Comparative Analysis of Edge Detection Method on Cardboard Packaging Images

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Abstract

Edge detection is a crucial process in digital image processing, particularly in automated visual inspection systems for packaging quality control. Cardboard packaging used in traditional food products often experiences deformation due to mechanical stress or poor distribution, thus requiring a reliable damage detection method. This study aims to compare the performance of five classical edge detection algorithms, Canny, Sobel, Prewitt, Roberts, and Laplacian of Gaussian (LoG), in identifying contours and structural deformations in product packaging images. Data were obtained through the acquisition of five cardboard images using a high-resolution smartphone camera. The processing steps include image conversion to grayscale, application of the edge detection algorithm, and quantitative evaluation of the results. The evaluation was conducted using three main metrics: Peak Signal-to-Noise Ratio (PSNR), Mean Squared Error (MSE), and processing time. The results show that the Sobel algorithm provides the best performance, with the highest PSNR and lowest MSE values consistently, despite having the longest processing time. In contrast, the Canny algorithm shows the highest efficiency in speed, but with low detection quality. Prewitt and LoG yielded relatively balanced intermediate results between accuracy and efficiency, while Roberts performed moderately across all aspects. These findings indicate that algorithm selection should be tailored to system requirements. Sobel is more appropriate for applications that prioritise accuracy, while Canny is recommended for real-time systems. This study provides an initial basis for the development of lightweight visual inspection systems in the traditional food industry and the MSME sector

Keywords: *Edge detection, PSNR, MSE, processing time, packaging inspection*

INTRODUCTION

Edge detection is one of the fundamental processes in digital image processing, as it allows the system to identify boundaries between objects through significant changes in pixel intensity. Edge information plays a crucial role in segmentation, object tracking, feature extraction, and visual shape classification in various applications such as computer vision, medical analysis, industrial surveillance, and automated inspection systems (Kalbasi & Nikmehr, 2020),(Zhou et al., 2022).

In the food industry, packaging functions not only as a physical protector, but also as a barrier against external contaminants such as moisture, light, dust, and microorganisms, and helps maintain product quality stability during storage and distribution.(Shaikh & Hyder, 2023) (Karate et al., 2024). Cardboard packaging, commonly used for traditional products, often faces damage due to mechanical stress, friction, or environmental exposure during the logistics process. Structural damage not only impacts aesthetics but also reduces the packaging's protective function, ultimately reducing product quality and causing financial losses (Song et al., 2023).

Edge detection can be used to recognize the physical contours of packaging and identify structural deformations as indicators of damage. In image-based visual inspection systems, this technique is an important initial step in distinguishing the main object from the background and extracting critical features. It is (Widodo et al., 2023) stated that the clarity of object boundaries is crucial for accurate measurement or subsequent classification in image processing systems.

Classical edge detection methods such as Sobel, Prewitt, Roberts, Laplacian of Gaussian

(LoG), and Canny are still widely used due to their efficiency and ease of implementation on various platforms such as OpenCV and MATLAB.(Bin & Samiei Yeganeh, 2012) (Avci, 2022)Several recent studies have conducted in-depth evaluations of the effectiveness of these algorithms in various domains. (G et al., 2025) showed that Canny excels in recall and F1-score, while Sobel exhibits the highest SSIM, indicating its ability to preserve edge structure. (Kasthuri, 2022) concluded that Canny and LoG excel in detecting smooth edges, while Roberts is less robust to noise.(Saxena et al., 2022) also found that Canny produced the best MSE and PSNR values on mammogram images.

In terms of system efficiency, (Nandhini et al., 2025) Sobel and Roberts are superior for FPGA-based real-time systems, while Canny remains visually superior under higher computational load. (Rahman & Zakaria, 2024) they even propose a combined method of four classical algorithms that can significantly improve the accuracy of complex object segmentation compared to a single approach.
This study aims to compare the performance of five classic edge detection algorithms: Sobel, Prewitt, Roberts, LoG, and Canny on images of Jenang food cardboard packaging. The evaluation was conducted using quantitative metrics such as Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), and processing time, to determine the most effective and efficient algorithm in identifying packaging shape, potential damage, and visual contours. This study is expected to be a baseline for research and development of lightweight visual inspection systems, especially for applications in the traditional food industry and MSMEs.

