

Laplacian Neural Network based Image Edge Detection Method using Supervised Learning System

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Abstract—Currently, edge detection techniques make extensively attention because of its high applicability and diversity in many human life applications. In order to extract important information, an efficient edge detection method is required. Edges are represented as the boundaries where particular intensity changes or discontinuities happen. Experimentally, discovered that it is hard to design an edge detector that's able of finding all the true edges in an image. Lots of conventional algorithms have been recommended to detect the edges such as Sobel, Prewitt, Roberts, and Laplacian. This paper presents the design of Laplacian Neural Network and convolutional neural network based edge detection methods. The proposed methods first determines the features used as the input to the supervised learning system, features are selected carefully for each input image. Next, Laplacian edge detector was utilized as the training for the proposed Back propagation Artificial Neural Network. The structure of the system is simple and defined by different features for the input images, number of neuron in the hidden layer, and the output layer. The suggested system applied on the tested images and produces subjectively accurate results in term of true\ false edges compared with Sobel, Prewitt, and classical Laplacian detectors.

Index Terms— Artificial Neural Network; Edge detection; Laplacian edge detector; Laplacian, Sobel, Kirsch.

I. INTRODUCTION

Numerous researches have been conducted on edge discovery or edge features detection for different sorts of image. Edge detection is a vital field in image processing. It can be utilized in numerous applications such as segmentation, certification, feature extraction, and recognizable proof of objects in a scene [1][6]. Edges contain important information of objects such as shapes and areas, and are often utilized to recognize diverse objects and/or isolate them from the foundation in a scene [13]. Edges are fast changes on the image profile. These speedy changes on the image can be recognized via traditional distinction filters which can be recognized using any image processing filters such as Laplacian, canny, kirsch, etc., the conventional strategies, firstly the mask cover are moved around the picture. The pixels which are the measurement of masks are prepared. At that point, unused pixels values on the modern image produce fundamental information about the edge [13][14]. Be that as it may, mistakes can be made due to the noise whereas the mask is moved around the picture [14]. In classic methods, noise impact is as insignificant as little for evacuating noise impact. In Laplacian strategy which is determined from classic strategy, image is decreased with the noise with spread to the surface and so, the

likelihood of error is decreased. But, for each strategy for adjusting mistakes, these filters are more sensitive to noise as a result of this state accessibility is ended up reduce at the classic channel [14].

Artificial Neural Network (ANN) has been effectively utilized in numerous computer-aided determination of medical imaging. Besides, medical picture segmentation and edge location remains a critical issue for all kinds of imaging applications, in which any computer helped determination will require edge detection combining with other methods [6]. Artificial neural systems give for a modern level of computation, completely unmistakable to the conventional Newman approach. With this unused perspective, one tries to apply the (so distant exceptionally constrained) information approximately what is running on within the brain to request advantage of the brain's tremendous computational control [12].

The back propagation algorithm was initially presented within the 1970s, but its significance wasn't completely acknowledged until 1986 [11]. Back propagation works distant speedier than prior approaches to learning, making it conceivable to utilize neural nets to illuminate issues that had already been insoluble. Nowadays, back propagation computation is the base for learning in neural techniques [2].

Many other techniques have been evolved for edge detection, such as active contour model, canny edge, detector graph theory, wavelet intensity gradient, and threshold [6], and Genetic algorithms (GAs) [19][20]. The motivation and innovation is empathized by applying the idea of implementing the Back propagation neural network method in combination with Laplacian edge operator to achieve accurate result in identifying edges. The structure of this paper is as follows: Section 2 presents related works. Section 3 describes edge detection operators. Section 4 describes the proposed supervised learning approach based edge detection Algorithm. Section 5 presents experimental results. Finally, conclusion and future work will be represented in Section 6.

II. RELATED WORK

Various conventional edge detection methods have been applied to detect edge in images, Laplacian operator can be defined as a second derivative operator normally used in edge discovery, Compared with the first derivative-based edge detectors such as Sobel operator, the Laplacian operator may surrender superior comes about in edge localization. Tragically, the Laplacian operator is exceptionally delicate to the noise [4]. It also can be useful for network security [21]. In [6], researchers presented artificial neural network based edge detection algorithm to identify MRI medical images, features used for the system are horizontal, vertical, and diagonal differences of the edges, and then canny edge detector was applied for system training.

