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A Review of Image Super Resolution using Deep Learning

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Abstract— The image processing methods collectively known as super-resolution have proven useful in creating high-quality images from a group of low-resolution photographic images. Single image super resolution (SISR) has been applied in a variety of fields. The paper offers an in-depth analysis of a few current picture super resolution works created in various domains. In order to comprehend the most current developments in the development of Image super resolution systems, these recent publications have been examined with particular emphasis paid to the domain for which these systems have been designed, image enhancement used or not, among other factors. To improve the accuracy of the image super resolution, a different deep learning techniques might be explored. In fact, greater research into the image super resolution in medical imaging is possible to improve the data's suitability for future analysis. In light of this, it can be said that there is a lot of scope for research in the field of medical imaging.

Keywords- Image Super Resolution, medical imaging, deep learning, MRI, CT

I. INTRODUCTION

In many different applications, including astronomy, video surveillance, and medical imaging, high resolution images are preferred. Pictures are acquired for use in medical imaging, which offers knowledge of the anatomy, physiology, and integrated modalities, like SPECT/CT, which has transformed modern medicine. MRI, PET, and CT are further imaging modalities [16]. Due to imaging conditions, system limitations for physical imaging, and quality-limiting factors like noise and blur, it is difficult to obtain an image at the desired resolution despite advancements, throughout the last two decades, there have been improvements in acquisition technology and the performance of optimal reconstruction algorithms. Distortion can occur in medical imaging, which may have a detrimental impact on the contrast and visibility of features that could contain important information. This impairs pathological diagnostics' accuracy and reliability.

For almost all applications, it’s preferable to produce an image with a super- resolution. High-resolution images may be used to obtain more precision in the location of a tumour in a medical imaging, as well as greater user pleasure while viewing videos in high quality on HDTV or web-based images [17]. The image acquisition device's resolution is usually directly proportional to the image's resolution. Nevertheless, the cost of the sensor rises as the resolution of the image produced by the sensor improves, therefore it might not be a cheap solution. Thus, it's crucial to comprehend whether there is a technique to raise the image's resolution.

II. REVIEW OF IMAGE SUPER RESOLUTION

This section contains critical reviews of current papers on image super resolution.

The field of medical imagery, which involves analysis of X-Ray, Magnetic Resonance Imaging (MRI), Sonography, etc. The images which are obtained or used for medical imagery are generally in low resolution. One of the techniques which can be used to increase the image resolution as SISR(Single Image Super resolution) The Extensive research have been done in field of image super resolution, but to detect any specific disease using medical imaging is very challenging task.

Haopeng Zhang et al. [1] presented a special Cycle-CNN. It can be trained using unpaired data and two generative CNNs for SR down sampling independently. They conducted extensive testing using land use data from UC Merced and panchromatic and multispectral images from the GaoFen-2 satellite. The goal of this work is to generate cutting-edge SISR findings that are highly resistant to noise and camera blur in remote sensing images. To properly analyse the time costs and image quality of super-resolved photos, the author suggested that a lot more study might be done in the future.

A framework for SR improved diagnosis is proposed by Zhen Chen et al. [2] and consists of a diagnostic network and an effective SR network. A MRC-Net with RCF is constructed to exploit global and local characteristics for SR tasks. The aim of the study is to undertake comprehensive testing using WCE and histopathology images to demonstrate the efficacy of the proposed technique, which outperforms cutting-edge diagnostic algorithms on both simulated and real LR images. As compared to the baseline diagnostic network, the SR enhanced diagnosis

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framework greatly improves the performance of HR pictures, with a 5.83% improvement in accuracy.

Faming Fang et al. [3] suggest using a SeaNet to replicate the SR image. The proposed SeaNet consists of three sub-networks: a RIRN, Edge-Net, and an IRN. There are two stages to the reconstruction process. By using the RIRN and Edge-Net, respectively, Stage-I recreates the basic SR feature maps and the SR soft-edge. Before submitting the findings of Stage-I to the IRN for superior SR picture reconstruction, Stage-II integrates the data from the earlier stages. The suggested approach converges quickly and works flawlessly thanks to the picture soft-edge. The scientists also recommended conducting a lot more future study to see whether there is a more effective technique to add visual elements that can boost the impact of the soft edge.

