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SISR of Multimedia Text Image using a 50 layers Architecture of Deep Regression Network

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Abstract

The super resolution of a sole image is a fundamental challenge in low-level computer vision with many applications. The intention of Single Image Super Resolution (SISR) is to transform low-resolution (LR) images into high-resolution (HR) images with all the necessary edge structures and texture information. The HR images provide more details that can be used for various purposes such as security, medical imaging, etc. However, the reconstructed image has some loss in detail parts present in the image, and attaining better accuracy with less error is quite challenging. To address these challenges, a regression network based super resolution (RNSR) is developed that converts LR images into HR images. A deep regression network with 50 layers is designed for the SISR. According to the simulation analysis, the proposed RNSR method achieves 98% accuracy, 0.02% error, 97% precision, and 94% specificity for converting LR multimedia text images to HR images. Based on the performance of the proposed RNSR method, the regression network can generate high quality images.

Keywords: *Single image super resolution, multimedia text, low resolution to high resolution image, super resolution image, deep regression network*

Introduction

Single Image Super Resolution (SISR) helps to provide high resolution (HR) images using single low resolution (LR) images while maintaining edge structures and texture information [1]. Security, medical imaging, satellite imaging, surveillance imaging and other applications can all benefit from higher-resolution images, which provide more detail about the images [2]. Image super resolution can be used to solve a variety of real-world challenges involving picture or video constraints such as scene details, size of pixel, bandwidth,and other variables [3]. In reduced-level computer vision, SISR is a fundamental problem with diverse applications [4]. Its technological intention is to produce an aesthetically compelling HRimageoutputfrom a single degraded LR observation [5].Consequently,this methodology was crucial rather than relying on sensor fabrication technology

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since it provides a much more cost-effective and promising method of addressing the inherent limitations of LR optical imaging systems [6]. The SISR approach employs a range of machine learning techniques. When the SISR machine learning method is used, it is probable that it will not produce sufficient results in the image resolution approach [7]. Most image Super Resolution reconstruction approaches depended on batch normalization and extrapolation before the advent of deep learning-based algorithms.In order to enhances the pixel quantity in an LR image, a picture interpolation approach was used. It is a method for determining the pixel value of a specific area within an image[8]. People have recently begun to utilise deep architecture neural networks for image SR, motivated by deep learning's enormous success in other computer vision applications [9]. Using a variety of basic deep learning principles, we show how domain expertise may be combined with large learning capacity to improve SR performance even further [10]. Several deep learning-based solutions to the SISR problem have been presented in recent years. Existing SISR approaches, which frequently utilised numerous pictures with variable scaling factors and handcrafted features, were outperformed by a convolutional neural network (CNN) SR[11].However, several detail areas of the image have been lost in the reconstructed image. To address these challenges, a regression network with 50 layers is presented that provides high quality images from the low quality images.

The remainder of the manuscript is organised as follows. Section 2 discusses various studies pertaining to the already-existing SISR. The proposed SISR approach is proposed in Section 3. The findings obtained after using the suggested strategy are discussed in Section 4. The proposed model's conclusion is found in Section 5.

Literature Review

Some of the relevant reviews based on SISR using various deep learning techniques have been discussed in this section. Seong-Jin Park et al. [12] have suggested a Feature-discrimination super-resolution of a single image using a feature domain discriminator, and a new GAN-based SISR technique is developed to solve the problem and produce more accurate outcomes. SISR has been recently applied to GAN, and the results with authentically synthesised high-frequency textures have been remarkable. This approach providedbetter results in terms perceived quality as well as the PSNR than the GAN. However, due to their complexity, it is insufficient to cope with the fine structures of many nature images.Zheng Hui et al. [13] have developed an information distillation based deep learning network, which havethe ability to achieveSISR in a quick and precise manner. A large and efficient convolutional network was suggested to create HR images straight from LR photographs.Because of the limited number of filters per layer and the usage of group convolution, the proposed network is quick to execute.According to experimental results, the proposed strategy beats existing strategies in terms of time performance. However, the training process will be unstable because of the greater training samples.

