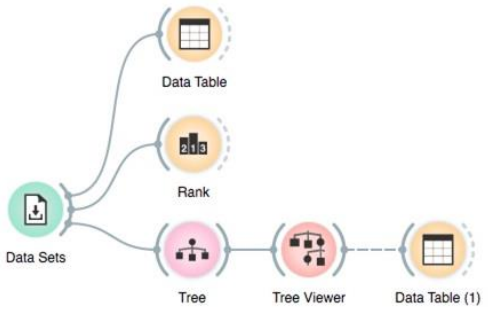
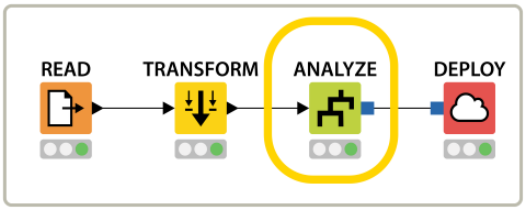
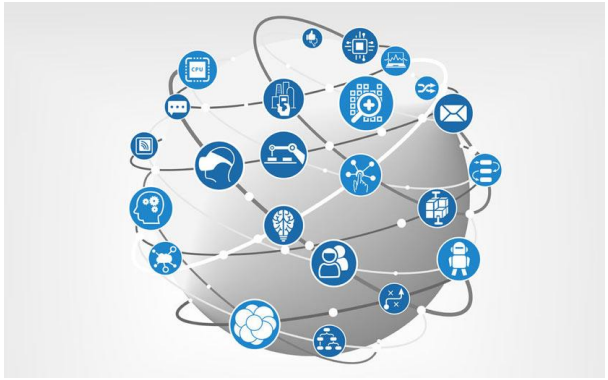
Predictive Analytics and Machine Learning Basics

Class 3: Machine Learning Basics







July 18, 2018

Don Wilcher

DesignNews

Presented by:

CEC CONTINUING EDUCATION CENTER

Digi-Key ELECTRONICS

Class 3: Machine Learning Basics

Agenda

- What is Machine Learning?
- What is Classification?
- Lab Project: Hand Writing Recognition Training Model.

What is Machine Learning?

Machine learning is a subset of artificial intelligence in the field of computer science that often uses statistical techniques to give computers the ability to "learn" (i.e., progressively improve performance on a specific task) with data, without being explicitly programmed.

Source:
https://en.wikipedia.org/wiki/Machine_learning

What is Machine Learning?. . .

Deriving meaning from data is the promise that machine learning provides (Guo, 2017).

" Machine learning draws on concepts and results from many fields, including statistics, artificial intelligence, philosophy, information theory, biology, cognitive science, computational complexity, and control theory" (Hall, 1997).

Devices act like human brains through cognition using computers and software (Daffodil Sofware,2017).

Source:

Hall, T.M. (1997). Machine learning. Ithaca, NY: McGraw-Hill.

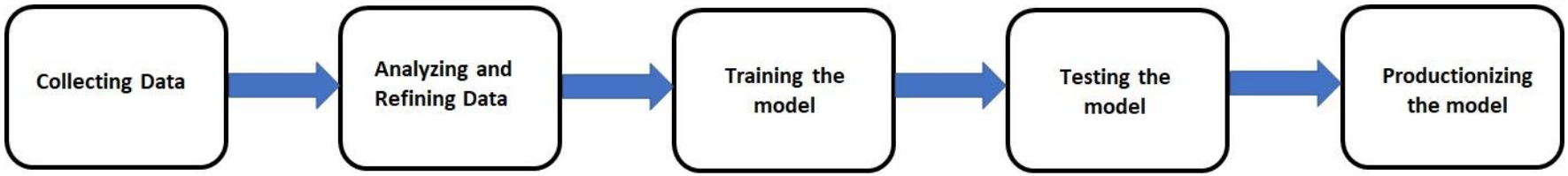
Guo, Y. (2017). What is machine learning?. Retrieved from https://towardsdatascience.com/what-is-machine-learning-8c6871016736

Daffodil Software (2017). 9 applications of machine learning from day-to-day life. Retrieved from https://medium.com/app-affairs/9-applications-of-machine-learning-from-day-to-day-life-112a47a429d0

What is Machine Learning?. . .

What is Machine Learning Workflow?

It's a development process that allows for the aggregation and training of data against a specific analytical model. Testing and productionizing of the model is also part of the machine learning workflow process. There five steps for the machine learning workflow process.



Question 1:

What is Machine Learning?

What is Machine Learning?. . .

What is Machine Learning Workflow?

Collecting Data:
The beginning step of the machine learning process. Data drives the entire machine learning workflow. Good quality and accurate data can provide better results for the machine learning model.

Analyzing and Refining the Data:
All data pre-processing takes place in this step. The dataset is analyzed and cleansed to ensure good results from the machine learning model.

Training the model:
An appropriate machine learning algorithm is selected. The dataset is split into training and test sets. The training set is the one where the model learns. The test set provides the analytics on the accuracy of the model.

What is Machine Learning?. . .

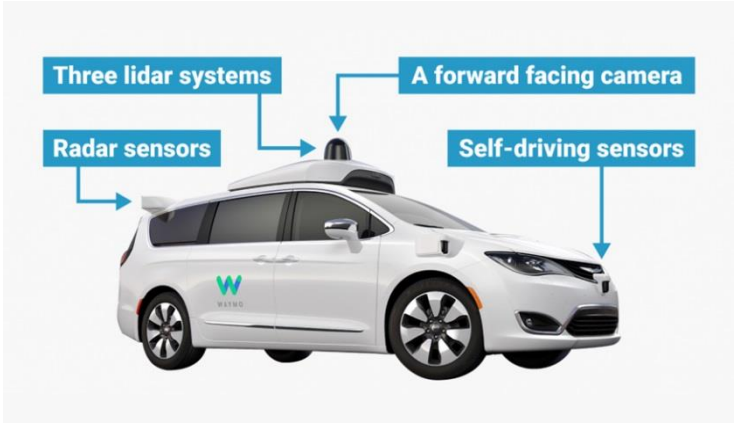
What is Machine Learning Workflow?

Testing the model:
With the model trained, live data can be applied to the model. If the results are not accurate, the model should be improved and retested.

Productionizing the model:
With the model tested and trained its released for production. This task is as simple as including the machine learning into the target software app or electronics product. Most machine learning models are deployed from the cloud.

What is Machine Learning?. . .

Machine Learning Applications



LIDAR: Laser Imaging Detecting And Ranging

What is Machine Learning?. . .