MATERIALS AND METHODS

The method in this research consists of several main stages arranged systematically, starting from the original image acquisition, conversion to grayscale, to the edge detection process using five algorithms: Canny, Sobel, Prewitt, Roberts, and LoG. The detection results are evaluated using three main metrics: MSE, PSNR, and processing time, and then compared quantitatively. The overall flowchart of the research process is presented in Figure 1.

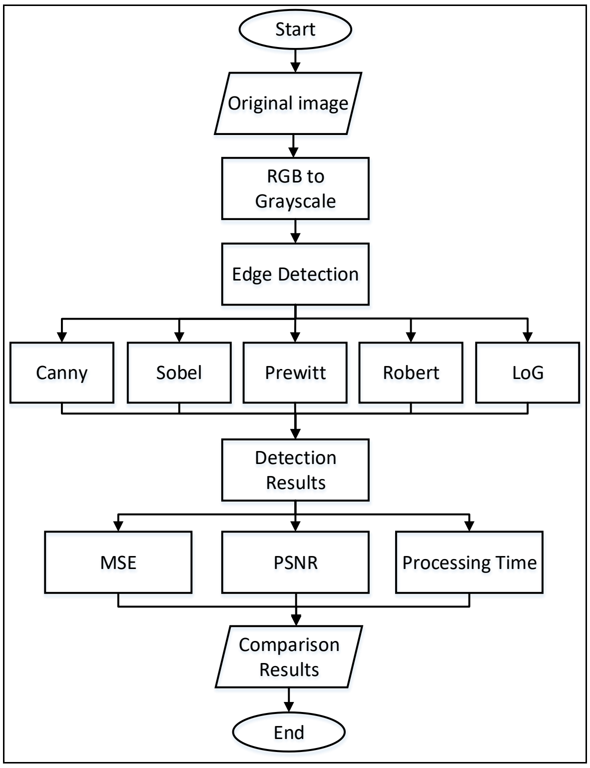

Figure 1. Proposed research stages

1. Image data acquisition

The image data acquisition process was carried out using a smartphone camera with a resolution of 8 megapixels. Images were taken under standard room lighting conditions with a plain white background to minimise visual interference from the surrounding environment. The camera was positioned perpendicular to the top and side surfaces of the packaging at a distance of approximately 20 cm. The image samples used consisted of five images of Jenang product packaging with dimensions of 26.5 cm in length, 10.5 cm in width, and 4 cm in height, each in JPG format with a resolution of 4000 × 1844 pixels. Two images with normal packaging conditions and three images showing visual defects in structural shape changes. This composition was chosen to represent the actual product conditions in the production and distribution process of the food industry, which reflects the need for edge detection system testing of shape variations and physical defects in packaging.

2. Canny

Canny edge detection works through a sequential process. The image is first smoothed with a Gaussian filter to reduce noise using equation 1.

$$G(x,y) = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \quad (1)$$

then the intensity gradient and edge direction are calculated, which is generally done with the Sobel operator using the kernel$Gx\ dan\ Gy$ shown in Figure 2 to obtain the edge magnitude in the direction of maximum change

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

Gx

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

Gy

Figure 2. Mask for Canny

The results are thinned through non-maximum suppression to make the contours sharp by one pixel. Next, a double threshold (high and low) is applied to separate strong and weak edges; and finally, hysteresis tracking is performed, which preserves low-threshold pixels if they are connected to strong edges while suppressing false edges, so that the final edges are accurate, well-localised, and minimise double responses (Guo & Wu, 2023),(Vemuru, 2022).

3. Sobel

The Sobel operator is a first derivative-based edge detector that approximates the intensity gradient using a pair of 3×3 convolution masks for the horizontal (Gx)and vertical) directions (Gy). In Figure 3, the second mask is a 90° rotation of the first mask so that the derivative responses are orthogonal to each other.

