

Efficient object detection technique using DWT based on deep learning

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Abstract

Artificial intelligence has great merit in solving many problems, such as the problem of distinguishing objects, distinguishing faces, and vehicles to determine vehicle plate numbers. With the help of image enhancement through noise reduction and image compression, the deep learning process is improved and better results are achieved. This is done by deriving new discrete wavelets from polynomials, especially Hermite polynomials (HP), to arrive at the discrete Hermite wavelet transform (DHWT) by relying on the mother wavelet and arriving at a new Hermite filter to be analyzed. Input image, denoising and image compression, with the help of the new filter, the most important quality standards were achieved, the most important of which were the amount of error, signal noise, number of pixels, and amount of compression. The new filter was used in the convolution process to build the convolutional neural network to complete the deep learning phase with the new wavelets to achieve improvement so that the new and fast algorithm was built to detect objects where the best results were achieved with 98.44% accuracy in 30 seconds.

Key words and phrases: Accuracy, Artificial Neural Network (ANN), Discrete Hermit wavelets Transform (DHWT), Object detection.

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1 Introduction

With the help of artificial intelligence and the creation of convolutional neural networks with deep learning, an important application has been achieved in many areas of daily life, including controlling roads and traffic through identifying vehicle plates, identifying people, and recognizing the face with its parts and facial emotions [1]-[3].

The classification process was implemented with the MATLAB program for face recognition, with training of deep learning neural networks. Here, institutions such as airports and security departments are served with training of the famous networks, Google Net, Alex Net [4]-[6]. Discrete wavelets emerged in the field of artificial intelligence after deducing the filter from polynomials with mathematical conditions achieved to perform the convolution process and building a convolutional neural network with discrete wavelets and results were achieved for face identification [7]. In addition to the role of discrete wavelets in image processing, after creating the filter and the important algorithm for adding it to the MATLAB program, good results were achieved for measuring the most important quality standards for the color image after removing noise from the image and compressing it [8]-[10]. As for applying watermarks with the help of discrete wavelets in [11]-[12], the filter is used in the image processing program with watermark immersion, where good results were achieved.

There are also some medical applications. The algorithm was implemented in artificial intelligence with discrete wavelets to form convolutional networks for deep learning. The identification and detection of kidney stones was achieved with good accuracy.

In this paper, we propose a new discrete wavelet DHWT derived from Hermite polynomials (HP) using mathematical equations. After verifying orthogonality and convergence, the new filter was derived and added to the MATLAB program through an algorithm to process the image for the application to reach the best results for the image quality criteria, which is PSNR, MSE, BPP, CR. Afterwards, taking the resulting image from the initial stage, the convolutional neural network was created with the new discrete wavelets DWCNN so the new and fast algorithm in deep learning was created to identify objects in the processing stage. Based on the results that were reached in the initial stage, an accuracy of 98.44% was reached in 30 seconds showing the efficiency of the proposed algorithm.

