ECE30007 Intro to AI Project

AutoEncoder (AE)

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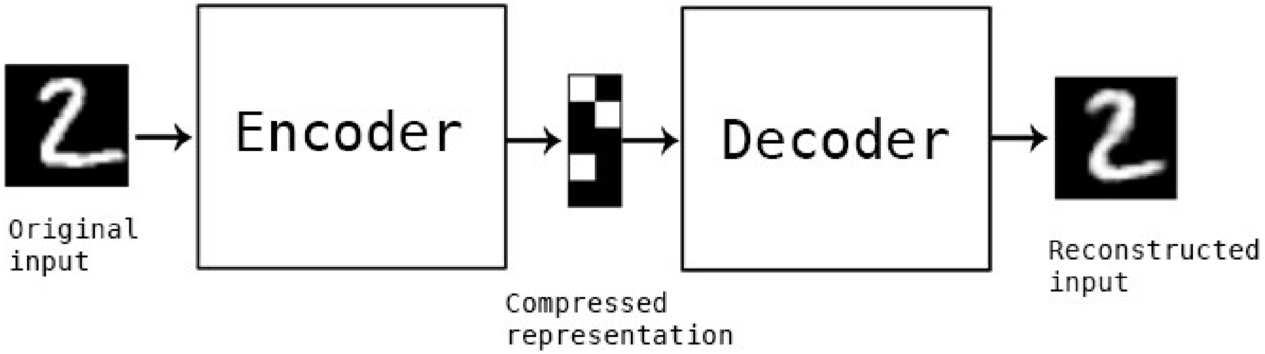
Content

- Introduction to AutoEncoder(AE)
- AE Implementation (using a basic NN)
- AE Implementation (using a basic CNN)
- AE application: Denoising

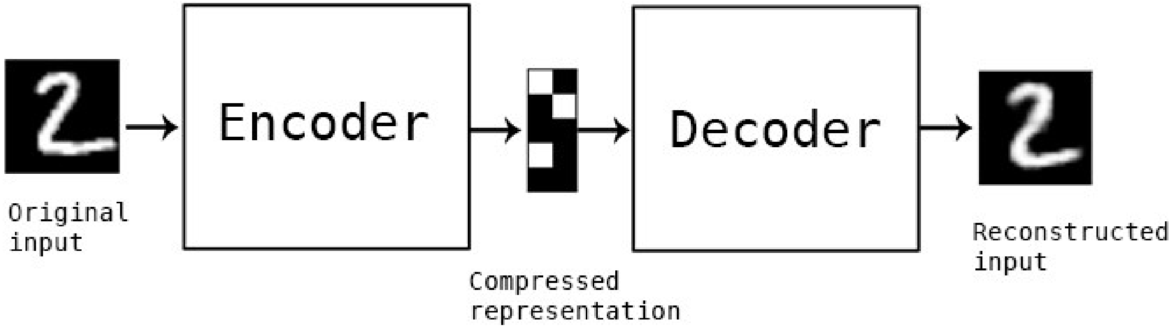
Introduction to AE

- AutoEncoder
  - that automatically
    - finds compressed representation
    - extracts features
    - finds latent space

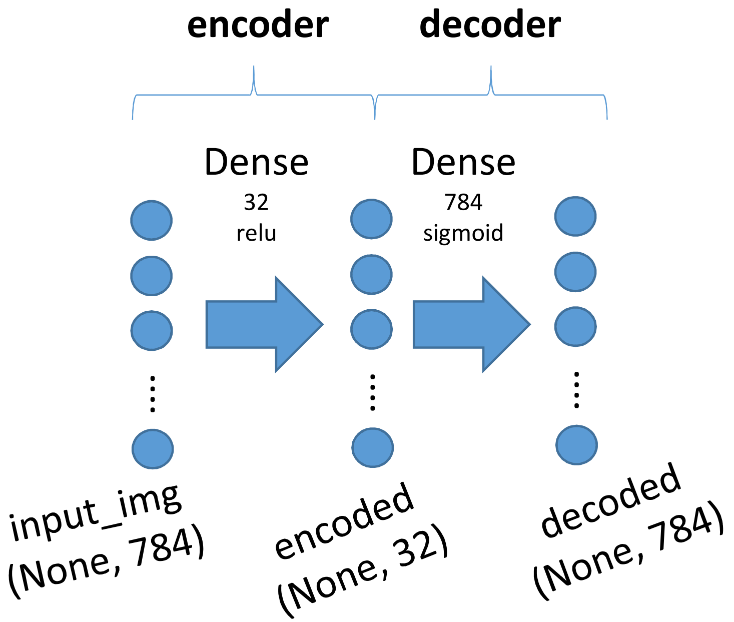


Introduction to AE

- AutoEncoder
  1) Data-specific
  2) Lossy
  3) Learning automatically from data examples



