

README

Azure Machine Learning Pipeline with AutoMLStep

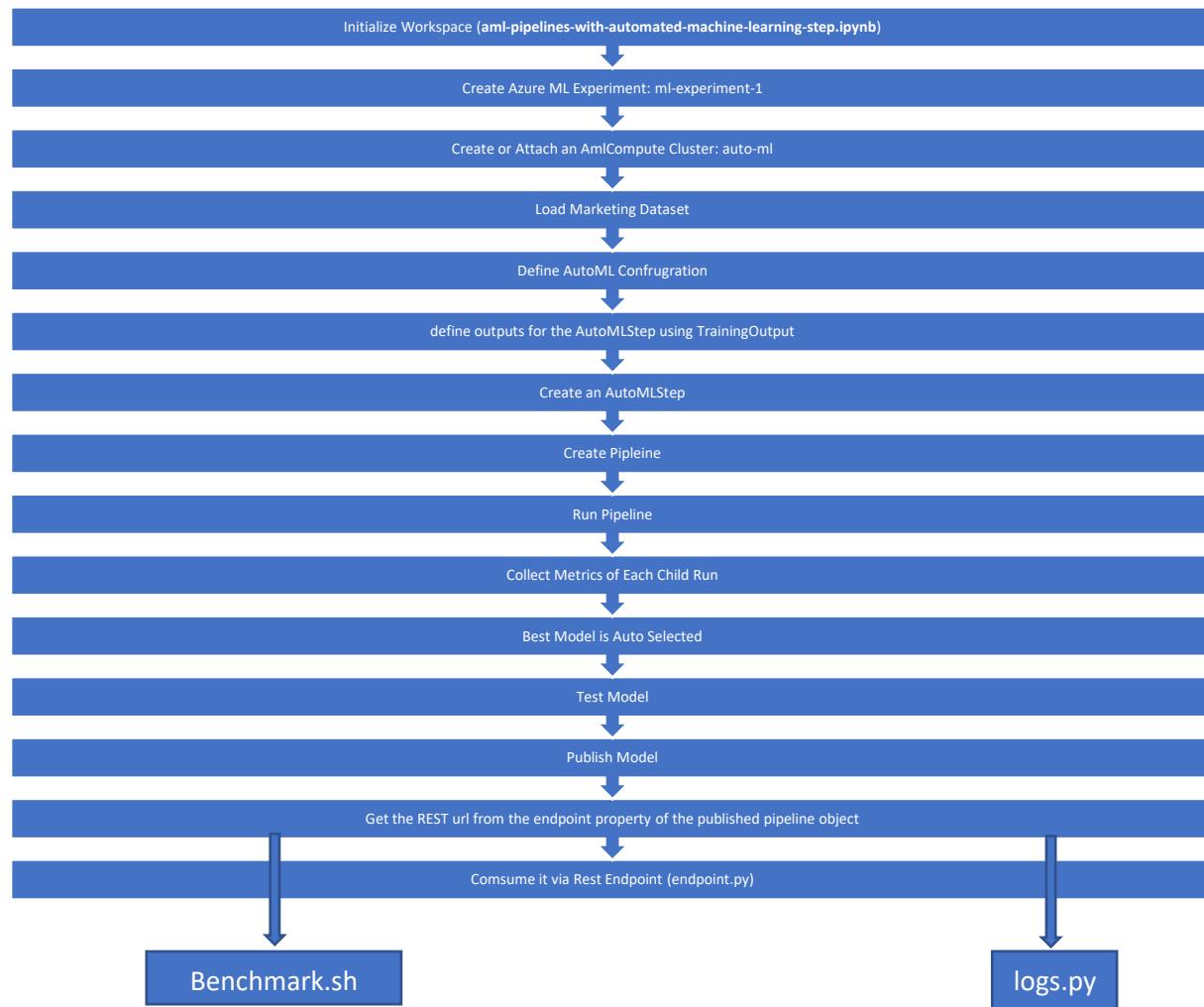
Overview:

The project demonstrates how Azure can be used to load data from a Bank Marketing Dataset for AutoML via AML Pipeline via AutoMLStep to solve a classification problem and how the auto selected generated model can be deployed and consumed via a REST end point. Here we study Machine Learning Ops Principles as well. We also study the benchmarking of the model with Apache Benchmark and logging of the steps in between. We study the project in two major steps one by creating an AutoML experiment via interface and another by deploying, running and altering the python code provided in the starter code on github. Provided Starter Code:

https://github.com/udacity/nd00333_AZMLND_C2/tree/master/starter_files

My Code (Completed Code): https://github.com/ashishsomvanshi/operationalizing_azureml

Architectural Diagram



Key Steps

We study the project in two major steps one by creating an AutoML experiment via interface and another by deploying, running and altering the python code provided in the starter code on github. Provided Starter Code:https://github.com/udacity/nd00333_AZMLND_C2/tree/master/starter_files. Relevant screenshots (87 items) are recorded. (link below). Also almost all major activity including the failed steps and repeated steps on rerun are recorded. (link below). Relevant python sdk was also installed including docker.

1) by creating an AutoML experiment via interface

Step 1: Authentication

In this step, I configured the azure cli (powershell) and the Azure Machine Learning Extension which allows you to interact with Azure Machine Learning Studio, part of the az command. After having the Azure machine Learning Extension, I created a Service Principal account and associate it with my workspace.

Since, I had installed the Azure Cli, installing az login module was not required, other steps needed to be followed as can be seen in the screen shots on next page. Creation of workspace, Installation and configuration of Azure Machine learning Extension along with creation of service principal and the Service Principal access to my workspace on Azure can be seen in the screenshots 1 to 14. Successful run of az ml workspace share can be seen in Screenshot 14 below.

Screenshot 1:

```
PS /home/ashish> az extension add -n azure-cli-ml
PS /home/ashish> az ml -h

Group
  az ml : AzureML CLI commands.

Subgroups:
  computetarget : Compute target subgroup commands.
  dataset      : Commands for managing datasets in Azure Machine Learning Workspace.
  datastore    : Commands for managing and using datastores with the Azure ML Workspace.
  endpoint     : Manage machine learning endpoints.
  environment  : Commands to manage environments.
  experiment   : Commands to manage experiments.
  folder       : Folder subgroup commands.
  model        : Manage machine learning models.
  pipeline     : Pipeline subgroup commands.
  run          : Commands for submitting, updating, and monitoring runs.
  service      : Manage operationalized services.
  workspace    : Workspace subgroup commands.

For more specific examples, use: az find "az ml"

You have 2 updates available. They will be updated with the next build of Cloud Shell.

Please let us know how we are doing: https://aka.ms/azureclihelps
PS /home/ashish> az ad sp create-for-rbac --sdk-auth --name ml-auth
Changing "ml-auth" to a valid URI or "http://ml-auth", which is the required format used for service principal names
Creating a role assignment under the scope of "/subscriptions/b2529fbd-c5eb-432c-9f53-718429853089"
Retrying role assignment creation: 1/36
{
  "clientId": "5fd1d203-654c-4e2a-ac7d-7de8282d35ca",
  "clientSecret": "YUax3ome79FswMT680-a_Phu6GjJ9Aij",
  "subscriptionId": "b2529fbd-c5eb-432c-9f53-718429853089",
  "tenantId": "4307b62d-0caa-49ac-8e8d-612a78446d81",
  "activeDirectoryEndpointUrl": "https://login.microsoftonline.com",
  "resourceManagerEndpointUrl": "https://management.core.windows.net/",
  "activeDirectoryGraphResourceId": "https://graph.windows.net",
  "sqlManagementEndpointUrl": "https://management.core.windows.net:8843/",
  "galleryEndpointUrl": "https://gallery.azure.com",
  "managementEndpointUrl": "https://management.core.windows.net"
}
PS /home/ashish> |
```

Screenshot 2:

```
PS /home/ashish> az extension add -n azure-cli-ml
PS /home/ashish> az ml -h

Group
  az ml : AzureML CLI commands.

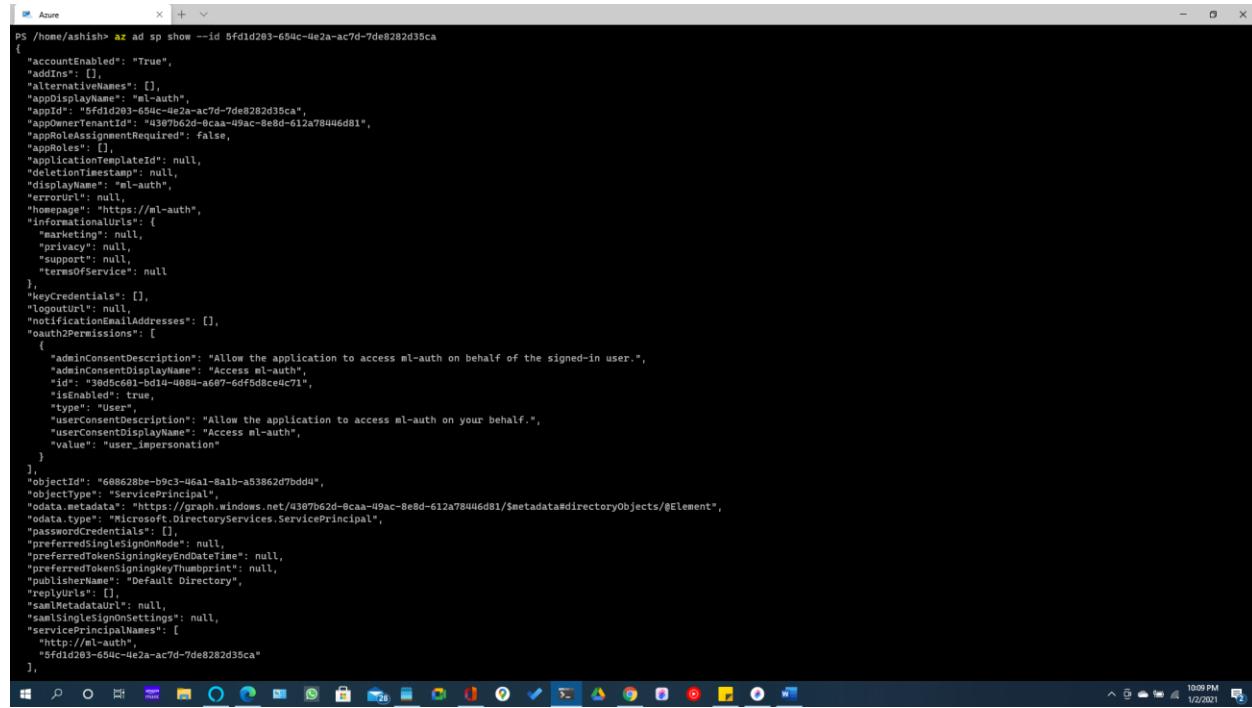
Subgroups:
  computetarget : Compute target subgroup commands.
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  endpoint     : Manage machine learning endpoints.
  environment  : Commands to manage environments.
  experiment   : Commands to manage experiments.
  folder       : Folder subgroup commands.
  model        : Manage machine learning models.
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  service      : Manage operationalized services.
  workspace    : Workspace subgroup commands.

For more specific examples, use: az find "az ml"

You have 2 updates available. They will be updated with the next build of Cloud Shell.

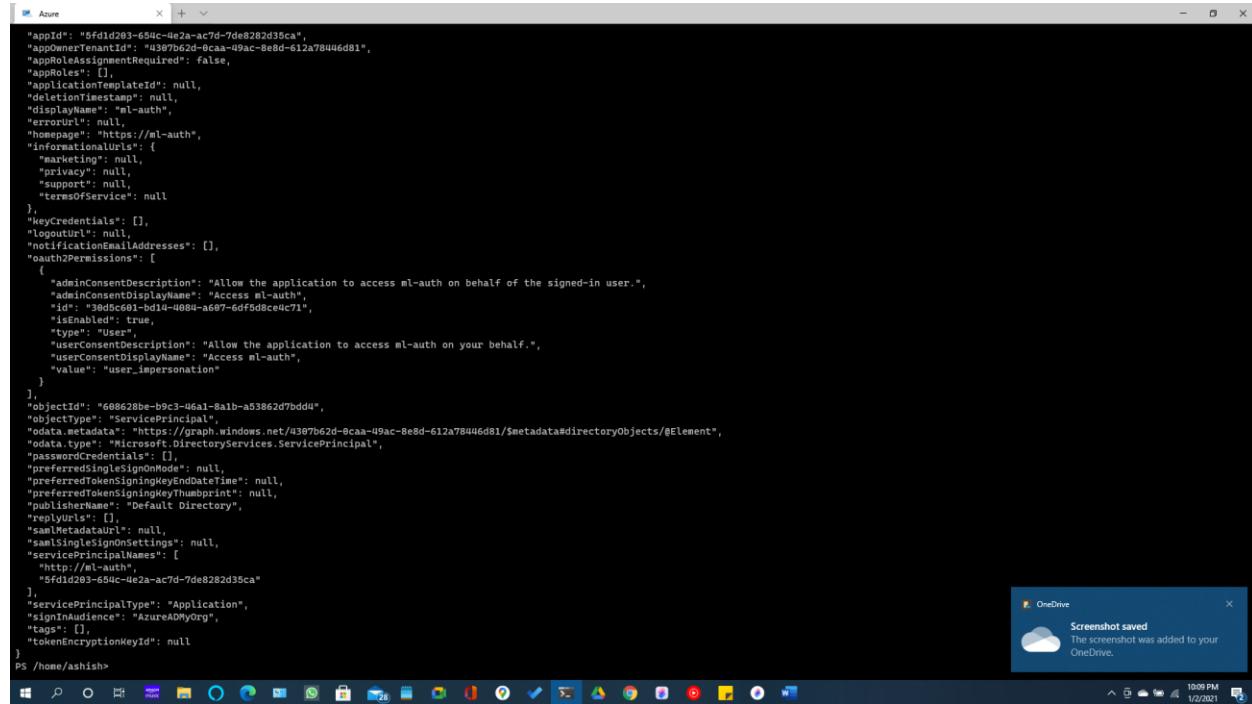
Please let us know how we are doing: https://aka.ms/azureclihelps
PS /home/ashish> az ad sp create-for-rbac --sdk-auth --name ml-auth
Changing "ml-auth" to a valid URI or "http://ml-auth", which is the required format used for service principal names
Creating a role assignment under the scope of "/subscriptions/b2529fbd-c5eb-432c-9f53-718429853089"
Retrying role assignment creation: 1/36
{
  "clientId": "5fd1d203-654c-4e2a-ac7d-7de8282d35ca",
  "clientSecret": "YUax3ome79FswMT680-a_Phu6GjJ9Aij",
  "subscriptionId": "b2529fbd-c5eb-432c-9f53-718429853089",
  "tenantId": "4307b62d-0caa-49ac-8e8d-612a78446d81",
  "activeDirectoryEndpointUrl": "https://login.microsoftonline.com",
  "resourceManagerEndpointUrl": "https://management.azure.com",
  "activeDirectoryGraphResourceId": "https://graph.windows.net",
  "sqlManagementEndpointUrl": "https://management.core.windows.net:8843",
  "galleryEndpointUrl": "https://gallery.azure.com",
  "managementEndpointUrl": "https://management.core.windows.net"
}
PS /home/ashish> az ad sp show --id 5fd1d203-654c-4e2a-ac7d-7de8282d35ca
{
  "accountEnabled": "True",
  "adDns": [],
  "alternativeName": [],
  "appDisplayName": "ml-auth",
  "appId": "5fd1d203-654c-4e2a-ac7d-7de8282d35ca",
  "appOwnerTenantId": "4307b62d-0caa-49ac-8e8d-612a78446d81",
  "applicationPermissionRequired": false,
  "appRoles": [],
  "applicationTemplateId": null,
  "deletionTimestamp": null,
  "displayName": "ml-auth",
  "errorUrl": null,
  "homepage": "https://ml-auth",
  "informationalUrls": {
    "marketing": null,
    "privacy": null,
    "support": null,
  },
}
```

