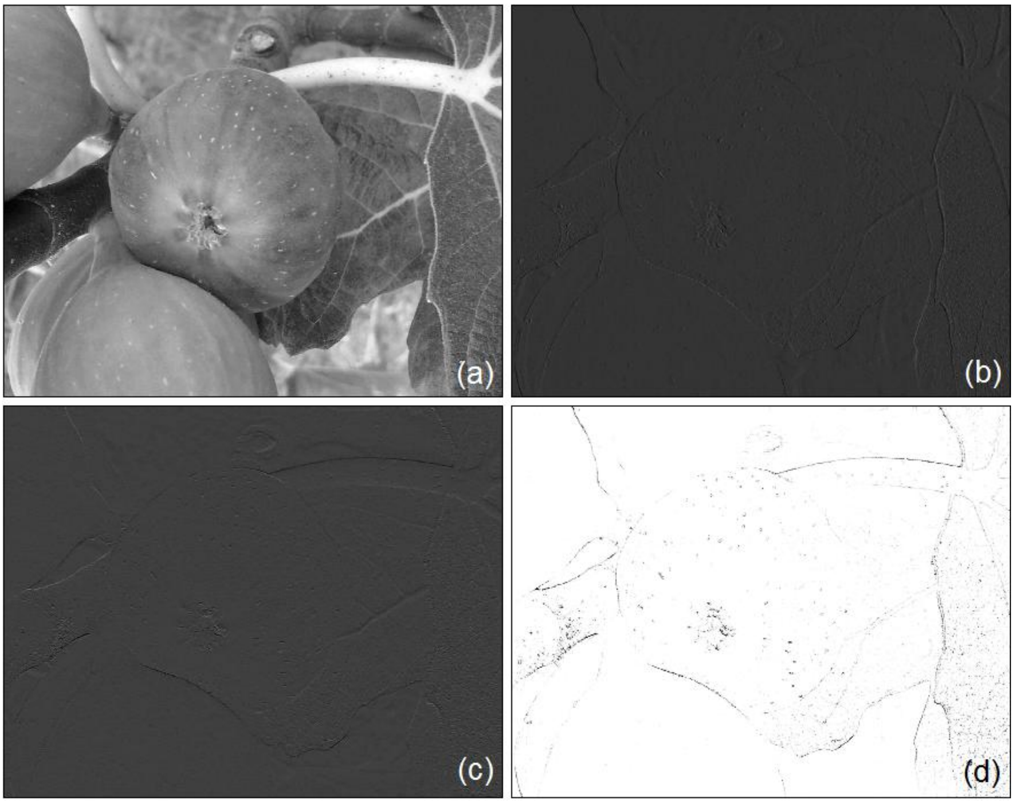
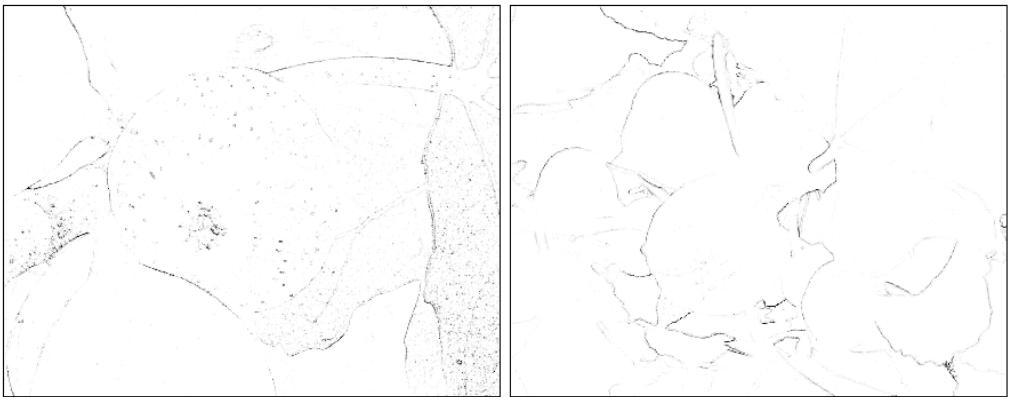
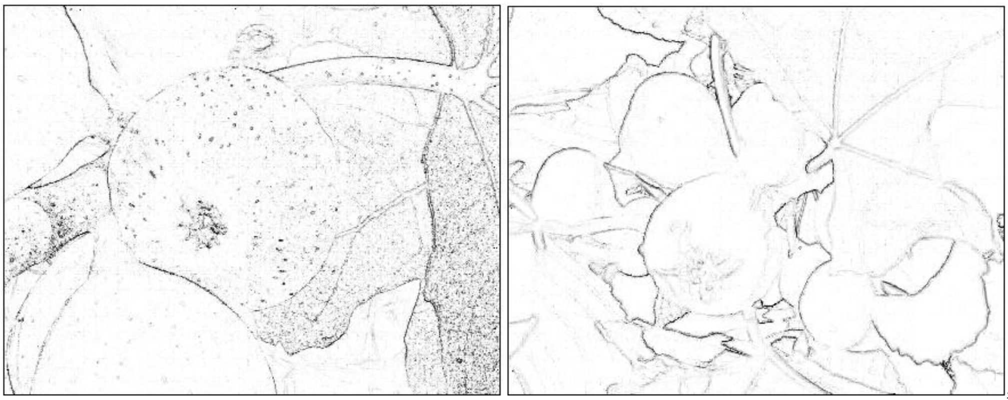