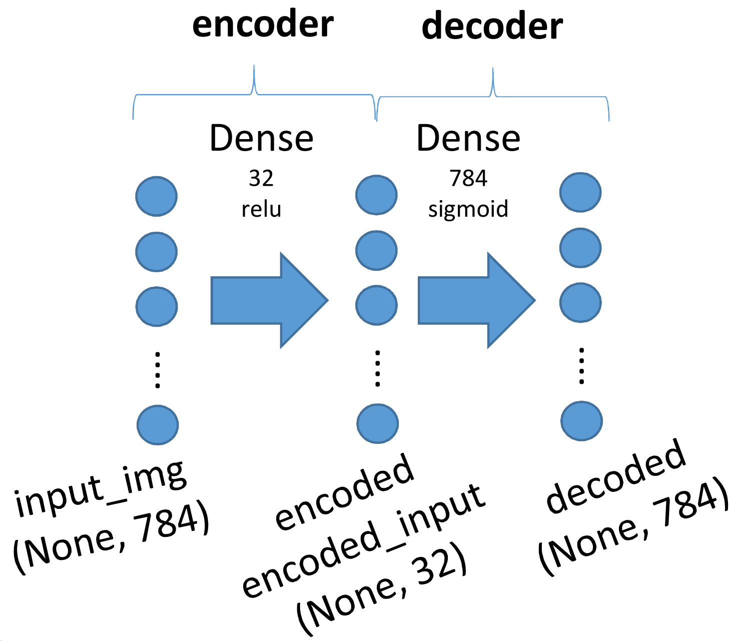
AE Implementation



```
from keras.layers import Input, Dense
from keras.models import Model

encoding_dim = 32

input_img = Input(shape=(784,)) #784 = 28x28
encoded = Dense(encoding_dim, activation='relu')(input_img)
encoder = Model(input_img, encoded)
```

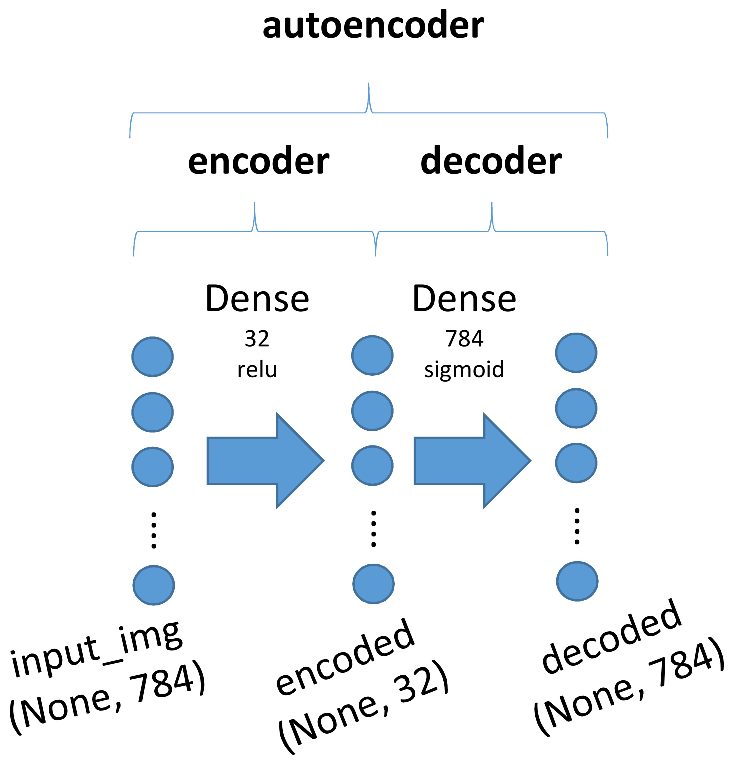
https://blog.keras.io/building-autoencoders-in-keras.html