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A technique for super-resolution has been developed by Juan M. Haut et al. [14], and it has the potential to significantly enhance a wide range of sensor technologies. Based on an unsupervised strategy, a novel convolutional method was proposed using Super-resolving LR remotely sensed data. The SISR Algorithm, which is based on the Deflection Block Features and Architectural Self-Similarity, was proposed by Yuantao Chen et al. [15]. A SISR technique based on structural self-similarity as well as deformation block characteristics was presented to address the issues of insufficient sample resources and low sound resistance in SISR recovery procedures. A deep Differential CNN was developed for SISR by Peng Liu et al. [16]. The recommended network employs a Differential CNN during the reconstruction stage in order to gather the rebuilt images and the variations between the LR and SR images. Detailed convolution is proposed in a SISR by Wuzhen Shi et al. [17]. An enhanced convolutionbased inception module was built to learn multi-scale information and a deep network for SISR. To improve picture super-resolution performance, the proposed end-to-end SISR network may use multi-scale information. Experimental results showed that the suggested work demonstrated a number of cutting-edge SISR techniques. Zhendong Zhang et al. [18] have introduced dilated convolutions are beneficial for pixel-level forecasting issues because they enable the receptive field to be enlarged without requiring parameter investigation or sacrificing resolution. Dilated convolutions (DCSR) are used to generate multiscale single picture super-resolution. According to the results, the proposed strategy exceeds other conventional approaches in terms of PSNR and SSIM, especially for large scale factors. However, increasing the size of the convolutional kernel or layer depth would increase computational complexity and memory consumption.Jun-Jie Huang & Wan-Chi Siu et al. [19] developed a SISR based on learning hierarchical decision trees.In order to produce rapid and high-quality images, a number of decision tree algorithms were applied. An input LR patch is categorised in SR using a few simple binary experiments through one of the intermediate nodes, as well asthe LR imagewas multiplied directly by the regression model just at that leaf node for regression. The classification and regression methods are quick to finish. Patch normalisation, however, is ineffective. Kai Zeng et al. [20] have suggested a Polymorphic parallel super-resolution of a single image CNN. CNNgives more and better objective solutions.This research investigates the capabilities of Deep Neural Networks for Single picture Super Resolution.The bicubic interpolated stepwas deleted from this inquiry because it is manual over the sample and not clever enough. A Deconvolution layer was employed rather than an up sampling layer. Many to Many links and a local polymorphic concurrent network were also built.A simulation experiment was done based on this approach to demonstrate the proposed technique's efficacy. Daniele Rav et al. [21] developed a video-registration-based reconstruction for single-image super-resolution that allows for fast deep learning training. Using the temporal information included in a succession of HR images and video registration algorithms may estimate HR images.A synthetic data production technique is presented for training exampler-based neural networks. The results suggest that the proposed technique improves image quality significantly after reconstruction. However, translating these methods to

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the pCLE domain is difficult and time-consuming. The fusion process necessitates the alignment of LR frames, which is time-consuming and error-prone. Based on the above revealed article, several significant challenges arise in single image super image resolution. Due to their complexity, dealing with fine structures of many nature images was insufficient [12].The training process was unstable because of the greater training samples[13].Random noise affects this process, which is also limited by the cost function [14].Because of the diminishing gradients, training such a deep network was difficult [16].The computational complexity and memory use would increase as the size of the convolutional kernel or layer depth was increased [18].Normalization of patches is ineffective [19].It is not easy to translate these procedures into the pCLE domain. In order to address these concerns, a regression network was developed to achieve SISR.

Proposed methodologyfor SISR

SISR aims to increase the resolution of LR image while maintaining the necessary edge structures and texture information. In low-level computer vision, SISR is a vital task with many applications. Its technological aim is to obtain a visually pleasing HR image output from a single degraded LR image observation. It has lately become essential to use picture super-resolution, which requires learning non-linear mapping to reconstruct HR images from HR photos. Existing methods, however, may have a number of limitations, such as the fact that downscaling an infinite number of HR photos to produce a single LR image sometimes results in an ill-posed problem when mapping from LR to HR images. As a result, there are an increasing number of viable methods for mapping LR to HR images. SR models frequently have performance problems due to adaptation problems. In order to overcome these issues, a Regression Network is created to convert the HR image into a HR image. The suggested SISR is represented diagrammatically in Figure 1.