Screenshot 3:



```
PS /home/ashish> az ad sp show --id 5fd1d203-654c-4e2a-ac7d-7de8282d35ca
{
  "accountEnabled": "True",
  "addIns": [],
  "alternativeNames": [],
  "appDisplayName": "ml-auth",
  "appId": "5fd1d203-654c-4e2a-ac7d-7de8282d35ca",
  "appOwnerTenantId": "4307b62d-0caa-49ac-8e8d-612a78446d81",
  "appRoleAssignmentRequired": false,
  "appRoles": [],
  "applicationTemplateId": null,
  "deletionTimestamp": null,
  "displayName": "ml-auth",
  "errorUrl": null,
  "homepage": "https://ml-auth",
  "informationalUrls": {
    "marketing": null,
    "privacy": null,
    "support": null,
    "termsOfService": null
  },
  "keyCredentials": [],
  "logoutUrl": null,
  "notificationEmailAddresses": [],
  "oauth2Permissions": [
    {
      "adminConsentDescription": "Allow the application to access ml-auth on behalf of the signed-in user.",
      "adminConsentDisplayName": "Access ml-auth",
      "id": "36ddc601-bd14-4084-a607-6df5d8ce4c71",
      "isEnabled": true,
      "type": "User",
      "userConsentDescription": "Allow the application to access ml-auth on your behalf.",
      "userConsentDisplayName": "Access ml-auth",
      "value": "user_impersonation"
    }
  ],
  "objectId": "608628be-b9c3-46a1-8a1b-a53862d7bdd4",
  "objectType": "ServicePrincipal",
  "odata.metadata": "https://graph.windows.net/4307b62d-0caa-49ac-8e8d-612a78446d81/$metadata#directoryObjects/@Element",
  "odata.type": "Microsoft.DirectoryServices.ServicePrincipal",
  "passwordCredentials": [],
  "preferredSingleSignOnMode": null,
  "preferredTokenSigningKeyEndDateTime": null,
  "preferredTokenSigningKeyThumbprint": null,
  "publisherName": "Default Directory",
  "replyUrls": [],
  "samlMetadataUrl": null,
  "samlSingleSignOnSettings": null,
  "servicePrincipalNames": [
    "http://ml-auth",
    "5fd1d203-654c-4e2a-ac7d-7de8282d35ca"
  ]
}
```

Screenshot 4:



```
PS /home/ashish> az ad sp show --id 5fd1d203-654c-4e2a-ac7d-7de8282d35ca
{
  "appId": "5fd1d203-654c-4e2a-ac7d-7de8282d35ca",
  "appOwnerTenantId": "4307b62d-0caa-49ac-8e8d-612a78446d81",
  "appRoleAssignmentRequired": false,
  "appRoles": [],
  "applicationTemplateId": null,
  "deletionTimestamp": null,
  "displayName": "ml-auth",
  "errorUrl": null,
  "homepage": "https://ml-auth",
  "informationalUrls": {
    "marketing": null,
    "privacy": null,
    "support": null,
    "termsOfService": null
  },
  "keyCredentials": [],
  "logoutUrl": null,
  "notificationEmailAddresses": [],
  "oauth2Permissions": [
    {
      "adminConsentDescription": "Allow the application to access ml-auth on behalf of the signed-in user.",
      "adminConsentDisplayName": "Access ml-auth",
      "id": "36ddc601-bd14-4084-a607-6df5d8ce4c71",
      "isEnabled": true,
      "type": "User",
      "userConsentDescription": "allow the application to access ml-auth on your behalf.",
      "userConsentDisplayName": "Access ml-auth",
      "value": "user_impersonation"
    }
  ],
  "objectId": "608628be-b9c3-46a1-8a1b-a53862d7bdd4",
  "objectType": "ServicePrincipal",
  "odata.metadata": "https://graph.windows.net/4307b62d-0caa-49ac-8e8d-612a78446d81/$metadata#directoryObjects/@Element",
  "odata.type": "Microsoft.DirectoryServices.ServicePrincipal",
  "passwordCredentials": [],
  "preferredSingleSignOnMode": null,
  "preferredTokenSigningKeyEndDateTime": null,
  "preferredTokenSigningKeyThumbprint": null,
  "publisherName": "Default Directory",
  "replyUrls": [],
  "samlMetadataUrl": null,
  "samlSingleSignOnSettings": null,
  "servicePrincipalNames": [
    "http://ml-auth",
    "5fd1d203-654c-4e2a-ac7d-7de8282d35ca"
  ]
},
"servicePrincipalType": "Application",
"signInAudience": "AzureADMyOrg",
"tags": [],
"tokenEncryptionKeyId": null
}
PS /home/ashish>
```

OneDrive

Screenshot saved

The screenshot was added to your OneDrive.

10:09 PM 1/2/2021

Screenshot 5:

The screenshot shows the 'Create a machine learning workspace' form in the Azure portal. The 'Basics' tab is selected. Under 'Project details', the subscription is set to 'Azure subscription 1' and the resource group is 'cloud-shell-storage-southeastasia'. In the 'Workspace details' section, the workspace name is 'MyAzureML', located in 'East US' with storage account '(new) myazureml7517765703'. Key vault, application insights, and container registry are all set to 'None'. At the bottom, there are 'Review + create' and 'Next: Networking' buttons.

Screenshot 6:

The screenshot shows the same workspace creation form as Screenshot 5, but with a message box at the top right indicating a deployment process: '*** Initializing deployment... 10:38 PM Initializing template deployment to resource group 'cloud-shell-storage-southeastasia''. The 'Networking' and 'Advanced' sections are also visible.

Screenshot 7:

The screenshot shows the Microsoft Azure Machine Learning Services Overview page. At the top, it displays the deployment name: Microsoft.MachineLearningServices, subscription: Azure subscription 1, and resource group: cloud-shell-storage-southeastasia. The deployment status is shown as "Deployment is in progress". The start time is 1/2/2021, 10:38:23 PM, and the correlation ID is 8995a9ae-bc8d-429e-94f3-aa14306bb0ce. Below this, there is a "Deployment details" section with a download link. On the right side of the page, there are links for Security Center, Free Microsoft tutorials, and Work with an expert.

Screenshot 8:

The screenshot shows the Microsoft Azure Machine Learning Services Overview page. It is identical to Screenshot 7 in terms of deployment status and metadata. However, the "Deployment details" section now lists four resources: MyAzureML (Type: Microsoft.MachineLearningServices/workspaces, Status: Accepted), myazurerm8273629959 (Type: Microsoft.Insights/components, Status: OK), myazurerm0023416128 (Type: Microsoft.KeyVault/vaults, Status: OK), and myazurerm7517765703 (Type: Microsoft.Storage/storageAccounts, Status: OK). The right sidebar also includes a "Work with an expert" section.

Screenshot 9:

The screenshot shows the Microsoft Machine Learning Services Overview page. At the top, it says "Your deployment is complete". Below that, it lists deployment details: Deployment name: Microsoft.MachineLearningServices, Subscription: Azure subscription 1, Resource group: cloud-shell-storage-southeastasia. It also shows the start time as 1/2/2021, 10:38:25 PM and a Correlation ID: 8995a9ae-bc8d-429e-94f3-aa14306bb0ce. On the right side, there are links for Security Center, Free Microsoft tutorials, and Work with an expert.

Screenshot 10:

The screenshot shows the Microsoft Machine Learning Services Overview page. At the top, it says "Your deployment is complete". Below that, it lists deployment details: Deployment name: Microsoft.MachineLearningServices, Subscription: Azure subscription 1, Resource group: cloud-shell-storage-southeastasia. It also shows the start time as 1/2/2021, 10:38:25 PM and a Correlation ID: 8995a9ae-bc8d-429e-94f3-aa14306bb0ce. Under "Deployment details", there is a table showing resource information:

Resource	Type	Status	Operation details
MyAzureML	Microsoft.MachineLearningServices/workspaces	OK	Operation details
myazureml8273629959	Microsoft.Insights/components	OK	Operation details
myazureml0023416128	Microsoft.KeyVault/vaults	OK	Operation details
myazureml7517765703	Microsoft.Storage/storageAccounts	OK	Operation details

On the right side, there are links for Security Center, Free Microsoft tutorials, and Work with an expert.