AE Implementation



```
#need to re-define input layer for decoder input
encoded_input = Input(shape=(encoding_dim,))
decoded = Dense(784, activation='sigmoid')(encoded_input)
decoder = Model(encoded_input, decoded)
```

AE Implementation



```
outputs = decoder(encoder(input_img))
autoencoder = Model(input_img, outputs)
autoencoder.compile(optimizer=adam', loss='binary_crossentropy')
```

AE Implementation (MNIST data importation)

```
from keras.datasets import mnist
import numpy as np
(x_train, _), (x_test, _) = mnist.load_data()

x_train = x_train.astype('float32') / 255.
x_test = x_test.astype('float32') / 255.
x_train = x_train.reshape((len(x_train), np.prod(x_train.shape[1:])))
x_test = x_test.reshape((len(x_test), np.prod(x_test.shape[1:])))
```

AE Implementation (MNIST data importation)

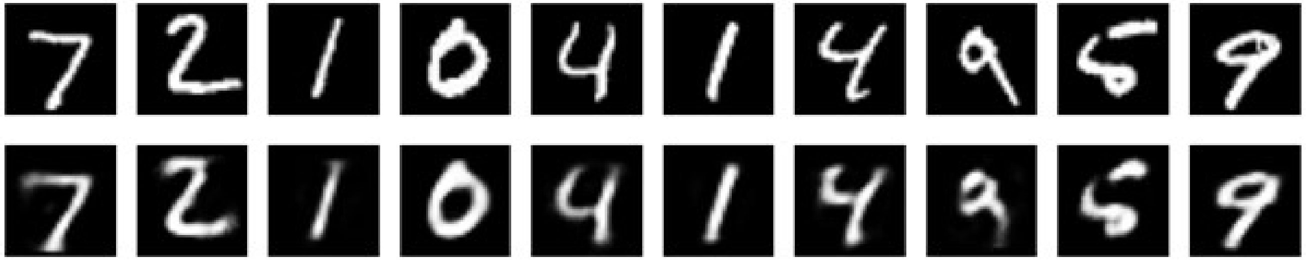
```
autoencoder.fit(x_train, x_train,
                epochs=50,
                batch_size=256,
                shuffle=True,
                validation_data=(x_test, x_test))
```

AE Implementation (encoding and decoding)

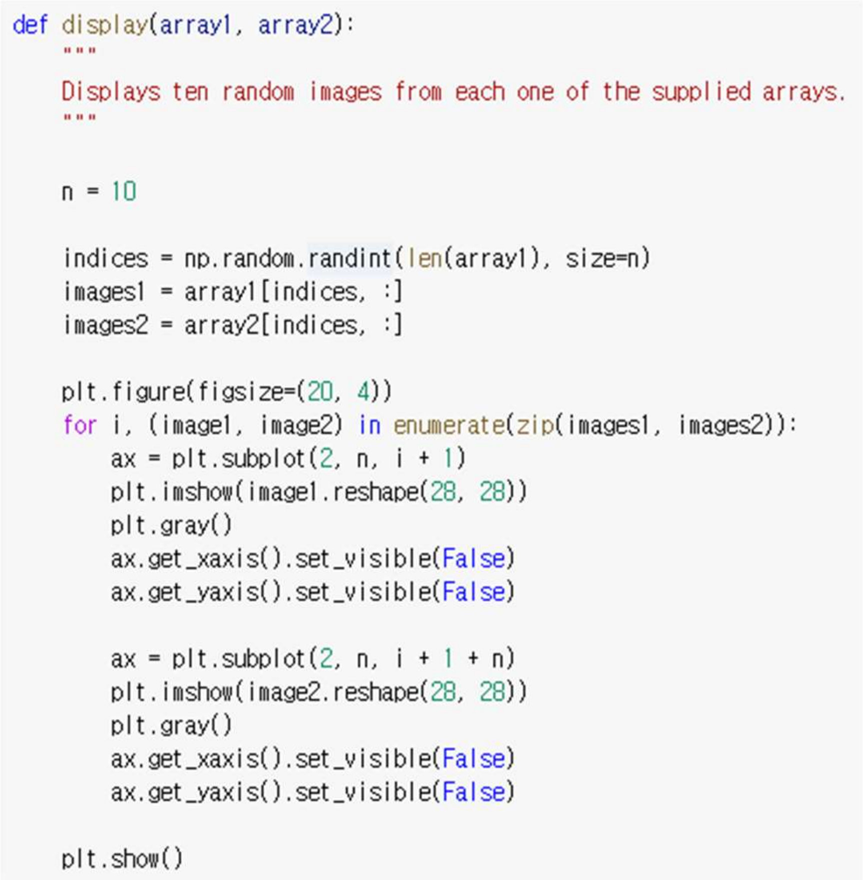
```
encoded_imgs = encoder.predict(x_test)
decoded_imgs = decoder.predict(encoded_imgs)
```