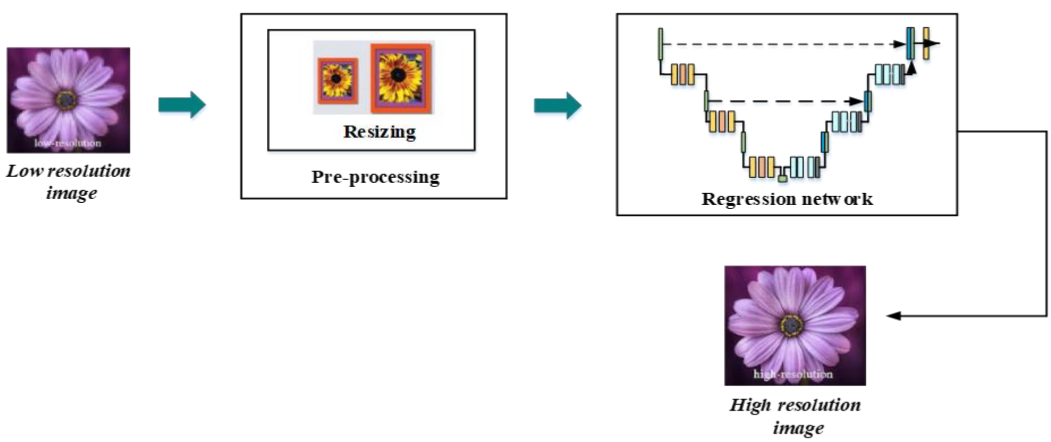

Figure 1: Architecture of proposed SISR method

Initially, raw input was changed to change the picture's size without changing the amount of

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information in the picture using HR photos as the input. An image's physical size changes when it is resized without changing the pixel dimensions due to resampling. After being scaled, the regression network was utilised to transform the LR image into a HR image. Since they provide more information about the images, higher-resolution photos may improve satellite imaging, medical imaging, security, and surveillance imaging, among other fields. As a result, it is necessary to look into the evaluation of image Super Resolution reconstruction with higher upscaling factors.

Image Pre-processing

Image resizing is a technique for reducing the size of an image without removing any of the image's content. The HR image is initially utilised as an input, and then it is scaled without cropping to adjust the image size. Image scaling is required to improve or reduce the overall pixel quantity in an image. The pixel data changes as you resize an image. Do not resample an image when resizing it; simply change the image's size without affecting the quantity of information it contains. For instance, a 700x700 image gets resized to 256x256 pixels [22].

Modelling of Proposed RNSR for SISR

The resized picture is fed into the regression network, which turns the HR image into a HR image. There are two networks in a regression network, a primary network and a secondary network. It takes the form of a deep U net model, which is divided into two sections: down sampling and up sampling.Regression networks have convolutional, max pooling, and ReLU layers. The architecture of the proposed regression network with 50 layers for SISR is shown in Figure 3.

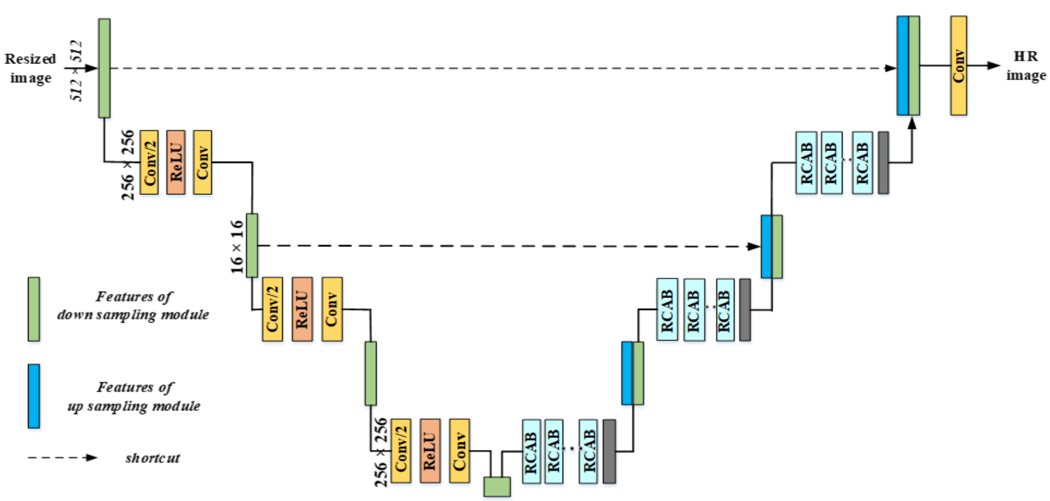

Figure 2: Architecture of regression network

A regression neural network is included in the U-design net for single picture super resolution. The

