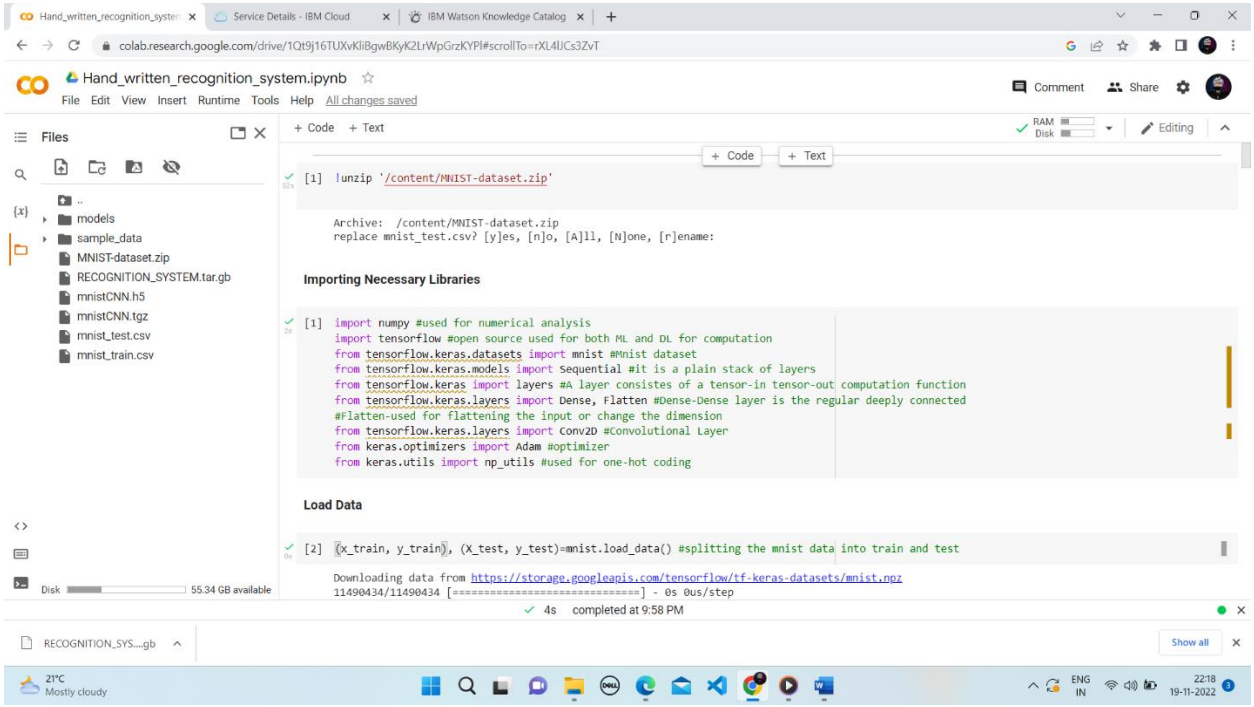
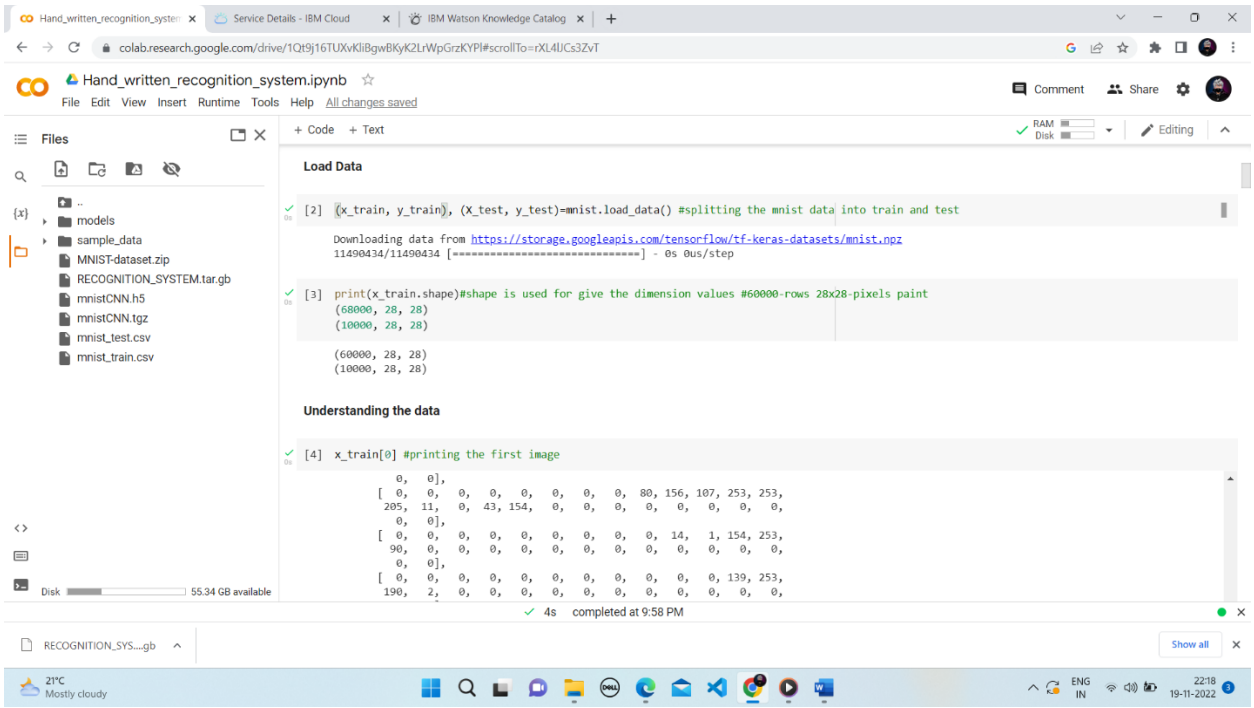
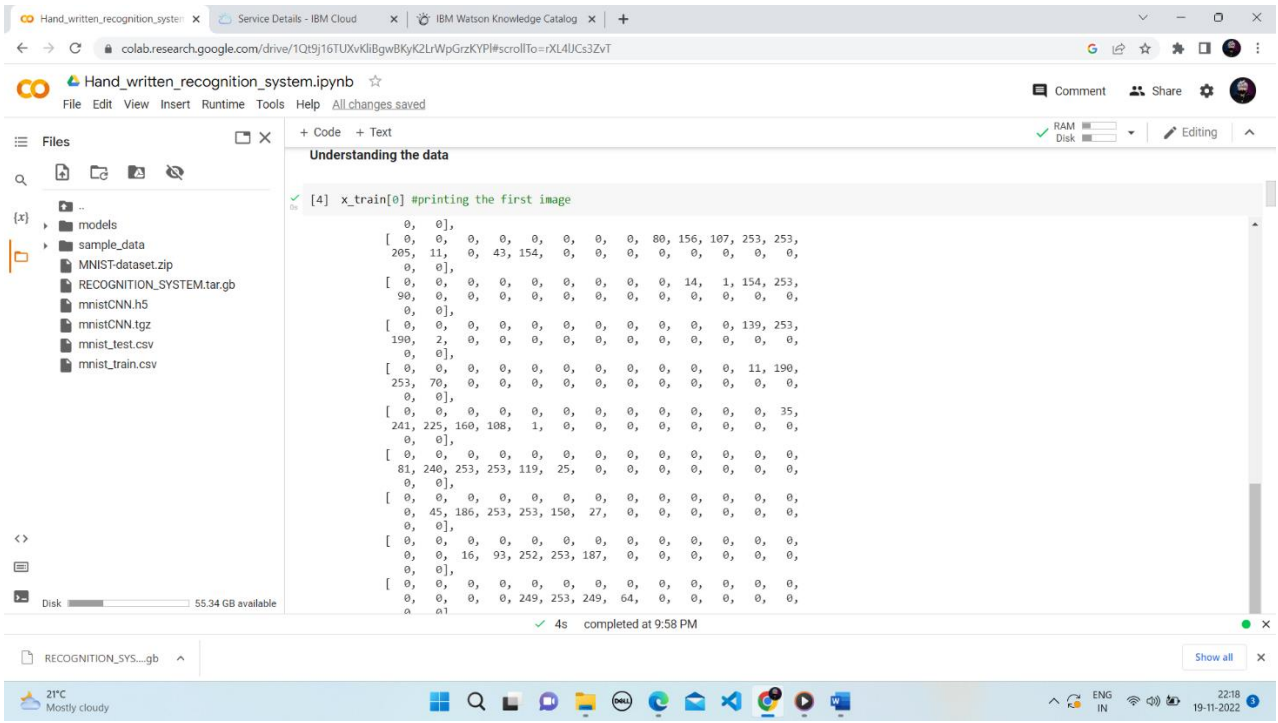
Project Development Phase
Sprint-4

Date	19 November 2022
Team ID	PNT2022TMID40411
Project Name	A Novel Method for Handwritten Digit Recognition System






Hand_written_recognition_system.ipynb
File Edit View Insert Runtime Tools Help All changes saved
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Files
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Editing
Understanding the data
[4] x_train[0] #printing the first image
models
sample_data
MNIST-dataset.zip
RECOGNITION_SYSTEM.tar.gb
mnistCNN.h5
mnistCNN.tgz
mnist_test.csv
mnist_train.csv
Disk 55.34 GB available
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RECOGNITION_SYS....gb
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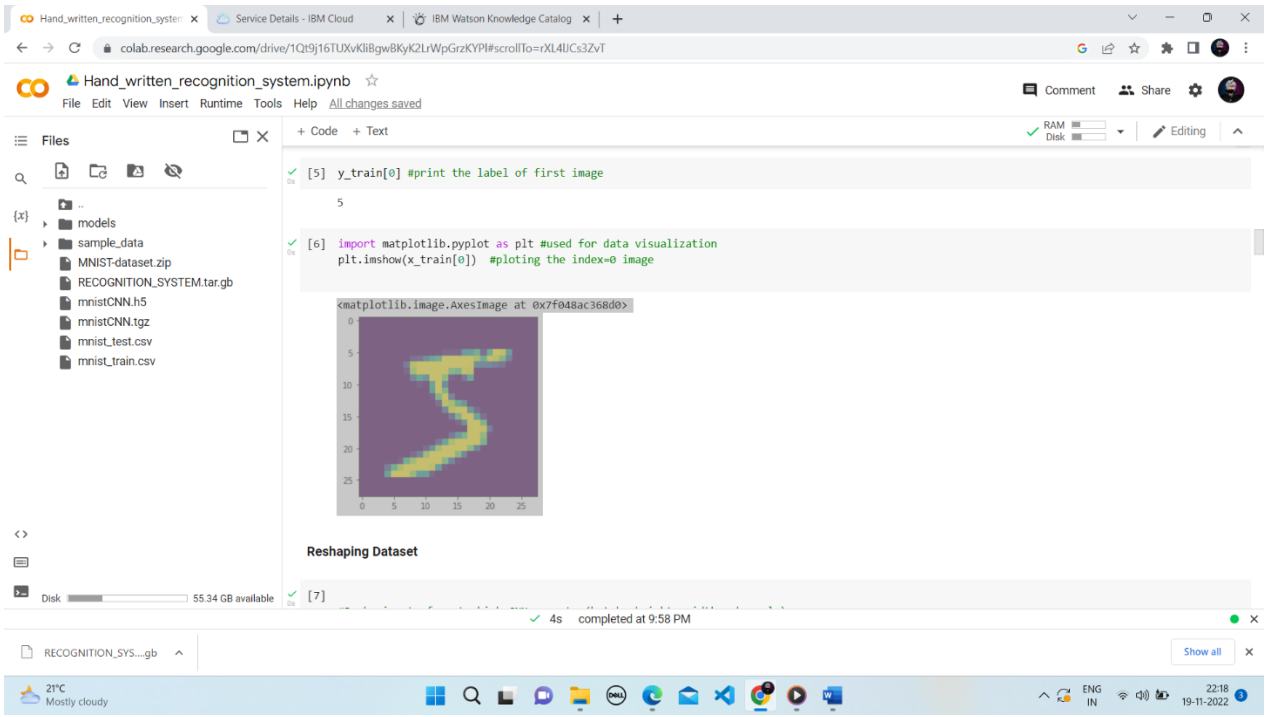
ENG IN
22:18 19-11-2022


Hand_written_recognition_system.ipynb
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Editing
[5] y_train[0] #print the label of first image
5
[6] import matplotlib.pyplot as plt #used for data visualization
plt.imshow(x_train[0]) #ploting the index=0 image
<matplotlib.image.AxesImage at 0x7f048ac368d0>
Reshaping Dataset
[7]
models
sample_data
MNIST-dataset.zip
RECOGNITION_SYSTEM.tar.gb
mnistCNN.h5
mnistCNN.tgz
mnist_test.csv
mnist_train.csv
Disk 55.34 GB available
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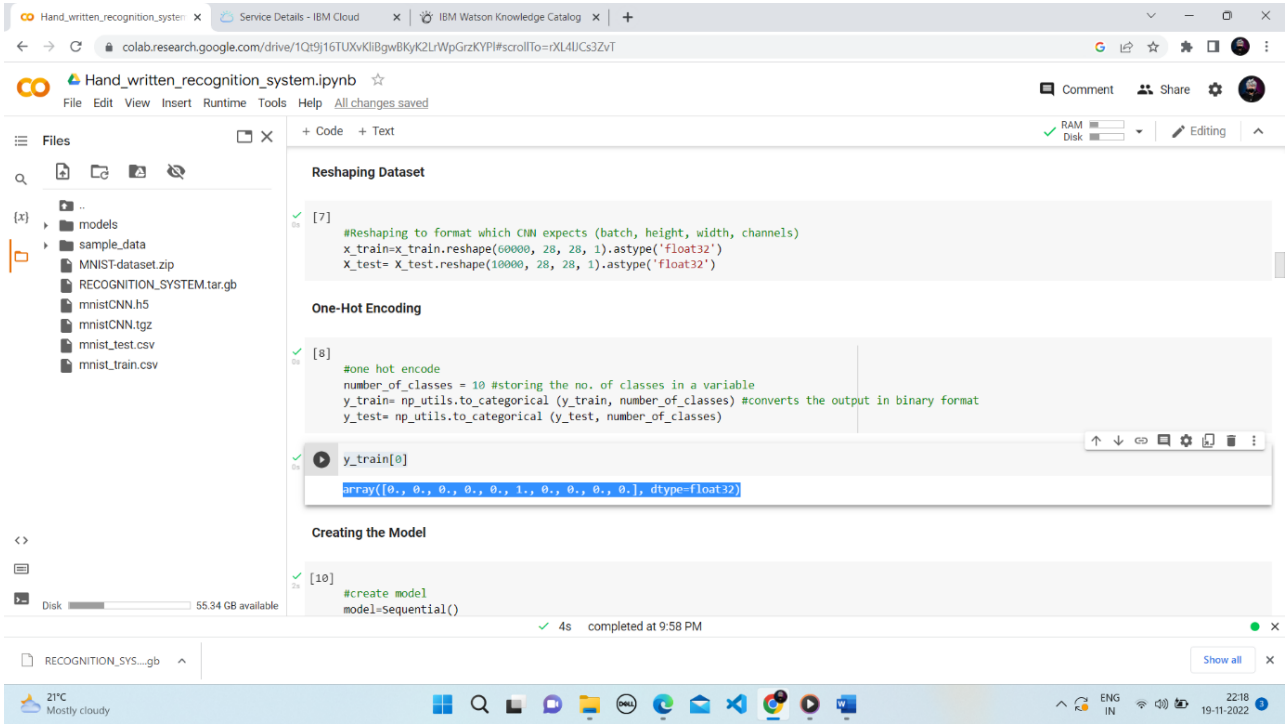
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models
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mnistCNN.tgz
mnist_test.csv
mnist_train.csv
Reshaping Dataset
[7]
#Reshaping to format which CNN expects (batch, height, width, channels)
x_train=x_train.reshape(60000, 28, 28, 1).astype('float32')
X_test= X_test.reshape(10000, 28, 28, 1).astype('float32')
One-Hot Encoding
[8]
#one hot encode
number_of_classes = 10 #storing the no. of classes in a variable
y_train= np_utils.to_categorical (y_train, number_of_classes) #converts the output in binary format
y_test= np_utils.to_categorical (y_test, number_of_classes)
y_train[0]
array([0., 0., 0., 0., 0., 1., 0., 0., 0., 0.], dtype=float32)
Creating the Model
[10]
#create model
model=Sequential()
Disk 55.34 GB available
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RECOGNITION_SYS....gb
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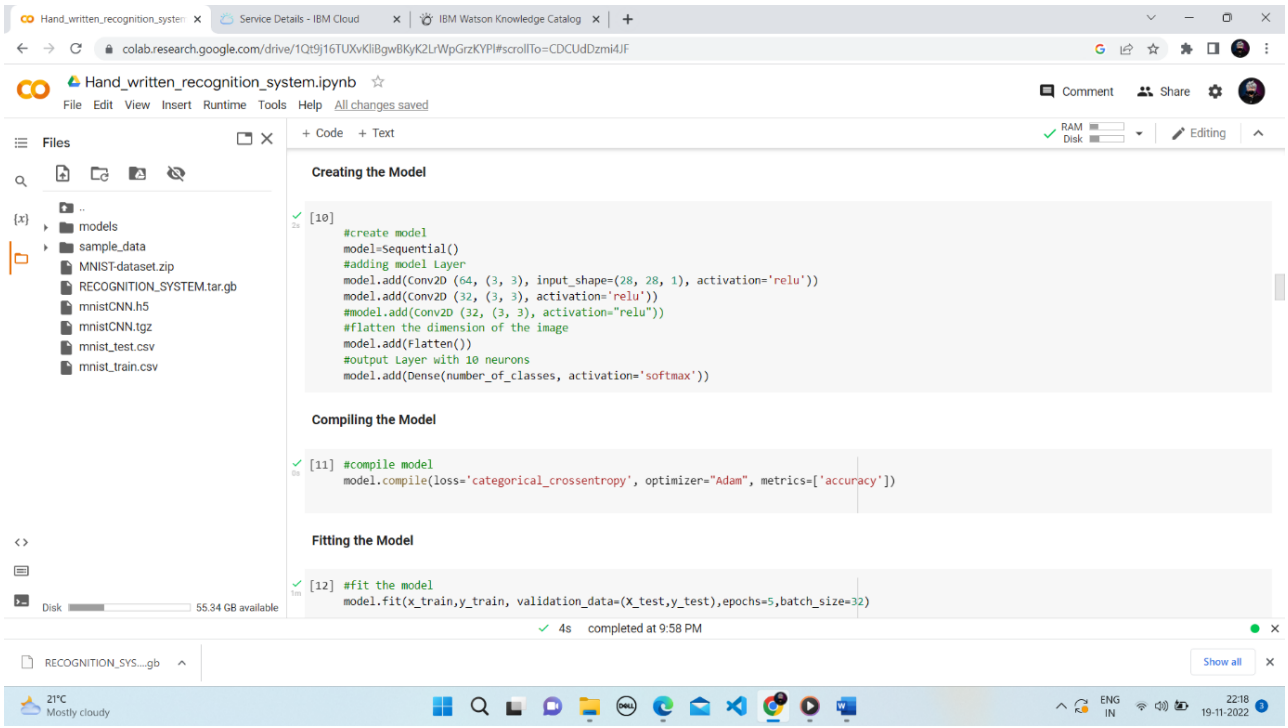
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MNIST-dataset.zip
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mnistCNN.tgz