In [17], authors introduce an edge detection method that depends on the integrating the denoising images with the existence of high impulse noise (or salt and pepper, they proposed switching adaptive median and fixed weighted mean filter (SAMFWMF) algorithm. The non-maximum suppression and new edge following maximum-sequence techniques have been used to track the edges and overcome edge discontinuities and noisy pixels, then several morphological operations have been used to remove noisy pixels and unwanted edges.

Researcher in [4] introduced an edge detectors model using Laplacian operator, and applied a Maximum a Posteriori (MAP) for obtaining estimate of edges. While researchers in [18], proposed a system for the adaptive selection of edge detection algorithms using the multi-criteria decision-making (MCDM) method and visual features of satellite images.

In [16], Authors suggested a method to solve the problem of classical category-agnostic edge detection, using the discussions of deep learning approach with semantic edge detection (SED). While artificial neural networks have been applied for edge detection based on the adaptive learning and nonlinear mapping characteristics, besides Fuzzy sets were employed during the training phase to improve the ability and performance of neural networks in [13].

To detect medical images also, researchers in [5] applied neural network and Laplacian edge detector for urinary bladder cancer diagnostic, and try to investigate the application of different neural methods. The suggested system introduces the best result when adjusting the input image into 50×50 and 100×100 images were used. Various researches have been investigated for edge detection using other artificial intelligence methods such as genetic algorithm [9], and fuzzy logic system besides hybrid artificial methodologies [10]. In [13] applied the fuzzy sets in the training phase to improve the general ability of multi-layer feed forward neural network algorithm, while researchers in [15] improved the method of detect edges from X-Ray images based on Gaussian filter and statistical range [15].

III. EDGE DETECTION OPERATORS

In this part, a brief explanation to the common traditional edge detection operators are presented which are Sobel, Prewitt, and classical Laplacian operators.

A. Sobel Operator

Sobel is one of the most commonly utilized edge locators. It is based on convolving the picture with a little, distinct, and numbers esteemed channel in a horizontal and vertical direction and is hence moderately reasonable in terms of computations. The result of an edge image generated by applying Sobel operator is shown in Figure 1(b).

B. Prewitt Operator

This operator is utilized for identifying vertical and horizontal edges in pictures. In any case, not at all like the Sobel, this operator does not put any attention on the pixels that are closer to the center of the mask. The result of an edge image generated by applying Prewitt operator is shown in Figure 1(c).

C. Laplacian Operator

The Laplacian edge detector utilizes one kernel mask. It calculates second-order derivatives in a single pass. The result of an edge image generated by applying Laplacian operator is shown in Figure 1(d).

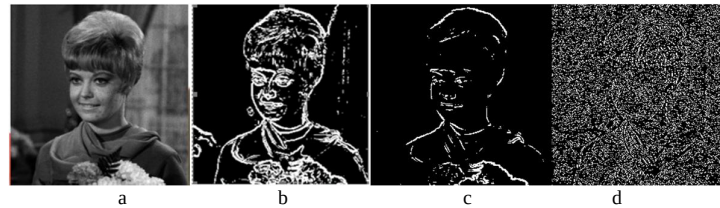


Fig. 1. Comparison of Various Edge Detection Algorithms. a) Original image, b) Sobel operator, c) Prewitt operator, d) Laplacian operator

IV. PROPOSED ANN BASED EDGE DETECTION ALGORITHM

The back propagation neural network experiences supervised training with a finite number of patterns. An input pattern is presented at the input layer. The neurons here pass the pattern digits to the next layer neurons, which are in a hidden layer. The outputs of the hidden layer neurons are obtained by using perhaps a bias, and also a threshold function with the activation determined by the weight and the inputs. These hidden layer outputs become inputs to the output neurons, which also process using possibly a bias and a threshold function with their activation to determine the final output from the network.