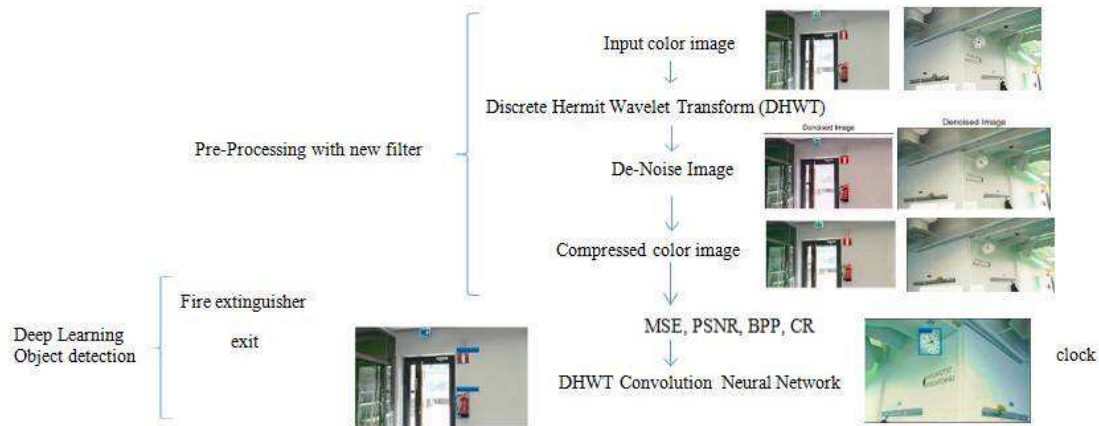


Figure 1: The efficiency stages of the new filter to improve the color image and introduce it to the convolutional neural network to detect objects in the input image.

2 Research Scheme

This work is divided into two stages. The first stage is the initial processing process in which a new filter is derived using mathematical equations starting from Hermite polynomials so that a new discrete Hermite wavelet is derived. With the help of this new filter, the input image is analyzed so that the noise is eliminated. Then the image is compressed so that the most important information is recorded. Image quality standards as shown in Figure 1.

As for the second stage, the convolutional neural network is trained with the new filter, so that the convolution process is completed to form the input layer, the hidden layers, and the output layer, completing the process of classifying objects in the image, and identifying the objects using the deep learning method.

2.1 Wavelet Transform

Wavelet technology is one of the important technologies in many applications, such as applications that depend on frequency and time, including image analysis, forecasting of weather changes, radars, and the field of artificial intelligence.

Through traditional mathematical methods, the new wavelets are derived from Equation 2.1 based on the coefficients (g, h) causing contraction and

expansion

$$\omega_{g,h}(x) = |g|^{\frac{1}{2}} \omega \left[\frac{x-h}{g} \right] \quad g, h \in R, \quad r \neq 0 \quad (2.1)$$

The basic role of wavelets in their work as a filter, with the help of frequencies, is to analyze the image or signal from these wavelets or filters as Haar, Daubechies, Coiflet, Symlet, and Biorthogonal, etc.

2.2 Proposed Discrete Wavelet Transform Technique

The proposed filter will be derived based on Equation 2.1 after changing the variables. The property that the wavelet has due to the operators g and h is expansion and contraction. The roles will be exchanged because the operators u and v here are with the variable t below are the most important transfers that are made to obtain the filter. Let $h = 2^{-(r+1)}$ in dilation wave and by $h = 2^{-(r+1)}(2u - 1)$ with translate x in Equation 2.1 will be $x = 2^{-(r+1)}(2^r t)$ then (Equation 2.2) represents the new Hermite wavelets:

$$\varphi_{u,v}(t) = \begin{cases} 2^{\frac{x}{2}} H_v^*(2^{r+1}t - 2u + 1) & t \in \left[\frac{u-1}{2^r}, \frac{u}{2^r} \right] \\ 0 & \text{otherwise} \end{cases} \quad (2.2)$$

$$H_v^* = \frac{1}{2^v v! \sqrt{\pi}} H_v \quad (2.3)$$

$$v = 0, 1, 2, \dots, V - 1, \quad u = 0, 1, 2, \dots, 2^r$$

2.3 Detect objects with new filter DHWT with deep learning

After analyzing the image and arriving at image quality standards, the resulting image is entered to begin the convolution process to train the convolutional neural network with wavelets DWCNN in deep learning.

2.4 Deep learning with discrete wavelets for convolutional neural network (DWCNN)

The weight function is responsible for generating layers in deep learning and the artificial neural network after entering information about the objects to be detected thanks to artificial intelligence with the new filter DHWT and with high accuracy and speed in the process of detecting objects based on

frequency and time after raising the noise and pressure for the two applications after introducing the new filter to the convolutional neural network. To create a new neural network (DWCNN), to create the input layers, and after entering the weights, the hidden layers are created, and the output layer is created, so that the result is the detection of objects.