Machine Learning Applications

- Virtual Personal Assistants – Siri, Alex, and Google Now are trained based on questions being asked. Obtains data from storage clouds.
- Predictions while commuting – GPS navigation apps build maps using data. Example: Traffic predictions.
- Videos Surveillance – Possible to detect a crime before it happens using deviant behavior data patterns.
- Product Recommendations – Online stores capable of suggesting products based on shopping patterns data.
- Autonomous Vehicles – With the use of electronic sensors, and GPS navigation data, self driving cars can transverse roads from cities and highways without human drivers.

What is Classification?

Classification Models – Predicts the object membership based on characteristics grouping.

FAQs:

- The focus is on binary decision making.
- Prediction based on a true or false, yes or no 1 or 0 hierarchical format.
- Assigning a task of assigned objects from several predefined categories (Tan, Steinbach et al., 2016).
- Classifications uses Decision Trees to aid in attribute or event predictions.

Source:

Tan, P.N., Steinbach, M., & Kumar, V. (2016). Introduction to data mining. Retrieved from https://www-users.cs.umn.edu/~kumar001/dmbook/ch4.pdf

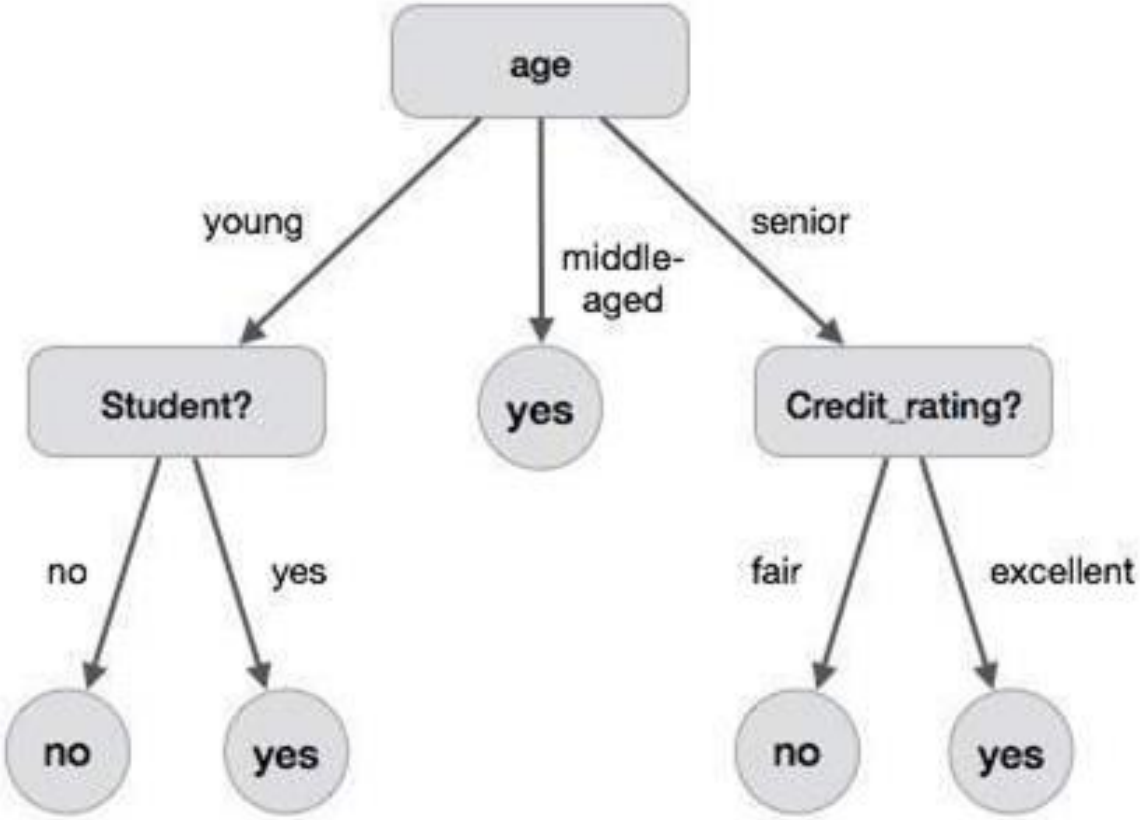
Question 2:

What are the five steps for the Machine Learning Workflow process?

What is Classification?. . .

Decision Tree Problem:

Determining the student's age and credit rating.



What is Classification?. . .

Decision Trees:

Decision trees used in data mining are of two main types:

- **Classification tree** analysis is when the predicted outcome is the class to which the data belongs.
- **Regression tree** analysis is when the predicted outcome can be considered a real number (e.g. the price of a house, or a patient's length of stay in a hospital).
- **Data mining** is the process of discovering patterns in large data sets involving methods at the intersection of machine learning, statistics, and database systems.

Source:

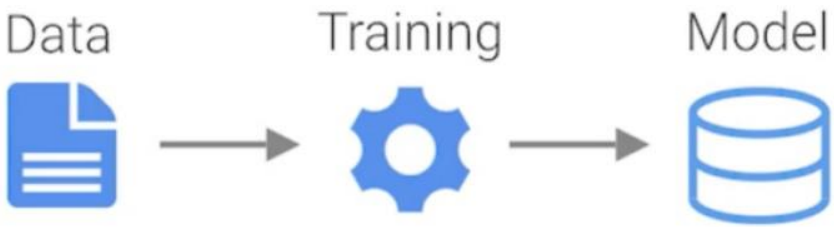
https://en.wikipedia.org/wiki/Decision_tree_learning#Decision_tree_types

What is Classification?. . .

Supervised learning: The output datasets are provided which are used to train the machine**. Classification Decision Trees** use supervised learning to predict outcomes of events or attributes. The key elements to classification is the training and prediction capabilities of the machine.

Training	Prediction
using	*answer*
data	*questions*

Data is the key



(Guo, 2017)

Source:

Guo, Y. (2017). What is machine learning?. Retrieved from https://towardsdatascience.com/what-is-machine-learning-8c6871016736

What is Classification?. . .

male_female_classifier.ipynb

File Edit View Insert Runtime Tools Help

CODE TEXT CELL CELL

```
from sklearn import tree

clf = tree.DecisionTreeClassifier()

# [height, weight, shoe_size]
X = [[181, 80, 44], [177, 70, 43], [160, 60, 38], [154, 54, 37], [166, 65, 40],
     [190, 90, 47], [175, 64, 39],
     [177, 70, 40], [159, 55, 37], [171, 75, 42], [181, 85, 43]]

Y = ['male', 'male', 'female', 'female', 'male', 'male', 'female', 'female',
     'female', 'male', 'male']


# train model with male and female data
clf = clf.fit(X, Y)

# make prediction with new data
prediction = clf.predict([[190, 70, 48]])

# print prediction
print(prediction)
```

