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Single Image De-Raining using Supervised CNN Model

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Abstract: ***An image captured in rain reduces the visibility quality of image which affects the analytical task like detecting objects and classifying pictures. Hence, image de-raining became important in last few years. Since pictures taken in rain include rain streaks of all sizes, single image de-raining is becoming much difficult issue to solve, which may flow in different direction and the density of each rain streak is different. Rain streaks have a varied effect on various areas of picture, and hence it becomes important for removing rain streak from rainy pictures as rainy images tend to lose its high frequency information; previously many methods were proposed for this purpose but they failed to provide accurate results. Hence we have studied and implemented a supervised machine learning method using convolutional neural network (CNN) algorithm to get more accurate result of rain streak removal from an image captured during rain and in less elapsed time by preserving high rated information of image during removal of rain streak.***

Keywords: CNN, elapsed time, single image de-raining, supervised machine learning, rain streaks.

I. INRODUCTION

Processing as well as interpretation of videos and pictures captured under bad weather conditions like rain, snow, haze, etc. is required for several operational computer vision-based system, like surveillance and autonomous driving. Such weather-related variables have a negative impact on image quality and, as a result, vision system performance is frequently harmed. Consequently, its essential to develop methods for automatically eliminating these artefacts before sending them to a vision-based system for additional processing. Rain streak eradication or picture de-raining is difficult issues because rain streaks in a wet photograph may differ in size, orientation, and density. Because of the presence of rain streaks, in the rain, high frequency information is more likely to be lost, resulting in poorer picture quality.

Image categorization, detection, and segmentation all need high-quality pictures to be successful. As consequence, computer vision now relies heavily on removing rain streaks. Recent years have seen a slew of methods for eliminating rain streaks with singular pictures displayed. Models with different priors or sparse dictionary learning are used in these strategies. Despite the fact that these models have made significant progress in some areas, there is still a lot of potential for improvement. Several deep learning methods for eliminating rain streaks have been presented due of powerful feature representation. The majority of available approaches, however, have two major drawbacks.

Deep convolutional neural networks are being used by certain solutions as starting point for removing complex effect of rain streaks. Consequently, final results are poor due to fact that training process is hampered by irrelevant information in pictures. Second, deep learning techniques fail when an object's form and size are comparable to rain streaks, resulting in overly smoothed results. Existing neural network-based techniques for de-raining single images provide poor results, such as they lack to provide accurate streak removal compared with modern day machine learning technique. Also if this method tries to check the multiple rain streaks in the image, the process takes lots of time and the analyses of process is also tedious one. Image de-raining or removing rain streaks is a tough task; hence to solve this problem we have implemented a method based on supervised machine learning algorithm, with this we can remove multiple rain streak from rainy pictures and to have processed high quality de-rained images. The main objective of our work is to study and implement a system for removing rain streak from rainy image by preserving image high frequency information such as sharp edges, lines, contours and so on. To do so we need an a new and improved method, edge detection or picture pattern detection may both be accomplished using this technique. Hence we have planned to study and implement single image de-raining using CNN (convolutional neural network) based technique with the hope that it is going to yield high accuracy and less computation time.

