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An Efficient Approach for Edge Detection Technique using Kalman Filter with Artificial Neural Network

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ABSTRACT

Edge identification is a technique for recognizing and detecting sharper breaks in an image. The halt is caused by a rapid change in the value of the pixel force dark level. Convoluting the picture with an administrator (Two-Directional channel) that is set to be noise sensitive is the standard approach for edge location. Edge finder is a method for locating precisely adjusted intensity esteem alterations that incorporate many significant neighborhoods image preparation methods. Edge recognition is a fundamental method in a wide range of image processing applications, including movement analysis, design identification, object recognition, clinical picture creation, and so on. It's recently shown up in a variety of edge detection systems, demonstrating both the advantages and disadvantages of these computations. The Kalman Filter with ANN method has two benefits that make it suitable for dealing with improvement issues: quicker merging and lower calculation rates. In this study, The ANN method was used to improve object localization accuracy. Kalman filtering is used to object coordinates acquired using the ANN method. Using ANN + Kalman Filtering increases localization accuracy and lowers localization error distances, according to the findings.

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1. INTRODUCTION

One of the most challenging challenges in image processing is edge detection in advanced images. In image processing and computer vision, it is critical [1, 4]. Separating things from their experiences is one of the most difficult issues, equivalent to the usage of machine vision and example recognition. Edges define the zone of interest for items of interest, allowing them to be legally identified in low-level handling situations. Later stages of the processing were impacted by the precision with which the picture was appraised.

The ability of the edge detection approach to remove the precise edge line with great direction in the thought about image is a major characteristic of the technology, and much writing nerve identification has been disseminated in the last two decades. In any case, there isn't currently a large enough execution file to evaluate the edge detection algorithms' presentation.

Many computer-aided imaging systems employ Artificial Neural Networks (ANN) [2]. In addition, picture segmentation and edge detection remain a significant issue for all imaging applications, with edge recognition and other approaches such as snake modeling, watershed, contour detection and area growth being required by every computer-assisted system [2]. ANN has also been used to achieve segmentation and edge detection by utilizing its learning capabilities and training methods to categories pictures into content consistent areas. Because various users have different criteria for the similar image, edge detection algo are always assessed subjectively.

Despite the development of various image recognition methods, both the processing cost and the abstract image quality may be improved. In this vein, the

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goal of research is to present a efficient Artificial Neural Network based edge detection solution for a variety of images. Here you'll find highlights with flat, vertical, and skewed contrasts. At that time, the preparation yield will be a cunning edge detector. Finally, as updated parameters, we'll get the number of concealed layers and the yield edge. In terms of computation time, several well-known methods such as Canny, Sobel, Prewitt, Roberts, and the Laplacian of Gaussian will be compared (LoG) [3]. The proposed approach, according to the findings, enhanced image quality while lowering preparation time by several times. Currently, we feel that the solution to a development problem will be referred to as a Kalman Filter, which will excel in a high-quality issue environment [4]. As a result, the Kalman Filter attracts a larger number of collaborators, allowing for a more thorough examination of the search space.

We provide a new edge detection technique with the use of Kalman Filter algo and an Artificial Neural Network in this paper, along with comparisons to the Canny [5], Sobel [6], LoG, and Prewitt [7] techniques.

1. 1. Kalman Filter Algorithm (KFA) Kalman filtering is used to filter noisy data, produce non-observable states, and forecast future states. Because many sensor outputs are too noisy to use directly, filtering noisy signals is required, and Kalman filtering allows you to account for the signal/uncertainty. State's one of the most common applications of creating non-observable states is estimating velocity. On various joints, position sensors (encoders) are commonly employed; however, isolating the position to get velocity produces noisy results. Kalman filtering may be used to compute velocity to rectify this. The Kalman filter can also be used to predict future occurrences. This is critical if your sensor feedback has significant time delays, since this might cause motor control system instability [8].

Kalman filters provide the best approximation for a linear system. As a result, a sensor or system must have (or be close to having) a linear response in order to use a Kalman filter. We will go through how to work with nonlinear systems in the next sections. The Kalman filter has the benefit of requiring no prior knowledge of a long state history because it just utilizes the most recent state and a covariance matrix to estimate the likelihood of the state being accurate [9].