The computed pattern and the input pattern are compared, a function of this error for each component of the pattern is determined, and adjustment to weights of connections between the hidden layer and the output layer is computed. A similar computation, still based on the error in the output, is made for the connection weights between the input and hidden layers. The process is then repeated as many times as needed until the error are within a prescribed tolerance. This procedure is repeated with each pattern pair assigned for training the network.

V. EXPERIMENTAL SETUP

In this section, we have discussed methodology and components of proposed method for edge detection. This section is divided into two sub-sections; the training stage, and testing stage, for applying Laplacian Neural edge detection method for supervised learning.

A. Training Stage

In this stage, we determine the number of features specified for each input image used in this work, the selected gray images used are shown in Figure 2.

Presently, we considered the image that has most extreme features for learning the neural network, if the network not learned, we can retry the learning steps. Figure 3 shows the training samples convergence while Figure 4 represents error convergence, for the network.

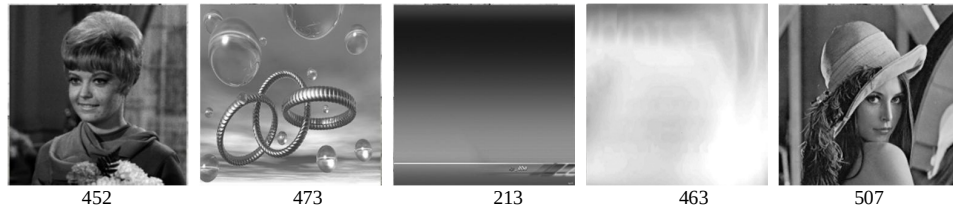


Fig. 2. The number of image feature defined for each input image. Each image represents the input image and the number below represents the number of features for that image

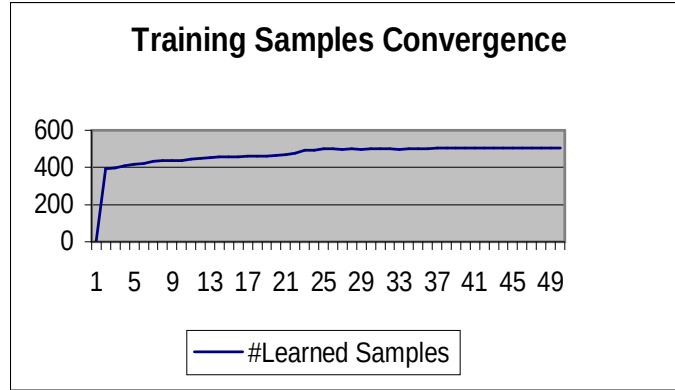


Fig. 3. Training samples convergence

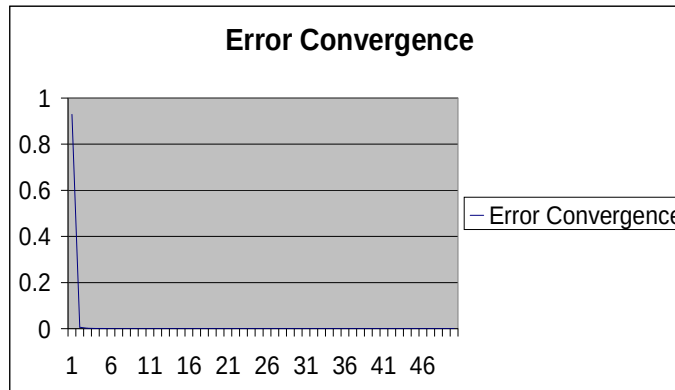


Fig. 4. Error convergence

B. Testing Stage

In this stage, the proposed method is examined for the input images and produces an edge for it. Figure 5 shows the results for number of images after executing the artificial Laplacian neural network edge detection method.

A comparison between each of the traditional methods separately, i.e. Sobel, Prewitt, and classical Laplacian with the proposed method are presented in figure 6, figure 7, and figure 8 respectively.

Also a comparison between the suggested method and other related statistical and neural network based edge detection strategies is presented in figure 9.

The true edges, and false edges as a result of applying these comparisons are introduced in Table 1, Table 2, Table 3, and Table 4 respectively.