mnist_test.csv
mnist_train.csv
Creating the Model
[10]
#create model
model=Sequential()
#adding model Layer
model.add(Conv2D (64, (3, 3), input_shape=(28, 28, 1), activation='relu'))
model.add(Conv2D (32, (3, 3), activation='relu'))
#model.add(Conv2D (32, (3, 3), activation="relu"))
#flatten the dimension of the image
model.add(Flatten())
#output Layer with 10 neurons
model.add(Dense(number_of_classes, activation='softmax'))
Compiling the Model
[11] #compile model
model.compile(loss='categorical_crossentropy', optimizer="Adam", metrics=['accuracy'])
Fitting the Model
[12] #fit the model
model.fit(x_train,y_train, validation_data=(X_test,y_test),epochs=5,batch_size=32)
Disk 55.34 GB available
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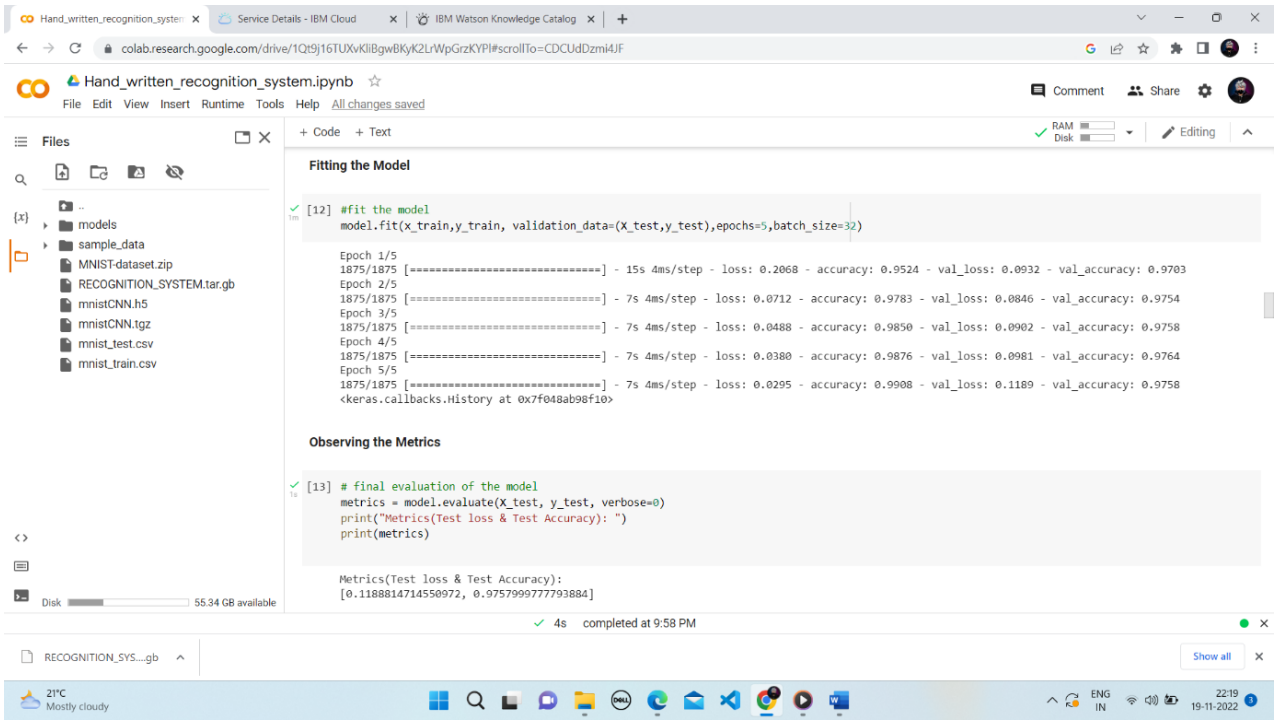
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Fitting the Model
[12] #fit the model
model.fit(x_train,y_train, validation_data=(X_test,y_test),epochs=5,batch_size=32)
Epoch 1/5
1875/1875 [==============================] - 15s 4ms/step - loss: 0.2068 - accuracy: 0.9524 - val_loss: 0.0932 - val_accuracy: 0.9703
Epoch 2/5
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0712 - accuracy: 0.9783 - val_loss: 0.0846 - val_accuracy: 0.9754
Epoch 3/5
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0488 - accuracy: 0.9850 - val_loss: 0.0902 - val_accuracy: 0.9758
Epoch 4/5
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0380 - accuracy: 0.9876 - val_loss: 0.0981 - val_accuracy: 0.9764
Epoch 5/5
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0295 - accuracy: 0.9908 - val_loss: 0.1189 - val_accuracy: 0.9758
<keras.callbacks.History at 0x7f048ab98f10>
Observing the Metrics
[13] # final evaluation of the model
metrics = model.evaluate(X_test, y_test, verbose=0)
print("Metrics(Test loss & Test Accuracy): ")
print(metrics)
Metrics(Test loss & Test Accuracy):
[0.1188814714550972, 0.9757999777793884]
4s completed at 9:58 PM
RECOGNITION_SYS....gb
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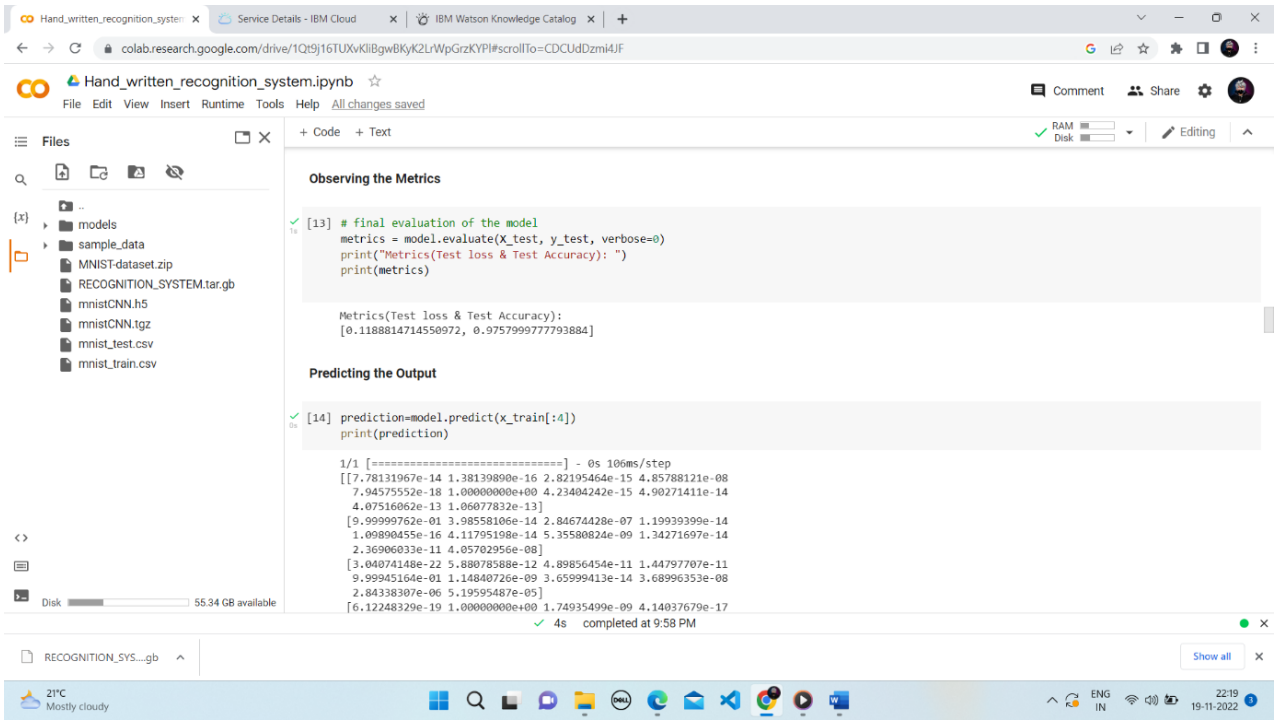
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print("Metrics(Test loss & Test Accuracy): ")
print(metrics)
Metrics(Test loss & Test Accuracy):
[0.1188814714550972, 0.9757999777793884]
Predicting the Output
[14] prediction=model.predict(x_train[:4])
print(prediction)
1/1 [==============================] - 0s 106ms/step
[[7.78131967e-14 1.38139890e-16 2.82195464e-15 4.85788121e-08
7.94575552e-18 1.00000000e+00 4.23404242e-15 4.90271411e-14