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II. RELATED WORK

Removing rain or rain streaks by single picture has been approached in number of ways. Detailed review of these approaches is shown in this section. In [1], a Scale-free single image de-raining method is proposed by using visibility-enhanced recurrent wavelet learning, which addresses the problem of Even with huge rain streaks and its build up, rain may be removed from a wet picture. Hierarchical wavelet representation is used in rain removal method to deal with streaks of varying sizes, and dilated remnant dense network is used as foundation for procedure. Uncertainty-guided Multi-scale Residual Learning (UMRL) network is suggested in [2] to deal with problem of rainy images containing different size of rain streaks, flow of rain streak in different direction and rain streaks with different density by Rain content is studied at several scales to anticipate final outcome of rainy picture, they also uses a technique called cycle spinning for training and testing purpose to have improvised final output. In [3], a deep detail network called convolutional neural network (CNN) is proposed for removing rain streak by single rainy picture and for making learning process easier by the input-output mapping range is being shrunk. This paper uses a priori domain knowledge for improving results of de-raining .they trained the network on synthetic data. In [4],a semi-supervised learning method is suggested for removing rain from image with labelled and unlabelled training dataset, this method uses the machine learning technique but for the training purpose feature extraction plays a very important role as it gives the complete features of the images for the training module which will make the module more robust in de-raining purposes. In [5], DID-MDN (Density-aware single image de-raining using a multi-stream dense network) with convolutional neural network based system is suggested for addressing issue of singular rainy picture containing non-uniform densities of rain streaks. This method collectively is used for estimating intensity of rain and for de-raining. The technique described in this article allows network to identify density of rain and eradicate rain from pictures taken under wet conditions on its own. In [6], it proposes a patch-based prior approach for picture and rain backdrop layers. They uses prior layer based on Gaussian mixture model for removing rain streak within singular picture qualitatively and quantitatively. Into [7], a novel framework has been proposed by utilizing local phase information identify and eliminate rain from video. Phase congruency characteristics are utilized in framework's initial step to identify rain. Second stage of framework utilizes the information from three different sources for removing the rain from the rainy images. In [8], for detection and removal of rain, a multi-task architecture is suggested from single image. This paper also uses binary map to get the rain streak locations which consist of rain streak layer and back ground layer. This paper also suggested recurring rain detecting and elimination network for solving the problem of handle rain streak accretion and variation in rain streaks overlapped in various shapes and orientations. In [9], this paper proposed an image decomposition method for automatically removing rain streak from single image. Suggested technique uses bilateral filter to divide picture into two pieces, one for low frequency and other for high frequency. The rainy and non-rainy parts of high frequency portion are further decomposed using sparse coding. After this rain streaks are removed by preserving its original features. In [10], this paper proposed a adversal network which is attentive and generative for removing rain drop from single image. In [11], hierarchical approached is proposed to remove of snow and rain by singular color picture. In [12], a Fast Derain network is suggested to remove rain from video by using directional gradient priors.

III. METHODOLOGY

Our research focuses on eliminating rain streaks from images shot in the rain using a powerful machine learning method called the supervised machine learning CNN algorithm. In supervised learning, CNN model is trained utilizing labeled dataset, and model adapts regarding every kind of input. Model is tested utilizing test data once training process is finished. (training set's subset), and it predicts image details such as the number of rain streak in picture taken in rain, the image's background, and the information it contains. The entire system can also be used for de-raining, so the module must first be pre-processed, trained, and tested using several images. Once the module has been trained, it can be used to remove streaks. In pre-processing, unwanted information is removed, training is done using CNN, and finally testing is done to check the rain streak removal from a given image.

Figure 3.1 displays the block diagram in its most basic form, The given raw data (rained images) is converted into clean image data by removing unwanted information from the image, and then that clean image data is passed to the training section, where it trained the large amount of data (rainy images with reference images) using the supervised learning algorithm CNN (convolutional neural network), which helps for reducing pictures in an arrangement which can be easy for further processing. After the images have been trained, testing is carried out to obtain results.

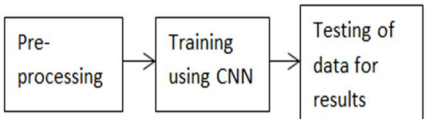

Fig.3.1. Basic block diagram of our work.

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A. Algorithm Used

We use a big amount of data for training purpose; hence we need an algorithm (CNN) that can handle enormous datasets.

As shown in Figure 3.2, a CNN consists of three layers: input, output, and hidden layers such as convolutional layer, ReLU (rectified linear unit) layer pooling levels, and completely connected Neural Network.

