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# Image Enhancement using Generative Adversarial Network Model

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**ABSTRACT**: Abstract: Based on the idea of improving the quality of images we launched in the proposal. In this report, I will introduce and implement SRGAN, a Generative Adversarial Network for image super-resolution. Data used is collected from Kaggle. They had been trained with high resolution for 4x scaling factors. The algorithm is an application of deep convolutional neural networks (CNN). Our model includes a Generator Network with residual blocks, skip-connections, and a Discriminator Network for distinguishing between fake and real images. A perceptual loss function consists of adversarial loss and content loss.

#### I. INTRODUCTION

In the medical field, image quality is crucial for accurate diagnosis and treatment planning. However, due to limitations in acquisition hardware or data compression, medical images often suffer from low resolution. Traditional upscaling techniques fail to recover meaningful textures. This paper addresses this issue using SRGAN, a Generative Adversarial Network capable of reconstructing photorealistic details from LR images.

SRGANs utilize adversarial training between a generator and a discriminator network, coupled with perceptual loss based on pre-trained VGG19 features. The result is a system capable of producing high-fidelity HR outputs that retain diagnostic quality. Our implementation targets X-ray images, particularly enhancing COVID-related chest scans. In conclusion, our project showcases how cutting-edge deep learning models like SRGAN can be leveraged to recover and enhance valuable visual content, offering a meaningful contribution to both technological progress and the preservation of human experiences

#### **II. LITERATURE SURVEY**

The demand for high-quality images in fields such as medical imaging, security, and photography has driven extensive research in the field of image super-resolution (SR). Traditional methods like nearest-neighbour, bilinear, and bicubic interpolation are computationally efficient but often result in overly smoothed images lacking fine details—especially when images are significantly upscaled.

To overcome these limitations, deep learning approaches have emerged. One of the earliest was SRCNN by Dong et al. (2014), which applied convolutional neural networks (CNNs) for Single Image Super-Resolution (SISR). While effective in improving resolution, it struggled to reconstruct textures due to reliance on Mean Squared Error (MSE) loss.

A major advancement came with SRGAN (Leydig et al., 2017), which combined adversarial loss with perceptual loss derived from the VGG19 network. This allowed the generator to produce photo-realistic details and textures, marking a shift towards perceptual quality rather than just pixel accuracy.

Building on this, ESRGAN (Wang et al., 2018) improved perceptual quality further by refining the generator architecture using Residual-in-Residual Dense Blocks (RRDB) and optimizing the perceptual loss function. These enhancements led to sharper and more detailed outputs.



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ESPCN (Shi et al., 2016) introduced sub-pixel convolution layers for real-time super-resolution, inspiring more efficient model designs. Recently, transformer-based models like SwinIR and IPT have pushed performance boundaries using self-attention mechanisms, though they often demand high computational resources. Despite newer models, SRGAN remains a popular baseline due to its effective balance between computational efficiency and visual quality. Our research leverages SRGAN's architecture, customizing it for the domain of medical image enhancement to restore critical visual details in low-resolution scans.

#### **III. METHODOLOGY**

This work applies Super-Resolution Generative Adversarial Networks (SRGAN) to enhance low-resolution medical images through a structured approach. High-resolution chest X-ray images were collected and downsampled using bicubic interpolation to simulate low-resolution data. The dataset was normalized, resized, and divided into training and testing sets. The SRGAN model comprises a Generator, built with residual blocks and sub-pixel convolution layers to upscale images, and a Discriminator, a convolutional neural network that distinguishes real from generated images using Conv2D layers with LeakyReLU activations. To improve visual fidelity, a pre-trained VGG19 network is used to extract deep perceptual features, which guide the generator through perceptual loss. The overall loss function is a weighted combination of content loss (based on MSE), adversarial loss, and perceptual loss, ensuring both accuracy and realism in the output. The model was trained for 40 epochs using adversarial learning, and performance was evaluated through convergence of loss values and visual inspection of the generated high-resolution images.

#### **IV. EXPERIMENTAL RESULTS**

To prepare the dataset, high-resolution images were cropped to a uniform size  $(96 \times 96)$  and then down sampled by a factor of 4 to create low-resolution  $(24 \times 24)$  counterparts. This formed the basis for training the SRGAN model, where the generator learns to reconstruct super-resolved images from LR inputs.





Figure 1 Adversarial Network Architecture

#### 4.1.1 Discriminator Network

The Discriminator in the SRGAN model is a deep convolutional neural network (CNN) designed to differentiate between real high-resolution images and those generated by the Generator. It consists of a series of Conv2D layers, each followed by Leaky ReLU activation functions (with  $\alpha = 0.2$ ) and Batch Normalization layers. Instead of traditional pooling operations, the model uses strided convolutions for downsampling, allowing more learnable parameters and better gradient flow. After extracting features, the final output is flattened and passed through a Dense layer with sigmoid activation, which outputs a probability indicating whether the image is real or fake.

#### 4.1.2 Generator Network

The Generator is responsible for reconstructing high-resolution (HR) images from low-resolution (LR) inputs. It starts with an initial Conv2D layer to extract low-level features, followed by a sequence of residual blocks that include skip connections and Batch Normalization to maintain feature flow and stability during training. The upsampling is performed using sub-pixel convolution layers (SubpixelConv2D), which efficiently increase the image resolution.



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Finally, a Conv2D output layer reconstructs the HR image. This architectural design ensures the retention of important image features while minimizing visual artifacts, resulting in sharper and more realistic image outputs.

#### Generator result for first 5 epochs:



Figure 2 Generator result 1

#### Generator result for last 5 epochs:



Figure 3 Generator result 2

#### 4.1.3 Perceptual Loss Using VGG19

To enhance the visual realism of the generated images, a pre-trained VGG19 network is employed as a fixed feature extractor. Instead of relying solely on pixel-wise differences, this network extracts high-level feature maps from both real and generated images. These features are used to compute perceptual loss, which captures semantic and texture-related information. By minimizing this loss, the generator is guided to produce images that are not only structurally accurate but also visually consistent with real high-resolution targets. This approach ensures that the output images align more closely with human perception.

#### V. CONCLUSION

In this study, we implemented the SRGAN model to enhance the resolution of low-quality medical images. Through our experiments, we observed significant improvements in the visual quality of generated high-resolution outputs compared to their low-resolution counterparts. Beyond technical implementation, this project provided valuable insights into the application of AI in image analysis and reinforced foundational knowledge in building and executing deep learning projects. The results demonstrate the potential of SRGAN for practical use in medical imaging and other domains where image clarity is critical.

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