Remember that a covariance is merely a measure of how two variables correlate (that is, how they change in relation to one another) (the values aren't always clear), and that a covariance matrix simply gives you the covariance for a particular row and column value.

Before we get into the mechanics of the filter, let's go through some terminology to make sure we're all on the same page. The positions/velocities/values associated with the system are known as states. The components that you may modify to impact the system are known as actions or inputs. For the Kalman filter, there are two sorts of equations. The prediction equations are the first. Based on the prior state and the needed action, these equations predict the present state [10]. The update equations look at your input sensors, how much you trust each sensor, and how much you trust the overall state estimate in the second set of equations. This filter uses prediction equations to forecast the current state, and then uses update equations to assess how well it predicted. This procedure is repeated endlessly to maintain the existing condition [11].

The prediction equations are

$$X=Ax_{k-1}+Bu_{k-1} \quad (1)$$

$$p=APA^{T}+Q \quad (2)$$

And the update equations are

$$K = pH^{T} (HpH^{T}+R)^{-1} \quad (3)$$

$$x_{k} = X+K(z-HX) \quad (4)$$

$$Px_{k} = (1-KH)p \quad (5)$$

1. 2. Artificial Neural Network A neural network is a conceptual framework that uses connection weights to link important multi-processing features. The connection weights, which are changed throughout the training time, demonstrate understanding. The two forms of neural network training are unsupervised learning and supervised learning [12]. Both the input and target values must be used in the initial sample of the training set. Back propagation, which is employed in the Multi-Layer perceptron (MLP), is the most frequent technique in this category, although it also covers most of the training methods for thrust basis networks, recurrent neural networks (RNN)and time delay neural networks. When the objective pattern is not entirely understood, unsupervised learning is utilized [13].

2 PROPOSED METHOD

Traditional modeling methods, such as response surface technique, have been shown to be unsuccessful in

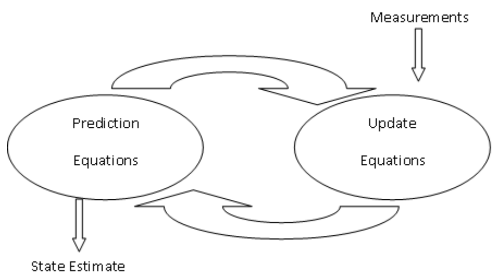

Figure 1. Kalman filter repeating process

accurately forecasting all QV values. For example, using a quadratic model to account for all interactions requires 44 terms, significantly complicating the procedure.

To complete the job, a multi-layer perceptron (MLP) artificial neural network (ANN) is used. After this phase, a recently found stochastic optimization technique must be used with the planned ANN to reduce QV and find the best set for each cutting condition [14].

2. 1. Artificial Neural Network

A neural network is a logical structure made up of several processing units connected by connection weights. The connection weights, which are changed throughout the training time, demonstrate understanding. Unsupervised learning and supervised learning are the two methods for training a neural network. Both the input and target values must be used in the initial sample of the training set. Back propagation, which is employed in the Multi-Layer Perceptron (MLP), is the most frequent technique in this category, although it also covers most of the training techniques fortime delay neural networks, thrust basis networks andrecurrent neural networks [15]. When the objective pattern is not entirely understood, unsupervised learning is utilised [13].

2. 2. Kalman Filter Algorithm (KFA)

The Kalman filter was created to address the problem of predicting the state of $x \in R^n$, a discrete time regulated process using a linear differential equation as its controller. The process measurement connection is not linear in most real-world scenarios. Using something like the 'I'aylor series, we may linear the estimation around the current estimate of the process and measurement functions of the non-linear process [16]. The process can be represented using a non-linear difference equation.

$$x_k = f(x_{k-1}, u_{k-1}, w_{k-1}) \tag{6}$$

with a measurement $z_k \in R^m$ that is:

$$z_k = h(s_k, u_k) \tag{7}$$

Using wk-1 as the driving function, the measurement Equation (7) connects the wk-1 measurement and measurement noise. The measurement equation's non-linear function h connects the state xk to the measurement z_k. For this sort of edge detection challenge, a variety of filters have been investigated. For the past three decades, Kalman filters have been used to solve the problem of target tracking. In 1960, the Kalman filter was proposed for the first time as an optimum linear estimator [17].

