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Image Restoration using Deep Learning Techniques

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Abstract: ***In the modern era, due to the emergence of various technologies, most of the human work is now being performed by the computer system. The computer's capacity to make everything possible is increasing as by the time. Photos are used to capture or freeze the moments in one's life. We can embrace those moments at any time by looking at the pictures. It is natural that, as time passes by, these photos gets damaged due to environmental conditions that leads to loss of our important moments. Hence, preserving the photos is as important as taking them. The process of taking corrupt or noisy image and estimating the clean, original image is image restoration. Many forms of noise such as motion blur, camera misfocus etc., increases the complexity to restore the image. Image corruption comes in varying degrees of severity, the complexity of restoring photos in real-world applications will likewise vary greatly. Also, manual restoration is time consuming leading to lots of work to be piled up. To increase the capability of restoring old images from various defects, we must address several degradations intermingled in one old photo, such as structural defects like scratches and dust spots, and unstructured defects like sounds and blurriness. Furthermore, we may use a different face refinement network to restore small details of faces in ancient pictures, resulting in higher-quality photos. The aim of the work is to create a image restoration system that will be used to restore the images irrespective of the type of noise. In this paper, we present a model that would take image as an input and remove all the noises present in it to give a clean and restored image.***

Keywords: Camera Misfocus, Image Restoration, Motion Blur, Noise, Restored Images.

I. INTRODUCTION

Old photographs are artefacts that preserve significant people, places, and things. It records crucial events in our lives and brings back memories. We save and treasure these vintage photos because they have meaning and influence for us.

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Weakening of photographs due to environmental factors such as too much exposure to sunlight, changing of temperature, humidity, handling, and breakdown of chemicals to the photo that was used in the developing process, scratches, missing or damaged areas, water spots, folded photos, and faded colour are just a few examples of problems that require restoration. To produce the best possible results, we proposed a method for restoring the old photos. We presented a strategy for restoring old images in order to achieve the best potential outcomes. This strategy will be simple but effective because it can be used by everyone. Restoration of ancient images would be easier with the current technology, modernization of the digital age, digital photo upgrades, and restoration processes. We will train two variational autoencoders (VAEs) to translate old and clean pictures into two latent spaces, respectively. Furthermore, to increase the capability of restoring old images from various defects, we must address several degradations intermingled in one old photo, such as structural defects like scratches and dust spots, and unstructured defects like sounds and blurriness. Furthermore, we may use a different face refinement network to restore small details of faces in ancient pictures, resulting in higher-quality photos.

II. LITERATURE SURVEY

Ran Li, Lin Luo and Yu Zhang proposed an approach to image restoration problem in their paper [3] 'Convolutional Neural Network Combined with Half-Quadratic Splitting Method for Image Restoration'. It has two methods i.e., model based optimization method and discriminative learning approach. Their primary goal was to incorporate a trained convolutional neural network (CNN) for denoising as a model into the model-based optimization method for solving image restoration problems. However, they used a Gaussian denoising model, which is insufficient in all cases to restore the details of low-quality images.

In another image restoration paper, [2] 'Poisson noisy image restoration via overlapping group sparse and nonconvex second-order total variation priors' written by Kyongson Jon, Jun Liu, Xiaoguang Lv, Wensheng Zhu, they used TVOGS and MM algorithm, Alternating direction method of multipliers [ADMM], Iteratively reweighted least squares algorithm[IRLS]. Because of the ill-conditioned non-quadratic data fidelity term, it is more difficult to optimise than Gaussian deblurring. Ganzhao Yuan and Bernard Ghanem proposed an approach to restore images in their paper [1] 'l0TV: A New Method for Image Restoration in the Presence of Impulse Noise' which was published in ieeexplore where their main objective image restoration in the presence of impulse noise.

