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What are AutoEncoders?

- Neural networks capable of learning dense representations of input data without supervision
  - Training data is not labelled
- Useful for dimensionality reduction and for visualization
- Can be used to generate new data that resembles input data
- In practice they
  - Copy input to output
  - They learn efficient ways to represent data

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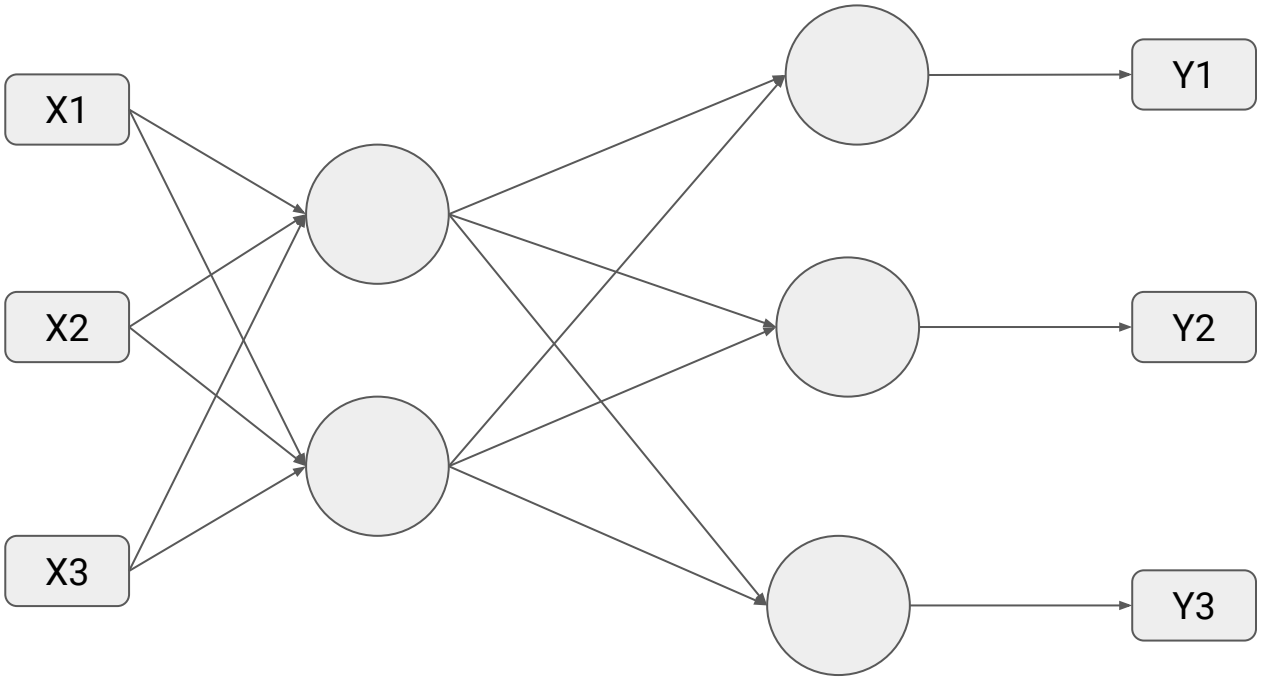
4 9 16 25 36 49 64 81 100 121 144 169

