Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 195 (2015) 2675 – 2682

Procedia
Social and Behavioral Sciences

World Conference on Technology, Innovation and Entrepreneurship

Comparison of Edge Detection Algorithms for Texture Analysis on Glass Production

Şaban Öztürk[a*], Bayram Akdemir[a]

[a]*Department of Electrical and Electronics Engineering, Selcuk University, Konya, Turkey*

Abstract

The use of technological innovations in production will increase the number of product and quality. With proposed method in this paper, it is aimed to improve the production process of glass which used almost every field. In this study, some of the popular edge detection algorithms (Roberts, Prewitt, Sobel, LoG and Canny) are used for the texture analysis process. It is aimed to determine glass surface defect with the applied of mentioned edge detection operators to same image. The results obtained from application are compared with the reference image and texture analysis performance of edge detection algorithms are evaluated. In this study the used material is glass and it is aimed to determine the glass surface defect such as scratch, crack and bubble with the use of edge detection operators. Glass is a difficult material to examine with cameras because glass has reflection and the transparency features. So, some improvement are applied in the image before edge detection algorithms are applied. Performed controlled experiments showed that LoG edge detection algorithm is better than other edge detection algorithms in determining texture analysis.

Peer-review under responsibility of Istanbul Univeristy.

Keywords: edge detection algorithms, image processing, texture analysis, defect detection, glass production

1. Introduction

Increasing economic opportunities and improving technology has led to the increase of urbanization and this situation has increased the rate of consumption. Some materials in the process of consumption are more demanded

* * Corresponding author. Tel.: +90-506-570-2451; fax: +90-332-241-0635.
E-mail address: sabanozturk@selcuk.edu.tr

Peer-review under responsibility of Istanbul Univeristy.
doi:10.1016/j.sbspro.2015.06.477

by consumers. These are substances which have been used in multiple fields. One of these mentioned materials is glass which can be used many fields such as kitchen, bathroom, bottling, construction, personal care etc. Production rate has increased considerably to meet the demand of growing consumption. This leads to the fall of the quality of products in spite of increase the number of products. Previously, human eye was able to catch up production defects and quality-control operations are performed by humans, but the human eye has become inadequate with the increasing speed (Vernon, 1991). To do so, computer vision systems that are more advantageous than human eye in many cases have been used. Some advantages of computer vision systems include; it can be made faster measurement and saves time, it can product control tirelessly for a long time, it is not exceed certain error tolerance, it can operate dangerous areas etc. Machine vision systems which have recently become widely provide economic advantages especially considering production quality and speed.

Defect analysis on the glass surface has some familiar defect types which are often encountered. These defect types; various scratches, bubbles formed in the glass, glass cracks and glass fractures. To be detected of these defects by the computer, first of all images should be taken with the help of camera. Images captured by the camera may not need to be apply pre-processing sometimes. But in this study, a number of pre-processing algorithms should be used before examined the characteristics of image. For this reason, glass has reflection and transparency features. These features lead to difficulties to take image of the camera. So background objects and noises must be removed from the glass image. And reflection objects from the glass surface must be removed, too.

Edge detection algorithms are of fundamental importance for image processing applications because it's simply can determine within a short time the boundaries of objects in the image. Edge detection process as simple as can be explained in the following way; the intensity values of pixels which are neighbor each other are compared. During this process, the remarkable changes of density is called edge regions. If image has noises, it should be well cleaned. Because noise affects the change of density in the image and it reduces the success rate for edge detection algorithms. To overcome noise problem, many studies were made for years and many different edge detection algorithms has emerged. With continuous development, edge detection algorithms have been used many areas thanks to the capability be able to simply use in short time and success rates increasing day to day. Areas of use; visual inspection part of automation systems (Hocenski, Vasilic & Hocenski, 2006),(Ersoy, 1987), identification of object boundaries by selecting the feature remotely sensed images (Ali & Clausi, 2001),(Zhang, Qiu, Yu & Xu 2015), the use of facial recognition (Lee, Cham & Chen, 2002),(Zhang, Tjondronegoro & Chandran 2014), feature extraction from images taken by satellite (Pirzada & Siddiqui, 2013),(Mostert & Kriegler, 2005), extraction the characteristics of medical images (Bao & Sheng, 2013), etc.