Impulse noises occurs mainly in data acquisition due to faulty sensors or analog to digital convertor errors. They used techniques like Total Variation (TV) [l0TV-PADMM], MPEC (Mathematical Program with Equilibrium Constraints), proximal Alternating Direction Method of Multipliers (PADMM). In [4] 'Shrinkage Fields for Effective Image Restoration' written by Uwe Schmidt Stefan Roth, their main objective was to develop an effective approach to image restoration that offers both computational efficiency and high restoration quality. They used Kodak dataset to train and evaluate their model. They used methods like Half-Quadratic Optimization, Shrinkage function, Cascading of Shrinkage Fields. But there could be a more efficient GPU implementation to further improve runtime for large image sizes. [5] 'Noise2Noise: Learning Image Restoration without Clean Data' by Jaakko Lehtinen, Jacob Munkberg, Jon Hasselgren, Samuli Laine, Tero Karras, Miika Aittala, Timo Aila used Convolutional neural network (CNN) on BSD300 dataset, IXI-T1 dataset to restore images. The L1 loss recovers the median of the targets i.e the expectation of the corrupted input data like in Low-light photography.

III. BACKGROUND

After the emergence of smart phones and hard disks, where we can store the images virtually, the usage of paper photographs has decreased. It is still challenging for those who are not ready to accept the development of the technology in this pace. So, still there are people who prefer to these photographs and albums over the electronics. Due to the environment conditions and chemical reactions over time, the photographs may lose its content. It is important to restore the images as they might play a vital role in one's life. But, manually to restore them would require lot of time leading to piles of photographs left out. To restore the images and bring back one's memory, we developed a model using deep learning that would convert the distorted image into a clean image without any noise.

IV. METHODOLOGY

A. PIL(Python Image Library)

The Python Pillow module is based on PIL (Python Image Library). It is one of the most important Python modules for image processing. However, Python 3 does not support it. However, we may use this module as a PIL with Python 3.x. It can handle a variety of image formats, including jpeg, png, bmp, gif, ppm, and tiff. Using the pillow module, we can do anything with the digital photographs. We'll learn how to filter photographs, create thumbnails, merge images, crop images, blur an image, resize an image, create a water mark, and many more actions in the next section. The image is displayed using the image class from the Python pillow library. The pillow package's image modules include a few built-in functions, such as loading images and creating new ones.

B. PyTorch

PyTorch is a tensor library designed for use in Deep Learning applications with GPUs and CPUs. It is an open-source machine learning package written in Python that was primarily developed by the Facebook AI Research team. Along with TensorFlow and Keras, it is one of the most popular machine learning libraries. NumPy is a well-known open-source Python toolkit for scientific and mathematical computations. It also allows you to work with massive multi-dimensional arrays and do calculations using linear algebra, Fourier transforms, and matrices. Pandas, Matplotlib, and OpenCV are just a few of the many supporting libraries for NumPy. PyTorch is well-known for its popularity in research rather than production. PyTorch, on the other hand, has seen rapid growth in professional developer adoption since its release a year after TensorFlow. Because of PyTorch's tight integration, you get: • Better memory and enhancement • More sensible error messages • Finer-grained control of model structure • More transparent model behaviour • Improved compatibility with NumPy

V. THE PROPOSED SYSTEM

The proposed system consists of the following stages.

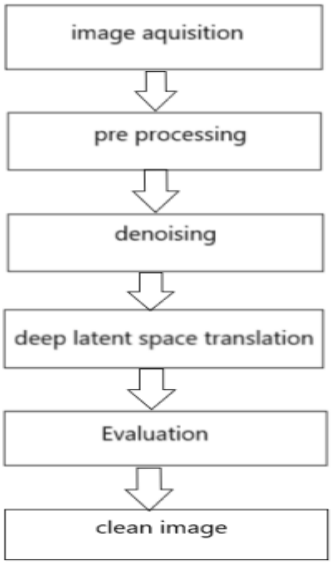

Figure 1: depicts the flowchart of our model.

In this part, the image restoration model is explained. Images can be damaged in many ways. This deterioration can be occurred in various forms like noise, blur, scratches, missing few parts etc., Different images have different level of degradation. Hence restoring damaged images is a challenging task.

A. Image acquisition
   In this section the system gets the input image.
B. Pre-processing
   The first step performed on the image is pre-processing. In this stage, the image is processed using standard techniques.
C. Denoising
   The goal of noise reduction is to reduce noise in natural photographs while preserving original features and increasing signal-to-noise ratio (SNR).
D. Deep latent space translation
   In this we train two variational autoencoders (VAEs) to transform old photos and clean photos into two latent spaces.