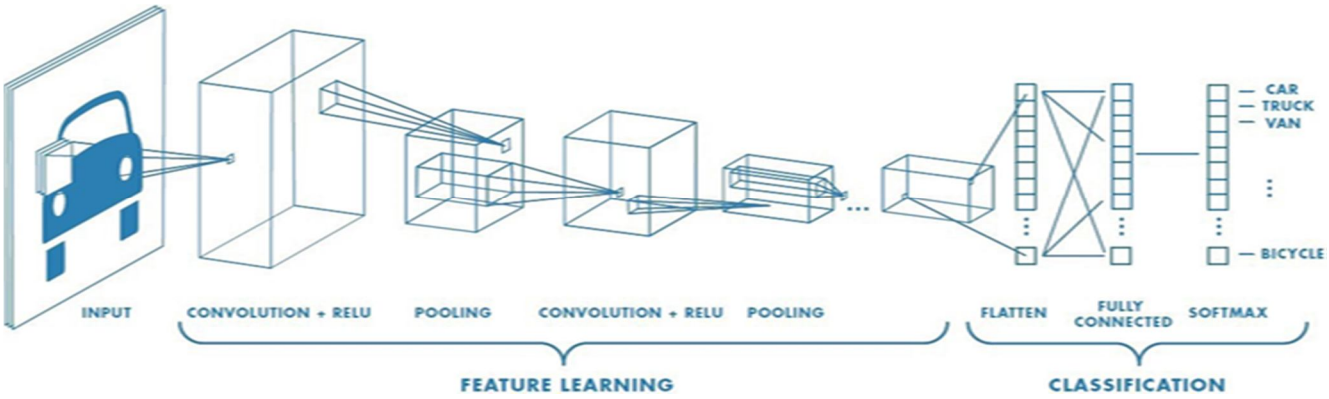

Fig.3.2. Process of Convolutional Neural Network.

Grayscale picture could be used as input for convolution layer, which will extract characteristics like as edges and interest spots from the image.

1) *Convolutional Layer:* A convolutional neural network's building block is the convolutional layer. The filter layer of the convolution layer is used to filter the image pixels. The overall aim of convolution process is retrieving high-level features from picture. When designing a neural network, it is always possible to use more than one convolution layer, with the first layer capturing gradients and the second layer catching edge. Option of layer relies upon intricacy of picture consequently there is no wizardry number upon the number of layers is to added.
2) *ReLU:* it is the process which applies an activating operation to have high non-linearity of networks without damaging receptive field of convolutional layer. It also helps in faster training of the data by skipping some hidden layers.
3) *Pooling Layer:* It is the process in which upon a convolved feature, non-linear down-sampling is utilized also sometime known as activation map. Pooling layer is used mainly to deduct the computational complexity; it is required when there is huge amount of data linked to an image. After pooling is done the output should be molded into A tabular structure that artificial neural network may utilise to accomplish categorization.
4) *Fully Connected Layer:* It forestalls over fitting by lessening the connection between neurons by using all activation maps during the test stage.

B. CNN Based Block Diagram

Figure 3.4 shows the methodology of our work which is based on CNN model with a labeled data set as shown in figure 2. In total ,our methodology works by training a huge amount of data set ,the dataset consist of images which is captured in rain along with its ground truth. Then this dataset is trained using convolutional network which extract the features of images and remove unwanted information present in the image and by using ReLu we can skips the several hidden layer in training to have faster computation. After training is done testing is done to have our output with removing of rain streak by rainy image.

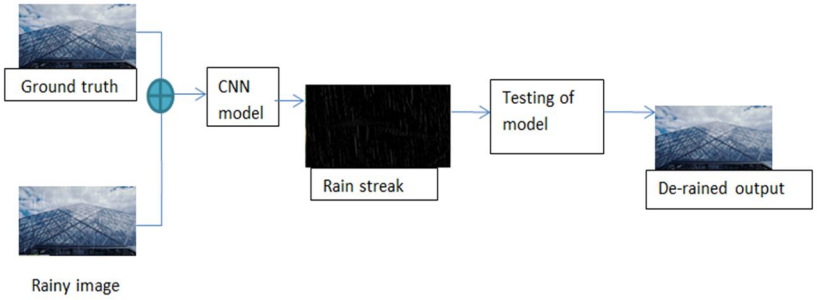

Fig.3.3. CNN based block diagram

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IV. MODEL DESIGN

The figure 4 shows the design steps of our work project ,where firstly rainy image dataset is taken as an input and then by aid of convolutional neural network dataset features being extracted which aims for reducing dimensions of image by discarding the less important features from the dataset and creating new features from the existing ones; after this it passes to residual layer is applied for rain streak to maps the identity ,weights and biases to fit the actual value ;then it passes to encoding and decoding techniques, where encoding is the process of converting given image Encoding is process of converting data into specific picture for safe transmission, while decoding is process of extracting information from transformed image ; afterwards extracting data it gives de rained image from which we extract a final processed image with removal of rain streaks.

