Durgesh Vishwakarma

MSc IT Sem4 2021-22 | **Deep Learning** Practical 10 (**PSIT4P3a**)

VPM's B. N. Bandodkar College of Science, Thane.

PRN: 2015430016

===

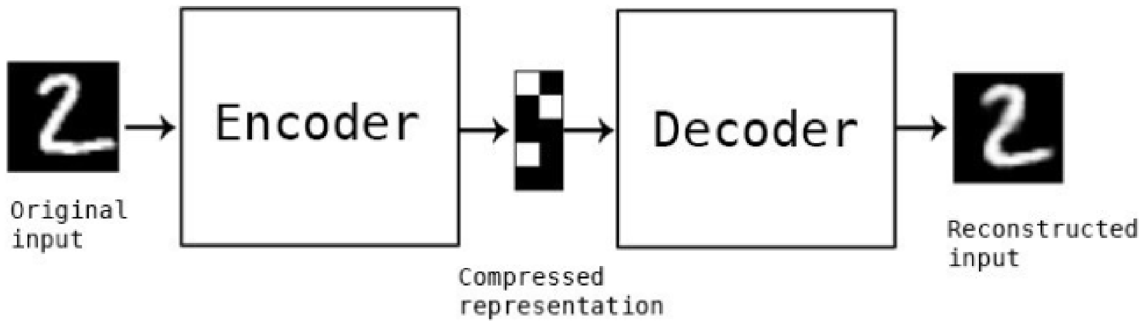
Aim: Denoising of images using autoencoders.

===

Table of Contents

What is an Autoencoder?

Autoencoder is an unsupervised artificial neural network that is trained to copy its input to output. Let’s consider that we are given an image, an autoencoder will first encode the image into a lower-dimensional representation, then decodes the representation back to the image.



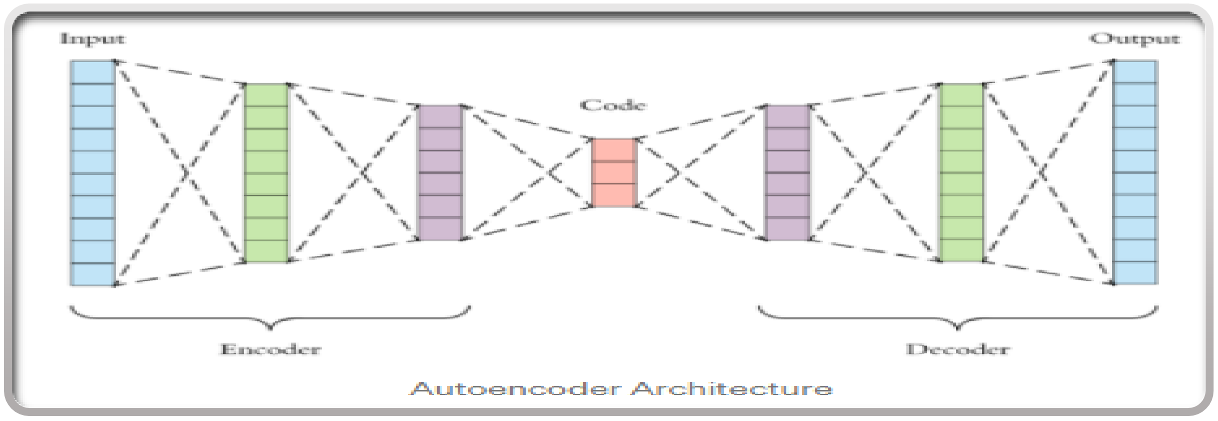
Architecture of Autoencoder

There are mainly 3 parts in autoencoders

1. **Encoder**: In this part of the architecture the model compresses the input data to represent the compressed data in a reduced dimension.
2. **Code**: Also known as Bottleneck this part of the architecture represents the compressed data that is going to be fed to the decoder.
3. **Decoder**: This part reconstructs the encoded data as close to the input data as possible. The output from the decoder is a lossy reconstruction of the original data.

The goal of an autoencoder is to get an output that is identical to the input. The dimensionality of the input and output is similar as obviously the goal is to get the output as identical to the input we can get.

