Build, Train, Save, Deploy and Test a Convolutional Neural Network Model using MNIST

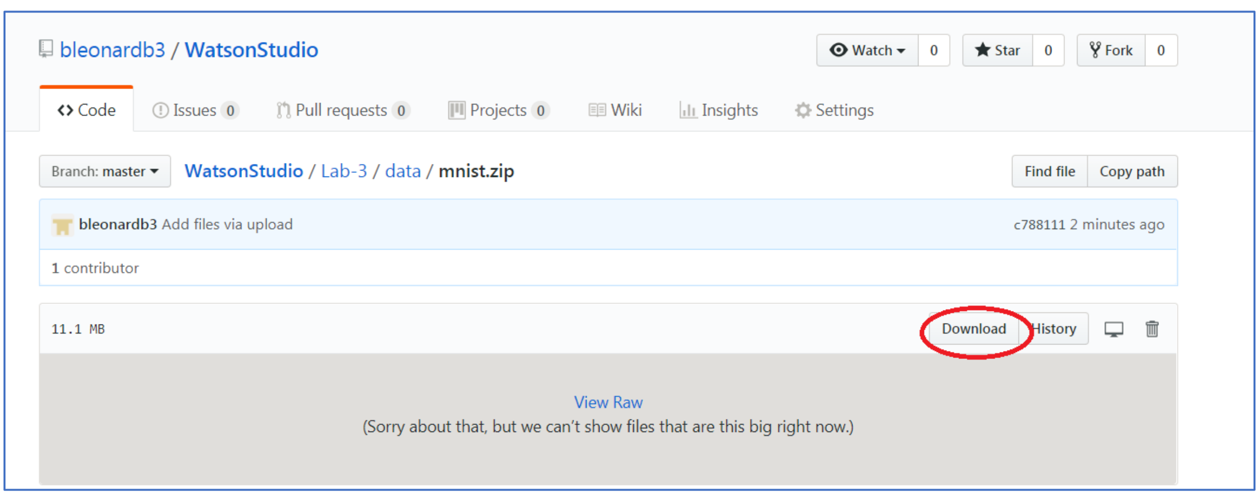
This lab will use the MNIST computer vision data set to train a deep learning model to recognize handwritten digits. A single layer convolutional neural network will be built in the Watson Studio neural network designer, and then trained using the Watson Studio Experiment Builder. The trained model will be saved in the model repository, deployed, and then tested with sample image data. The lab consists of the following steps:

1. Set up the data files in IBM Cloud Storage.
2. Design the neural network
3. Train the model
4. Monitor the training progress and results
5. Save and Deploy the Trained Model
6. Test the Deployment

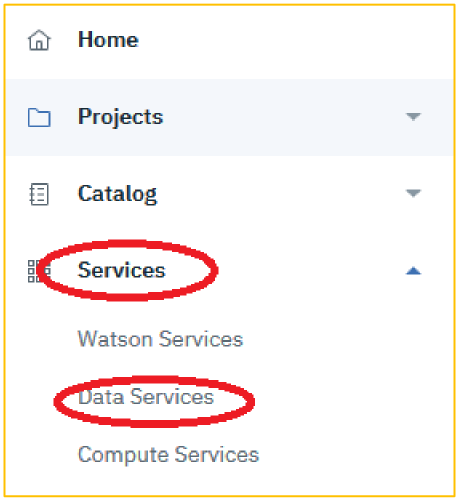
Step 1: Set up the Data Files in IBM Cloud Storage

Training a deep learning model using Watson Machine Learning relies on using Cloud Object Storage for reading input (such as training data) as well as for storing results (such as log files.)

1. Download the mnist.zip file. Extract the files. Four files should be extracted:
   1. a training file (mnist-tf-train.pkl) – pkl – pickle format.
   2. a test file(mnist-tf-test.pkl)
   3. a validation file (mnist-tf-valid.pkl)
   4. test.json (will be used to test the deployed model)



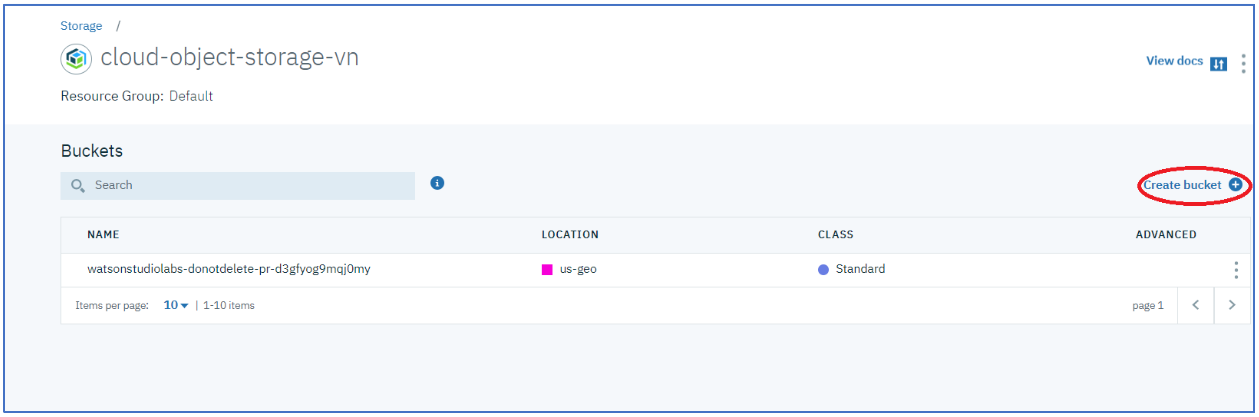
2. Return to Watson Studio, click on the icon, then click on **Services**, and then **Data Services**.



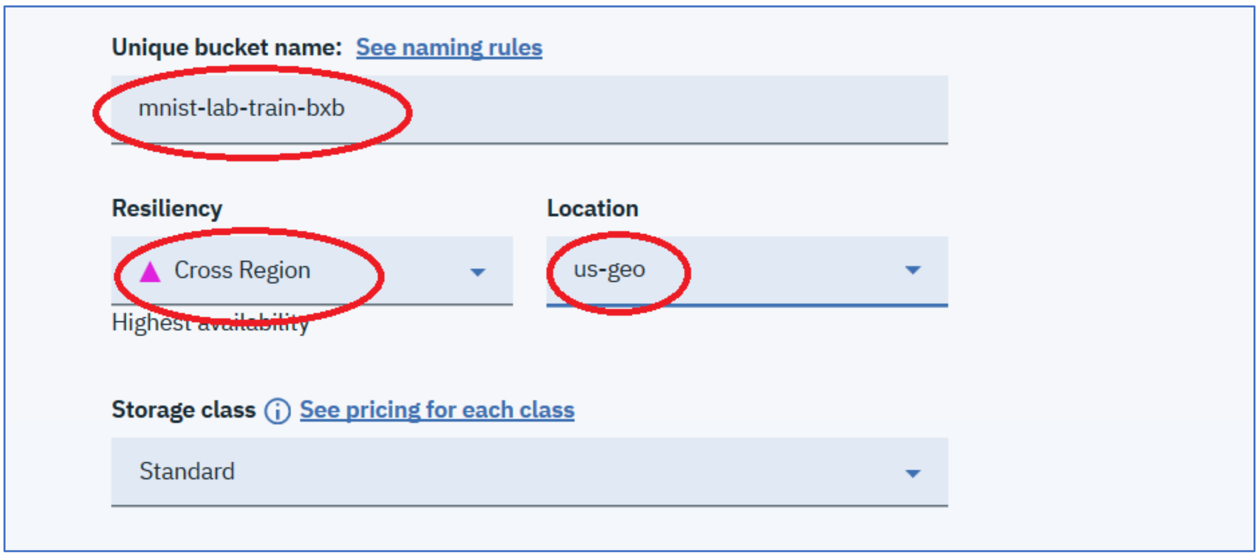
3. Select the vertical **ellipse** on the right-hand side of the cloud object storage entry, and then click on **Manage in IBM Cloud**.

4. A new browser tab **Create Object Storage – IBM Cloud** is created. This is the IBM Cloud user interface to the object storage subsystem

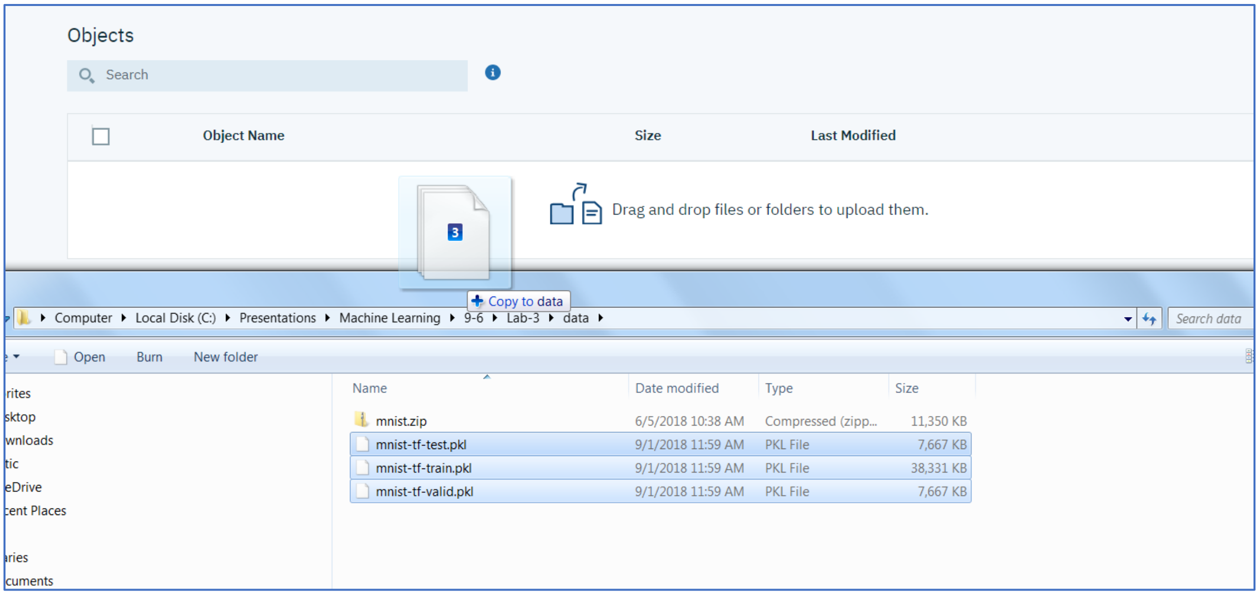
5. Click on **Create bucket**



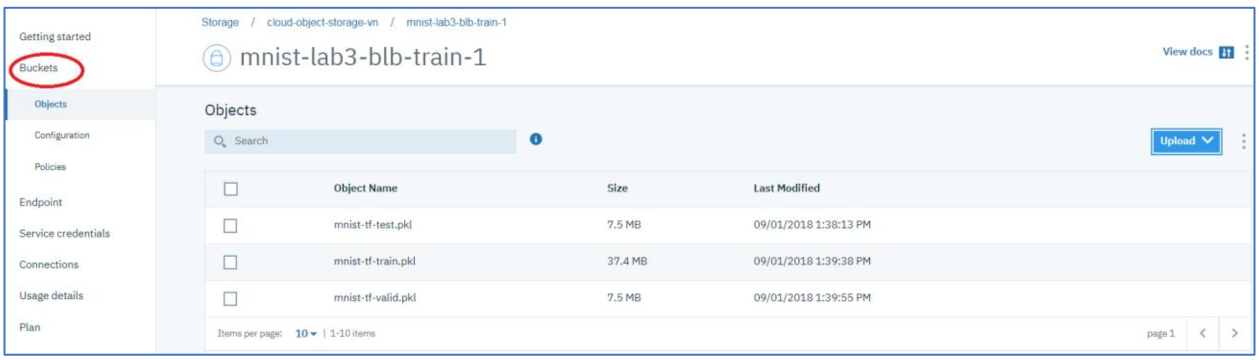
6. Enter a unique name for the bucket - mnist-lab-train-xxx (replace xxx with your initials), click on **Cross-Region** for the **Resiliency**, and click on **us-geo** for the **Location**. **MAKE SURE YOU CHANGE THE LOCATION TO US-GEO BECAUSE IT DEFAULTS TO AP-GEO**. Scroll down and click on **Create bucket.**



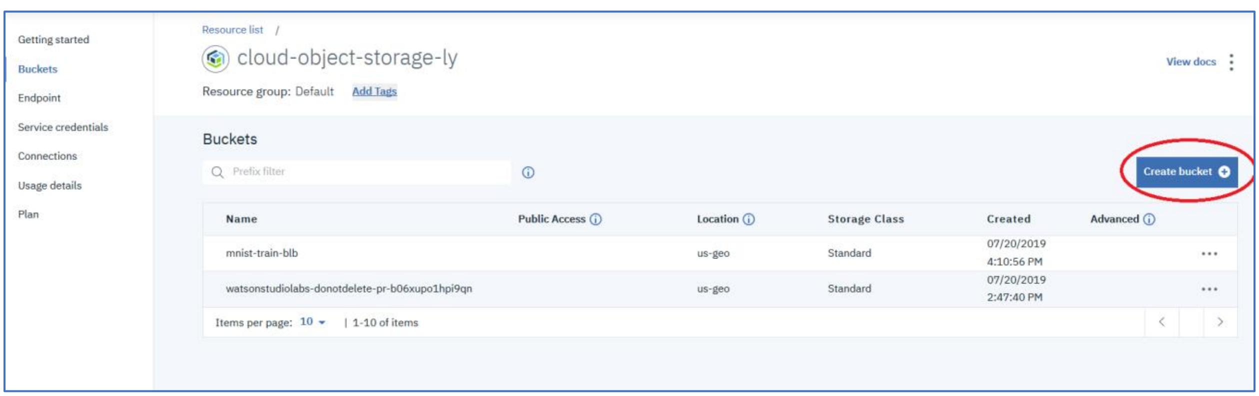
7. Navigate to the directory where the 3 mnist files are stored. Select these 3 files and drag and drop where indicated.