Wei Wei et al. [4] offer a novel HSI super-resolution network that implicitly uses a deep structure as the regularizer/prior. One of the three sub-optimization problems, one of which is tied to the regularizer while the others are not, is specially reformulated from the original unified optimization problem. For this sub-optimization issue, a recursive residual network is recommended since the regularizer's inherent difficulty equates to a denoising issue. In addition, construct end-to-end network representations for all remaining sub-optimization problems so that the initial unified optimization problem may be seen as a complete network. Also, a new loss function is created by modelling the additional spectral transformation loss, ensuring that the recommended method would result in better spectrum reconstruction outcomes.

Zhi-Wei Pan et al. [5] developed the SRIF multispectral image super-resolution approach by combining a LR multispectral image with a HR RGB image. It tackles the general problem that, whereas picture resilience is nonlinear and unknowable for the majority of RGB cameras, with multispectral imaging equipment, it is linear to scene radiance. The experimental results show that, in terms of computation effectiveness and reconstruction accuracy.

Using correlations, Qingzheng Wang et al. [6] developed a unified optimization strategy for predicting both the super-resolved RGB image and the super-resolved depth image from multi-observed LR RGB-D images. The authors claim that the proposed framework leverages the RGB picture and depth image as a priori information to improve the accuracy of the SR process. Moreover, this approach is unable to properly handle multi-observed images captured from random viewpoints since it requires a challenging and dependable RGBD registration in the 3D environment. Also, it's possible that the recommended approach won't be able to handle the occlusion issue well. The idea of photo-consistency could help to tackle this problem.

Tae Bok Lee et al. [7] proposed a super-resolution network that is resistant to noisy images by building multi-modules in simultaneously. The suggested approach uses a CNN-based image SR network, which can function effectively with noisy LR images. Our technique efficiently lowers just unwanted noise components, in contrast to standard SR methods that amplify both detail and noise in LR photos. the attention modules-based parallel branching architecture that is being presented. This enables our model to distinguish the high-frequency characteristic of the provided image from the noise and detail. This framework will be used in further work to address various picture restoration techniques.

The DPSRResNet developed by Hongyuan Tao et al.[8] uses Gaussian blur kernels to reconstruct HR RS images from LR SR image. For the purpose of utilising well-known deblurring techniques, a degradation model from the DPSR framework is provided. A deep plug-and-play strategy that permits the plugging in of any super-resolver with a previous term may also be employed to optimise the energy function. A number of experimental findings are presented to show how well the suggested approach works with RS pictures, and the proposed DPSRResNet is the system's essential super-resolver.

.A unique resilient deep CS framework is put forth by Hossam M. Kasem et al. [9] that can minimise geometric modification and recover HR pictures. The suggested architecture can specifically handle two jobs. With the aid of a created measurement matrix that has been optimized, it can first compress the modified picture. Second, the suggested framework can minimize the transformation impacts in addition to recovering the image from the compressed version. According to PSNR and comparable structural index measures, the simulation results presented in this research demonstrate that the suggested framework can achieve a high level of resilience against various geometric changes (SSIM).

For bistatic SAR pictures, Xi Cen, et al.[10] offer a brand-new super-resolution reconstruction methodology called FSRCNN. A feature extractor with several structural variations, a feedback feature improvement block, and a feature fusion module define the suggested model. This approach is demonstrated to produce clearer visual effects than existing picture super-resolution reconstruction methods during trials using bistatic SAR measurement data PSNR and SSIM measurements show that the proposed model performs best, proving that it can successfully super-resolution reconstruct bistatic SAR pictures.