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

Gx

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

Gy

Figure 3. Mask for Sobel

The magnitude of the gradient at each pixel is calculated using equation 2.

$$|G| = \sqrt{G_x^2 + G_y^2} \quad (2)$$

The gradient direction at each pixel is calculated by equation 3

$$\theta = arctan\left(\frac{G_y}{G_x}\right) \quad (3)$$

.

The weights provide a local smoothing effect so that the gradient estimator is more stable against noise and remains computationally light, so that Sobel is widely used as a baseline for contour extraction before Non-Maximum Suppression or advanced thresholding in the edge detection process (Cheng et al., 2023)(Zhu et al., 2023).

4. Prewitt

The Prewitt operator has characteristics similar to Sobel, using a pair of 3×3 convolution kernels to approximate the intensity gradient in the horizontal and vertical directions, so that the edge orientation can be estimated from the maximal response of its mask. Figure 4 is a commonly used kernel form.

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy

Figure 4. Mask for Prewitt

In noise-free, high-contrast images, this approach tends to be compu`tationally lighter and faster for edge detection (Idris et al., 2022). Prewitt is a gradient-based operator that extracts gradient information (Li et al., 2021). Its main difference from Sobel lies in the spectral response of the kernel; the implication is that, while effective for clean images, Prewitt's stability tends to decrease in noisy or low-contrast conditions compared to more robust approaches (Juneja & Sandhu, 2009).

5. Roberts

Roberts (Roberts Cross) approximates the spatial gradient of an image through discrete differentiation on diagonally opposite pixel pairs. This operator was proposed by Lawrence Roberts (1963) and is understood as a fast and straightforward way to estimate spatial gradients, namely by exploiting the diagonal intensity differences in neighbouring pixels with high spatial frequency. Roberts uses two orthogonal 2×2 convolution masks as shown in Figure 5, each extracting gradient components in two diagonal directions.(Hidayat & Kartowisastro, 2024)(Ighoyota Ben et al., 2017)

+1	0
0	-1

Gx

0	+1
-1	0

Gy

Figure 5. Mask for Robert

The magnitude of the edge response is expressed in equation 4.

$$G(x,y) = |G_x(x,y)| + |G_y(x,y) \quad (4)$$

and the gradient orientation on Roberts can be expressed concisely in equation 5

$$\theta(x,y) = \arctan\left(\frac{G_y(x,y)}{G_x(x,y)}\right) - \frac{3\pi}{4} \quad (5)$$

6. LogG

LoG (Laplacian of Gaussian) detects edges in two steps. First, the image is smoothed using a Gaussian to suppress noise, then the Laplacian operator (second-order derivative) is applied so that edges appear at the zero-crossing points of the second-order derivative response. Practically, the LoG (Gaussian+Laplacian) kernel is used directly, and the edge location is marked by a sign change (positive-negative) in the output after smoothing, resulting in thin and well-localised contours at sharp intensity changes (yahya et al., 2024)(Mathur & Sandeep Gupta, 2024).

To detect points where there is a very sharp change in intensity, namely the locations of the edges or boundaries of the object, equation 6 is used.

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} \quad (6)$$

The kernel form is formulated in equation 7.

$$Log = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^{2+}y^2}{2\sigma^2}\right] e^{\frac{x^{2+}y^2}{2\sigma^2}} \quad (7)$$

The LoG edge detection method uses two 3×3 convolutional masks, as shown in Figure 6.

+1	+1	+1
+1	-8	+1
+1	+1	+1

Gx

-1	+2	-1
+2	-4	+2
-1	+2	-1

Gy

Figure 6. Mask for LoG

7. PSNR

Peak Signal-to-Noise Ratio (PSNR) is a quantitative measure that compares the maximum signal power to the level of noise that can degrade the accuracy of image representation. This metric is measured in decibels (dB) (Poobathy & Chezian, 2014). It is widely used as an indicator of the quality between the original image and the compressed or reconstructed image. The higher the PSNR value, the better the quality of the resulting reconstructed image (Jose et al., 2014). The PSNR calculation refers to equation 8.

$$PSNR = 10.\log_{10}\frac{R^2}{MSE} \quad (8)$$

the R value is the maximum fluctuation in the input image data. For grayscale images, R is generally 255 because each pixel is encoded as an 8-bit integer.