Screenshot 11:

This screenshot shows the Azure Machine Learning workspace overview page for 'MyAzureML'. The left sidebar contains navigation links for Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Events, Settings (Private endpoint connections, Properties, Locks), Monitoring (Alerts, Metrics, Diagnostic settings, Logs), Automation (Tasks (preview), Export template), Support + troubleshooting (Usage + quotas, New support request), and Help + feedback.

The main content area displays workspace details under the 'Essentials' section:

Setting	Value
Workspace edition	Basic
Resource group	cloud-shell-storage-southeastasia
Location	East US
Subscription	Azure subscription 1
Subscription ID	b2529fb0-c5eb-432c-9f53-718429053009
Studio web URL	https://ml.azure.com/?id=4307b62d-0caa-49ac-9e8d-612a78446d81&wsid=/subscriptions/b2529fb0-c5eb-432c-9f53-718429053009
Storage	myazureml7517765703
Registry	...
Key Vault	myazureml0023416128
Application Insights	myazureml8273629959

Below the essentials section, there is a 'Manage your machine learning lifecycle' section with a 'Launch studio' button.

Screenshot 12:

This screenshot shows the 'Deployment Details' blade for the 'MyAzureML' deployment. The left sidebar includes links for Overview, Inputs, Outputs, and Template.

The main content area shows deployment status:

Your deployment is complete

Deployment name: Microsoft.MachineLearningServices
Subscription: Azure subscription 1
Resource group: cloud-shell-storage-southeastasia

Start time: 1/2/2021 10:38:25 PM
Correlation ID: 8995a9ae-bc8d-429e-94f3-aa14306bb0ce

Deployment details (Download)

Resource	Type	Status	Operation details
MyAzureML	Microsoft.MachineLearningServices/workspaces	OK	Operation details
myazureml8273629959	Microsoft.Insights/components	OK	Operation details
myazureml0023416128	Microsoft.KeyVault/vaults	OK	Operation details
myazureml7517765703	Microsoft.Storage/storageAccounts	OK	Operation details

Next steps

[Go to resource](#)

Right sidebar sections include:

- Security Center**: Secure your apps and infrastructure. [Go to Azure security center >](#)
- Free Microsoft tutorials**: [Start learning today >](#)
- Work with an expert**: Azure experts are service provider partners who can help manage your assets on Azure and be your first line of support. [Find an Azure expert >](#)

Screenshot 13:

The screenshot shows the Azure Machine Learning service dashboard for a workspace named 'MyAzureML'. The left sidebar contains navigation links for Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Events, Settings (Private endpoint connections, Properties, Locks), Monitoring (Alerts, Metrics, Diagnostic settings, Logs), Automation (Tasks (preview), Export template), Support + troubleshooting (Usage + quotas, New support request), and Manage your machine learning lifecycle (Launch studio). The main content area displays workspace details: Workspace edition: Basic; Resource group: cloud-shell-storage-southeastasia; Location: East US; Subscription: Azure subscription 1; Subscription ID: b2529fb0-c5eb-432c-9f53-718429053009. It also shows the Studio web URL: <https://ml.azure.com/?id=4307b62d-0caa-49ac-9e8d-612a78446d81&wsid=/subscriptions/b2529fb0-c5eb-432c-9f53-718429053009>. Other details include Storage: myazureml7517765703, Registry: ..., Key Vault: myazureml0023416128, and Application Insights: myazureml8273629959. A 'Download config.json' button is available at the top left.

Screenshot 14:

The screenshot shows the Azure Cloud Shell terminal window. The session is titled 'PowerShell' and the tenant is 'Default Directory (ashishsomvanshioutlook.onmicrosoft.com)'. The terminal displays the following command execution:

```
Tenant 0: Default Directory (ashishsomvanshioutlook.onmicrosoft.com)
Please enter the desired tenant number.
Enter n to login with a new account
Enter r to remove the above saved connection settings.
> 0
Requesting a cloud shell instance...
Succeeded.
Requesting a terminal (this might take a while)...

Welcome to Azure Cloud Shell

Type "az" to use Azure CLI
Type "help" to learn about Cloud Shell

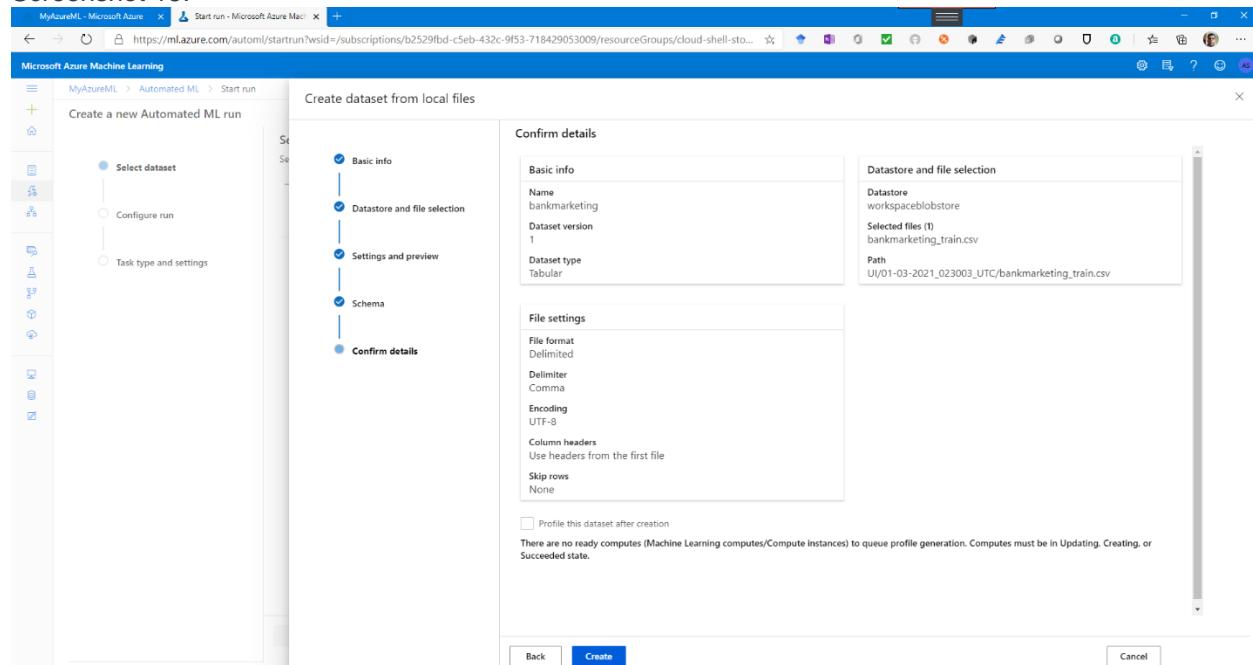
MOTD: Scripts installed with 'Install-Script' can be run from the shell

VERBOSE: Authenticating to Azure ...
VERBOSE: Building your Azure drive ...
PS /home/ashish> az ml workspace share -w MyAzureML -g cloud-shell-storage-southeastasia --user 608628be-b9c3-46a1-8a1b-a53862d7bdd4 --role owner
PS /home/ashish>
PS /home/ashish>
```

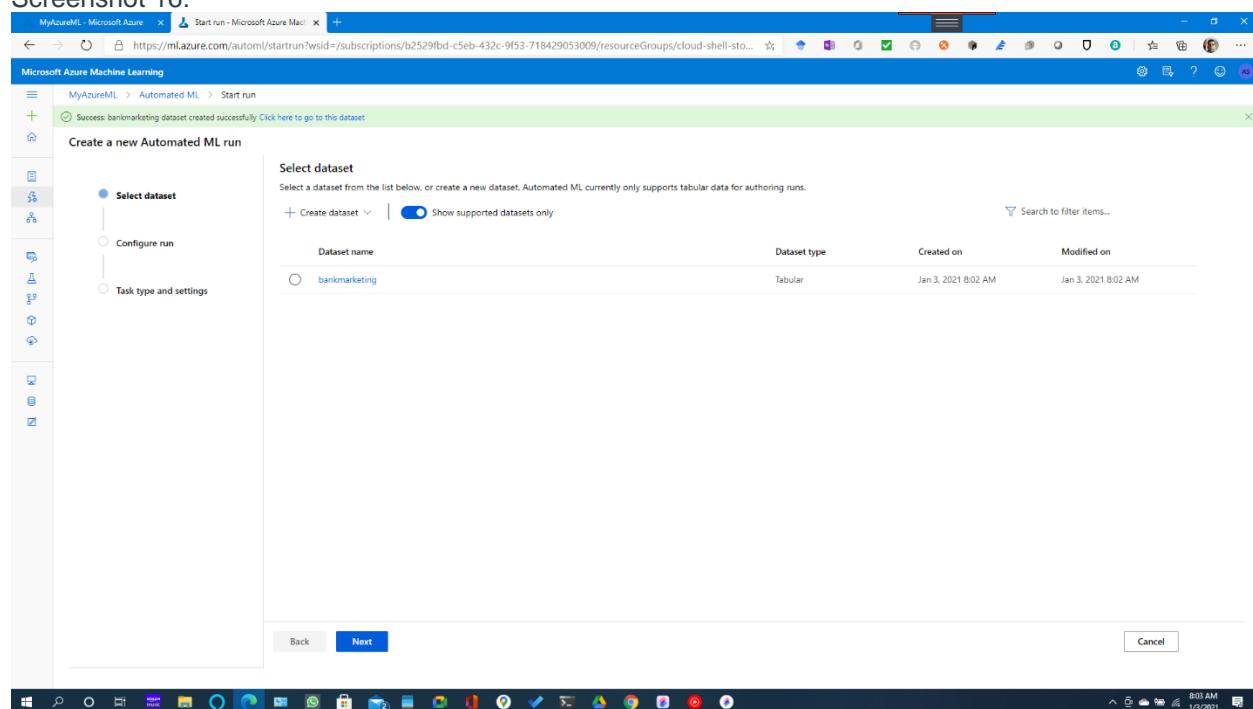
Step 2: Create and run Auto ML Experiment and creation of dataset via interface

Screenshot of Registered Dataset can be seen in Screenshot 16. Screenshot of Experiment as complete can be seen in Screenshot 27. The details of the auto selected best model can be seen in Screenshots 24 to 26 including the metrics of run can be seen in graphical format.

Screenshot 15:



Screenshot 16:



Screenshot 17:

The screenshot shows the Microsoft Azure Machine Learning Studio interface. The top navigation bar includes 'MyAzureML - Microsoft Azure' and 'Start run - Microsoft Azure Machine Learning'. A success message 'Success: bankmarketing dataset created successfully. Click here' is displayed. The main area is titled 'Create a new Automated ML run' and shows the 'Select dataset' step. Below this, there are three options: 'Configure run', 'Task type and settings', and a 'Data preview' tab which is currently selected. The 'Data preview' tab displays the 'bankmarketing' dataset with 44 columns and approximately 44,000 rows. The columns include fault, housing, loan, contact, day_of_week, duration, campaign, pdays, previous, poutco..., emp.varrate, cons.price.idx, cons.confidx, euribor3m, nr.employed, and y.

Screenshot 18:

The screenshot shows the Microsoft Azure Machine Learning Studio interface, identical to Screenshot 17 but with a different dataset. The top navigation bar includes 'MyAzureML - Microsoft Azure' and 'Start run - Microsoft Azure Machine Learning'. A success message 'Success: bankmarketing dataset created successfully. Click here' is displayed. The main area is titled 'Create a new Automated ML run' and shows the 'Select dataset' step. Below this, there are three options: 'Configure run', 'Task type and settings', and a 'Data preview' tab which is currently selected. The 'Data preview' tab displays the 'bankmarketing' dataset with 17 columns and approximately 44,000 rows. The columns include age, job, marital, education, default, housing, loan, contact, day_of_week, duration, campaign, pdays, previous, poutco..., emp.varrate, cons.price.idx, and cons.con.

Screenshot 19:

This screenshot shows the Microsoft Azure Machine Learning Studio interface. The left sidebar shows the experiment path: MyAzureML > Automated ML > myazureautomlexp > Run 1. The main area displays 'Run 1' which is 'Not started'. It includes a 'Details' tab and a 'Run summary' section. The 'Run summary' section contains fields for Task type (Classification), Primary metric (Accuracy), and Run status (Not started). The experiment name is listed as 'myazureautomlexp'. A 'Description' field is present with a placeholder 'Click edit icon to add a description'.

