Autoencoders Tutorial : A Beginner's Guide to Autoencoders

Last updated on May 14,2020 *14.3K Views*

Sayantini
A Data Science Enthusiast with in-hand skills in programming languages such as...

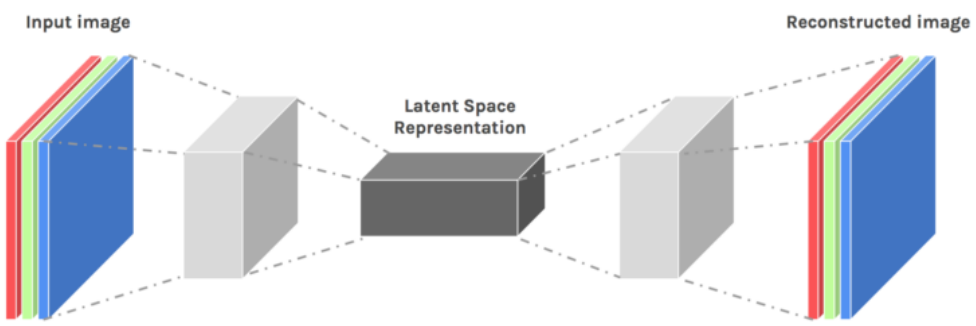
Artificial Intelligence encircles a wide range of technologies and techniques that enable computer systems to solve problems like Data Compression which is used in computer vision, computer networks, computer architecture, and many other fields. **Autoencoders** are *unsupervised neural networks* that use machine learning to do this compression for us. This **Autoencoders Tutorial** will provide you with a complete insight into autoencoders in the following sequence:

- **What are Autoencoders?**
- **The need for Autoencoders**
- **Applications of Autoencoders**
- **Architecture of Autoencoders**
- **Properties & Hyperparameters**
- **Types of Autoencoders**
- **Data Compression using Autoencoders (Demo)**

Let's begin with the most fundamental and essential question, What are autoencoders?

What are Autoencoders?

An autoencoder **neural network** is an **Unsupervised Machine learning** algorithm that applies backpropagation, setting the target values to be equal to the inputs. Autoencoders are used to reduce the size of our inputs into a smaller representation. If anyone needs the original data, they can reconstruct it from the compressed data.



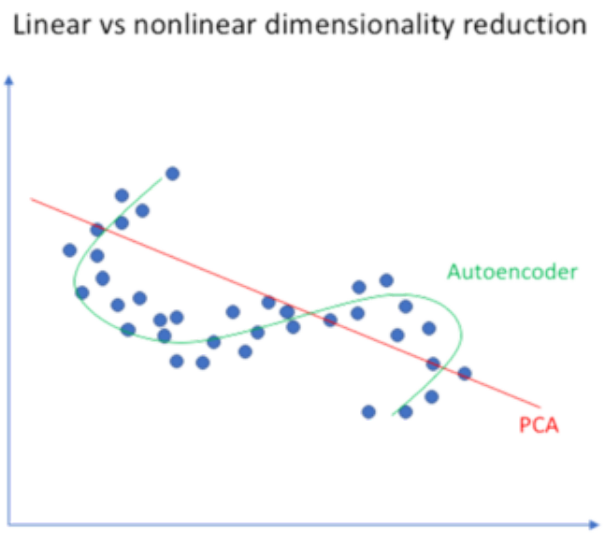
We have a similar machine learning algorithm ie. PCA which does the same task. So you might be thinking why do we need Autoencoders then? Let's continue this Autoencoders Tutorial and find out the reason behind using Autoencoders.

Autoencoders Tutorial: Its Emergence

Autoencoders are preferred over PCA because:

- An autoencoder can learn **non-linear transformations** with a **non-linear activation function** and multiple layers.
- It doesn't have to learn dense layers. It can use **convolutional layers** to learn which is better for video, image and series data.
- It is more efficient to learn several layers with an autoencoder rather than learn one huge transformation with PCA.
- An autoencoder provides a representation of each layer as the output.
- It can make use of **pre-trained layers** from another model to apply transfer learning to enhance the encoder/decoder.