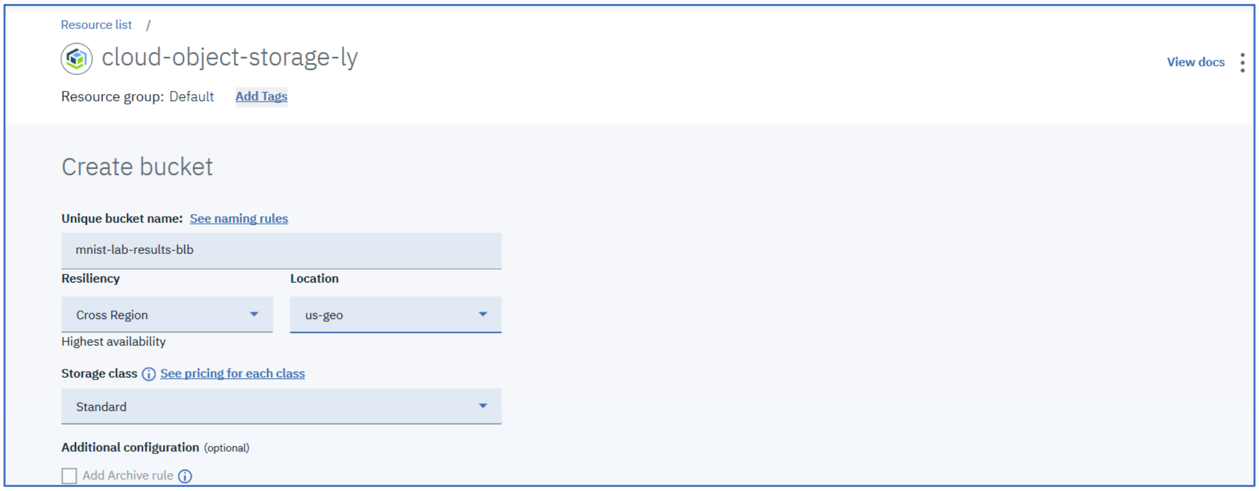
8. Click on **Buckets** to add a second bucket.



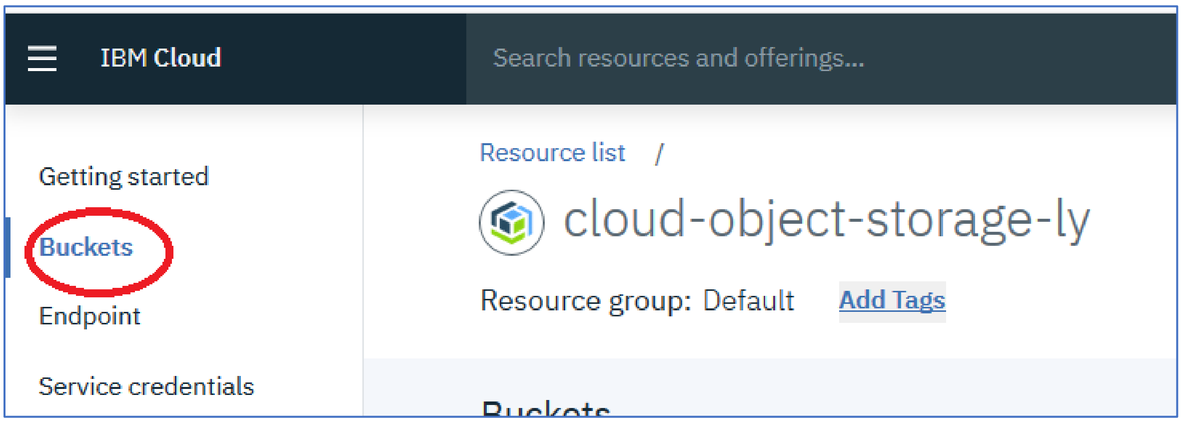
9. Click on **Create Bucket**



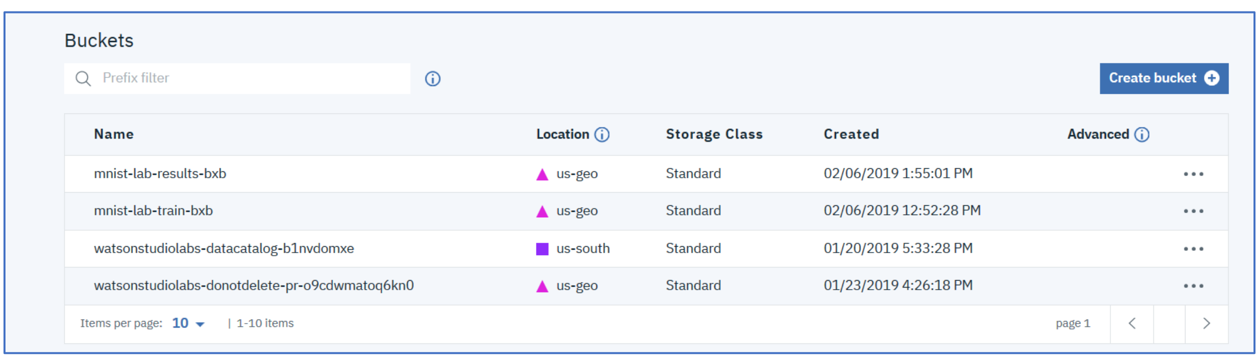
10. Name it mnist-lab-results-xxx, where xxx are your initials. Follow the procedure above to create the second bucket. No files need to be added. **MAKE SURE YOU CHANGE THE LOCATION TO US-GEO.**



11. Click on Buckets.



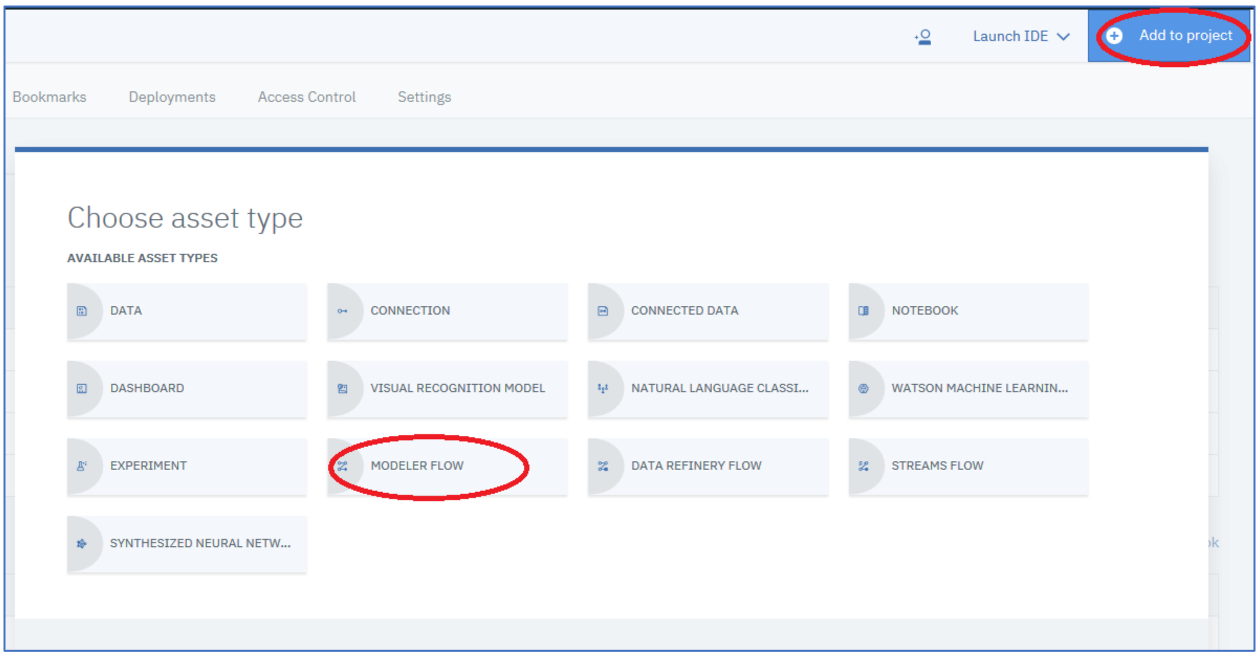
12. The Cloud Object Storage panel should appear as below. Note, you may not have the datacatalog bucket listed.



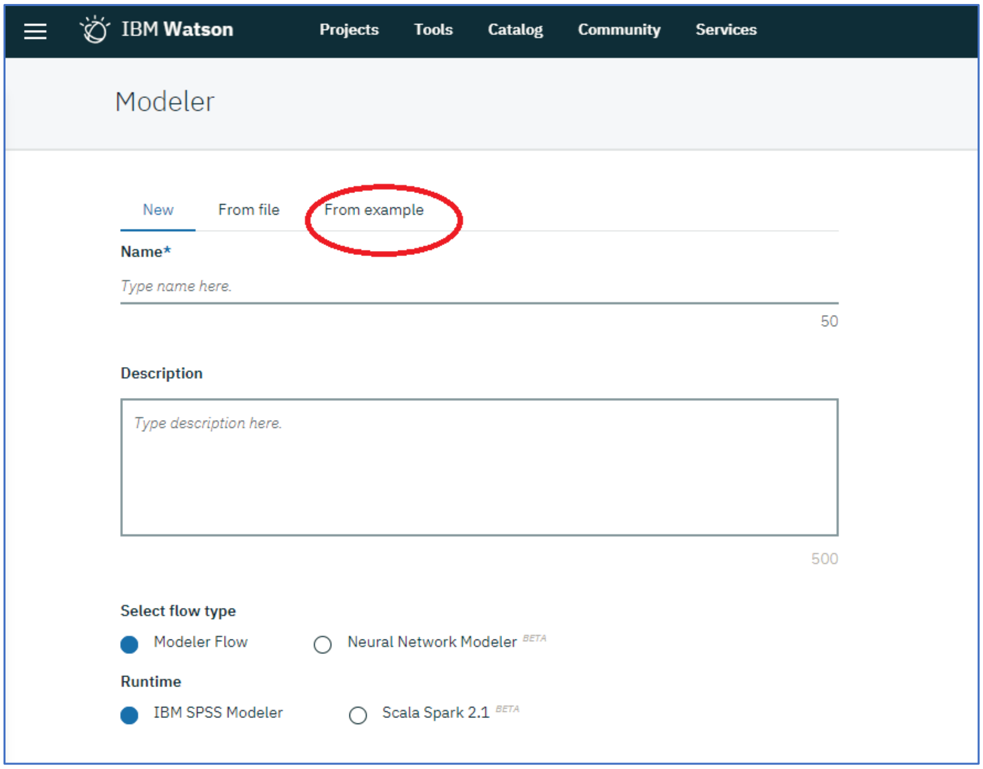
Step 2: Design the Neural Network and Publish Training Definition