AE Implementation (plotting the result)

```
import matplotlib.pyplot as plt

n = 10  # how many digits we will display
plt.figure(figsize=(20, 4))
for i in range(n):
    ax = plt.subplot(2, 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)
    ax = plt.subplot(2, n, i + 1 + 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()
```



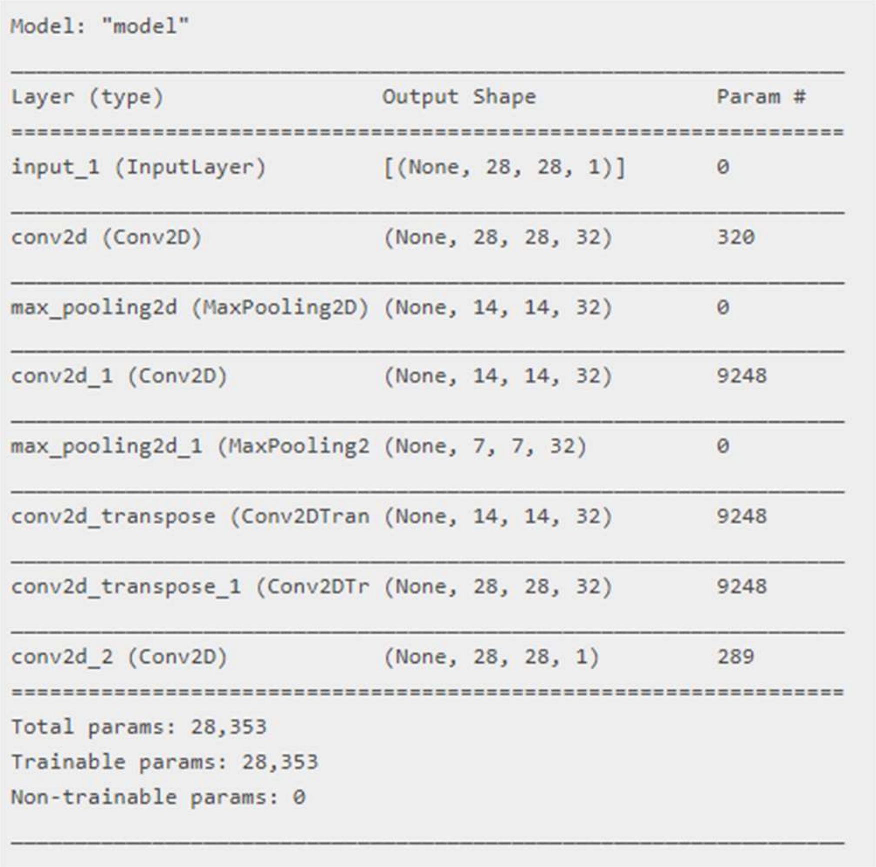
AE Implementation (plotting the result)



```
def display(array1, array2):
    """
    Displays ten random images from each one of the supplied arrays.
    """

    n = 10

    indices = np.random.randint(len(array1), size=n)
    images1 = array1[indices, :]
    images2 = array2[indices, :]

    plt.figure(figsize=(20, 4))
    for i, (image1, image2) in enumerate(zip(images1, images2)):
        ax = plt.subplot(2, n, i + 1)
        plt.imshow(image1.reshape(28, 28))
        plt.gray()
        ax.get_xaxis().set_visible(False)
        ax.get_yaxis().set_visible(False)

        ax = plt.subplot(2, n, i + 1 + n)
        plt.imshow(image2.reshape(28, 28))
        plt.gray()
        ax.get_xaxis().set_visible(False)
        ax.get_yaxis().set_visible(False)

    plt.show()
```

