Low-Light Image Enhancement using Deep-Learning

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Abstract: Deep Learning is a recent and very powerful machine learning approach which uses neural networks to mimic activities in layers of neurons. Deep learning algorithms have achieved remarkable performances in various image processing and computer vision tasks. low-light image enhancement is very challenging due to the difficulty in handling various factors simultaneously including brightness, contrast, artifacts and noise. So, we are going to propose a deep learning-based method for low-light image enhancement. The model here uses a Convolutional Neural Network (CNN) which makes the use of a dataset of raw short-exposure night-time images, with corresponding long-exposure reference images. This makes results from extreme scenarios like night photography very easy and efficient as compared to traditional denoising and deblurring techniques. The low-light image enhancement is of high importance for several computer vision and computational photography tasks. Low-light and image enhancement is important for video surveillance. In addition, low-light image enhancement leads to increasing the scope of many computer vision algorithms designed to deal with normal light images. However, a high quality low-light image enhancement is a challenging task and developing fast and reliable methods for low-light image enhancement still a topic for intensive research.

Key Terms: Deep learning, CNN model, image enhancement, computer vision

1. Introduction

Images contains rich and detailed information of the scenes, and processing the image data, intelligent systems can be developed for various task such as image classification, segmentation, image recognition, object detection [1], scene understanding and 3D reconstruction, and afterward can be utilized in numerous applications like automated driving, video surveillance and virtual reality.

So many different analysts have been submitted their work for low light image enhancement. They focus on restoring the image brightness, contrast [1] and suppressing the unexpected visual effects like difference in the color and brightness. Existing methods can be generally partitioned into two categories, the histogram equalization-based methods [2] and the second one retinex theory-based methods. Algorithms in the former category optimizing the pixels brightness based on the ideas of histogram equalization.

Deep learning is a machine learning approach, it can be used in an image processing and computer vision. Here in this paper I am going to be use deep learning approach for image filtering, mainly filters focus on image quality and its enhancement. All we know, Deep learning is a sub branch of AI, uses supervised learning and unsupervised learning methods to train a neural network. neural net is mainly of two types artificial neural network and convolution neural network and in this paper a convolution neural network (CNN) is used to be work with the image. The CNN network is trained with a pair of image data, first given low exposure image as an input with reference high exposure image data, it is a type of supervised learning approach to train a neural network. later the trained network can be used for new input to get a desire output. The accuracy of the result depends on volume of the training data and the number of hidden layers used by the neural network.

A literature survey work has been done on an existing methods and approaches which would be using deep learning approach and other image enhancement method to enhance quality of image. The analysis of an existing work helps in producing a proper model which full fill our requirements and produce a desire output. This paper proposed a deep learning method which uses supervise learning approach to teach a CNN

model, which takes an input and next processed it though the network and save the produced output in a file. The training data paly very crucial role in an any Depp learning approach to get a desire output.

2. Literature Survey

2.1 Low-light image enhancement using CNN and bright channel prior [3]

In this paper, the proposed method works in two steps, in first step its uses CNN (convolutional neural network) model to filter noise from the image and then based on atmosphere scattering model, they produced a low-light model to enhance an imagesetter proposed method is joint frame work of CNN noise filtering and image enhancement model. They propose image prior, bright channel prior, to estimate the transmission parameter, and an effective filter is designed to adapt idly estimate environment light in different image area.

2.2 Deep Residual Learning for Image Recognition [4]

Deep neural networks are more difficult to train. They proposed a residual learning framework to make easy the training of networks and that are substantially deeper than those used previous network. They explicitly reformulate the layers as learning residual functions with reference to the layer inputs, instead of learning unreferenced functions. they provide comprehensive empirical evidence showing that these residual networks are easier to optimize and can gain accuracy from considerably increased depth. On the ImageNet dataset we evaluate residual nets with a depth of up to 152 layers—8× deeper than VGG nets but still having lower complexity.

2.3 Contrast Enhancement Techniques [5]

Image contrast is an important parameter to conclude the quality of an image. A good quality image has a good and well-balanced contrast. A lot of image contrast enhancement techniques are proposed like histogram equalization [5] (enhancing image contrast), Histogram stretching techniques and its variants like brightness preserving bi-histogram equalization (BBHE) and quantized bi-histogram equalization (QBHE) gained prominence to enhance on the artifacts of histogram equalization [6,7]. Along these, we can work with both gray and colored image separately for image enhancement.

2.4 Image denoising [8]

Noise in an image is random variation of brightness or color information in images and is usually an aspect of electronic noise. It is always present in a digital image. It can be produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Noise Models in Digital Image Processing [8] paper explained about noise in a digital image in detail. noise is generating in an image during image acquisition, coding, transmission, and processing steps. they present a complete and quantitative analysis of noise models available in digital images.