This study is carried out glass texture analysis using some popular edge detection algorithms. Reason for using edge detection algorithms that they can operate in a shorter time and more simple than other algorithms. Also, when considering the characteristics of defect that can occur on the glass surface is understood that these defect characteristics are very similar to working principle of edge detection algorithms. Simple explanation of this situation; defects which occur on the glass generally disrupt the homogenous structure of the glass and fort his reason density gradient occur in these regions of the glass. So the use of edge detection algorithms is considered to be very convenient for glass texture analysis and the experiments were performed on a few glass using them. Tested algorithms are Sobel, Roberts, Prewitt, Canny and LoG edge detection algorithms which are still maintains its popularity today. The performance of these algorithms are compared by applying the same images and results are reviewed.

Rest of this paper is organized as follow; Section 2 is mentioned methods used in this study, Section 3 is explained the performing experiment and experimental results, Section 4 is focused on conclusion.

2. Edge Detection Algorithms for Glass Surface Inspection

To understand the working principle of the edge detection algorithms, firstly we should know what the edge is. Edge that is very important feature for image processing applications provides boundaries information of objects in the image and location information. Image and every object in the image has own uniform density value. Points which changes this density value can be referred to as edge. On the basis of the mentioned definition of the edge, we can conclude that the edge detection algorithms works density difference in the image (Swargha & Rodrigues, 2012). Although there are many different edge detection algorithm and these algorithms work in different ways to get better results, their basic function is to calculate density value of each pixel and is to check remarkable density change among the neighbor pixels. In order to detect edges more easily, the images generally are converted to gray level. Each pixel of gray level images has a value between 0-255 according to density value own.

In edge detection process, noise of the image and image features have a significant impact on results. To reduce these effects, a variety of edge detection algorithms are used. In this study, gradient based and Laplacian based algorithms are investigated. The gradient based edge detection are trying to make maximum and minimum points by taking first derivative in the image. Pixels which have high gradient value are considered edge regions. In Laplacian based edge detection operators are taken second derivative of the image and try to have zero-crossing points. It is a good method to determine the sharp edge transition in image, but it is significantly affected by the noise. So the image is softening before edge detection process.

Roberts Operator;

Robert edge detection operator (Roberts, 1963) has a fast and simple structure. It has 2x2 convolution kernels and as shown in figure 1 these two convolution kernels is rotated 90° to each other.

1	0
0	-1

0	1
-1	0

Figure 1. Robert Kernels

The kernels as seen is Figure 1 are applied to sequence on the image and then edge images are obtained by sum of calculated two results.

Sobel Operator;

It has two pieces and 3x3 kernels as shown in figure 2. These kernel maps is rotated 90° each other and are applied image with the convolution. Sobel operator (Sobel, 1970) is gradient based edge detection algorithms. Therefore it use maximum points during the edge detection process.

1	2	1
0	0	0
-1	-2	-1

-1	0	1
-2	0	2
-1	0	1

Figure 2. Sobel Kernels

Prewitt Operator;

Prewitt operator (Prewitt, 1970) shows many similarities with the property of Sobel operator. It has two pieces kernels and these size is 3x3 as shown in Figure 3. It is gradient based edge detection operator and it has gradient features. Compared to the success of edge detection in complex image, success of Prewitt operator is greater than Roberts's operator.

-1	0	1	-1	-1	-1
-1	0	1	0	0	0
-1	0	1	1	1	1

Figure 3. Prewitt Kernels

Laplacian of Gaussian;

Laplacian of an image reveals that fast changing points of density in the image. Because of this property, it can used edge detection. LoG filter (Maini & Aggarval, 2009) take second derivative in the image and try to find zero-crossing points. Since the second derivative of the image is used, this filter is very sensitive to noise. To overcome this problem, firstly the noise should be reduced by applying Gaussian smooth filter. And then Laplacian filter must be implemented to image.

Laplacian pixel density value is calculated as shown in Equation 1.

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} \tag{1}$$

Commonly used 3x3 kernels to the LoG filter which is very successful in image processing applications that has less noise level shown in Figure 4.