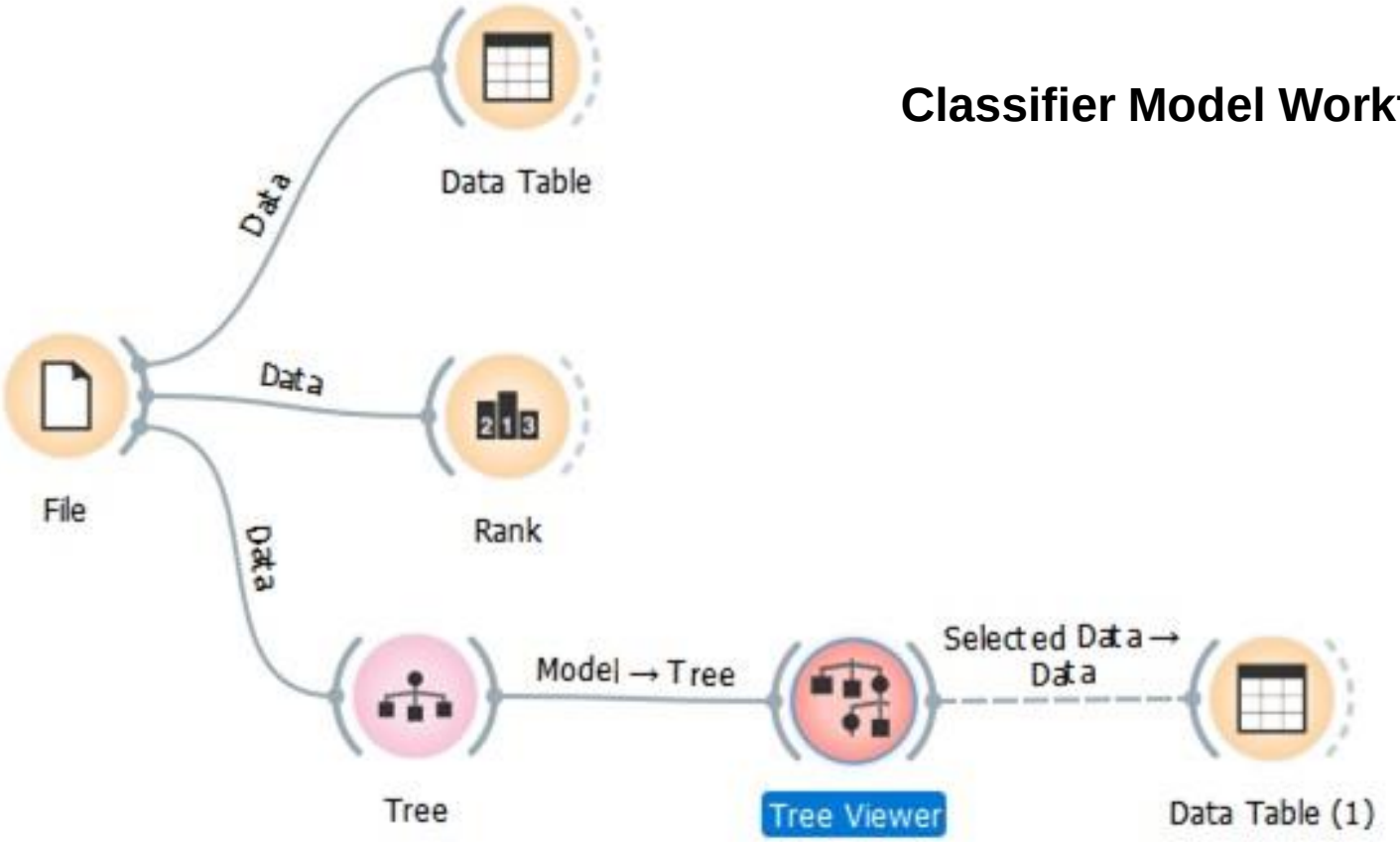
```
['male']
```

Question 3:

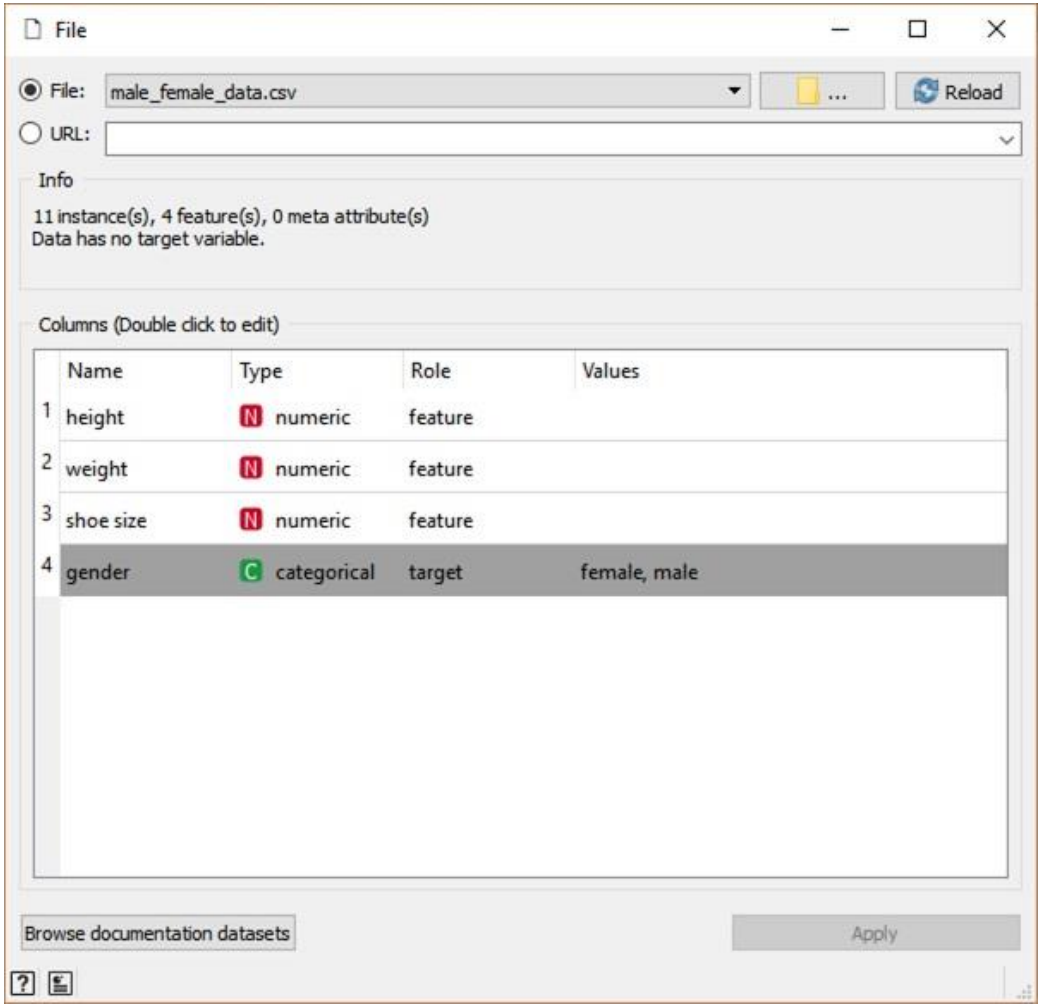
What is a Classification Model?