4.07516062e-13 1.06077832e-13]
[9.99999762e-01 3.98558106e-14 2.84674428e-07 1.19939399e-14
1.09890455e-16 4.11795198e-14 5.35580824e-09 1.34271697e-14
2.36906033e-11 4.05702956e-08]
[3.04074148e-22 5.88078588e-12 4.89856454e-11 1.44797707e-11
9.99945164e-01 1.14840726e-09 3.65999413e-14 3.68996353e-08
2.84338307e-06 5.19595487e-05]
[6.12248329e-19 1.00000000e+00 1.74935499e-09 4.14037679e-17
4s completed at 9:58 PM
RECOGNITION_SYS....gb
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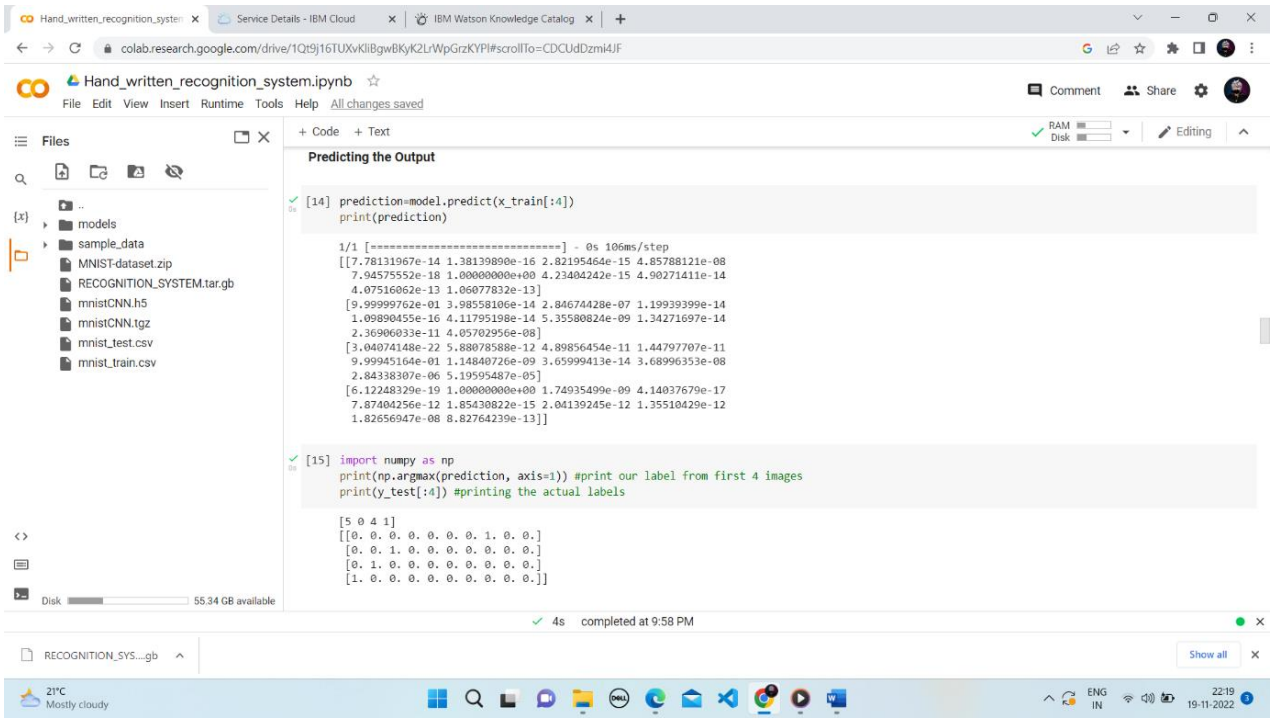
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Predicting the Output
[14] prediction=model.predict(x_train[:4])
print(prediction)
1/1 [==============================] - 0s 106ms/step
[[7.78131967e-14 1.38139890e-16 2.82195464e-15 4.85788121e-08
7.94575552e-18 1.00000000e+00 4.23404242e-15 4.90271411e-14
4.07516062e-13 1.06077832e-13]
[9.99999762e-01 3.98558106e-14 2.84674428e-07 1.19939399e-14
1.09890455e-16 4.11795198e-14 5.35580824e-09 1.34271697e-14
2.36906033e-11 4.05702956e-08]
[3.04074148e-22 5.88078588e-12 4.89856454e-11 1.44797707e-11
9.99945164e-01 1.14840726e-09 3.65999413e-14 3.68996353e-08
2.84338307e-06 5.19595487e-05]
[6.12248329e-19 1.00000000e+00 1.74935499e-09 4.14037679e-17
7.87404256e-12 1.85430822e-15 2.04139245e-12 1.35510429e-12
1.82656947e-08 8.82764239e-13]]
[15] import numpy as np
print(np.argmax(prediction, axis=1)) #print our label from first 4 images
print(y_test[:4]) #printing the actual labels
[5 0 4 1]
[[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
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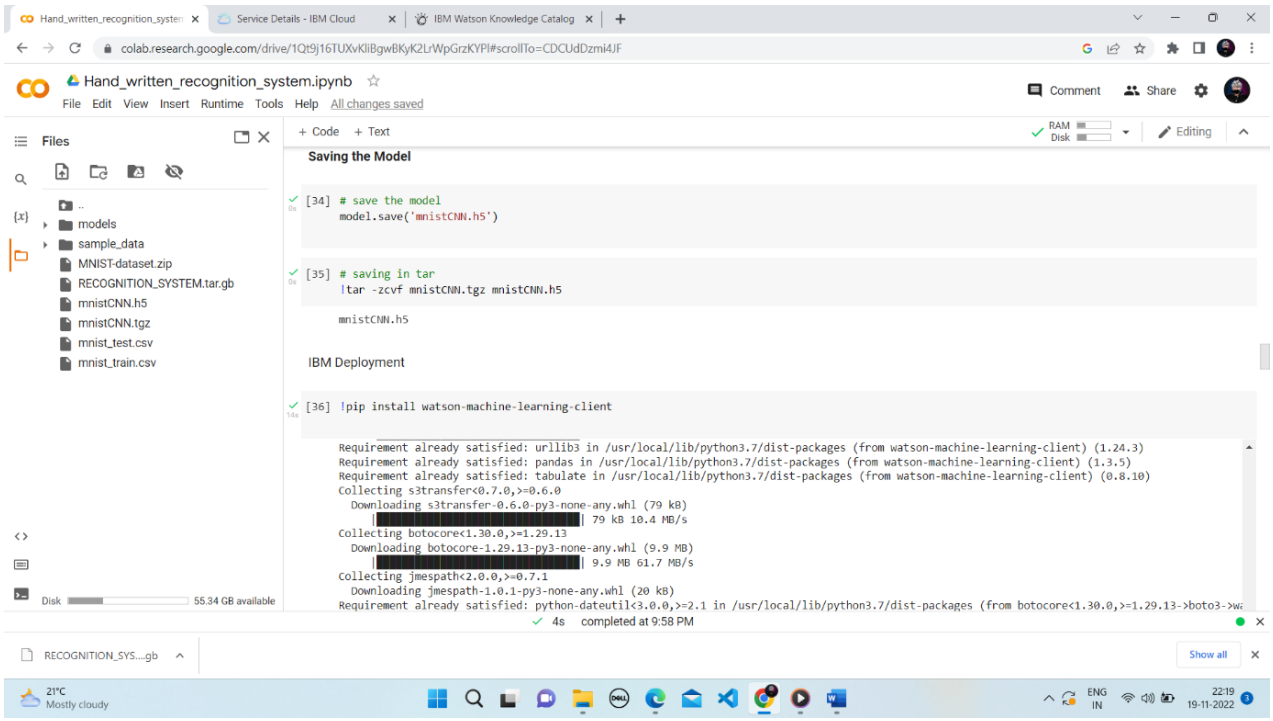
Hand_written_recognition_system.ipynb
File Edit View Insert Runtime Tools Help All changes saved
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Files
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Editing
Saving the Model
[34] # save the model
model.save('mnistCNN.h5')
[35] # saving in tar
!tar -zcvf mnistCNN.tgz mnistCNN.h5
mnistCNN.h5
IBM Deployment
[36] !pip install watson-machine-learning-client
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages (from watson-machine-learning-client) (1.24.3)
Requirement already satisfied: pandas in /usr/local/lib/python3.7/dist-packages (from watson-machine-learning-client) (1.3.5)
Requirement already satisfied: tabulate in /usr/local/lib/python3.7/dist-packages (from watson-machine-learning-client) (0.8.10)
Collecting s3transfer<0.7.0,>=0.6.0
Downloading s3transfer-0.6.0-py3-none-any.whl (79 kB)
79 kB 10.4 MB/s