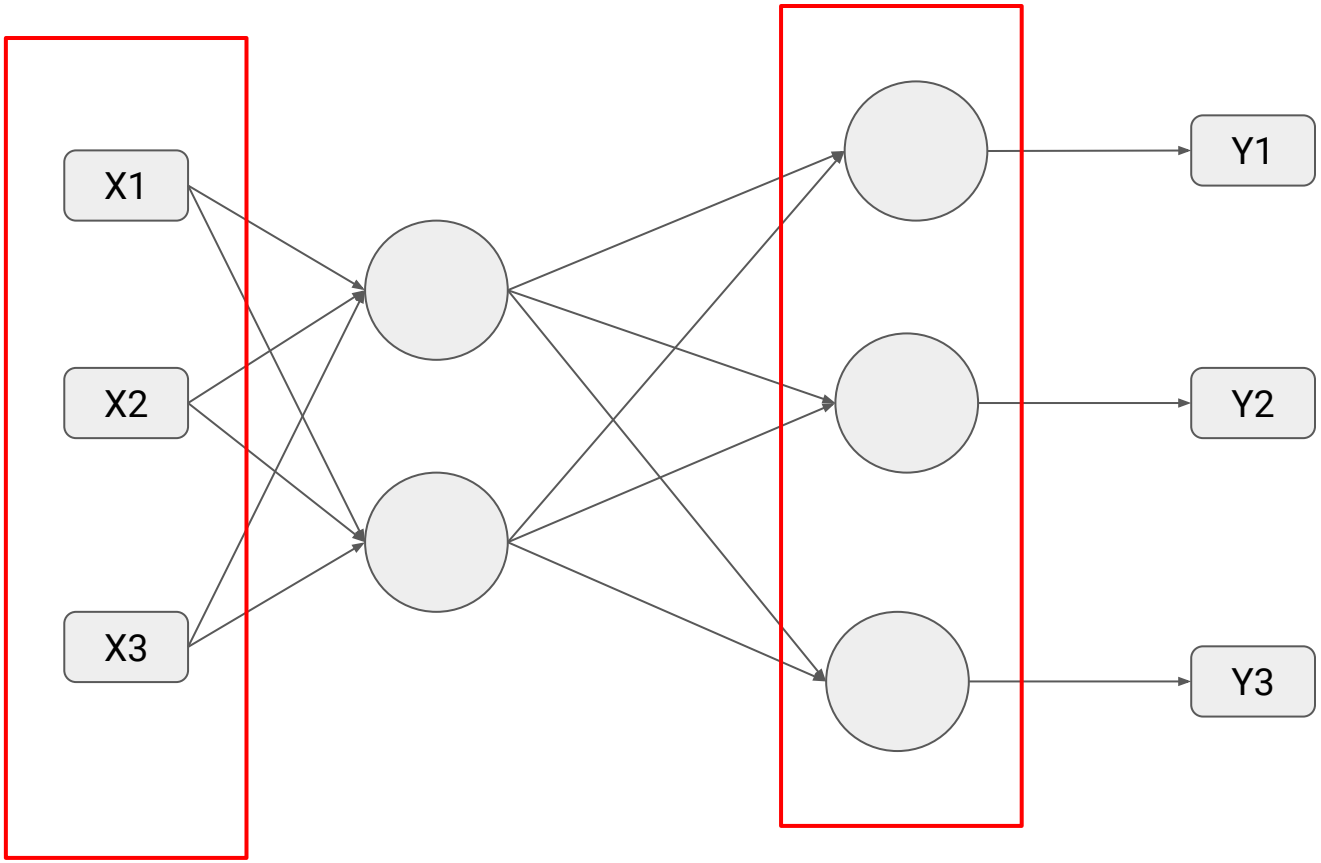
83 12 21 42 99 18 51

4 9 16 25 36 49 64 81 100 121 144 169

83 12 21 42 99 18 51

4 9 16 25 36 49 64 81 100 121 144 169


X1
X2
X3
Y1
Y2
Y3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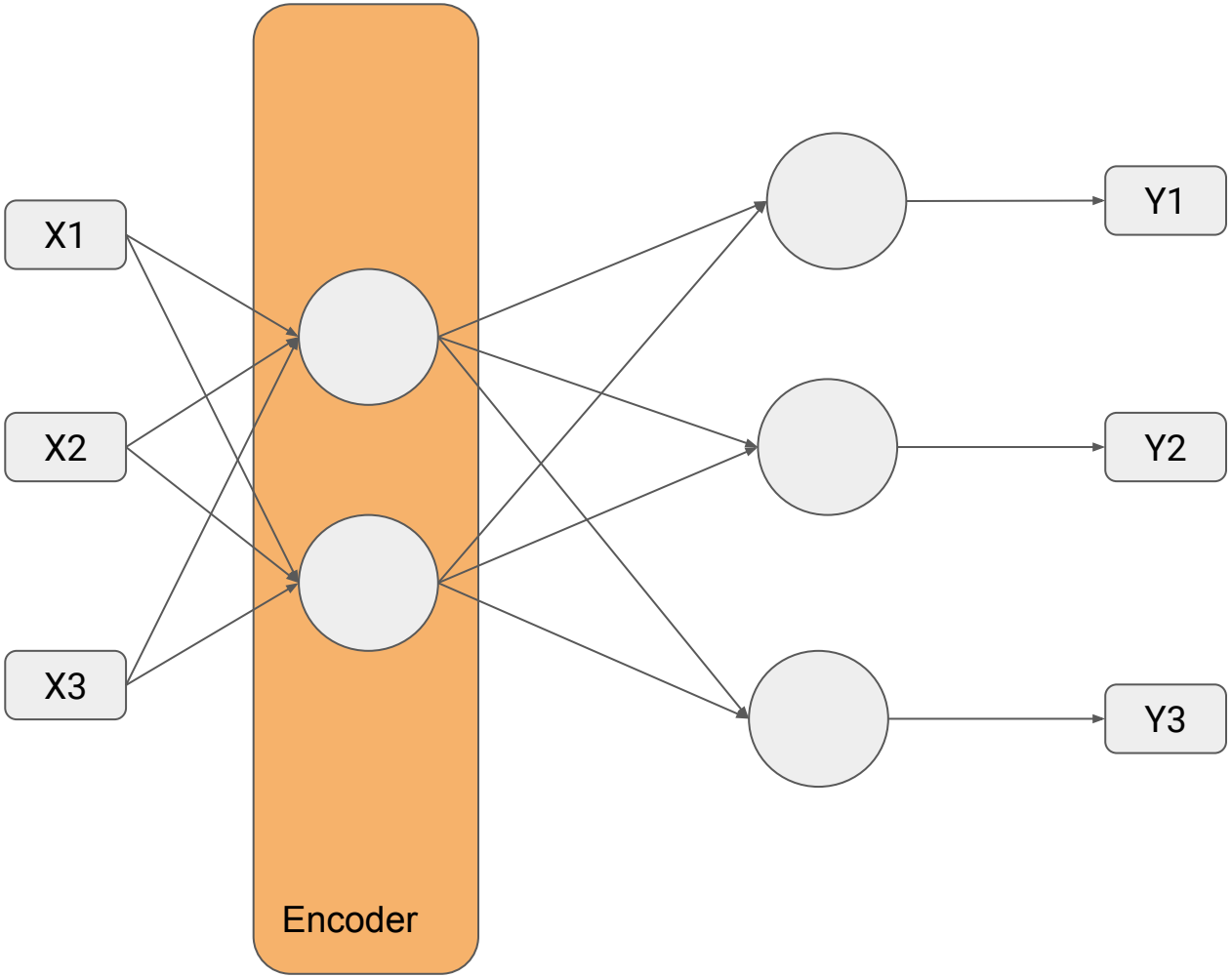
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Encoder
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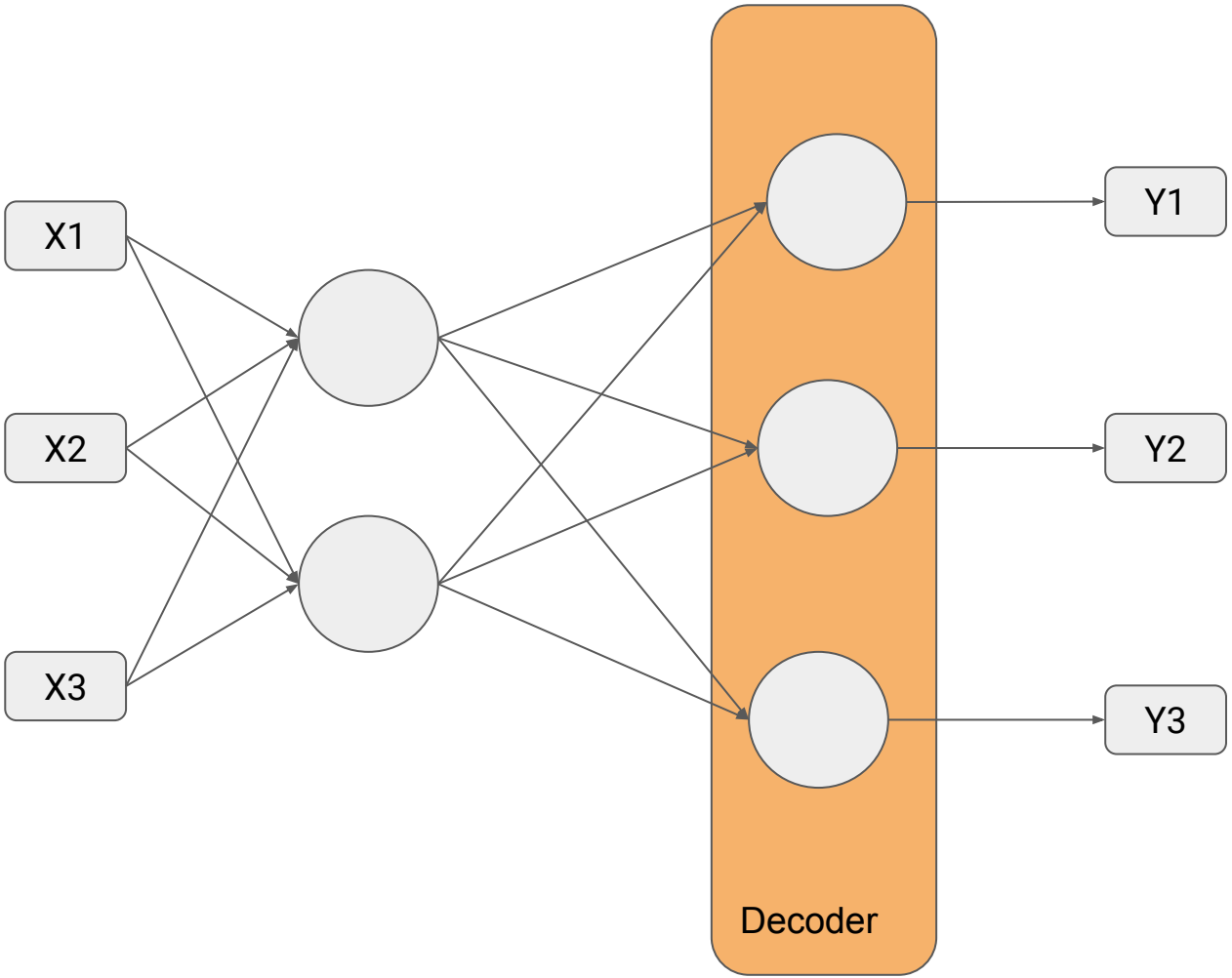
Y2
Y3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Y1
Y2
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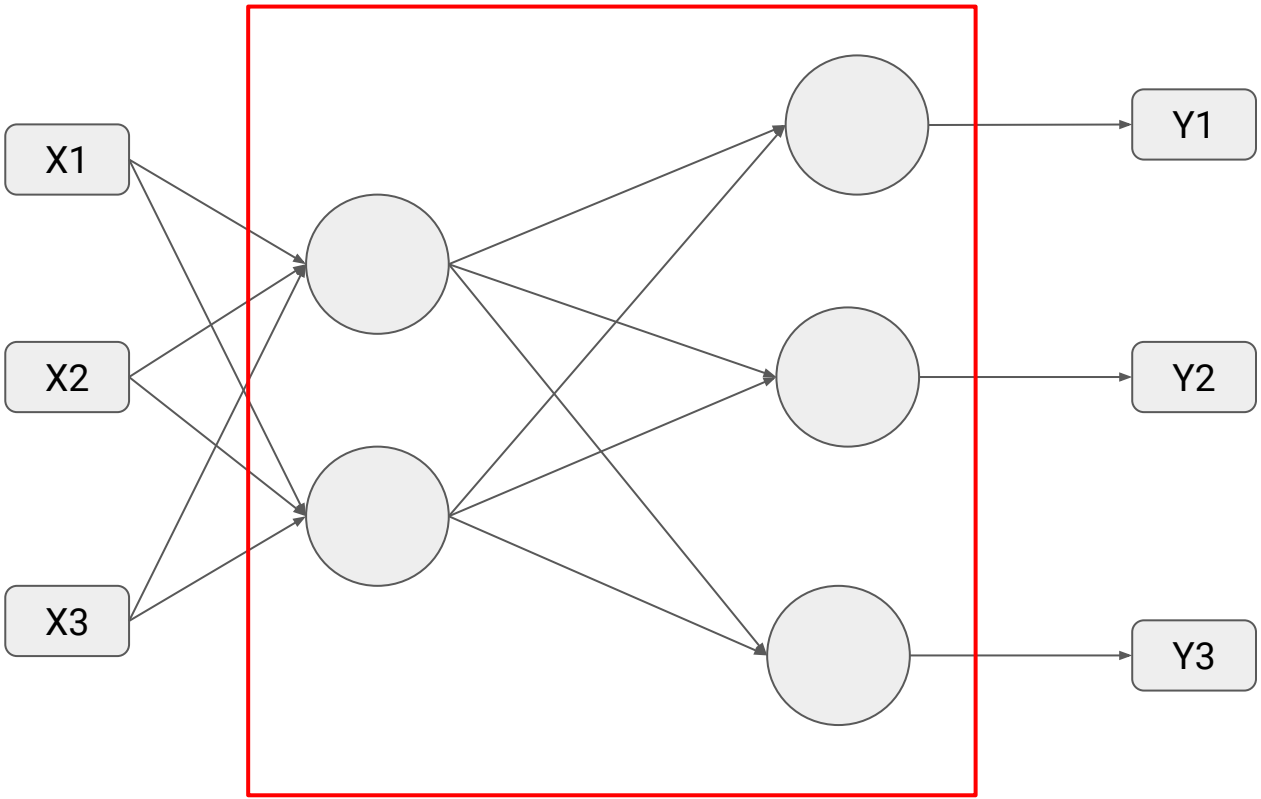
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Y1
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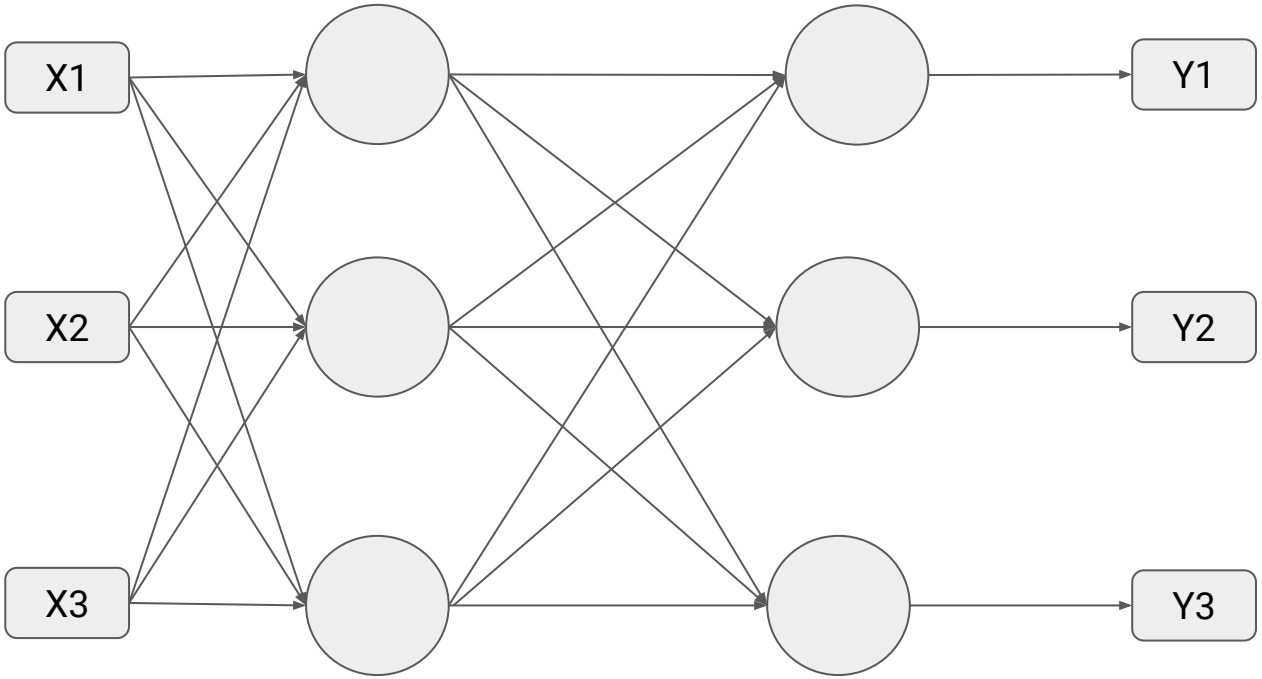
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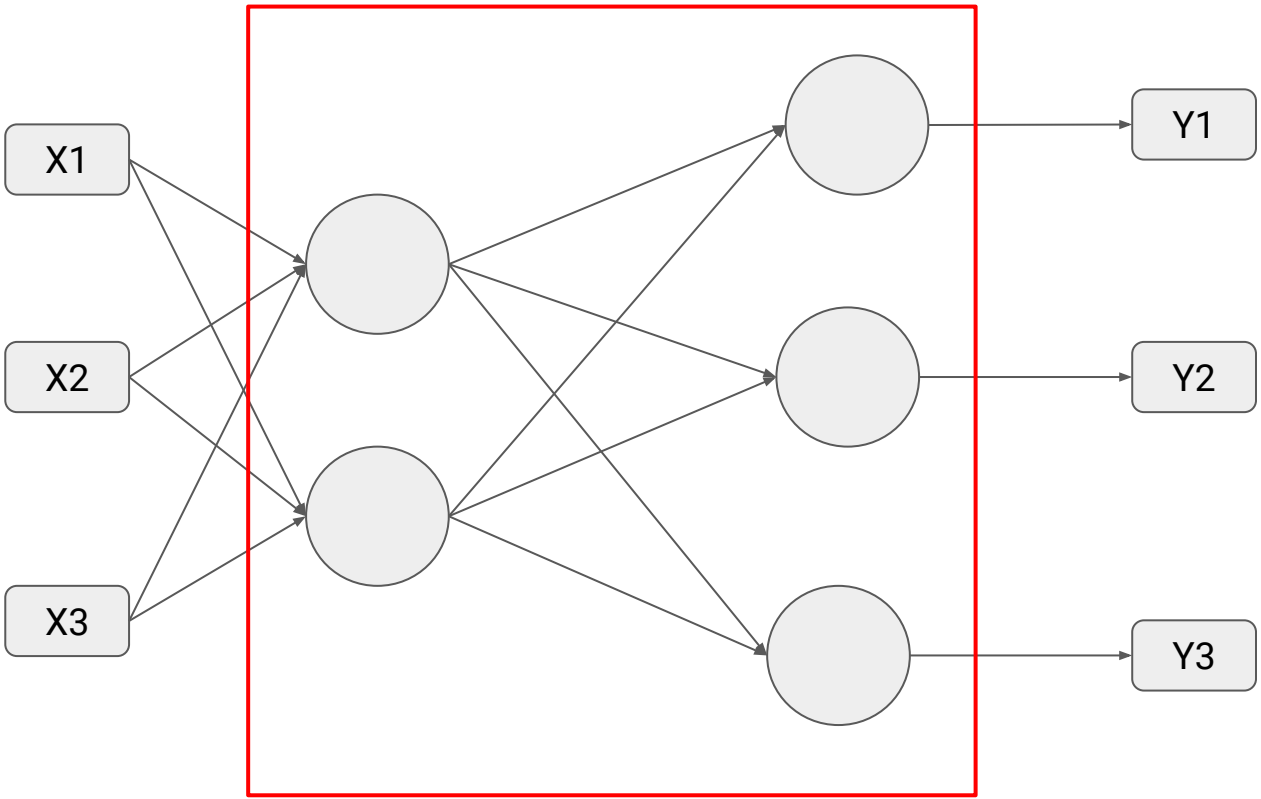
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X2
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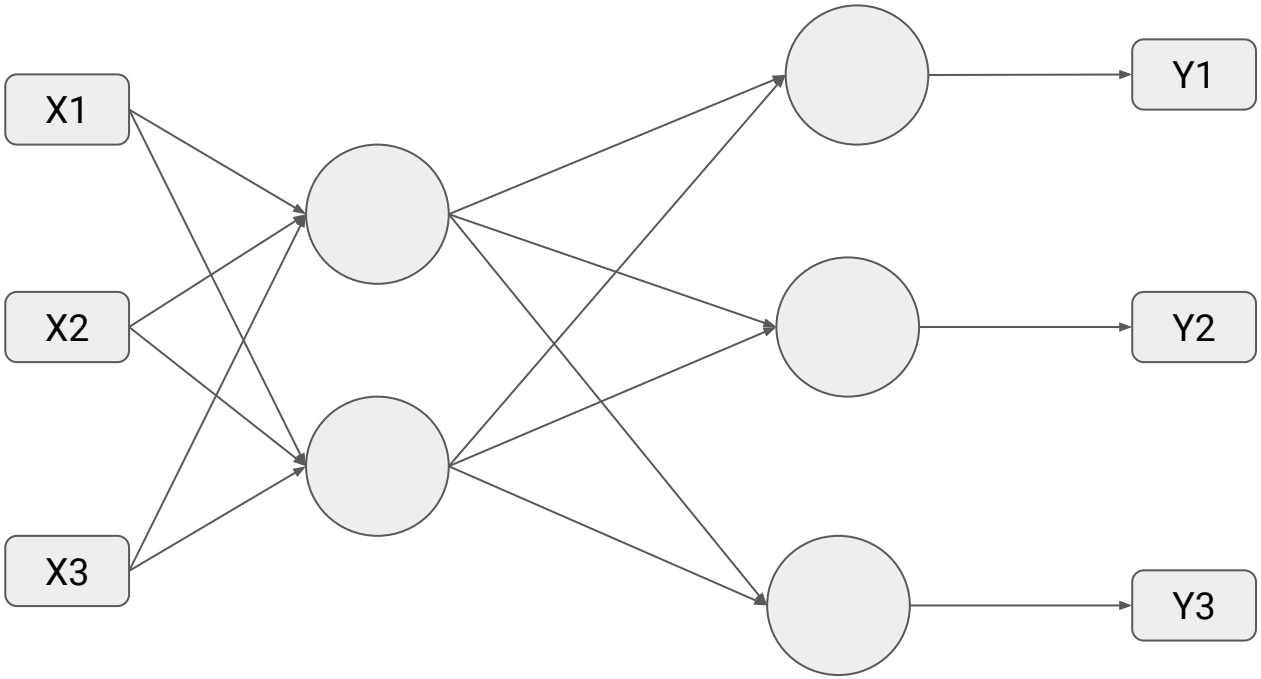
X1
X2
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Y1
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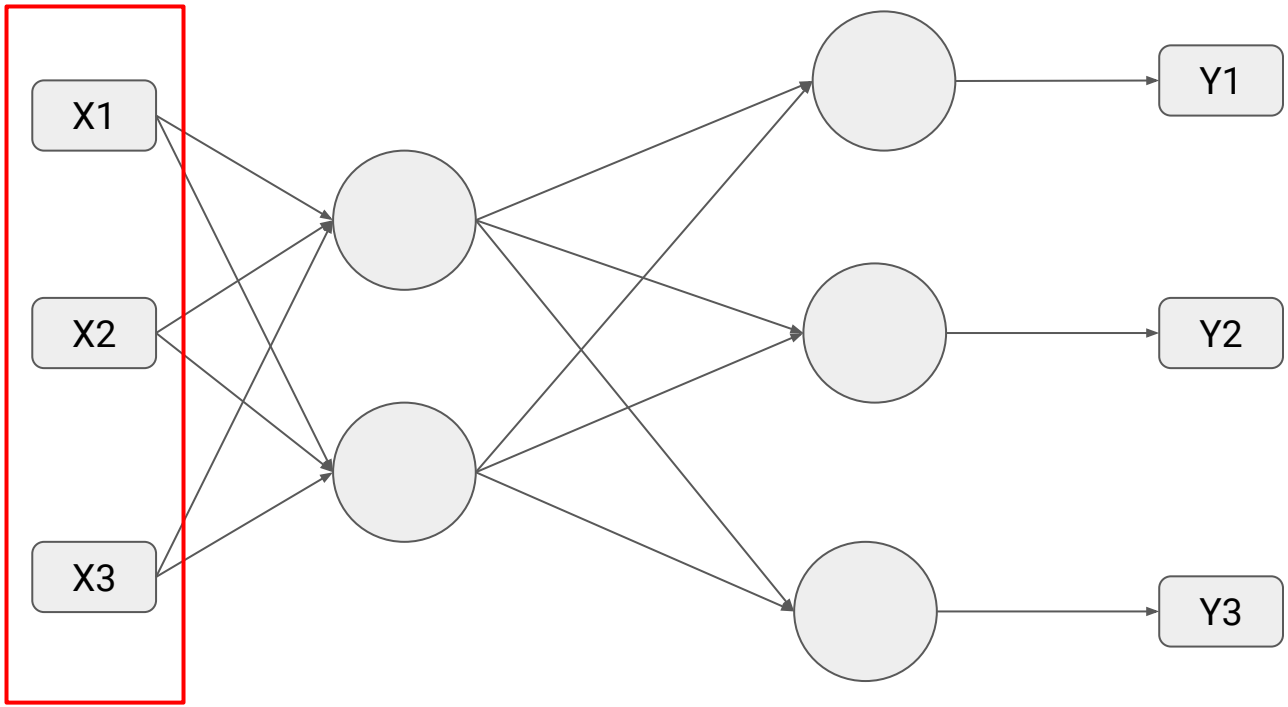
X1
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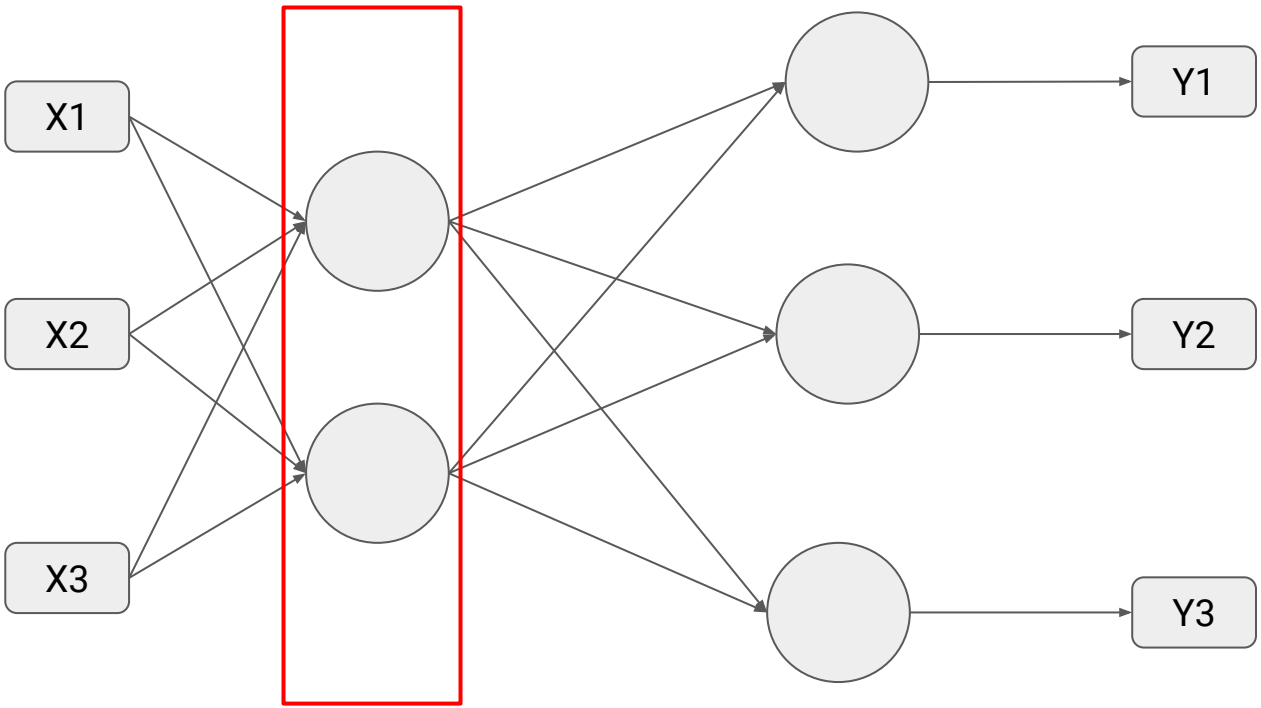
Y2
Y3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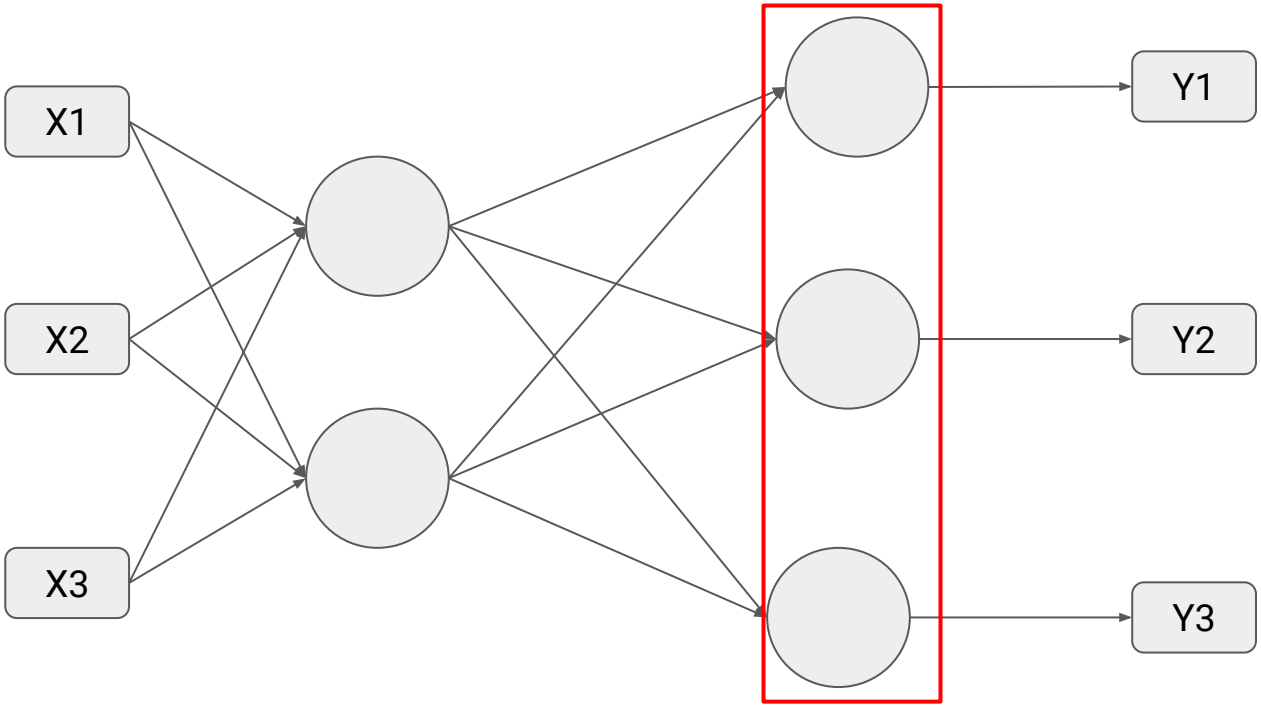
Y3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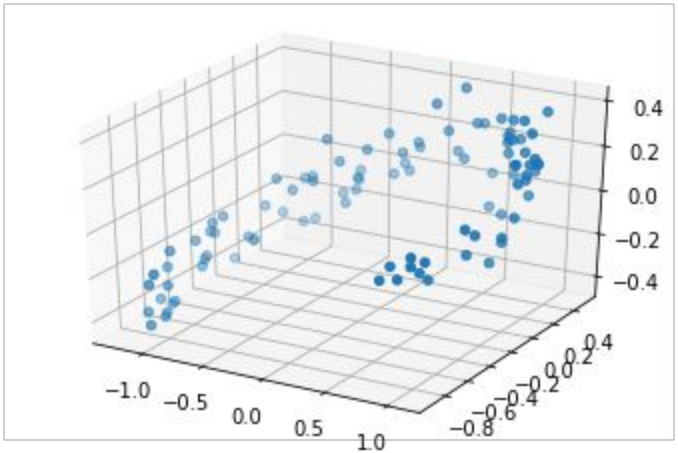
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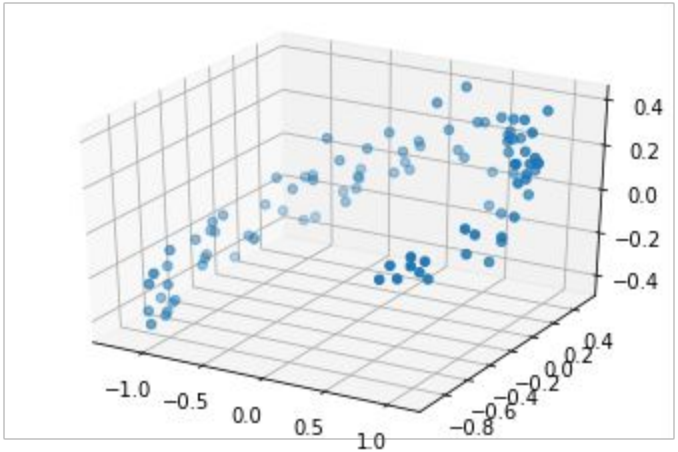
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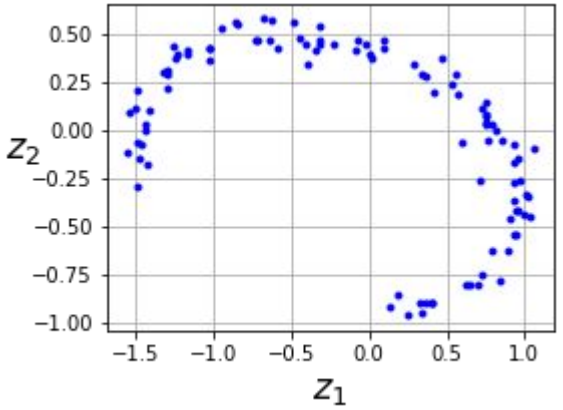
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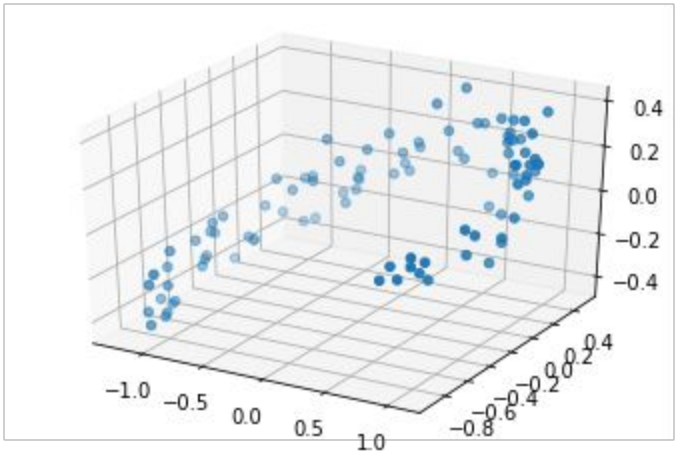
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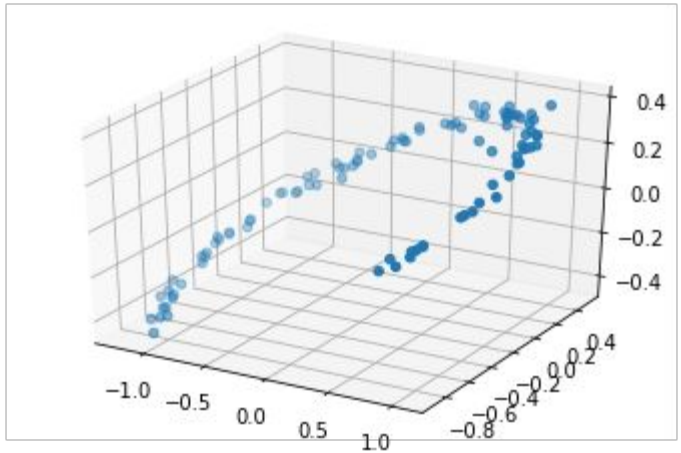
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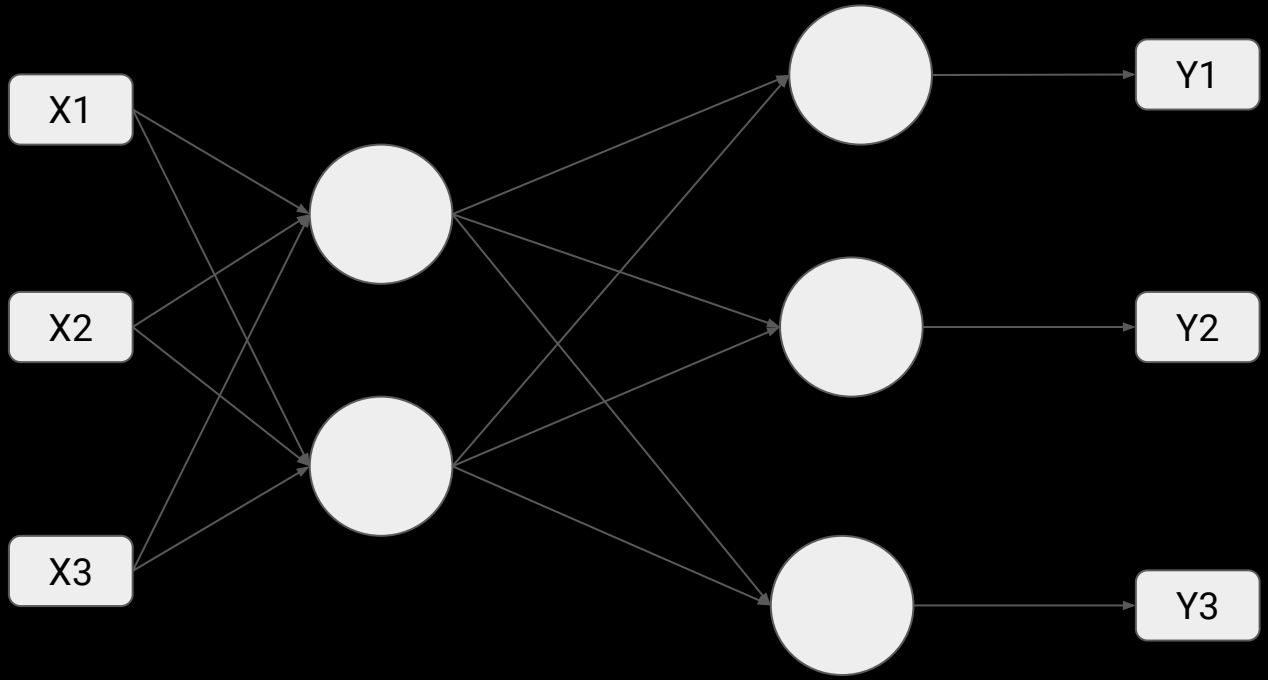
```
encoder = keras.models.Sequential([keras.layers.Dense(2, input_shape=[3])])

decoder = keras.models.Sequential([keras.layers.Dense(3, input_shape=[2])])

autoencoder = keras.models.Sequential([encoder, decoder])

autoencoder.compile(loss="mse", optimizer=keras.optimizers.SGD(lr=1.5))
```



