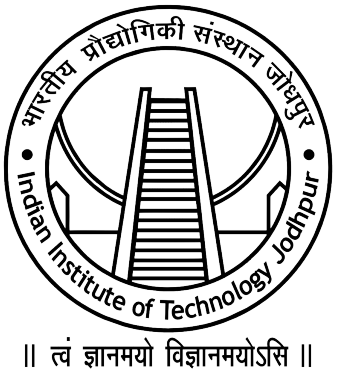
Indian Institute of Technology, Jodhpur, India

Department of Computer Science and Engineering

Advanced Biometrics CSL7430

Assignment 1



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Contents

1 Question 1

Implementation of AE and CNN image to image enhancement models.

1.1 Image to image enhancement

I have tried to showcase the result working of 2 different types of Auto-Encoders, i.e. Dense Layers based Auto-Encoder and CNN Based auto-encoders.

1.1.1 Dense Layers based Auto-encoder

Refer Figure 1. and 2. for implemented model's block diagram details and Figure 3,4 for model summary details.

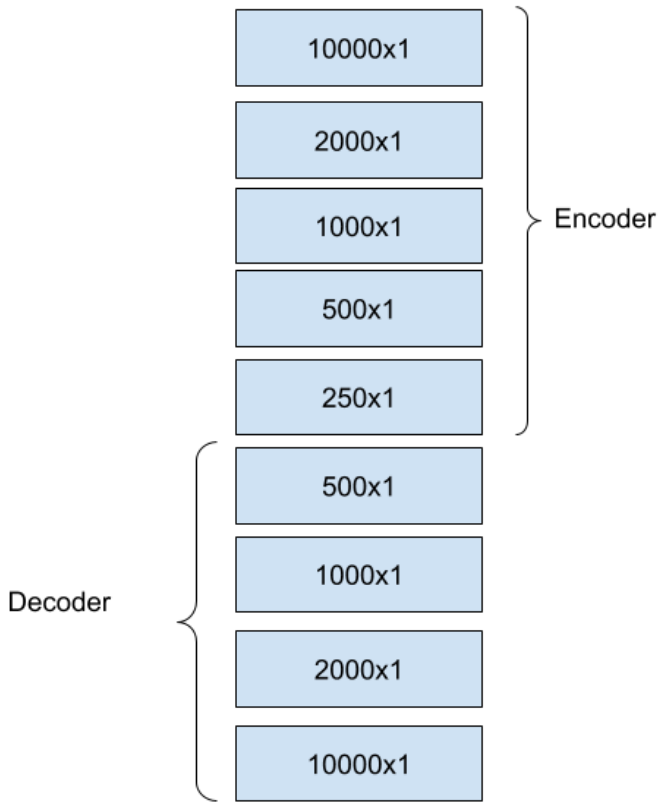

Figure 1: *Dense Layer based AE Model Block Diagram*

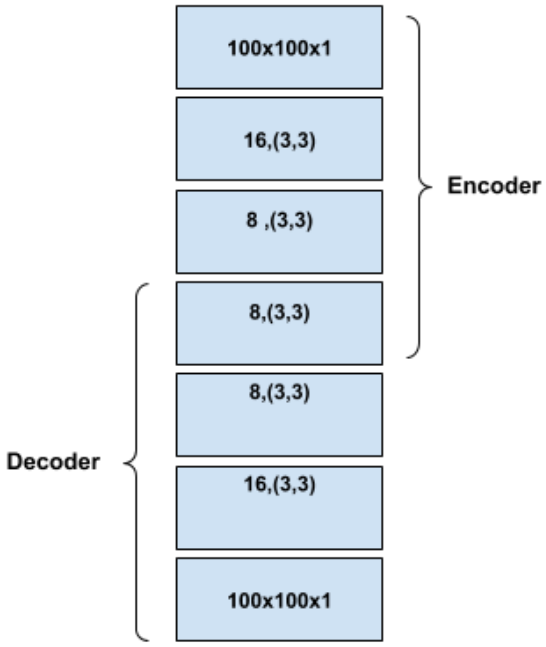

Figure 2: *CNN AE Model Block Diagram*

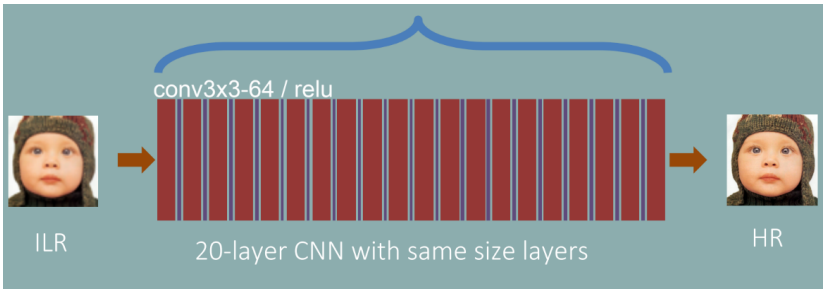

Figure 3: *CNN Enhancement Model Block Diagram*

```
Model: "functional_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_2 (InputLayer)         [(None, 19500)]           0
_________________________________________________________________
dense (Dense)                (None, 2000)              39002000
_________________________________________________________________
dense_1 (Dense)              (None, 1000)              2001000
_________________________________________________________________
dense_2 (Dense)              (None, 500)               500500
_________________________________________________________________
dense_3 (Dense)              (None, 250)               125250
_________________________________________________________________
dense_4 (Dense)              (None, 500)               125500
_________________________________________________________________
dense_5 (Dense)              (None, 1000)              501000
_________________________________________________________________
dense_6 (Dense)              (None, 2000)              2002000
_________________________________________________________________
dense_7 (Dense)              (None, 19500)             39019500
=================================================================
Total params: 83,276,750
Trainable params: 83,276,750
Non-trainable params: 0
_________________________________________________________________
```

Figure 4: *Dense Layer based AE Model Summary*

1.1.2 CNN based Auto-encoder

Refer Figure 5. for model details.

```
Model: "functional_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 100, 100, 1)]     0
_________________________________________________________________
conv2d (Conv2D)              (None, 100, 100, 64)      640
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_8 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_9 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_12 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_13 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_14 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_15 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_16 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_17 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_18 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_19 (Conv2D)           (None, 100, 100, 1)       577
=================================================================
Total params: 665,921
Trainable params: 665,921
Non-trainable params: 0
_________________________________________________________________
```

Figure 5: *CNN AE Model Summary*

1.1.3 CNN for Image Enhancement

Refer Figure 6. for model details.

```
Model: "functional_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 100, 100, 1)]     0
_________________________________________________________________
conv2d (Conv2D)              (None, 100, 100, 64)      640
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_8 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_9 (Conv2D)            (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_12 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_13 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_14 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_15 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_16 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_17 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_18 (Conv2D)           (None, 100, 100, 64)      36928
_________________________________________________________________
conv2d_19 (Conv2D)           (None, 100, 100, 1)       577
=================================================================
Total params: 665,921
Trainable params: 665,921
```