- Code from
  - https://keras.io/examples/vision/autoencoder/

AE Implementation (CNN)



```
Model: "model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
input_1 (InputLayer)         [(None, 28, 28, 1)]       0         
_________________________________________________________________
conv2d (Conv2D)              (None, 28, 28, 32)        320       
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 14, 14, 32)        0         
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 14, 14, 32)        9248      
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 7, 7, 32)          0         
_________________________________________________________________
conv2d_transpose (Conv2DTran (None, 14, 14, 32)        9248      
_________________________________________________________________
conv2d_transpose_1 (Conv2DTr (None, 28, 28, 32)        9248      
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 28, 28, 1)         289       
=================================================================
Total params: 28,353
Trainable params: 28,353
Non-trainable params: 0
_________________________________________________________________
```

AE Implementation (CNN)

```
from tensorflow.keras import layers
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Model


def preprocess(array):
    """
    Normalizes the supplied array and reshapes it into the appropriate format.
    """

    array = array.astype("float32") / 255.0
    array = np.reshape(array, (len(array), 28, 28, 1))
    return array
```

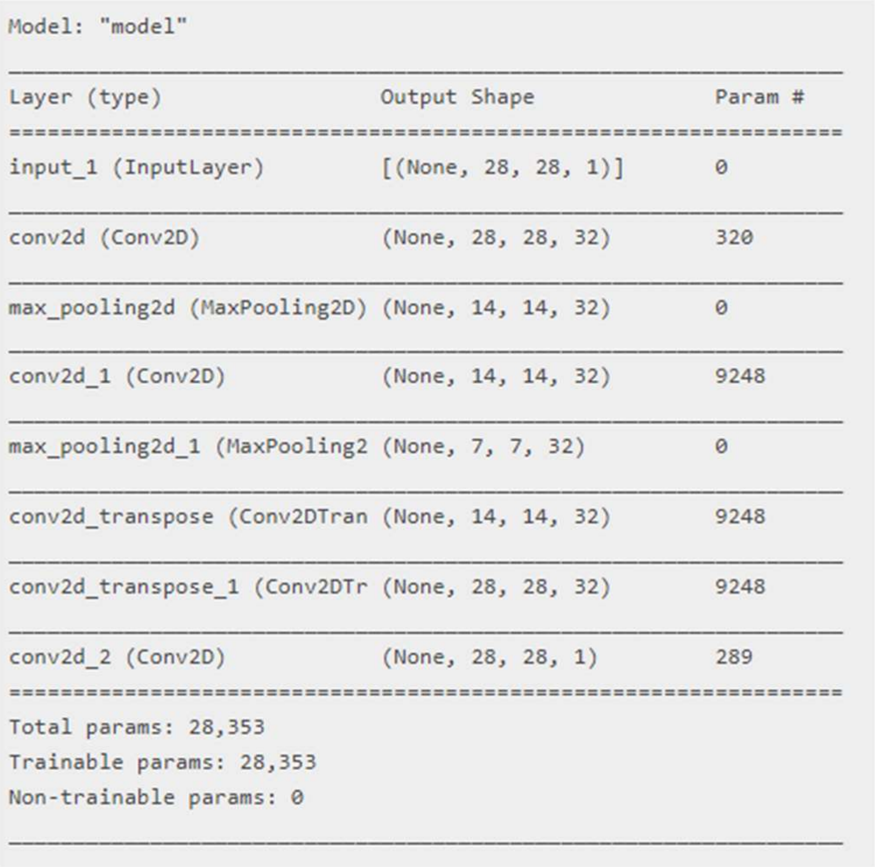
- Code from
    - https://keras.io/examples/vision/autoencoder/

AE Implementation (CNN)

```
(train_data, _), (test_data, _) = mnist.load_data()

# Normalize and reshape the data
train_data = preprocess(train_data)
test_data = preprocess(test_data)
```

AE Implementation (CNN)

```
input = layers.Input(shape=(28, 28, 1))

# Encoder
x = layers.Conv2D(32, (3, 3), activation="relu", padding="same")(input)
x = layers.MaxPooling2D((2, 2), padding="same")(x)
x = layers.Conv2D(32, (3, 3), activation="relu", padding="same")(x)
x = layers.MaxPooling2D((2, 2), padding="same")(x)

# Decoder
x = layers.Conv2DTranspose(32, (3, 3), strides=2, activation="relu", padding="same")(x)
x = layers.Conv2DTranspose(32, (3, 3), strides=2, activation="relu", padding="same")(x)
x = layers.Conv2D(1, (3, 3), activation="sigmoid", padding="same")(x)

# Autoencoder
autoencoder = Model(input, x)
autoencoder.compile(optimizer="adam", loss="binary_crossentropy")
autoencoder.summary()
```



