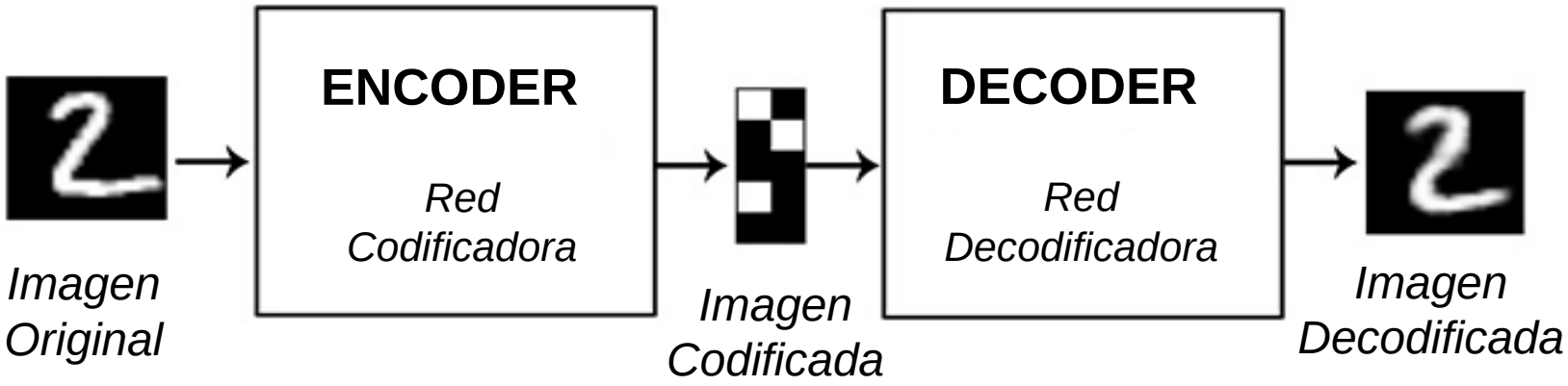
AUTOENCODERS
(AUTO CODIFICADORES)

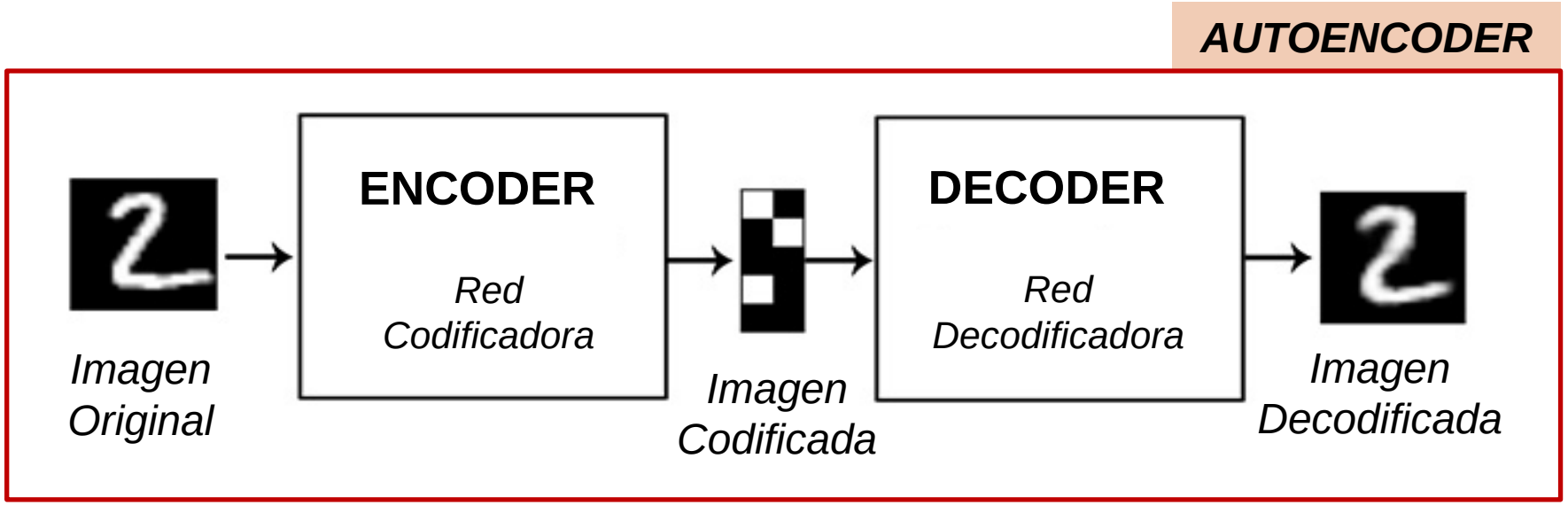
Autoencoding (Auto codificación)

