Prewitt and Canny Methods on Inversion Image Edge Detection: An Evaluation

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Abstract. The use of the edge detection method in an image will produce the edges of the image object. The goal is to mark the part that becomes the image's detail and fix the point of the blurred vision, which occurs because of an error or the effect of the image acquisition process. This study aims to see the combination of the Prewitt and Canny methods in detecting the edges of the inverted image. The image dataset used is a bonsai image consisting of 10 typical images, and ten bonsai images reversed based on the standard image dataset. The research dataset was obtained from the Caltech 101 website http://www.vision.caltech.edu/Image_Datasets/Caltech101/ with an image size of approximately 200x300 pixels. Based on the analysis of 10 experiments that have been carried out, the combination of the Prewitt and Canny methods can perform edge detection quite well with an average accuracy of 78.90% and an error rate of 21.10%. Thus it can be concluded that these methods combine to yield a reasonable level of precision, though the extent is very limited.

1. Introduction
Digital image processing (DIP) is a technology that can be used to improve image quality and image identification process to enrich the information that comes from the image [1]. Image is one of the essential multimedia features which has an essential role as a form of visual information [2]. Image has characteristics that are rich in information and is not owned by text data. Image can provide more details than information presented in text form [3]. The edge detection method is one of the most popular operations in image analysis [4]. The use of edge detection methods in an image will produce the edges of the image object [5], the goal is to mark the part that becomes the detail of the image and improve the point of the blurred vision, which occurs because of an error or the effect of the image acquisition process [6]. Therefore, the selection of the image edge detection method must be precise, so that the manipulation of the image is easier to do [7]. Edge detection is divided into two parts, namely first-order edge detection and second-order edge detection [8]. Some of the first-order methods include Sobel [9], Prewitt [10], Roberts [11], and Canny [12]. Whereas second-order edge detection is like Laplacian of Gaussian (LoG) [13].
Many studies have been carried out using edge detection methods to solve many image identification problems, it is evident from the growing breadth of research related to it. D N Lohare, et al (2021) Using image processing techniques, a comparison analysis was performed between the Prewitt and Canny methods. The Prewitt and Canny operators are compared with different images to extract the edges of objects in an image in this paper. The Prewitt method has a major drawback because it is very sensitive to noise while the Canny edge detection method is highly dependent on sigma variable parameters. Computationally the Canny method is more proprietary but Canny's edge detection method achieves improvements over Prewitt operators in all states. Canny provides the sharpest images and the highest possible edge continuity in this edge detector comparison. The findings also show that the Canny approach offers the most substantial and most precise edges as opposed to Prewitt's method [14]. B K Shah, et al (2020) The analysis of Laplacian and gradient-based edge detection techniques is discussed in this article. The entire picture is subjected to methods and techniques. The 2nd order derivative filter works better than the 1st order derivative in this situation. The experiment clearly shows that some methods yield lower-quality edge maps than others. The Canny method can detect both sides and appears to be a better match than the Gaussian Laplacian among the methods investigated. Although the canny edge detection technique takes a long time to complete, it is more effective than other methods [15]. P Vinista and M M Joe (2019) Modified the Sobel algorithm for better image edge detection. In this paper, various characteristics of edge detection methods (Sobel, Prewitt, Laplacian, and Roberts edge detection) were analyzed and studied then compared with the modified Sobel method with a threshold value of 100. Based on the comparative analysis it was found that the Sobel edge detection method worked well. compared to other edge detection methods. The results showed that the detection of the modified Sobel edges took less time to detect the edges of the various sampled images [16]

Based on the discussions outlined in previous related research, this paper proposes the use of a combination of Prewitt and Canny methods. This is done to measure the ability of the two methods combined to correctly detect the edges of the inverted bonsai image so that the results can be used as references or knowledge by academics.

2. Methodology

2.1. Research Dataset

This paper uses 20 datasets of bonsai plant imagery with an image scale of approximately 200x300 pixels from the Caltech 101 website http://www.vision.caltech.edu/Image Datasets/Caltech101/ [17]. 20 datasets of bonsai plant images consist of 2 groups, namely 10 original images in group 1 as training data and 10 inversion images in group 2 as test data.
Figure 1. Original image of bonsai plants (group 1 / training data)

Figure 2. Image of bonsai plant inversion (group 2 / test data)

Source: Caltech 101

Figure 1 contains ten original images of group 1 bonsai plants used as training data. In the meantime, Figure 2 includes ten images: inversion images of group 2 bonsai plants that will be used as test results. Figure 2 displays ten images that were used as samples to see whether the combination of the two edge detection methods (Prewitt and Canny) could distinguish bonsai images.