8. MSE

Mean Squared Error (MSE) is used to evaluate the difference in pixel intensity values between the original image and the degraded transformed image. In general, MSE is calculated as the average of the squared differences in intensity between pixels. A smaller MSE value reflects a lower level of distortion, thus indicating higher image quality and more accurate reconstruction results. (Setiawan et al., 2022). The MSE calculation is done with equation 9.

$$MSE = \frac{1}{n}|x - x'| = \frac{1}{n}\sum_{i=1}^{n}(x - x')^2 \quad (9)$$

RESULTS AND DISCUSSION

The results of edge detection experiments using five algorithms (Canny, Sobel, Prewitt, Roberts, and LoG) were analysed on five Jenang product packaging image datasets, which included both defective and normal conditions. The system was implemented using Google Colab with Python and the OpenCV library. The process began with converting colour images to grayscale as a preprocessing stage, before applying edge detection. The goal was to evaluate the ability of each algorithm to detect object edges under defective conditions that commonly occur in industrial packaging. The following is a visual comparison of the edge detection results from the five methods, shown in Table 1.

Table 2 shows the PSNR values of five edge detection algorithms for five test image data sets. The results show that the Sobel algorithm consistently performs best on all image data sets, with the highest PSNR value recorded in Image Data 4 at 3.76 dB, followed by values of 3.56 dB and 3.10 dB in Image Data 2 and 3, respectively. This indicates that Sobel is able to produce edge maps that are closest to the original image structure, with relatively low noise.

Meanwhile, the LoG and Roberts algorithms produce very similar performance, with consistent PSNR in the range of 2.06–3.62 dB. LoG has a slight advantage in detecting smooth boundaries and reducing local noise due to the nature of the Gaussian operator, but it is not significantly superior to Roberts on this test data. The Prewitt algorithm showed intermediate performance, outperforming Canny on almost all datasets but still behind Sobel. This is consistent with Prewitt's similarity to Sobel but is less sensitive to sharp intensity changes.The Canny algorithm showed the lowest PSNR in this experiment, especially in Image Data 1 at 1.98 dB and Image Data 5 at 2.28 dB.

Based on the results of the Mean Squared Error (MSE) calculation described in Table III, the Sobel method consistently shows the best performance, with the lowest MSE value in all datasets, such as 27378.82 in Image Data 4 and