From above comparisons, it is noticeable that Laplacian neural network method seems to be the best method as an average because the number of false edges is the minimum as an average and as well as the number of false edges reduces the methods becomes better but under the condition of the edges should be connected with no random edges along the picture, so, visually, the Laplacian neural network edges are better edges than the other methods and almost the edges are thin to indicate the existence of an edge rather than the thick edges that other methods produces.

TABLE I. TRUE AND FALSE EDGE FOR SOBEL OPERATOR AND PROPOSED METHOD

Image No.	Sobel method		Proposed method	
	<i>True edge</i>	<i>False edge</i>	<i>True edge</i>	<i>False edge</i>
1	2074	7762	2074	2051
2	5679	16741	5679	2796
3	304	1750	304	1089
4	0	4	0	2781
5	277	12168	277	1792

TABLE II. TRUE AND FALSE EDGE FOR PREWITT OPERATOR AND PROPOSED METHOD.

Image No.	Prewitt method		Proposed method	
	<i>True edge</i>	<i>False edge</i>	<i>True edge</i>	<i>False edge</i>
1	791	1416	791	3334
2	2664	5152	2664	5211
3	158	898	158	1235
4	0	0	0	2781
5	1534	4044	1534	3034

TABLE III. TRUE AND FALSE EDGE FOR CLASSICAL LAPLACIAN OPERATOR AND PROPOSED METHOD.

Image No.	classical Laplacian method		Proposed method	
	<i>True edge</i>	<i>False edge</i>	<i>True edge</i>	<i>False edge</i>
1	1422	12838	1422	2703
2	2600	16995	2600	5275
3	253	13218	253	1140
4	861	18161	861	1920
5	2048	12479	2048	2520

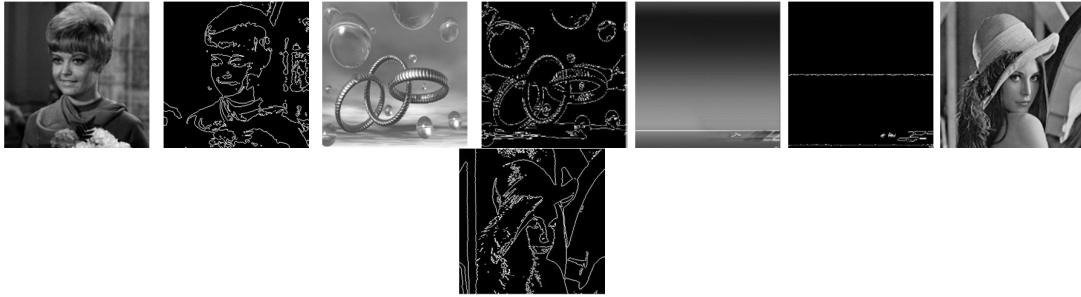


Fig. 5. Results of applying proposed Laplacian Neural method

VI. CONCLUSION AND FUTURE WORK

This paper has presented the design of Laplacian Neural Network based edge detection. The system first determine the features used as the input to the ANN. Features are selected carefully for each input image. Next, Laplacian edge detector was utilized as the training for the proposed ANN. The structure of the system is simple and defined by varying features for the input images, number of neuron in the hidden layer, and the output layer. Experimental results discover that the Back propagation had the best outcomes in training stage. The suggested system applied on the tested images and produces subjectively accurate results in term of true edges\ false edges compared with Sobel, Prewitt, and classical Laplacian detectors. Further research could be conducted on the use of Laplacian of Gaussian (LOG) with deep neural network based edge detection algorithm with other modalities.