1. Return to Watson Studio, and click on the ☰ icon, then click on **Projects,** then **Watson Studio Labs**.

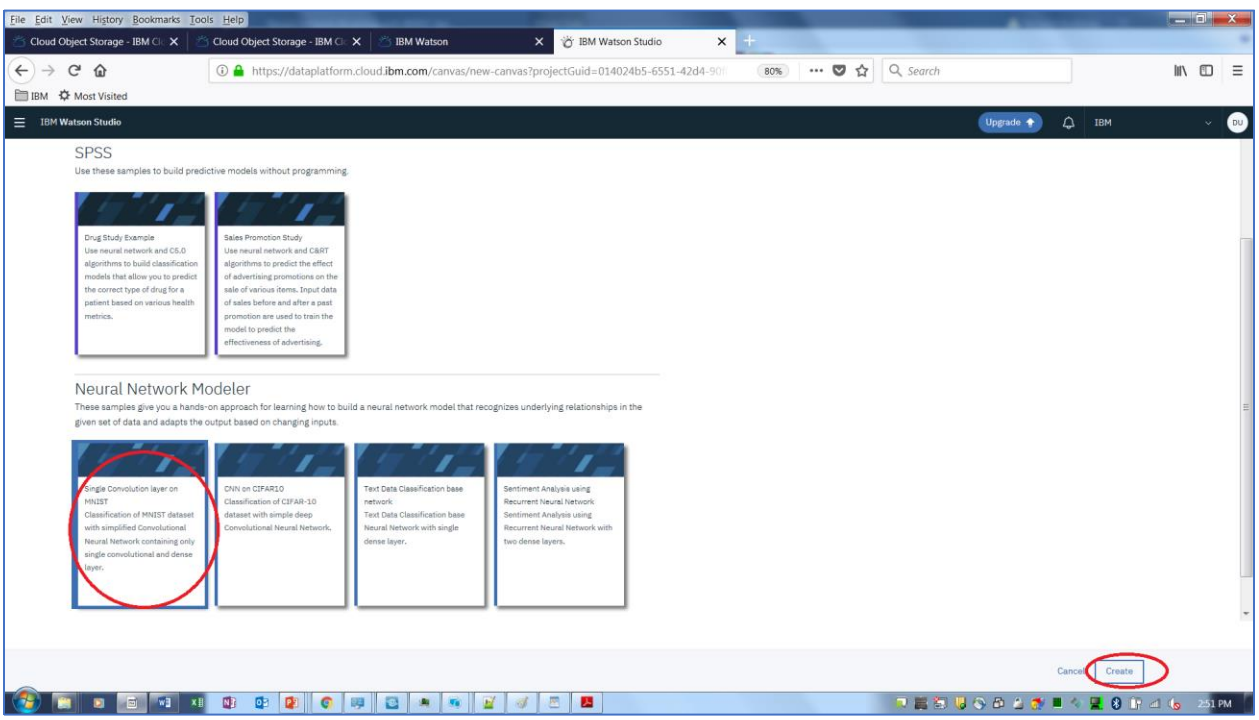
2. Click on the **Add to project** and then click on **MODELER FLOW**.



3. Click on **From example**.



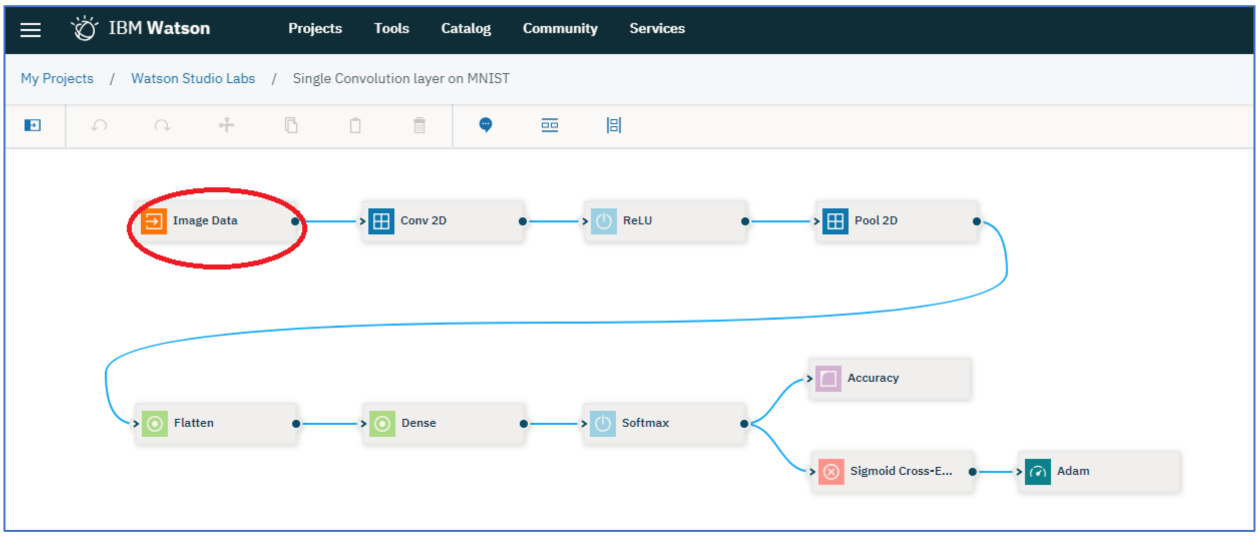
4. Click on the **Single Convolution Layer on MNIST** and then click on **Create**



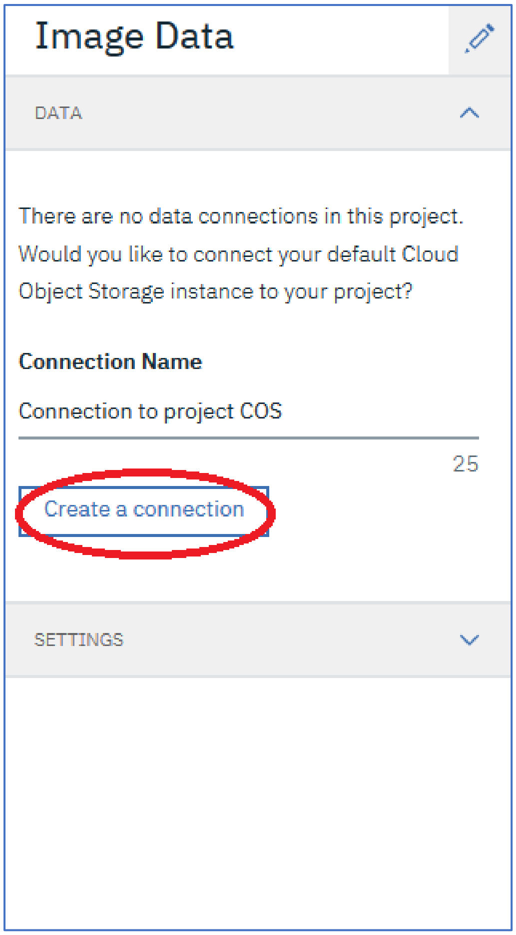
5. A standard convolution neural network (CNN) architecture is displayed on the Neural Network Modeler canvas. The Neural Network is represented in a graphical form instead of code. You will find a sidebar on the left of the screen containing all available neural

network components. The Neural Network Modeler enables the user to drag and drop nodes representing the different layers of a Neural Network and to connect them to create a **Flow**. Here, we have an already created neural network flow via the example.

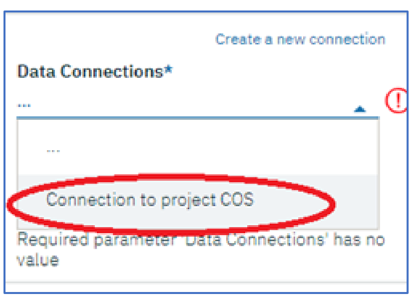
6. We still need to provide our neural network with a way to access the data we uploaded earlier. We configure the **Image Data** node for this purpose. Double-click on the **Image Data** node.



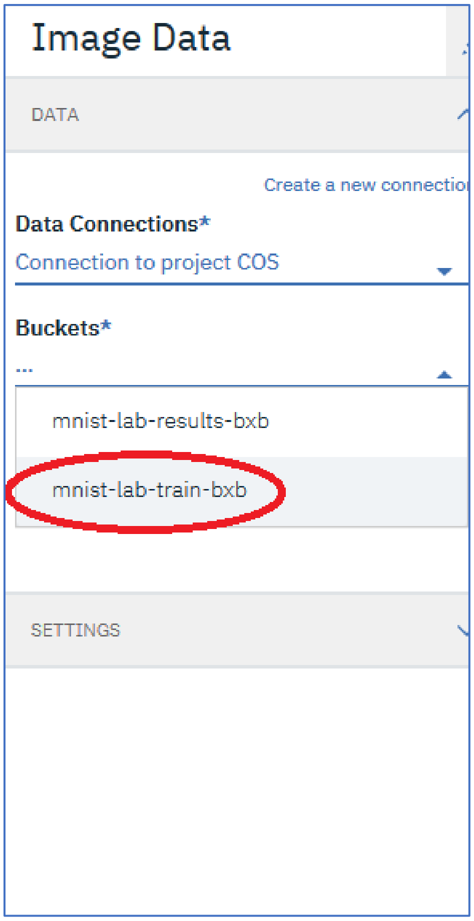
7. Leave the default **Connection Name** and click **Create Connection**.



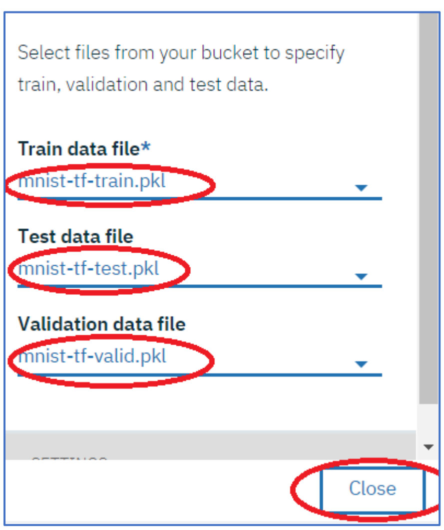
8. Click on the downward triangle icon underneath **Data Connections*.** Click on the connection that was just created.



9. Click on the downward triangle icon underneath **Buckets***, and then click on the **mnist-lab-train-xxx** where "xxx" are your initials.

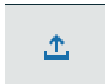


10. Click on the ▾ icon underneath **Train data file*** and select the **mnist-tf-train-pkl.** Assign the **Test data file** (**mnist-tf-test-pkl**), and **Validation data files** (**mnist-tf-valid-pkl**) in the same way and then click on **Close**.