Table 1. Edge Detection Results on Cardboard Packaging

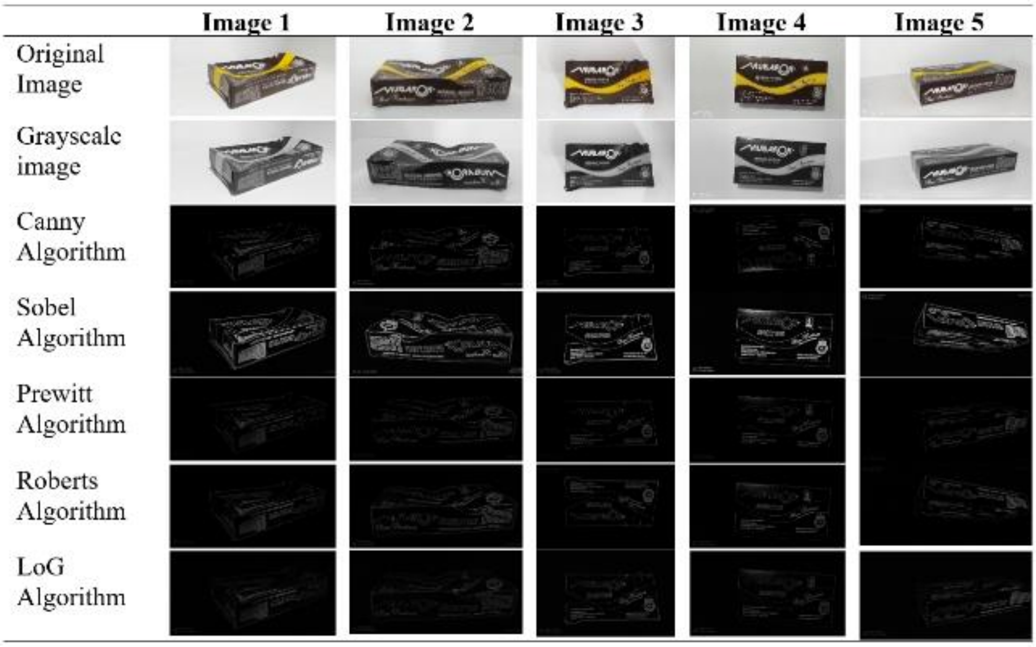

Table 2. PSNR Results

Algo rithm	Image Data 1	Image Data 2	Image Data 3	Image Data 4	Image Data 5
Canny	1.98	3.19	2.85	3.48	2.28
Sobel	2.26	3.56	3.10	3.76	2.55
Prewitt	2.05	3.32	2.93	3.59	2.36
Roberts	2.06	3.34	2.95	3.61	2.37
LoG	2.06	3.34	2.96	3.62	2.38

28614.92 in Image Data 2. This shows that the Sobel method produces edge detection that is most similar to the reference image, so the quality of the results is numerically higher. In contrast, the Canny method produces the highest MSE values on almost all datasets, for example, 41256.09 on Image Data 1 and 38495.60 on Image Data 5. This shows that although Canny is often used due to its accuracy in detecting fine edges, in terms of pixel match with the original image, its performance is less than optimal on this dataset. Other methods, such as Prewitt, Roberts, and LoG, show relatively similar intermediate performance.

Table 3. MSE Results

Algorithm	Image Data 1	Image Data 2	Image Data 3	Image Data 4	Image Data 5
Canny	41256.09	31159.15	33720.56	29204.85	38495.60
Sobel	38633.13	28614.92	31826.74	27378.82	36130.74
Prewitt	40512.76	30246.37	33093.34	28467.22	37783.24
Roberts	40453.52	30102.38	32940.27	28304.21	37648.97
LoG	40485.07	30117.90	32870.79	28240.78	37614.15

Table 4 shows the execution times (in seconds) of the five edge detection algorithms. Overall, the Canny algorithm recorded the fastest processing times, with the lowest time being 0.02 seconds on three of the five datasets (Image Data 1, 2, and 3), and only 0.03 seconds and 0.06 seconds on the other datasets. This gives Canny the edge in computational efficiency, despite previously being found to have the highest MSE values. Conversely, Sobel was the algorithm with the highest processing time, especially on Image Data 5, with a time reaching 0.51 seconds, significantly higher than the other methods. This high time was also recorded on Image Data 4 (0.20 seconds) and Image Data 1 (0.19 seconds), indicating that while Sobel excels in detection accuracy (MSE and PSNR), it is less efficient in terms of processing speed. This is in line with Sobel's nature of involving convolution in both directions (horizontal and vertical), which requires additional computational time. Meanwhile, the Prewitt and Roberts algorithms demonstrated the most stable and fastest processing performance after Canny, with times ranging from 0.05 to 0.07 seconds across all datasets. This stability makes them suitable for implementation in real-time detection systems with limited processing resources. LoG (Laplacian of Gaussian) displayed intermediate performance with times between 0.09 and 0.11 seconds.

Table 4. Processing Time Results

Algorithm	Image Data 1	Image Data 2	Image Data 3	Image Data 4	Image Data 5
Canny	0.02	0.02	0.02	0.03	0.06
Sobel	0.19	0.11	0.13	0.20	0.51
Prewitt	0.05	0.05	0.07	0.06	0.07
Roberts	0.05	0.05	0.06	0.06	0.07
LoG	0.09	0.09	0.09	0.10	0.11

The results of the comparison of edge detection performance based on the PSNR, MSE, and Processing Time parameters of the five images are also shown in the graphs in Figures 7 to 9. Figure 7 presents a comparison graph of PSNR values across the entire image. The Sobel method produces the best image quality based on PSNR values. Canny and LoG also perform quite well, while Prewitt and Roberts produce lower quality. Overall, Sobel is the most effective edge detection method on the tested image data.