They are trained similarly to ANNs via backpropagation



Implementation:

1. Importing libraries and dataset

First, we'll import all required libraries and MNIST image dataset.

```
#Importing libraries
from keras.layers import Input, Dense
from keras.models import Model
from keras.datasets import mnist
import keras.layers as layers
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline

(x_train, _), (x_test, _) = mnist.load_data()

x_train = x_train.astype('float32') / 255.
x_test = x_test.astype('float32') / 255.
x_train = np.reshape(x_train, (len(x_train), 28, 28, 1))
x_test = np.reshape(x_test, (len(x_test), 28, 28, 1))
```

2. Adding Noise to MNIST Image dataset

We will add some noise to encode our original image into a noisy image dataset, which we'll send later as input to Autoencoders to decode or denoising it.

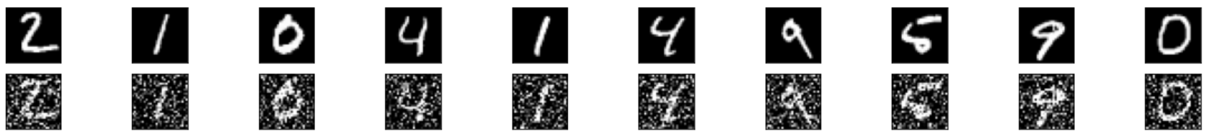
```
noise_factor = 0.5
x_train_noisy = x_train + noise_factor * np.random.normal(loc=0.0, scale
=1.0, size=x_train.shape)
x_test_noisy = x_test + noise_factor * np.random.normal(loc=0.0, scale=1
.0, size=x_test.shape)

x_train_noisy = np.clip(x_train_noisy, 0., 1.)
x_test_noisy = np.clip(x_test_noisy, 0., 1.)
```

```
print("Below is some sample of Original vs Noisy dataset for review")
n = 10
plt.figure(figsize=(20, 2))
```

```
for i in range(1, n + 1):
    #Display original
    ax = plt.subplot(2, n, i)
    plt.imshow(x_test[i].reshape(28, 28))
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)

    #Display Encoded
    ax = plt.subplot(2, n, i+n)
    plt.imshow(x_test_noisy[i].reshape(28, 28))
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)
plt.show()
```

Output:

```
Below is some sample of Original vs Noisy dataset for review
```



3. Building Autoencoder model using Keras

Here we will build Autoencoder model using Keras and train it with 100 epochs for better output. It may take few minutes to execute and produce output.

```
input_img = Input(shape=(28, 28, 1))

x = layers.Conv2D(32, (3, 3), activation='relu', padding='same')(input_i
mg)
x = layers.MaxPooling2D((2, 2), padding='same')(x)
x = layers.Conv2D(32, (3, 3), activation='relu', padding='same')(x)
encoded = layers.MaxPooling2D((2, 2), padding='same')(x)

x = layers.Conv2D(32, (3, 3), activation='relu', padding='same')(encoded
)
x = layers.UpSampling2D((2, 2))(x)
x = layers.Conv2D(32, (3, 3), activation='relu', padding='same')(x)
x = layers.UpSampling2D((2, 2))(x)
```

```
decoded = layers.Conv2D(1, (3, 3), activation='sigmoid', padding='same')
(x)

autoencoder = Model(input_img, decoded)
autoencoder.compile(optimizer='adam', loss='binary_crossentropy')
```

```
autoencoder.fit(x_train_noisy, x_train, epochs=100, batch_size=128, shuf
fle=True, validation_data=(x_test_noisy, x_test))
```

Output:

```
Epoch 1/100
469/469 [==============================] - 7s 8ms/step - loss: 0.2495 - val_loss: 0.1147
Epoch 2/100
469/469 [==============================] - 3s 7ms/step - loss: 0.1133 - val_loss: 0.1064
Epoch 3/100
469/469 [==============================] - 3s 7ms/step - loss: 0.1069 - val_loss: 0.1035
Epoch 4/100
469/469 [==============================] - 3s 7ms/step - loss: 0.1040 - val_loss: 0.1015
```

....

```
Epoch 98/100
469/469 [==============================] - 3s 7ms/step - loss: 0.0927 - val_loss: 0.0929
Epoch 99/100
469/469 [==============================] - 3s 7ms/step - loss: 0.0928 - val_loss: 0.0930
Epoch 100/100
469/469 [==============================] - 3s 7ms/step - loss: 0.0929 - val_loss: 0.0930
<tensorflow.python.keras.callbacks.History at 0x7f408e322410>
```