Figure 6: *CNN Image Enhancement Model Summary*

1.1.4 Results

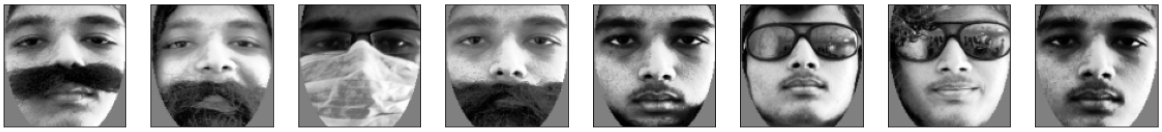

Figure 7: *Original Images*

Figure 8: *Corrupted Images with Gaussian Noise*

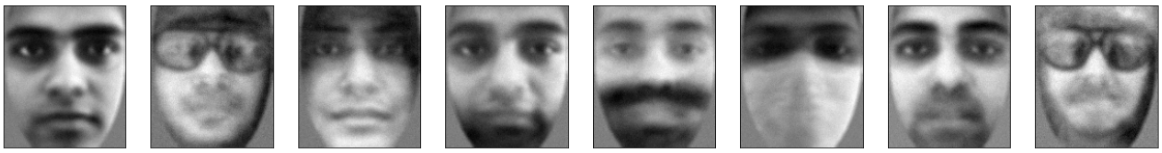

Figure 9: *AE : Image Enhancement*

Figure 10: *CNN AE : Image Enhancement*

Figure 11: *CNN : Image Enhancement*

Figure 12: *Results : Image Enhancement Using AE, CNN AE and CNN*

2 Question 2

Using one of the existing GANs, implement LR to SR problem

2.1 Low Resolution to Super Resolution

Image super-resolution (SR) techniques reconstruct a higher-resolution image from the observed lower-resolution images. An intuitive method for this topic is interpolation, for which texture detail in the reconstructed images is typically absent. Super-Resolution Generative Adversarial Network, or SRGAN, is a generative adversarial network (GAN) for image super-resolution that is more appealing to human perspective. The reference architecture for this implementation is inspired by SRGAN and followed for LR to SR conversion as shown in Figure 13.

2.1.1 Model

For Generator Model details refer Figure and for Discriminator Model details refer Figure

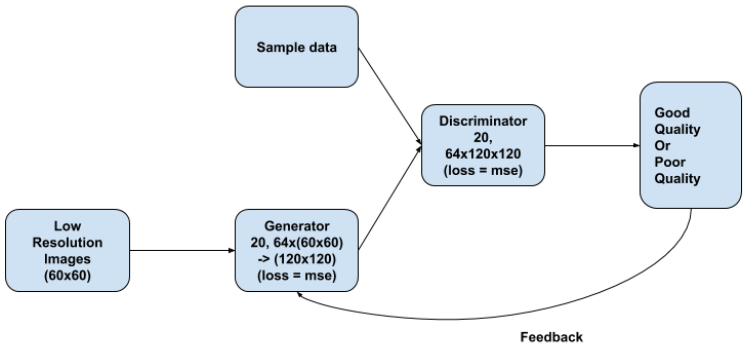

Figure 13: *Basic Block Diagram*

```
Model: "functional_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_3 (InputLayer)         [(None, 60, 60, 1)]       0
_________________________________________________________________
conv2d_40 (Conv2D)           (None, 60, 60, 64)        640
_________________________________________________________________
conv2d_41 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_42 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_43 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_44 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_45 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_46 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_47 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_48 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_49 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_50 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_51 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_52 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_53 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_54 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_55 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_56 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_57 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_58 (Conv2D)           (None, 60, 60, 64)        36928
_________________________________________________________________
conv2d_59 (Conv2D)           (None, 60, 60, 1)         577
=================================================================
Total params: 665,921
Trainable params: 665,921
```

Figure 14: *Generator Model Summary*

```
Model: "functional_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_4 (InputLayer)         [(None, 120, 120, 1)]     0
_________________________________________________________________
conv2d_60 (Conv2D)           (None, 120, 120, 64)      640
_________________________________________________________________
conv2d_61 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_62 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_63 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_64 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_65 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_66 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_67 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_68 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_69 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_70 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_71 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_72 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_73 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_74 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_75 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_76 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_77 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_78 (Conv2D)           (None, 120, 120, 64)      36928
_________________________________________________________________
conv2d_79 (Conv2D)           (None, 120, 120, 1)       577
=================================================================
Total params: 665,921
Trainable params: 665,921
```