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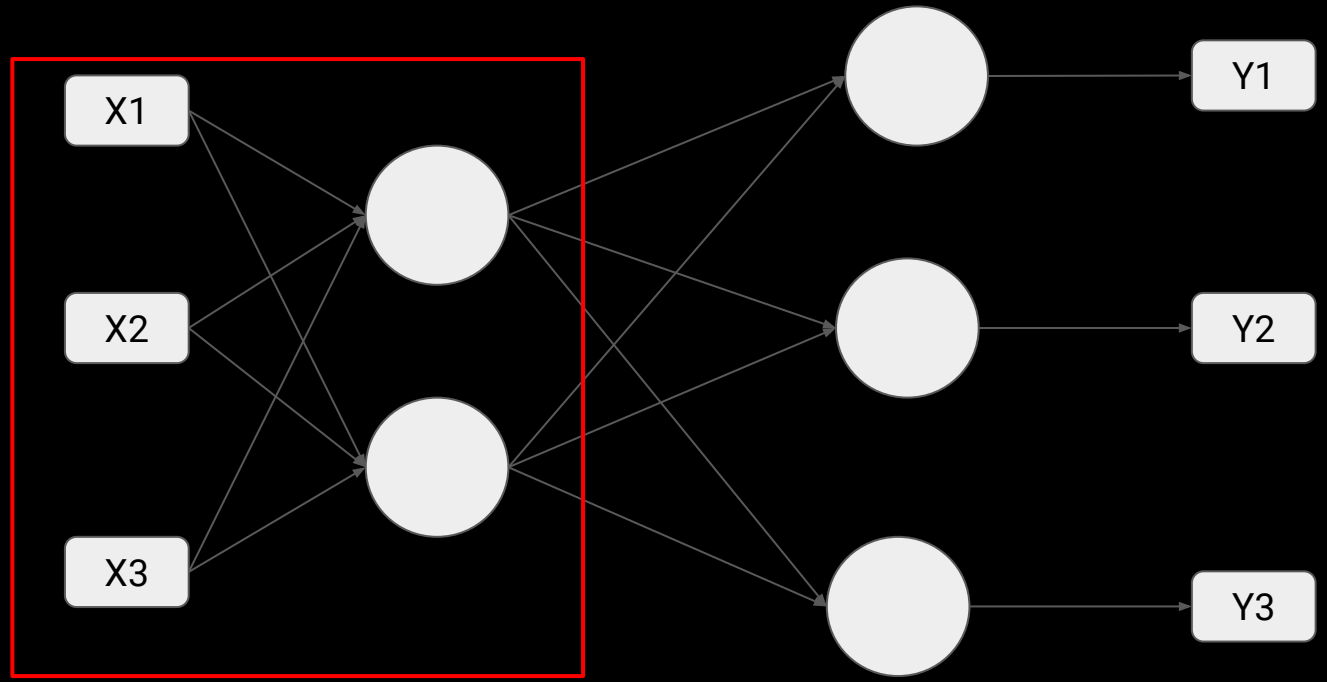

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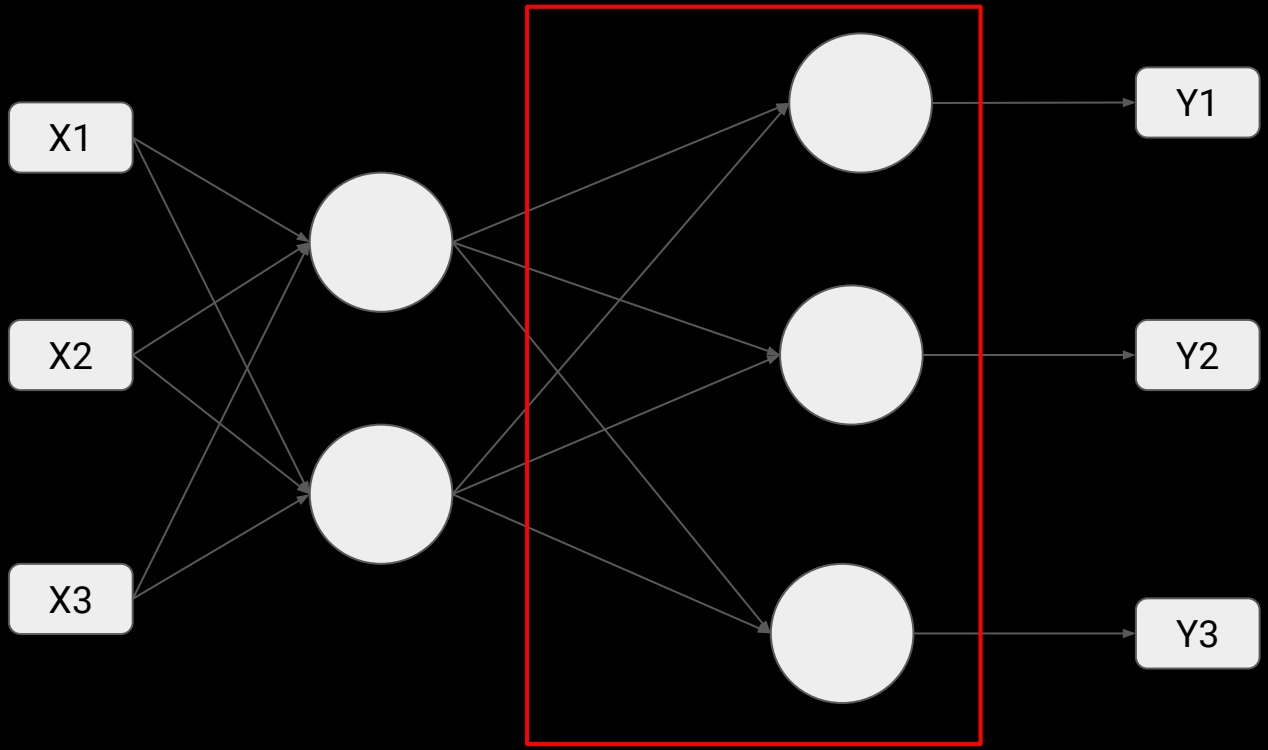