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primal network in a regression network follows the down sampling-up sampling model of U-Net.A down sampling procedure is shown in the left half of Figure 3, whereas the right half represents an up sampling method. The basic blocks in both the down and up sampling modules are denoted in the form of$log_2(s)$, where s is scale factor. Instead of using baseline U-Net, every basic frame was developed using B residual channel attention block. Additional outputs were added and proposed loss was applied to them to train the model in order to create images within a corresponding scale $(1 \times 2 \times, and\ 4 \times$ images).

The fundamental learning tasks can be utilised to close the loop and provide appropriate supervision for the training of models $S\ and\ T$.If $S(x)$was the appropriate HR image, the down-sampled image $T(S(x))$ should be very close to the input LR image. The function space of alternative mappings can limit by imposing this constraint, subsequently developed a better mapping to reconstruct HR pictures. We proposed that the super resolution models be trained by mastering these tasks. Given an N-sample collection is given in Eqn. (1)

$$M_S = \{(X_i, y_i)\}_{i=1}^N \qquad (1)$$

Where, $X_i\ and\ y_i$represent the i-th pair of LR and HRimage sample. Eqn (2) can be used to compute the training loss for primal regression.

$$\sum_{i=1}^N L_P\ (P(X_i), y_i) \qquad (2)$$

The loss function for primal tasks is denoted byL_P. We additionally apply a downscaling and upscaling constraint to the HR domain to recover the original HR image.The calculation cost is reduced and performance is increased when the primal regression loss is used.

To assure the restoration evaluation of HR pictures, utilize the information from data that may be collected quickly. Eqn (3) can be used to calculate the objective function given M poor resolution samples and M fake samples.

$$\sum_{i=1}^{M+N} 1_{S_p}(X_i) L_P\ (P(X_i), y_i) \qquad (3)$$

Where the indicator functionis denoted as $1_{S_p}(X_i)$which is equal to number one i.e., $1_{S_p}(X_i) = 1$ when$X_i \in S_P$, otherwise the function equal to 0 [23].

Regression task

Find a mapping$F_N: M \to \bar{N}$, so that the prediction $F_N(M)$in the normal regression challenge is similar to the matching real surface normal N. A standard regression task consists of a maximum pooling function, an extractor and a regressor. To begin, Eqn (4) can be used to determine the extractor F_{Ne}. [24]

$$\phi = \ F_{Ne}(M: \theta_{Ne}) \qquad (4)$$

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Where $F_{Ne}(M: \theta_{Ne})$ is a residual block mapping function having two down sampled convolutional layers, and θ_{Ne}stands for learnable parameters. Using max-pooling, create a permanent feature map $\phi' \epsilon R^{C_1 \times H' \times W'}$ from a multi-fusion feature map $\phi \in \phi' \epsilon R^{C_1 \times H' \times W'}$. Then the surface normal $\overline{N}$ is calculated by using Eqn. (5)$F_{Nr}(.; \theta_{Nr})$

$$\overline{N} = F_{Nr}(\phi'; \theta_{Nr}) \qquad (5)$$

$F_{Nr}(.; \theta_{Nr})$ Is a regressor that consists of three 3*3 convolution layer and two 3*3 deconvolutional layers, followed by an L2 normalisation that converts each pixel into a unit vector$\overline{N}_p$, and θ_{Nr} are the regressor's parameters.