Collecting botocore<1.30.0,>=1.29.13
Downloading botocore-1.29.13-py3-none-any.whl (9.9 MB)
9.9 MB 61.7 MB/s
Collecting jmespath<2.0.0,>=0.7.1
Downloading jmespath-1.0.1-py3-none-any.whl (20 kB)
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /usr/local/lib/python3.7/dist-packages (from botocore<1.30.0,>=1.29.13->boto3->wa
Disk 55.34 GB available
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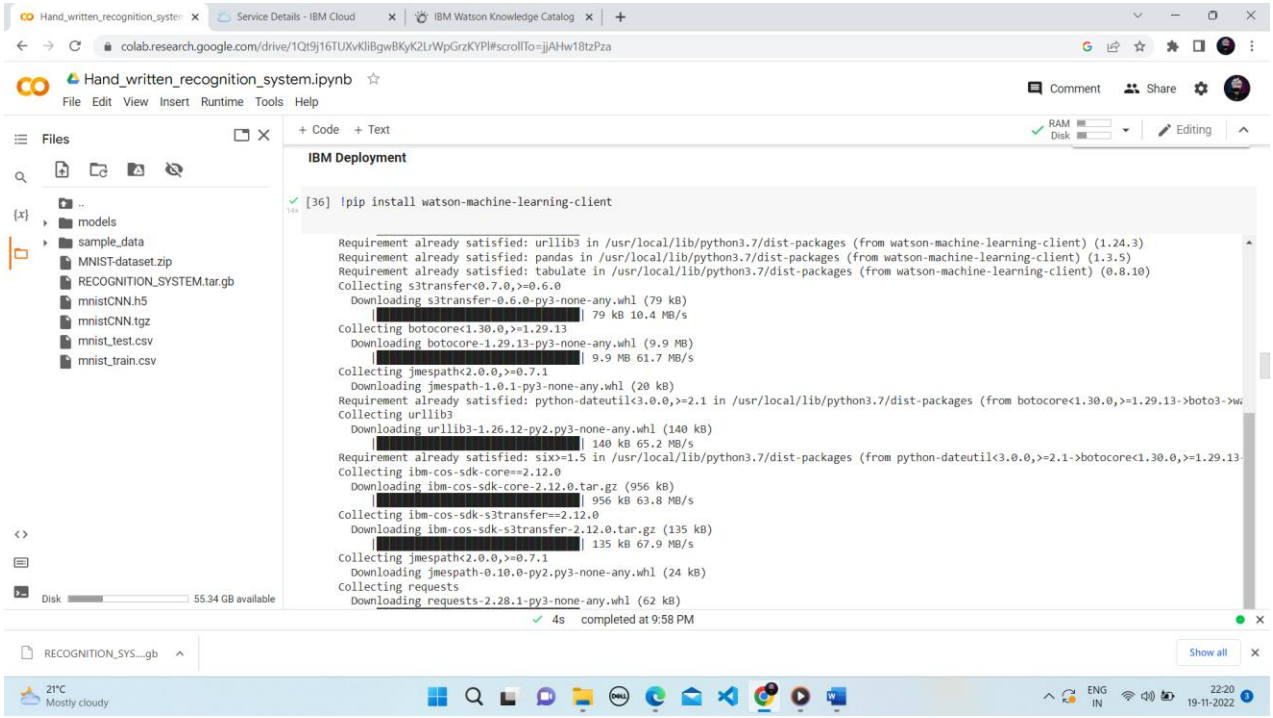
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File Edit View Insert Runtime Tools Help
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IBM Deployment
[36] !pip install watson-machine-learning-client
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages (from watson-machine-learning-client) (1.24.3)
Requirement already satisfied: pandas in /usr/local/lib/python3.7/dist-packages (from watson-machine-learning-client) (1.3.5)
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79 kB 10.4 MB/s
Collecting botocore<1.30.0,>=1.29.13
Downloading botocore-1.29.13-py3-none-any.whl (9.9 MB)
9.9 MB 61.7 MB/s
Collecting jmespath<2.0.0,>=0.7.1
Downloading jmespath-1.0.1-py3-none-any.whl (20 kB)
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /usr/local/lib/python3.7/dist-packages (from botocore<1.30.0,>=1.29.13->boto3->wa
Collecting urllib3
Downloading urllib3-1.26.12-py2.py3-none-any.whl (140 kB)
140 kB 65.2 MB/s
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.7/dist-packages (from python-dateutil<3.0.0,>=2.1->botocore<1.30.0,>=1.29.13
Collecting ibm-cos-sdk-core==2.12.0
Downloading ibm-cos-sdk-core-2.12.0.tar.gz (956 kB)
956 kB 63.8 MB/s
Collecting ibm-cos-sdk-s3transfer==2.12.0
Downloading ibm-cos-sdk-s3transfer-2.12.0.tar.gz (135 kB)
135 kB 67.9 MB/s
Collecting jmespath<2.0.0,>=0.7.1
Downloading jmespath-0.10.0-py2.py3-none-any.whl (24 kB)
Collecting requests
Downloading requests-2.28.1-py3-none-any.whl (62 kB)
4s completed at 9:58 PM
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RECOGNITION_SYS....gb
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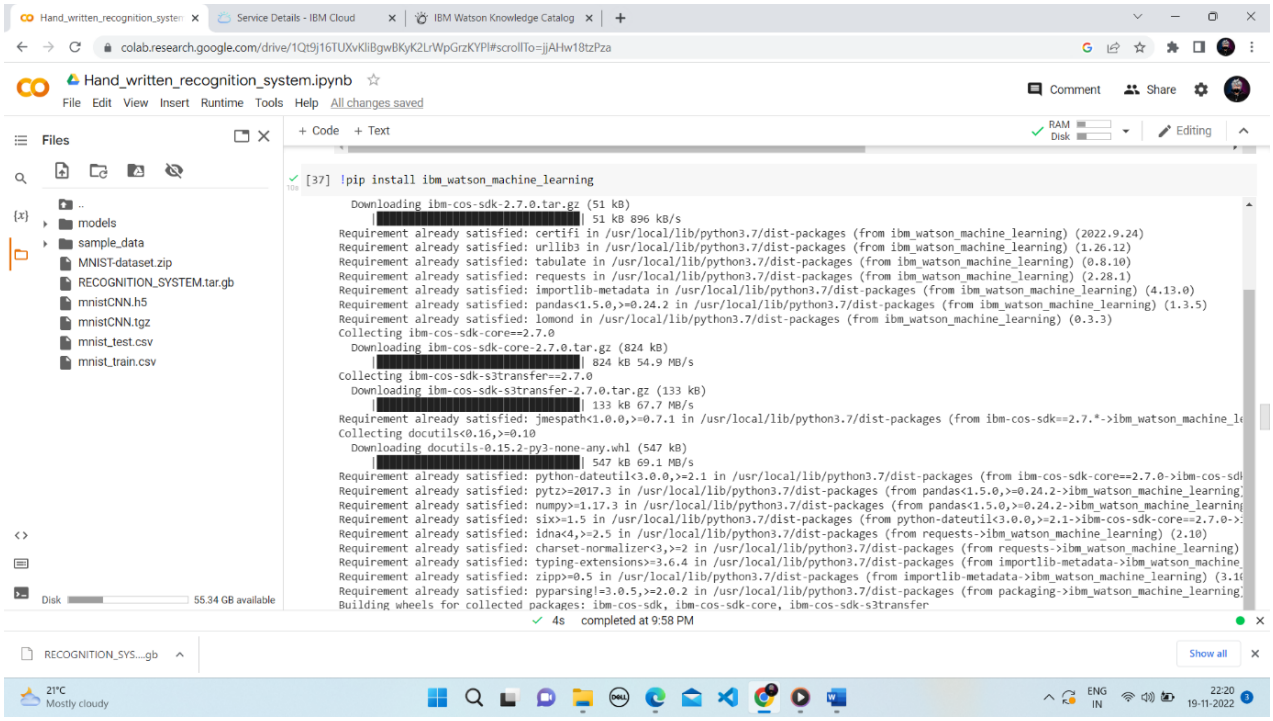
Hand_written_recognition_system.ipynb
File Edit View Insert Runtime Tools Help All changes saved
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Editing
[37] !pip install ibm_watson_machine_learning
Downloading ibm-cos-sdk-2.7.0.tar.gz (51 kB)
51 kB 896 kB/s
Requirement already satisfied: certifi in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (2022.9.24)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (1.26.12)