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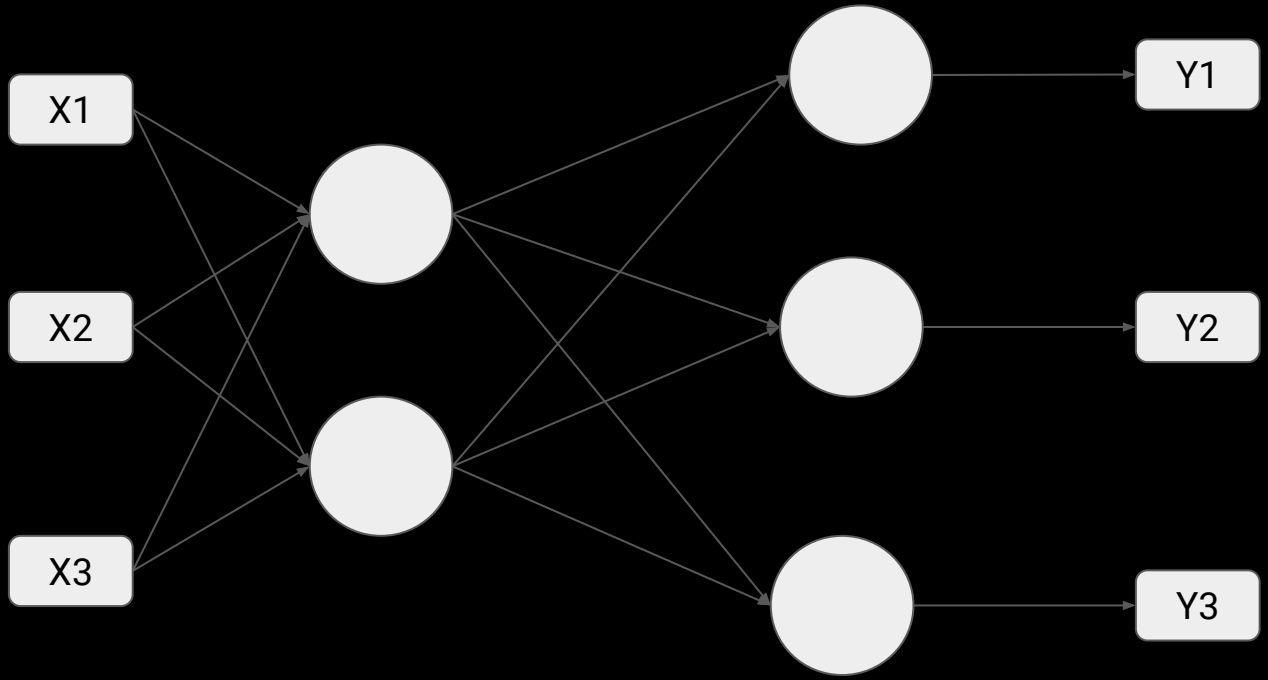

```
history = autoencoder.fit(X_train, X_train, epochs=200)
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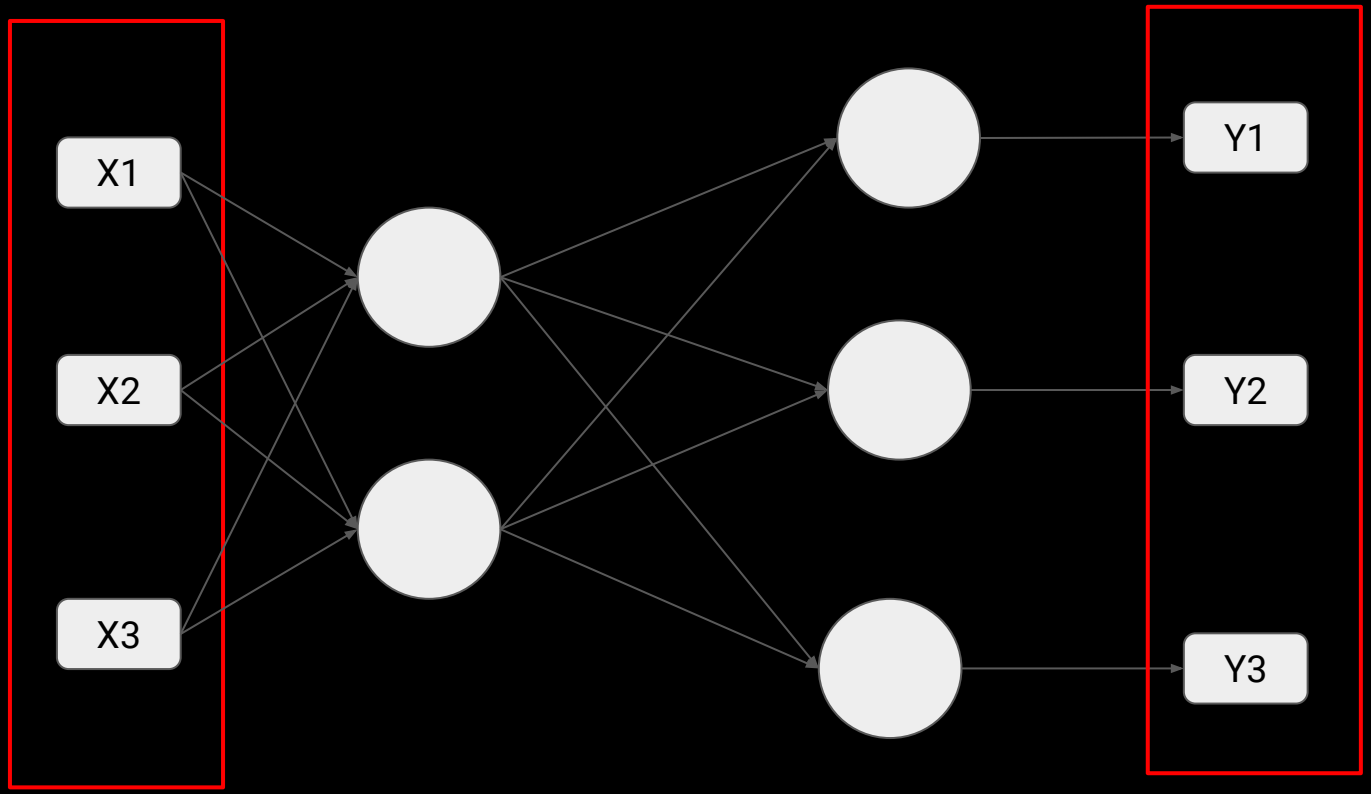
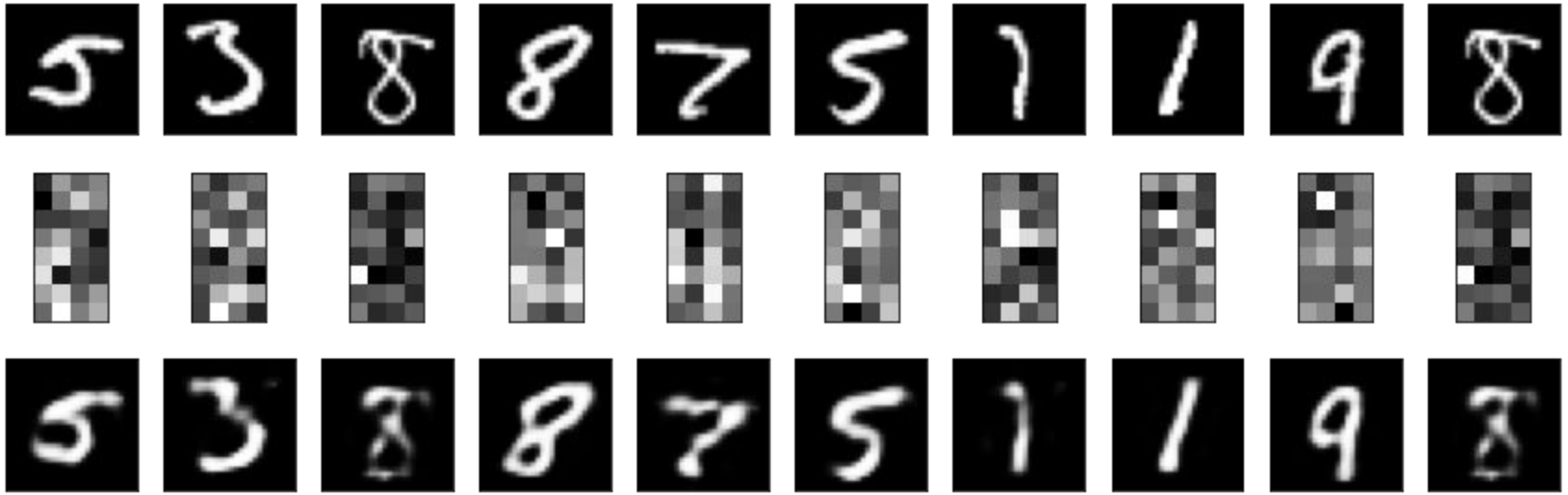
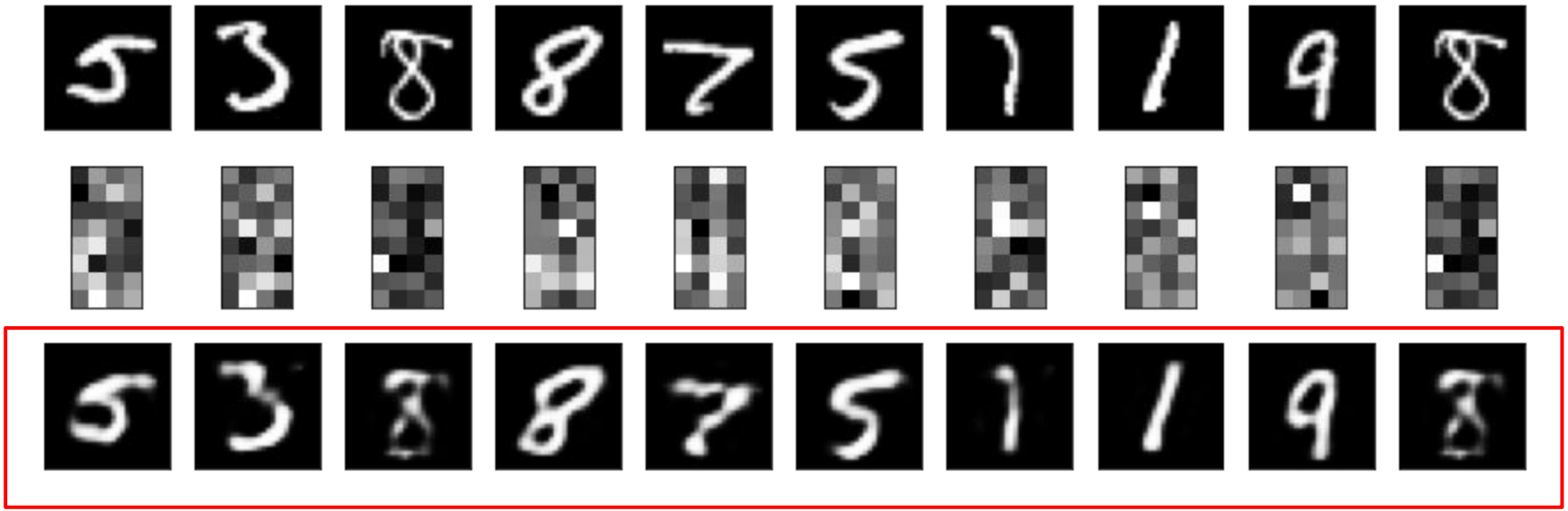


```
codings = encoder.predict(data)
```

```
decodings = decoder.predict(codings)
```





```
inputs =  tf.keras.layers.Input(shape=(784,))

def simple_autoencoder():
    encoder = tf.keras.layers.Dense(units=32, activation='relu')(inputs)
    decoder = tf.keras.layers.Dense(units=784, activation='sigmoid')(encoder)
    return encoder, decoder

encoder_output, decoder_output = simple_autoencoder()

encoder_model = tf.keras.Model(inputs=inputs, outputs=encoder_output)

autoencoder_model = tf.keras.Model(inputs=inputs, outputs=decoder_output)
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```

```
autoencoder_model.compile(
        optimizer=tf.keras.optimizers.Adam(),
        loss='binary_crossentropy')
```

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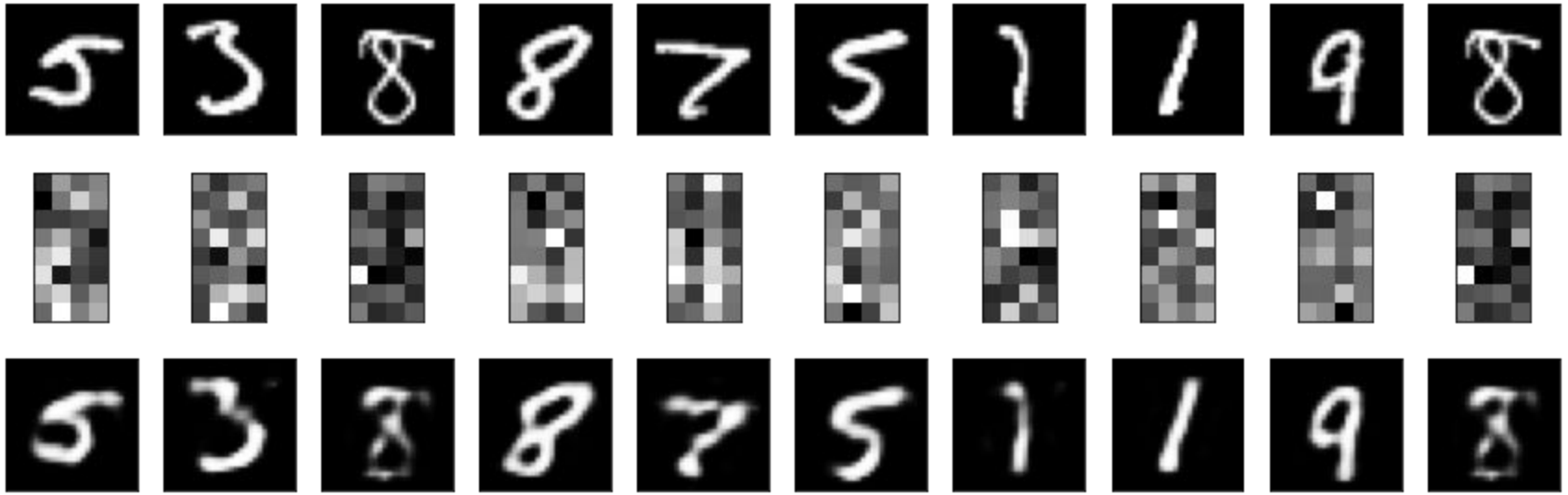
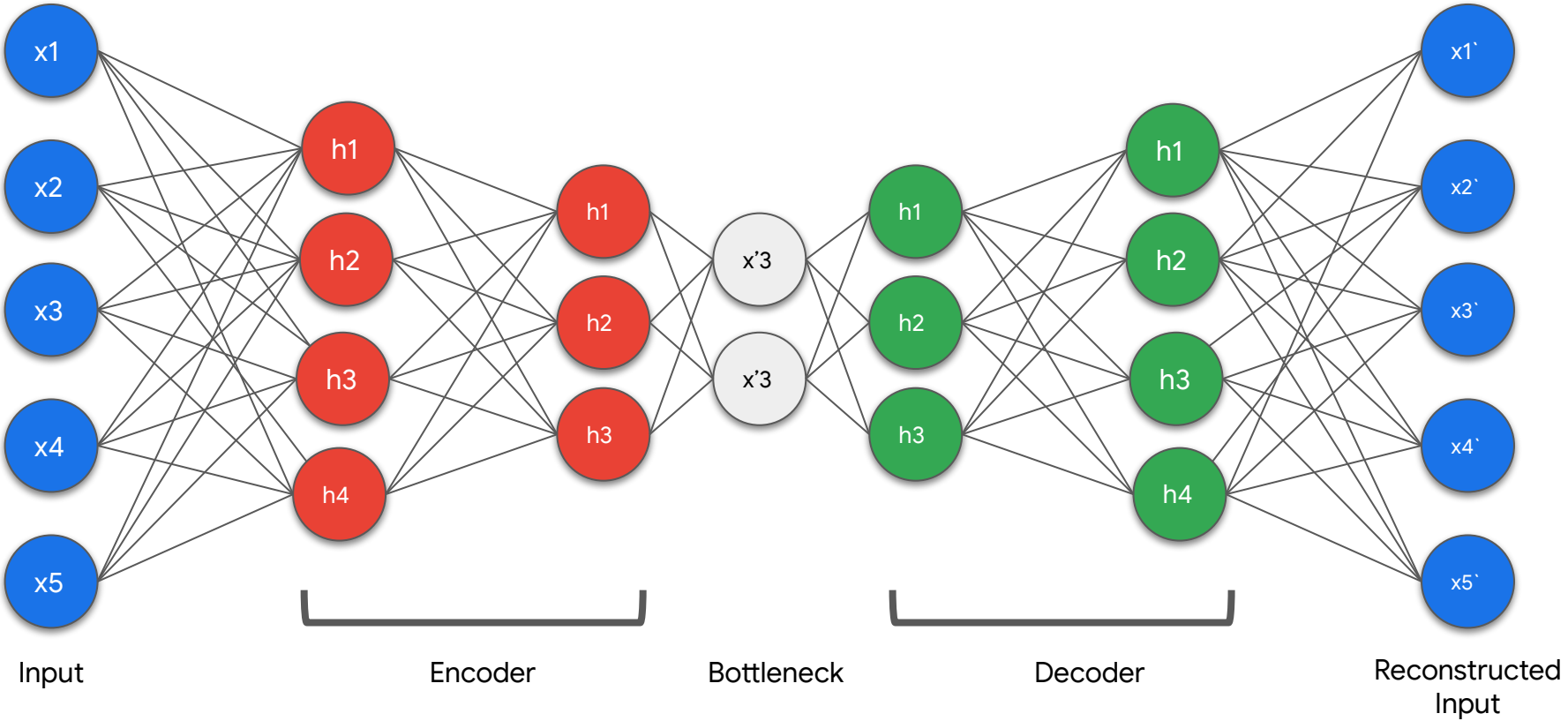
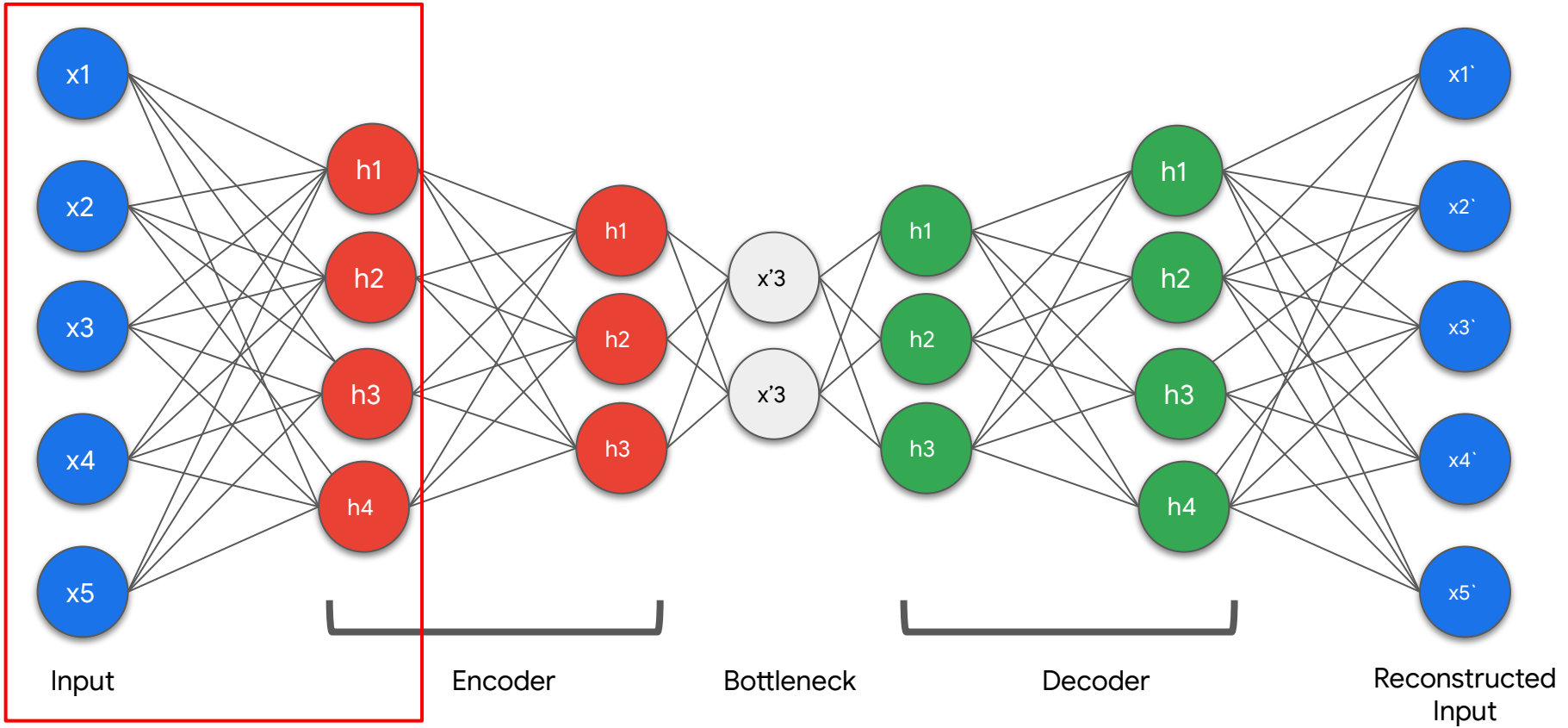