Regression loss function and Training approach

To optimise the network parameters, we lower the combined loss function of the two regression tasks that is θ_{Ne} andθ_{Nr}. Then the joint training loss function can be calculated by using Eqn. (6)

$$L = \boldsymbol{L_{normal}}(\overline{N}, N) + \lambda_t L_{recons}(\bar{I}_i, I_i, \forall i) \qquad (6)$$

In normal regression tasks, weighting for the reconstruction loss is referred as λ_t and the normal loss between the predicted surface normal (N) and the ground truth $\overline{N}$ is$\boldsymbol{L_{normal}}$which is provided in Eqn. (7)

$$L_{normal}(\overline{N}, N) = \frac{1}{HW} \sum_p^{HW} (1 - \overline{N}_p \odot N_p) \qquad (7)$$

The dot operation is denoted by $\odot$. If the ground-truth $\overline{N}_p$ is oriented similarly to the predicted surface normal $N_p$at pixel p, $\overline{N}_p \odot N_p$will be close to 1 and the related loss will be close to 0.

The reconstruction loss between the reconstructed and observation pictures is denoted by$L_{recons}(\bar{I}_i, I_i, \forall i)$. Eqn (8) is used to calculate the reconstruction image.

$$L_{recons}(\bar{I}_i, I_i, \forall i) = \frac{1}{n} \sum_{i=1}^{n} \| \bar{I}_i - I_i \|_2^2 \qquad (8)$$

We may adjust SR models to varied data while maintaining good reconstruction performance using the suggested regression network scheme.

Result and Discussion

The proposed method was developed using a regression network to provide an HR image. The proposed regression network was developed in this section. The testing is performed with the help of Python 3.8.The raw data are collected and resized.Resizing makes it possible to control the dimensions of apicture without increasing the quantity of information it contains.After resizing the HR image, transform the HR picture into HRimage using a regression network. Images with higher resolution provide further detail, which can be utilized in a range of fields, like safety and surveillance imaging, diagnostic imaging, satellite imaging, and others. Here we take eight datasets, and all these datasets are executed with some existing super resolution algorithms and our proposed algorithm. Figure 4 shows the sample images and then compares the input LR images with some existing techniques, which are DBPN (Deep Back Projection Network), RCAN (Residual Channel Attention Network), and EDSR (Enhanced Deep Super Resolution Network). In this street view image text dataset, our proposed RNSR attain a better view and HR image compared to other existing techniques.

Dataset Description:

- **Dataset 1:**The Street View Text (SVT) dataset was collected from Google Street View. This data's image text is highly **variable** and frequently has LR [22]. For this dataset, the LR street view images with some existing and proposed algorithms is evaluated.
- **Dataset 2:** There are 433 LR images in this dataset with bounding box annotations of the car licence plates [23]. The LR car license plate images for this dataset with some existing and proposed algorithms is evaluated to show the performance of proposed RNSR.
- **Dataset 3:** SeveralIndian license plate recognition data [24]. The LR license plate images in this dataset with some existing techniques is analysed.
- **Dataset 4:** This dataset contains several photo realistic super resolution images [25]. The LR realistic images in this dataset with existing techniques are evaluated to analyze the performance.
- **Dataset 5:** Several LR face images are present in this dataset [26]. The LR face images in this dataset with some existing techniques is evaluated in this section.
- **Dataset 6:** This dataset contains several photo realistic super resolution images [27]. The LR realistic images in this dataset with some existing techniques is also compared.
- **Dataset 7:** This dataset contain some LR paper images with code [28]. The FUNSD dataset differs from the original dataset in that each document image is reduced to 224x224 pixels. The FUNSD dataset contains a collection of annotated forms.
- **Dataset 8:** Several vehicle license plate recognition data are present in this dataset [29]. The LR vehicle license plate images in this dataset with some existing techniques is also evaluated.

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Figure 4: SR image generated by different techniques for various dataset

The performance analysis of the proposed model is performed based on accuracy, precision, recall,andf1_score. The analysis is performed comparing the proposed technique with some

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conventional techniques such as RCAN, DBPN (Deep Back Projection Network), and EDSR (Enhanced Deep Super Resolution Network).