Requirement already satisfied: tabulate in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (0.8.10)
Requirement already satisfied: requests in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (2.28.1)
Requirement already satisfied: importlib-metadata in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (4.13.0)
Requirement already satisfied: pandas<1.5.0,>=0.24.2 in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (1.3.5)
Requirement already satisfied: lomond in /usr/local/lib/python3.7/dist-packages (from ibm_watson_machine_learning) (0.3.3)
Collecting ibm-cos-sdk-core==2.7.0
Downloading ibm-cos-sdk-core-2.7.0.tar.gz (824 kB)
824 kB 54.9 MB/s
Collecting ibm-cos-sdk-s3transfer==2.7.0
Downloading ibm-cos-sdk-s3transfer-2.7.0.tar.gz (133 kB)
133 kB 67.7 MB/s
Requirement already satisfied: jmespath<1.0.0,>=0.7.1 in /usr/local/lib/python3.7/dist-packages (from ibm-cos-sdk==2.7.*->ibm_watson_machine_le
Collecting docutils<0.16,>=0.10
Downloading docutils-0.15.2-py3-none-any.whl (547 kB)
547 kB 69.1 MB/s
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /usr/local/lib/python3.7/dist-packages (from ibm-cos-sdk-core==2.7.0->ibm-cos-sd
Requirement already satisfied: pytz>=2017.3 in /usr/local/lib/python3.7/dist-packages (from pandas<1.5.0,>=0.24.2->ibm_watson_machine_learning
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.7/dist-packages (from pandas<1.5.0,>=0.24.2->ibm_watson_machine_learnin
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.7/dist-packages (from python-dateutil<3.0.0,>=2.1->ibm-cos-sdk-core==2.7.0->
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.7/dist-packages (from requests->ibm_watson_machine_learning) (2.10)
Requirement already satisfied: charset-normalizer<3,>=2 in /usr/local/lib/python3.7/dist-packages (from requests->ibm_watson_machine_learning)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/lib/python3.7/dist-packages (from importlib-metadata->ibm_watson_machine_
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packages (from importlib-metadata->ibm_watson_machine_learning) (3.1
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python3.7/dist-packages (from packaging->ibm_watson_machine_learning
Building wheels for collected packages: ibm-cos-sdk, ibm-cos-sdk-core, ibm-cos-sdk-s3transfer
4s completed at 9:58 PM
Disk 55.34 GB available
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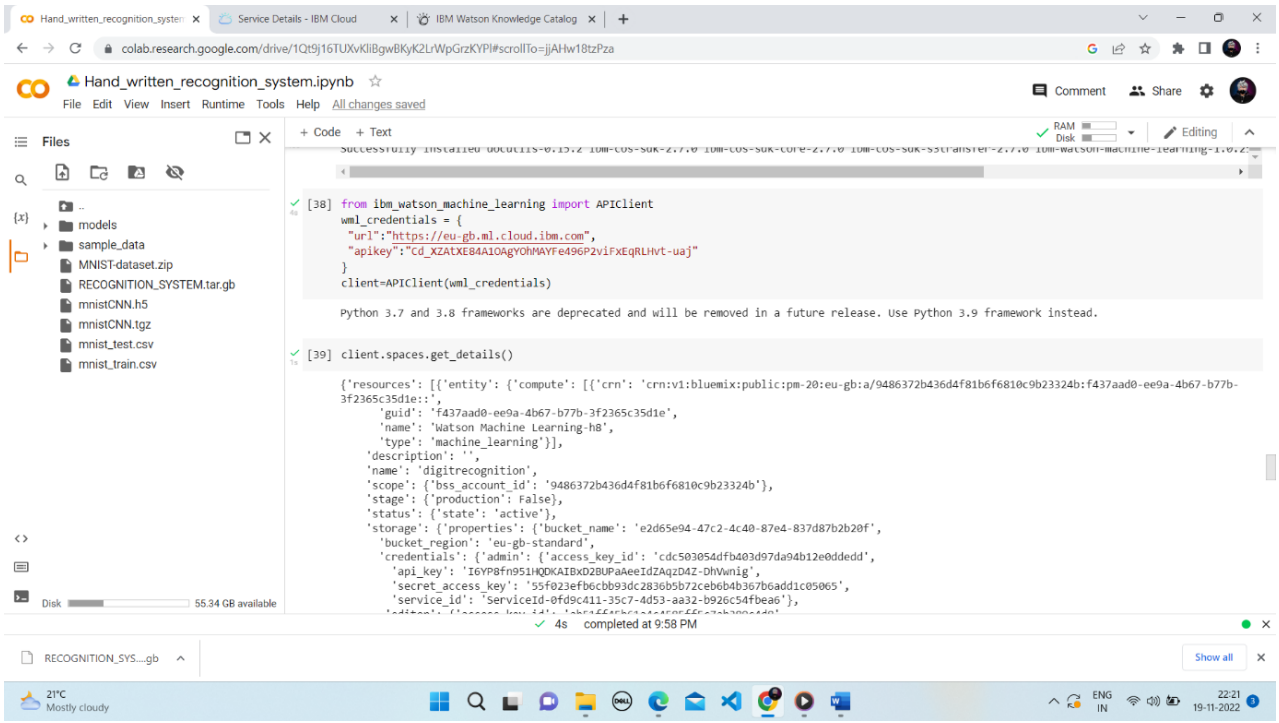
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mnist_train.csv
Disk 55.34 GB available
[38] from ibm_watson_machine_learning import APIClient