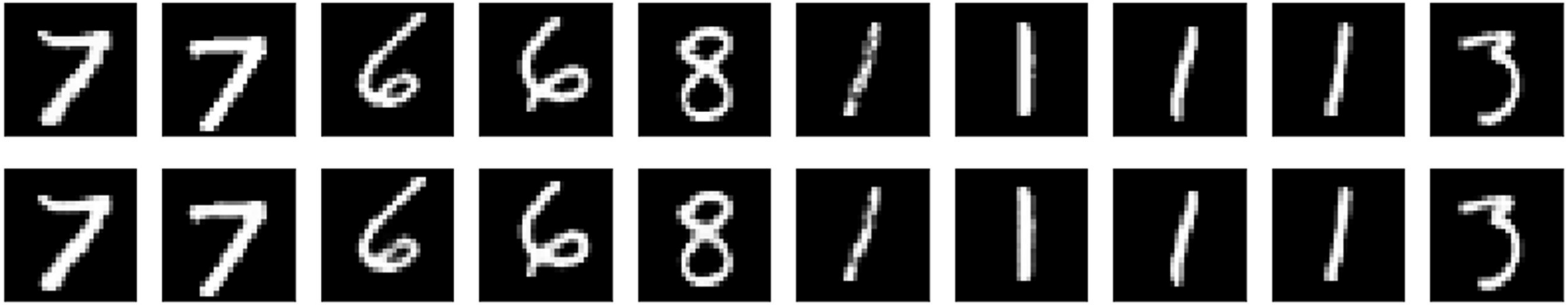
```
Model: "model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 28, 28, 1)]       0
_________________________________________________________________
conv2d (Conv2D)              (None, 28, 28, 32)        320
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 14, 14, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 14, 14, 32)        9248
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 7, 7, 32)          0
_________________________________________________________________
conv2d_transpose (Conv2DTran (None, 14, 14, 32)        9248
_________________________________________________________________
conv2d_transpose_1 (Conv2DTr (None, 28, 28, 32)        9248
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 28, 28, 1)         289
=================================================================
Total params: 28,353
Trainable params: 28,353
Non-trainable params: 0
_________________________________________________________________
```

AE Implementation (CNN)

```
autoencoder.fit(
    x=train_data,
    y=train_data,
    epochs=50,
    batch_size=128,
    shuffle=True,
    validation_data=(test_data, test_data),
)
```

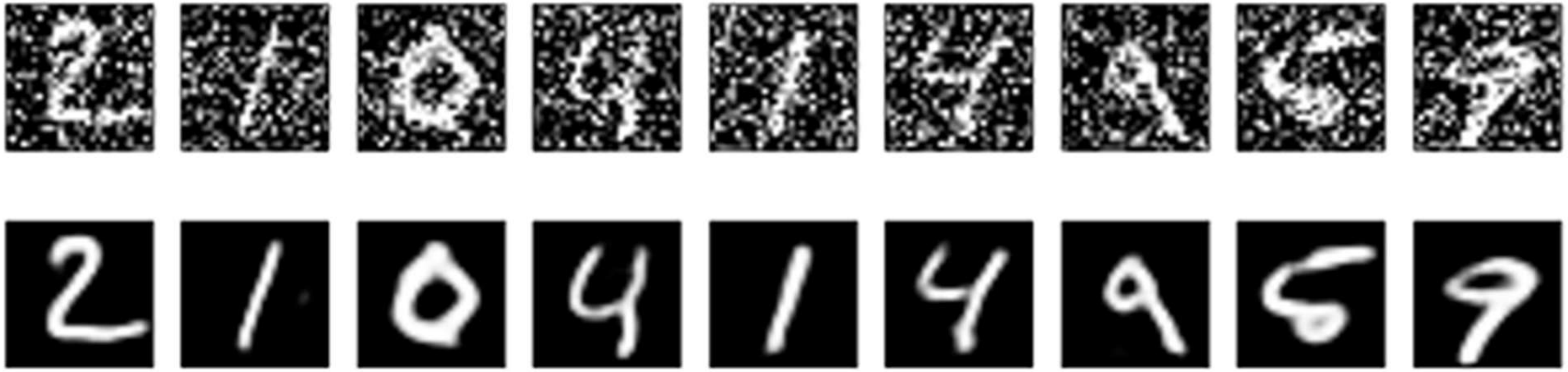
AE Implementation (CNN)

```
predictions = autoencoder.predict(test_data)
display(test_data, predictions)
```