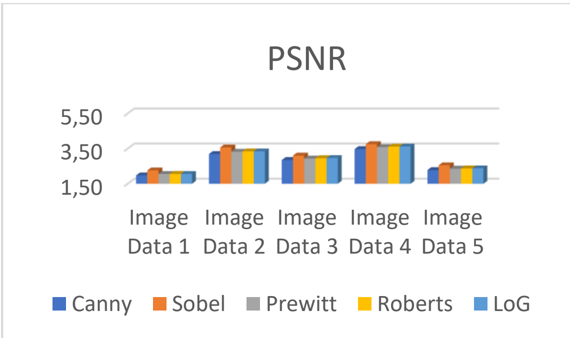

Figure 7. PSNR Chart

Figure 8 presents a comparison graph of the MSE values of the five edge detection methods. The Sobel method still performs best, producing the lowest error on most of the image data. A low MSE value indicates that the edge-detected image is still close to the original image. Conversely, the Canny method tends to produce the highest error, especially on some image data. Other methods, such as Prewitt, Roberts, and LoG, produce fairly consistent results but still lag behind Sobel in terms of accuracy.

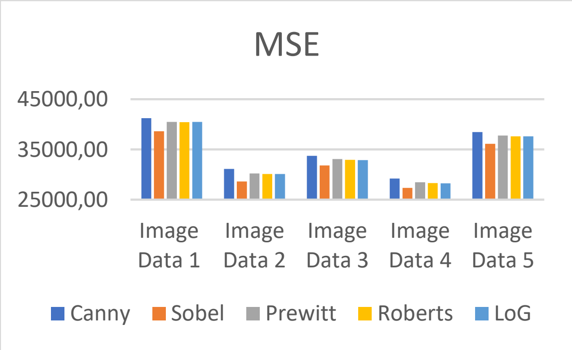

Figure 8. MSE Chart

Based on the processing time test results in Figure 9, the Sobel method has the highest execution time on all images. In contrast, the Canny method shows the lowest processing time on almost all images. The Prewitt, Roberts, and LoG methods have relatively balanced processing times and are between Canny and Sobel. This indicates that Canny is more efficient in terms of speed, while Sobel requires a longer computational time.

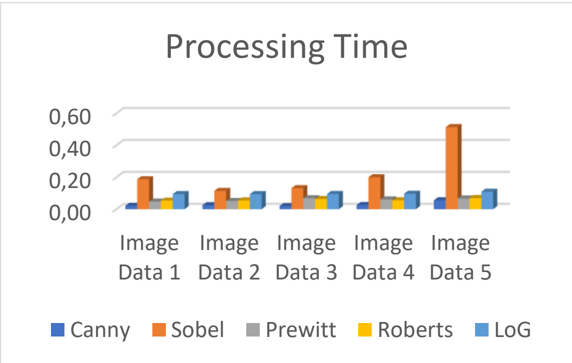

Figure 9. Processing Time Chart.

CONCLUSION

This study compares five edge detection algorithms: Canny, Sobel, Prewitt, Roberts, and LoG using three main evaluation metrics: PSNR, MSE, and processing time. The results show that the Sobel algorithm provides the best edge detection quality, with the highest PSNR and lowest MSE values. However, Sobel also has the longest processing time. Conversely, the Canny algorithm is the fastest but produces the lowest edge quality. The Prewitt and LoG algorithms provide a fairly balanced result between quality and speed, while Roberts shows moderate performance in all aspects. Thus, Sobel is suitable for applications requiring high accuracy, while Canny is more appropriate for real-time applications requiring high speed.