The best aspect of a filter is calculating the gain using a minimal variance equation, which gives the highest weight to the data (observation or predicted data) with the least volatility. The Kalman filter is a linear predictor. The filter is optimal only when the process to be assessed is linear. In nonlinear circumstances, the Kalman filter works poorly. When missile velocity and range were lower, Kalman filters could manage the problem, but as technology has evolved, missile velocity and range have increased, and air drag has become a key factor. As a result, their voyage has taken an unexpected detour. Before the Kalman filter can be utilized for tracking, it must undergo several changes. Several filters have been created to solve non-linear tracking problems in various applications, and research is now continuing to identify the best filter performance [18].

The kalman filter offers the following benefits over another well-known filter.

1. Although the kalman filter method may be implemented on a digital computer, when it was initially presented, analogue circuitry was used to estimate and operate the kalman filter.
2. The kalman filter's stationary characteristics aren't necessary for deterministic dynamics or random processes. Non-stationary stochastic processes are used in many important applications.
3. The kalman filter may be used to design state space optical controllers for dynamic systems. It benefits both the estimation and control characteristics of these systems.
4. The kalman filter requires minimum additional mathematical instruction for a modern engineering student.
5. The kalman filter offers information for recognizing and rejecting abnormal data using mathematically accurate, statistically based decision-making approaches.

The complete flowchart is given as follows,

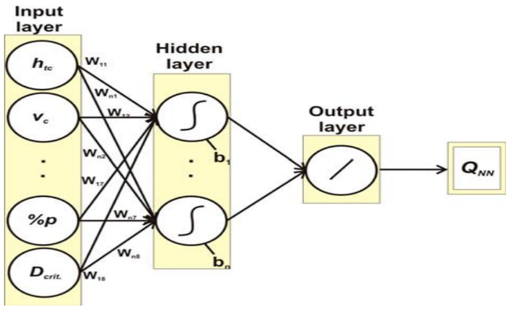

Figure 2. ANN architecture

3. EXPERIMENTAL RESULTS

In the figures below, you'll find comparisons of the performance of KFA and KFA+ANN on various pictures, as well as comparisons of the two approaches:

Figure 4(a) KFA edge detection is shown in (a), proposed method (KFA + ANN) edge detection is shown in Figure 4(b), and suggested algorithm (KFA + ANN) edge detection is shown in Figure 4(c).

The original grayscale image of "Modiji" is shown in Figure 5(a), whereas Figure 5(b) exhibits edge detect