What is Classification?. . .

Classifier Model Workflow:



What is Classification?. . .



Formatting data file

What is Classification?. . .

Data Table

Info

11 instances (no missing values)
3 features (no missing values)
Discrete class with 2 values (no missing values)
No meta attributes

Variables

- [x] Show variable labels (if present)
- [ ] Visualize numeric values
- [x] Color by instance classes

Selection

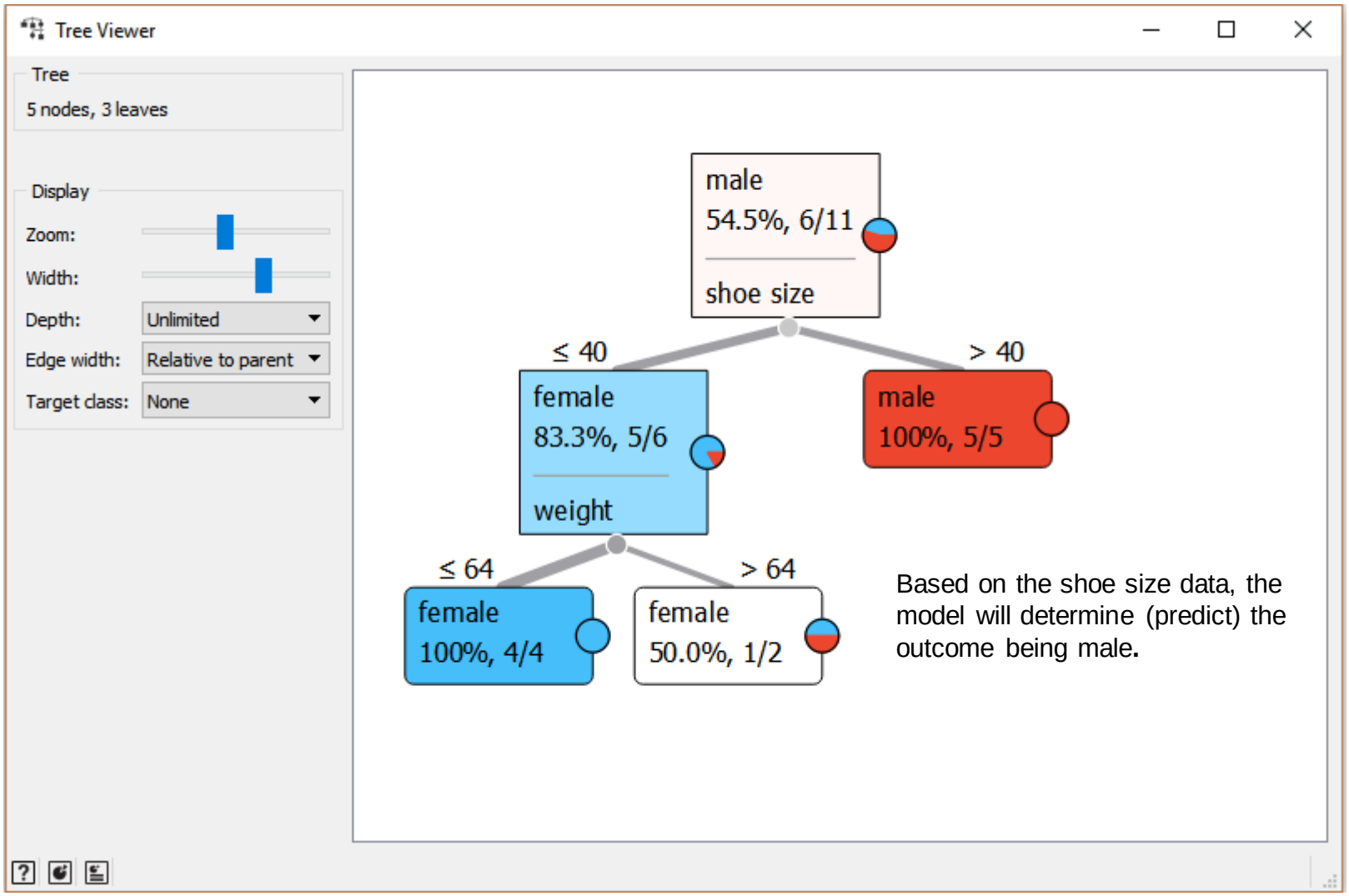
- [x] Select full rows

Restore Original Order

- [x] Send Automatically

	gender	height	weight	shoe size
1	male	181	80	44
2	male	177	70	43
3	female	160	60	38
4	female	154	54	37
5	male	166	65	40
6	male	190	90	47
7	female	175	64	39
8	female	171	70	40
9	female	159	55	37
10	male	171	75	42
11	male	181	85	43

What is Classification?. . .



Based on the shoe size data, the model will determine (predict) the outcome being male.

Lab Project: The MNIST Handwriting Recognition Training Model. . .

Lab Project Objectives:

a. Learn about the MNIST dataset.

b. Learn about tensors.

c. Learn how to run and analyze the MNIST Handwriting Recognition Training Model Tutorial in Colaboratory.

Lab Project: The MNIST Handwriting Recognition Training Model. . .

What is the MNIST database?

a. MNIST is the abbreviation for Modified National Institute of Standards and Technology database.

b. A large database of handwritten digits.

c. Commonly used for training various image processing systems.

d. Database is used for training and testing in the field of machine learning.

e. Database contains 60,000 training images and 10,000 testing images.

Source:

https://en.wikipedia.org/wiki/MNIST_database

Lab Project: The MNIST Handwriting Recognition Training Model. . .

What is the MNIST database?

Sample images from MNIST test dataset.

Source:

https://en.wikipedia.org/wiki/MNIST_database

Lab Project: The MNIST Handwriting Recognition Training Model…

What is the MNIST Database?

a.A combination of two NIST's databases:

i. Special database 1 and Special database 3

b.The database of consists digits written by high school students and employees of the United States Census Bureau.

c.Special database 1 is for high school students.

d.Special database 3 is for United State Census Bureau.

e.A variety of classifiers where used for training methods of the machine learning model.

Lab Project: The MNIST Handwriting Recognition Training Model. . .

What is a Tensor?

a.Are geometric objects that describes linear relations between

- i. vectors
- ii. scalars
- iii. matrices

b.Example relations include:

- i. dot product
- ii. cross product
- iii. linear maps
- iv. geometric vectors

Question 4:

What Orange widget is used to display or view a decision tree?