Screenshot 20:

This screenshot shows the Microsoft Azure Machine Learning Studio interface. The left sidebar shows the dataset path: MyAzureML > Datasets. The main area displays the 'Datasets' page with a table titled 'Registered datasets'. The table has columns: Name, Version, Data source, Created on, Modified on, Properties, Created by, and Tags. One dataset, 'bankmarketing', is listed with a version of 1, data source 'workspaceblobstore', created on Jan 3, 2021, modified on Jan 3, 2021, properties 'Tabular', and created by 'Ashish Somvanshi'. A search bar at the top right is labeled 'Search to filter items...'.

Name	Version	Data source	Created on	Modified on	Properties	Created by	Tags
bankmarketing	1	workspaceblobstore	Jan 3, 2021 8:02 AM	Jan 3, 2021 8:02 AM	Tabular	Ashish Somvanshi	

Screenshot 21:

This screenshot shows the Microsoft Azure Machine Learning Studio interface. The left sidebar navigation bar includes 'MyAzureML', 'Datasets', 'bankmarketing' (selected), 'Version 1 (latest)', 'Details', 'Consume', 'Explore', and 'Models'. Below the navigation bar, there are several tabs: 'Refresh', 'Generate profile', 'Unregister', and 'New version'. The main content area is titled 'Attributes' and displays the following dataset information:

- Properties**: Tabular
- Description**: (empty)
- Created by**: Ashish Somvanshi
- Datastore**: workspaceblobstore
- Relative path**: UI/01-03-2021_023003_UTC/bankmarketing_train.csv
- Profile**: No profile generated
- Files in dataset**: 1
- Total size of files in dataset**: 3.958 MB
- Current version**: 1
- Latest version**: 1
- Created time**: Jan 3, 2021 8:02 AM
- Modified time**: Jan 3, 2021 8:02 AM

The right side of the screen shows a 'Tags' section with a note: 'No data'.

Screenshot 22:

This screenshot shows the Microsoft Azure Machine Learning Studio interface for an experiment named 'myazureautoml'. The left sidebar navigation bar includes 'Run 1' (Running), 'Data guardrails', 'Models', 'Outputs + logs', 'Child runs', and 'Snapshot'. Below the navigation bar, there are several tabs: 'Refresh', 'Cancel', 'Details', 'Data guardrails', 'Models', 'Outputs + logs', 'Child runs', and 'Snapshot'. The main content area is divided into two sections: 'Properties' on the left and 'Run summary' on the right.

Properties (Left):

- Status**: Running
- Created**: Jan 3, 2021 8:10 AM
- Started**: Jan 3, 2021 8:10 AM
- Compute target**: myazuremlcomp
- Run ID**: AutoML_ac9ab0ea-2563-48b5-90ad-4941e916b560
- Run number**: 1
- Script name**: --
- Created by**: Ashish Somvanshi
- Input datasets**: Input name: training_data, ID: d7ed7b49-6ff4-4eb6-a5c3-0ff64ed6ab44
- Output datasets**: None
- Arguments**: None
- See all properties**
- Raw JSON**

Run summary (Right):

- Task type**: Classification ([View all run settings](#))
- Primary metric**: Accuracy
- Run status**: Generating dataset features
- Experiment name**: myazureautoml

The bottom of the screen shows a Windows taskbar with various pinned icons and the system tray indicating the date and time as 8:14 AM on 1/3/2021.

Screenshot 23:

Run 1 • Running

Details Data guardrails Models Outputs + logs Child runs Snapshot

Properties

Status: Running
Created: Jan 3, 2021 8:10 AM
Started: Jan 3, 2021 8:10 AM
Compute target: myazuremlcomp
Run ID: AutoML_ac9ab0ea-2563-48b5-90ad-4941e916b560
Run number: 1
Script name: --
Created by: Ashish Somvanshi
Input datasets: Input name: training_data, ID: d7ed7b49-6ff4-4eb6-a5c3-0ff64ed6ab44
Output datasets: None
Arguments: None
See all properties Raw JSON

Run summary

Task type: Classification View all run settings
Primary metric: Accuracy
Run status: Training child models

Experiment name: myazureautomlexp

Description

Click edit icon to add a description

Screenshot 24:

Run 1 • Completed

Details Data guardrails Models Outputs + logs Child runs Snapshot

Properties

Status: Completed
Created: Jan 3, 2021 8:10 AM
Started: Jan 3, 2021 8:10 AM
Duration: 56m 8.561s
Compute target: myazuremlcomp
Run ID: AutoML_ac9ab0ea-2563-48b5-90ad-4941e916b560
Run number: 1
Script name: --
Created by: Ashish Somvanshi
Input datasets: Input name: training_data, ID: d7ed7b49-6ff4-4eb6-a5c3-0ff64ed6ab44
Output datasets: None
Arguments: None
See all properties Raw JSON

Run Metrics

Accuracy: 0.91866
AUC macro: 0.94480
AUC micro: 0.97996
AUC weighted: 0.94480
Average precision score macro: 0.82050
Average precision score micro: 0.98086
Average precision score weighted: 0.95428
Balanced accuracy: 0.75764
F1 score macro: 0.77854
F1 score micro: 0.91866
F1 score weighted: 0.91524
Log loss: 0.21568
Matthews correlation: 0.56067
Norm macro recall: 0.51528
Precision score macro: 0.80503

Best model summary

Algorithm name: VotingEnsemble
Accuracy: 0.91866 View all other metrics
Sampling: 100.00 %
Registered models: No registration yet
Deploy status: No deployment yet

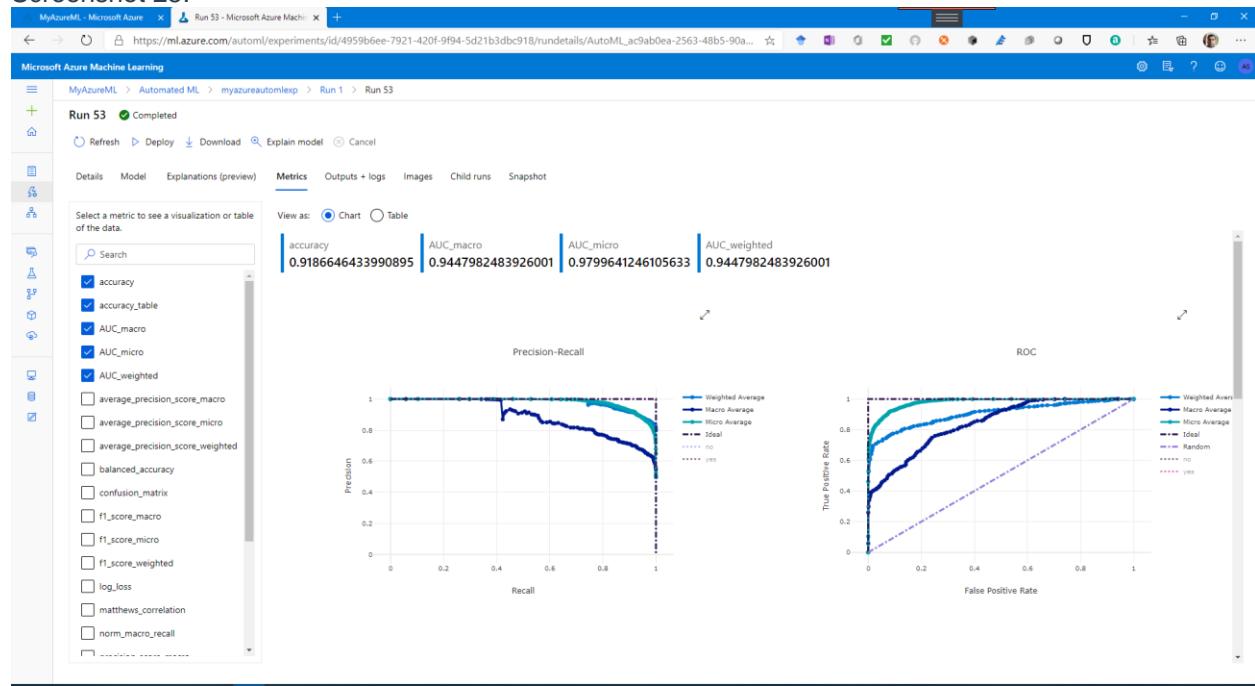
Run summary

Task type: Classification View all run settings
Primary metric: Accuracy
Run status: Completed
Experiment name: myazureautomlexp