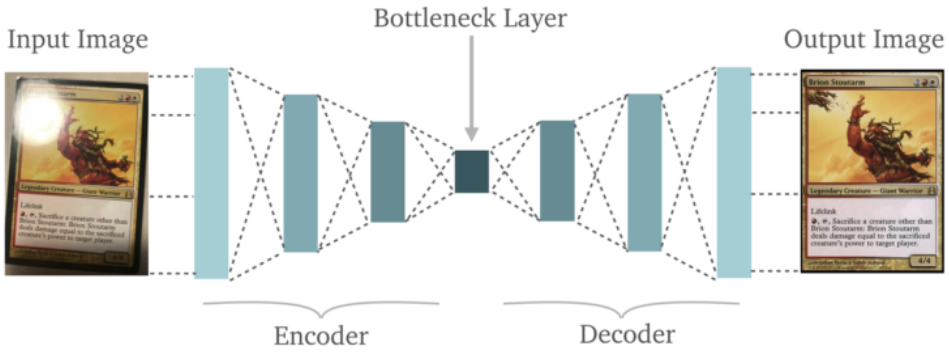
Now let's have a look at a few Industrial Applications of Autoencoders.



Applications of Autoencoders

Image Coloring

Autoencoders are used for converting any black and white picture into a colored image. Depending on what is in the picture, it is possible to tell what the color should be.

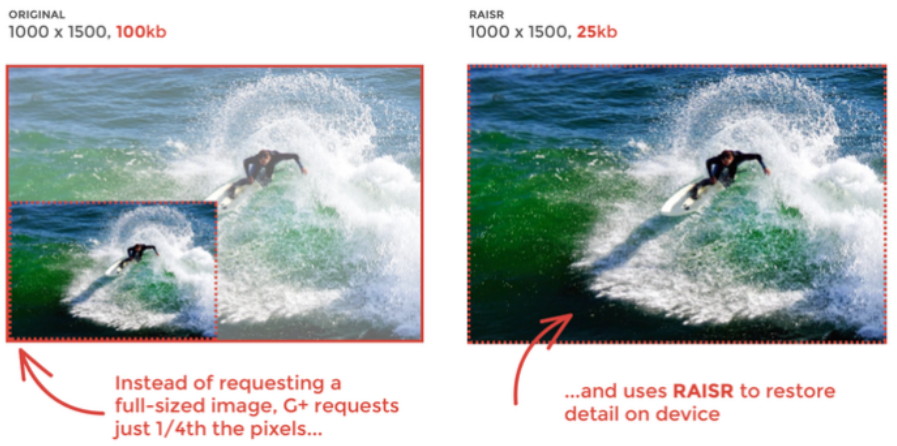


Feature variation

It extracts only the required features of an image and generates the output by removing any noise or unnecessary interruption.