Lab Project: The MNIST Handwriting Recognition Training Model. . .

What is a Tensor?

- A **scalar** is a number, like **3, -5, 0.368, etc,**
- A **vector** is a **list** of numbers (can be in a row or column),
- A **matrix** is an **array** of numbers (one or more rows, one or more columns).

Scalar

24

Vector

$\begin{bmatrix} 2 & -8 & 7 \end{bmatrix}$ row

or column $\begin{bmatrix} 2 \\ -8 \\ 7 \end{bmatrix}$

Matrix

$\begin{bmatrix} 6 & 4 & 24 \\ 1 & -9 & 8 \end{bmatrix}$

row(s) × column(s)

Source:

https://www.mathsisfun.com/algebra/scalar-vector-matrix.html

Lab Project: The MNIST Handwriting Recognition Training Model. . .

What is TensorFlow?

a.A framework to define and run computations involving **tensors**.

b. An open source library for high performance numerical computation.

c.A flexible architecture that allows easy deployment of computation across a variety of hardware platforms.

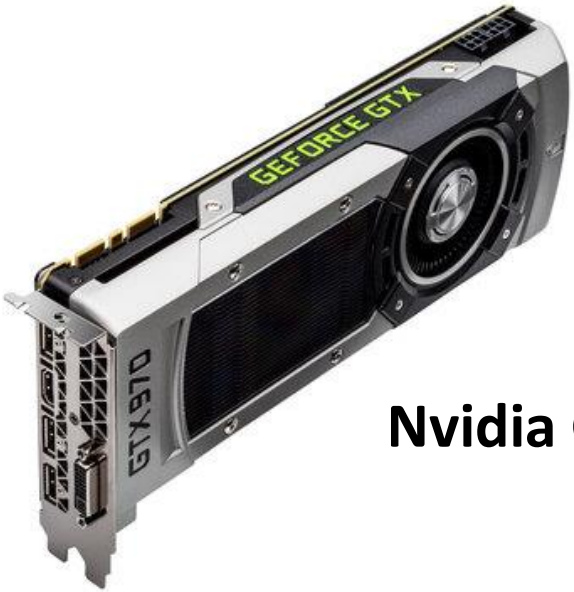
i. Central Processing Units (CPUs)

ii. Graphics Processing Units (GPUs)

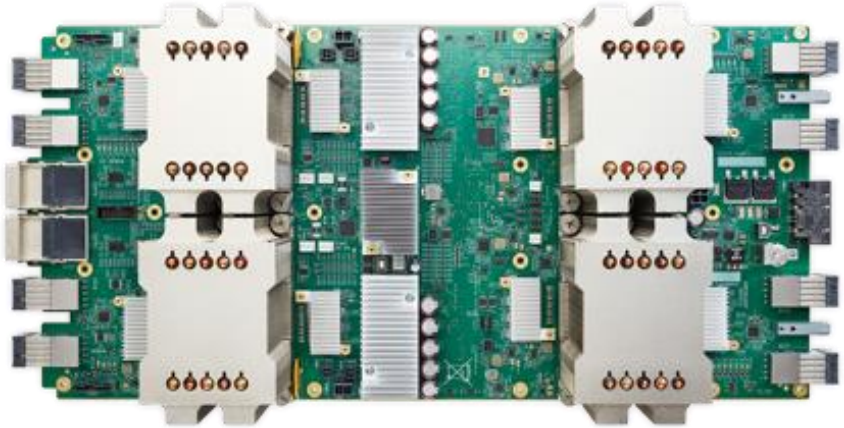
iii. Tensor Processor Units (TPUs)

Lab Project: The MNIST Handwriting Recognition Training Model. . .

CPU



Nvidia GPU



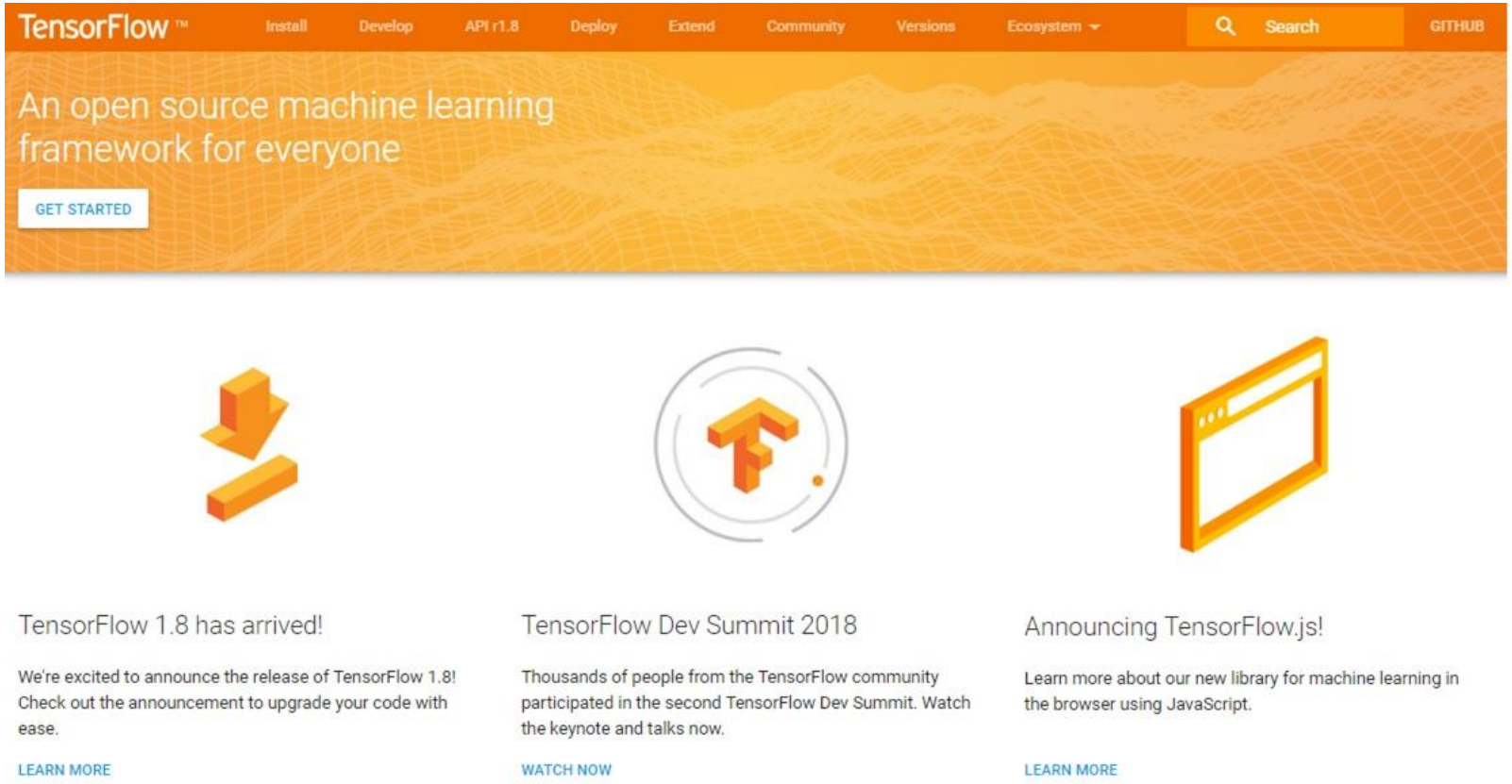
Google Cloud TPU

Question 5:

What three ways can a tensor be represented?