Figure 15: *Discriminator Model Summary*

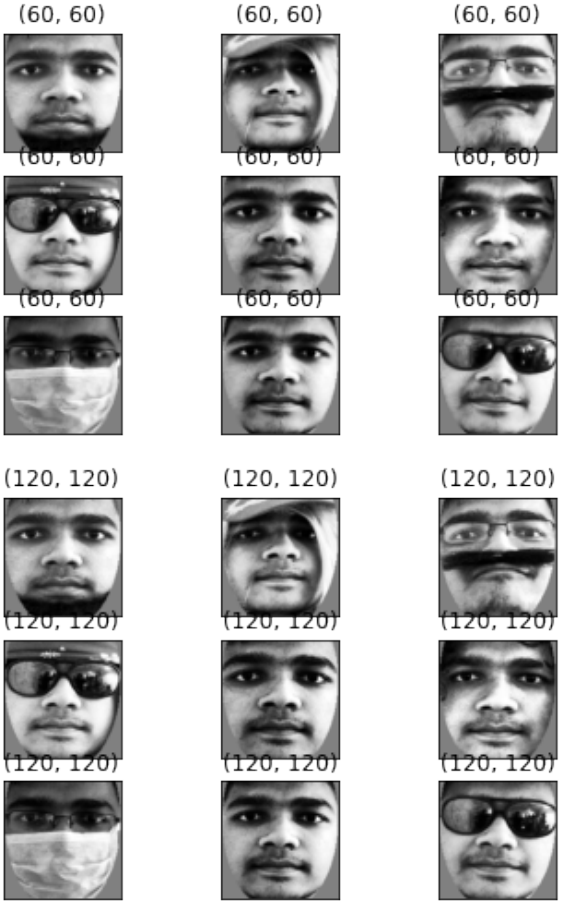

Figure 16: *Original Image and Images after Down-sampling*

2.1.2 Results

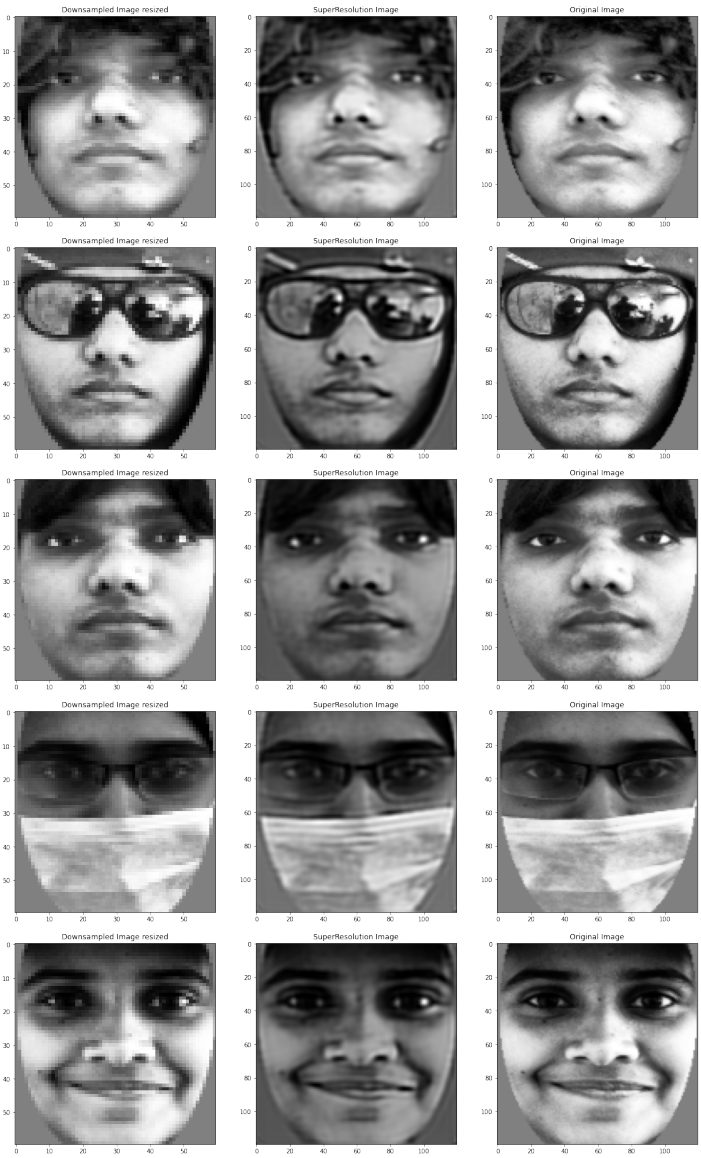

Figure 17: *Result : Low Resolution(60,60) to Super Resolution (120,120)*