- Es un algoritmo de compresión de datos en el que las funciones de compresión y descompresión son
  - Específicas de los datos
  - Con pérdida
  - Aprendidas automáticamente



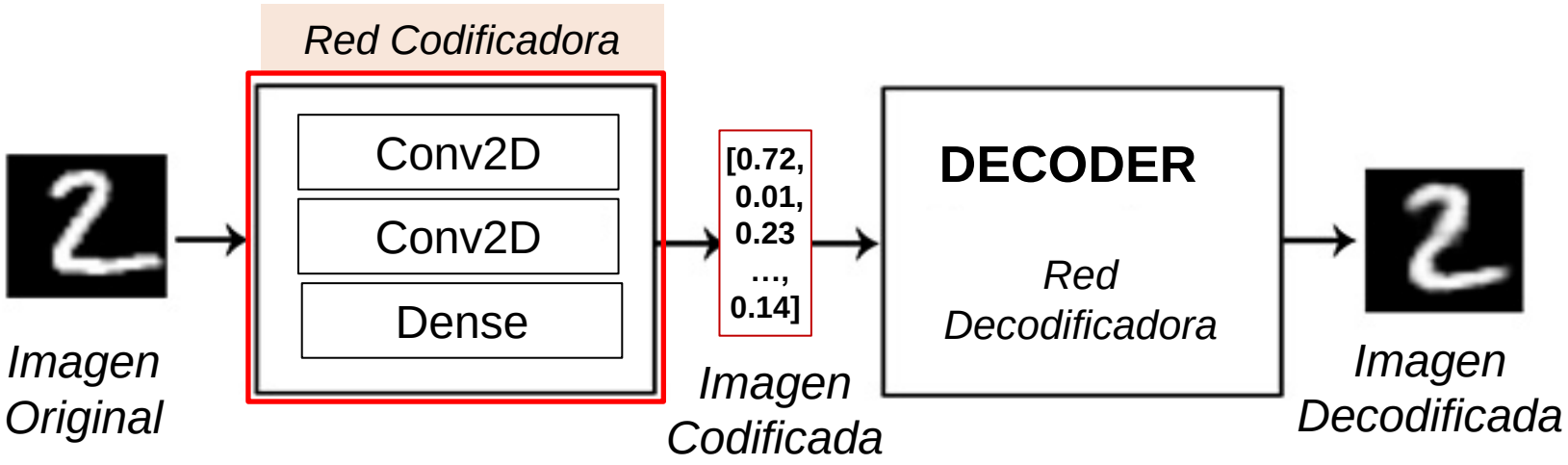
Autoencoder

- Entrenamiento
  - La entrada y la salida son iguales.
  - Entrenamiento NO supervisado aunque usa mecanismos supervisados.
- Tres modelos: encoder, decoder, autoencoder=decoder(encoder(x))



Red Codificadora

- Genera una representación vectorial de tamaño K
  - K << tamaño original de la imagen
- La nueva representación comprime la imagen
- Es una red neuronal feedforward o convolucional



Red Decodificadora

- Recibe la imagen codificada y genera una imagen de igual tamaño que la imagen de entrada.
- Descomprime la imagen.
- Es una red neuronal feedforward o convolucional