3 Deep Learning

Deep learning concept is totally different from the traditional programming way.in an traditional approach we are generating an algorithm to process with the input ,but here in deep learning we are not going to generate any algorithm, actually machine itself generating an algorithm by making relation between the input and output data and then generated algorithm use for new input to get desire output. so, the set of input and output data matters too much in an any deep learning approach.

In present time the computers can not automatically classify photos, but they can also describe the various elements in pictures. and describing each segment with proper English grammar. All this possible because of the Deep Learning Network (CNN), which learns patterns that naturally occur in photos. ImageNet is one of the biggest databases of labeled images to train the Convolutional Neural Networks using GPU-accelerated Deep Learning frameworks for the image classification. Caffe2, Chainer, MXNet are some example of classification model.

First, Neural Networks was used in 2009 for speech recognition and were only implemented by Google in 2012. Deep Learning, also called Neural Networks, is a subset of Machine Learning that uses a model of computing that's very much inspired by the structure of the human brain. Google uses deep learning from so long in their google search and image search. It will soon be used in machine translation, I believe." said Geoffrey Hinton, the Godfather of Neural Networks.

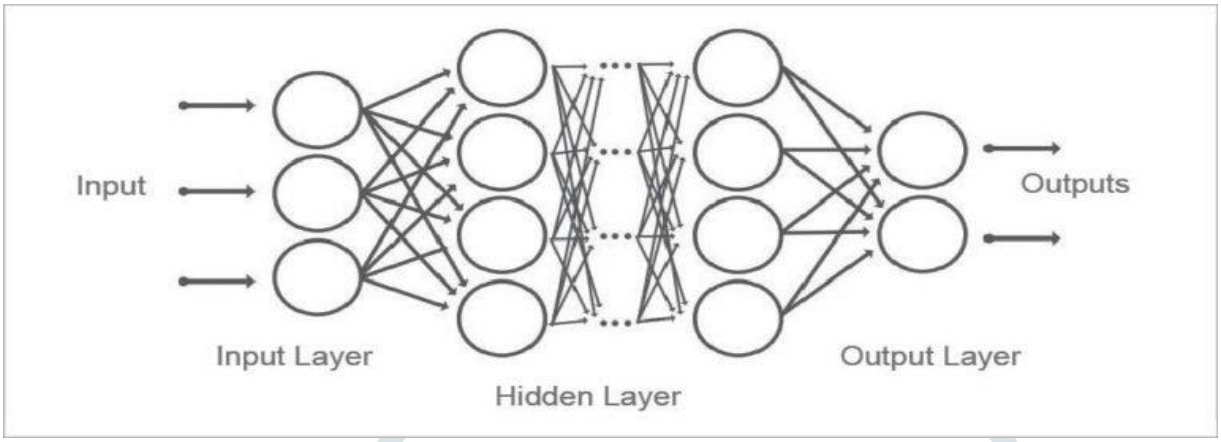


Figure: 1 Traditional neural net

Deep Learning models, with multi-hidden layers structures, as shown above, are very efficient and powerful in extracting complicated information from images. To work fast with Convolutional Neural Networks, we have required GPU and it can also able to drastically reduce computation time by using GPU for fast computation which many other networks fail to utilize.

3.1 Deep Learning in Image Filtering

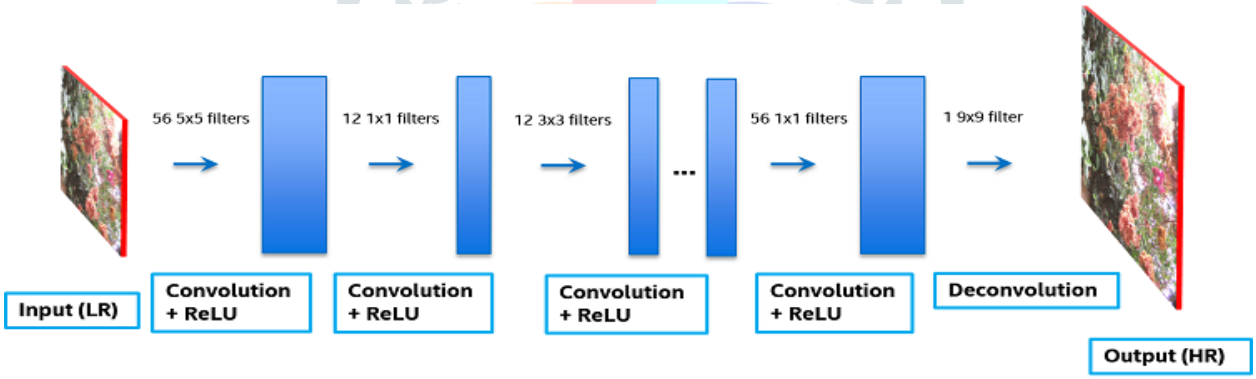


Figure: 2 Image filtering model

Image filtering in a deep learning approach is the process of filtering an image and extract some important information from the image. In an image filtering application, both the input output should be image. traditional neural network are not suitable for image processing because it cannot able to produce image as an output ,and also it is fully connected neural net that also we do not required for processing image .convolution neural net uses mainly three filters as in the form of layer ,first one is convolution layer with ReLU activation function, second is pooling layer and in last de-convolution layer.