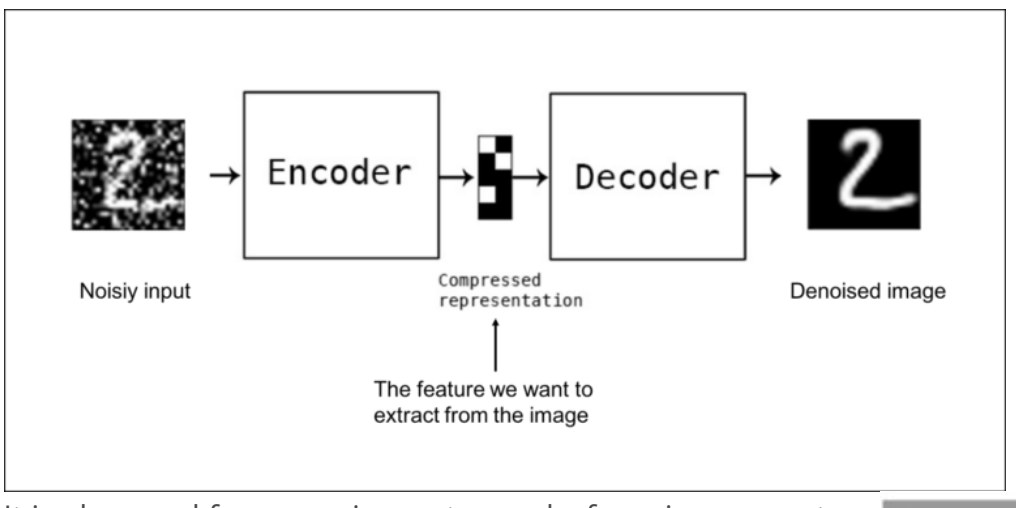
Dimensionality Reduction

The reconstructed image is the same as our input but with reduced dimensions. It helps in providing the similar image with a reduced pixel value.



Denoising Image

The input seen by the autoencoder is not the raw input but a stochastically corrupted version. A denoising autoencoder is thus trained to reconstruct the original input from the noisy version.



Watermark Removal

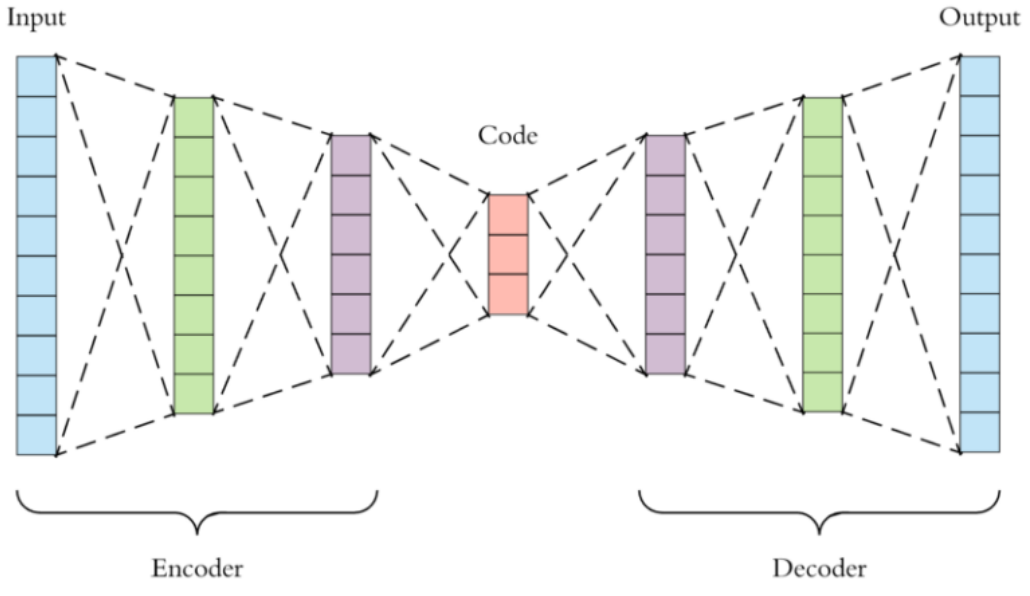
It is also used for removing watermarks from images or to remove any object while filming a video or a movie.

Now that you have an idea of the different industrial applications of Autoencoders, let's continue our Autoencoders Tutorial Blog and understand the complex architecture of Autoencoders.