Practice

- AE Application to Image Denoising

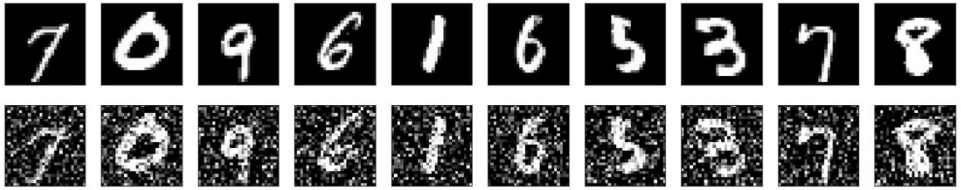


AE Application to Image Denoising

```
def noise(array):
    """
    Adds random noise to each image in the supplied array.
    """

    noise_factor = 0.4
    noisy_array = array + noise_factor * np.random.normal(
        loc=0.0, scale=1.0, size=array.shape
    )

    return np.clip(noisy_array, 0.0, 1.0)
```

AE Application to Image Denoising

```
(train_data, _), (test_data, _) = mnist.load_data()

# Normalize and reshape the data
train_data = preprocess(train_data)
test_data = preprocess(test_data)

# Create a copy of the data with added noise
noisy_train_data = noise(train_data)
noisy_test_data = noise(test_data)

# Display the train data and a version of it with added noise
display(train_data, noisy_train_data)
```

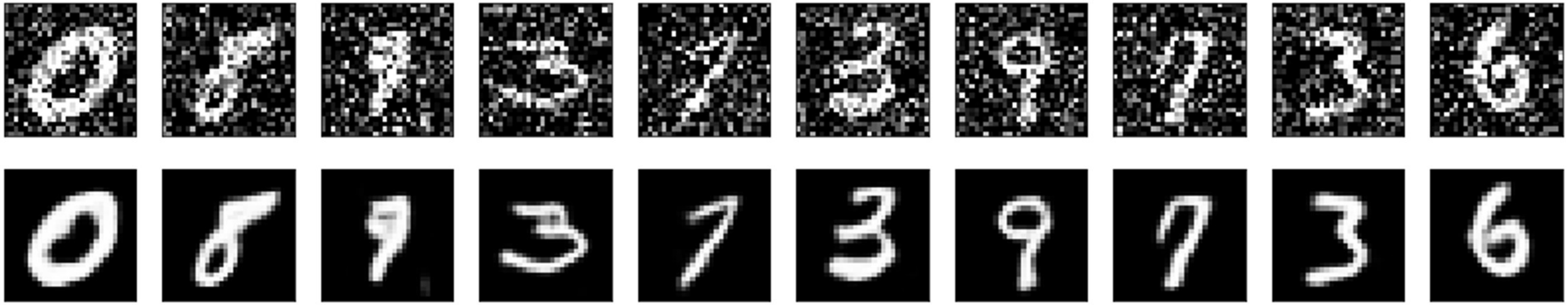


AE Application to Image Denoising

```
autoencoder.fit(
    x=noisy_train_data,
    y=train_data,
    epochs=100,
    batch_size=128,
    shuffle=True,
    validation_data=(noisy_test_data, test_data),
)
```