Following are the two of the most important mathematical equations involving the three variables (n_H, n_W, n_c) in training the DWCNN network with the new filter ($K = 1$ starts the convolution process):

$$C(Y, Z)_{e,f} = \sum_{i=1}^{n_H} \sum_{j=1}^{n_W} \sum_{Z=1}^{n_c} Z_{i,j-Z} Y_{e+i-1}, Z \quad (2.4)$$

To obtain the number of channels by adhering to the dimensions above, the merging process begins from here:

$$\dim(C(Y, Z)) = \left(\left[\frac{n_H + 2P - R}{S} + 1 \right], \left[\frac{n_W + 2P - R}{S} + 1 \right] \right), S > 0. \quad (2.5)$$

Letting $S = 1$, the right-hand side of Equation 2.5 reduces to $(n_H + 2P - R + 1, n_W + 2P - R + 1)$.

2.5 Object detection algorithm with DWCNN

The advanced technology in detecting objects with the proposed algorithm and the MATLAB program with the new filter DHWT is responsible for obtaining good results for the proposed application to be detected fire extinguisher, exit and clock.

Enter the two applications required to detect objects.

Step 1: The process of analyzing the image of the two applications entered with the new filter DHWT so that the transactions are divided into two parts, approximate and detailed.

Step 2: In this step, the process of removing noise from the image is carried out so that the resulting image is taken and compressed after adding the new filter in the MATLAB program.

Step 3: Recording the most important quality standards for the resulting image, which are MSE, PSNR, BPP, CR so that the resulting image is taken and transferred to the deep learning stage.

Step 4: Input the color image resulting from the three-channel compression process RGB to complete the convolution process with the new filter, which represents the input layer. The network is called DWCNN.

Step 5: The feature extraction and classification process to detect objects using MATLAB.

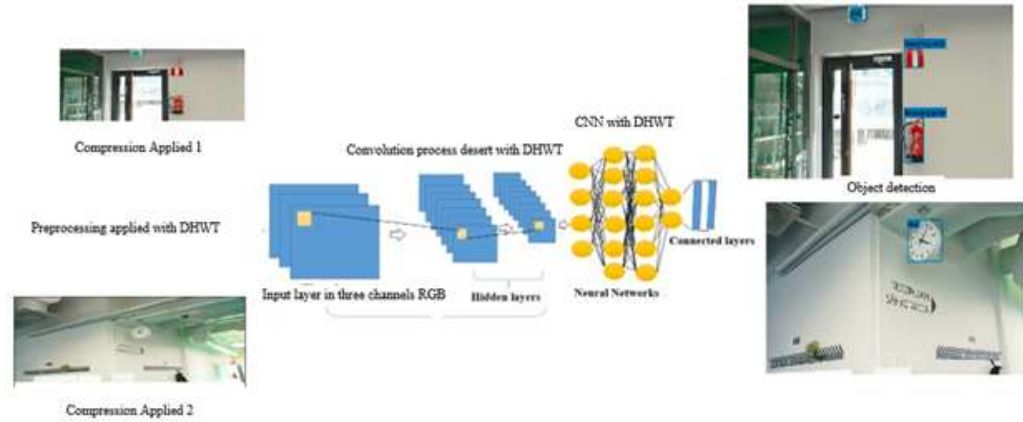


Figure 2: Deep Learning Object Detection theory with the help of the new filter DWCNN .

Figure 2 shows the items that were detected in different proportions such as a fire extinguisher, a chair, a watch, a trash can, and a printer.

3 Conclusion

One of the most important technologies in the field of artificial intelligence, and in particular deep learning, is the technology of identifying objects due to its importance in daily life like movements of vehicles and recycling some garbage items. This work was carried out in two stages. The first stage relied on building the new filter derived from Hermite polynomials based on the basic wavelet equation to derive the DHWT through which the image for the proposed application was processed to remove noise from it and compress it with the MATLAB program to achieve the best results for image quality standards to be achieved. Directing this filter to create a convolutional neural network in order to form a new network, which is DWCNN. Here the role of deep learning begins to form the hidden layers. After configuring the algorithm in the MATLAB program to identify objects, the objects are identified in the place in question and the level of accuracy 98.44% is reached in only 30 seconds.

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