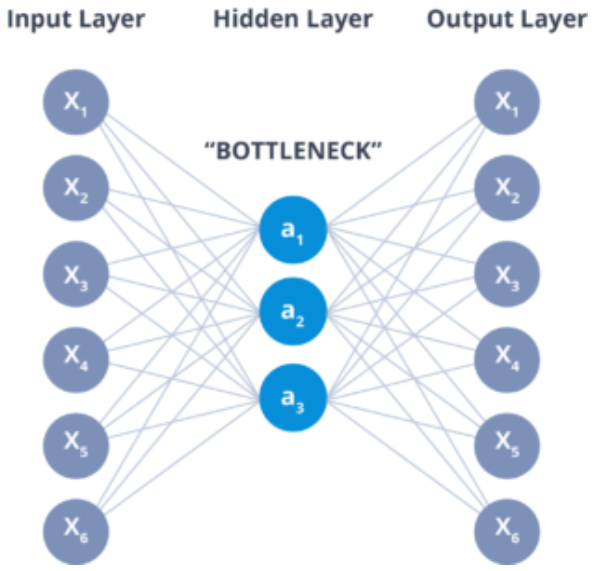
Architecture of Autoencoders

An Autoencoder consist of three layers:

1. **Encoder**
2. **Code**
3. **Decoder**



- **Encoder:** This part of the network compresses the input into a **latent space representation**. The encoder layer **encodes** the input image as a compressed representation in a reduced dimension. The compressed image is the distorted version of the original image.
- **Code:** This part of the network represents the compressed input which is fed to the decoder.
- **Decoder:** This layer **decodes** the encoded image back to the original dimension. The decoded image is a lossy reconstruction of the original image and it is reconstructed from the latent space representation.



The layer between the encoder and decoder, ie. the code is also known as **Bottleneck**. This is a well-designed approach to decide which aspects of observed data are relevant information and what aspects can be discarded. It does this by balancing two criteria :

- Compactness of representation, measured as the compressibility.
- It retains some behaviourally relevant variables from the input.

Now that you have an idea of the architecture of an Autoencoder. Let's continue our Autoencoders Tutorial and understand the different properties and the Hyperparameters involved while training Autoencoders.

Properties and Hyperparameters

Properties of Autoencoders:

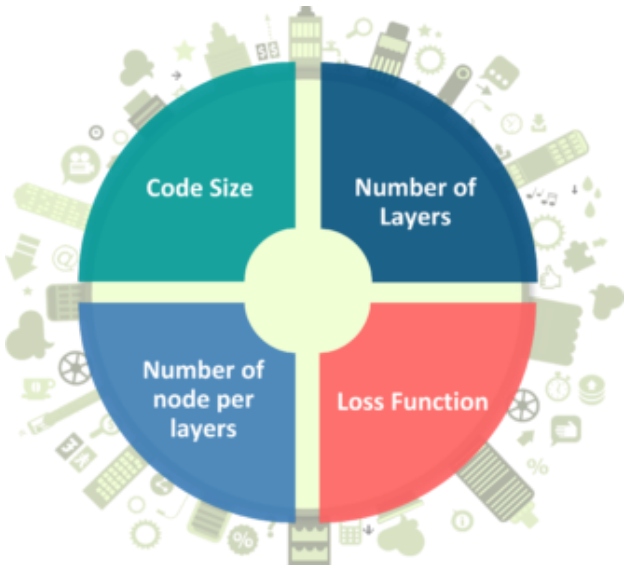
- **Data-specific**: Autoencoders are only able to compress data similar to what they have been trained on.
- **Lossy:** The decompressed outputs will be degraded compared to the original inputs.

- **Learned automatically from examples:** It is easy to train specialized instances of the algorithm that will perform well on a specific type of input.

Hyperparameters of Autoencoders:

There are **4** hyperparameters that we need to set before training an autoencoder:

- **Code size**: It represents the number of nodes in the middle layer. Smaller size results in more compression.
- **Number of layers**: The autoencoder can consist of as many layers as we want.
- **Number of nodes per layer**: The number of nodes per layer decreases with each subsequent layer of the encoder, and increases back in the decoder. The decoder is symmetric to the encoder in terms of the layer structure.
- **Loss function:** We either use mean squared error or binary cross-entropy. If the input values are in the range [0, 1] then we typically use cross-entropy, otherwise, we use the mean squared error.