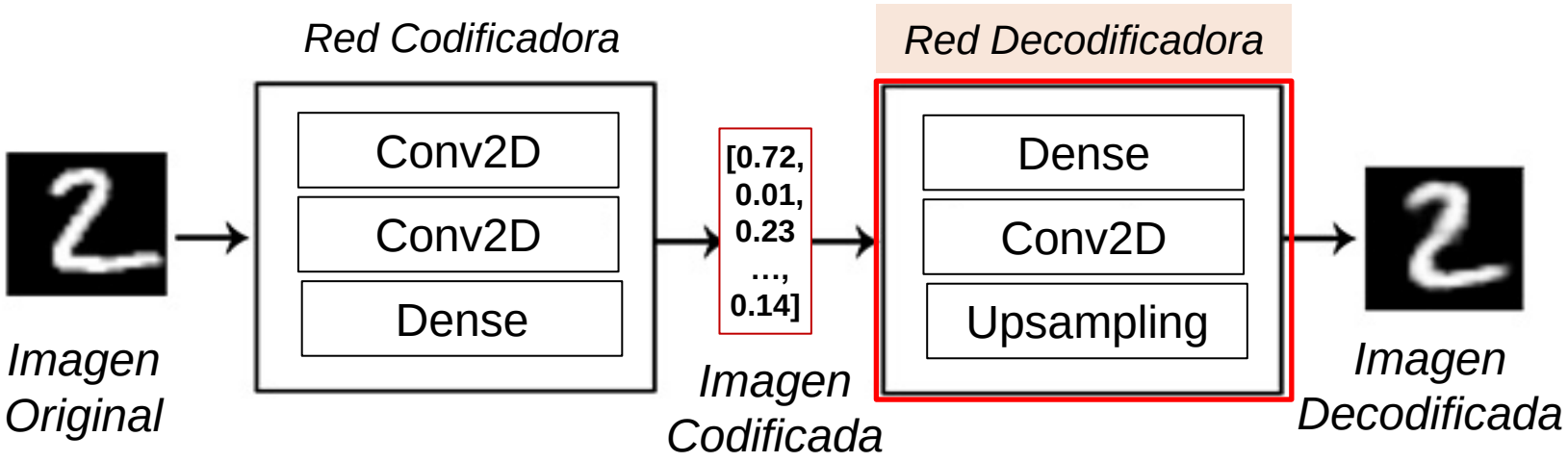
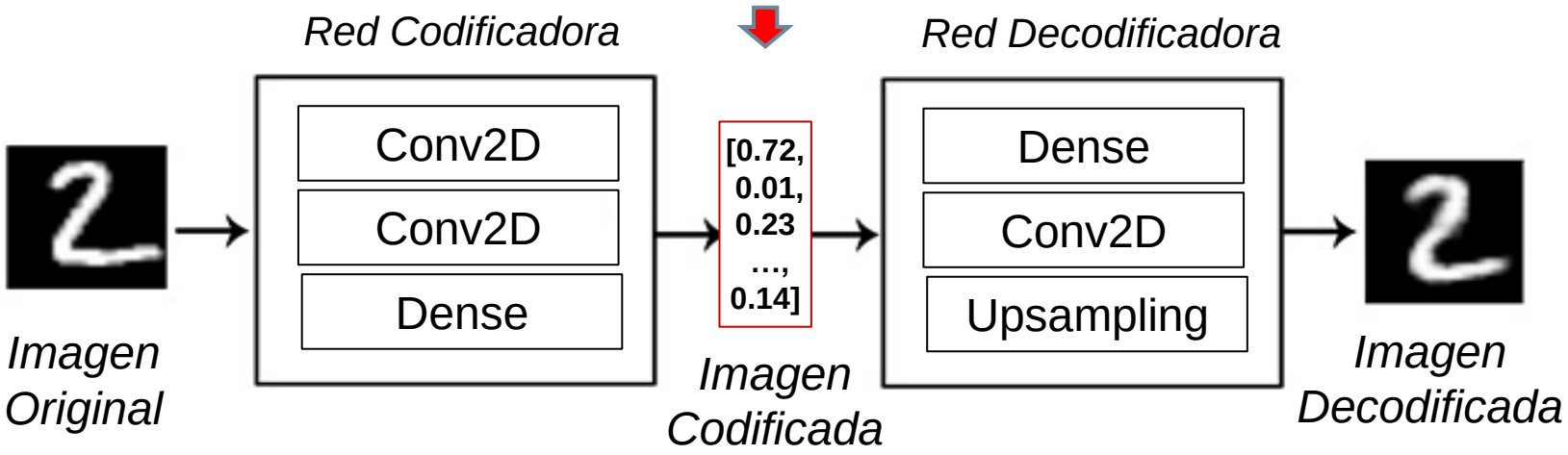