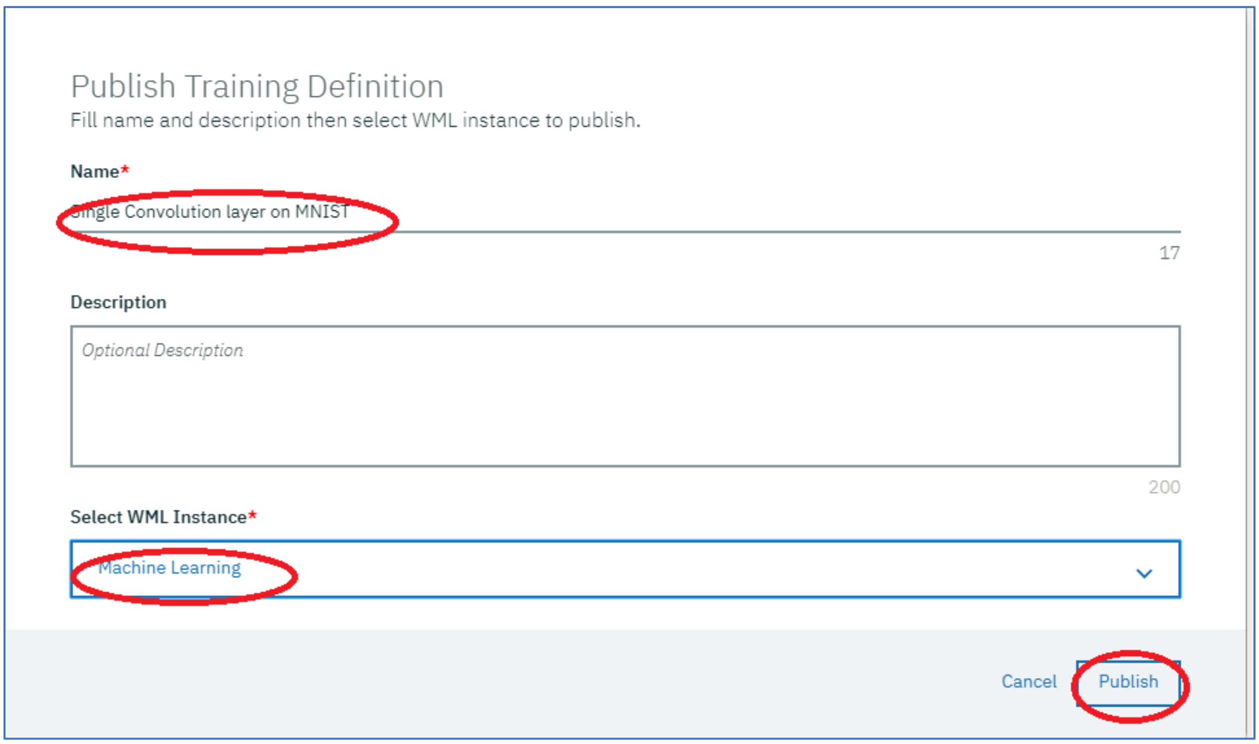


11. Explore the neural network flow modeler options

1. Click on the  icon to see the list of neural network component categories that are available
2. Explore the contents in each category. Hover over the components to get a pop-up description.
3. Click on the download icon  to see the multiple options for code generation.

12. Click on the **Publish** icon  to create a training definition.

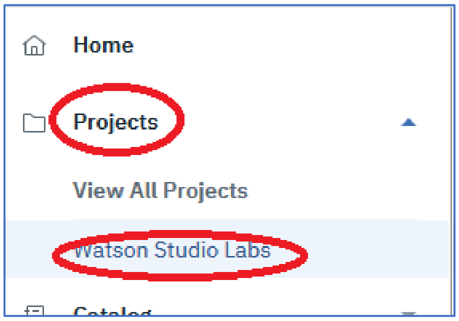
13. Enter a name for the training definition (or leave the default) and select the Machine Learning service that you created. Note, it will not be named Machine Learning unless that is the name that you used. Click on **Publish**.



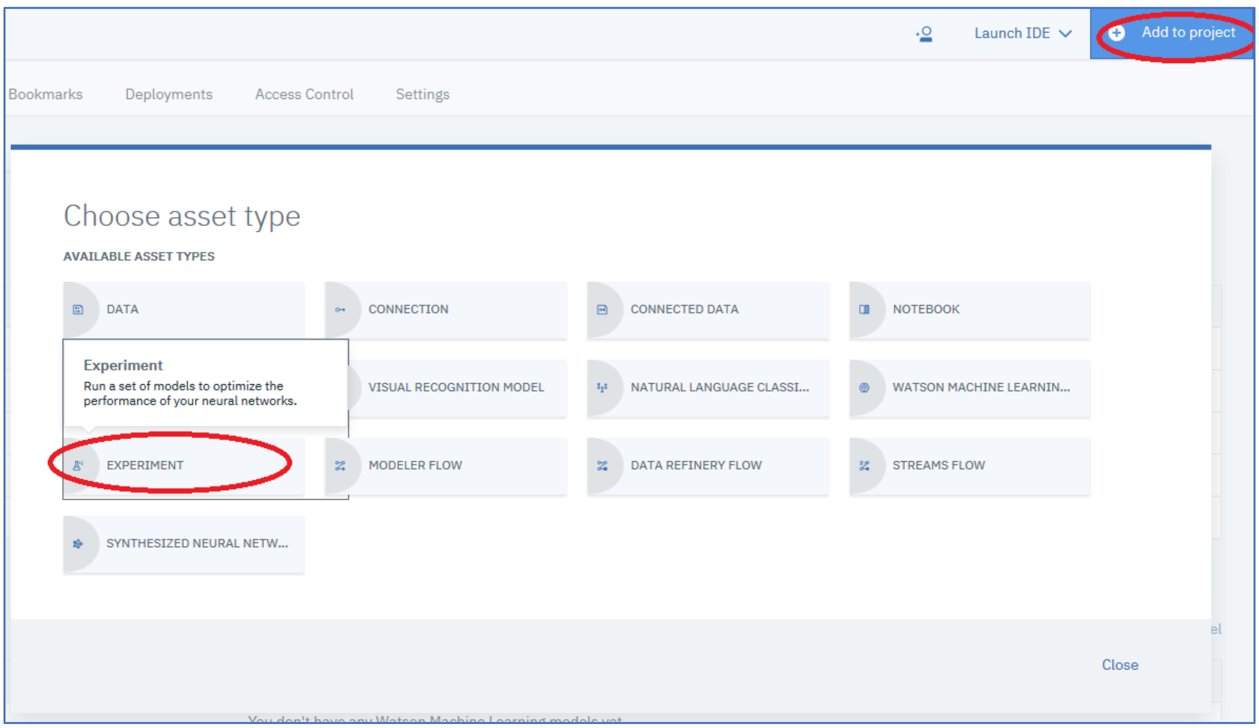
Step 3: Train the Model using Experiment Builder

As part of the model building process, we want to be able to compare different algorithms, and/or different algorithmic parameters to determine the best model. Experiment Builder is a facility in Watson Studio that supports this effort. Different training runs can be defined and run in parallel and their results can then be compared. In this lab, we will define only one training run to minimize the training time.

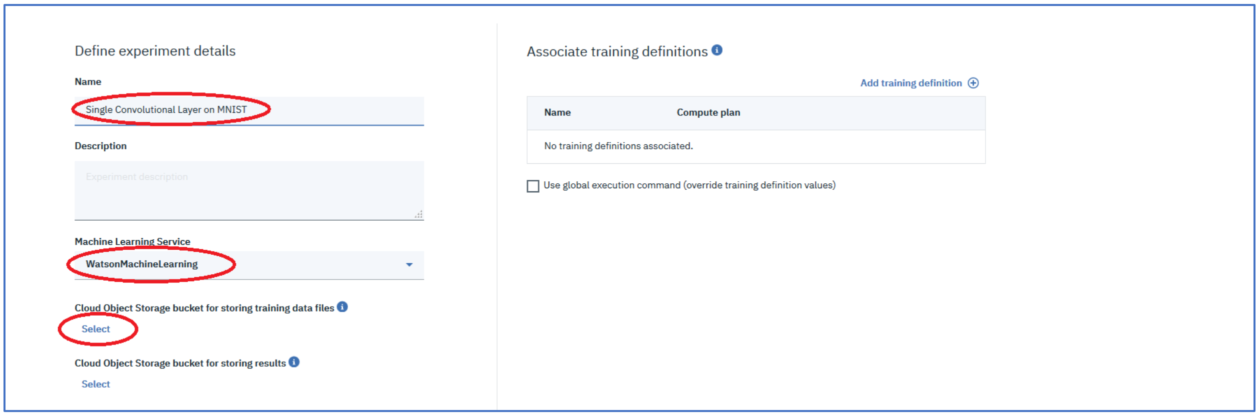
1. Return to the Watson Studio Labs **Assets** panel by clicking on the icon, then click on **Projects,** and then **Watson Studio Labs**. Click on the **Assets** tab if the Assets panel is not displayed.



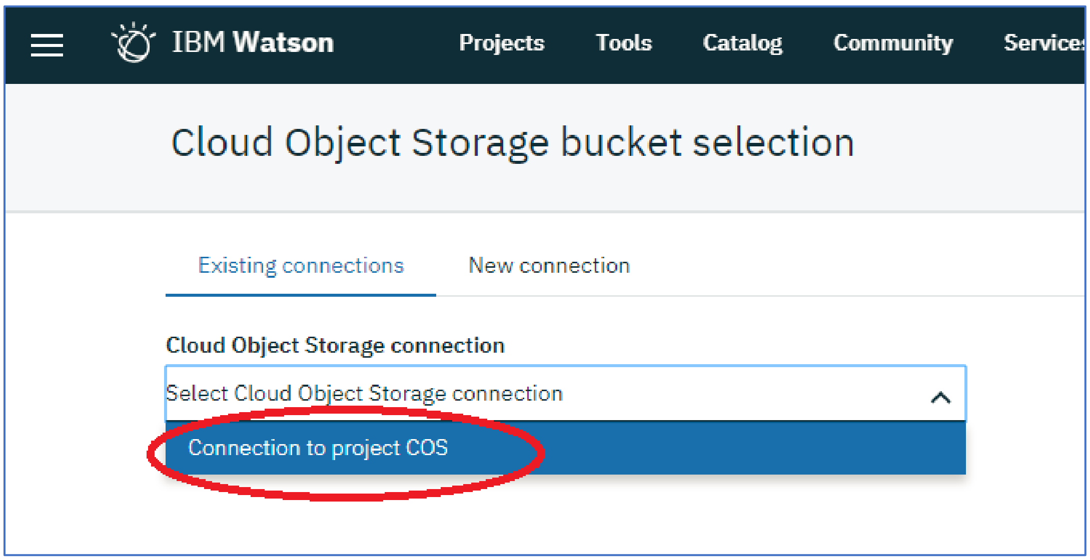
2. Click on **Add to project**, and then click **Experiment** to create a new Experiment.



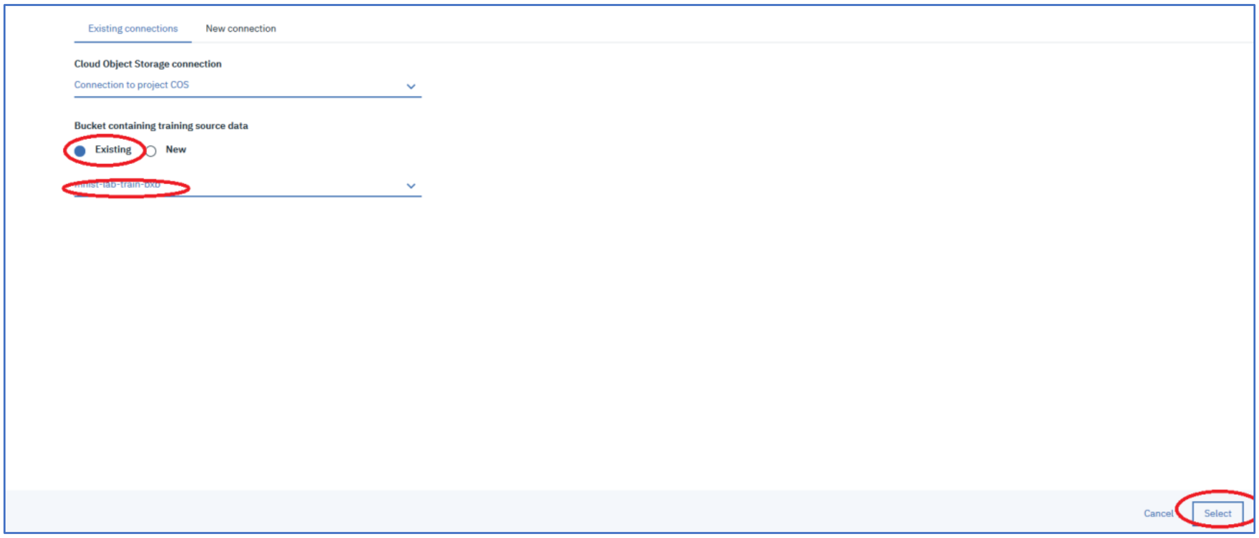
3. Enter an Experiment **Name**, select the **Machine Learning** service, and then click on **Select** to assign a Cloud Storage bucket.