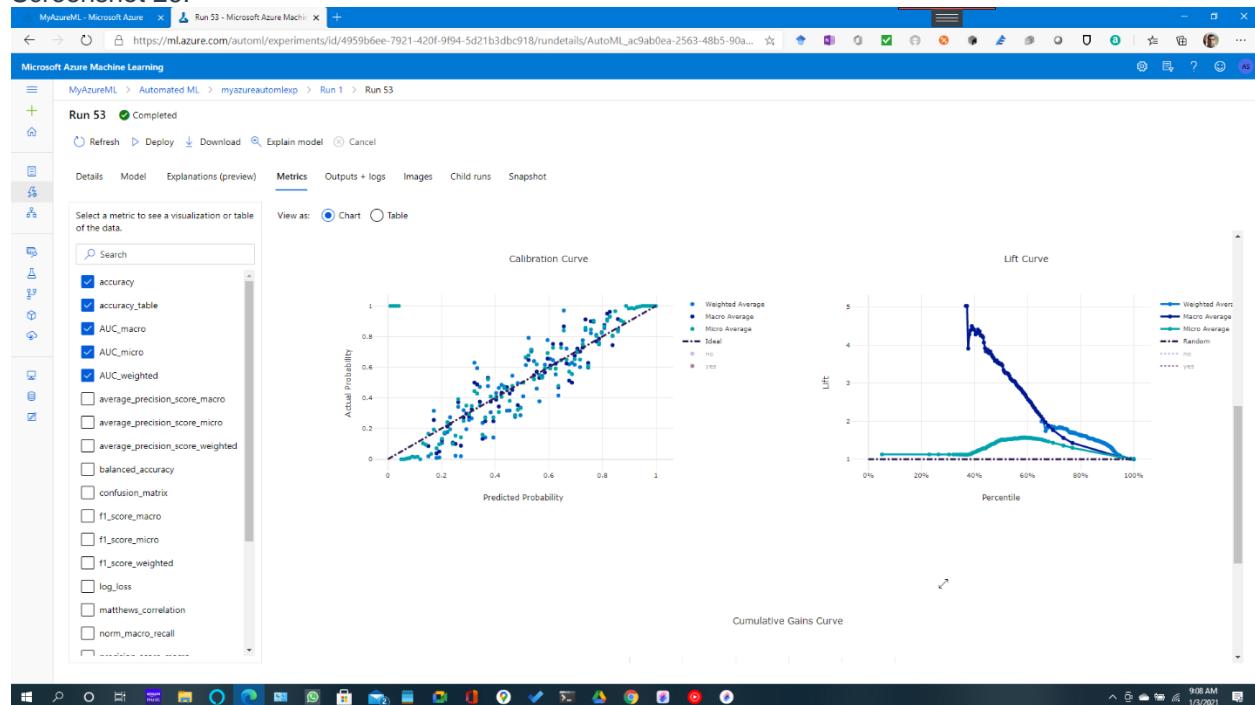
Description

Click edit icon to add a description

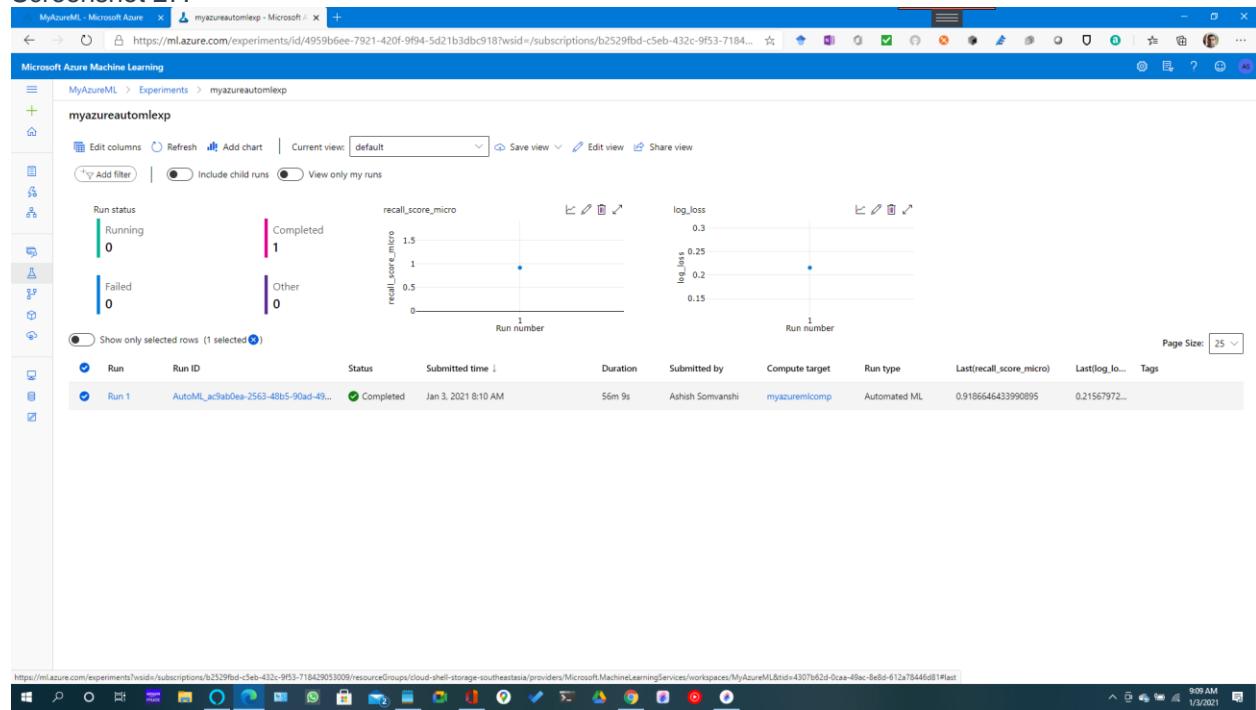
Screenshot 25:



Screenshot 26:



Screenshot 27:



Step 3: Deploy the Best Model

Screenshot 28:

The screenshot shows the Microsoft Azure Machine Learning studio interface. The left sidebar has a tree view with 'MyAzureML' selected, followed by 'Endpoints' and 'myazuremlmodel'. The main content area is titled 'myazuremlmodel'. It displays various properties of the endpoint, including:

- Service ID: myazuremlmodel
- Description: --
- Deployment state: Transitioning (blue circle)
- Compute type: ACI
- Created by: Ashish Somvanshi
- Model ID: AutoMLac9ab0ea248:1
- Created on: 1/3/2021 9:12:48 AM
- Last updated on: 1/3/2021 9:12:48 AM
- Image ID: --
- REST endpoint: null
- Key-based authentication enabled: true
- Swagger URI: --
- CPU: 1.8
- Memory: 4 GB
- Application Insights enabled: false

A 'Properties' section on the right shows the run ID: AutoML_ac9ab0ea-2563-48b5-90ad-4941e916b560_48.

Screenshot 29:

The screenshot shows the Microsoft Azure Machine Learning studio interface. The left sidebar has a tree view with 'MyAzureML' selected, followed by 'Experiments' and 'Run 53'. The main content area is titled 'Run 53' and shows the status as 'Completed'. The 'Model' tab is selected. The 'Model summary' section contains the following information:

- Algorithm name: VotingEnsemble
- Accuracy: 0.91865 (View all other metrics)
- Sampling: 100.00 % (blue circle)
- Registered models: AutoMLac9ab0ea248:1
- Deploy status: myazuremlmodel (green circle) Succeeded

The top status bar indicates the date and time as 9:13 AM 1/3/2021.

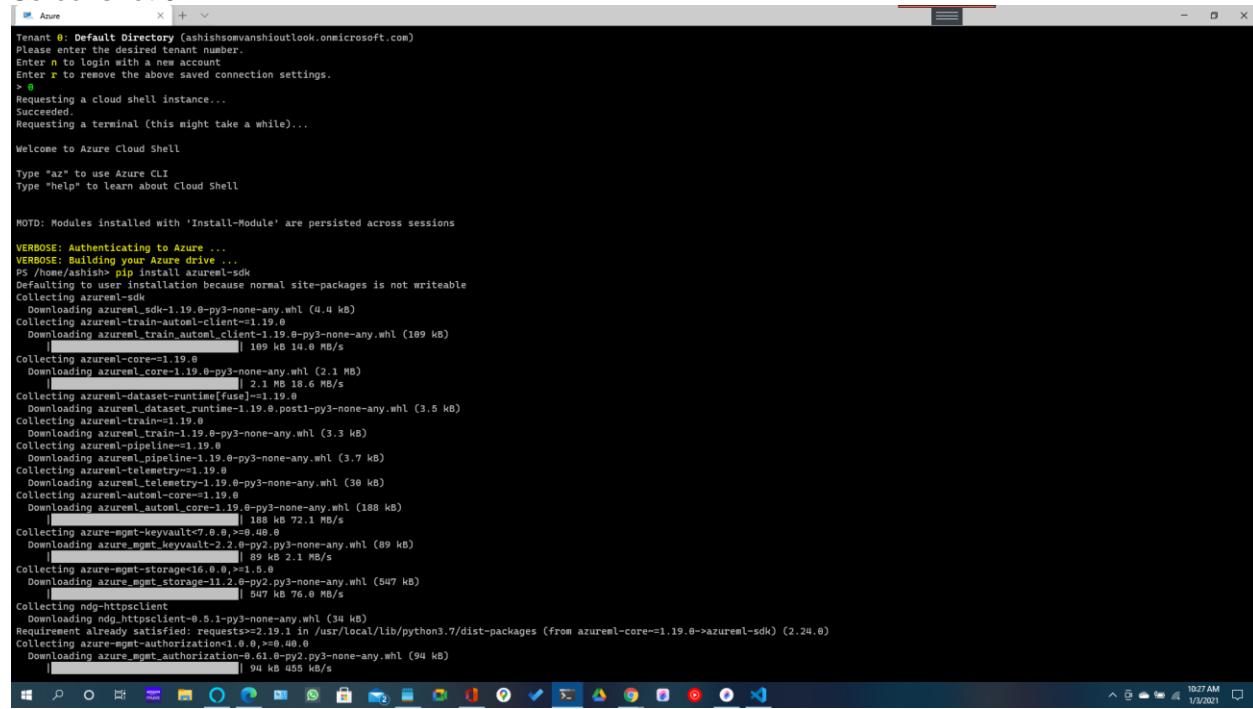
Screenshot 30:

The screenshot shows a Microsoft Azure Machine Learning Studio interface. The browser title bar reads "MyAzureML - Microsoft Azure < Run 33 - Microsoft Azure Machine Learning - myazuremlmodel - Microsoft Azure". The main content area is titled "Microsoft Azure Machine Learning" and shows the "Endpoints" section for the "myazuremlmodel" endpoint. The "Basic consumption info" panel displays the REST endpoint URL: "http://23ee020f-ec49-4441-8218-19d8afe69439.eastus.azurecontainer.io/score". The "Authentication types" section indicates "Using key" is selected, with two keys listed: "Primary key" (n3zmMcCRBt-AT04mPwYvLhhW9bfifJhd) and "Secondary key" (0WSRoZmrX3zLzEzG51079VvoyTKYfQ4G). Both keys have a "Regenerate" link next to them. The left sidebar contains icons for creating new resources like datasets, models, and pipelines.

Step 4: Enable Application Insights (Enabling logs)

Installation and configuration of Azure Python Sdk and Opencensus extension can be seen in screenshots 31-32. Code of logs.py modified can be seen in Screenshot 33, logs generated can be seen in Screenshot 34.

Screenshot 31:

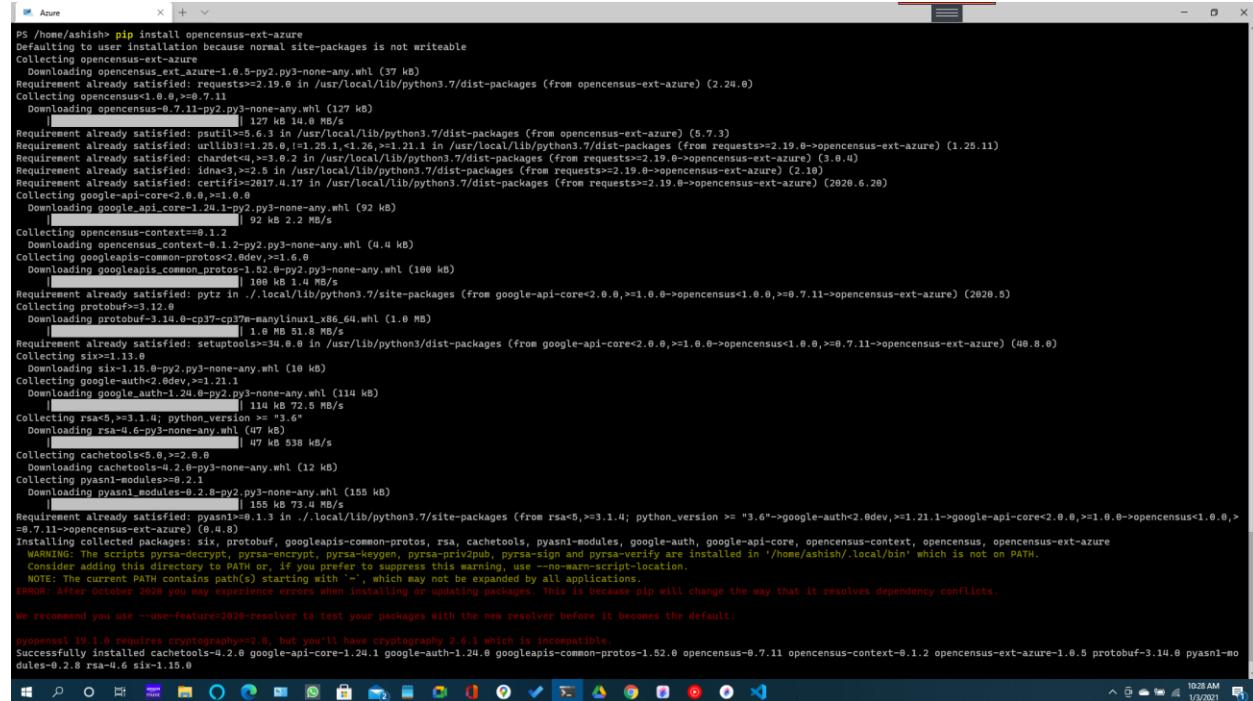


```
Tenant 0: Default Directory (ashishsomvanshioutlook.onmicrosoft.com)
Please enter the desired tenant number.
Enter n to login with a new account
Enter r to remove the above saved connection settings.
> 0
Requesting a cloud shell instance...
Succeeded.
Requesting a terminal (this might take a while)...
Welcome to Azure Cloud Shell
Type "az" to use Azure CLI
Type "help" to learn about Cloud Shell

MOTD: Modules installed with 'Install-Module' are persisted across sessions

VERBOSE: Authenticating to Azure ...
VERBOSE: Building your Azure drive ...
PS /home/ashish> pip install azureml-sdk
Defaulting to user installation because normal site-packages is not writable
Collecting azureml-sdki
  Downloading azureml_sdi-1.19.0-py3-none-any.whl (4.4 kB)
Collecting azureml-train-autonl-client<=1.19.0
  Downloading azureml_train_autonl_client-1.19.0-py3-none-any.whl (109 kB)
    [██████████] 109 kB 14.0 MB/s
Collecting azureml-core<=1.19.0
  Downloading azureml_core-1.19.0-py3-none-any.whl (2.1 MB)
    [██████████] 2.1 MB 18.6 MB/s
Collecting azureml-dataset-runtime[fuse]<=1.19.0
  Downloading azureml_dataset-runtime-1.19.0.post1-py3-none-any.whl (3.5 kB)
Collecting azureml-train<=1.19.0
  Downloading azureml_train-1.19.0-py3-none-any.whl (3.3 kB)
Collecting azureml-pipeline<=1.19.0
  Downloading azureml_pipeline-1.19.0-py3-none-any.whl (3.7 kB)
Collecting azureml-telemetry<=1.19.0
  Downloading azureml_telemetry-1.19.0-py3-none-any.whl (30 kB)
Collecting azureml-automl-core<=1.19.0
  Downloading azureml_automl_core-1.19.0-py3-none-any.whl (188 kB)
Collecting azure-mgmt-keyvault<=7.0.8,>=8.48.0
  Downloading azure_mgmt_keyvault-2.2.0-py2.py3-none-any.whl (89 kB)
    [██████████] 89 kB 2.1 MB/s
Collecting azure-mgmt-storage<16.0.0,>=1.5.0
  Downloading azure_mgmt_storage-11.2.0-py2.py3-none-any.whl (507 kB)
    [██████████] 507 kB 76.0 MB/s
Collecting ndg-httpsclient
  Downloading ndg_httpsclient-0.5.1-py3-none-any.whl (34 kB)
Requirement already satisfied: requests<=>2.19.0 in /usr/local/lib/python3.7/dist-packages (from azureml-core=<=1.19.0->azureml-sdki) (2.24.0)
Collecting azure-mgmt-authorization<0.0,>=0.48.0
  Downloading azure_mgmt_authorization-0.61.0-py2.py3-none-any.whl (94 kB)
    [██████████] 94 kB 455 kB/s
```