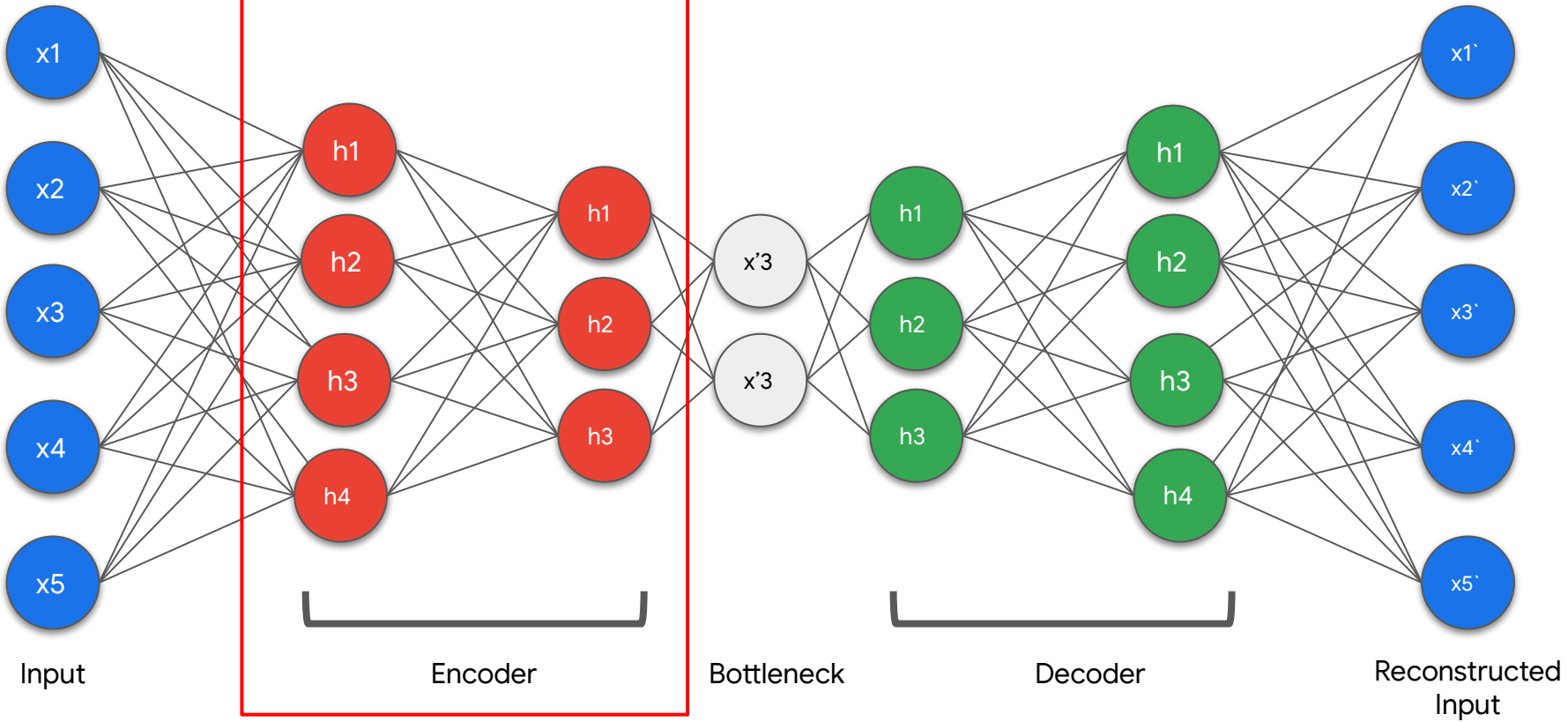
Stacked Auto-Encoders



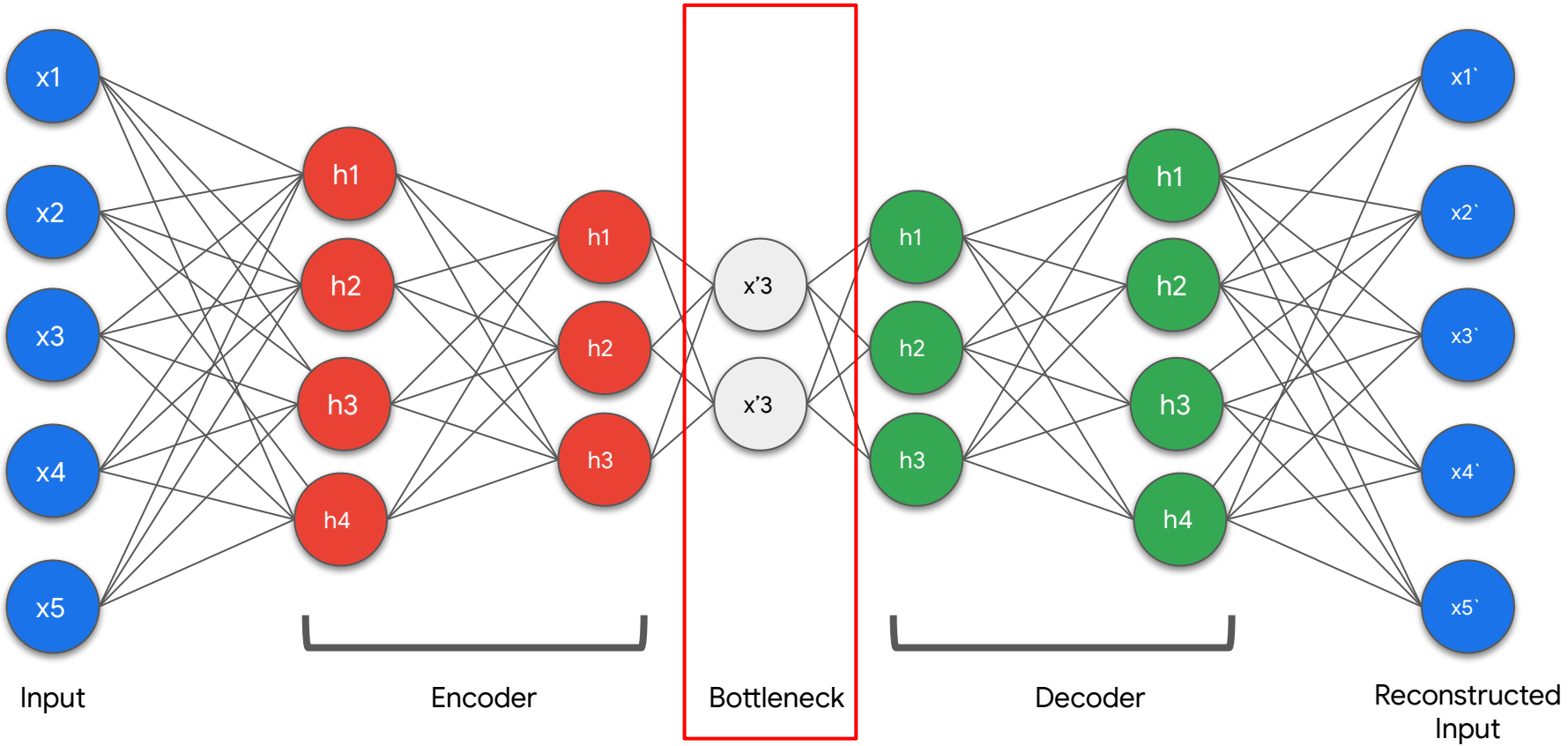
Stacked Auto-Encoders



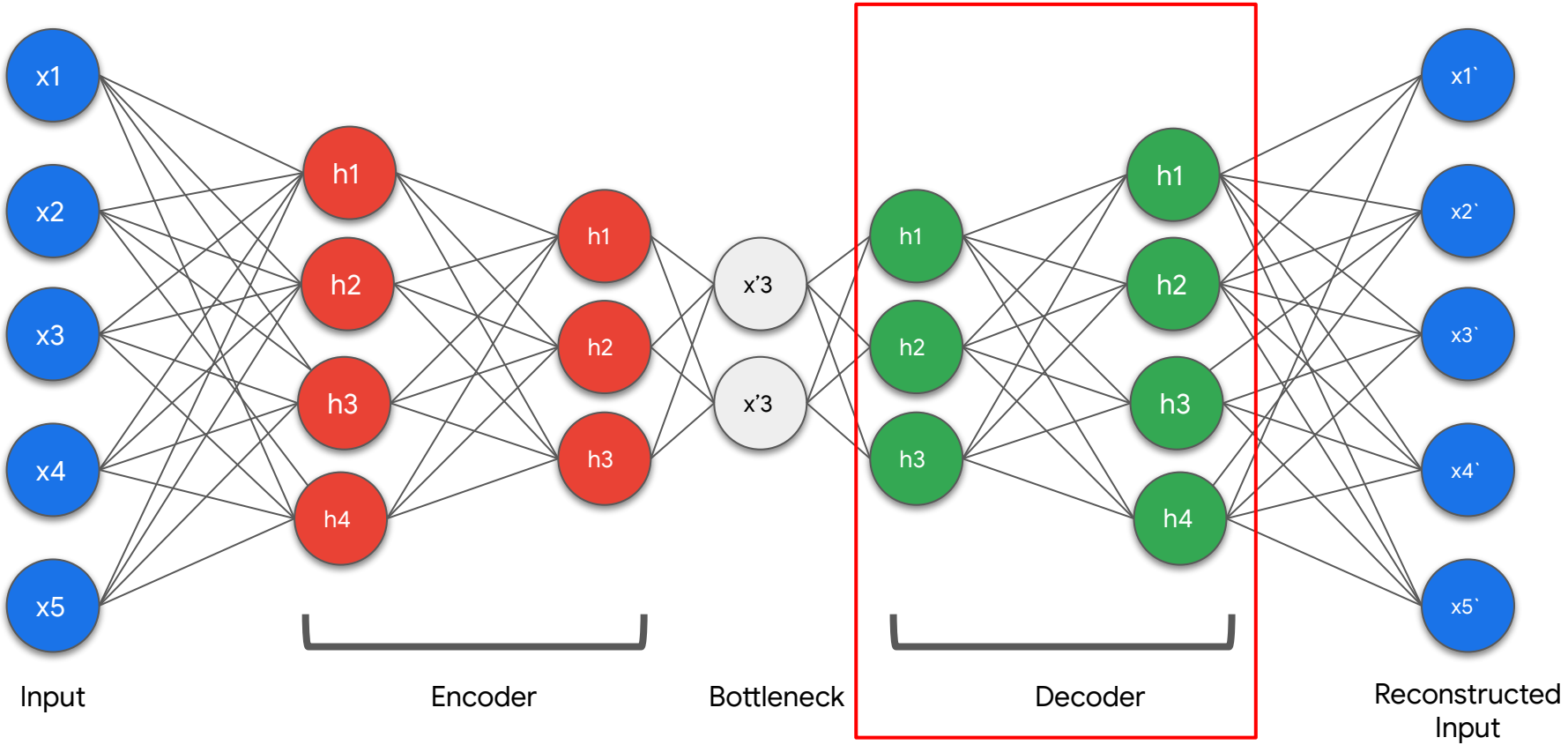
Stacked Auto-Encoders



Stacked Auto-Encoders



Stacked Auto-Encoders



```
inputs =  tf.keras.layers.Input(shape=(784,))

def deep_autoencoder():
 encoder = tf.keras.layers.Dense(units=128, activation='relu')(inputs)
 encoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 encoder = tf.keras.layers.Dense(units=32, activation='relu')(encoder)

 decoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 decoder = tf.keras.layers.Dense(units=128, activation='relu')(decoder)
 decoder = tf.keras.layers.Dense(units=784, activation='sigmoid')(decoder)

 return encoder, decoder

deep_encoder_output, deep_autoencoder_output = deep_autoencoder()

deep_encoder_model = tf.keras.Model(inputs=inputs, outputs=deep_encoder_output)
deep_autoencoder_model = tf.keras.Model(inputs=inputs, outputs=deep_autoencoder_output)
```

```
def deep_autoencoder():
 encoder = tf.keras.layers.Dense(units=128, activation='relu')(inputs)
 encoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 encoder = tf.keras.layers.Dense(units=32, activation='relu')(encoder)

 decoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 decoder = tf.keras.layers.Dense(units=128, activation='relu')(decoder)
 decoder = tf.keras.layers.Dense(units=784, activation='sigmoid')(decoder)

 return encoder, decoder

deep_encoder_output, deep_autoencoder_output = deep_autoencoder()

deep_encoder_model = tf.keras.Model(inputs=inputs, outputs=deep_encoder_output)
deep_autoencoder_model = tf.keras.Model(inputs=inputs, outputs=deep_autoencoder_output)
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```
def deep_autoencoder():
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 decoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 decoder = tf.keras.layers.Dense(units=128, activation='relu')(decoder)
 decoder = tf.keras.layers.Dense(units=784, activation='sigmoid')(decoder)

 return encoder, decoder

deep_encoder_output, deep_autoencoder_output = deep_autoencoder()

deep_encoder_model = tf.keras.Model(inputs=inputs, outputs=deep_encoder_output)
deep_autoencoder_model = tf.keras.Model(inputs=inputs, outputs=deep_autoencoder_output)
```