Future work should validate these findings on a larger and more diverse dataset (different lighting conditions, backgrounds, viewing angles, and defect types) and, when possible, use ground-truth edge annotations to report task-oriented metrics such as precision, recall, and F1-score, in addition to PSNR, MSE, and runtime. Further research may also investigate parameter optimisation and noise-robust preprocessing, explore hybrid combinations of classical detectors, and integrate the selected method into an end-to-end, real-time packaging defect inspection pipeline deployable on resource-constrained edge devices.

REFERENCES

Avci, I. (2022). Threshold Values of Different Classical Edge Detection Algorithms. *Traitement Du Signal*, *39*(5), 1775–1780. https://doi.org/10.18280/ts.390536

Bin, L., & Samiei Yeganeh, M. (2012). Comparison for Image Edge Detection Algorithms. *IOSR Journal of Computer Engineering (IOSRJCE)*, *2*(6), 1–04. www.iosrjournals.org

Cheng, D., Gao, X., Mao, Y., Xiao, B., You, P., Gai, J., Zhu, M., Kang, J., Zhao, F., & Mao, N. (2023). Brain tumor feature extraction and edge enhancement algorithm based on U-Net network. *Heliyon*, *9*(11). https://doi.org/10.1016/j.heliyon.2023.e22536

G, O. E., C, A. D., & N, O. J. (2025). Exploring the Effectiveness of Sobel, Canny, and Prewitt Edge Detection Algorithms. *World Journal of Advanced Engineering Technology and Sciences*, *15*(01), 1722–1730.

Guo, L., & Wu, S. (2023). FPGA Implementation of a Real-Time Edge Detection System Based on an Improved Canny Algorithm. *Applied Sciences (Switzerland)*, *13*(2). https://doi.org/10.3390/app13020870

Hidayat, N. R. P., & Kartowisastro, I. H. (2024). Comparison of Edge Detection Methods Using Road Images. *International Journal of Engineering Trends and Technology*, *72*(10), 64–72. https://doi.org/10.14445/22315381/IJETT-V72I10P107

Idris, B., Abdullah, L. N., Halim, A. A., Taufik, M., Selimun, A., & Malaysia, P. (2022). Comparison of Edge Detection Algorithms for Texture Analysis on Copy-Move Forgery Detection Images. *IJACSA) International Journal of Advanced Computer Science and Applications*, *13*(10), 152–160. www.ijacsa.thesai.org

Ighoyota Ben, A., Nicholas.O., O., & Charles O., O. (2017). Optimum Fuzzy based Image Edge Detection Algorithm. *International Journal of Image, Graphics and Signal Processing*, *9*(4), 44–55. https://doi.org/10.5815/ijigsp.2017.04.06

Jose, A., Dixon K, D. M., Joseph, N., George E, S., & Anjitha V, M. (2014). Performance Study of Edge Detection Operators. *International Conference on Embedded Systems - (ICES)*, 7–11.

Juneja, M., & Sandhu, P. S. (2009). Performance Evaluation of Edge Detection Techniques for Images in Spatial Domain. *International Journal of Computer Theory and Engineering*, *1*(5), 614–621.

Kalbasi, M., & Nikmehr, H. (2020). Noise-Robust, Reconfigurable Canny Edge Detection and its Hardware Realization. *IEEE Access*, *8*, 39934–39945. https://doi.org/10.1109/ACCESS.2020.2976860

Karate, M., Bakane, P., Sangekar, V., & Khobragade, U. (2024). A Review on Recent Advances of Packaging in Food Industry. *International Journal of Horticulture, Agriculture and Food Science (IJHAF)*, *8*(2), 18–25. https://doi.org/10.22161/ijhaf.8.2

Kasthuri, M. (2022). Performance Analysis of Gradient Based Image Edge Detection. *International Journal of Health Sciences*, *6*, 12851–12857. https://doi.org/10.53730/ijhs.v6ns1.8205

Li, Y., Huang, N., Liu, K., Chen, H., Wang, Z., & Yu, J. (2021). A Modified HOG Algorithm based on the Prewitt Operator. *Proceedings of the 2021 International Conference on Bioinformatics and Intelligent Computing, BIC 2021*, 257–261. https://doi.org/10.1145/3448748.3448789