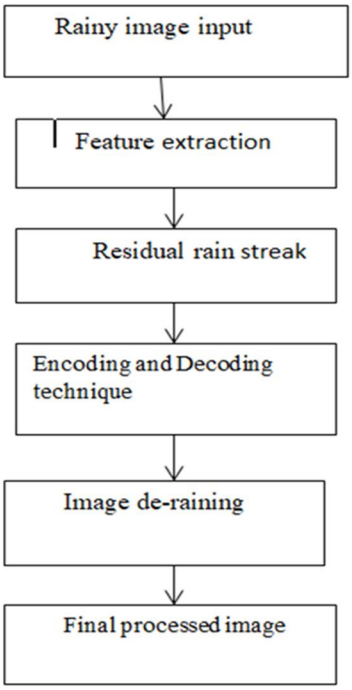

Fig.4.1.Design steps

V. RESULTS AND DISCUSSION

Following fig 5.1 and 5.2 shows the results of our implemented work such as rain streak removal from the single rainy image. Where figure (a) and (b) are input, figure(c) and (d) are output.

Fig a)ground truth image Fig b) rainy image

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Fig c) Rain streaks Fig d) De-rained image

Fig.5.1.Single Image De-raining using CNN

Fig a)ground truth image Fig b) rainy image

Fig c) Rain streaks Fig d) De-rained image

Fig.5.2. single image de-raining using CNN

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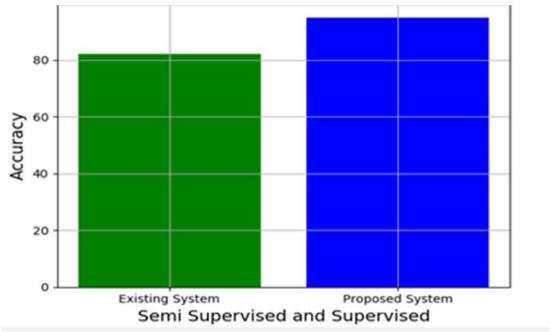

Fig.5.3. Accuracy

Fig 5.3 shows the graphical comparison of accuracy between the existing and our work system, the accuracy of existing system is low as it done using image processing, and as it is semi-supervised learning method It makes use of big quantity of unlabeled data and tiny quantity of labelled data., and our work is done using the advanced machine learning method and as it is supervised it uses only labeled dataset while training an algorithm.

Table 1: Comparison of our work system with existing system

S.No	Parameter	Existing system	Our work System
1.	Accuracy	82%	95%
2.	Time elapsed	20.5S	10.3S
3.	Loss	20%	5%

Here we are comparing the our de-raining method which we have studied and implemented (supervised) with existing method(semi-supervised) in terms of accuracy, elapsed time and the amount of loss of rain streaks from the rainy image .As from the table 1 we can see the accuracy of our work system is 95% which is much higher than the existing system. Quantitative evaluation demonstrates the effectiveness of our work. From the above table it is clear that our work for removing rain streak from rainy images using powerful supervised learning method outperforms existing weakly supervised learning methods.

VI. CONCLUSION

In this work a powerful supervised machine learning approach is used for getting rid of rain streak from single rainy pictures i.e. supervised convolutional neural network (CNN) model is studied and implemented. CNN is followed by convolution layer, pooling layer, fully connected layers and it has an activation function known as ReLu(rectified linear unit) network. With the help of CNN training of model is done with labeled data set for rain streak elimination, hence image de-raining issue can be solved as rainy images may have rain streak of numerous size by using residual rain streak. CNN extracts feature of the image (amount of rain streaks present within image) easily with help of pooling layer and convolutional layer to provide more accurate results with more loss of rain streak from rainy image compared to existing method with lesser computation time. In future our work can be implemented by using different machine learning method and algorithms to have more accurate results.