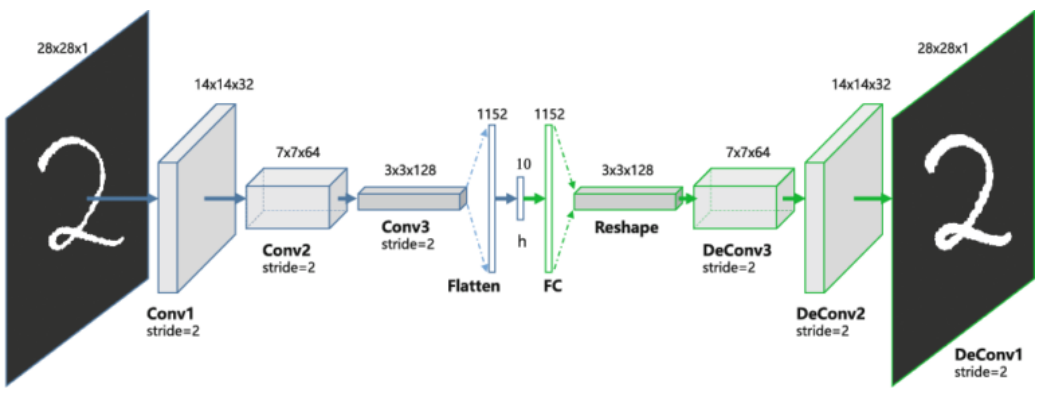


Now that you know the properties and hyperparameters involved in the training of Autoencoders. Let's move forward with our Autoencoders Tutorial and understand the different types of autoencoders and how they differ from each other.

Types of Autoencoders

Convolution Autoencoders

Autoencoders in their traditional formulation does not take into account the fact that a signal can be seen as a sum of other signals. Convolutional Autoencoders use the convolution operator to exploit this observation. They learn to encode the input in a set of simple signals and then try to reconstruct the input from them, modify the geometry or the reflectance of the image.



Use cases of CAE:

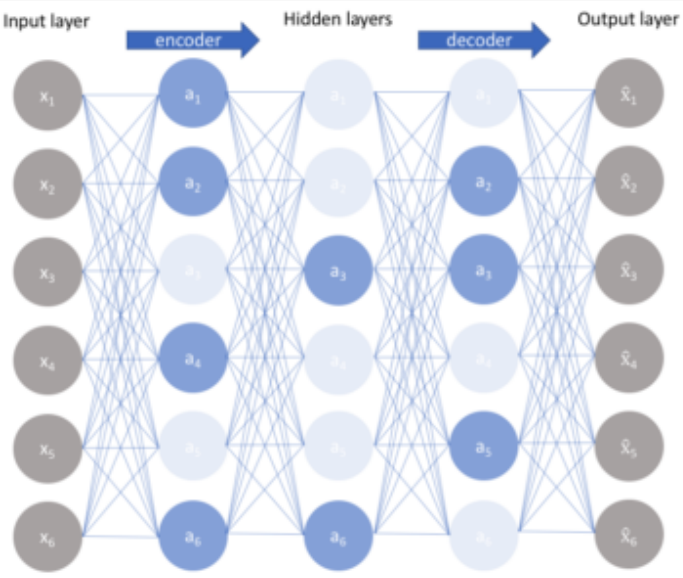
- Image Reconstruction
- Image Colorization
- latent space clustering
- generating higher resolution images

Sparse Autoencoders

Sparse autoencoders offer us an alternative method for introducing an information bottleneck **without requiring a reduction in the number of nodes** at our hidden layers. Instead, we'll construct our loss function such that we penalize activations within a layer.

