

Project Development Phase Sprint-4

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

The screenshot shows a Jupyter Notebook interface with the following content:

- Files:** A sidebar on the left shows a file explorer with folders like 'models' and 'sample_data', and files like 'MNIST-dataset.zip', 'RECOGNITION_SYSTEM.tar.gb', 'mnistCNN.h5', 'mnistCNN.tgz', 'mnist_test.csv', and 'mnist_train.csv'.
- Code Cell [1]:** Contains a command to unzip the dataset: `!unzip '/content/MNIST-dataset.zip'`. Below it, a message indicates the archive is unzipped and a prompt to replace 'mnist_test.csv?' is shown with options [y]es, [n]o, [A]ll, [N]one, and [r]ename.
- Section: Importing Necessary Libraries**
- Code Cell [2]:** Imports necessary libraries: `import numpy #used for numerical analysis`, `import tensorflow #open source used for both ML and DL for computation`, `from tensorflow.keras.datasets import mnist #mnist dataset`, `from tensorflow.keras.models import Sequential #it is a plain stack of layers`, `from tensorflow.keras.layers import layers #A layer consists of a tensor-in tensor-out computation function`, `from tensorflow.keras.layers import Dense, Flatten #Dense-Dense layer is the regular deeply connected`, `#Flatten-used for flattening the input or change the dimension`, `from tensorflow.keras.layers import Conv2D #convolutional layer`, `from keras.optimizers import Adam #optimizer`, and `from keras.utils import np_utils #used for one-hot coding`.
- Section: Load Data**
- Code Cell [2]:** Loads the data: `(x_train, y_train), (x_test, y_test)=mnist.load_data() #splitting the mnist data into train and test`. Below it, a message indicates data is downloading from <https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz> with progress bar and completion time of 4s.

The screenshot shows a Jupyter Notebook interface with the following content:

- Files:** The sidebar on the left is the same as the previous screenshot.
- Section: Load Data**
- Code Cell [2]:** Same as the previous screenshot, loading the data: `(x_train, y_train), (x_test, y_test)=mnist.load_data() #splitting the mnist data into train and test`.
- Code Cell [3]:** Prints the shape of the training data: `print(x_train.shape)#shape is used for give the dimension values #60000-rows 28x28-pixels paint`. The output shows: `(60000, 28, 28)` and `(10000, 28, 28)`.
- Section: Understanding the data**
- Code Cell [4]:** Prints the first image: `x_train[0] #printing the first image`. The output shows a 28x28 pixel array representing a handwritten digit.

Hand_written_recognition_system.ipynb

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Files

- models
- sample_data
- MNIST-dataset.zip
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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., 0., 1., 0., 0., 0.], dtype=float32])
```

Creating the Model

```
[10]
#create model
model=Sequential()
```

4s completed at 9:58 PM

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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)
```

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Code

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]

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Code

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]

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

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Code

Predicting the Output

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[14] prediction=model.predict(x_train[:4])
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 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. 0. 1. 0. 0.]
 [0. 0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
```

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Code

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)
Collecting botocore<1.30.0,>=1.29.13
  Downloading botocore-1.29.13-py3-none-any.whl (9.9 MB)
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->botocore) (2.8.0)
```

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Hand_written_recognition_system.ipynb

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Code

```
IBM Deployment
```

```
[36] !pip install watson-machine-learning-client
```

```
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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)
    [REDACTED] 79 kB 10.4 MB/s
Collecting boto3<1.30.0,>=1.29.13
  Downloading boto3-1.29.13-py3-none-any.whl (9.9 MB)
    [REDACTED] 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 boto3<1.30.0,>=1.29.13->boto3) (2.8.1)
Collecting urllib3
  Downloading urllib3-1.26.12-py2.py3-none-any.whl (140 kB)
    [REDACTED] 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->boto3<1.30.0,>=1.29.13->boto3) (1.16.0)
Collecting ibm-cos-sdk-core==2.12.0
  Downloading ibm-cos-sdk-core-2.12.0.tar.gz (956 kB)
    [REDACTED] 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)
    [REDACTED] 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)
    [REDACTED] 62 kB
4s completed at 9:58 PM
```

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Code

```
[37] !pip install ibm_watson_machine_learning
```

```
Downloading ibm-cos-sdk-2.7.0.tar.gz (51 kB)
  [REDACTED] 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: lxml 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)
    [REDACTED] 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)
    [REDACTED] 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==2.7.0->ibm_watson_machine_learning) (0.10.0)
Collecting docutils<0.16,>=0.10
  Downloading docutils-0.15.2-py3-none-any.whl (547 kB)
    [REDACTED] 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==2.7.0->ibm_watson_machine_learning) (2.8.1)
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) (2022.7.1)
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_learning) (1.24.3)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.7/dist-packages (from python-dateutil<3.0.0,>=2.1->ibm_watson_machine_learning) (1.16.0)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.7/dist-packages (from requests->ibm_watson_machine_learning) (3.4)
Requirement already satisfied: charset-normalizer<3,>=2 in /usr/local/lib/python3.7/dist-packages (from requests->ibm_watson_machine_learning) (2.1.0)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/lib/python3.7/dist-packages (from importlib-metadata->ibm_watson_machine_learning) (4.5.0)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packages (from importlib-metadata->ibm_watson_machine_learning) (3.15.0)
Requirement already satisfied: pyparsing<3.0.5,>=2.0.2 in /usr/local/lib/python3.7/dist-packages (from packaging->ibm_watson_machine_learning) (3.1.0)
Building wheels for collected packages: ibm-cos-sdk, ibm-cos-sdk-s3transfer
4s completed at 9:58 PM
```