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The framework is trained on two VAEs(variational autoencoders):

VAE1 is trained for pictures in real photos r R and synthetic images x X, while VAE2 is trained for clean images y Y. Images are converted to compact latent space using VAEs. The mapping then uses a partial non-local block to restore the corrupted (blurry, noisy, damaged) images to clean ones in the latent space. The primary goal of this initiative is to bridge the gap between data and authentic historic photographs. To translate and clean old photographs into two latent spaces, we train two variational autoencoders (VAEs). Synthetic paired data is used to learn the translation between these latent areas. As a result, the learned network can generalise effectively to real-world images.

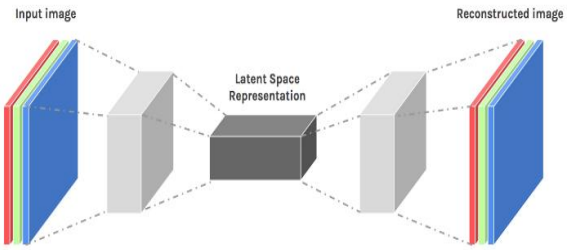
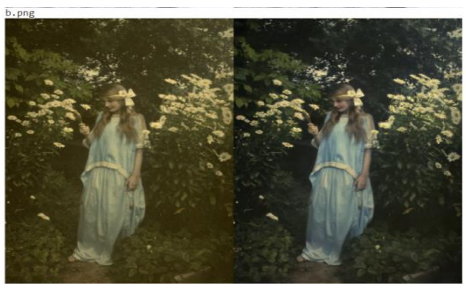


Figure 2: depiction of neural network

In Figure 2, we can notice that initially the input image (png format) is converted into grey scale image. Then, it is sent to encoder which compresses the image using loss less compression so that all the extraneous information (such as noise, blur, etc.,) and focuses only on the important pixels. This is then sent to decoder which will enlarge the image to its original size while storing the important pixels. At the end, we will be getting the reconstructed image without any degradations.

VI. RESULTS

(a)



(b)

Figure 4: The images (a), (b) shows the outputs by restoring the degraded image.

Output for scratch detections:

(c)

(d)

Figure 5: The images (c), (d) shows the outputs in which the scratches which are due to degradation are removed.

VII. APPLICATIONS OF IMAGE RESTORATION

1. Image restoration has played a critical role in the field of imaging in astronomical applications defined by poisson and Gaussian noise.
2. Medical imaging, such as computerised tomography (CT) and magnetic resonance imaging, benefit from the SR approach (MRI)
   Multiple photos can be acquired because the resolution is limited while the resolution quality is not. This can aid the surgeon in performing more precise operations on the particular portion of the body.
3. Multispectral image restoration can be performed on satellite imagery's multispectral bands in order to improve the resolution of the collected satellite images.
4. To improve the mobile camera's HR.
5. Motion blur estimation can be conducted in real-time video image processing systems in order to improve video resolution.

VIII. CONCLUSIONS

Image restoration is a difficult topic to solve. The primary goal of this project is to do a comparative analysis. Though each strategy has its own way of dealing with the situation and its own set of benefits and drawbacks. The use of the methodologies is governed by the comprehension, requirement, and standard of the output required, as shown by the previous explanations. The descriptor that results is compact, discriminative, and efficient. We have shown clear data that have drawn a reduction in complexity and an increase in the capacity to learn very complex aspects since the introduction of this method. This method, we hope, will be effective for future jobs involving the extraction of strong discriminative characteristics.

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Akurathi Aravinda, B tech Fourth year, Department of Computer Science, Gokaraju Rangaraju Institute of Engineering and Technology. With her team, she has developed a project called “Object Recognition in photography using Convolutional neural networks”. In this, they developed a convolutional neural network model using python to classify images from CIFAR -10 dataset into their respective classes. When we give the index of the image as input, it returns the corresponding predicted class label. She is interested in various domains like master data management, data science and artificial intelligence. She is certified in AWS academy cloud foundations and Microsoft AI classroom series.

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