Lab Project: The MNIST Handwriting Recognition Training Model. . .

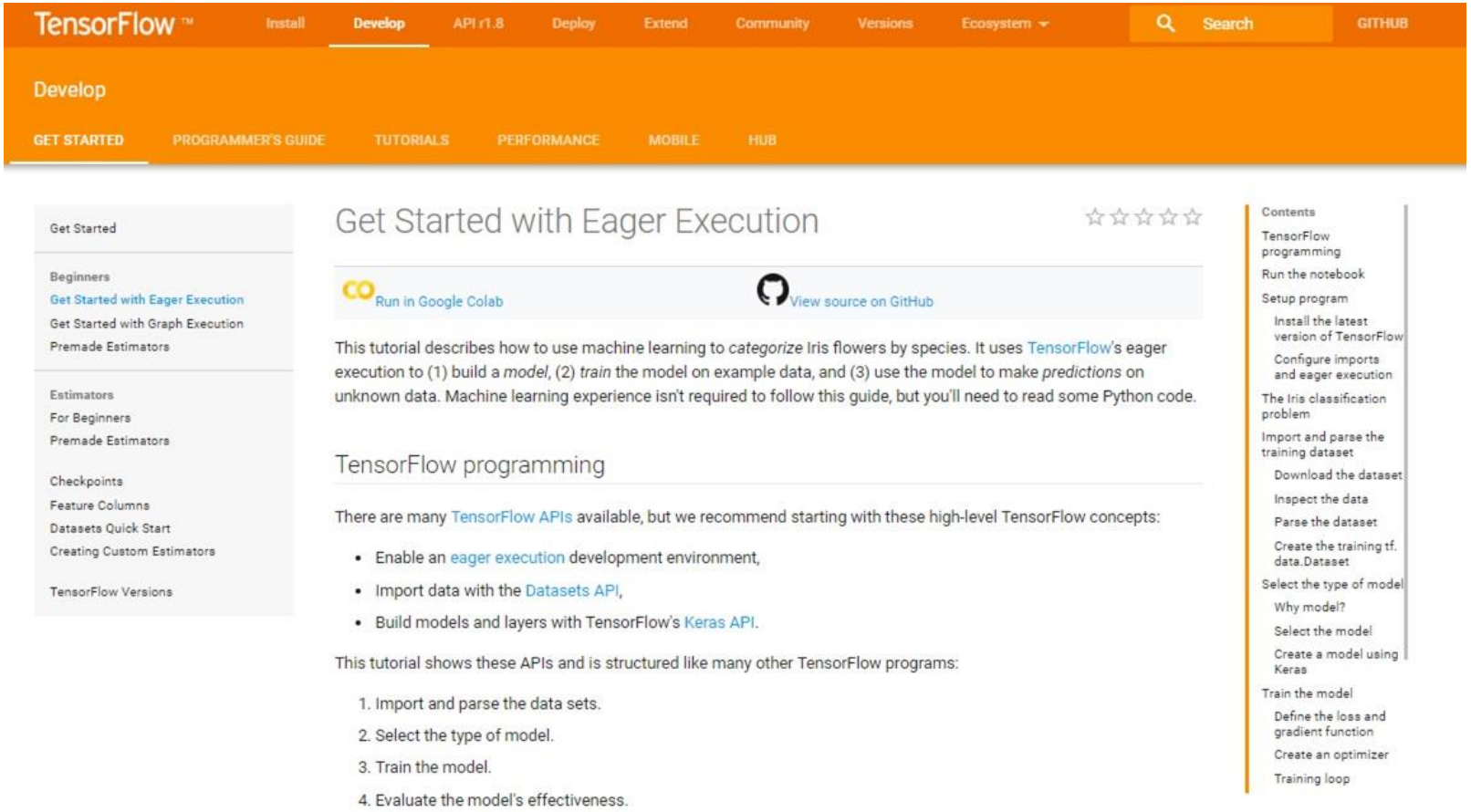
TensorFlow web page



Source:
https://www.tensorflow.org/

Lab Project: The MNIST Handwriting Recognition Training Model. . .

Getting Started web page



Source:
https://www.tensorflow.org/get_started/eager

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Getting access to MNIST Tutorial

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Vector Representations of Words
Kernel Methods

Non-ML
Mandelbrot Set
Partial Differential Equations

TensorFlow Versions

A Guide to TF Layers: Building a Convolutional Neural Network

The TensorFlow `layers` module provides a high-level API that makes it easy to construct a neural network. It provides methods that facilitate the creation of dense (fully connected) layers and convolutional layers, adding activation functions, and applying dropout regularization. In this tutorial, you'll learn how to use `layers` to build a convolutional neural network model to recognize the handwritten digits in the MNIST data set.

Convolutional Neural Network using classification for handwriting recognition imaging.

The MNIST dataset comprises 60,000 training examples and 10,000 test examples of the handwritten digits 0–9, formatted as 28x28-pixel monochrome images.

Getting Started

Let's set up the skeleton for our TensorFlow program. Create a file called `cnn_mnist.py`, and add the following code:

```
from __future__ import absolute_import
from __future__ import division
from __future__ import print_function

# Imports
import numpy as np
import tensorflow as tf
```

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Getting Started
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Pooling Layer #1
Convolutional Layer #2 and Pooling Layer #2
Dense Layer
Logits Layer
Generate Predictions
Calculate Loss
Configure the Training Op
Add evaluation metrics
Training and Evaluating the CNN MNIST Classifier
Load Training and Test Data
Create the Estimator
Set Up a Logging Hook

Source:
https://www.tensorflow.org/tutorials/layers

Lab Project: The MNIST Handwriting Recognition Training Model. . .