---

tificial Intelligence Training

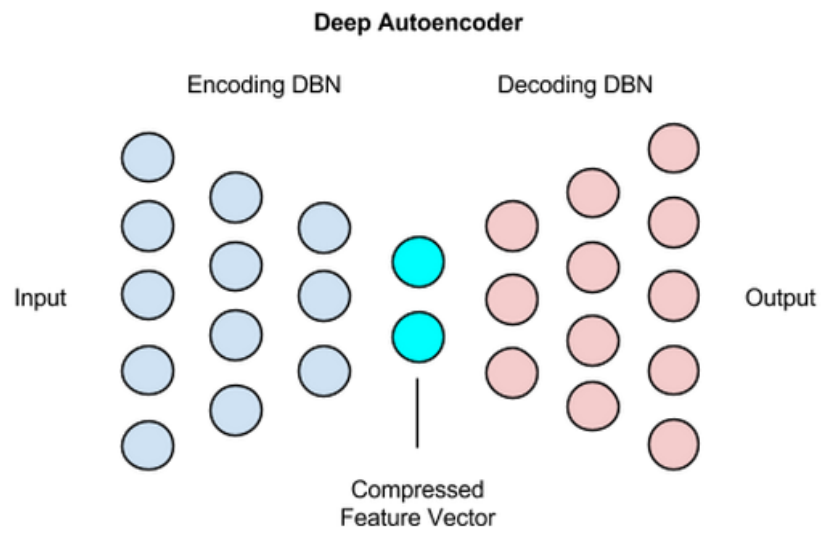


Deep Autoencoders

The extension of the simple Autoencoder is the **Deep Autoencoder**. The first layer of the Deep Autoencoder is used for first-order features in the **raw input**. The second layer is used for second-order features corresponding to **patterns** in the appearance of first-order features. Deeper layers of the Deep Autoencoder tend to learn even higher-order features.

A **deep autoencoder** is composed of two, symmetrical deep-belief networks-

1. First four or five shallow layers representing the encoding half of the net.
2. The second set of four or five layers that make up the decoding half.

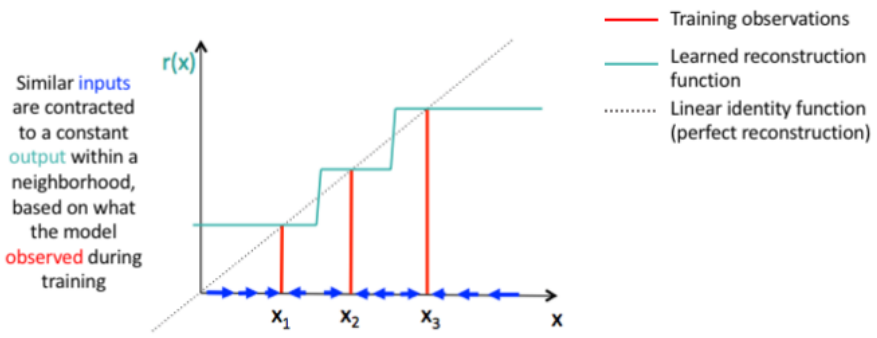


Use cases of Deep Autoencoders

- Image Search
- Data Compression
- Topic Modeling & Information Retrieval (IR)

Contractive Autoencoders

A **contractive autoencoder** is an unsupervised deep learning technique that helps a neural network encode unlabeled training data. This is accomplished by constructing a **loss term** which penalizes large derivatives of our hidden layer activations with respect to the input training examples, **essentially penalizing** instances where a small change in the input leads to a large change in the encoding space.



Now that you have an idea of what Autoencoders is, it's different types and it's properties. Let's move ahead with our Autoencoders Tutorial and understand a simple implementation of it using TensorFlow in Python.