wml_credentials = {
"url":"https://eu-gb.ml.cloud.ibm.com",
"apikey":"Cd_XZAtXE84A1OAgYOhMAYFe496P2viFxEqRLHvt-uaj"
}
client=APIClient(wml_credentials)
Python 3.7 and 3.8 frameworks are deprecated and will be removed in a future release. Use Python 3.9 framework instead.
[39] client.spaces.get_details()
{'resources': [{'entity': {'compute': [{'crn': 'crn:v1:bluemix:public:pm-20:eu-gb:a/9486372b436d4f81b6f6810c9b23324b:f437aad0-ee9a-4b67-b77b-3f2365c35d1e::',
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'name': 'Watson Machine Learning-h8',
'type': 'machine_learning'}],
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'name': 'digitrecognition',
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'stage': {'production': False},
'status': {'state': 'active'},
'storage': {'properties': {'bucket_name': 'e2d65e94-47c2-4c40-87e4-837d87b2b20f',
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'credentials': {'admin': {'access_key_id': 'cdc503054dfb403d97da94b12e0ddedd',
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'secret_access_key': '55f023efb6cbb93dc2836b5b72ceb6b4b367b6add1c05065',
'service_id': 'ServiceId-0fd9c411-35c7-4d53-aa32-b926c54fbea6'},
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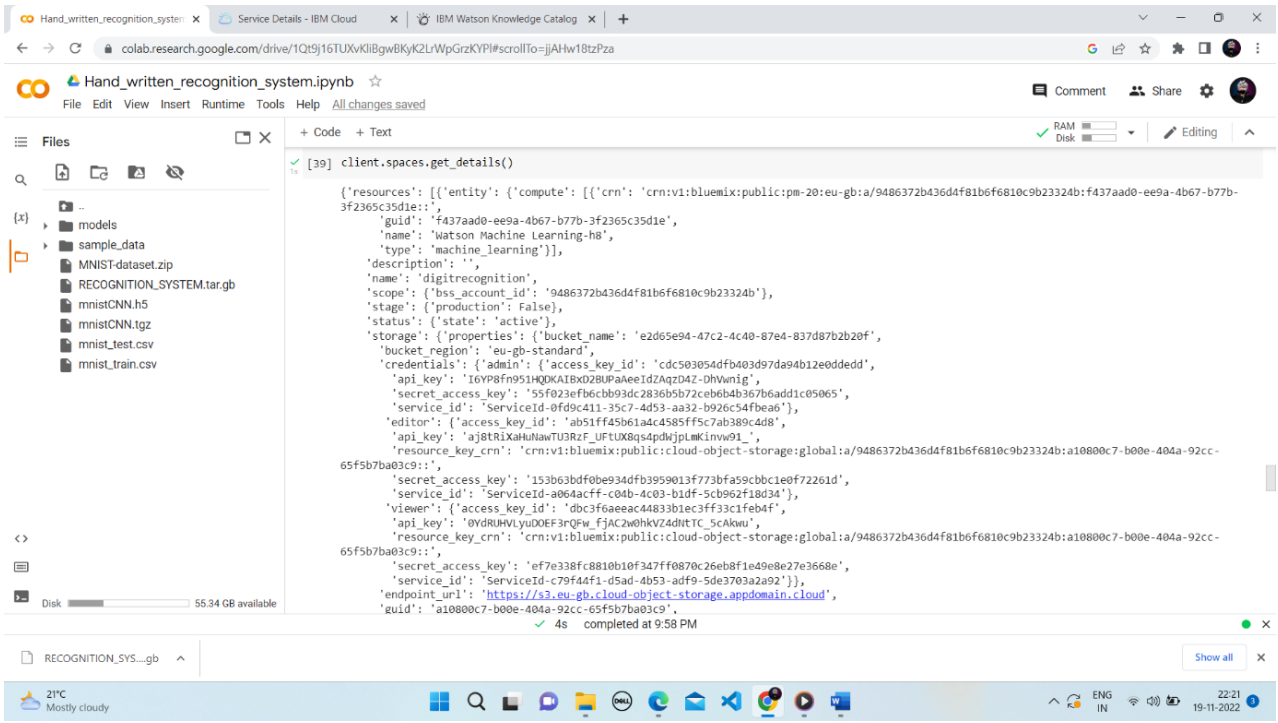
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RAM Disk
Editing
models
sample_data
MNIST-dataset.zip
RECOGNITION_SYSTEM.tar.gb
mnistCNN.h5
mnistCNN.tgz
mnist_test.csv
mnist_train.csv
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[39] client.spaces.get_details()
{'resources': [{'entity': {'compute': [{'crn': 'crn:v1:bluemix:public:pm-20:eu-gb:a/9486372b436d4f81b6f6810c9b23324b:f437aad0-ee9a-4b67-b77b-3f2365c35d1e::',
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'type': 'machine_learning'}],
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'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/9486372b436d4f81b6f6810c9b23324b:a10800c7-b00e-404a-92cc-65f5b7ba03c9::',
'secret_access_key': '153b63bdf0be934dfb3959013f773bfa59cbbc1e0f72261d',
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'viewer': {'access_key_id': 'dbc3f6aeeac44833b1ec3ff33c1feb4f',
'api_key': '0YdRUHVLyuDOEF3rQFw_fjAC2w0hkVZ4dNtTC_5cAkwu',
'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/9486372b436d4f81b6f6810c9b23324b:a10800c7-b00e-404a-92cc-65f5b7ba03c9::',
'secret_access_key': 'ef7e338fc8810b10f347ff0870c26eb8f1e49e8e27e3668e',
'service_id': 'ServiceId-c79f44f1-d5ad-4b53-adf9-5de3703a2a92'}},