Imagen codificada

- Es un vector numérico de tamaño K (vector latente)
- El valor de K es arbitrario
  - A mayor valor de K mejora la representación y se reduce la compresión.

Su valor se infiere



AutoencoderDense-01.ipynb

Ejemplo

- Construiremos un autoencoder para comprimir los dígitos de MINIST

- Tanto el codificador como el decodificador estarán formados por una única capa densa.

Carga de datos

AutoencoderDense-01.ipynb

```
from tensorflow.keras.layers import Dense, Input
from tensorflow.keras.models import Model
from tensorflow.keras.datasets import mnist

(x_train, _), (x_test, _) = mnist.load_data()
input_dim = 28*28
x_train = np.reshape(x_train, [-1, input_dim])/255.0
x_test = np.reshape(x_test,   [-1, input_dim])/255.0

print(x_train.shape,x_test.shape,input_dim)
```

Nombre	Tipo	Tamaño
input_dim	int	1
x_test	Array of uint8	(10000, 28, 28)
x_train	Array of uint8	(60000, 28, 28)

Nombre	Tipo	Tamaño
input_dim	int	1
x_test	Array of floa…	(10000, 784)
x_train	Array of floa…	(60000, 784)

AutoencoderDense-01.ipynb

Modelos Encoder y Decoder

```
encoding_dim = 32  #factor de compresion 24.5, si entrada de 28x28=784
##------- ENCODER ------------
encoder_input = Input(shape=(input_dim,), name='encoder_input')
code = Dense(encoding_dim, activation='relu',
             name='latent_vector')(encoder_input)
encoder = Model(encoder_input, code, name='encoder')
```

```
Model: "encoder"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
encoder_input (InputLayer)   [(None, 784)]             0
_________________________________________________________________
latent_vector (Dense)        (None, 32)                25120
=================================================================
Total params: 25,120
```

AutoencoderDense-01.ipynb

Modelos Encoder y Decoder

```
encoding_dim = 32  #factor de compresion 24.5, si entrada de 28x28=784
##------- ENCODER ------------
encoder_input = Input(shape=(input_dim,), name='encoder_input')
code = Dense(encoding_dim, activation='relu',
             name='latent_vector')(encoder_input)
encoder = Model(encoder_input, code, name='encoder')
##------- DECODER -----------
latent_input = Input(shape=(encoding_dim,), name='decoder_input')
decoded_image = Dense(input_dim, activation="sigmoid",
                      name='decoder_output') (latent_input)
decoder = Model(latent_input, decoded_image, name='decoder')
```

AutoencoderDense-01.ipynb

Modelos Encoder y Decoder

```
Model: "decoder"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
decoder_input (InputLayer)   [(None, 32)]              0
_________________________________________________________________
decoder_output (Dense)       (None, 784)               25872
=================================================================
Total params: 25,872
```

```
##------- DECODER -----------
latent_input = Input(shape=(encoding_dim,), name='decoder_input')
decoded_image = Dense(input_dim, activation="sigmoid",
                      name='decoder_output') (latent_input)
decoder = Model(latent_input, decoded_image, name='decoder')
```