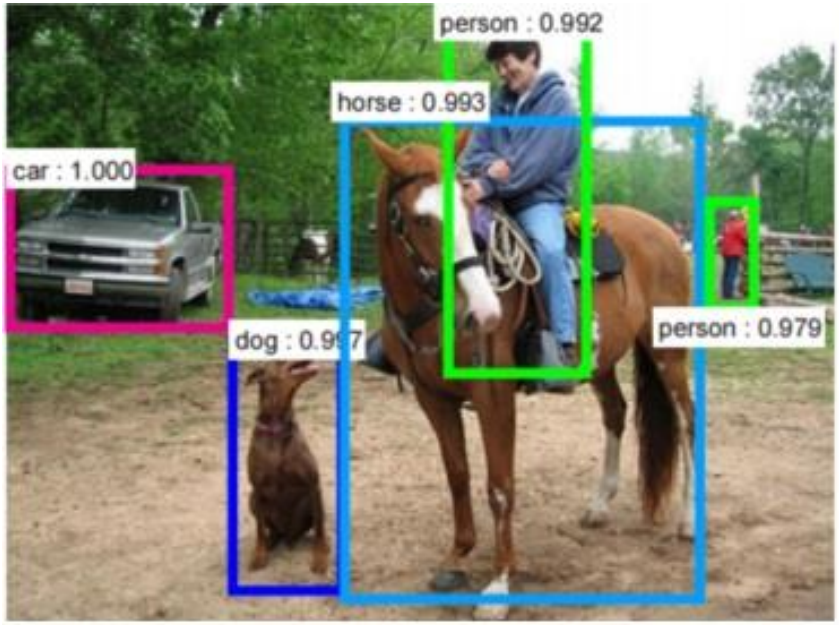
"Convolutional Neural Networks (ConvNets or CNNs) are a category of Neural Networks that have proven very effective in areas such as image recognition an classification. ConNets have been successful in identifying faces, objects and traffic signs apart from powering vision in robots and self driving cars" (ujjwalkarn, 2017).

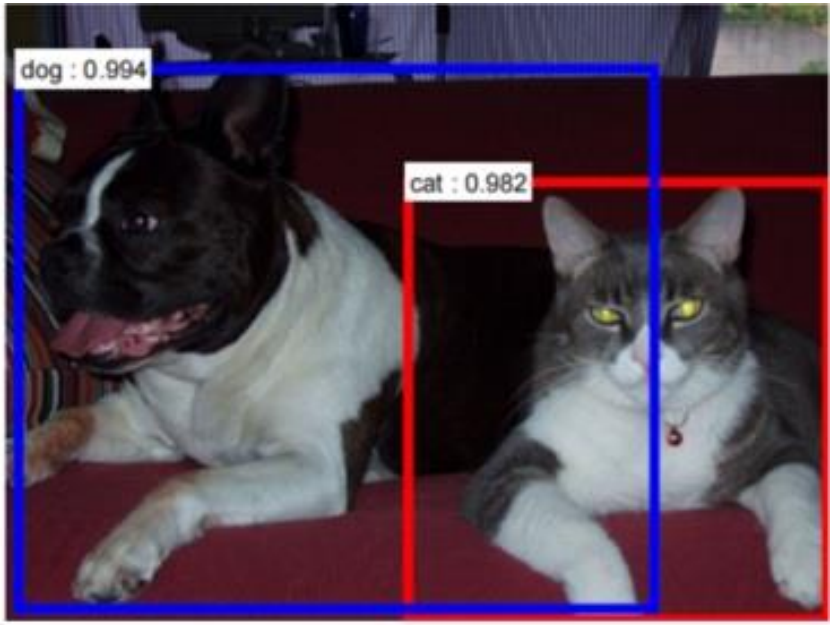
Source:

ujjwalkarn.(2017). What are convolutional neural networks and why are they important? Retrieved from https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Lab Project: The MNIST Handwriting Recognition Training Model. . .

ConvNets Examples





Source:

ujjwalkarn.(2017). What are convolutional neural networks and why are they important? Retrieved from https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Lab Project: The MNIST Handwriting Recognition Training Model. . .

Getting access to code

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from __future__ import absolute_import
from __future__ import division
from __future__ import print_function

# Imports
import numpy as np
import tensorflow as tf

tf.logging.set_verbosity(tf.logging.INFO)

# Our application logic will be added here

if __name__ == "__main__":
  tf.app.run()
```

As you work through the tutorial, you'll add code to construct, train, and evaluate the convolutional neural network. The complete final code can be found here.

Click here

Intro to Convolutional Neural Networks

Convolutional neural networks (CNNs) are the current state-of-the-art model architecture for image classification tasks.

Contents
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Load Training and Test Data
Create the Estimator

Source:
https://www.tensorflow.org/tutorials/layers

Lab Project: The MNIST Handwriting Recognition Training Model. . .

Getting access to cnn_mnist.py code

tensorflow / tensorflow

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Branch: r1.8 ▾ tensorflow / tensorflow / examples / tutorials / layers / cnn_mnist.py

Find file | Copy path

MarkDaoust Use sparse loss to avoid the warning being thrown by tf.nn.softmax_cr... b1c3222 on Dec 7, 2017

5 contributors

160 lines (134 sloc) | 5.58 KB

Raw | Blame | History

```
1  # Copyright 2016 The TensorFlow Authors. All Rights Reserved.
2  #
3  # Licensed under the Apache License, Version 2.0 (the "License");
4  # you may not use this file except in compliance with the License.
5  # You may obtain a copy of the License at
6  #
7  #  http://www.apache.org/licenses/LICENSE-2.0
```

Source:
https://github.com/tensorflow/tensorflow/blob/r1.8/tensorflow/examples/tutorials/layers/cnn_mnist.py

Lab Project: The MNIST Handwriting Recognition Training Model. . .

Past cnn_mnist.py code to Colaboratory Python 3 Notebook

cnn_mnist.ipynb

File Edit View Insert Runtime Tools Help

CODE TEXT CELL CELL

```
#  Copyright 2016 The TensorFlow Authors. All Rights Reserved.
#
#  Licensed under the Apache License, Version 2.0 (the "License");
#  you may not use this file except in compliance with the License.
#  You may obtain a copy of the License at
#
#   http://www.apache.org/licenses/LICENSE-2.0
#
#  Unless required by applicable law or agreed to in writing, software
#  distributed under the License is distributed on an "AS IS" BASIS,
#  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
#  See the License for the specific language governing permissions and
#  limitations under the License.
"""Convolutional Neural Network Estimator for MNIST, built with tf.layers."""