For SISR, Furui Bai et al. [11] propose a non-local hierarchical residual network (NHRN). Prior to learning the association of different features, it is crucial to build an efficient method for picture super-resolution. To evaluate the self-similarity between each pixel in the feature map and produce a weight matrix that would direct the deep network to establish a more precise association between the LR and HR pictures, the authors specifically incorporate a non-local module. The

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suggested approach may thereby rebuild pictures with greater precision. The technique can cut down on executive time while maintaining the reconstructed image quality. Thorough testing demonstrates NHRN outperforms in terms of accuracy and speed.

Rewa Sood, et. al.[12] . paper 's describes three studies that aim to capture low resolution (LR) pictures and analyse them using the SRGAN to produce the enhanced version of an image. In the initial evaluation, factors of 4 and 8 are used to increase the in-plane MR image resolution. It demonstrates that the SRGAN can produce images with high edge fidelity, despite the fact that the PSNR and SSIM measures are lower than the baseline isotropic bicubic interpolation.

The input images to the network in the second experiment are anisotropically down sampled copies of HR images, which are used to study anisotropic super-resolution. In the third experiment, the SRGAN algorithm is changed, and super-resolve anisotropic images made from through-plane slices of volumetric MR data are used. The output of HR images are visually similar to their HR counterparts because they have a considerable quantity of high frequency information.

Zhang Yanfeng, et al .al[13] The SISR method described in this study upscales a given LR input image to a SR image while maintaining the structural and textural details. Based on the suggested model, the proposed system develops a single-image SR method. The texture and non-texture portions of the LR input image are separated, and the picture is then interpolated using the properties of the local structure. The crucial step is the computation of the scaling factor, namely in the texture region. They offer a technique based on local fractal analysis for precisely calculating scaling factors.

Yang-Yi Luo et al. [14] employ image SR technology, which converts LR images into HR images using a sequence of ML algorithms. The modified WGAN algorithm can increase the stability of model training, which is problematic with the traditional GAN approach. This approach, which is based on the SRGAN model, substitutes the standard GAN algorithm with the enhanced WGAN algorithm. The MERSI-II data from the FY-3D spacecraft will be used, and super-resolution methods will be used to considerably improve the visual quality of the reconstructed image. Three criteria can be used to evaluate an image: PSNR, SSIM, and visual impact.

According to Michal Kawulok et al.,[15In this study, Reconstruction accuracy is frequently determined by comparing the final product with a reference image that was obtained using ground truth. To test the resilience of several image similarity measures against various degrees of deformation given to Proba-V images, they look into a number of these metrics.

According to the literature review, significant research is being conducted in the topic of image super resolution as it provides better results. But the images which are obtained or used for medical imagery are generally in low resolution. Because of this low resolution of images, the accuracy might be affected. Also, some future work needs to be incorporate to get better results.

III. ANALYSIS

The analysis of the publications discussed in the previous part is provided in Tables No. 1, 2, and 3. The language processing method, research area, image resolution enhancement, deep learning algorithm, dataset, and accuracy were all taken into consideration during the research.

TABLE I: ANALYSIS OF IMAGE SUPER RESOLUTION-1

Paper Title	**Nonpairwise-Trained Cycle Convolutional Neural Network for Single Remote Sensing Image Super-Resolution [1]**	**Super-Resolution Enhanced Medical Image Diagnosis With Sample Affinity Interaction[2]**	**Soft-Edge Assisted Network for Single Image Super-Resolution[3]**	**Deep Recursive Network for Hyperspectral Image Super-Resolution[4]**	**Multispectral Image Super-Resolution via RGB Image Fusion and Radiometric Calibration [5]**
Domain of study	Remote Sensing Image	Medical Image	General Animal Images	Hyperspectral Imagery	Multispectral Imaging
Image resolution enhancement used	Yes	Yes	Yes	Yes	Yes
Deep Learning algorithm used	Cycle CNN	MRC-Net With RCF	SeaNet-RIRN, Edge-Net, IRN	Deep Learning,HSI Super Resolution Network	Multispectral Image Super-Resolution Algorithm
Dataset	Approx.720 Images	1,78,240 Images	1000 Images	187 Images(25000 Epox.)	Approx.210 Images
Accuracy	PSNR=24.33 ,SSIM=0.7456	PSNR=38.32	PSNR=26.05 SSIM=0.79 (Urban 100)	PSNR=37.57	PSNR=41.95(Hardward Dataset)