Modelo Autoencoder

AutoencoderDense-01.ipynb

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

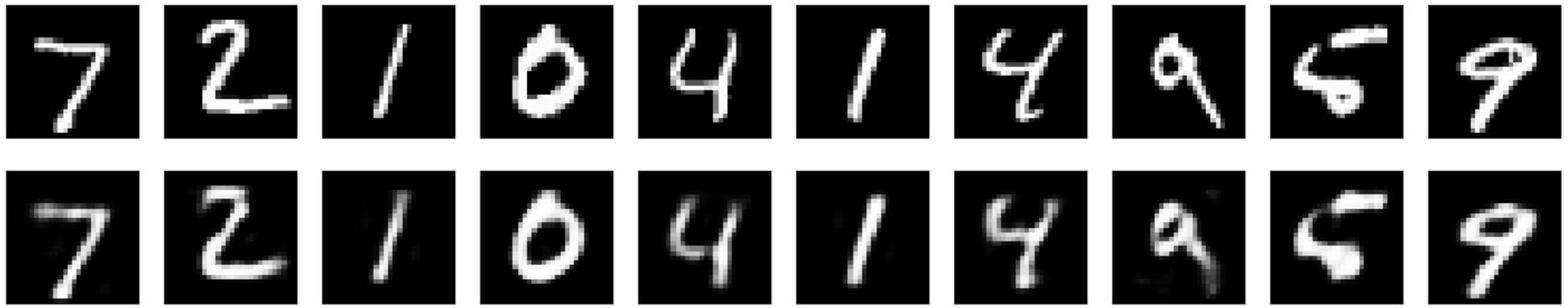
```
Model: "autoencoder"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
encoder_input (InputLayer)   [(None, 784)]             0
_________________________________________________________________
encoder (Functional)         (None, 32)                25120
_________________________________________________________________
decoder (Functional)         (None, 784)               25872
=================================================================
Total params: 50,992
```

AutoencoderDense-01.ipynb

Entrenamiento y uso

```
batch_size = 128
autoencoder.fit(x_train, x_train, validation_data=(x_test, x_test),
                epochs=50, batch_size=batch_size)

# Predicción del Autoencoder
x_decoded = autoencoder.predict(x_test)

# Codifica y decodifica algunos dígitos
encoded_imgs = encoder.predict(x_test)
decoded_imgs = decoder.predict(encoded_imgs)
```

Después de 50 épocas, el error en entrenamiento y testeo es de aprox. 0.09



Deep Autoencoder

AutoencoderDense-02.ipynb

```
input_img = layers.Input(shape=(784,))
encoded = layers.Dense(128, activation='relu')(input_img)
encoded = layers.Dense(64, activation='relu')(encoded)
encoded = layers.Dense(32, activation='relu')(encoded)

decoded = layers.Dense(64, activation='relu')(encoded)
decoded = layers.Dense(128, activation='relu')(decoded)
decoded = layers.Dense(784, activation='sigmoid')(decoded)

autoencoder = Model(input_img, decoded)
```