1	1	1	-1	2	-1
1	-8	1	2	-4	2
1	1	1	-1	2	-1

Figure 4. LoG Kernels

Canny Operator;

Canny edge detection algorithm (Canny, 1986) known as optimal edge detection algorithm and the most commonly used edge detection algorithm in practice. Canny has worked to improve edge detection algorithms that used popularly in those days by specifying a number of criteria. As a result of this work, Canny found that canny edge detection algorithm. The most important of criteria which are selected by Canny is to catch the low error rate. Another important criterion is that the location of identified edges should be correct.

Canny edge detection algorithm is composed of a few simple steps. First step of this algorithm is to clean noise in the image. Because noise can cause errors in the determination of boundaries of objects in the image. In the next step, two-dimensional derivative (Gx, Gy) of the image intensity is taken using an edge detection operator like

Sobel, Prewitt. And then, gradient of the image is calculated with the help of these results (Gx, Gy). Figure 5 shows a 3x3 kernel pair which can be used for canny algorithms.

-1	0	1	1	2	1
-2	0	2	0	0	0
-1	0	1	-1	-2	-1

Gx Gy

Figure 5. Kernels for Value of Canny Gradient

Equation 2 given the formula used to calculate the density of gradient.

$$|G|=|Gx|+|Gy| \quad (2)$$

In the next step, the direction of edge regions is determined by looking at x and y directions of calculated gradient. And the direction of gradient is determined by scanning the pixels at certain angles (often 0°, 45°, 90°, 135°). After the process of determining the direction of edge, non-maximum points are suppressed. This means that non-edge pixels is reduced to 0 level. As final stage of canny edge detection algorithm, threshold is applied to the image. A T value are chosen as a limit- value in the threshold process. Thus, gray-scale image converted to binary image by pixels which above and below the T value are grouped.

3. Experiment and Experimental Results

In this study is used glass surface to measure the availability of edge detection algorithms at the texture analysis applications. Glass has the same property homogeneously throughout because of its structural properties. It is because the reflectivity property of glass and glass cannot hide the background because it is homogeneous. Therefore glass image should be taken carefully. In this study, glass images are taken from controlled experiment unit which is illuminated homogeneously. Glass images that are received from our experiment unit are very noisy to be able to edge detection. So, the noise in the image are cleaned firstly. 2D median filter is used to clean the noise in the image. Median filter is very successful to cleaning salt&pepper noise and similar noises. In addition, this filter does not damage the edge regions while noise cleaning process. And the most important reason for selecting the median filter is this property. Finally, images which were cleaned of noise was ready to be used for edge detection process.

Edge detection filters used in this study are Roberts, Prewitt, Sobel, LoG, Canny edge detection algorithms which are used very common. These filters are applied on the three glass-images and obtained results are shown in Figure 6. In figure 6, original glass images were shown the first line , in the second line are shown reference drawing images, in the other line edge detection algorithm outputs are shown.

Success measurement for the edge detection process is carried out as follow; the reference image and image which is applied edge detection algorithm are compared and performance of edge detection filter are evaluated according to specified criteria. The obtained results are shown Table 1. Description of the terms in the table is as follow; true positive=correctly determined white pixels, false positive=incorrectly determined white pixels, true negative=correctly determined black pixels, false negative=incorrectly determined black pixels. Taking the average

of similarity rate of the algorithms seen from Table 1; LoG %76.52, Canny %75.79, Roberts %69.4, Prewitt %68.26, Sobel %64.92. It is clear that these results may impact the glass characteristics and the condition of scratches. In the experimental conditions of this work, LoG edge detection algorithm is more successful than other tested edge detection algorithms for texture analysis in the glass surface.