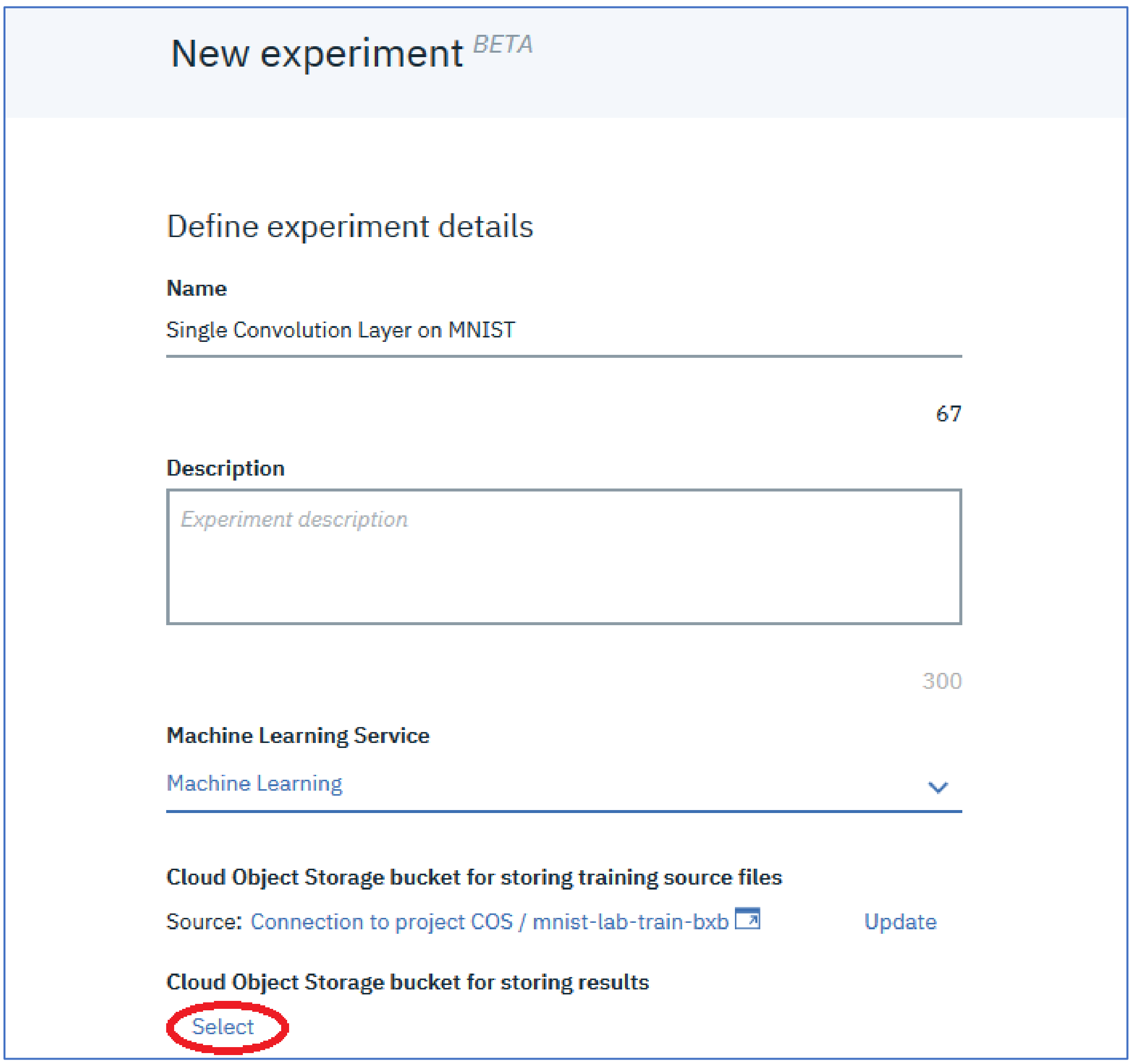
4. Select **Existing connections**, and then select the **Connection to project COS** connection.



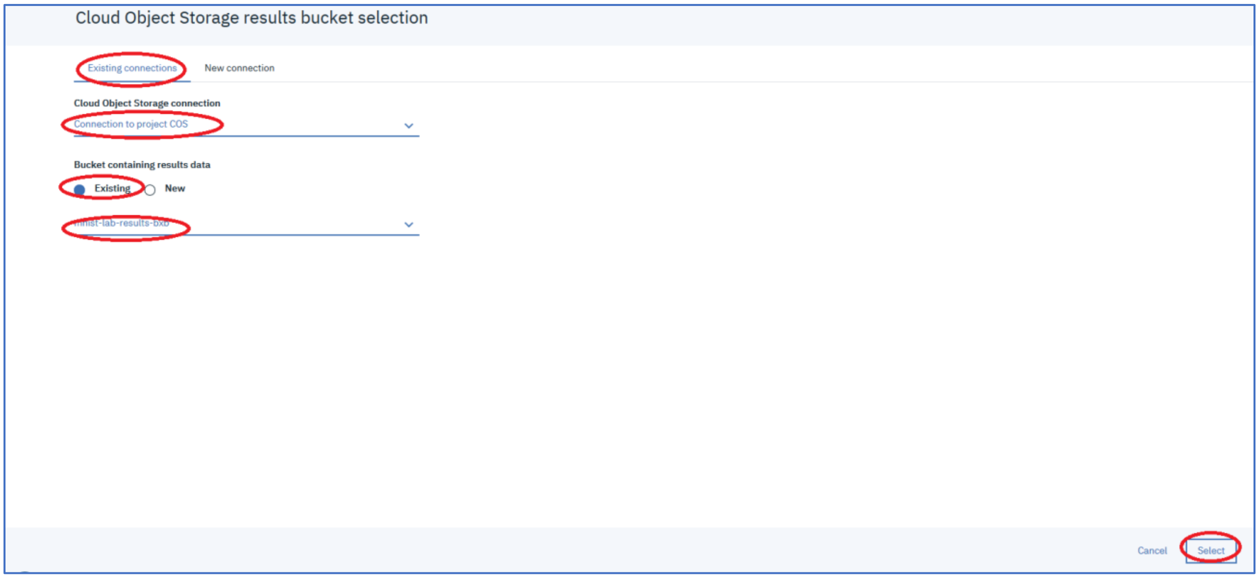
5. We now need to assign the Training buckets. Select **Existing** underneath **Bucket containing training source data** and click on mnist-lab-train-xxx, where "xxx" are your initials. Click on **Select**.



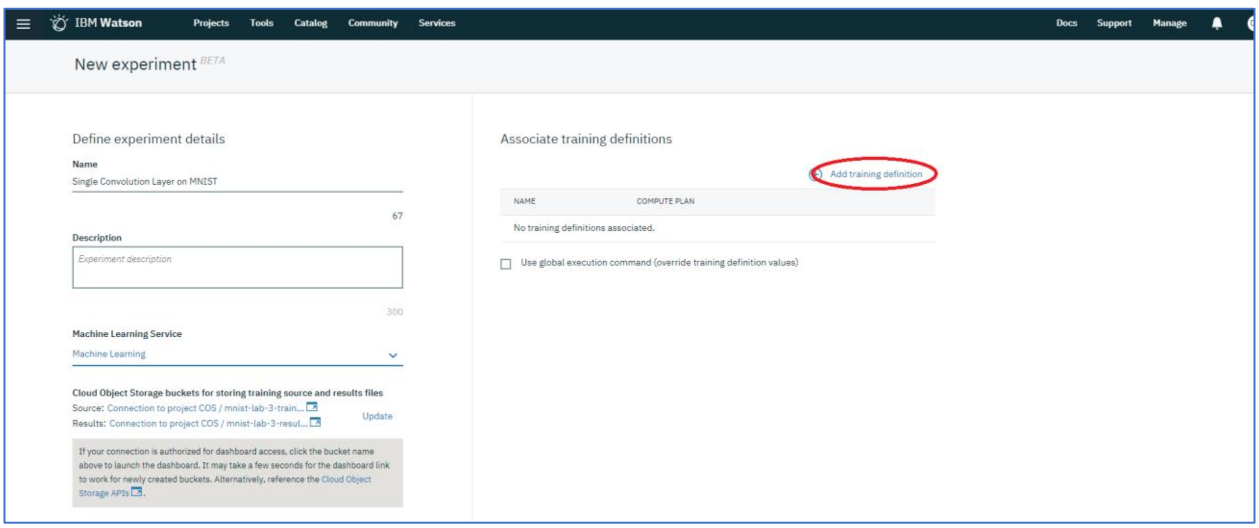
6. Click on **Select** underneath **Cloud Object Storage for storing results.**



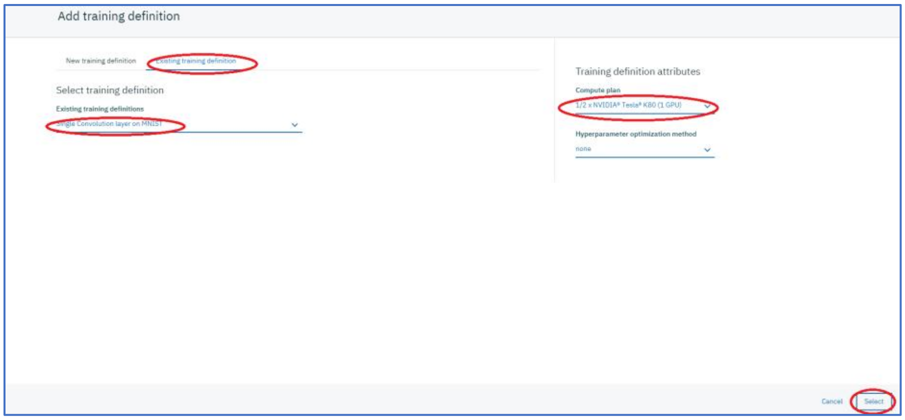
7. Follow the same procedure used to assign the training bucket to assign the results bucket. Assign bucket mnist-lab-results-xxx, where "xxx" are your initials, and then click on **Select.**



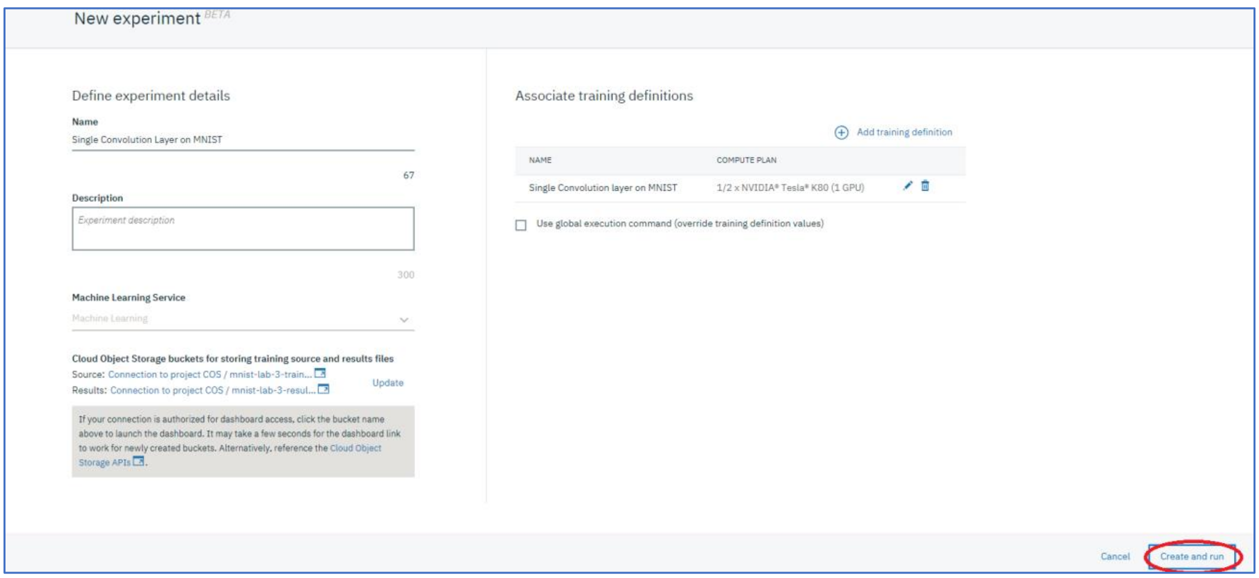
8. We now need to associate a Training Definition. Click on **Add Training Definition**.



9. Click on **Existing training definition,** and select **Single Convolution Layer on MNIST**, select 1/**2 x NVIDIA Tesla K80 (1 GPU)** for the compute plan, and then click **Select**.