Total params: 222,384

Después de 100 épocas, el error en entrenamiento y testeo es de aprox. 0.08

Autoencoder convolucional

AutoencoderConv-03.ipynb

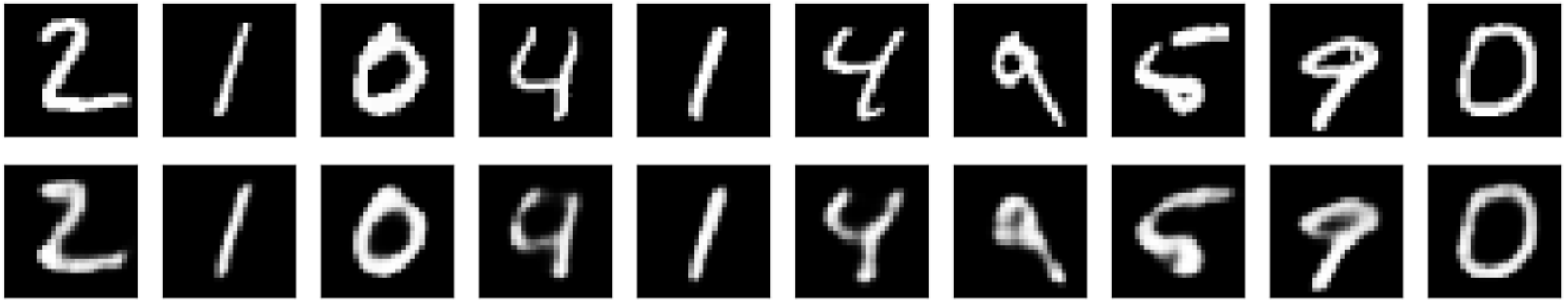
Layer (type)	Output Shape	Param #
input_5 (InputLayer)	[(None, 28, 28, 1)]	0
conv2d_17 (Conv2D)	(None, 28, 28, 16)	160
max_pooling2d_7 (MaxPooling2	(None, 14, 14, 16)	0
conv2d_18 (Conv2D)	(None, 14, 14, 8)	1160
max_pooling2d_8 (MaxPooling2	(None, 7, 7, 8)	0
conv2d_19 (Conv2D)	(None, 7, 7, 8)	584
max_pooling2d_9 (MaxPooling2	(None, 4, 4, 8)	0
conv2d_20 (Conv2D)	(None, 4, 4, 8)	584
up_sampling2d_7 (UpSampling2	(None, 8, 8, 8)	0
conv2d_21 (Conv2D)	(None, 8, 8, 8)	584
up_sampling2d_8 (UpSampling2	(None, 16, 16, 8)	0
conv2d_22 (Conv2D)	(None, 14, 14, 16)	1168
up_sampling2d_9 (UpSampling2	(None, 28, 28, 16)	0
conv2d_23 (Conv2D)	(None, 28, 28, 1)	145

Total params: 4,385

Autoencoder convolucional

AutoencoderConv-03.ipynb

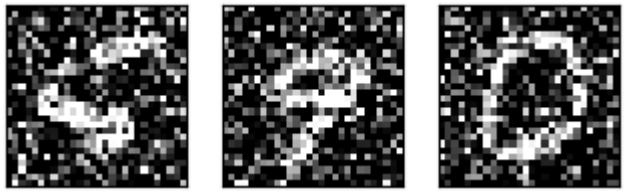
- Resultado del entrenamiento con 10 épocas



Imágenes con ruido

AutoencoderConvRuido-04.ipynb

```
(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))

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.)
```



Modelo convolucional usado

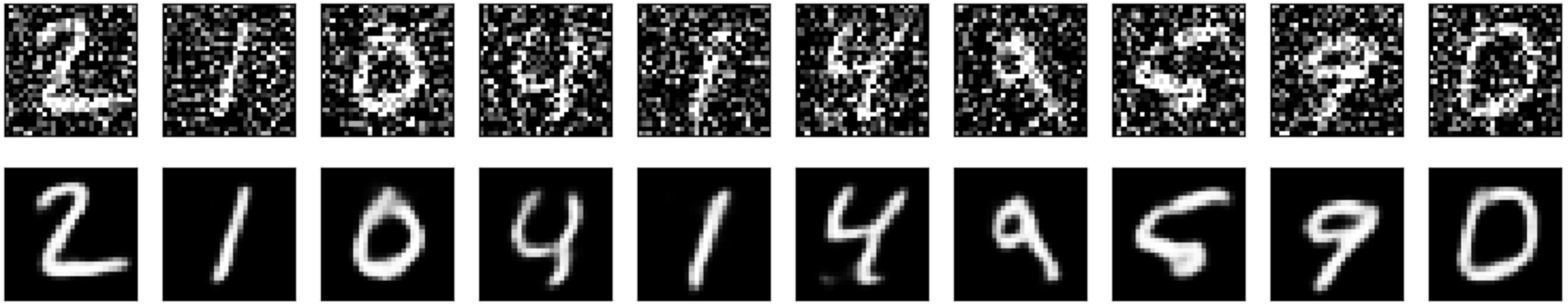
AutoencoderConvRuido-04.py

```
input_img = layers.Input(shape=(28, 28, 1))
x = layers.Conv2D(32, (3, 3), activation='relu', padding='same')(input_img)
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)

# En este punto la representación es de (7, 7, 32)
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)
print(autoencoder.summary())
```