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TABLE II: ANALYSIS OF IMAGE SUPER RESOLUTION-2

Paper Title	Super-resolution of Multi- Observed RGB-D Images based on Nonlocal Regression and Total Variation [6]	Single Image Super Resolution Using Convolutional Neural Networks for Noisy Images [7]	Super-Resolution Of Remote Sensing Images Based On A Deep Plug-And-Play Framework [8]	DRCS-SR: Deep Robust Compressed Sensing for Single Image Super-Resolution [9]	A Deep Learning-based Super-resolution Model for Bistatic SAR Image [10]
Domain of study	RGB-D Images	General Images	Remote Sensing Image	General Images	Bistatic SAR Image
Image resolution enhancement used	Yes	Yes	Yes	Yes	Yes
Deep Learning algorithm used	Unified Optimization Framework,Normalized Bilateral Total Variation, Non-Local Regression	CNN Based Super-Resolution Network,Parallel Branching Architecture	Deep Plug-And-Play Residual Network (Dpsrresnet)	Deep CS Framework	Novel Super-Resolution Reconstruction Model (FSRCNN)
Dataset	50 Images	900 Images	100 Images	200 Images	600 Images
Accuracy	PSNR=29.64(Laundry)	PSNR=25.64(Urban100)	PSNR=38.62	PSNR=24.20(BSD)	PSNR=38.0362

TABLE III: ANALYSIS OF IMAGE SUPER RESOLUTION-3

Paper Title	Non-Local Hierarchical Residual Network for Single Image Super-Resolution [11]	Anisotropic Super Resolution In Prostate Mri Using Super Resolution Generative Adversarial Networks [12]	Single-Image Super-Resolution Based on Rational Fractal Interpolation [13]	Super-Resolution Algorithm of Satellite Cloud Image Based on WGAN-GP [14]	Evaluating Super-Resolution of Satellite Images: A Proba-V Case Study [15]
Domain of study	General Images	Medical Image	General Images	General Images	Proba-V images
Image resolution enhancement used	Yes	Yes	Yes	Yes	Yes
Deep Learning algorithm used	Non-Local Hierarchical Residual Network (NHRN)	Super Resolution Generative Adversarial Network (SRGAN)	Bivariate Rational Fractal Interpolation Model	improved Wasserstein GAN	CNN(Convolution Neural Network)
Dataset	291 Images	329 Images	15 Images	200 images	441 images
Accuracy	PSNR=32.89(Urban 100)	PSNR=29.51	PSNR=21.538(Set 14)	PSNR=21.32	Not mentioned

IV. CONCLUSION

High resolution images are preferred in many applications, including astronomy, video surveillance, and medical imaging. A key diagnostic tool for determining the presence of particular illnesses is medical imaging. Pictures are obtained for anatomical information and medical investigation purposes. Hence, increasing picture resolution ought to significantly improve the ability to identify for corrective therapy. Also, with increased resolution, the results of automated recognition and picture segmentation may be greatly improved.

It is evident from the review that, despite the fact that numerous research papers have been produced and image super resolution has been used in a variety of fields, the majority of the publications continue to concentrate on the application of image super resolution to generic images.

It has been discovered that image resolution is critical in retrieving significant information. Improved image quality will facilitate quicker patient treatment and more accurate disease detection. However, because of how the human body is built anatomically and because of the sensors in image capture devices, medical images frequently have a lot of noise and abnormalities. To solve this resolution issue, the Super Resolution approach has been described.

A range of machine learning or deep learning techniques may be researched to increase the accuracy of image super resolution. In reality, more investigation into the image super resolution in medical imaging is possible to enhance the data's effectiveness for future processing. In light of this, it can be concluded that there is a lot of scope for research in the domain of medical imaging.

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