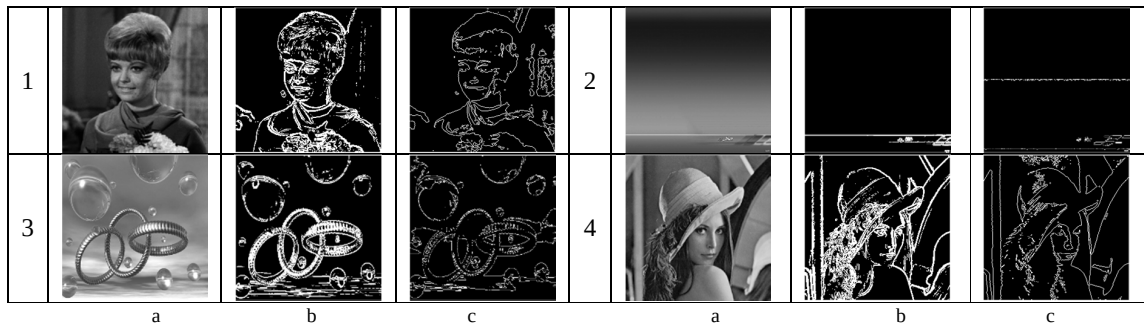


Fig. 6. Comparison between Sobel method and proposed method. a. input image, b. the result of applying Sobel operator, c. the result of applying proposed method

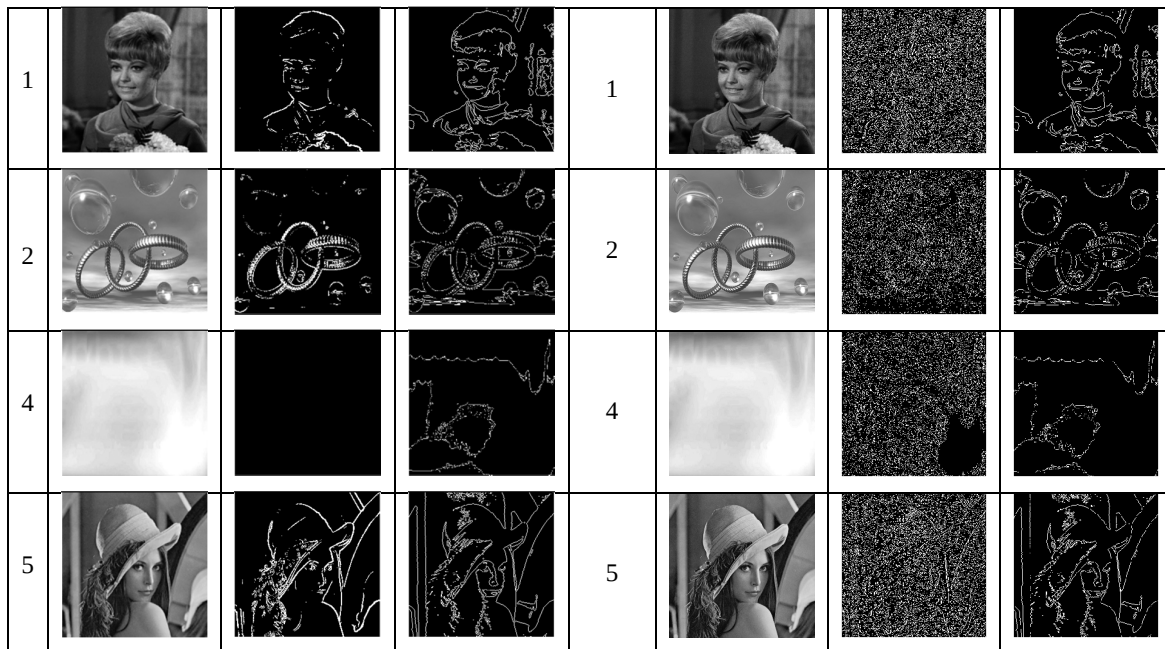


Fig. 7. Comparison between Prewitt method and proposed method. a. input image, b. the result of applying Prewitt operator, c. the result of applying proposed

Fig. 8. Comparison between classical Laplacian method and proposed method. a. input image, b. the result of applying classical Laplacian operator, c. the result of applying proposed method

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TABLE IV. COMPARISON WITH OTHER RELATED WORK

Reference number	Description	image	Reference number	Description	image
[13]	applied the fuzzy sets in the training phase to improve the general ability of multi-layer feed forward neural network algorithm		[15]	implemented Gaussian filter and statistical techniques for edge detection	
[14]	Used supervised neural network learning with momentum and Laplacian edge detector		proposed method	Utilized Laplacian Neural Network based edge detection. The system first determine the features used as the input to the ANN	

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