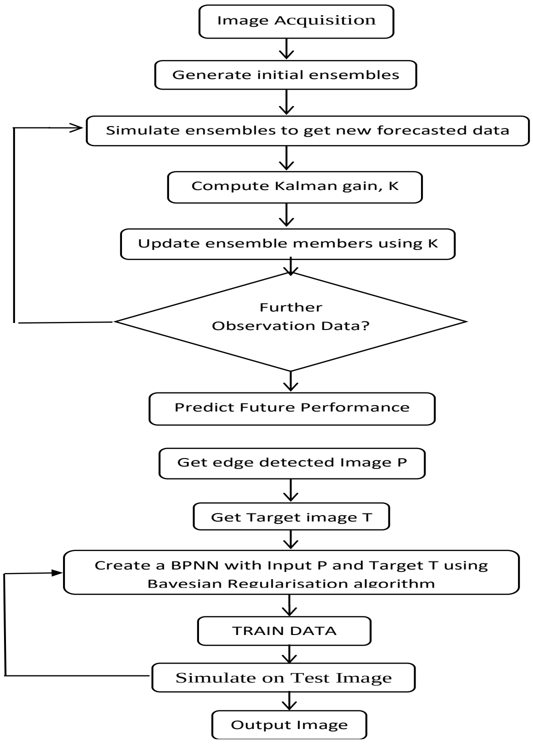

Figure 3. Proposed algorithm flow chart

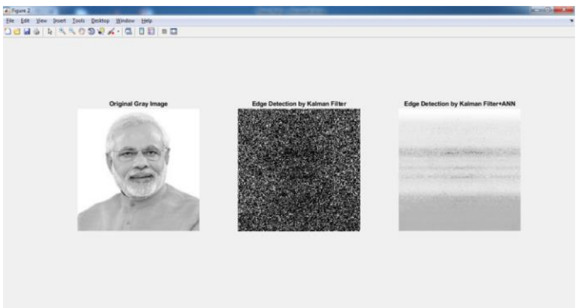

Figure 4. Edge detection using KFA and KFA+ANN

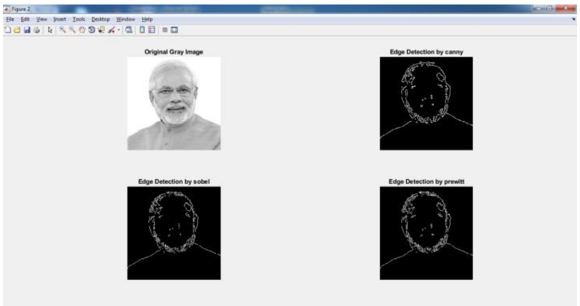

Figure 5. Result Comparison of classical edge detection methods and novel method

using the Canny method. The edge detect by the Sobel method is shown in Figure 5(c), whereas the edge detection by the Prewitt method is shown in Figure 5(d).

The original grayscale picture of 'Lena' is seen in Figure 6(a). Figure 6(b) KFA edge detection is shown, and Figure 6(c) recommended algorithm (KFA + ANN) edge detection is shown.

Figure 7 (a) depicts "Lena's" original grey picture, whereas Figure 7(b) depicts edge detection using the Cannymethod. The edge detection by the Sobel methodis shown in Figure 7(c), whereas the edge detection by the Prewitt methodis shown in Figure 7(d).

Figure 8 shows the grey image(a), KFA edge detection Figure 8(b), and proposed algorithm (KFA + ANN) edge detection Figure 8(c).

The original grey image of the 'building' is shown in Figure 9(a), whereas Figure 9(b) features Canny method. Figure 9(c) shows the edge detection by the Sobel method, whereas Figure 9(d) shows the edge detection by the Prewitt method Figure 9(d).