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Code

```
[38] from ibm_watson_machine_learning import APIClient
wml_credentials = {
    "url": "https://eu-gb.ml.cloud.ibm.com",
    "apikey": "Cd_XZATXE84A10AgYOHMAYFe496P2vIFxEqRLHvt-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::',
'guid': 'f437aad0-ee9a-4b67-b77b-3f2365c35d1e',
'name': 'Watson Machine Learning-h8',
'type': 'machine_learning'}]},
'description': '',
'name': 'digitrecognition',
'scope': {'bss_account_id': '9486372b436d4f81b6f6810c9b23324b'},
'stage': {'production': False},
'status': {'state': 'active'},
'storage': {'properties': {'bucket_name': 'e2d65e94-47c2-4c40-87e4-837d87b2b20f',
'bucket_region': 'eu-gb-standard',
'credentials': {'admin': {'access_key_id': 'cdc503054dfb403d97da94b12e0ddedd',
'api_key': 'I6YP8f951HQKAI8XDZBUPAAeIdZaQZD4Z-DHvwn1g',
'secret_access_key': '55f023efb6cb93dc2836b5b72ceb6b4b367b6add1c05065',
'service_id': 'ServiceId-0fd9c411-35c7-4d53-aa32-b926c54fbae6'},
'editor': {'access_key_id': 'ab51ff45b61a4c4585ff5c7ab389c4d8',
'api_key': 'aj8tRiXaHwU3RZF_UFTUX8q54pdwJpLMcinw91',
'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/9486372b436d4f81b6f6810c9b23324b:a10800c7-b00e-404a-92cc-65f5b7ba03c9::',
'secret_access_key': '153b63bdf0be934dfb3959013f773bfa59cbbc1e0f72261d',
'service_id': 'ServiceId-a064acff-c04b-4c03-b1df-5cb962f18d34'},
'viewer': {'access_key_id': 'dbc3f6aeac4A833b1ec3ff33c1feb4f',
'api_key': '0YdRUHvLYuDOEF3rQFw_fJACZw0hkvZ4dntTC_5Akaw',
'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/9486372b436d4f81b6f6810c9b23324b:a10800c7-b00e-404a-92cc-65f5b7ba03c9::',
'secret_access_key': 'ef7e338fc8810b10f347ff0870c26ebf1e49e8e27e3668e',
'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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Code

```
[39] client.spaces.get_details()

{'resources': [{'entity': {'compute': [{'crn': 'crn:v1:bluemix:public:pm-20:eu-gb:a/9486372b436d4f81b6f6810c9b23324b:f437aad0-ee9a-4b67-b77b-3f2365c35d1e::',
'guid': 'f437aad0-ee9a-4b67-b77b-3f2365c35d1e',
'name': 'Watson Machine Learning-h8',
'type': 'machine_learning'}]},
'description': '',
'name': 'digitrecognition',
'scope': {'bss_account_id': '9486372b436d4f81b6f6810c9b23324b'},
'stage': {'production': False},
'status': {'state': 'active'},
'storage': {'properties': {'bucket_name': 'e2d65e94-47c2-4c40-87e4-837d87b2b20f',
'bucket_region': 'eu-gb-standard',
'credentials': {'admin': {'access_key_id': 'cdc503054dfb403d97da94b12e0ddedd',
'api_key': 'I6YP8f951HQKAI8XDZBUPAAeIdZaQZD4Z-DHvwn1g',
'secret_access_key': '55f023efb6cb93dc2836b5b72ceb6b4b367b6add1c05065',
'service_id': 'ServiceId-0fd9c411-35c7-4d53-aa32-b926c54fbae6'},
'editor': {'access_key_id': 'ab51ff45b61a4c4585ff5c7ab389c4d8',
'api_key': 'aj8tRiXaHwU3RZF_UFTUX8q54pdwJpLMcinw91',
'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/9486372b436d4f81b6f6810c9b23324b:a10800c7-b00e-404a-92cc-65f5b7ba03c9::',
'secret_access_key': '153b63bdf0be934dfb3959013f773bfa59cbbc1e0f72261d',
'service_id': 'ServiceId-a064acff-c04b-4c03-b1df-5cb962f18d34'},
'viewer': {'access_key_id': 'dbc3f6aeac4A833b1ec3ff33c1feb4f',
'api_key': '0YdRUHvLYuDOEF3rQFw_fJACZw0hkvZ4dntTC_5Akaw',
'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/9486372b436d4f81b6f6810c9b23324b:a10800c7-b00e-404a-92cc-65f5b7ba03c9::',
'secret_access_key': 'ef7e338fc8810b10f347ff0870c26ebf1e49e8e27e3668e',
'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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RECOGNITION_SYS....gb