Data Compression using Autoencoders(Demo)

Let's import the required libraries

```
import numpy as np
from keras.layers import Input, Dense
from keras.models import Model
from keras.datasets import mnist
import matplotlib.pyplot as plt
```

Declaration of Hidden Layers and Variables

```
# this is the size of our encoded representations
encoding_dim = 32 # 32 floats -> compression of factor 24.5, assuming the input is 784 floats

# this is our input placeholder
input_img = Input(shape=(784,))
# "encoded" is the encoded representation of the input
encoded = Dense(encoding_dim, activation='relu')(input_img)
# "decoded" is the lossy reconstruction of the input
decoded = Dense(784, activation='sigmoid')(encoded)
# this model maps an input to its reconstruction
autoencoder = Model(input_img, decoded)
# this model maps an input to its encoded representation
encoder = Model(input_img, encoded)
# create a placeholder for an encoded (32-dimensional) input
encoded_input = Input(shape=(encoding_dim,))
# retrieve the last layer of the autoencoder model
decoder_layer = autoencoder.layers[-1]
# create the decoder model
decoder = Model(encoded_input, decoder_layer(encoded_input))
# configure our model to use a per-pixel binary crossentropy loss, and the Adadelta optimizer:
autoencoder.compile(optimizer='adadelta', loss='binary_crossentropy')
```

Preparing the input data (MNIST Dataset)

```
(x_train, _), (x_test, _) = mnist.load_data()
# normalize all values between 0 and 1 and we will flatten the 28x28 images into vectors of size 784.
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:])))
print x_train.shape
print x_test.shape
```

Training Autoencoders for 50 epochs

```
autoencoder.fit(x_train, x_train,
epochs=50,
batch_size=256,
shuffle=True,
validation_data=(x_test, x_test))
# encode and decode some digits
# note that we take them from the *test* set
encoded_imgs = encoder.predict(x_test)
decoded_imgs = decoder.predict(encoded_imgs)
```

Visualizing the reconstructed inputs and the encoded representations using Matplotlib

```
n = 20 # how many digits we will display
plt.figure(figsize=(20, 4))
for i in range(n):
# display original
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)



# display reconstruction
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()
```

Input

Output

Now with this, we come to an end to this Autoencoders Tutorial. I Hope you guys enjoyed this article and understood the power of Tensorflow, and how easy it is to decompress images. So, if you have read this, you are no longer a newbie to Autoencoders. Try out these examples and let me know if there are any challenges you are facing while deploying the code.

Autoencoders Tutorial using TensorFlow | Edureka

This video provides you with a brief introduction about autoencoders and how they compress unsupervised data.

Undersatnd Deep Learning from Experts

Enroll Now

---

*Now that you have understood the basics of Autoencoders, check out the **AI and Deep Learning With Tensorflow** by Edureka, a trusted online learning company with a network of more than 250,000 satisfied learners spread across the globe. This Certification Training is curated by industry professionals as per the industry requirements & demands. You will master concepts such as SoftMax function, Autoencoder Neural Networks, Restricted Boltzmann Machine (RBM) and work with libraries like Keras & TFLearn. Got a question for us? Please mention it in the comments section of "Autoencoders Tutorial" and we will get back to you.*

Recommended videos for you

What Is Deep Learning – Deep Learning Simplified

Watch Now

Deep Learning Tutorial – Deep Learning With TensorFlow

Watch Now

Introduction to Mahout

Watch Now

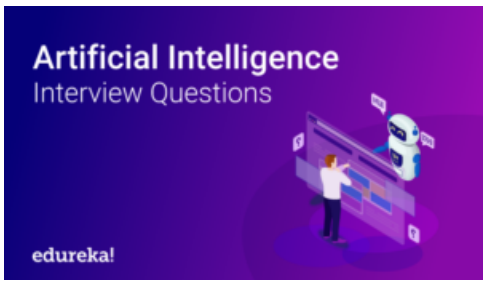
Recommended blogs for you

Object Detection Tutorial in TensorFlow: Real-Time Object Detection

Read Article

Understanding Distance Measures in Mahout

Read Article



Most Frequently Asked Artificial Intelligence Interview Questions

Read Article

Top 10 Machine Lea You Need to Know A

Read Article

Comments

0 Comments

Join the discussion

Trending Courses in Artificial Intelligence

AI & Deep Learning with TensorFlow

- 19k Enrolled Learners
- Weekend
- Live Class

Reviews

★★★★★ 5 (7250)