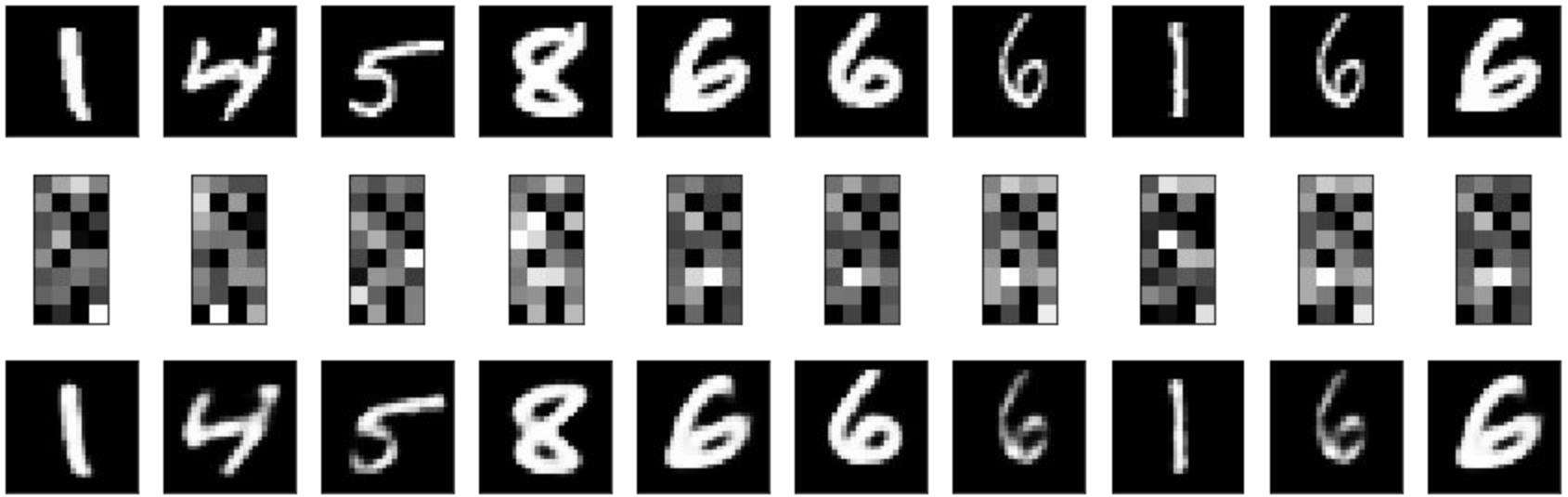
```
def deep_autoencoder():
 encoder = tf.keras.layers.Dense(units=128, activation='relu')(inputs)
 encoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 encoder = tf.keras.layers.Dense(units=32, activation='relu')(encoder)

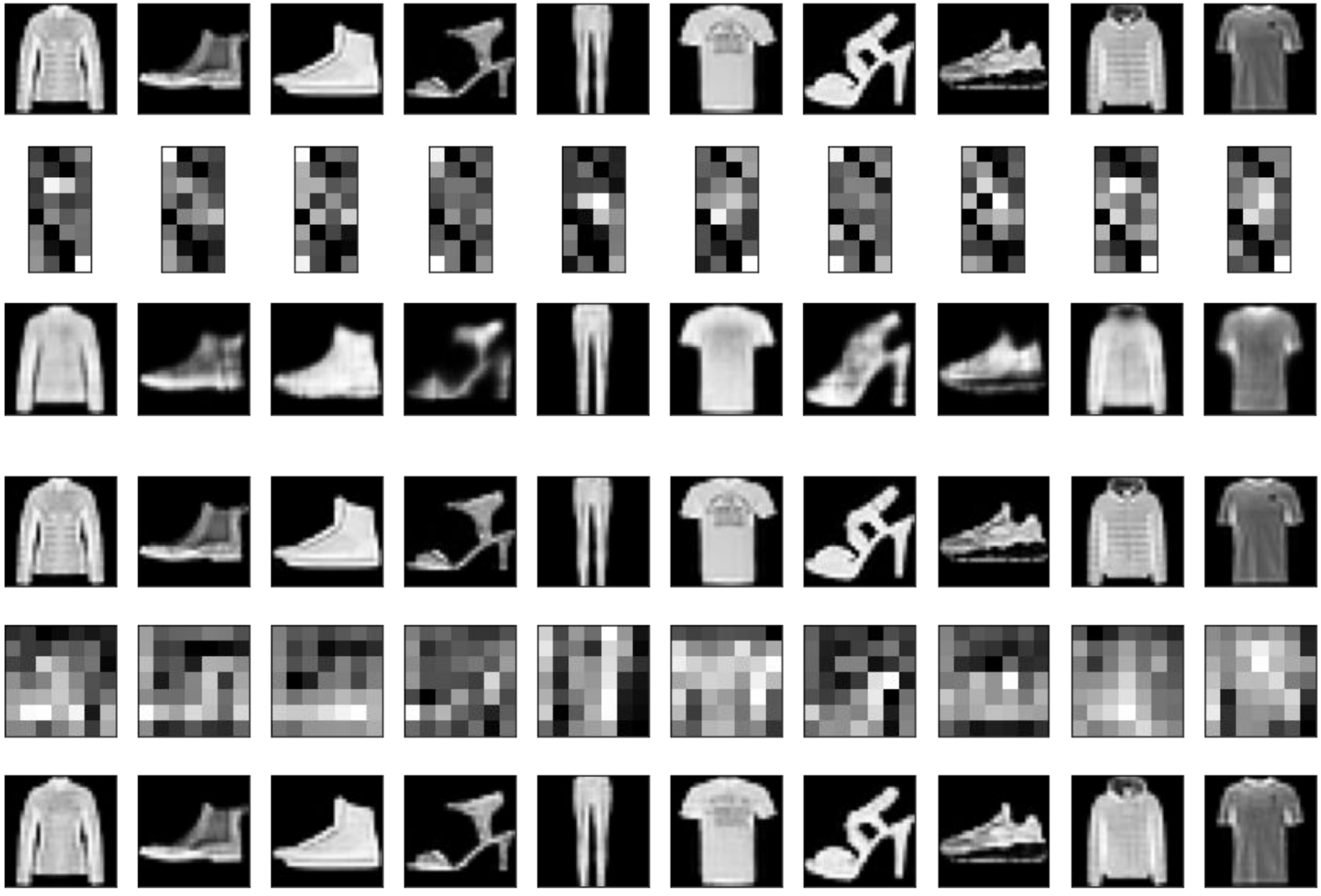
 decoder = tf.keras.layers.Dense(units=64, activation='relu')(encoder)
 decoder = tf.keras.layers.Dense(units=128, activation='relu')(decoder)
 decoder = tf.keras.layers.Dense(units=784, activation='sigmoid')(decoder)

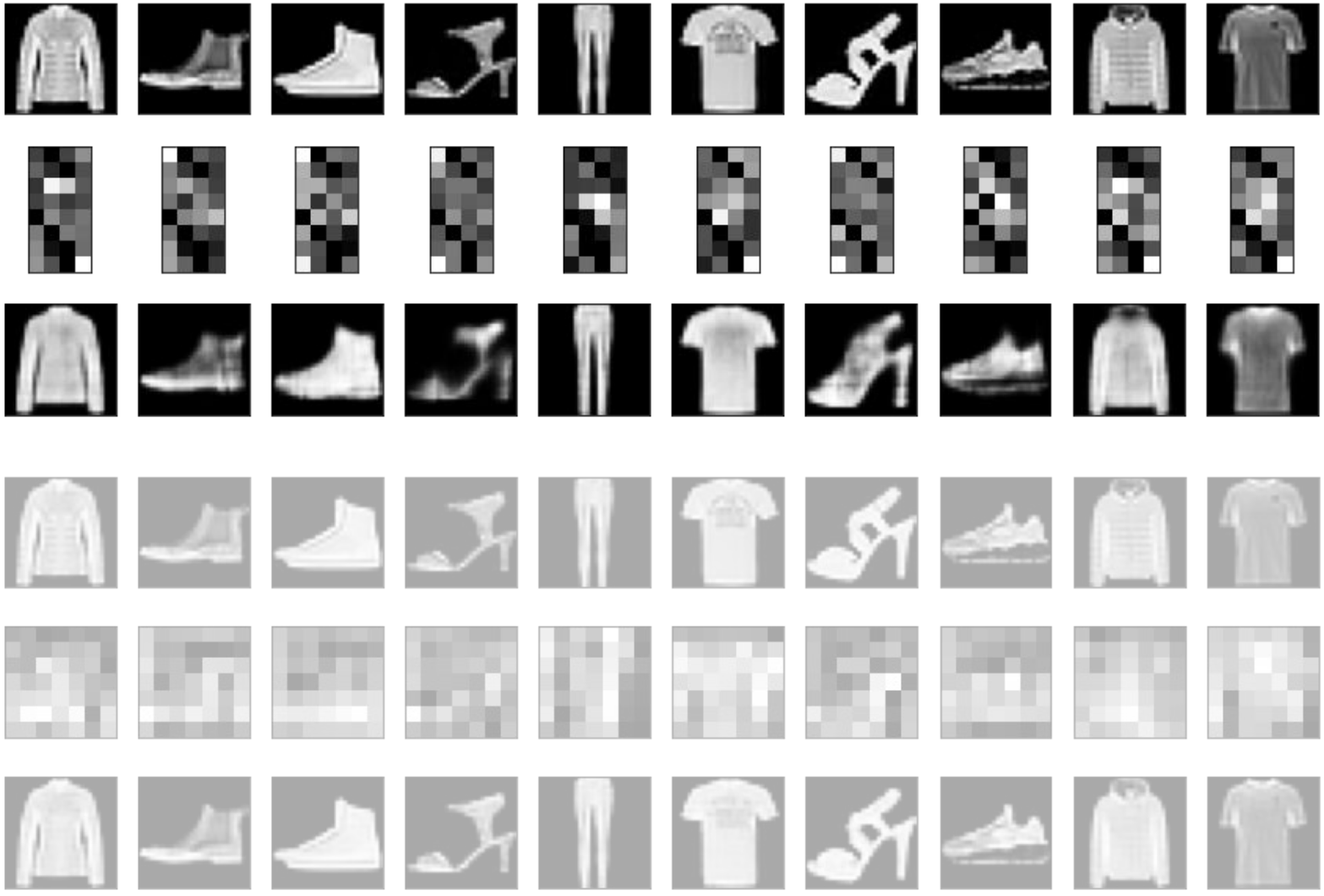
 return encoder, decoder

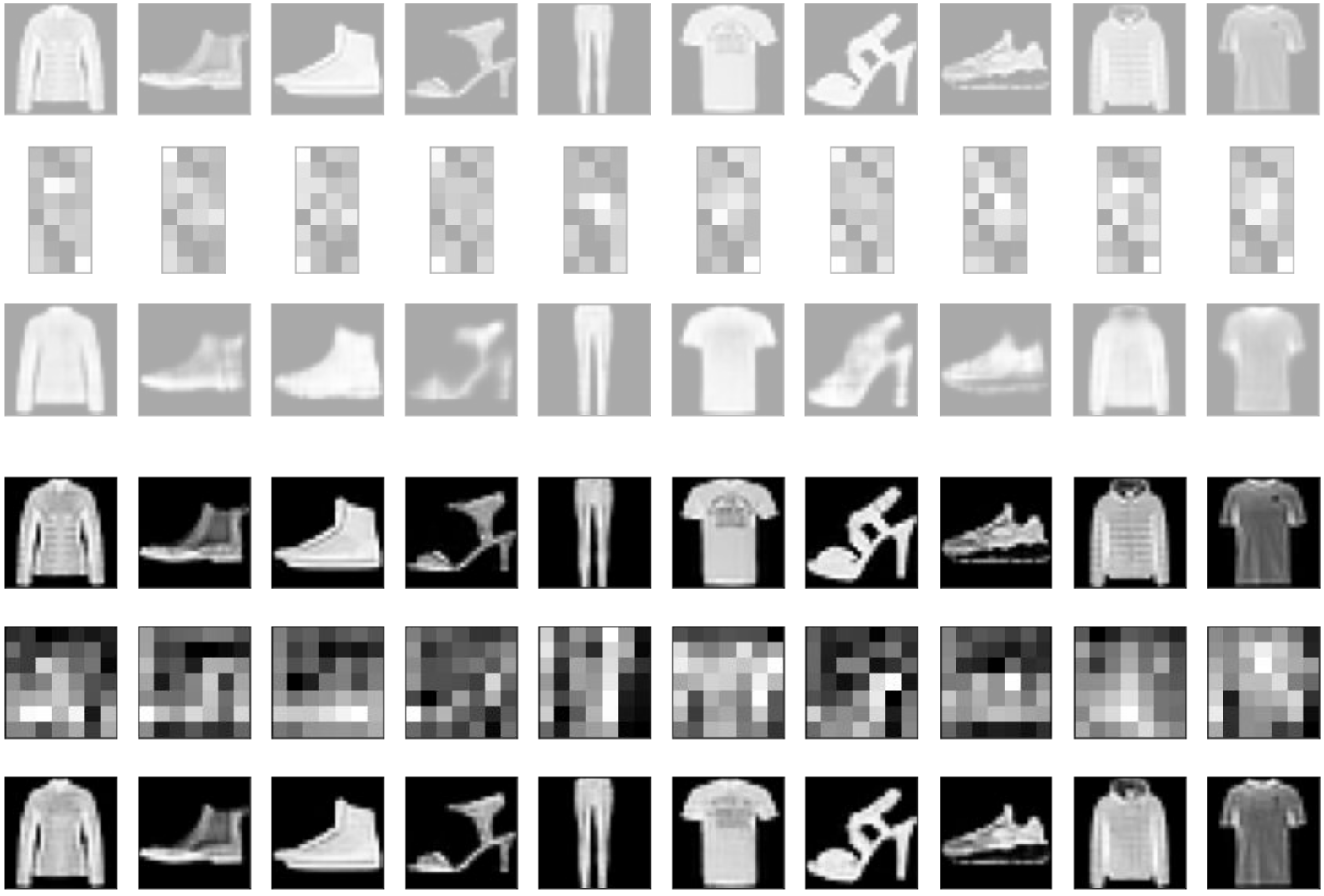
deep_encoder_output, deep_autoencoder_output = deep_autoencoder()

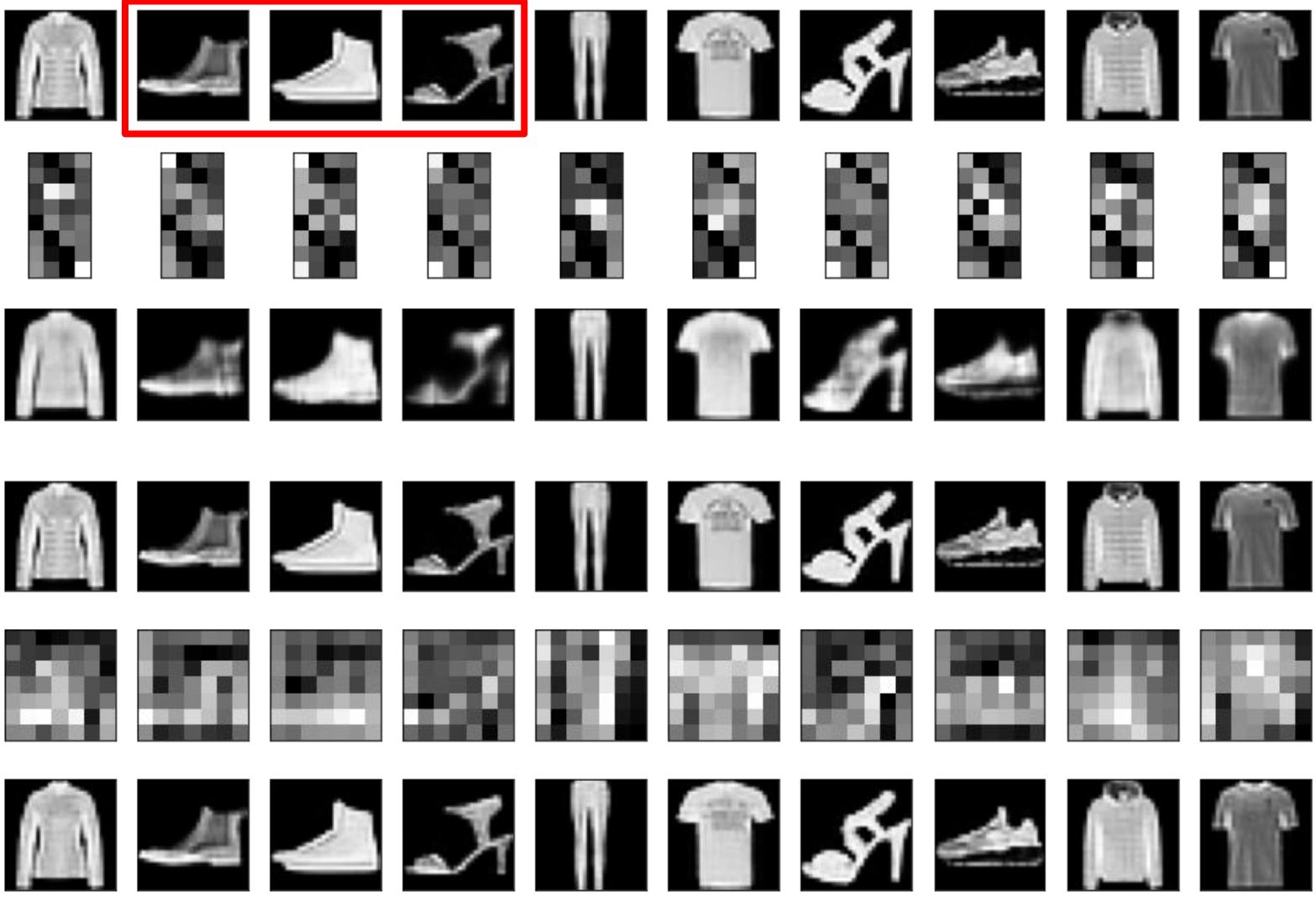
deep_encoder_model = tf.keras.Model(inputs=inputs, outputs=deep_encoder_output)
deep_autoencoder_model = tf.keras.Model(inputs=inputs, outputs=deep_autoencoder_output)
```