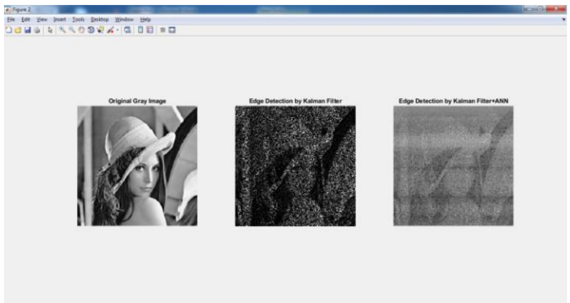

Figure 6. Edge detection using KFA and KFA+ANN

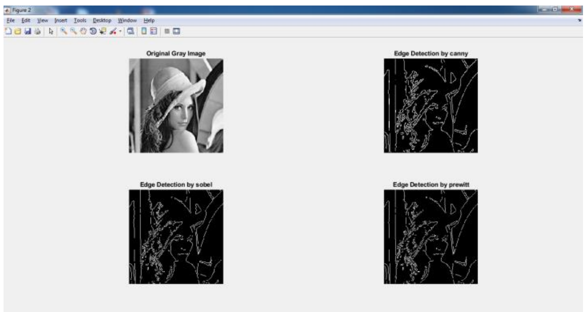

Figure 7. Result Comparison of classical edge detection methods and novel method

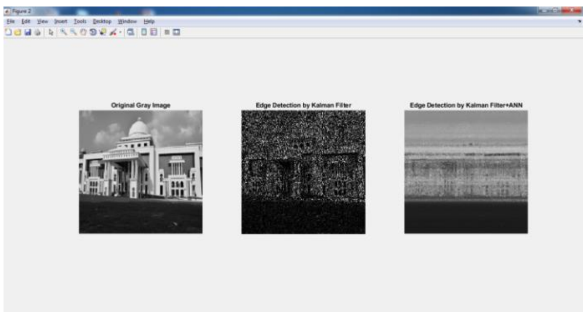

Figure 8. Edge detection using KFA and KFA+ANN

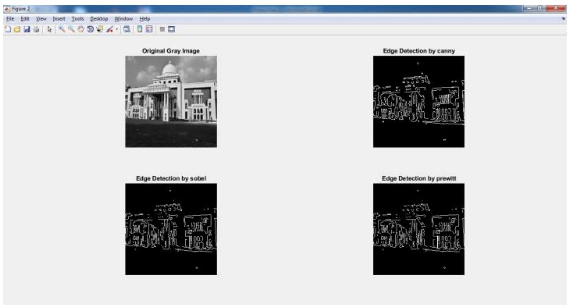

Figure 9. Result Comparison of classical edge detection methods and novel method

Figure 10(a) illustrates the 'Baboon's' original grey picture, Figure 10(b) KFA edge detection, and Figure 10(c) recommended algorithm (KFA+ANN) edge detection.

Figure 11(a) depicts the 'Baboon's' original grey picture, whereas Figure 11(b) depicts edge detection using the Canny edge detector. The edge detection by the Sobel edge detector is shown in Figure 11(c), whereas the edge detection by the Prewitt edge detector is shown in Figure 11(d).

We utilized the peak signal to noise ratio (PSNR) approach to objectively evaluate our findings; the higher the PSNR value, the better the reconstructed picture quality.

$$PSNR = 10\log_{10}\frac{(L-1)^2}{\frac{1}{MN}\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}[E(r,c)-o(r,c)]^2} \quad (8)$$

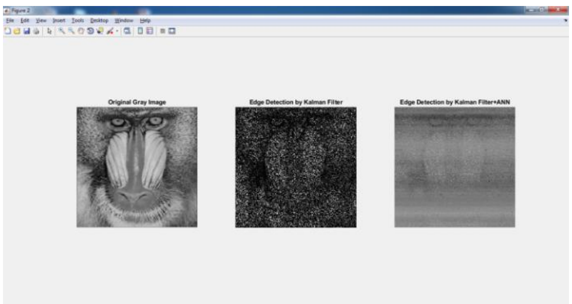

Figure 10. Edge detection using KFA and KFA+ANN

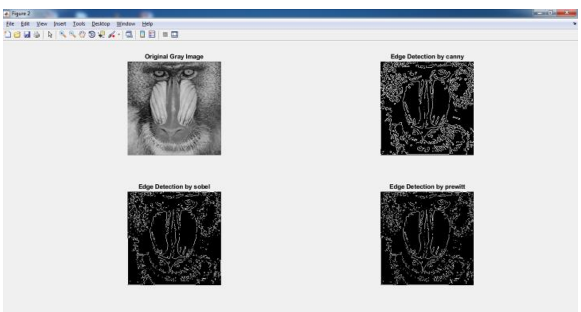

Figure 11. Result Comparison of classical edge detection methods and novel method

where E(r,c) stands for the original image, o(r,c) for the result, L for the number of grey levels equal to 256, [M,N] for the number of rows and columns of pictures, and L for the number of grey levels equal to 256.

In addition, the root means square error (rmse) As seen below, the lower the rmse value, the higher the reconstructed picture quality:

$$\mathrm{RMSE}=\sqrt{\frac{1}{\mathrm{MN}}\sum_{\mathrm{r}=0}^{\mathrm{M}-1}\sum_{\mathrm{c}=0}^{\mathrm{N}-1}[\mathrm{E}(\mathrm{r},\mathrm{c})-\mathrm{o}(\mathrm{r},\mathrm{c})]^2} \quad (9)$$

Tables 1 and 2 show the results of the PSNR and RMSE methods used to analyse the image. The assessment findings reveal that in the great majority of situations, edge detected pictures are superior. It also demonstrated the suggested technique's capacity to identify edges.