**Fig. 4.** – Proposed edge detection algorithm: a) Input grayscale image, b) Image gradient along horizontal direction, c) Image gradient along vertical direction, and d) Edge detected using fuzzy logic

The proposed fuzzy algorithm for image edge detection was tested for different values from the start, peak and end of the triangles of the membership functions. These values influence the intensity of the detected edges. The resulting images shown below in Fig. 5a and 5b compare the proposed fuzzy edge detection algorithm with triangular membership functions, white and black, for $I_{out}$: $w_a$=0.1; $w_b$=1; $w_c$=1; $b_a$=0; $b_b$=0; $b_c$=0.7 and $w_a$=0.6; $w_b$=1; $w_c$=1; $b_a$=0; $b_b$=0; $b_c$=0.99, respectively. It was observed that the output that has been generated by the $I_{out}$: $w_a$=0.6; $w_b$=1; $w_c$=1; $b_a$=0; $b_b$=0; $b_c$=0.99 has found out the edges of the image more distinctly as compared to the ones that have been found out by the $I_{out}$: $w_a$=0.1; $w_b$=1; $w_c$=1; $b_a$=0; $b_b$=0; $b_c$=0.7. In addition, it was tested for different standard deviations ($s_x$ and $s_y$) for the zero membership functions for the image gradients (Ix and Iy) inputs. These values adjust the edge detector performance. The resulting images shown below in Fig. 5a and 5c compare the proposed fuzzy edge detection algorithm with standard deviations $s_x$=$s_y$=0.1 and $s_x$=$s_y$=0.01, respectively. It was observed that the output that has been generated by the standard deviation $s_x$=$s_y$=0.01 has found out the edges of the image more darkly as compared to the ones that have been found out by the standard deviation with $s_x$ =$s_y$=0.1.



(a)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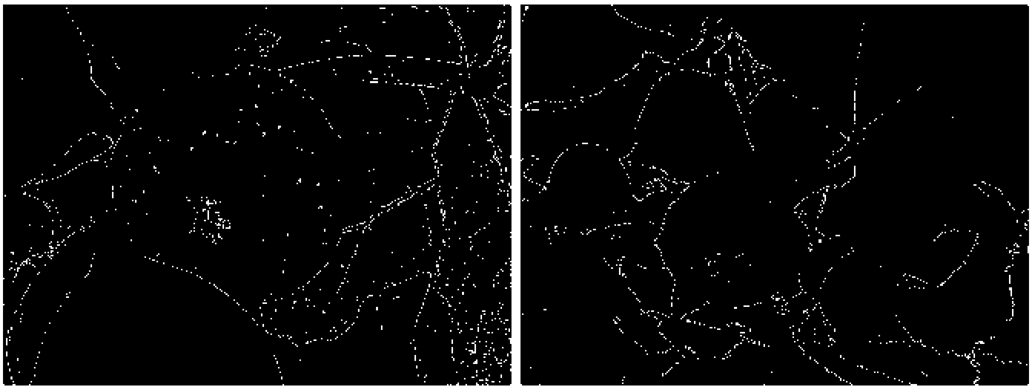
(b)