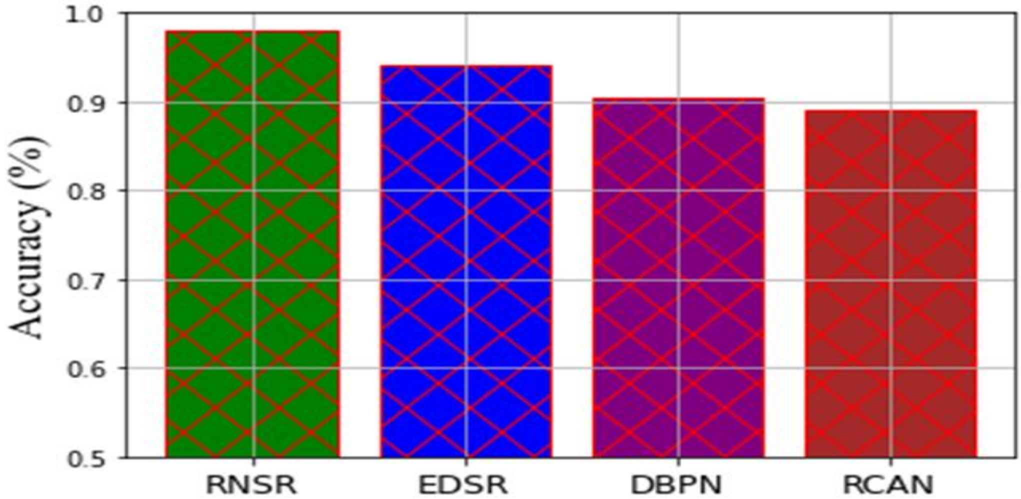

Figure 5: Accuracy of Different Deep Learning technique for SISR

Figure 5 displays the accuracy comparison between the different deep learning techniques for SISR. The proposed method outperformed the three previous methods by achieving 98%, whereas EDSR achieved 94%, DBPN achieved 90%, and RCAN achieved 89%.

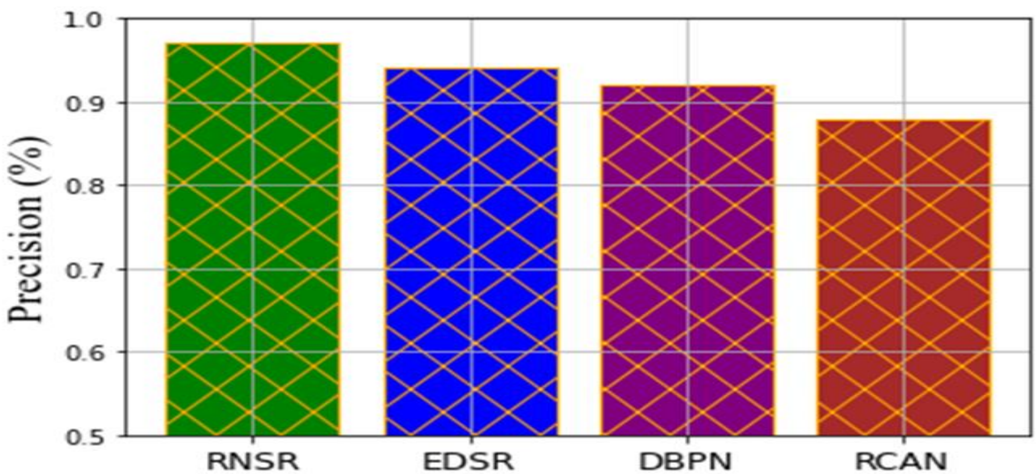

Figure 6: Precision of Different Deep Learning technique for SISR

Figure 6shows the comparison of different deep learning technique for SISR in terms of precision value. The proposed method achieving a precision value of 97%. Accordingly, EDSR achieves

94%, DBPN achieves 92%, and RCAN achieves 88%.