Natural Language Processing with Python Certi

- 3k Enrolled Learners
- Weekend
- Live Class

Reviews

★★★★★ 5 (900)

Graphical Models Certification Training

- 2k Enrolled Learners
- Weekend
- Live Class

Reviews

★★★★★ 5 (550)

Reinforcement Le

- 2k Enrolled Learners
- Weekend
- Live Class

Reviews

★★★★★ 5 (550)

Browse Categories

BI and Visualization | Big Data | Blockchain | Cloud Computing | Cyber Security | Data Science | Data Warehousing and ETL | Databases | DevOps | Digital Marketing | Front End Web Development | Mobile Development | Operating Systems | Programming & Frameworks | Project Management and Methodologies | Robotic Process Automation | Software Testing | Systems & Architecture

edureka!

TRENDING CERTIFICATION COURSES

DevOps Certification Training

AWS Architect Certification Training

Big Data Hadoop Certification Training

Tableau Training & Certification

Python Certification Training for Data Science

Selenium Certification Training

PMP® Certification Exam Training

Robotic Process Automation Training using UiPath

Apache Spark and Scala Certification Training

Microsoft Power BI Training

Online Java Course and Training

Python Certification Course

TRENDING MASTERS COURSES

Data Scientist Masters Program

DevOps Engineer Masters Program

Cloud Architect Masters Program

Big Data Architect Masters Program

Machine Learning Engineer Masters Program

Full Stack Web Developer Masters Program

Business Intelligence Masters Program

Data Analyst Masters Program

Test Automation Engineer Masters Program

Post-Graduate Program in Artificial Intelligence & Machine Learning

Post-Graduate Program in Big Data Engineering

COMPANY

About us

News & Media

Reviews

Contact us

Blog

Community

Sitemap

Blog Sitemap

Community Sitemap

Webinars

WORK WITH US

Careers

Become an Instructor

Become an Affiliate

Become a Partner

Hire from Edureka

DOWNLOAD APP

Download on the App Store | GET IT ON Google Play

CATEGORIES

CATEGORIES

Cloud Computing | DevOps | Big Data | Data Science | BI and Visualization | Programming & Frameworks | Software Testing | Project Management and Methodologies | Robotic Process Automation | Frontend Development | Data Warehousing and ETL | Artificial Intelligence | Blockchain | Databases | Cyber Security | Mobile Development | Operating Systems | Architecture & Design Patterns | Digital Marketing

TRENDING BLOG ARTICLES

Selenium tutorial | Selenium interview questions | Java tutorial | What is HTML | Java interview questions | PHP tutorial | JavaScript interview questions | Spring tutorial | PHP interview questions | Inheritance in Java | Polymorphism in Java | Spring interview questions | Pointers in C | Linux commands | Android tutorial | JavaScript tutorial | jQuery tutorial | SQL interview questions | MySQL tutorial | Machine learning tutorial | Python tutorial | What is machine learning | Ethical hacking tutorial | SQL injection | AWS certification career opportunities | AWS tutorial | What Is cloud computing | What is blockchain | Hadoop tutorial | What is artificial intelligence | Node Tutorial | Collections in Java | Exception handling in java | Python Programming Language | Python interview questions | Multithreading in Java | ReactJS Tutorial | Data Science vs Big Data vs Data Analyt... | Software Testing Interview Questions | R Tutorial | Java Programs | JavaScript Reserved Words and Keywor... | Implement thread.yield() in Java: Exam... | Implement Optical Character Recogniti... | All you Need to Know About Implemen...