AutoencoderConvRuido-04.py

Resultado de la decodificación

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

# Predicción del Autoencoder para las imágenes de testeo
decoded_imgs = autoencoder.predict(x_test_noisy)
```

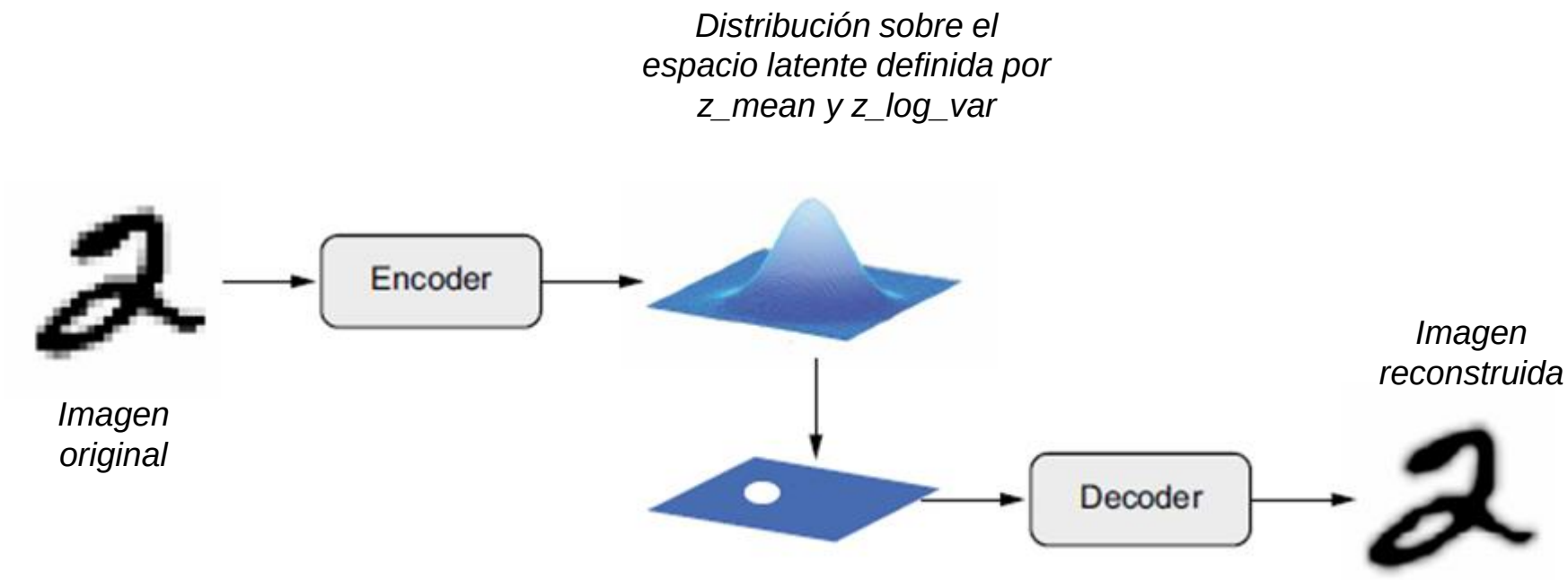


Detección de fraudes

- El conjunto de datos contiene transacciones realizadas por tarjetas de crédito en septiembre de 2013 por titulares de tarjetas europeas.
- Este conjunto de datos presenta las transacciones que se produjeron en dos días, donde tenemos 492 fraudes de 284.807 transacciones.