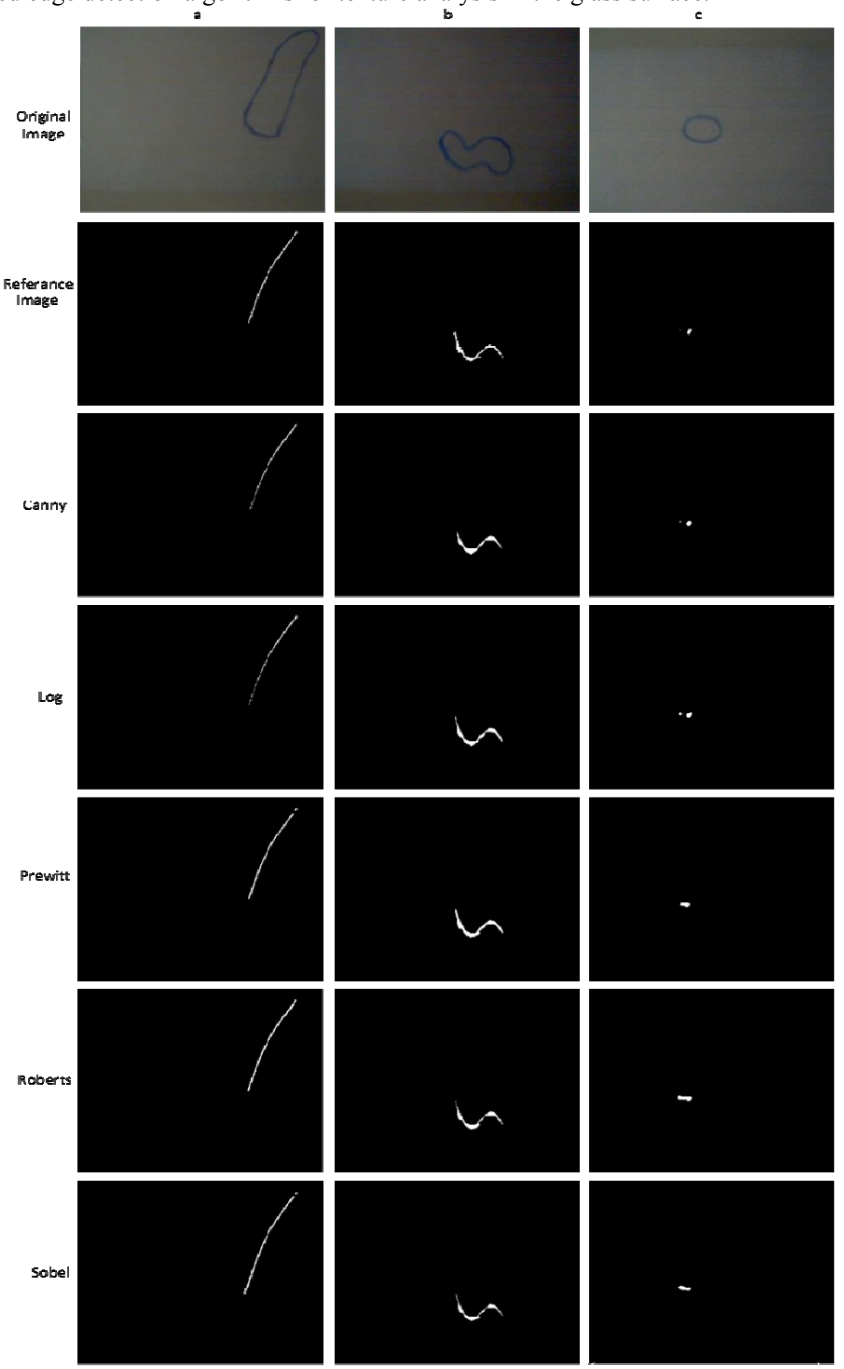

Figure 6. Implementation of Edge Detection Algorithms to Images

Table 1. Experiment Results

	True Positive (Pixel)	True Negative (Pixel)	False Positive (Pixel)	False Negative (Pixel)	Similarity Percentage (%)
Canny(a)	146	76082	21	71	%75.44
Canny(b)	188	75956	90	86	%73.76
Canny(c)	22	76206	11	2	%78.17
LoG(a)	152	76093	9	66	%80.99
LoG(b)	228	75944	100	48	%76.68
LoG(c)	23	76183	34	1	%71.89
Prewitt(a)	148	76001	102	69	%73.43
Prewitt(b)	241	75905	139	35	%74.31
Prewitt(c)	10	76171	43	17	%57.04
Roberts(a)	209	76022	81	8	%81.26
Roberts(b)	203	75965	79	73	%72.67
Roberts(c)	22	76154	63	2	%54.27
Sobel(a)	161	75957	142	60	%71.19
Sobel(b)	171	75964	80	105	%67.85
Sobel(c)	14	76161	56	10	%55.72