Screenshot 32:



```
PS /home/ashish> pip install opencensus-ext-azure
Defaulting to user installation because normal site-packages is not writable
Collecting opencensus-ext-azure
  Downloading opencensus_ext_azure-1.0.5-py2.py3-none-any.whl (37 kB)
Requirement already satisfied: requests<=>2.19.0 in /usr/local/lib/python3.7/dist-packages (from opencensus-ext-azure) (2.24.0)
Collecting opencensus<1.0.0,>=0.7.11
  Downloading opencensus-0.7.11-py2.py3-none-any.whl (127 kB)
    [██████████] 127 kB 14.0 MB/s
Requirement already satisfied: psutil<=>5.6.3 in /usr/local/lib/python3.7/dist-packages (from opencensus-ext-azure) (5.7.3)
Requirement already satisfied: urllib3<1.25.0,>=1.25.1 in /usr/local/lib/python3.7/dist-packages (from requests<=>2.19.0->opencensus-ext-azure) (1.25.11)
Requirement already satisfied: charset<4,>=3.0.2 in /usr/local/lib/python3.7/dist-packages (from requests<=>2.19.0->opencensus-ext-azure) (3.0.4)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.7/dist-packages (from requests<=>2.19.0->opencensus-ext-azure) (2.10)
Requirement already satisfied: certifi<=2017.4.17 in /usr/local/lib/python3.7/dist-packages (from requests<=>2.19.0->opencensus-ext-azure) (2020.6.28)
Collecting google-api-core<2.0.0,>=1.0.0
  Downloading google_api_core-1.24.1-py2.py3-none-any.whl (92 kB)
    [██████████] 92 kB 2.2 MB/s
Collecting opencensus-context<=>0.1.2
  Downloading opencensus_context-0.1.2-py2.py3-none-any.whl (4.4 kB)
Collecting googleapis-common-protos<2.0dev,>=1.6.0
  Downloading googleapis_common_protos-1.52.0-py2.py3-none-any.whl (100 kB)
    [██████████] 100 kB 1.4 MB/s
Requirement already satisfied: pytz in ./local/lib/python3.7/site-packages (from google-api-core<2.0.0,>=1.0.0->opencensus<1.0.0,>=0.7.11->opencensus-ext-azure) (2020.5)
Collecting protobuf<=3.12.0
  Downloading protobuf-3.12.0-py2.py3-none-any.whl (1.0 kB)
    [██████████] 1.0 kB 51.8 MB/s
Requirement already satisfied: setuptools<=>34.0.0 in /usr/lib/python3/dist-packages (from google-api-core<2.0.0,>=1.0.0->opencensus<1.0.0,>=0.7.11->opencensus-ext-azure) (40.8.0)
Collecting six<1.13.0
  Downloading six-1.15.0-py3-none-any.whl (10 kB)
Collecting google-auth<2.0dev,>=1.21.1
  Downloading google_auth-1.24.0-py2.py3-none-any.whl (114 kB)
    [██████████] 114 kB 72.5 MB/s
Collecting rsa<8,>=3.1.4; python_version >= "3.6"
  Downloading rsa-4.6-py3-none-any.whl (47 kB)
    [██████████] 47 kB 538 kB/s
Collecting cachetools<5.0,>=2.0.0
  Downloading cachetools-4.2.0-py3-none-any.whl (12 kB)
Collecting pyasn1-modules<0.2.1
  Downloading pyasn1_modules-0.2.8-py2.py3-none-any.whl (155 kB)
    [██████████] 155 kB 73.4 MB/s
Requirement already satisfied: pyasn1<0.1.3 in ./local/lib/python3.7/site-packages (from pyasn1-modules<0.2.1->opencensus<1.0.0,>=0.7.11->opencensus-ext-azure) (0.1.3)
Installing collected packages: six, protobuf, googleapis-common-protos, rsa, cachetools, pyasn1-modules, google-auth, google-api-core, opencensus, opencensus-ext-azure
  WARNING: The scripts pyrsa-decrypt, pyrsa-encrypt, pyrsa-keygen, pyrsa-prv2pub, pyrsa-sign and pyrsa-verify are installed in '/home/ashish/.local/bin' which is not on PATH.
  Consider adding this directory to PATH or, if you prefer to suppress this warning, use --no-warn-script-location.
  NOTE: The current PATH contains path(s) starting with '.', which may not be expanded by all applications.
ERROR: After October 2020 you may experience errors when installing or updating packages. This is because pip will change the way that it resolves dependency conflicts.

We recommend you use --use-feature=2020resolver to test your packages with the new resolver before it becomes the default.

opencensus 10.1.0 requires cryptography<3.8 but you'll have cryptography 3.6.1 which is incompatible
Successfully installed cachetools-4.2.0 google-api-core-1.24.1 google-auth-1.24.0 googleapis-common-protos-1.52.0 opencensus-0.7.11 opencensus-context-0.1.2 opencensus-ext-azure-1.0.5 protobuf-3.14.0 pyasn1-0.2.8 rsa-4.6 six-1.15.0
```

Screenshot 33:

```
GNU nano 3.2                         myappinights.py                         Modified

from azureml.core import Workspace
from azureml.core.webservice import Webservice

# Requires the config to be downloaded first to the current working directory
ws = Workspace.from_config()

# Set with the deployment name
name = "myazuremlmodel"

# Load existing web service
service = Webservice(name=name, workspace=ws)
service.update(enable_app_insights=True)
logs = service.get_logs()

for line in logs.split("\n"):
    print(line)
```

Screenshot 34

```
2021-01-03T03:46:05,229588400+00:00 - iot-server/run
rsyslogd: /azureml-envs/azureml_8eff280157f42edcd24245aae6c8074/lib/libuuid.so.1: no version information available (required by rsyslogd)
EdgeConnectivityString and IOTEDGE_IOTHUBHOSTNAME are not set. Exiting...
2021-01-03 03:46:06,270871300+00:00 - iot-server/finish 1 0
2021-01-03T03:46:06,270878200+00:00 - Exit code 1 is normal. Not restarting iot-server.
Starting unicorn 19.9.0
Listening at: http://127.0.0.1:31311 (63)
Listening at: http://127.0.0.1:31311 (63)
Using worker: sync
worker timeout is set to 300
Booting worker with pid: 94
SPARK_HOME not set. Skipping PySpark Initialization.
Generating sparkConfManager, this may take some time...
Initialising logger
2021-01-03 03:46:10,75 | root | INFO | Starting up app insights client
Starting up app insights client
2021-01-03 03:46:10,757 | root | INFO | Starting up request id generator
Starting up request id generator
2021-01-03 03:46:10,757 | root | INFO | Starting up app insight hooks
Starting up app insight hooks
2021-01-03 03:46:10,757 | root | INFO | Invoking user's init function
Invoking user's init function
2021-01-03 03:46:10,757 | root | INFO | User's init has completed successfully
User's init has completed successfully
2021-01-03 03:46:10,757 | root | INFO | Skipping middleware: dbg_model_info as it's not enabled.
Skipping middleware: dbg_model_info as it's not enabled.
2021-01-03 03:46:10,757 | root | INFO | Skipping middleware: dbg_resource_usage as it's not enabled.
Skipping middleware: dbg_resource_usage as it's not enabled.
2021-01-03 03:46:10,757 | root | INFO | Scoring timeout is found from os.environ: 60000 ms
2021-01-03 03:46:10,757 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:46:19 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:46:35,517 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:46:35 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:46:36,226 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:46:36 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:51:49,069 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:51:49 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:51:50,512 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:51:50 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:57:32,653 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:57:32 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:57:38,462 | root | INFO | 200
200
127.0.0.1 - - [03/Jan/2021:03:57:38 +0000] "GET /swagger.json HTTP/1.0" 200 3252 "-" "Go-http-client/1.1"
2021-01-03 03:57:38,462 | root | INFO | 200
200
PS /home/ashish> |
```

Screenshot 35:

```

1 2021-01-03T05:40:58,507569000+00:00 - iot-server/run
2 2021-01-03T05:40:58,509398100+00:00 - unicorn/run
3 2021-01-03T05:40:58,528794200+00:00 - rsyslog/run
4 2021-01-03T05:40:58,532069400+00:00 - nginx/run
5 /usr/sbin/nginx: /azureml-envs/azureml_beef28b157f42edcd2424a5aae6c8074/lib/libcrypto.so.1.0.0: no version information available (required by /usr/sbin/nginx)
6 /usr/sbin/nginx: /azureml-envs/azureml_beef28b157f42edcd2424a5aae6c8074/lib/libssl.so.1.0.0: no version information available (required by /usr/sbin/nginx)
7 /usr/sbin/nginx: /azureml-envs/azureml_beef28b157f42edcd2424a5aae6c8074/lib/libcrypto.so.1.0.0: no version information available (required by /usr/sbin/nginx)
8 /usr/sbin/nginx: /azureml-envs/azureml_beef28b157f42edcd2424a5aae6c8074/lib/libssl.so.1.0.0: no version information available (required by /usr/sbin/nginx)
9 /usr/sbin/nginx: /azureml-envs/azureml_beef28b157f42edcd2424a5aae6c8074/lib/libssl.so.1.0.0: no version information available (required by /usr/sbin/nginx)
10 rsyslogd: /azureml-envs/azureml_beef28b157f42edcd2424a5aae6c8074/lib/libuv.so.1: no version information available (required by rsyslogd)
11 Starting unicorn 19.9.0
12 Listening at: http://127.0.0.1:31311 (9)
13 Using worker: sync
14 worker time set to 300
15 Building worker with pid: 91
16 Service connection and TORNODE_IDTHEBHOSTNAME are not set. Exiting...
17 2021-01-03T05:41:00,227769300+00:00 - iot-server/finish 1 0
18 2021-01-03T05:41:00,145223200+00:00 - Exit code 1 is normal. Not restarting iot-server.
19 SPARK_HOME not set. Skipping PySpark Initialization.
20 Generating new fontManager, this may take some time...
21 Initializing logger
22 2021-01-03 05:41:03,018 | root | INFO | Starting up app insights client
23 Starting up app insights client
24 2021-01-03 05:41:03,019 | root | INFO | Starting up request id generator
25 Starting up request id generator
26 2021-01-03 05:41:03,019 | root | INFO | Starting up app insight hooks
27 Starting up app insight hooks
28 2021-01-03 05:41:03,020 | root | INFO | Invoking user's init function
29 Invoking user's init function
30 2021-01-03 05:41:10,417 | root | INFO | User's init has completed successfully
31 User's init has completed successfully
32 2021-01-03 05:41:10,425 | root | INFO | Skipping middleware: dbg_model_info as it's not enabled.
33 2021-01-03 05:41:10,425 | root | INFO | Skipping middleware: dbg_resource_usage as it's not enabled.
34 2021-01-03 05:41:10,425 | root | INFO | Skipping middleware: dbg_resource_usage as it's not enabled.
35 Skipping middleware: dbg_resource_usage as it's not enabled.
36 2021-01-03 05:41:10,427 | root | INFO | Scoring timeout is found from os.environ: 60000 ms
37 Scoring timeout is found from os.environ: 60000 ms
38