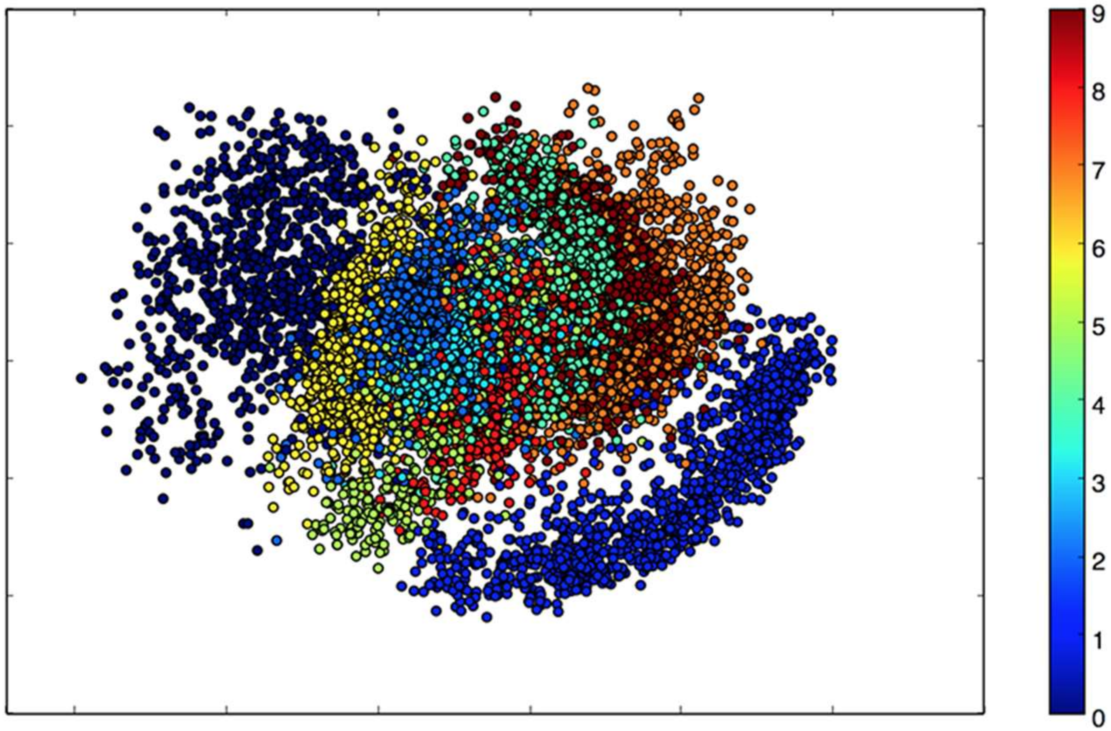
AE Application to Image Denoising

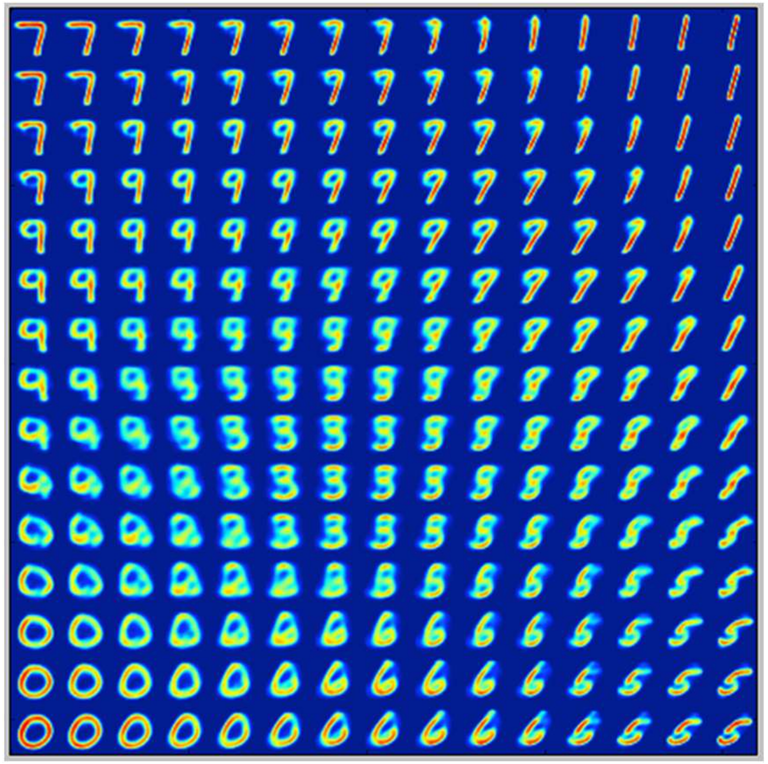
```
predictions = autoencoder.predict(noisy_test_data)
display(noisy_test_data, predictions)
```



Next time…

- Variational Autoencoder (VAE)





Assignment

- 19페이지까지 학습된 CNN AE에, Noisy 이미지를 입력하면, 어떤 출력 결과가 나올까?
  - 해당 내용을 구현하고 확인할 수 있는 코드 작성
  - 결과 분석

Thank you!