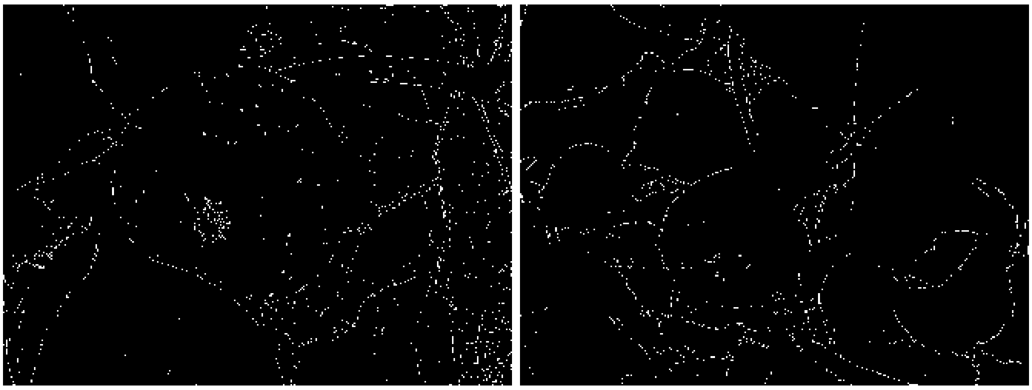
(c)

**Fig. 5.** – Resulting images of the proposed edge detected algorithm

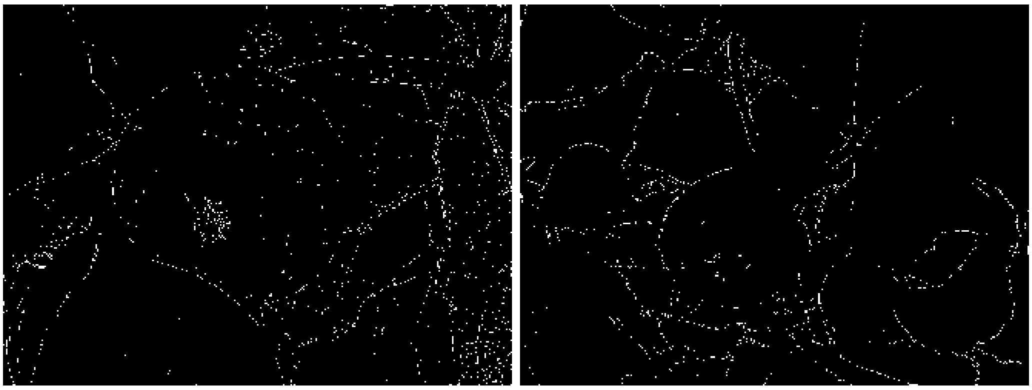
The classical edge detection techniques (Roberts, Prewitt, Sobel, LOG, and Canny edge operators) of ficuscarica trees images are described in detail and tested on the article GRAVALOS (2013). As shown in Fig. 6, the resulting images of the proposed edge detected algorithm are compared with the existing classical edge operators.



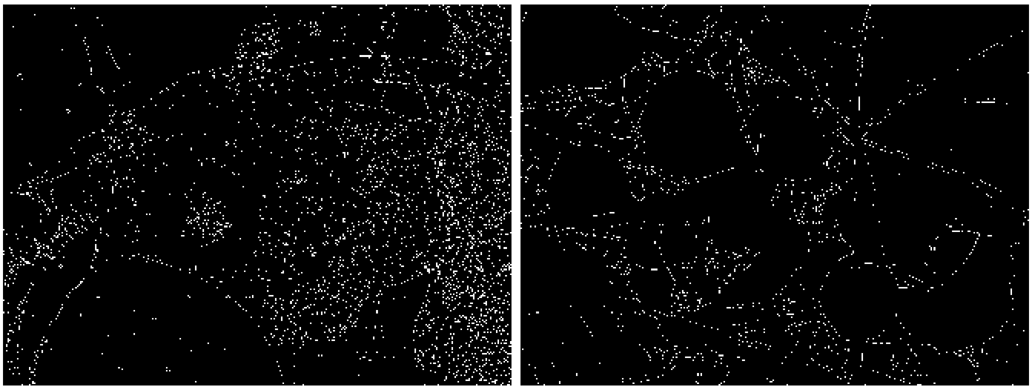
(a)