'endpoint_url': 'https://s3.eu-gb.cloud-object-storage.appdomain.cloud',
'guid': 'a10800c7-b00e-404a-92cc-65f5b7ba03c9',
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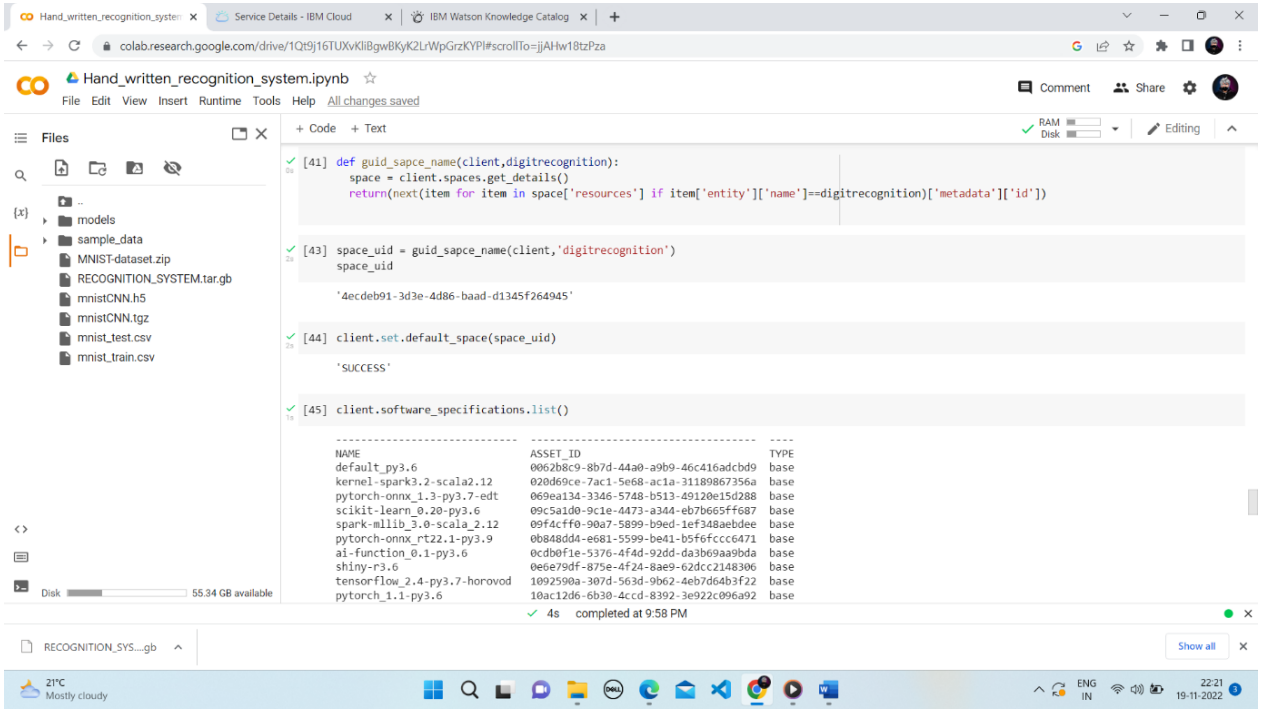
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Editing
Files
models
sample_data
MNIST-dataset.zip
RECOGNITION_SYSTEM.tar.gb
mnistCNN.h5
mnistCNN.tgz
mnist_test.csv
mnist_train.csv
Disk 55.34 GB available
[41] def guid_sapce_name(client,digitrecognition):
space = client.spaces.get_details()
return(next(item for item in space['resources'] if item['entity']['name']==digitrecognition)['metadata']['id'])
[43] space_uid = guid_sapce_name(client,'digitrecognition')
space_uid
'4ecdeb91-3d3e-4d86-baad-d1345f264945'
[44] client.set.default_space(space_uid)
'SUCCESS'
[45] client.software_specifications.list()
NAME ASSET_ID TYPE
default_py3.6 0062b8c9-8b7d-44a0-a9b9-46c416adcbd9 base
kernel-spark3.2-scala2.12 020d69ce-7ac1-5e68-ac1a-31189867356a base
pytorch-onnx_1.3-py3.7-edt 069ea134-3346-5748-b513-49120e15d288 base
scikit-learn_0.20-py3.6 09c5a1d0-9c1e-4473-a344-eb7b665ff687 base
spark-mllib_3.0-scala_2.12 09f4cff0-90a7-5899-b9ed-1ef348aebdee base
pytorch-onnx_rt22.1-py3.9 0b848dd4-e681-5599-be41-b5f6fccc6471 base
ai-function_0.1-py3.6 0cdb0f1e-5376-4f4d-92dd-da3b69aa9bda base
shiny-r3.6 0e6e79df-875e-4f24-8ae9-62dcc2148306 base
tensorflow_2.4-py3.7-horovod 1092590a-307d-563d-9b62-4eb7d64b3f22 base
pytorch_1.1-py3.6 10ac12d6-6b30-4ccd-8392-3e922c096a92 base
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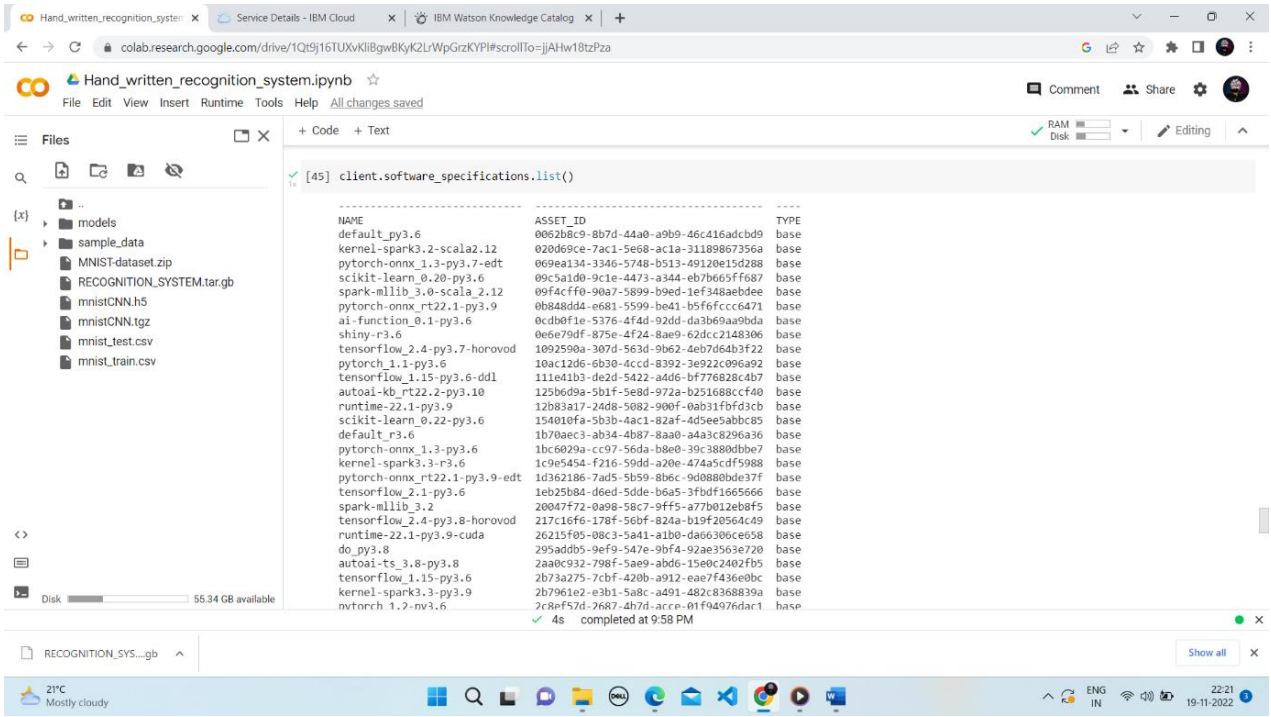
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Files
models
sample_data
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[45] client.software_specifications.list()
NAME ASSET_ID TYPE
default_py3.6 0062b8c9-8b7d-44a0-a9b9-46c416adcbd9 base
kernel-spark3.2-scala2.12 020d69ce-7ac1-5e68-ac1a-31189867356a base
pytorch-onnx_1.3-py3.7-edt 069ea134-3346-5748-b513-49120e15d288 base
scikit-learn_0.20-py3.6 09c5a1d0-9c1e-4473-a344-eb7b665ff687 base
spark-mllib_3.0-scala_2.12 09f4cff0-90a7-5899-b9ed-1ef348aebdee base
pytorch-onnx_rt22.1-py3.9 0b848dd4-e681-5599-be41-b5f6fccc6471 base
ai-function_0.1-py3.6 0cdb0f1e-5376-4f4d-92dd-da3b69aa9bda base
shiny-r3.6 0e6e79df-875e-4f24-8ae9-62dcc2148306 base
tensorflow_2.4-py3.7-horovod 1092590a-307d-563d-9b62-4eb7d64b3f22 base
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pytorch-onnx_1.3-py3.6 1bc6029a-cc97-56da-b8e0-39c3880dbbe7 base
kernel-spark3.3-r3.6 1c9e5454-f216-59dd-a20e-474a5cdf5988 base