4. Testing Autoencoder model

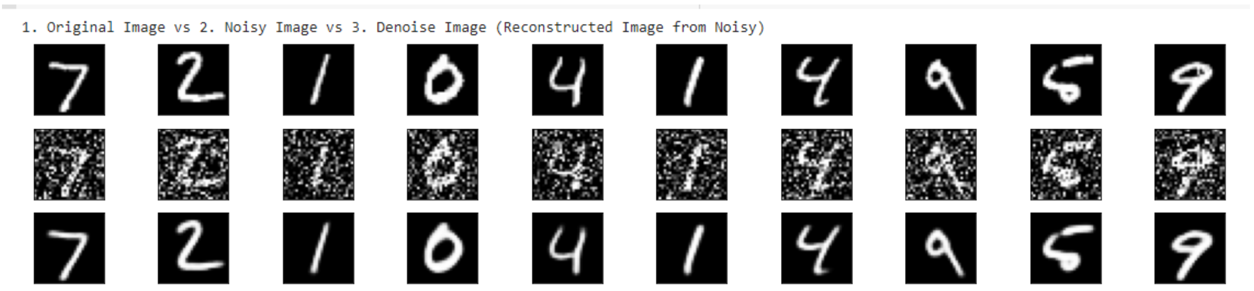
As our Autoencoder model is ready now. We will compare below to test the model.

1. Original Image
2. Noisy Image
3. Denoise Image

```
decoded_imgs = autoencoder.predict(x_test)

n = 10

print("1. Original Image vs 2. Noisy Image vs 3. Denoise Image (Recon
structed from Noisy Image)")
```

```
    plt.figure(figsize=(20, 4))
    for i in range(n):
        # display original
        ax = plt.subplot(3, n, i + 1)
        plt.imshow(x_test[i].reshape(28, 28))
        plt.gray()
        ax.get_xaxis().set_visible(False)
        ax.get_yaxis().set_visible(False)

        #Display Encoded
        ax = plt.subplot(3, n, i+1+n)
        plt.imshow(x_test_noisy[i].reshape(28, 28))
        plt.gray()
        ax.get_xaxis().set_visible(False)
        ax.get_yaxis().set_visible(False)

        # display reconstruction
        ax = plt.subplot(3, n, i+1+n+n)
        plt.imshow(decoded_imgs[i].reshape(28, 28))
        plt.gray()
        ax.get_xaxis().set_visible(False)
        ax.get_yaxis().set_visible(False)
    plt.show()
```

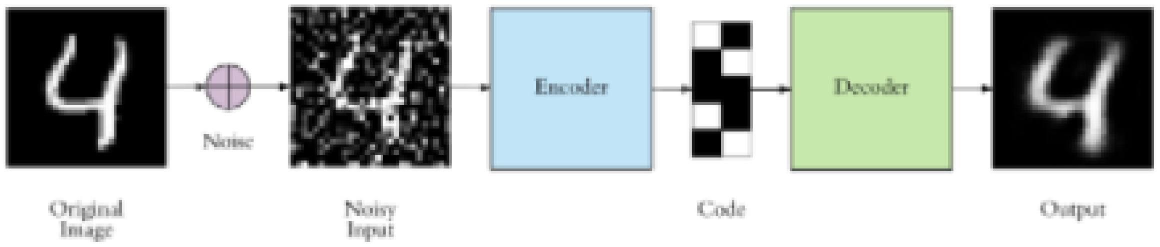
Final Output:



```
1. Original Image vs 2. Noisy Image vs 3. Denoise Image (Reconstructed Image from Noisy)
```

Conclusion:

- We have successfully performed following actions in Denoising of images using autoencoders.
    - Pulled Original image dataset from TensorFlow's MNIST dataset.
    - Transformed Original Image into Noisy Image
    - Encoded Noisy Image into code using Keras's autoencoders model.
    - Decoded Code to reconstruct Original Image using Keras's autoencoders model.
- For more details please review PPT file of this.
-


Original Image
Noise
Noisy Input
Encoder
Code
Decoder
Output