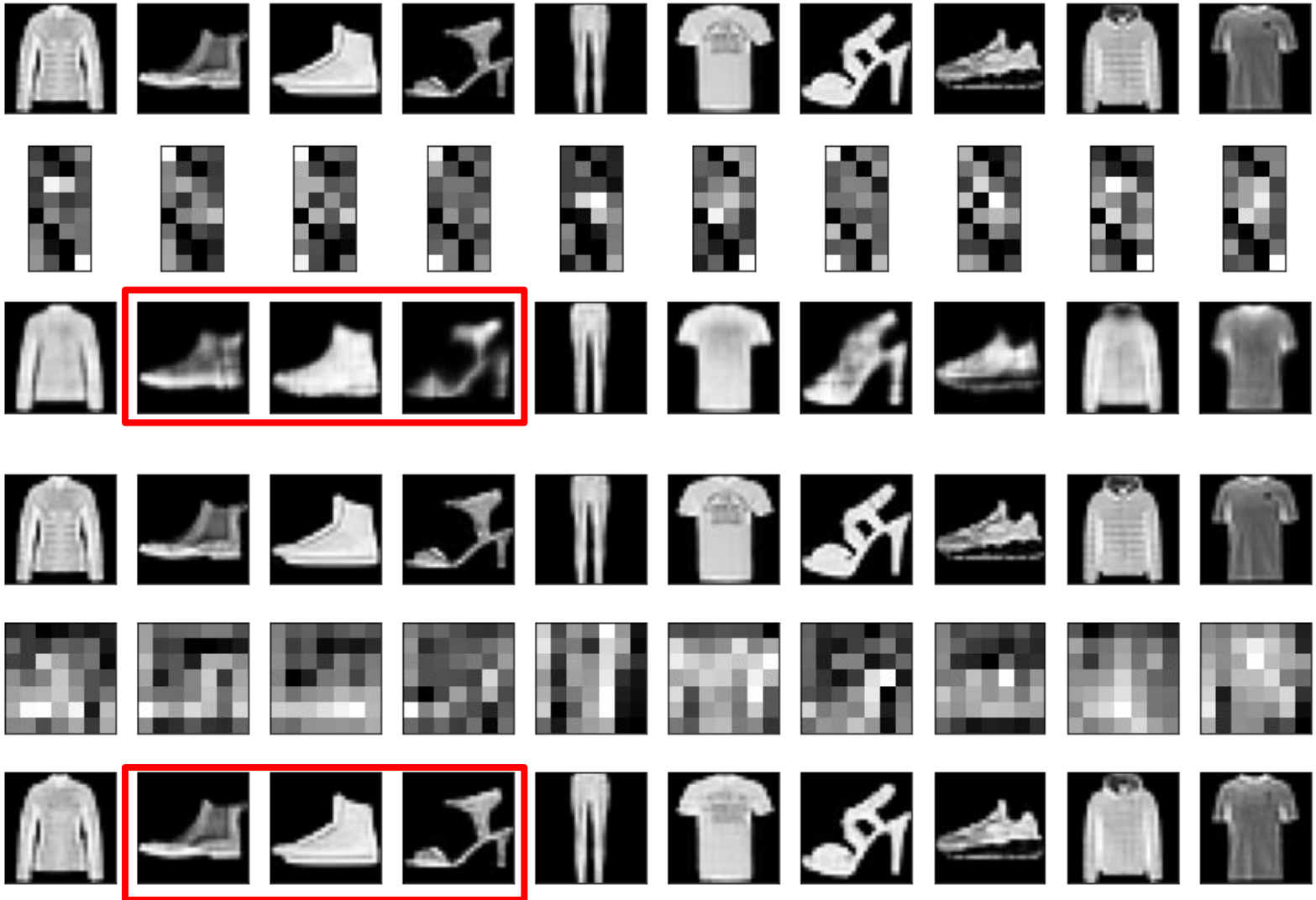


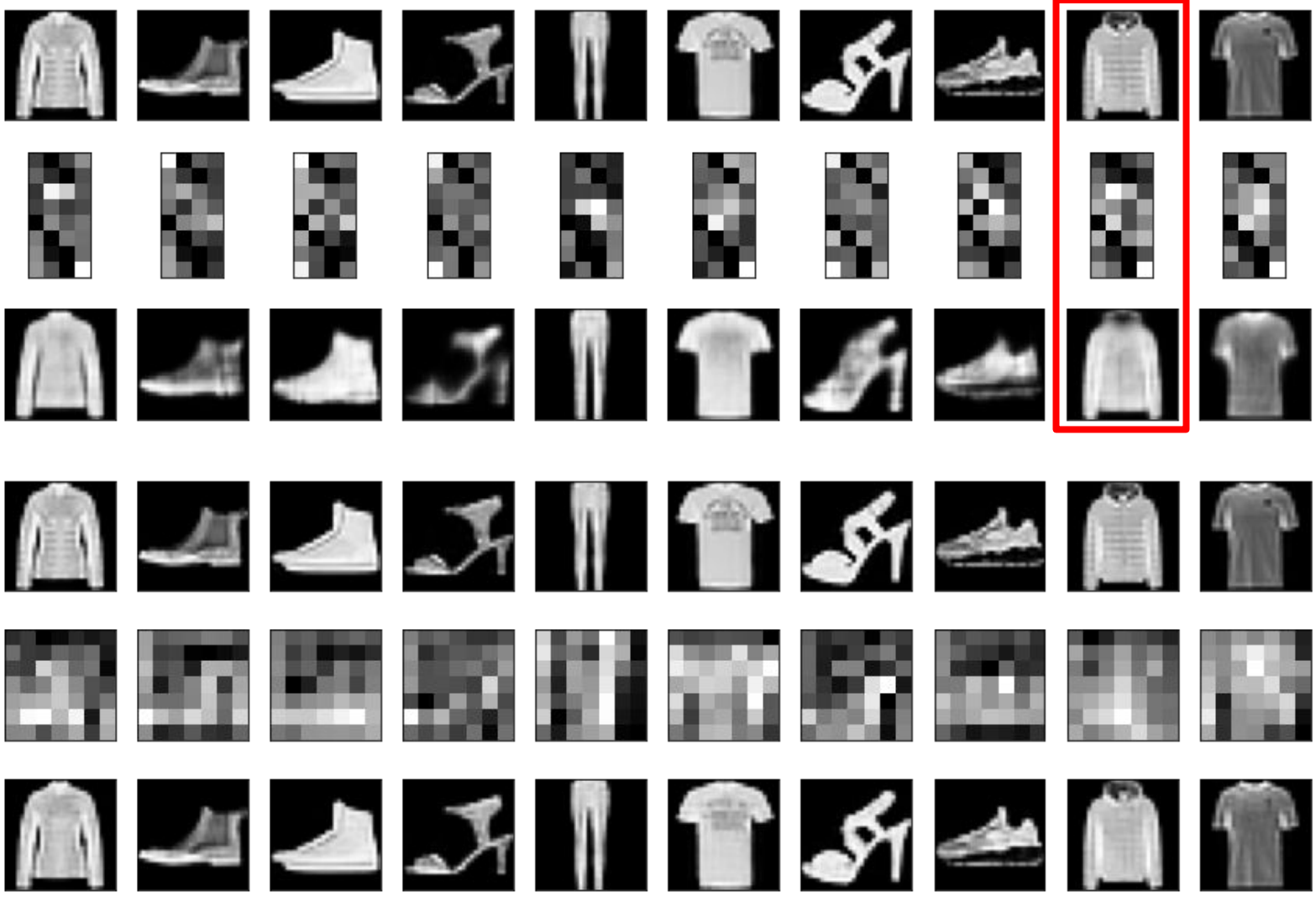


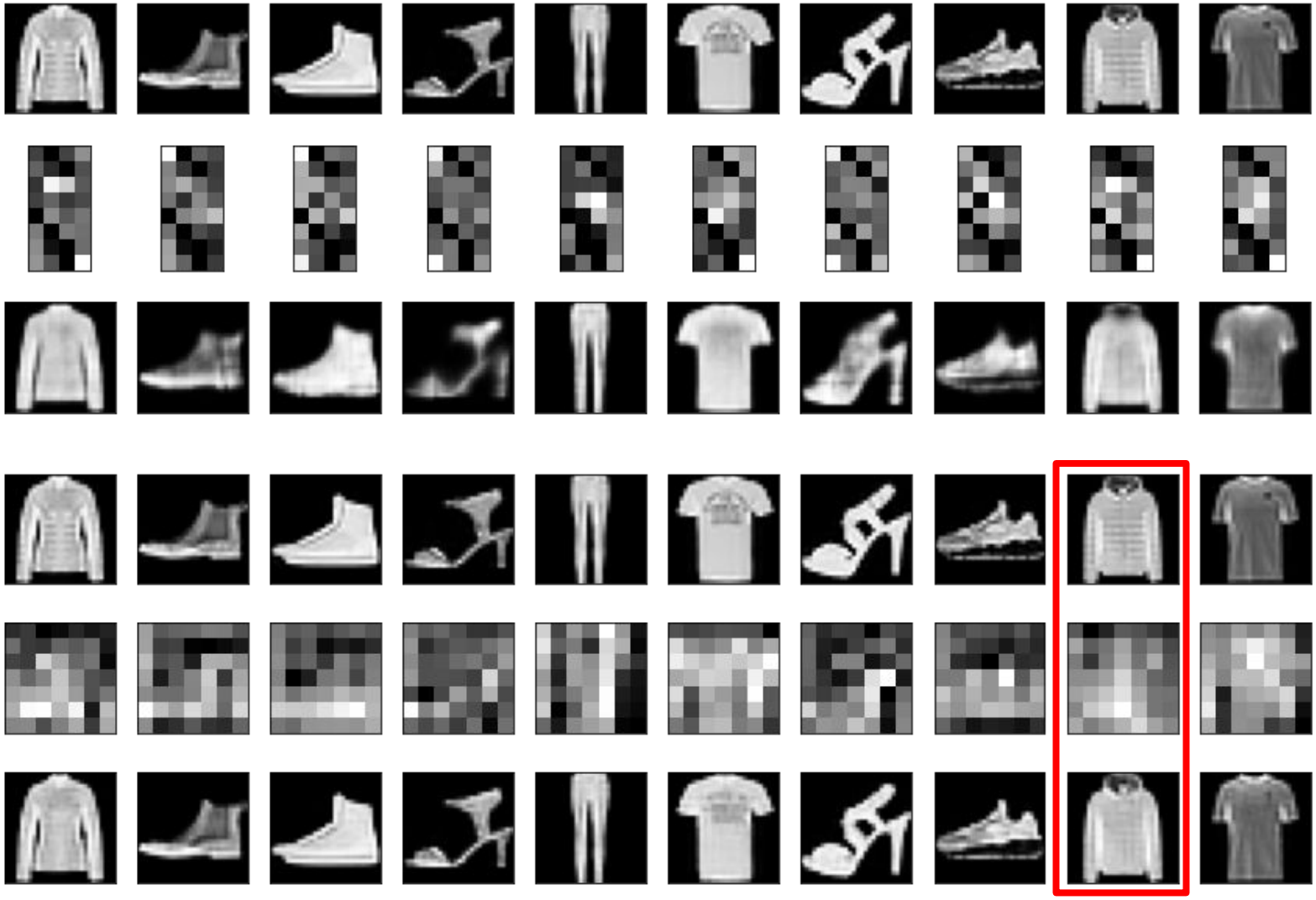




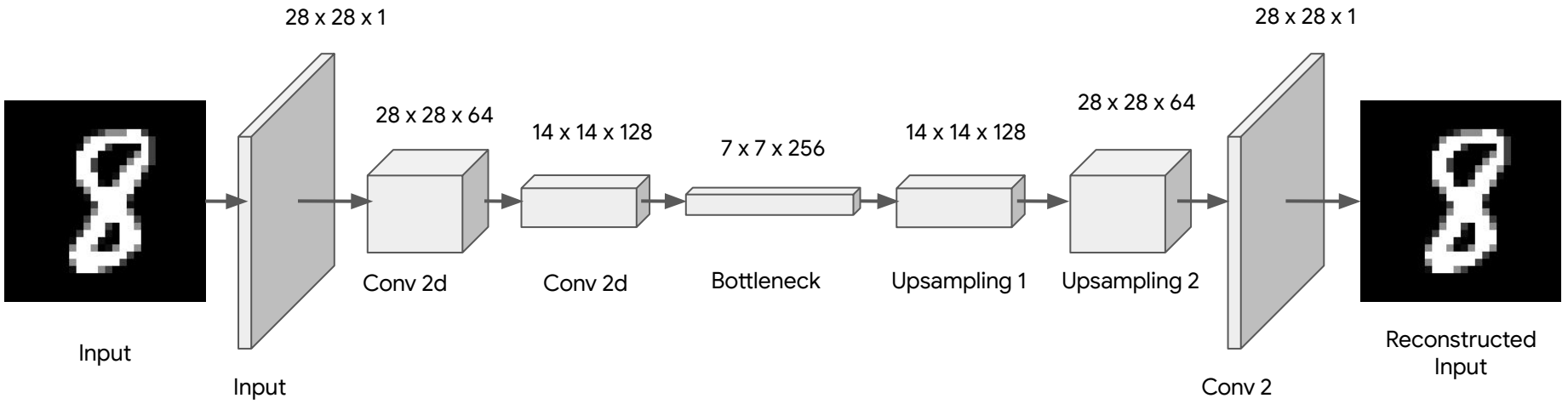




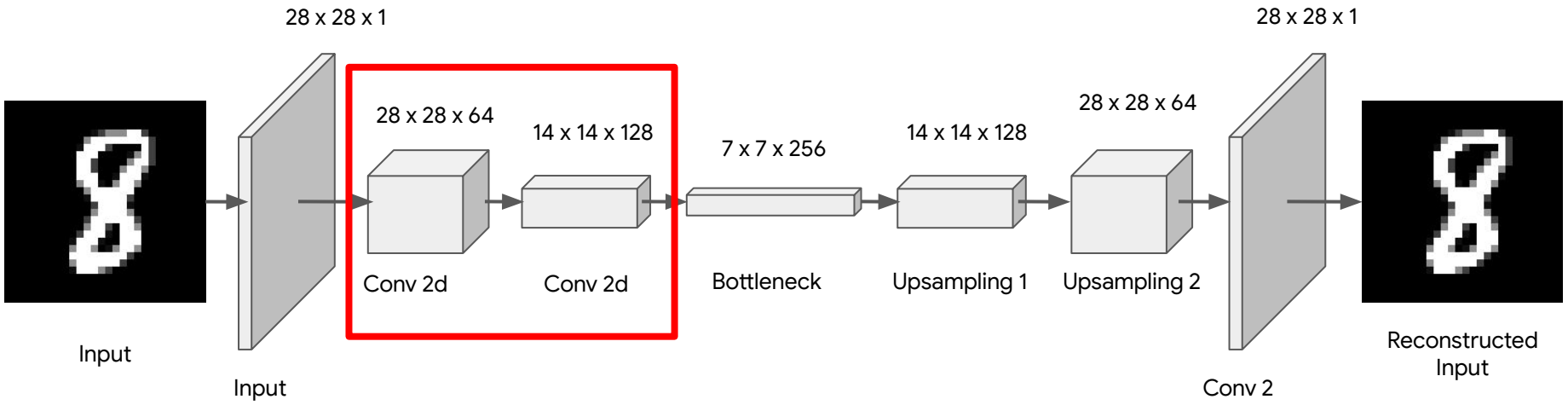




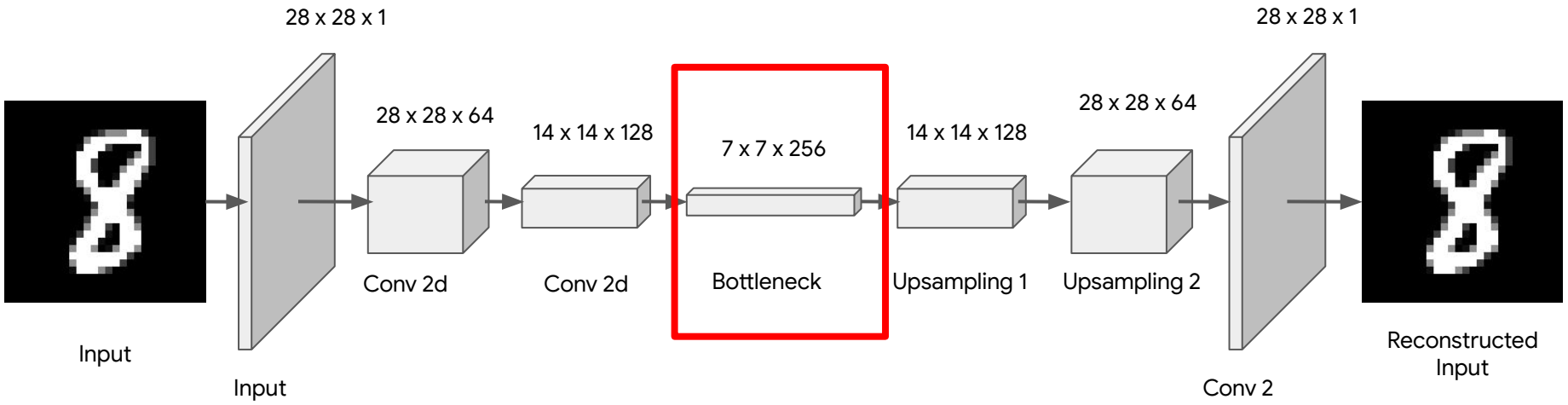
Convolutional Auto-Encoders



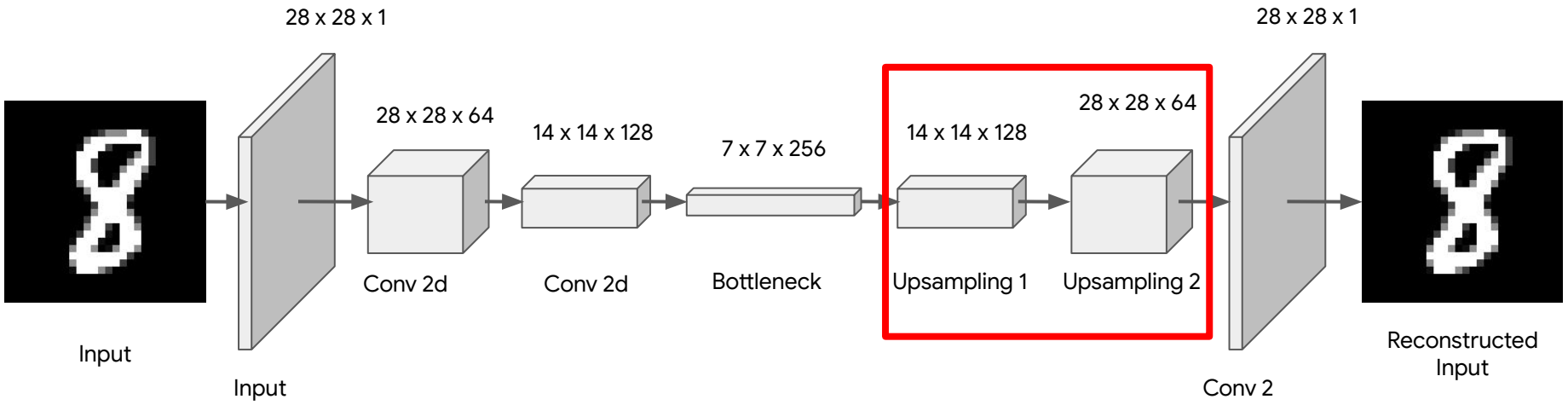
Convolutional Auto-Encoders



Convolutional Auto-Encoders



Convolutional Auto-Encoders



```
def encoder(inputs):
  conv_1 = tf.keras.layers.Conv2D(filters=64, kernel_size=(3,3),
                                  activation='relu', padding='same')(inputs)

  max_pool_1 = tf.keras.layers.MaxPooling2D(pool_size=(2,2))(conv_1)

  conv_2 = tf.keras.layers.Conv2D(filters=128, kernel_size=(3,3),
                                  activation='relu', padding='same')(max_pool_1)

  max_pool_2 = tf.keras.layers.MaxPooling2D(pool_size=(2,2))(conv_2)

  return max_pool_2
```

```
def encoder(inputs):
  conv_1 = tf.keras.layers.Conv2D(filters=64, kernel_size=(3,3),
                                  activation='relu', padding='same')(inputs)

  max_pool_1 = tf.keras.layers.MaxPooling2D(pool_size=(2,2))(conv_1)

  conv_2 = tf.keras.layers.Conv2D(filters=128, kernel_size=(3,3),
                                  activation='relu', padding='same')(max_pool_1)

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                                  activation='relu', padding='same')(max_pool_1)

  max_pool_2 = tf.keras.layers.MaxPooling2D(pool_size=(2,2))(conv_2)

  return max_pool_2
```

```
def bottle_neck(inputs):
  bottle_neck = tf.keras.layers.Conv2D(filters=256, kernel_size=(3,3),
                                       activation='relu', padding='same')(inputs)



  encoder_visualization = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                                 activation='sigmoid',
                                                 padding='same')(bottle_neck)

  return bottle_neck, encoder_visualization
```

```
def bottle_neck(inputs):
  bottle_neck = tf.keras.layers.Conv2D(filters=256, kernel_size=(3,3),
                                       activation='relu', padding='same')(inputs)


  encoder_visualization = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                                 activation='sigmoid',
                                                 padding='same')(bottle_neck)

  return bottle_neck, encoder_visualization
```

```
def bottle_neck(inputs):
  bottle_neck = tf.keras.layers.Conv2D(filters=256, kernel_size=(3,3),
                                       activation='relu', padding='same')(inputs)


  encoder_visualization = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                                 activation='sigmoid',
                                                 padding='same')(bottle_neck)

  return bottle_neck, encoder_visualization
```

```
def bottle_neck(inputs):
  bottle_neck = tf.keras.layers.Conv2D(filters=256, kernel_size=(3,3),
                                       activation='relu', padding='same')(inputs)



  encoder_visualization = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                                 activation='sigmoid',
                                                 padding='same')(bottle_neck)

  return bottle_neck, encoder_visualization
```

```
def decoder(inputs):
  conv_1 = tf.keras.layers.Conv2D(filters=128, kernel_size=(3,3),
                                  activation='relu', padding='same')(inputs)
  up_sample_1 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_1)

  conv_2 = tf.keras.layers.Conv2D(filters=64, kernel_size=(3,3),
                                  activation='relu', padding='same')(up_sample_1)
  up_sample_2 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_2)

  conv_3 = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                  activation='sigmoid',
                                  padding='same')(up_sample_2)

  return conv_3
```

```
def decoder(inputs):
  conv_1 = tf.keras.layers.Conv2D(filters=128, kernel_size=(3,3),
                                  activation='relu', padding='same')(inputs)
  up_sample_1 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_1)

  conv_2 = tf.keras.layers.Conv2D(filters=64, kernel_size=(3,3),
                                  activation='relu', padding='same')(up_sample_1)
  up_sample_2 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_2)

  conv_3 = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                  activation='sigmoid',
                                  padding='same')(up_sample_2)

  return conv_3
```

```
def decoder(inputs):
  conv_1 = tf.keras.layers.Conv2D(filters=128, kernel_size=(3,3),
                                  activation='relu', padding='same')(inputs)
  up_sample_1 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_1)

  conv_2 = tf.keras.layers.Conv2D(filters=64, kernel_size=(3,3),
                                  activation='relu', padding='same')(up_sample_1)
  up_sample_2 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_2)

  conv_3 = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                  activation='sigmoid',
                                  padding='same')(up_sample_2)

  return conv_3
```