4. Conclusion

In this study Roberts, Sobel, Prewitt, LoG and Canny edge detection algorithms which are commonly used edge detection process are compared based on their glass defect detection performance. These algorithms are applied three different input image with sequence. Obtained images which are determined edges are compared the reference image and similarity ratio is calculated. The results are not as successful as often used texture analysis filters such as gabor filter, wavelet transform. But they are not far behind texture analysis filters. Their most important advantages compared to other systems; the simplicity of use and work very quickly. If LoG and Canny edge detection algorithms applied to image with little noise or image that optimized image processing methods, they can get much better results. In future works will be conducted studies to be more successful in texture analysis use these edge detection algorithms. In addition the glass surface, commonly used materials and surfaces which have easier analysis properties like tiles, fabric will be examined.

References

Ali, M. & Clausi, D. (2001). Using the Canny edge detector for feature extraction and enhancement of remote sensing images. Geoscience and Remote Sensing Symposium, IGARSS'01, Vol. 5, IEEE.

Bao, C. & Sheng, C. (2013). A parameterized logarithmic image processing method based on Laplacian of Gaussian filtering for lung nodules enhancement in chest radiographs. Instrumentation and Measurement, Sensor Network and Automation (IMSNA), 2013 2nd International Symposium on. IEEE.

Canny, J. (1986). A Computational Approach to Edge Detection. IEEE Transactions on Pattern Analysis and Machine Intelligence, pp. 679-700.

Ersoy, O. (1987). Fast Algorithms and Architectures for SignaL/Image Processing and Understanding in Intelligent Automation Systems. In Microcomputer application in process control: selected papers from the IFAC symposium, Istanbul, Turkey, 22-25 July 1986 (p. 5). Pergamon.

Hocenski, Z.,Vasilic, S. & Hocenski V. (2006). Improved Canny edge detector in ceramic tiles defect detection. IEEE Industrial Electronics, IECON 2006-32nd Annual Conference on. IEEE.

Lee, K.K., Cham, W.K. & Chen Q.R. (2002). Chin contour estimation using modified Canny edge detector. Control, Automation, Robotics and Vision, ICARCV 2002 7th International Conference on, Vol. 2, IEEE.

Maini, R. & Aggarwal, R. (2009). Study and comparison of various image edge detection techniques. International Journal of Image Processing (IJIP).

Mostert, S., & Kriegler, E. (2005). Implementing an image processing system for the next generation Earth observation sensors for the SUNSAT 2 micro-satellite programme. Acta Astronautica, 56(1), 171-174.

Pirzada, S.J.H., & Siddiqui, A. (2013). Analysis of edge detection algorithms for feature extraction in satellite images. Space Science and Communication (IconSpace), 2013 IEEE International Conference on. IEEE.

Prewitt, J. (1970). Object Enhancement and Extraction. Picture Processing and Psychopictorics, NY, Academic Pres.

Roberts, L.G. (1963). Machine Perception of Three-Dimensional. Diss. Massachusetts Institute of Technology.

Sobel, I. (1970). Camera Models and Perception. Ph.D. thesis, Standford University, CA.

Swargha, K., & Rodrigues, P. (2012). Performance Amelioration of Edge Detection Algorithms Using Concurrent Programming. Procedia Engineering, 38, 2824-2831.

Vernon, D. (1991). Machine vision-Automated visual inspection and robot vision. NASA STI/Recon Technical Report A 92.

Zhang, L., Qiu, B., Yu, X., & Xu, J. (2015). Multi-scale hybrid saliency analysis for region of interest detection in very high resolution remote sensing images. Image and Vision Computing, 35, 1-13.

Zhang, L., Tjondronegoro, D., & Chandran, V. (2014). Random Gabor based templates for facial expression recognition in images with facial occlusion. Neurocomputing, 145, 451-464.