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- mnist_train.csv

Code

```
[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-eb7b6e5ff687	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	0cdeb0f1e-5376-4f4d-92dd-da3b69aa9bda	base
shiny-r3.6	0e6e79df-875e-4f24-8ae9-62dc2148306	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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Code

```
[45] client.software_specifications.list()
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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-eb7b6e5ff687	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	0cdeb0f1e-5376-4f4d-92dd-da3b69aa9bda	base
shiny-r3.6	0e6e79df-875e-4f24-8ae9-62dc2148306	base
tensorflow_2.4-py3.7-horovod	1092590a-307d-563d-9b62-4eb7d64b3f22	base
pytorch_1.1-py3.6	10ac12d6-6b30-4ccd-8392-3e922c096a92	base
tensorflow_1.15-py3.6-ddl	111e41b3-de2d-5422-a4d6-bf776828c4b7	base
autoai-kb_rt22.2-py3.10	125b6d9a-5b1f-5e8d-972a-b251088ccf40	base
runtime-22.1-py3.9	12083a17-24d8-5082-908f-0ab311bf4dcb	base
scikit-learn_0.22-py3.6	154010fa-5b3b-4ac1-82af-d5ee5abbc05	base
default_r3.6	1b70a6c3-ab34-4b87-8a00-a4a3c8296a36	base
pytorch-onnx_1.3-py3.6	1bc6029a-cc97-56da-b8e0-39c3880dbbe7	base
kernel-spark3.3-r3.6	1c9e5454-f216-59dd-a20e-474a5cdf5988	base
pytorch-onnx_rt22.1-py3.9-edt	1d362186-7ad5-5b59-8b6c-9d088a0bde37f	base
tensorflow_2.1-py3.6	1eb25b84-d6ed-5dde-b6a5-3fbd1665666	base
spark-mllib_3.2	20047f72-0a98-58c7-9ff5-a77b012ebf5	base
tensorflow_2.4-py3.8-horovod	217c16fe-178f-56bf-824a-b19f20564c49	base
runtime-22.1-py3.9-cuda	26215f05-08c3-5a41-a1b0-da66306ce658	base
do_py3.8	295add05-9ef9-547e-90f4-92ae3563e720	base
autoai-ts_3.8-py3.8	2a08c932-798f-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
nvtorch_1.7-nv3.6	2c8ef57d-7687-4b7d-acc6-01f94976dac1	base

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```
[48] software_space_uid = client.software_specifications.get_uid_by_name('tensorflow_rt22.1-py3.9')
software_space_uid

'acd9c798-6974-5d2f-a657-ce06e986dfad'

[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-ce06e986dfad',
'name': 'tensorflow_rt22.1-py3.9'},
'type': 'tensorflow_2.7'},
'metadata': {'created_at': '2022-11-19T16:25:42.199Z',
'id': '60f6932b-8cf7-456d-b974-390397091ce5',
'modified_at': '2022-11-19T16:25:45.841Z',
'name': 'Handwritten Digit',
'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)
model_id

'60f6932b-8cf7-456d-b974-390397091ce5'

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```

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```
[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'

4s completed at 9:58 PM
```

RECOGNITION_SYS...gb

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IBM Deployment:

The screenshot displays the IBM Watson Knowledge Catalog web interface. The browser's address bar shows the URL: `eu-gb.dataplatform.cloud.ibm.com/home?context=cpdaas&apps=watson_machine_learning&nocache=true&quick_start_target=data_science_experience`. The interface features a dark-themed sidebar on the left with a search bar and navigation links. The main content area is divided into several panels:

- Quick start:** Contains four cards with icons and text: "Build customer profiles with IBM Match 360 with Watson", "Catalog and govern data with Watson Knowledge Catalog", "Build and manage ML models with Watson Studio", and "Query data anywhere with Watson Query".
- What's new:** Lists recent updates, including "New Runtime 2022 release for Python 3.10 and R 4.2" (Nov 18, 2022) and "Spark 3.3 replaces Spark 3.2 for Watson Studio and Watson Machine Learning" (Nov 18, 2022).
- Projects:** A panel titled "No recent projects" with a subtext "After you create projects, you'll see your recently updated projects here." and a "New project +" button.
- Catalogs:** A panel titled "No catalogs" with a subtext "Your catalogs show here after you create or join them. Click New catalog to get started." and a "New catalog +" button.
- Notifications:** A panel titled "No notifications" with a subtext "You will see your most recent notifications here."
- Deployments:** A panel showing a deployment named "digitrecognition" with a timestamp "Today at 08:04 PM".
- New in gallery:** A panel titled "SAMPLE PROJECT AI governance" with a description: "Tutorials in this project: Build and deploy a machine learning model to predict which applicants qualify for mortgages; Test and validate the model for fairness, accuracy, trustworthiness, and readiness for production." and an "Explore" link.

The bottom of the interface shows a Windows taskbar with various application icons, a system clock displaying "23:02 19-11-2022", and a language indicator set to "ENG IN".