4. PROS AND CONS

The "layers" of an ANN are rows of data points that all neurons in the same neural network share. ANN uses weights to learn. After each cycle across the neuron, the weights of ANN are changed. The weights are subsequently adjusted by ANN according to the accuracy assessed by a "cost function." Using the image input, several features are discovered and connected to the n-dimensional output. The user can then receive the classification output. To test the efficacy of the models created to improve learning, ANN methods employ error measures and epochs. A good approach for dealing with

TABLE 1. The recommended technique is compared to the Kalman Filter Algorithm, the 'Canny', 'Sobel', and 'Prewitt' approaches using PSNR and RMSE criteria

PSNR	Proposed Work (KFA+ANN)	Kalman Algorithm	Canny	Sobel	Prewitt
Modiji	13.4481	6.2853	4.8506	4.8475	4.8547
Lena	13.6274	9.1830	7.6232	7.6597	7.6595
Aktu	15.4916	9.5200	8.0088	7.9867	7.9977
Baboon	14.7841	8.2100	7.0728	6.9720	6.9676

TABLE 2. The recommended technique is compared to the Kalman Filter Algorithm, the 'Canny', 'Sobel', and Prewitt' approaches using RMSE criterion

RMSE	Proposed Work (KFA+ANN)	Kalman Filter	Canny	Sobel	Prewitt
Modiji	0.1330	0.3895	0.4831	0.4833	0.4828
Lena	0.1295	0.2522	0.3187	0.3170	0.3170
Aktu	0.0979	0.2398	0.3008	0.3018	0.3013
Baboon	0.1089	0.2919	0.3461	0.3514	0.3516

data-related difficulties is artificial neural networks (ANN). Forward-facing algorithms can be used to process image, text, and tabular data. You'll need to use a variety of data augmentation strategies to widen the scope of your data in order to achieve the same level of data processing accuracy as an ANN. Indirectly, ANN may discover complex nonlinear relationships between dependent and independent variables. ANN still reigns supreme in instances when there are few datasets and no requirement for image inputs.

5. CONCLUSION AND FUTURE SCOPE

In this paper, we used the Kalman Filter technique to provide an unique filter, KFA+ANN, for edge detection of grey level images. In the recommended approach, we employ a basic photo and its edge map to construct a new filter. The projected filter may be used on a range of images and evaluated using a number of different criteria. The obtained results, as well as subjective and objective assessments, indicate the usefulness of the recommended filter in edge detection. In this work, shown that using the ANN method, object localization accuracy was shown to improve. Kalman filtering is used to object coordinates acquired using the ANN method. Combining ANN with Kalman Filtering increases localization accuracy and decreases error distances, according to the findings.

Despite the fact that there are various methods for recognizing image edges, deciding which one is appropriate for the image content can be difficult due to the numerous elements that impact the selection. The proposed technique should be utilized to verify edge detection algorithms' evaluations if pictures with varying content have high criterion values and weights. More artificial neural network approaches will be used in the future to investigate the indoor localization of moving persons. To increase positioning accuracy even more, the object coordinates of these approaches will be subjected to Kalman filtering.

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Persian Abstract

چکیده

تشخیص لبه یک تکنیک برای تشخیص شکستگی های واضح تر در یک تصویر است. توقف ناشی از تغییر سریع مقدار سطح تاریک نیروی پیکسل است. متداول کردن تصویر با یک مدیر (کانال د جهته) که به نویز حساس است رویکرد استاندارد برای مکان لوبه است. Edge Finder روشی برای مکان یابی تغییرات شدت و شدت تنظیم شده است که بسیاری از روشهای آماده سازی تصویر در محله های مهم را شامل می شود. تشخیص لبه یک روش اساسی در طیف گسترده ای از برنامه های پردازش تصویر از جمله تجزیه و تحلیل حرکت ، شناسایی طراحی ، تشخیص اشیاء ، ایجاد تصویر بالینی و غیره است. اخیراً در انواع سیستم های تشخیص لبه نشان داده شده است که مزایا و معایب این محاسبات را نشان می دهد. فیلتر کالمن با روش ANN دارای دو مزیت است که آن را برای مقابله با مسائل بهبود مناسب می کند: ادغام سریعتر و نرخ محاسبه کمتر. در این مطالعه ، از روش ANN برای بهبود دقت محلی سازی شی استفاده شد. فیلترینگ کالمن برای شیء مختصات به دست آمده با استفاده از روش ANN استفاده می شود. بر اساس یافته ها ، استفاده از فیلتر ANN + Kalman دقت محلی سازی را افزایش می دهد و فاصله خطاهای محلی سازی را کاهش می دهد.