- El conjunto de datos es muy desequilibrado, la clase positiva (fraudes) representa el 0,172% de todas las transacciones
  - Link al dataset

Autoencoder_detecta_fraude.ipynb

Variational autoencoders (VAE)

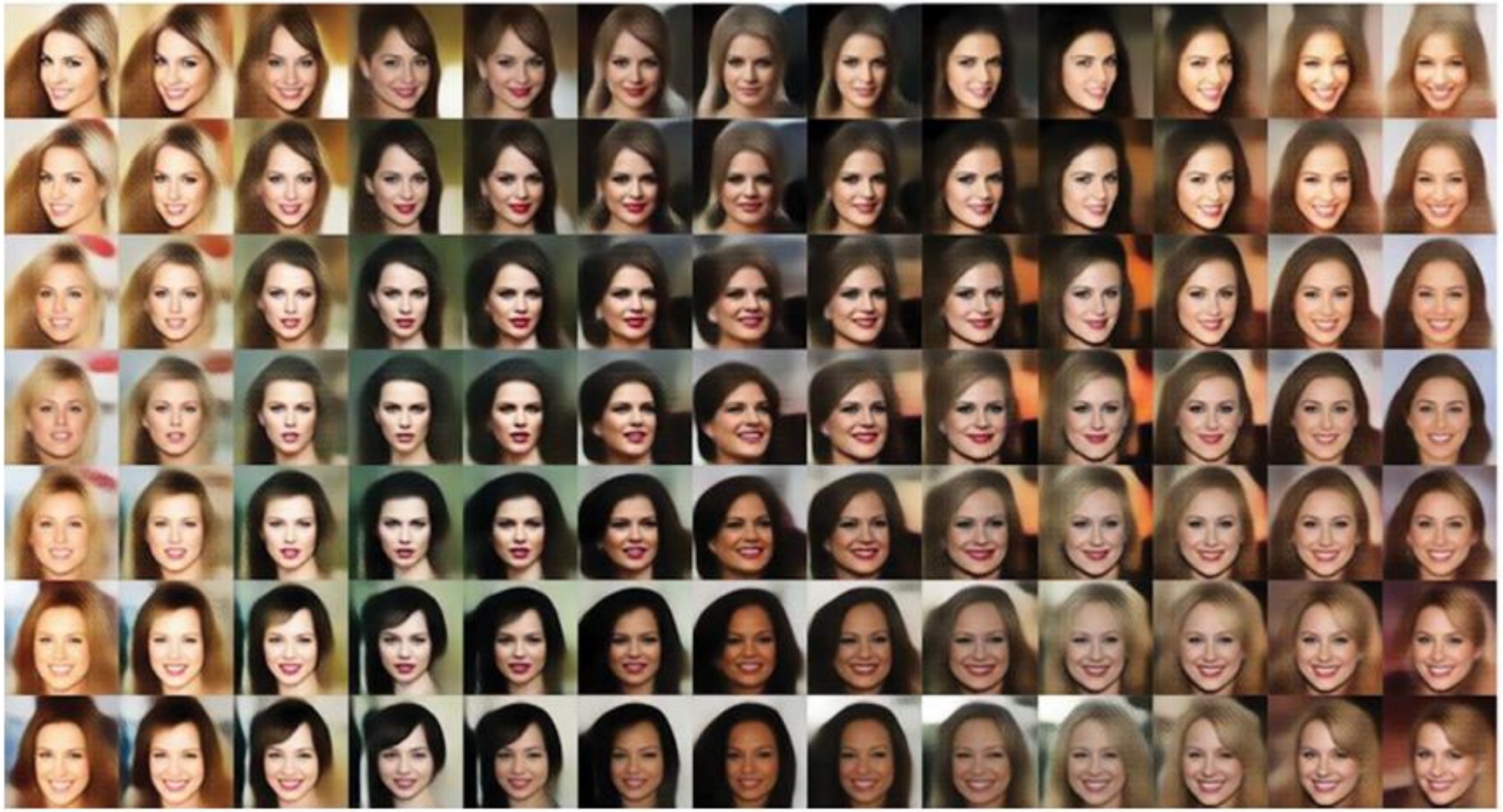


Variational-autoencoders.ipynb

Variational autoencoders (VAE)

Variational-encoder.ipynb

Variational autoencoders (VAE)



Un espacio continuo de caras generadas por Tom White usando VAEs

(Figura 12.14 del libro de Chollet)