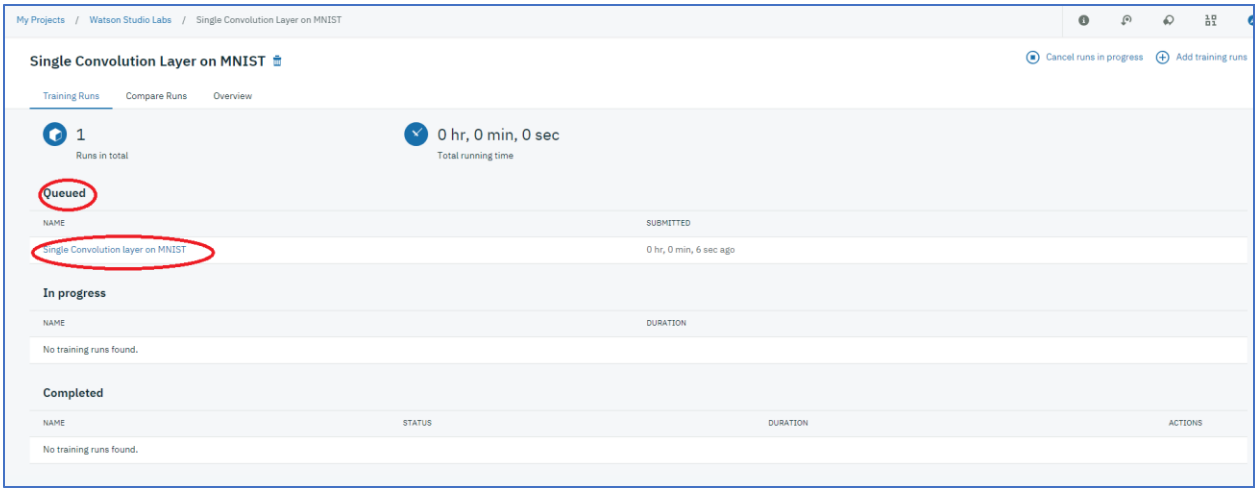
10. Click **Create and run**.



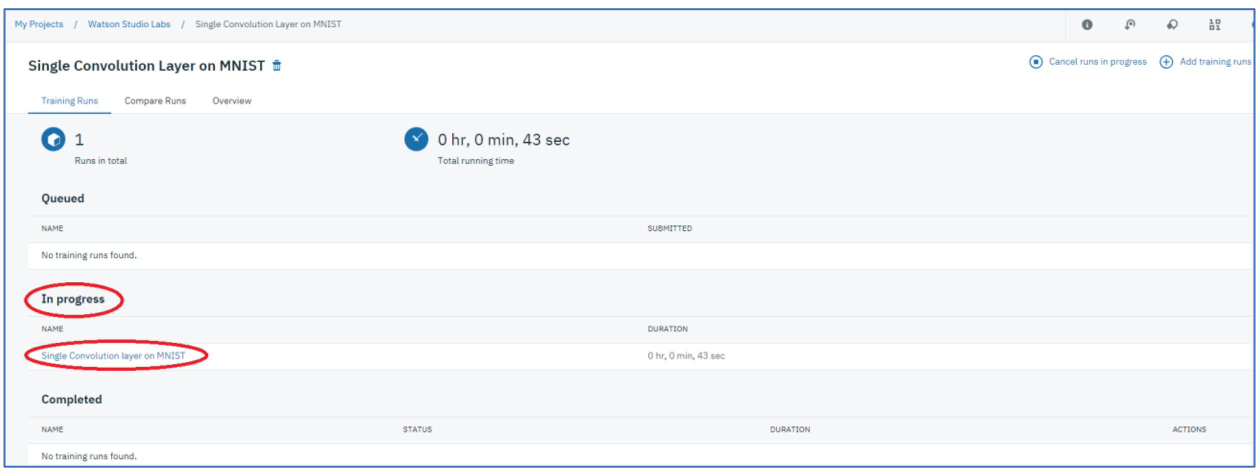
Step 4: Monitor the Training Progress and Results

Training runs will be first queued, then in-process, and then completed. Use the **Training Runs** tab to keep track of progress. Usually, it will take between 3-5 minutes.

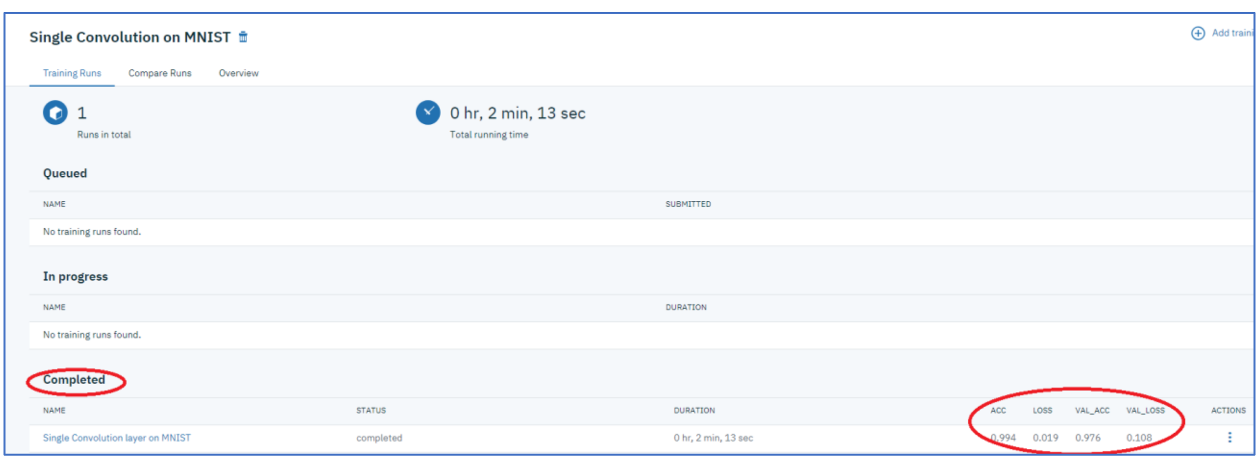
Queued Status



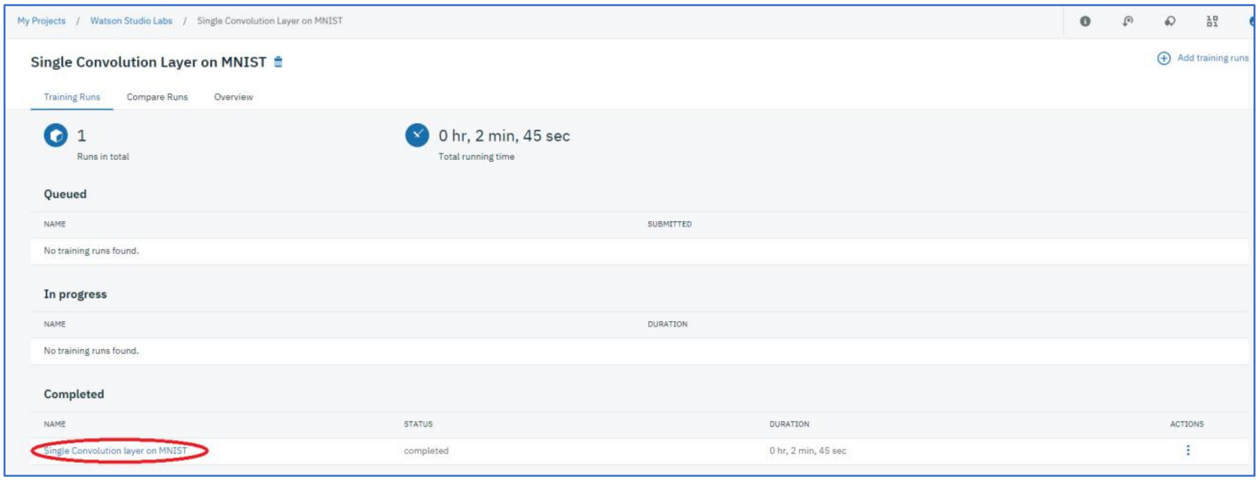
In-Process Status



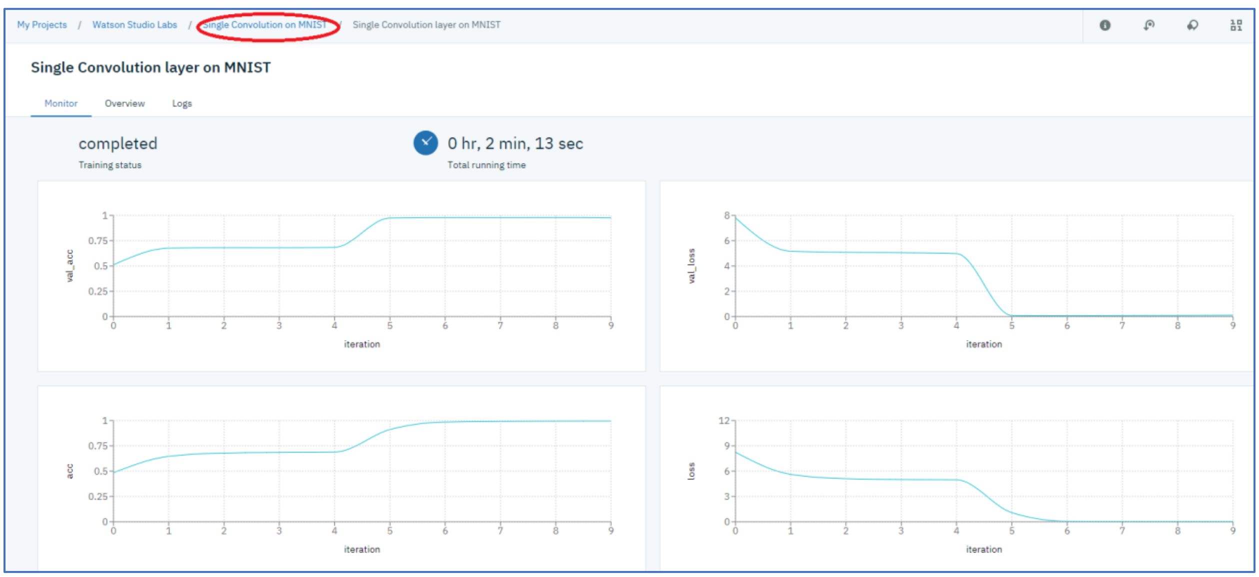
Completed Status – Note the statistics on the accuracy of the training set and validation set.



1. When completed, click on the Single Convolution layer on MNIST link.



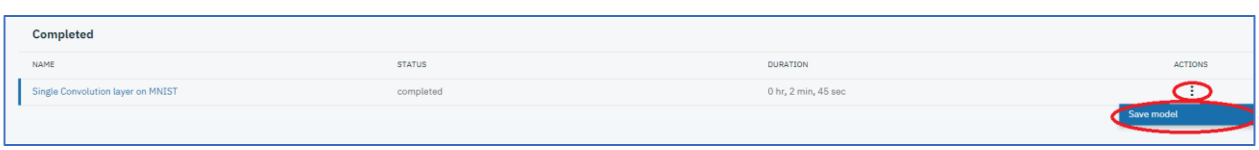
2. The display of the statistics over the training iterations is displayed. Click on the Single Convolution on MNIST tab to return to the Training Runs screen.