2.2. Research Flowchart

Based on Figure 3, it can be explained that the first step carried out is data collection. The image dataset used is a bonsai image consisting of 10 standard images and ten bonsai images that have been inverted based on the standard image dataset. The next step is implementing a combination of the Prewitt and Canny methods using the Matlab 2019a application. Each bonsai image dataset will be tested one by one by entering the program code in Matlab. The program code that has been entered in Matlab will produce an object edge detection image for each trained and tested image based on a combination of the Prewitt and Canny methods. The next step is to analyze the results of detecting the object edges of each bonsai image with a variety of the two ways to obtain accuracy and error results.
so that it can be concluded whether the combination of the two methods can detect the edges of the inverted bonsai image object or not.

3. Results and Discussion

3.1. Image Pair
Based on the bonsai image presented in Figure 1 and Figure 2, the dataset is first paired between the training data and the test data. Image 1 (training data) is paired with Image 11 (test data), Image 2 (training data) with Image 12 (test data), Image 3 (training data) with Image 13 (test data), Image 4 (training data) with Image 14 (test data), Image 5 (training data) with Image 15 (test data), Image 6 (training data) with Image 16 (test data), Image 7 (training data) with Image 17 (test data), Image 8 (training data) with Image 18 (test data), Image 9 (training data) with Image 19 (test data), and Image 10 (training data) with Image 20 (test data).

![Image of a bonsai plant pair](image)

Then the simplification process is to change the color intensity to gray (grayscale). Next, do edge detection through the bonsai image that has been determined in figure 4 using a combination of the Prewitt and Canny methods, which creates a binary image. The segmentation process continues utilizing a combination of these methods to get the resulting image so that objects that have been segmented will be visible.

3.2. Segmentation Results Combining Prewitt and Canny Methods
Segmentation of bonsai images with a combination of the Prewitt and Canny methods was carried out and analyzed using the Matlab 2019a application. After that, the Matlab application results are entered into Ms. Excel to calculate and find out the overall accuracy and error value.

![Table 1. Segmentation Result of Bonsai Image by Combining Prewitt and Canny Methods](table)
| Original Image | Inversion Image | Segmentation (a) | Segmentation (b) | Database Image (Pixel) | Test Image (Pixel) | Accuracy (%) | Error |
|----------------|-----------------|-------------------|------------------|------------------------|-------------------|--------------|-------|
| ![Image 1](image1) | ![Image 2](image2) | ![Image 3](image3) | ![Image 4](image4) | 1336 | 983 | 73,58 | 26,42 |
| ![Image 5](image5) | ![Image 6](image6) | ![Image 7](image7) | ![Image 8](image8) | 1060 | 769 | 72,55 | 27,45 |
| ![Image 9](image9) | ![Image 10](image10) | ![Image 11](image11) | ![Image 12](image12) | 1270 | 1980 | 64,14 | 35,86 |
| ![Image 13](image13) | ![Image 14](image14) | ![Image 15](image15) | ![Image 16](image16) | 1399 | 1144 | 81,77 | 18,23 |
| ![Image 17](image17) | ![Image 18](image18) | ![Image 19](image19) | ![Image 20](image20) | 1486 | 1248 | 83,98 | 16,02 |
| ![Image 21](image21) | ![Image 22](image22) | ![Image 23](image23) | ![Image 24](image24) | 429 | 271 | 63,17 | 36,83 |
| ![Image 25](image25) | ![Image 26](image26) | ![Image 27](image27) | ![Image 28](image28) | 4825 | 5613 | 85,96 | 14,04 |
In table 1, it can be explained that based on ten experiments on bonsai images using a combination of the Prewitt and Canny methods, it produces an average accuracy of 78.90% with an error rate of 21.10%. The minimum number of pixels produced is 271 pixels in the image database, and the maximum is 25772 pixels. Meanwhile, the minimum and maximum number of pixels created in the test image are 429 pixels and 25768 pixels.

### 3.3. Accuracy Graph

The graph of the accuracy of the results of 10 bonsai image trials with a combination of the Prewitt and Canny methods can be seen in Figure 5.
Based on the information presented in Figure 5, it can be explained that the best accuracy is in trials 5, 6, 8, 9, and 10 because it produces an accuracy of more than 80%. Meanwhile, trials 1, 2, 3, 4, and 7 are considered not good because they only make accuracy below 75%. Based on Figure 6, it can be seen that the average accuracy is 78.90%, which means the error rate is 100% - 78.90% = 21.10%.