Mathur, S., & Sandeep Gupta, M. (2024). An Enhanced Edge Detection Using Laplacian Gaussian Filtering Method from Different Denoising Images. *Original Research Paper International Journal of Intelligent Systems and Applications in Engineering IJISAE*, *2024*(18s), 313–323. www.ijisae.org

Nandhini, M., Faridha Banu, D., Madhumitha, D., Shivanandham, R. S., Srisanjana, K., & Roshaan, J. S. (2025). Evaluating Edge Detection Algorithms for Robust Image Processing and FPGA Implementation. *Proceedings of 5th International Conference on Trends in Material Science and Inventive Materials, ICTMIM 2025*, 1588–1595. https://doi.org/10.1109/ICTMIM65579.2025.10988244

Poobathy, D., & Chezian, R. M. (2014). Edge Detection Operators: Peak Signal to Noise Ratio Based Comparison. *International Journal of Image, Graphics and Signal Processing*, *6*(10), 55–61. https://doi.org/10.5815/ijigsp.2014.10.07

Rahman, A. Y., & Zakaria, Z. (2024). A Novel Hybrid Canny, Sobel, Robert, and Prewitt Algorithm for Enhanced Schematic Edge Detection in Power Distribution Networks. *2024 IEEE Sustainable Power and Energy Conference, ISPEC 2024*, 265–273. https://doi.org/10.1109/iSPEC59716.2024.10892535

Saxena, S., Singh, Y., Agarwal, B., & Poonia, R. C. (2022). Comparative analysis between different edge detection techniques on mammogram images using PSNR and MSE. *Journal of Information and Optimization Sciences*, *43*(2), 347–356. https://doi.org/10.1080/02522667.2021.2000168

Setiawan, A., Triyanto, W. A., Setiawan, A., Warsito, B., & Wibowo, A. (2022). Underwater Shrimp Digital Image Segmentation Using Edge Detection Method on Fog Network. *Proceedings - 2022 2nd International Conference on Information Technology and Education, ICIT and E 2022*, 81–86. https://doi.org/10.1109/ICITE54466.2022.9759876

Shaikh, M. J., & Hyder, M. (2023). Green Packaging as a Positive Catalyst for Green Environment: Implementation in Emerging Markets around the Globe. *Pakistan Journal of Humanities and Social Sciences*, *11*(1), 655–669. https://doi.org/10.52131/pjhss.2023.1101.0382

Song, B., Wang, Y., & Lou, L. P. (2023). SSD-Based Carton Packaging Quality Defect Detection System for the Logistics Supply Chain. *Ecological Chemistry and Engineering S*, *30*(1), 117–123. https://doi.org/10.2478/eces-2023-0011

Vemuru, K. V. (2022). Implementation of the Canny Edge Detector Using a Spiking Neural Network. *Future Internet*, *14*(12). https://doi.org/10.3390/fi14120371

Widodo, C. E., Adi, K., Gernowo, R., & Setiawan, A. (2023). Pleural Effusion Measurement Method on Thoracic Image of Dengue Fever Patient Using Image Processing Technique. *Mathematical Modelling of Engineering Problems*, *10*(4), 1467–1472. https://doi.org/10.18280/mmep.100443

yahya, sara, elsanary, hameda, Hassan, M., & ali, abdelmgeid. (2024). An Improved Edge Detection Method for Image Analysis in Diverse Domains. *Aswan Science and Technology Bulletin*, *0*(0), 1–19. https://doi.org/10.21608/astb.2024.310816.1004

Zhou, W., Yu, W., & Yang, H. (2022). Research on Part Edge Detection Algorithm Based on Deep Learning. *2022 5th International Conference on Robotics, Control and Automation Engineering, RCAE 2022*, 280–285. https://doi.org/10.1109/RCAE56054.2022.9996046

Zhu, M., Yu, L., Wang, Z., Ke, Z., & Zhi, C. (2023). Review: A Survey on Objective Evaluation of Image Sharpness. In *Applied Sciences (Switzerland)* (Vol. 13, Issue 4). MDPI. https://doi.org/10.3390/app13042652