```

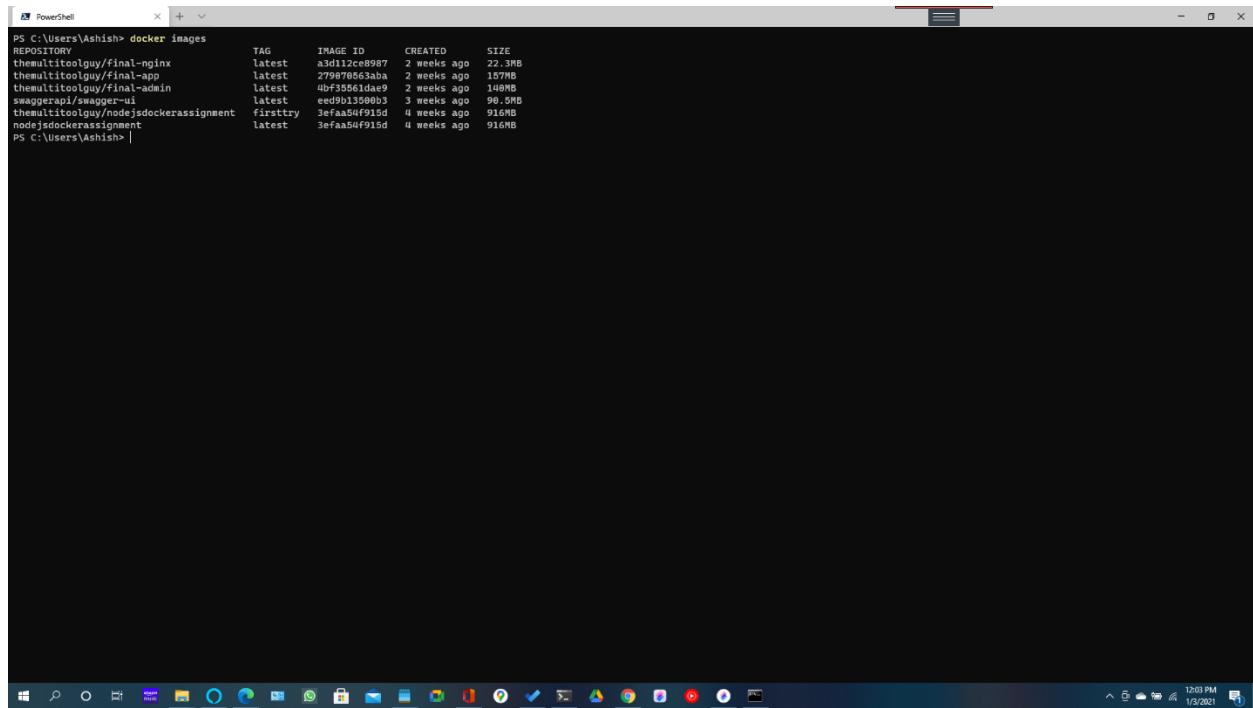
Properties	
runId	AutoML_ac9ab0ea-2563-4b5-90ad-4941e916b560_48
hasInferenceSchema	True
hasHttps	False

Step 5: Swagger Documentation

In this step, I consumed the deployed model using Swagger via Azure provided swagger.json for deployed models. A few steps were also flowed.

- swagger.sh downloaded the latest Swagger container, and it was made to run on port 8000.

Screenshot 37:



A screenshot of a Windows PowerShell window titled "PowerShell". The command "docker images" is run, displaying a table of images. The table has columns: REPOSITORY, TAG, IMAGE ID, CREATED, and SIZE. The data is as follows:

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
themultitoolguy/final-nginx	latest	a3d112cc8987	2 weeks ago	22.3MB
themultitoolguy/final-app	latest	279976563a9a	2 weeks ago	187MB
themultitoolguy/final-admin	latest	4bf95561dae9	2 weeks ago	148MB
swaggerapi/swagger-ui	latest	eed9b0135900b3	3 weeks ago	98.5MB
themultitoolguy/nodejsdockerassignment	firsttry	3efaa54ff915d	4 weeks ago	916MB
nodejsdockerassignment	latest	3efaa54ff915d	4 weeks ago	916MB

PS C:\Users\Ashish> |

serve.py started a Python server on port 8000. This script needs to be right next to the downloaded swagger.json file. swagger.json was placed in same directory. Screenshots of swagger running on localhost can be seen in Screenshots 38 to 43.

Screenshot 38:

Machine Learning Engineer with Swagger UI

localhost:9000

Swagger <http://localhost:8080/swagger.json>

Explore

myazuremimodel

API specification for the Azure Machine Learning service myazuremimodel

Schemes **HTTPS**

default

GET /

POST /score

Models

ServiceInput >

ServiceOutput >

ErrorResponse >

Screenshot 39:

Machine Learning Engineer with Swagger UI

localhost:9000

Swagger <http://localhost:8080/swagger.json>

Explore

myazuremimodel

API specification for the Azure Machine Learning service myazuremimodel

Schemes **HTTPS**

default

GET /

POST /score

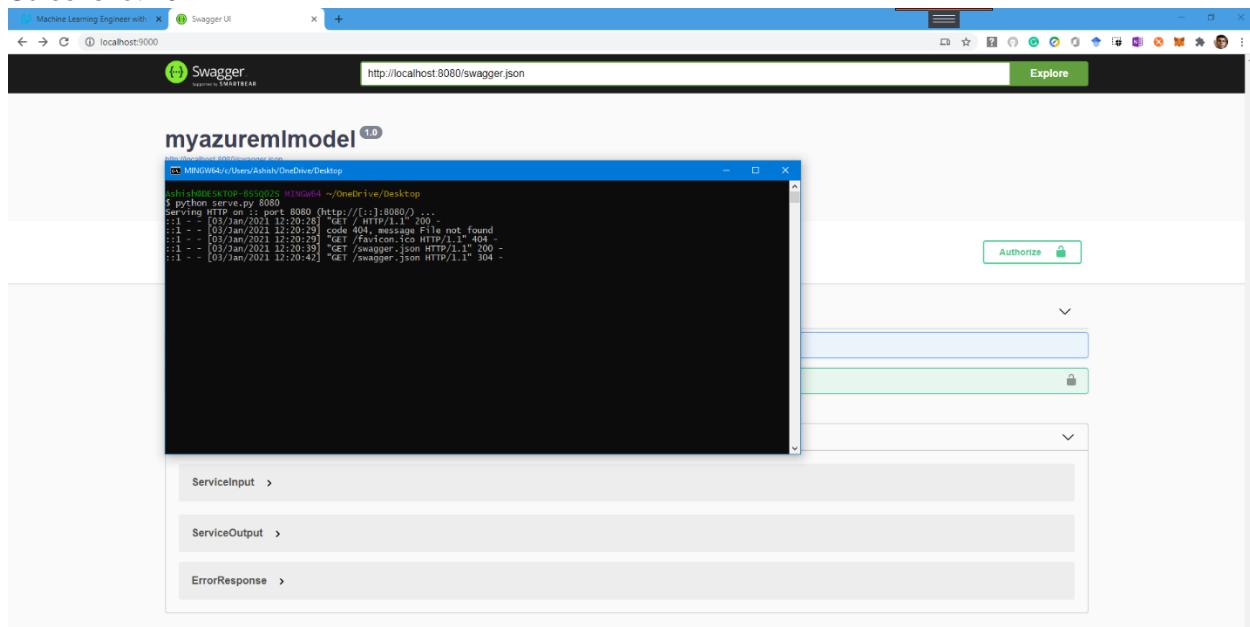
Models

ServiceInput >

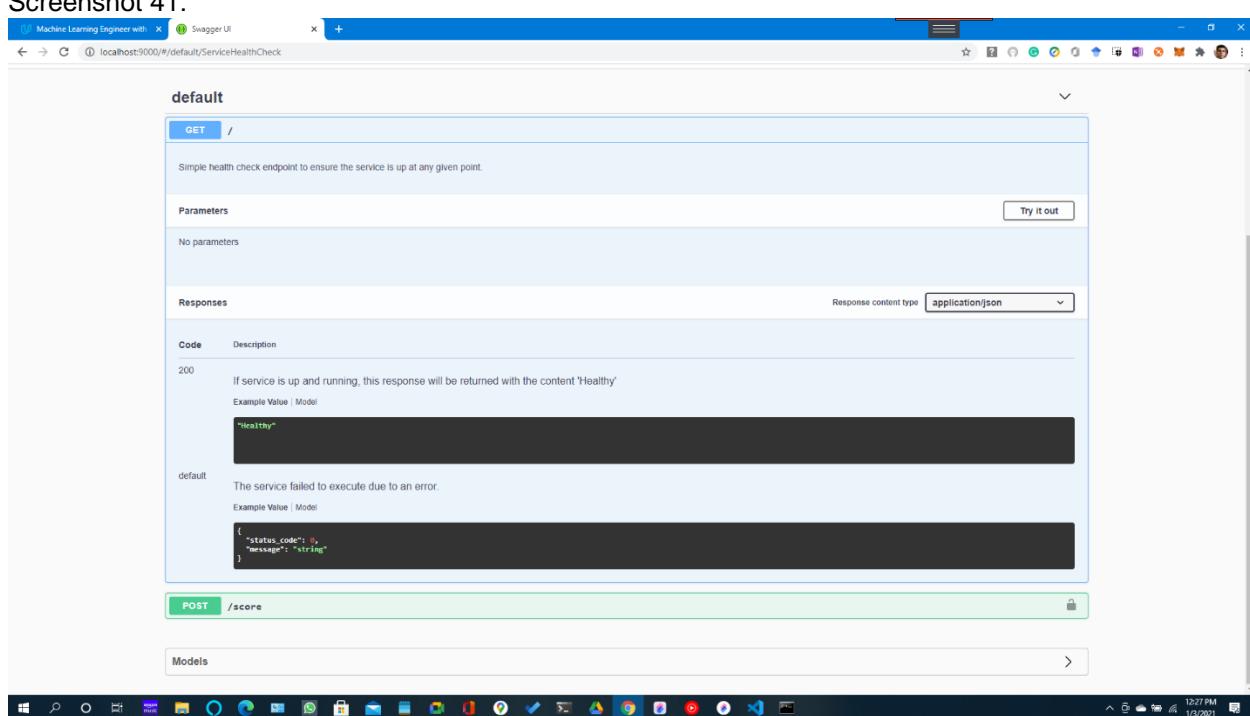
ServiceOutput >

ErrorResponse >

Screenshot 40:



Screenshot 41:



Screenshot 42:

The screenshot shows a Swagger UI interface for a machine learning service. At the top, there is a status bar with tabs for "Machine Learning Engineer with..." and "Swagger UI". The main window has a title bar "POST /score" and a sub-header "Run web service's model and get the prediction output". Below this is a "Parameters" section with a table:

Name	Description
serviceInputPayload	The input payload for executing the real-time machine learning service.
object (body)	Example Value Model

The "serviceInputPayload" row contains a JSON example:

```
{"data": [ { "age": 0, "job": "example_value", "marital": "example_value", "education": "example_value", "default": "example_value", "housing": "example_value", "loan": "example_value", "contact": "example_value", "month": "example_value", "day_of_week": "example_value", "duration": 0, "campaing": 0, "pdays": 0, "previous": 0, "poutcome": "example_value", "emp.var.rate": 0, "cons.price.idx": 0, "cons.consid": 0, "euribor": 0, "nr.employed": 0 } ]}
```

Below the table, there is a "Parameter content type" dropdown set to "application/json". To the right, there is a "Response content type" dropdown set to "application/json".