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  conv_1 = tf.keras.layers.Conv2D(filters=128, kernel_size=(3,3),
                                  activation='relu', padding='same')(inputs)
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                                  activation='relu', padding='same')(up_sample_1)
  up_sample_2 = tf.keras.layers.UpSampling2D(size=(2,2))(conv_2)

  conv_3 = tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3),
                                  activation='sigmoid',
                                  padding='same')(up_sample_2)

  return conv_3
```

```
def convolutional_auto_encoder():
  inputs = tf.keras.layers.Input(shape=(28, 28, 1,))

  encoder_output = encoder(inputs)

  bottleneck_output, encoder_visualization = bottle_neck(encoder_output)

  decoder_output = decoder(bottleneck_output)

  model = tf.keras.Model(inputs =inputs, outputs=decoder_output)
  encoder_model = tf.keras.Model(inputs=inputs, outputs=encoder_visualization)

  return model, encoder_model
```

```
def convolutional_auto_encoder():
  inputs = tf.keras.layers.Input(shape=(28, 28, 1,))

  encoder_output = encoder(inputs)

  bottleneck_output, encoder_visualization = bottle_neck(encoder_output)

  decoder_output = decoder(bottleneck_output)

  model = tf.keras.Model(inputs =inputs, outputs=decoder_output)
  encoder_model = tf.keras.Model(inputs=inputs, outputs=encoder_visualization)

  return model, encoder_model
```

```
def convolutional_auto_encoder():
  inputs = tf.keras.layers.Input(shape=(28, 28, 1,))

  encoder_output = encoder(inputs)

  bottleneck_output, encoder_visualization = bottle_neck(encoder_output)

  decoder_output = decoder(bottleneck_output)

  model = tf.keras.Model(inputs =inputs, outputs=decoder_output)
  encoder_model = tf.keras.Model(inputs=inputs, outputs=encoder_visualization)

  return model, encoder_model
```

```
def convolutional_auto_encoder():
  inputs = tf.keras.layers.Input(shape=(28, 28, 1,))

  encoder_output = encoder(inputs)

  bottleneck_output, encoder_visualization = bottle_neck(encoder_output)

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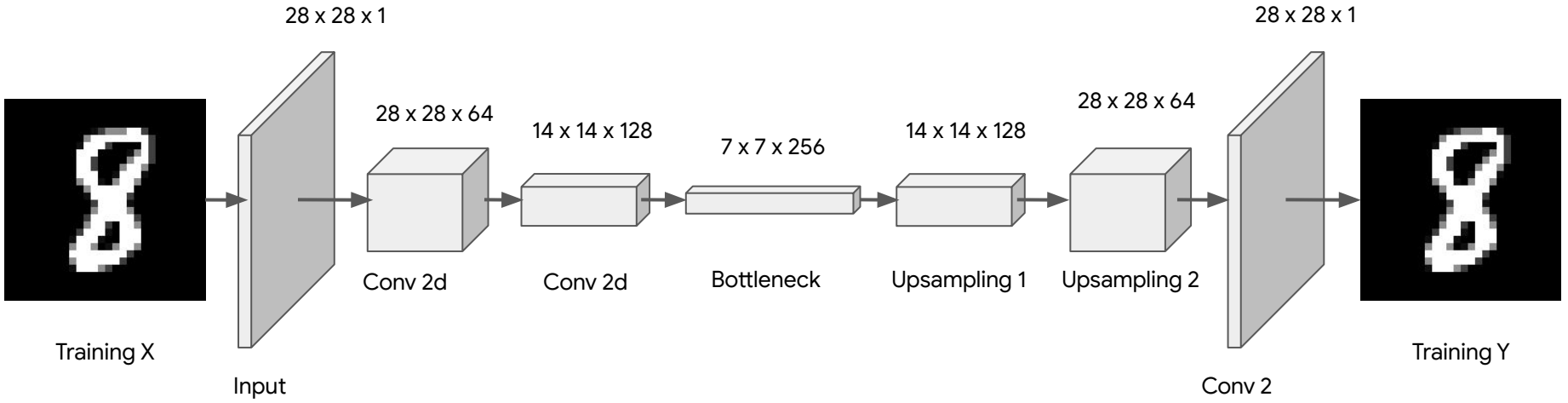
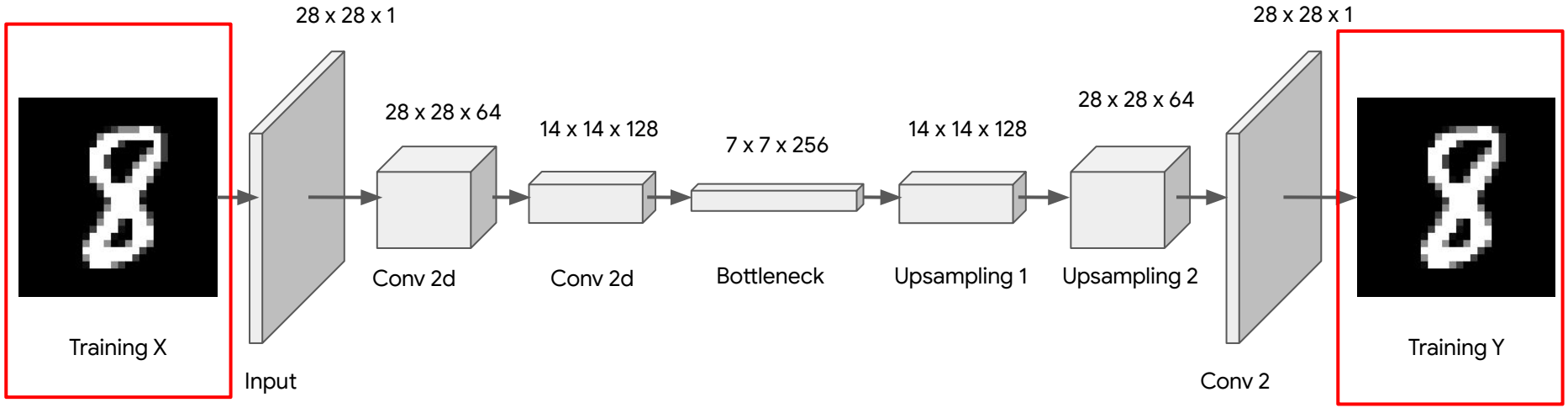
  model = tf.keras.Model(inputs =inputs, outputs=decoder_output)
  encoder_model = tf.keras.Model(inputs=inputs, outputs=encoder_visualization)

  return model, encoder_model
```

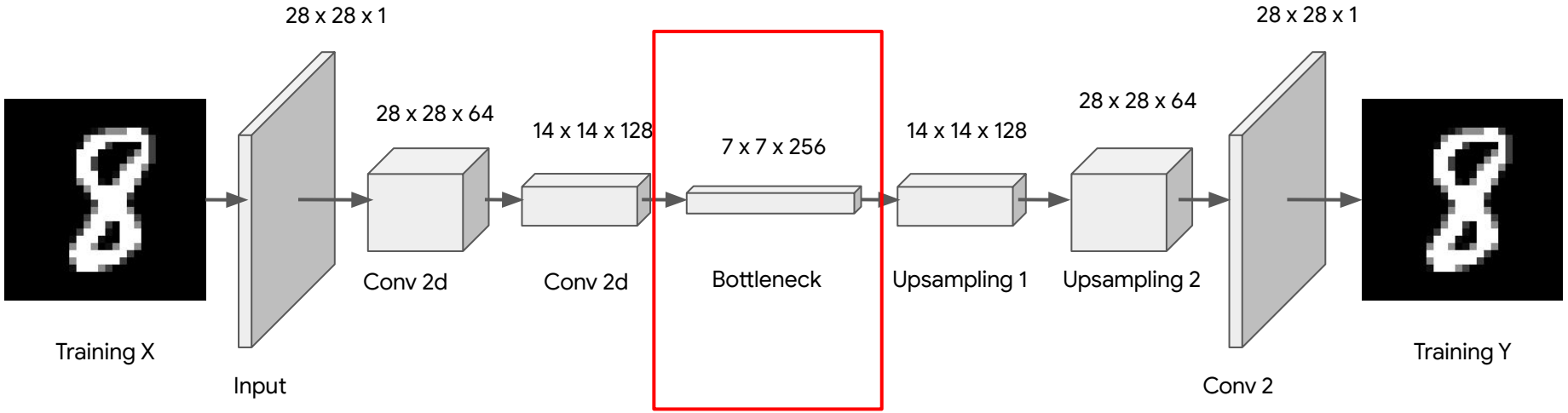
Convolutional Auto-Encoders



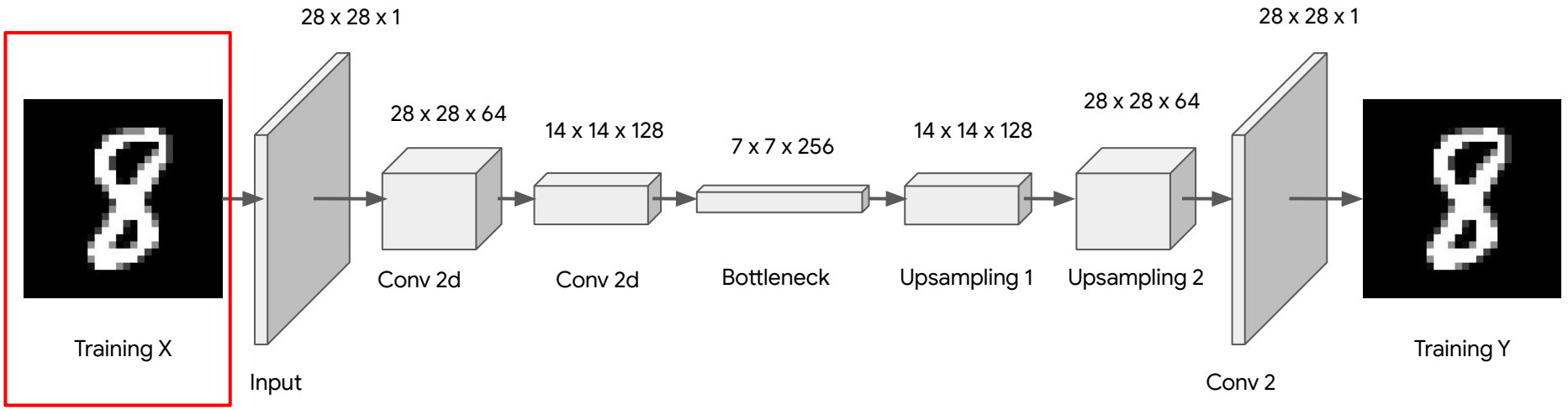
Convolutional Auto-Encoders



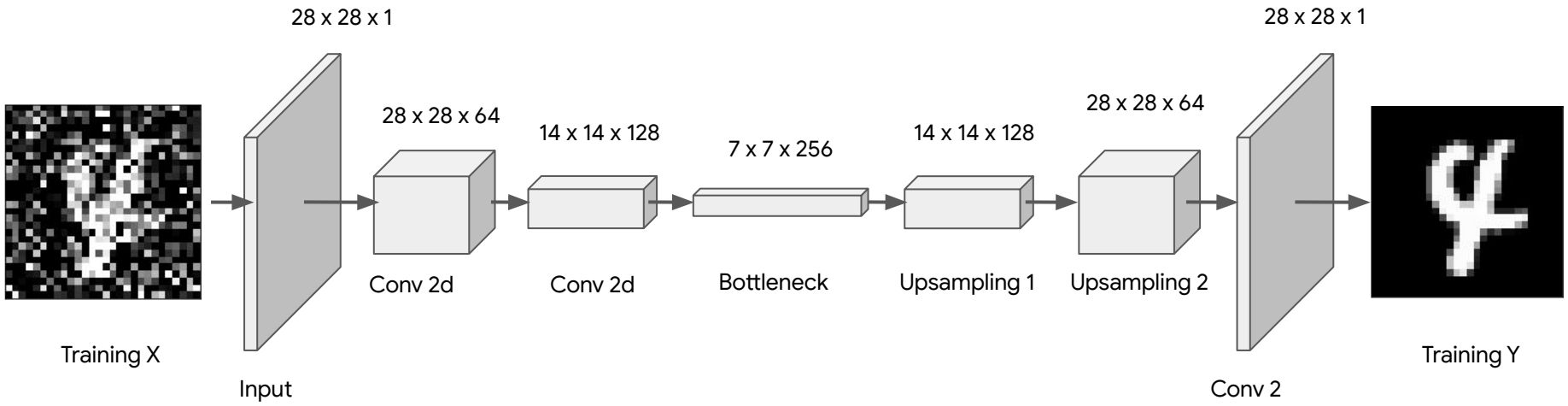
Convolutional Auto-Encoders

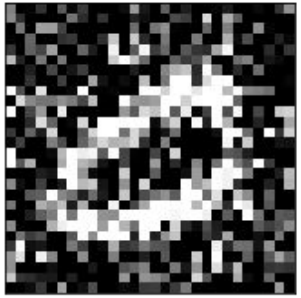
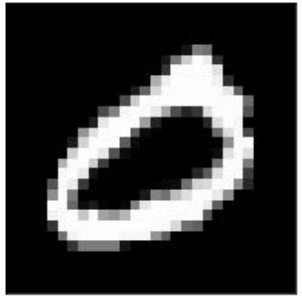
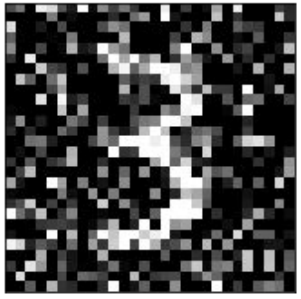


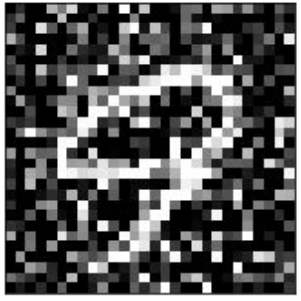
Convolutional Auto-Encoders

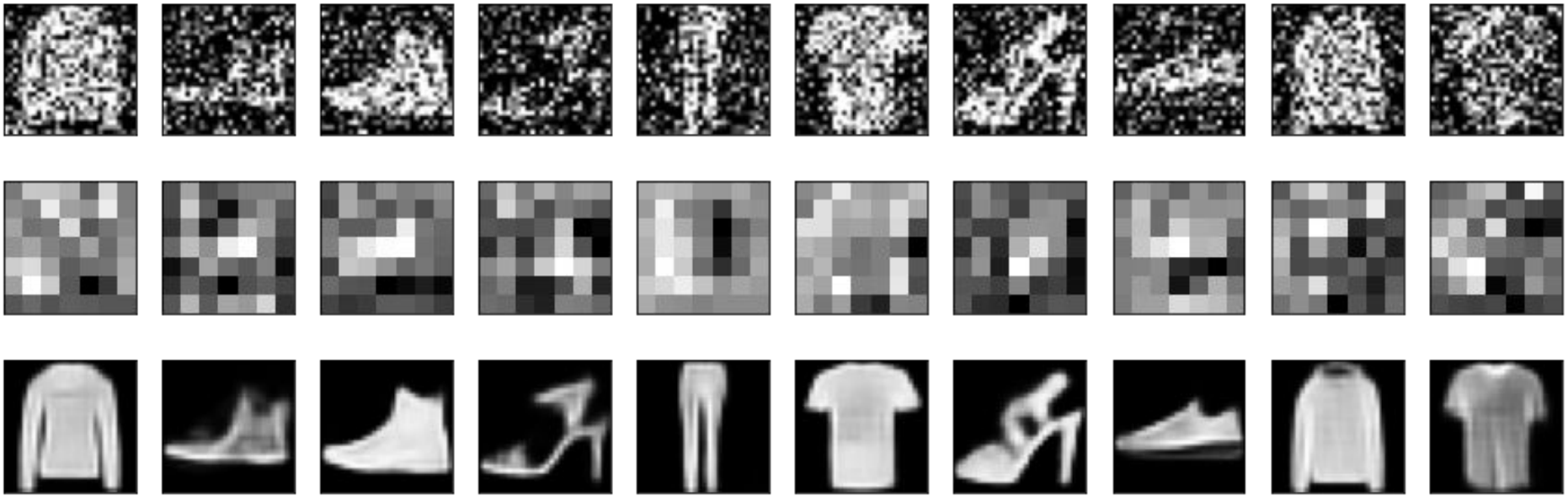


Convolutional Auto-Encoders





```
def map_image_with_noise(image, label):
  noise_factor = 0.5
  image = tf.cast(image, dtype=tf.float32)
  image = image / 255.0

  factor = noise_factor * tf.random.normal(shape=image.shape)
  image_noisy = image + factor
  image_noisy = tf.clip_by_value(image_noisy, 0.0, 1.0)

  return image_noisy, image
```

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