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tensorflow_2.1-py3.6 1eb25b84-d6ed-5dde-b6a5-3fbdf1665666 base
spark-mllib_3.2 20047f72-0a98-58c7-9ff5-a77b012eb8f5 base
tensorflow_2.4-py3.8-horovod 217c16f6-178f-56bf-824a-b19f20564c49 base
runtime-22.1-py3.9-cuda 26215f05-08c3-5a41-a1b0-da66306ce658 base
do_py3.8 295addb5-9ef9-547e-9bf4-92ae3563e720 base
autoai-ts_3.8-py3.8 2aa0c932-798f-5ae9-abd6-15e0c2402fb5 base
tensorflow_1.15-py3.6 2b73a275-7cbf-420b-a912-eae7f436e0bc base
kernel-spark3.3-py3.9 2b7961e2-e3b1-5a8c-a491-482c8368839a base
pytorch_1.2-py3.6 2c8ef57d-2687-4b7d-acce-01f94976dac1 base
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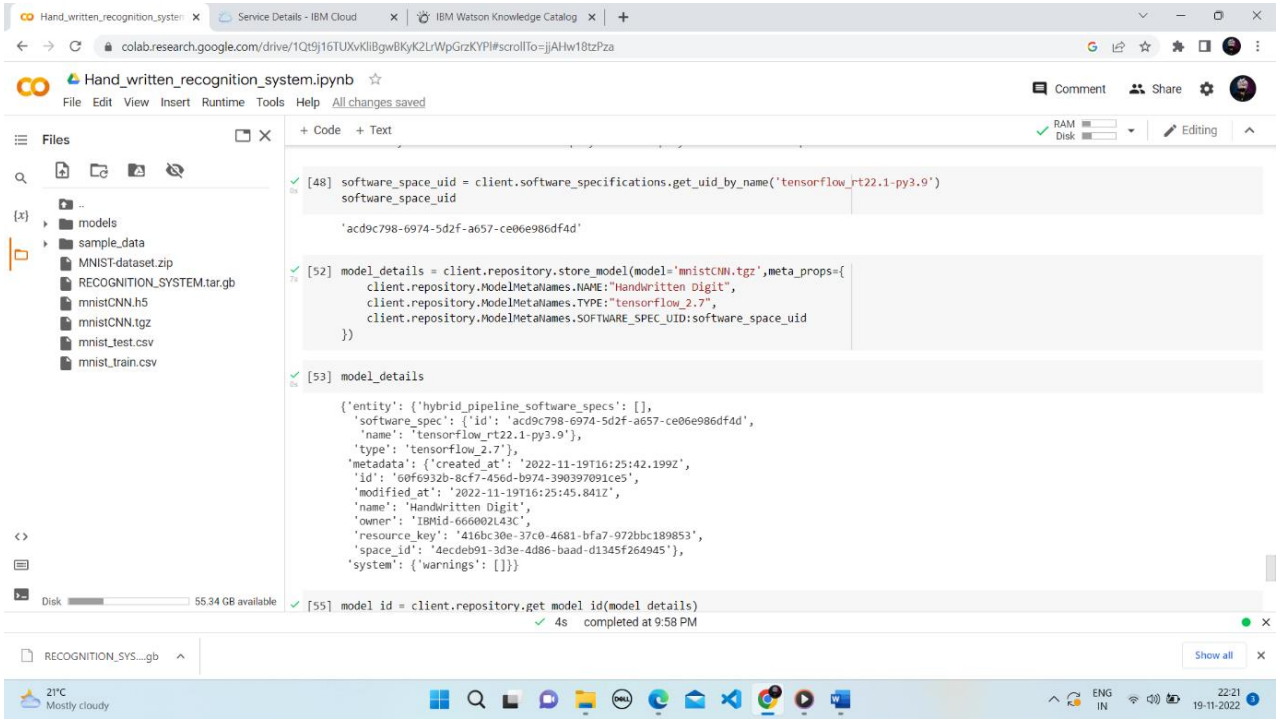
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Editing
models
sample_data
MNIST-dataset.zip
RECOGNITION_SYSTEM.tar.gb
mnistCNN.h5
mnistCNN.tgz
mnist_test.csv
mnist_train.csv
[48] software_space_uid = client.software_specifications.get_uid_by_name('tensorflow_rt22.1-py3.9')
software_space_uid
'acd9c798-6974-5d2f-a657-ce06e986df4d'
[52] model_details = client.repository.store_model(model='mnistCNN.tgz',meta_props={
client.repository.ModelMetaNames.NAME:"HandWritten Digit",
client.repository.ModelMetaNames.TYPE:"tensorflow_2.7",
client.repository.ModelMetaNames.SOFTWARE_SPEC_UID:software_space_uid
})
[53] model_details
{'entity': {'hybrid_pipeline_software_specs': [],
'software_spec': {'id': 'acd9c798-6974-5d2f-a657-ce06e986df4d',
'name': 'tensorflow_rt22.1-py3.9'},
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'modified_at': '2022-11-19T16:25:45.841Z',
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'owner': 'IBMid-666002L43C',
'resource_key': '416bc30e-37c0-4681-bfa7-972bbc189853',
'space_id': '4ecdeb91-3d3e-4d86-baad-d1345f264945'},
'system': {'warnings': []}}
[55] model_id = client.repository.get_model_id(model_details)
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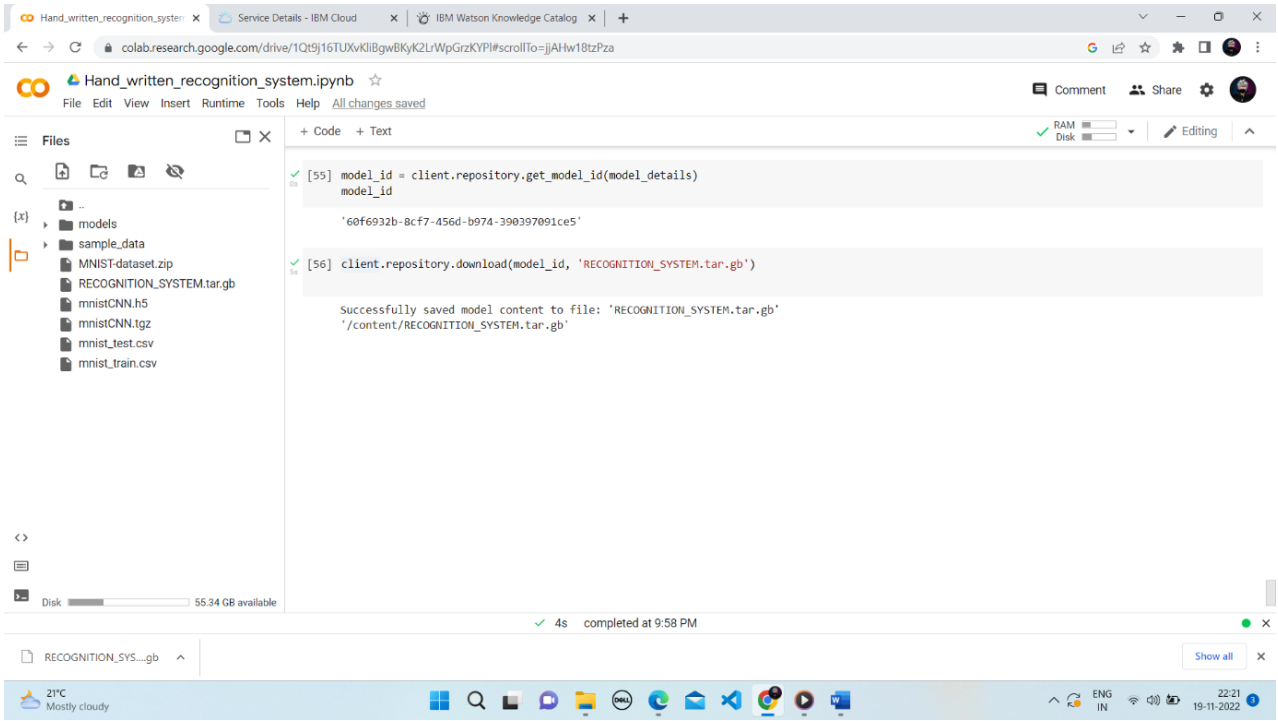
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Files
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Editing
models
sample_data
MNIST-dataset.zip
RECOGNITION_SYSTEM.tar.gb
mnistCNN.h5
mnistCNN.tgz
mnist_test.csv
mnist_train.csv
[55] model_id = client.repository.get_model_id(model_details)
model_id
'60f6932b-8cf7-456d-b974-390397091ce5'
[56] client.repository.download(model_id, 'RECOGNITION_SYSTEM.tar.gb')
Successfully saved model content to file: 'RECOGNITION_SYSTEM.tar.gb'
'/content/RECOGNITION_SYSTEM.tar.gb'
Disk 55.34 GB available
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