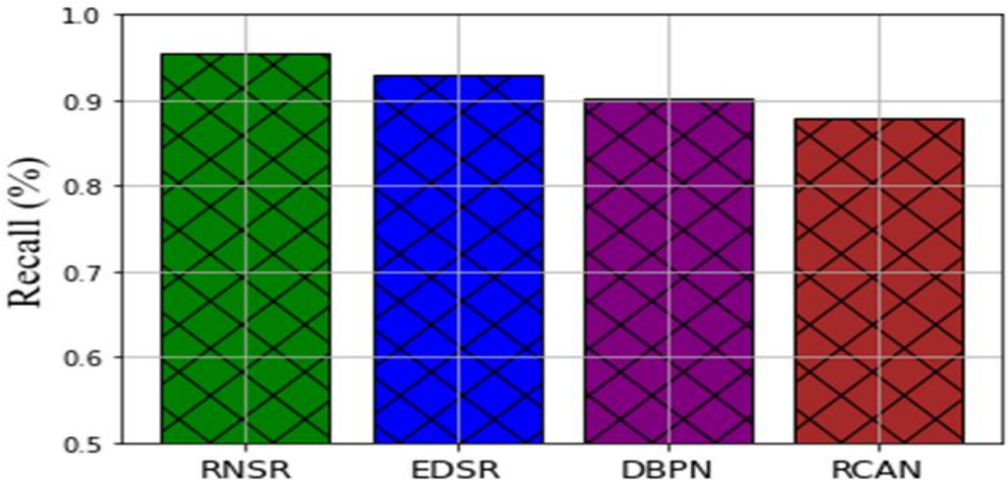

Figure 7: Recall of Different Deep Learning technique for SISR

The comparison of the proposed and existing recall metrics is shown in Figure 7. The RNSR network has a recall value of 95%, which is higher than other existing systems like EDSR, DBPN, and RCAN, whose recall rates are 92%, 90%, and 87%, respectively.

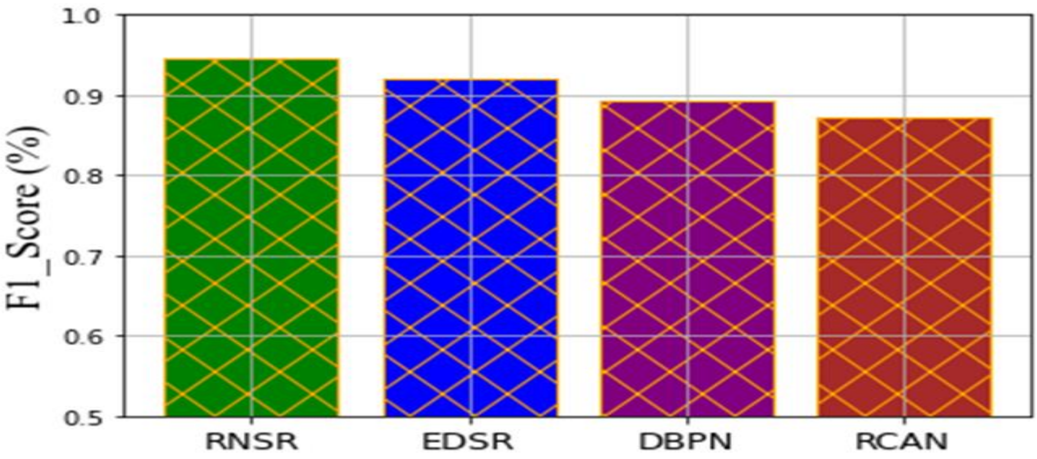

Figure 8:F1_Score of Different Deep Learning technique for SISR

The proposed and existing F1_Score value of different deep learning technique are compared in Figure 8 for clarity. The RNSR network's F1_Score value is 94%, which is higher than other existing systems like EDSR, DBPN, and RCAN, whose F1_Score values are 92%, 89%, and 87%, respectively.

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Conclusion

A regression network was created to convert an LR image into an HR image. An excellent reconstruction technique can improve image quality and provide additional information for subsequent processing. The unprocessed data are gathered and resized. A regression network with 50 layers is used to convert the LR image to anHR image after scaling it. The effectiveness of the proposed RNSR is also assessed, and its results are contrasted with those of earlier methods like EDSR, DBPN, and RCAN. The results showed that the methods used worked as intended and produced results with a 98% accuracy rate.In comparison to other current methodologies, the results demonstrated that the suggested regression network can produce the best answer. As a result, the suggested method may be a good improvement over the ones already in use. In order to test novel SISR model training techniques, we intend to enlarge the dataset in the future by gathering more image pairs.

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http://vision.ucsd.edu/~kai/svt/

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License plate recognition using CNN | Kaggle

[APTOS2019] Image Super Resolution | Kaggle

Single-Image Super Resolution GAN (SRGAN)[Pytorch] | Kaggle

Super Image Resolution | Kaggle

https://guillaumejaume.github.io/FUNSD/

Vehicle License Plate Detection | VGG16 | Kaggle

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