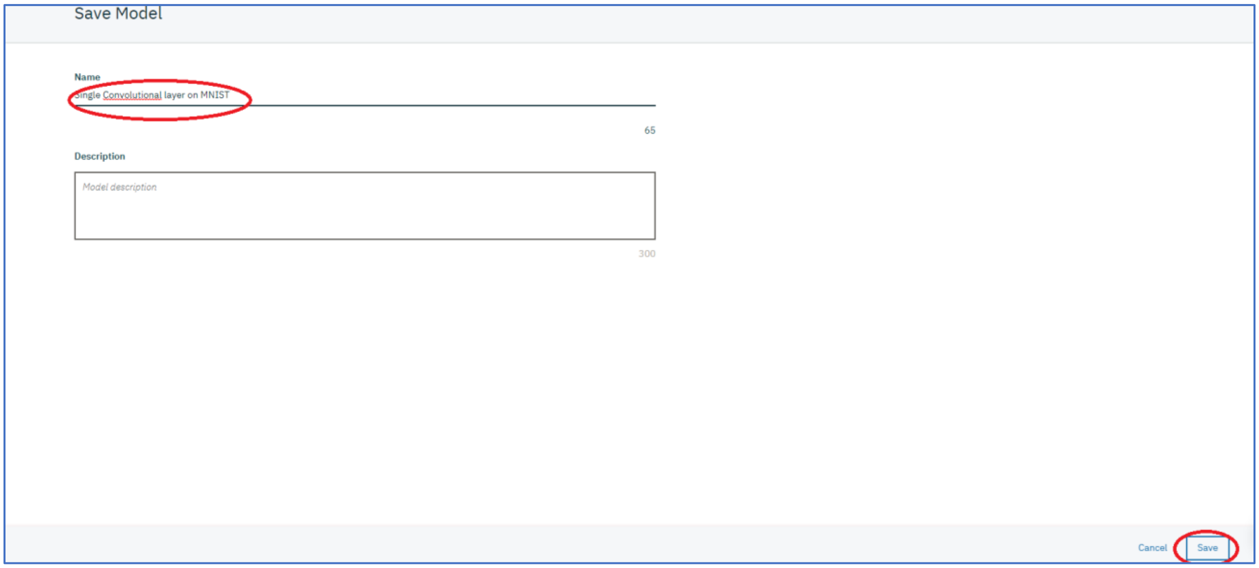
Step 5: Save and Deploy the Trained Model

We will now save the trained model to the Watson Machine Learning repository.

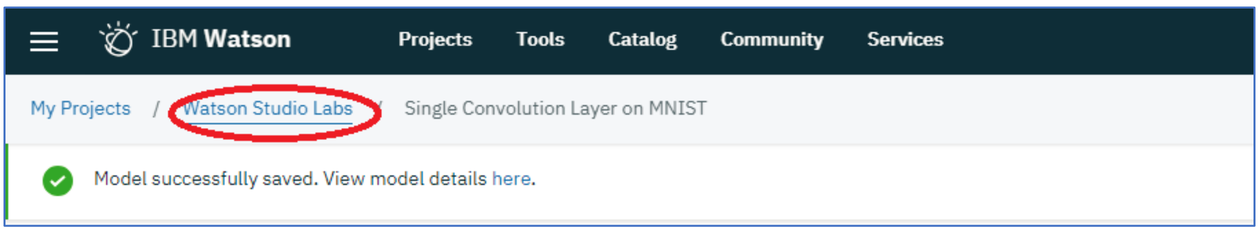
1. Click on the vertical ellipse under ACTIONS and click **Save model**.



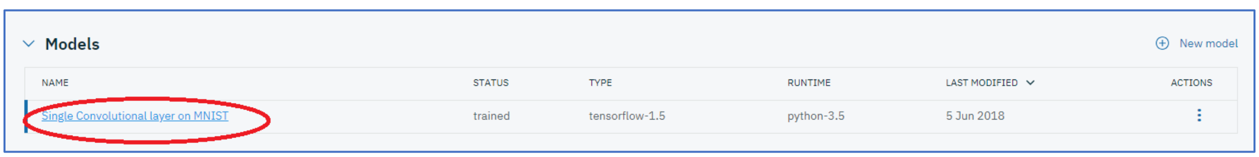
2. Enter a **Name** for the model (Single Convolution layer on MNIST) and click **Save.**



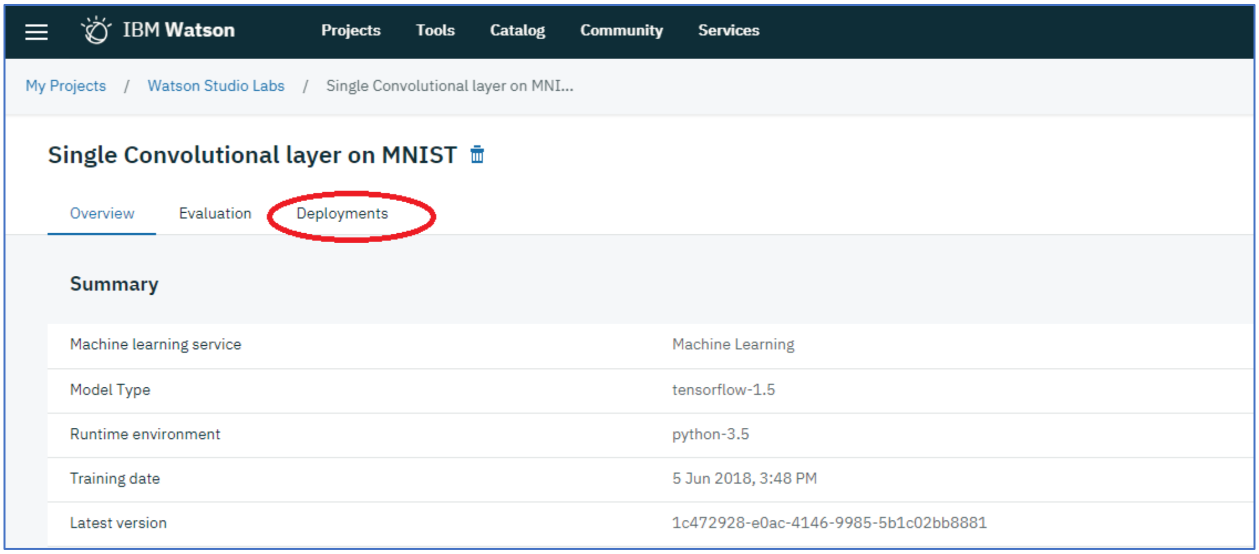
3. Return to the Watson Studio **Assets** panel, by clicking on **Watson Studio Labs** in the breadcrumb path. Click on the **Assets** tab if the Assets panel is not showing.



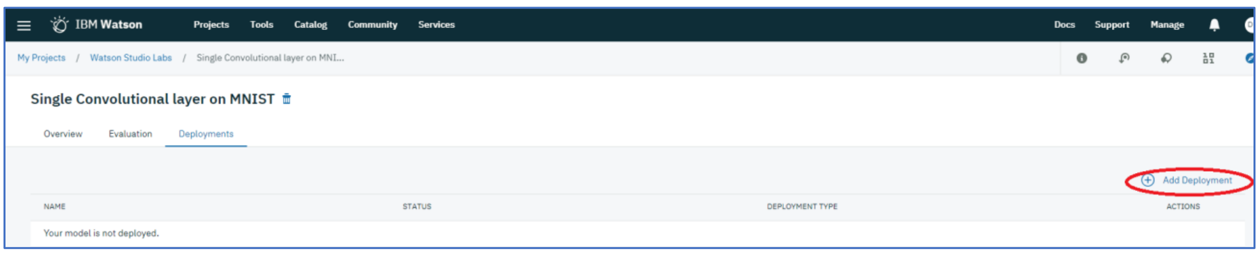
4. Click on the newly saved model



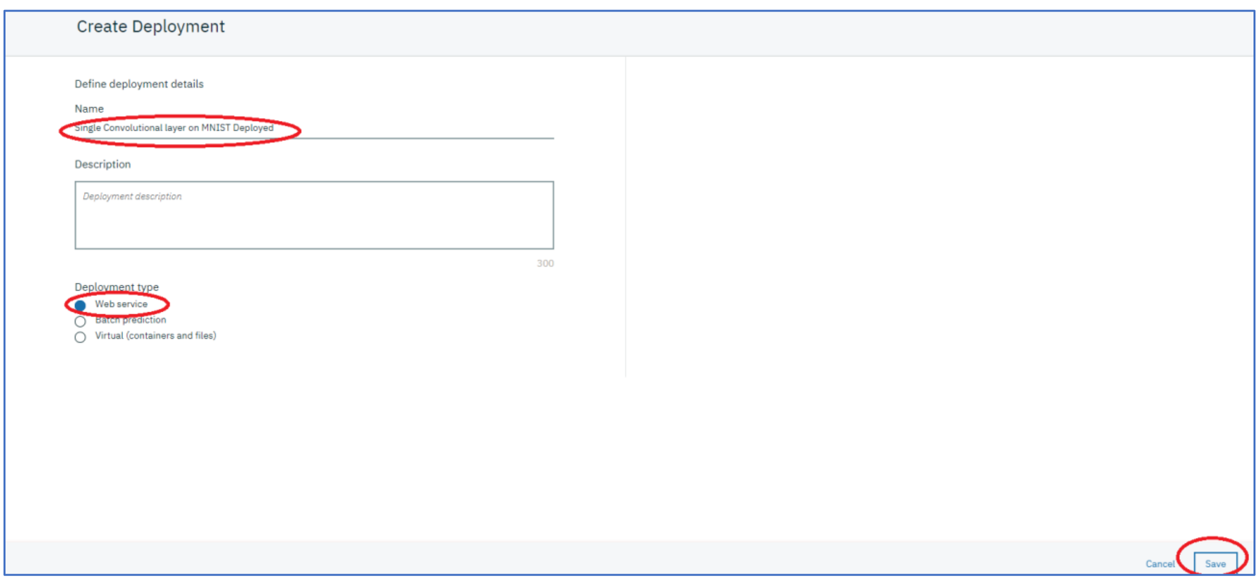
5. Click on **Deployments.**



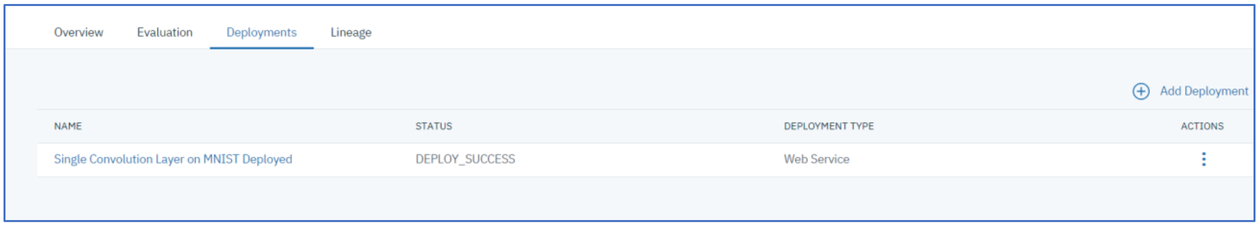
6. Click on **Add Deployment**.



7. Enter a **Name** (e.g. Single Convolution layer on MNIST Deployed), select **Web Service** (should be the default), and click on **Save**.

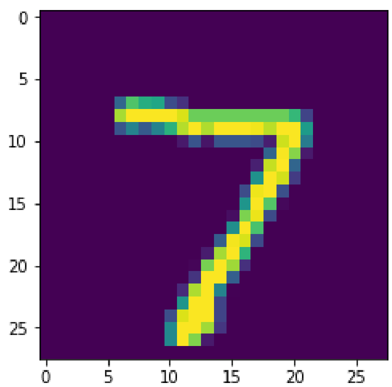


8. The model is successfully deployed.

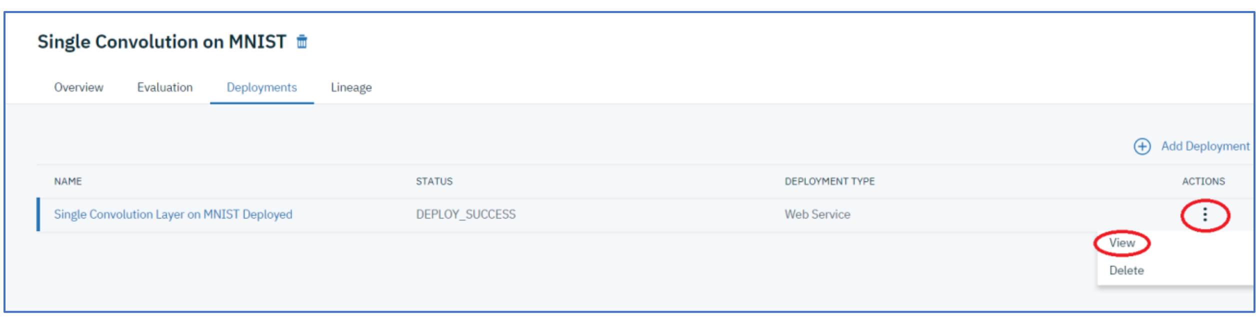


Step 6: Test the Deployed Model

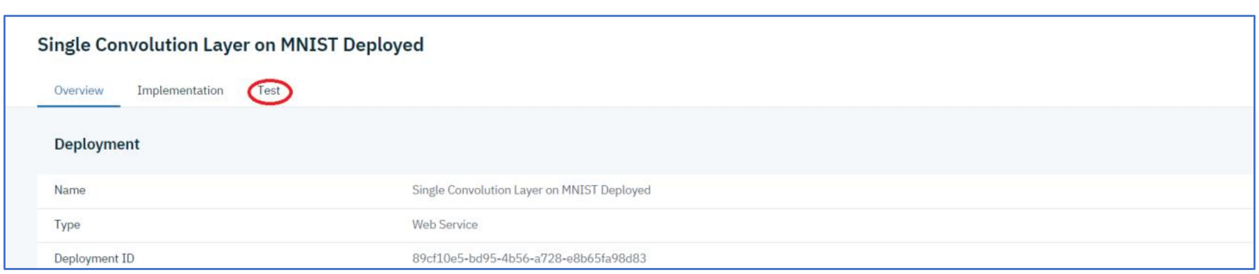
We will now test the deployed model using the sample image data contained in the file test.json that was extracted from the mnist.zip file previously. The test.json file is a representation of the following image.