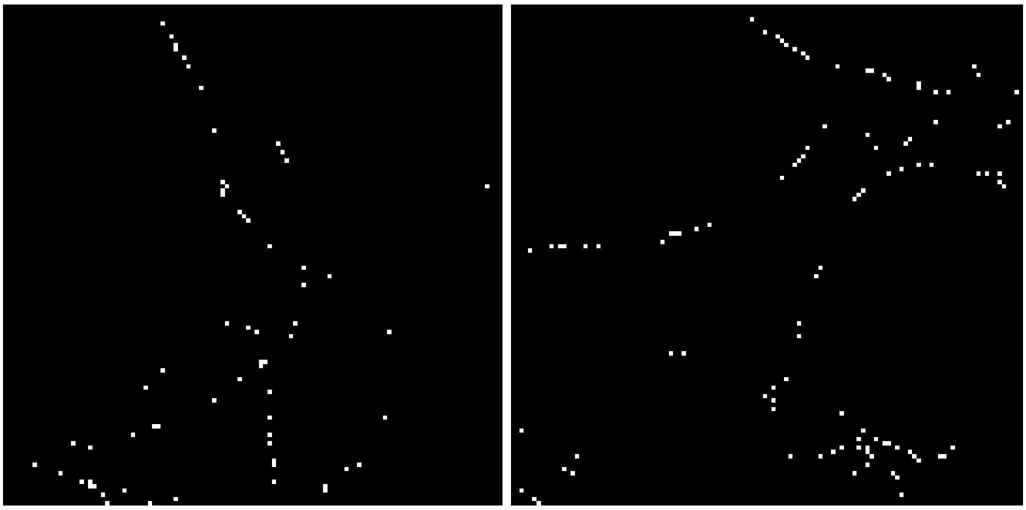
(b



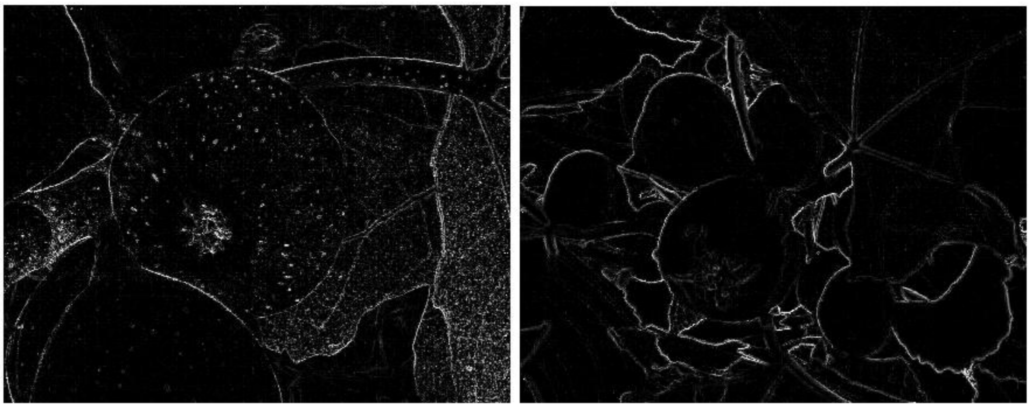
(c)



(d)



(e)



(f)

**Fig. 6.** – Resulting images: a) Edge detected using Roberts operator, b) Edge detected using Prewitt operator, c) Edge detected using Sobel operator, d) Edge detected using Laplacian of Gaussian (LOG) operator, e) Edge detected using Canny operator, and f) Edge detected using fuzzy logic

It is shown that the proposed fuzzy image processing algorithm improves the quality of edges as compared to Roberts, Prewitt, Sobel, LOG and Canny operators. It is observed that the output images that were generated by the fuzzy image processing algorithm has found out the edges of the images more distinctly as compared to the images that were found out by the classic edge detection operators. Therefore, the fuzzy rule based on the algorithm provides better edge detection and has a comprehensive set of fuzzy conditions, which helps to extract the edges with very high efficiency. This algorithm is suitable for applications in the area of digital image processing for agricultural imaging, where specific boundaries need to be specified for further image analysis.

## CONCLUSIONS

The results allow us to conclude that: The proposed fuzzy image processing algorithm is an attractive solution to improve the quality of edges as much as possible. It shows greater accuracy compared to the other edge detection techniques (Roberts, Prewitt, Sobel, LOG, and Canny edge operators) avoiding double edges. This algorithm has the potential to be applied in various areas of digital image processing.

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