Convolution layer is a series of layer that consists a sequence of filters, and nature of the filter trained by the network. the input image first filter with convolution layer, filter size number of filters depends on user, it is useful in extracting feature, special pattern from an input image.

Poling layer just use to reduce the dimensionality of an input whatever it is getting as an input from the previous layer. Some time it's required and some time we don't need if out input previously in suitable for next layer processing in a convolution neural network. Here also we don't require.

And in last it is using de-convolution layer, the purpose of deconvolution to fuses all previous layer filter layered output and produce it as an in single entity form for convolution neural network output.in an traditional neural network we are using full connected network but here we are using deconvolution because we want output also as image, traditional network fails to produce image as an output.

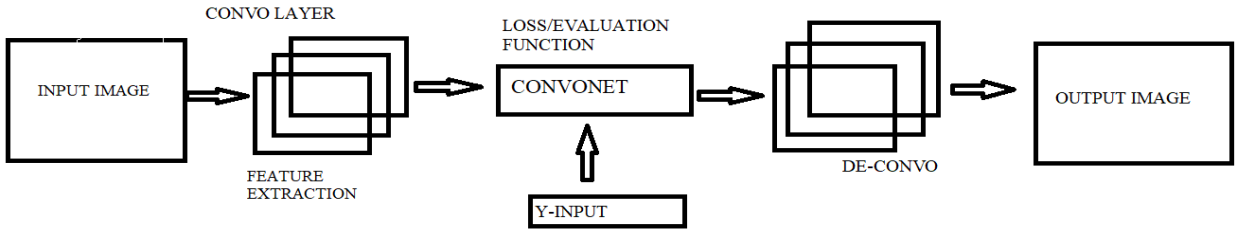
4 Low-Light Image enhancement with Deep Learning

The model here uses a fully trained Convolutional Neural Network which makes the use of a dataset of raw short-exposure night-time images, with corresponding long-exposure reference images. This makes obtaining results from extreme scenarios like night photography very easy and efficient as compared to traditional denoising and deblurring techniques.

The CNN is trained on two sets of images.

- A dimly lit (almost dark) scene or short-exposure picture as an input.
- A corresponding normal lighting scene or long-exposure picture of the same scene as target.

Figure: 3 Proposed model architecture



CNN Model architecture proposed for low light image enhancement is shown in above figure, take an image as an input and produces an enhance output image. Before getting the output from the model, we need to train it first. So, if you want to train the network, you will have to first click a photograph under normal lighting conditions which will be used as a target variable to obtain error by the network. Next, you will have to click a low exposure photograph of the same scene so that it looks dark. Here for training purpose, it uses a supervised-learning [9] approach to train a model. In supervised learning approach the model requires an input and also require reference image to that input, so that model learn from the reference.

Steps used in processing model

1- convolution (feature extraction) (more than one hidden layer can be used for better performance)
   - it takes short-exposure night time image as an input and uses a convolution filter to filter a low-light image in 1st step.
2- ReLU layer (activation function)
   - Its decided which feature is important and useful for next layer. Model has other option also as an activation
3- loss estimation and optimization (using L1 loss function and Adam optimizer)
   - Here in this step model minimizing the loss function as much as possible and optimizing the model performance using Adm optimizer function
4- de-convolution
   - After training, model takes a new image an input, it passed through all filter and lastly in last it uses de-convolution layer to get an enhance output
5- output (enhanced image) shown in figure 5.

The training was carried out using L1 loss and an Adam Optimizer, which gave results which of exceptional quality and makes the model most efficient. The picture blow is showing result for low-light image enhancement of deep learning approach using proposed methods.

Figure: 4 Input to the model

Figure: 5 model output

Conclusion

Deep Learning has risen as another very important field of AI and has obtained extensive interests in different research region. In contrast to traditional methods for image enhancement, Deep Learning a better a fast to deal with noisy, blurred and low-quality image. Now that a network has been built which can take low-light images and output filtered versions of that image, work will be done to allow the network to process larger images where more significant results can be seen. This will require a lot more training time, meaning future work will likely lean towards optimization of the network, using different network structures, cost functions and learning rates to attempt to maximize cost reduction per unit of computation time. Deep learning algorithms need to be trained more and more to get more accurate results. In addition, low-light image enhancement leads to increasing the scope of many computer vision algorithms designed to deal with normal light images.

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