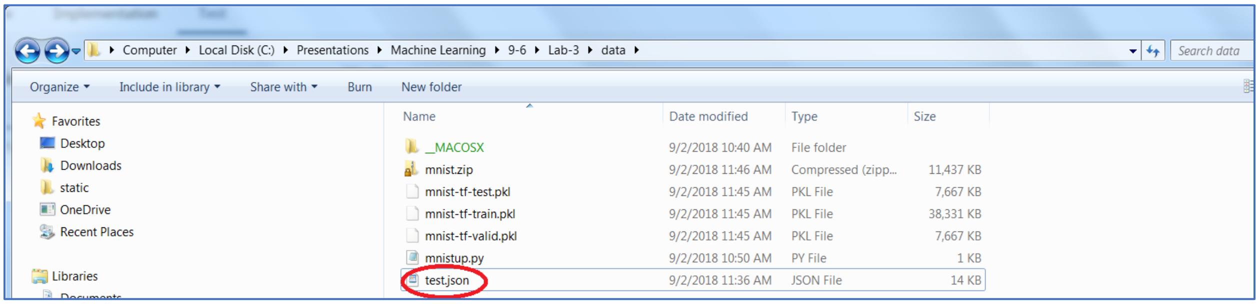
1. Click on the vertical ellipse, and then click on **View**.



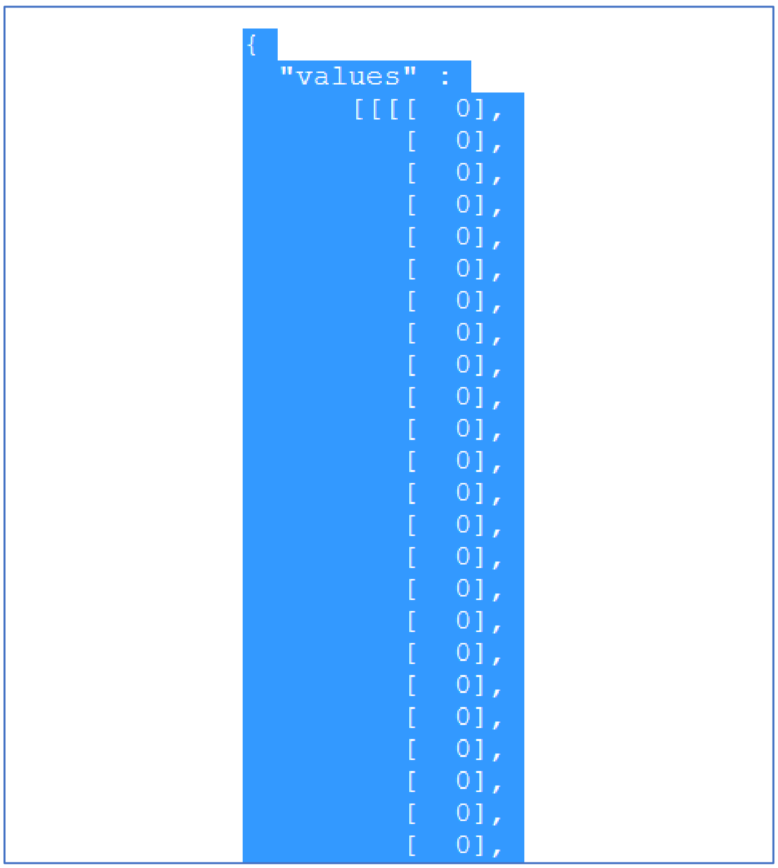
2. Click on **Test**.



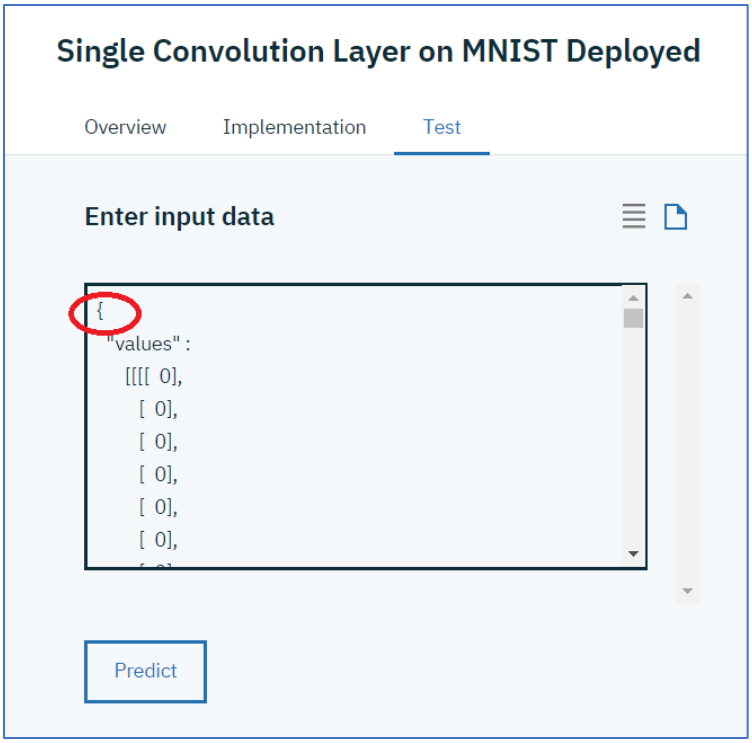
3. Go to the file directory where you have the “test.json” file stored, and double-click on the file.

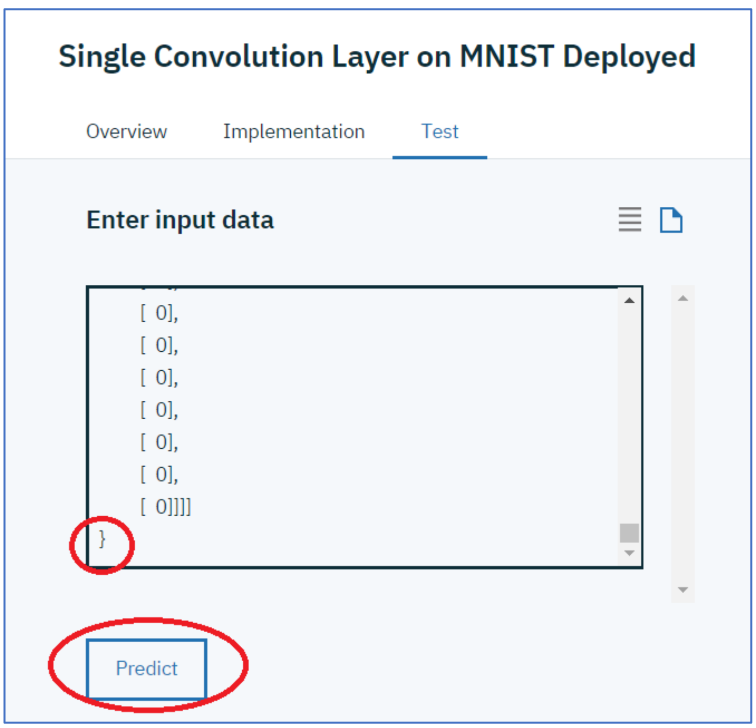


4. Select the contents of the file by placing the cursor to the left of the { and pressing and holding the <Shift><Ctrl><End> keys.

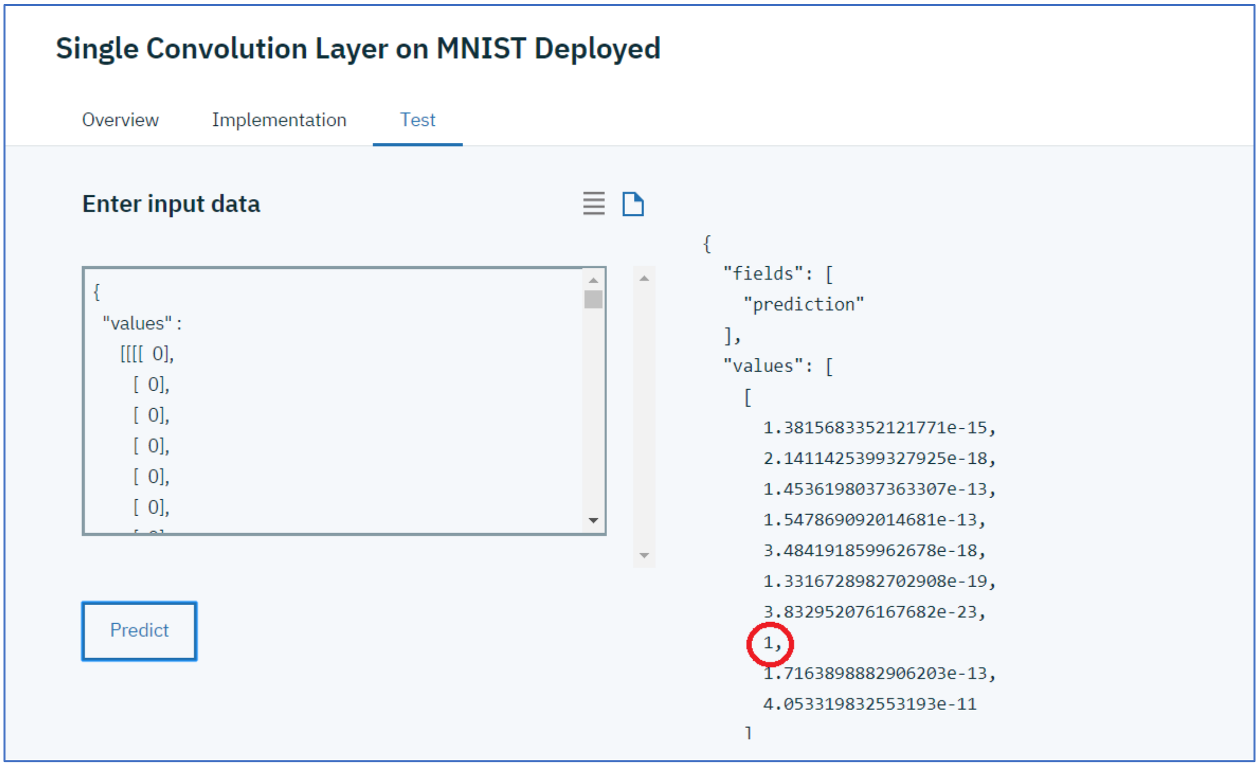


5. Copy and paste the content into the **Paste the request payload here** input data section. Make sure you have both the top bracket { at the beginning of the input data section and the bottom bracket } at the end of the input section data section, and then click on **Predict**.





6. Each of the values represent the confidence level for the digits 0,1,2,3,4,5,6,7,8, and 9. The digit that is recognized would have the largest of the confidence levels. Based on the values returned, we can see that the number 7 would be selected as the best fit for this sample image which matches the image shown above.



You have completed the Lab!

- ✓ Uploaded the data files to IBM Cloud Storage.
- ✓ Designed the neural network
- ✓ Trained the model
- ✓ Monitored the training progress and results
- ✓ Saved and Deployed the Trained Model
- ✓ Tested the Deployment