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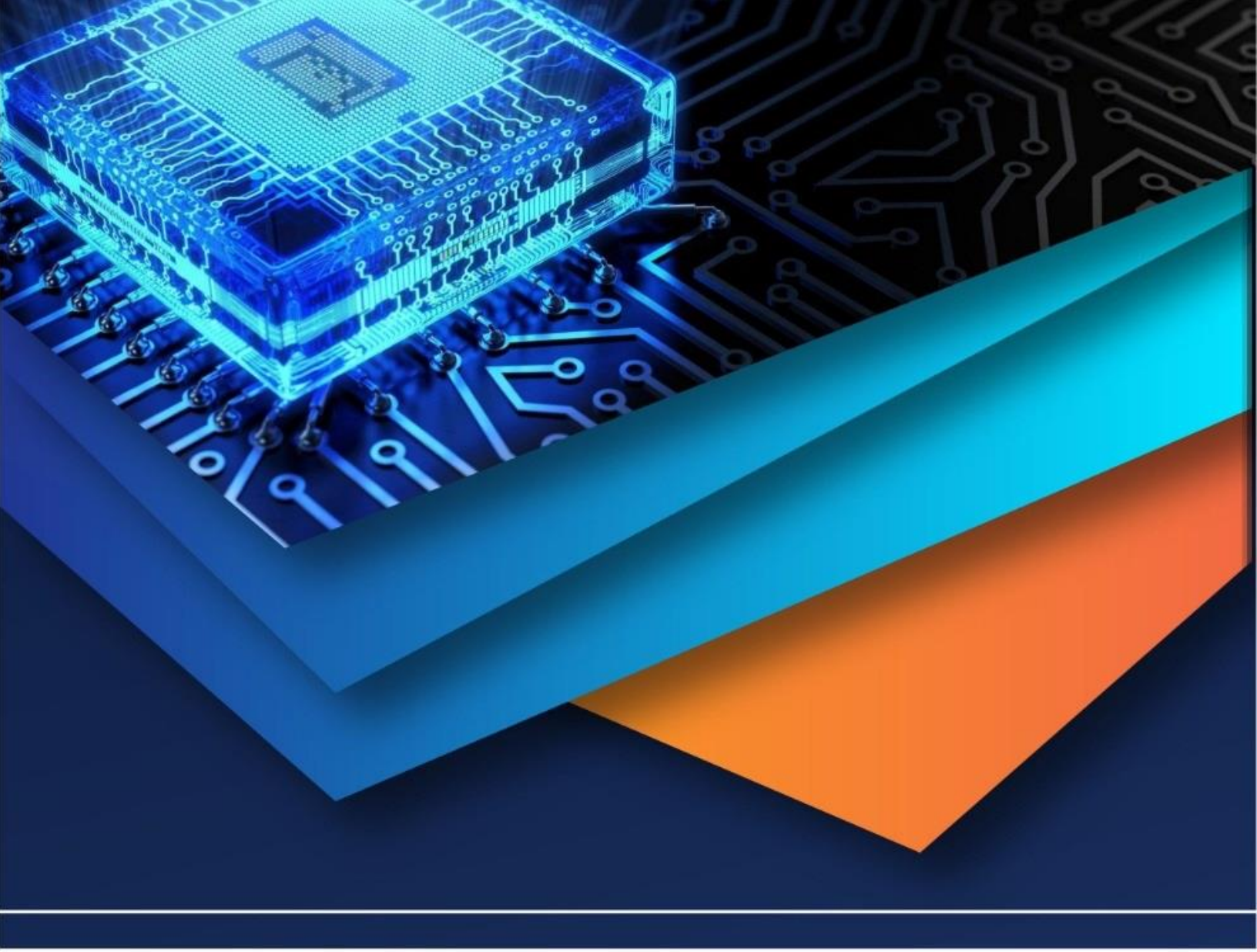

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