from __future__ import absolute_import
from __future__ import division
from __future__ import print_function

import numpy as np
import tensorflow as tf

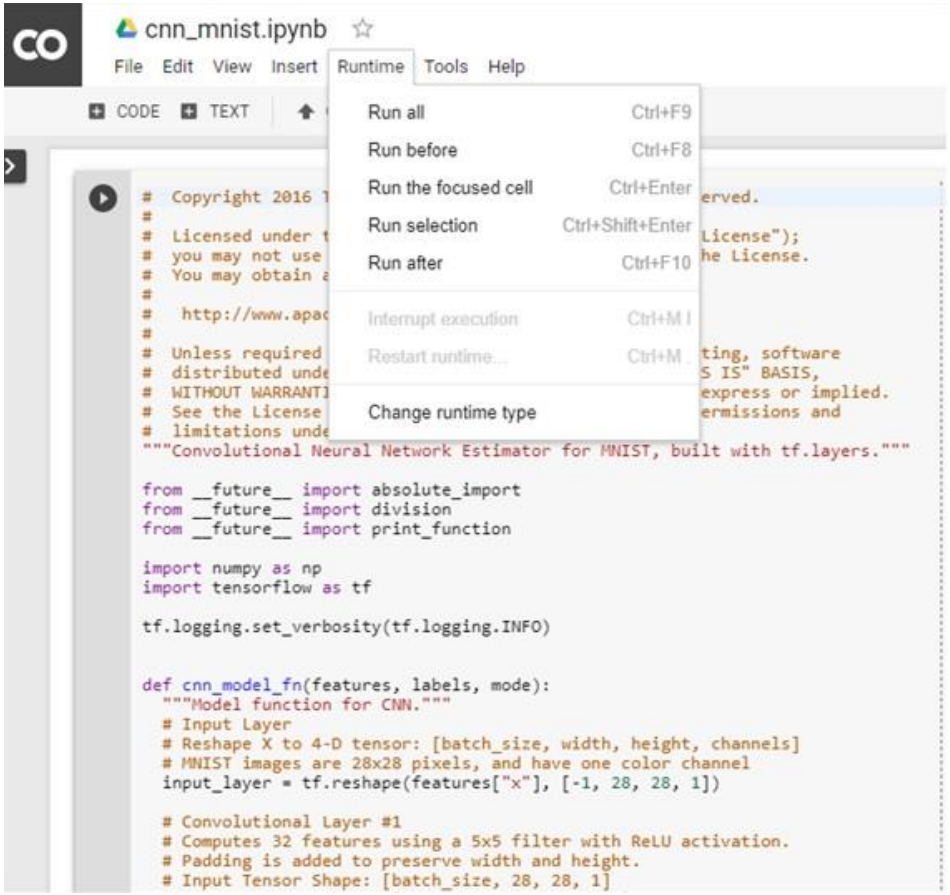
tf.logging.set_verbosity(tf.logging.INFO)

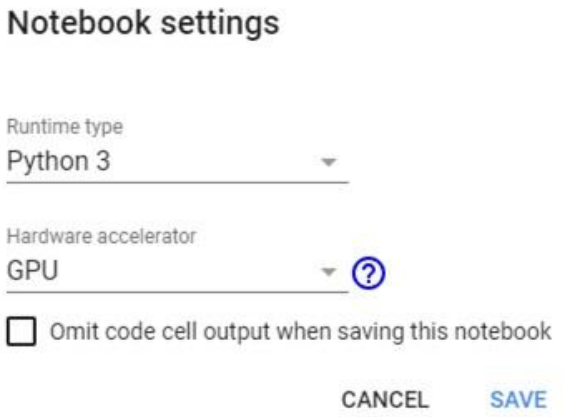

def cnn_model_fn(features, labels, mode):
  """Model function for CNN."""
  # Input Layer
  # Reshape X to 4-D tensor: [batch_size, width, height, channels]
  # MNIST images are 28x28 pixels, and have one color channel
  input_layer = tf.reshape(features["x"], [-1, 28, 28, 1])

  # Convolutional Layer #1
  # Computes 32 features using a 5x5 filter with ReLU activation.
  # Padding is added to preserve width and height.
  # Input Tensor Shape: [batch_size, 28, 28, 1]
```

Lab Project: The MNIST Handwriting Recognition Training Model. . .

Setting up GPU accelerator in Colaboratory





Question 6:

CNN is the abbreviation for what learning network?

Lab Project: The MNIST Handwriting Recognition Training Model. . .

cnn_mnist.py model execution in Colaboratory

```
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Saving checkpoints for 0 into /tmp/mnist_convnet_model/model.ckpt.
INFO:tensorflow:probabilities = [[0.1066287  0.10955735 0.09914126 0.10538703 0.08441452 0.09878851
  0.0944709  0.10377745 0.09739114 0.10044319]
 [0.11355278 0.10299338 0.11910446 0.10840292 0.09291752 0.0855775
  0.11543529 0.09210476 0.08986214 0.08004922]
 [0.09947766 0.09893823 0.12037378 0.09706676 0.10363767 0.09726461
  0.09274231 0.10032655 0.09706403 0.09310838]
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  0.08931969 0.10550156 0.10997788 0.08018147]
 [0.10256396 0.10188145 0.10524397 0.10076568 0.09899912 0.08570551
  0.10031036 0.10967723 0.10784163 0.0870111 ]
 [0.10486739 0.10353167 0.11136277 0.09224382 0.10399847 0.09699368
  0.0929009  0.10217349 0.09773475 0.09419312]
 [0.09833891 0.10148518 0.11815596 0.1029433  0.09473046 0.09467994
  0.09519491 0.10257208 0.09606482 0.09583447]
 [0.11254442 0.10387653 0.11105592 0.09954738 0.093248   0.11201217
  0.09125062 0.09444547 0.09863495 0.08338456]
 [0.09822995 0.10594261 0.11880096 0.09246188 0.08720967 0.0920168
  0.11006038 0.10693932 0.08384804 0.10449035]
 [0.09782036 0.10665842 0.11286556 0.10899431 0.09256672 0.09355388
  0.09687366 0.10113562 0.10588426 0.08364727]
```

Lab Project: The MNIST Handwriting Recognition Training Model. . .

cnn_mnist.py model final results in Colaboratory

As the model trains, you'll see log output like the following:

```
INFO:tensorflow:loss = 2.36026, step = 1
INFO:tensorflow:probabilities = [[ 0.07722801  0.08618255  0.09256398, ...]]
...
INFO:tensorflow:loss = 2.13119, step = 101
INFO:tensorflow:global_step/sec: 5.44132
...
INFO:tensorflow:Loss for final step: 0.553216.

INFO:tensorflow:Restored model from /tmp/mnist_convnet_model
INFO:tensorflow:Eval steps [0,inf) for training step 20000.
INFO:tensorflow:Input iterator is exhausted.
INFO:tensorflow:Saving evaluation summary for step 20000: accuracy = 0.9733, loss = 0.0902271
{'loss': 0.090227105, 'global_step': 20000, 'accuracy': 0.97329998}
```

Here, we've achieved an accuracy of 97.3% on our test data set.

Note:
Depending on machine processor, final training and prediction results may take up to an hour.