4. Conclusion
Based on the results of the analysis of the trials that have been carried out, it can be concluded that the ability of the combination of first-order edge detection (Prewitt) and second-order edge detection (Canny) methods is quite good in performing edge detection and identifying inverted bonsai image objects, with an average 78.90% accuracy and 21.10% error. However, this capability is still not maximal because the error is still quite large, so it needs to be corrected, or further research is carried out using other edge detection methods.

References
[1] Y. Wang, Y. Yu, X. Zhu, and Z. Zhang, “Pattern recognition for measuring the flame stability of gas-fired combustion based on the image processing technology,” Fuel, vol. 270, no. 117486, pp. 1–13, 2020.
[2] A. Latif et al., “Content-Based Image Retrieval and Feature Extraction: A Comprehensive Review,” Mathematical Problems in Engineering, vol. 2019, pp. 1–21, 2019.
[3] S. Hassanpour, N. Tomita, T. DeLise, B. Crosier, and L. A. Marsch, “Identifying substance use risk based on deep neural networks and Instagram social media data,” Neuropsychopharmacology, vol. 44, no. 3, pp. 487–494, 2019.
[4] D. N. Trivedi, N. D. Shah, A. M. Kothari, and R. M. Thanki, “Dental image processing for human identification,” Dental Image Processing for Human Identification, pp. 1–81, 2019.
[5] L. H. Gong, C. Tian, W. P. Zou, and N. R. Zhou, “Robust and imperceptible watermarking scheme based on Canny edge detection and SVD in the contourlet domain,” Multimedia Tools and Applications, vol. 80, no. 1, pp. 439–461, 2021.
[6] B. Watkins and A. van Niekerk, “A comparison of object-based image analysis approaches for field boundary delineation using multi-temporal Sentinel-2 imagery,” Computers and Electronics in Agriculture, vol. 158, no. November 2018, pp. 294–302, 2019.
[7] R. G. Zhou, H. Yu, Y. Cheng, and F. X. Li, “Quantum image edge extraction based on improved Prewitt operator,” Quantum Information Processing, vol. 18, no. 261, pp. 1–24, 2019.
[8] M. Versaci and F. C. Morabito, “Image Edge Detection: A New Approach Based on Fuzzy Entropy and Fuzzy Divergence,” International Journal of Fuzzy Systems, 2021.
[9] G. Chen, Z. Jiang, and M. M. Kamruzzaman, “Radar remote sensing image retrieval algorithm based on improved Sobel operator,” Journal of Visual Communication and Image Representation, vol. 71, no. 102720, pp. 1–8, 2020.

[10] Erwin and T. Yuningsih, “Detection of Blood Vessels in Optic Disc with Maximum Principal Curvature and Wolf Thresholding Algorithms for Vessel Segmentation and Prewitt Edge Detection and Circular Hough Transform for Optic Disc Detection,” Iranian Journal of Science and Technology, Transactions of Electrical Engineering, vol. 9, pp. 1–12, 2020.

[11] M. Yasir et al., “Automatic Coastline Extraction and Changes Analysis Using Remote Sensing and GIS Technology,” IEEE Access, vol. 8, pp. 180156–180170, 2020.

[12] B. Iqbal, W. Iqbal, N. Khan, A. Mahmood, and A. Erradi, “Canny edge detection and Hough transform for high resolution video streams using Hadoop and Spark,” Cluster Computing, vol. 23, no. 1, pp. 397–408, 2020.

[13] Y. Cho et al., “Keypoint Detection Using Higher Order Laplacian of Gaussian,” IEEE Access, vol. 8, pp. 10416–10425, 2020.

[14] D. N. Lohare, R. R. Manza, and N. Tiwari, “Comparative Study of Prewitt and Canny Edge Detector Using Image Processing Techniques,” Advances in Intelligent Systems and Computing, vol. 1187, pp. 705–713, 2021.

[15] B. K. Shah, V. Kedia, R. Raut, S. Ansari, and A. Shroff, “Evaluation and Comparative Study of Edge Detection Techniques,” IOSR Journal of Computer Engineering, vol. 22, no. 5, pp. 6–15, 2020.

[16] P. Vinista and M. M. Joe, “A Novel Modified Sobel Algorithm for Better Edge Detection of Various Images,” International Journal of Emerging Technologies in Engineering Research (IJETER), vol. 7, no. 3, pp. 25–31, 2019.

[17] F.-F. Li, M. Andreetto, and M. Aurelio Ranzato, “101 categories - Bonsai,” Computational Vision At Caltech. [Online]. Available: http://www.vision.caltech.edu/Image_Datasets/Caltech101/. [Accessed: 23-Feb-2021].