Screenshot 43:

The screenshot shows a Swagger UI interface for a machine learning service. At the top, there is a status bar with tabs for "Machine Learning Engineer with..." and "Swagger UI". The main window has a title bar "POST /score" and a sub-header "Run web service's model and get the prediction output". Below this is a "Responses" section with a "Curl" example:

```
curl -X POST "https://localhost:8080/score" -H "accept: application/json" -H "Content-Type: application/json" -d "[ { \"age\": 0, \"job\": \"example_value\", \"marital\": \"example_value\", \"education\": \"example_value\", \"default\": \"example_value\", \"housing\": \"example_value\", \"loan\": \"example_value\", \"contact\": \"example_value\", \"month\": \"example_value\", \"day_of_week\": \"example_value\", \"duration\": 0, \"campaing\": 0, \"pdays\": 0, \"previous\": 0, \"poutcome\": \"example_value\", \"emp.var.rate\": 0, \"cons.price.idx\": 0, \"cons.consid\": 0, \"euribor\": 0, \"nr.employed\": 0 } ]"
```

Below the curl command, there is a "Request URL" field containing "https://localhost:8080/score" and a "Server response" section. In the "Server response" section, under the "Code" tab, there is an error message:

TypeError: Failed to fetch

Under the "Responses" section, there is a table:

Code	Description
200	The service processed the input correctly and provided a result prediction, if applicable.
Example Value Model	[{ "status_code": 0, "message": "string" }]
default	The service failed to execute due to an error.
Example Value Model	[{ "status_code": 0, "message": "string" }]

Screenshot 44:

The screenshot shows a Swagger UI interface for a machine learning service. At the top, there are two tabs: "Machine Learning Engineer will..." and "Swagger UI". The URL bar indicates the page is at localhost:9000/#/default/RunMLService.

The main content area displays the API definition. It starts with a table for the "serviceInputPayload" object:

Name	Description
serviceInputPayload	The input payload for executing the real-time machine learning service.

Below this, there is an "Edit Value" and "Model" link. A "ServiceInput" dropdown is expanded, showing a "data" field with an example value:

```
example: OrderedMap { "data": List [ OrderedMap { "age": 0, "job": "example_value", "marital": "example_value", "education": "example_value", "default": "example_value", "housing": "example_value", "loan": "example_value", "contact": "example_value", "month": "example_value", "day_of_week": "example_value", "duration": 0, "campaign": 0, "pdays": 0, "previous": 0, "poutcome": "example_value", "emp.var.rate": 0, "cons.price.idx": 0, "cons.conf.idx": 0, "euribor3m": 0, "nr.employed": 0 } ] }
```

Below the input payload, there is a large blue "Execute" button. To its right, the "Response content type" is set to "application/json".

Under the "Responses" section, there are two entries:

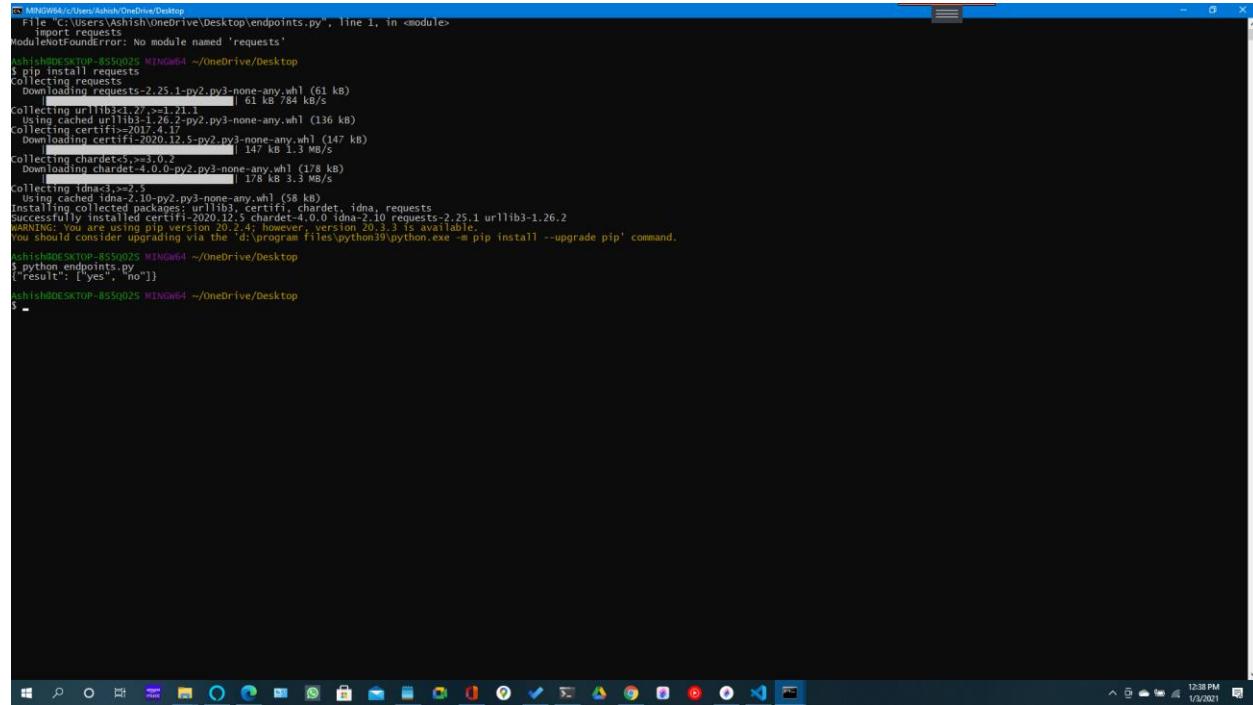
Code	Description
200	The service processed the input correctly and provided a result prediction, if applicable. Example Value Model [{"status_code": 0, "message": "string"}]
default	The service failed to execute due to an error. Example Value Model [{"status_code": 0, "message": "string"}]

At the bottom left, there is a "Models" link. The bottom right corner of the window shows the Windows taskbar with the date and time as 1/3/2021 12:31 PM.

Step 6: Consume Model Endpoints

Once the model was deployed, the endpoint.py script provided to interact with the trained model was run by modifying both the scoring_uri and the key to match the key for my service and the URI that was generated after deployment. Apache Benchmark (ab) was also executed and calculated. Screenshot of run of endpoint.py producing the required output can be seen in Screenshot 45. Screenshot of Apache Benchmark ab running can be seen in screenshot 46.

Screenshot 45:



```
MINGW64 /c/Users/Akash/OneDrive/Desktop
$ File: C:\Users\Akash\OneDrive\Desktop\endpoints.py", line 1, in <module>
      import requests
ModuleNotFoundError: No module named 'requests'
akash@DESKTOP-855Q025 MINGW64 ~/OneDrive/Desktop
$ pip install requests
Collecting requests
  Downloading requests-2.25.1-py2.py3-none-any.whl (61 kB)
    61 kB / 784 kB/s
Collecting urllib3<1,2>>=1.21.1
  Using cached urllib3-1.26.2-py2.py3-none-any.whl (136 kB)
Collecting certifi>=2017.4.17
  Downloading certifi-2020.12.5-py2.py3-none-any.whl (147 kB)
    147 kB / 1.3 MB/s
Collecting chardet<5,>=3.0.2
  Downloading chardet-4.0.0-py2.py3-none-any.whl (178 kB)
    178 kB / 3.0 MB/s
Collecting idna<3,>=2.5
  Using cached idna-2.10-py2.py3-none-any.whl (58 kB)
Installing collected packages: urllib3, certifi, chardet, idna, requests
Successfully installed certifi-2020.12.5-py2.py3-none-any.whl, idna-2.10-py2.py3-none-any.whl, requests-2.25.1 urllib3-1.26.2
WARNING: You are using pip version 20.2.4; however, version 20.3.3 is available.
You should consider upgrading via the 'd:\program files\python39\python.exe -m pip install --upgrade pip' command.
akash@DESKTOP-855Q025 MINGW64 ~/OneDrive/Desktop
$ python endpoints.py
['result': ['yes', 'no']]
akash@DESKTOP-855Q025 MINGW64 ~/OneDrive/Desktop
$
```

Screenshot 46:

```
Administrator:~ /OneDrive/Desktop
$ ./benchmark.sh
This is ApacheBench, Version 2.3 (Revision: 187490 $)
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/
benchmarking 23ee02f-ec49-4441-8218-19d8afe69439.eastus.azurecontainer.io (be patient)...INFO: POST header ==
POST /score HTTP/1.0
Content-type: application/json
Authorization: Bearer j3xmCR8FcATO4mPwvLlh9bfifhd
X-Ms-Request-Id: aad-aa44e-abeef-448f-86ca-a442e1c0e796
User-Agent: ApacheBench/2.3
Accept: */*

--LOG: header received:
HTTP/1.0 200 OK
Content-Length: 33
Content-Type: application/json
Date: Sun, 03 Jan 2021 07:25:53 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Run-Function-Failed: False

["{"result": ["\\"yes\\", \"no\"]"}"]
LOG: Response code = 200
--LOG: header received:
HTTP/1.0 200 OK
Content-Length: 33
Content-Type: application/json
Date: Sun, 03 Jan 2021 07:25:54 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Run-Function-Failed: False

["{"result": ["\\"yes\\", \"no\"]"}"]
LOG: Response code = 200
--LOG: header received:
Content-Length: 33
Content-Type: application/json
Date: Sun, 03 Jan 2021 07:25:54 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: beebf-42b4-4762-a-43d-6fed9ce4d2b7
X-Ms-Run-Function-Failed: False

["{"result": ["\\"yes\\", \"no\"]"}"]
LOG: Response code = 200
--LOG: header received:
Content-Length: 33
Content-Type: application/json
Date: Sun, 03 Jan 2021 07:25:55 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: 221163d-42b-4c9a-9ebd-03195da3bf23
X-Ms-Run-Function-Failed: False

["{"result": ["\\"yes\\", \"no\"]"}"]
LOG: Response code = 200
--LOG: header received:
Content-Length: 33
Content-Type: application/json
Date: Sun, 03 Jan 2021 07:25:56 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: 0d4fc1d-f2e8-4218-92ea-f4d0e41cab8
X-Ms-Run-Function-Failed: False
```

Screenshot 48:

```
HTTP/1.0 200 OK
Content-Length: 33
Content-Type: application/json
Date: Mon, 07 Mar 2022 07:35:59 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: 8f09314-f15c-492e-5f8e-58F80645ea73
X-Ms-Run-Function-Failed: False

[{"result": ["\\yes\\", "\\no\\"]}]
LOG: Response code is 200
LOG: header received
Content-Length: 33
Content-Type: application/json
Date: Mon, 07 Mar 2022 07:35:59 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: d0c5928c-2fb8-4fc8-844d-bc5b65a2b67f
X-Ms-Run-Function-Failed: False

[{"result": ["\\yes\\", "\\no\\"]}]
LOG: Response code is 200
LOG: done

Server Software: nginx/1.10.3
Server Hostname: 25ed02f-ec49-4441-8218-19d8afe69439.eastus.azurecontainer.io
Server Port: 80
Document Path: /score
Document Length: 33 bytes

Concurrency Level: 1
Time taken for tests: 7.832 seconds
Complete requests: 10
Unsuccessful requests: 0
Total transferred: 2600 bytes
Total body sent: 10560
Total transferred: 33 bytes
Requests per second: 1.28 [#/sec] (mean)
Time per request: 783.207 [ms] (mean)
Time per request: 783.207 [ms] (stdev, across all concurrent requests)
Transfer rate: 0.32 [kbytes/sec] received
0.34 [kbytes/sec] sent
1.64 kB/s total
1.64 kB/s total

Connection Times (ms)
min mean [+/-sd] median max
Connect: 243 306 140.7 257 699
Disconnecting: 452 521 210.5 513 517
Waiting: 440 468 211.0 467 513
Total: 704 783 137.8 732 1166

Percentage of the requests served within a certain time (ms)
 50% 732
 60% 743
 75% 784
 80% 795
 90% 1166
 95% 1166
 99% 1166
100% 1166 (longest request)

ashishDESKTOP-BSSQD26 MINGW64 ~/OneDrive/Desktop

```

2) Via given python code

Step 7: Create, Publish and Consume a Pipeline

- 1) For this part of the project, I used the Jupyter Notebook provided in the starter files. And all necessary alterations were done to relevant files as per instructions. Apache Benchmark (ab) was also executed and calculated.

2) Published Dataset

Screenshot 49:

The screenshot shows the Microsoft Azure Machine Learning interface. A dataset named "bankmarketing" is selected. The "Explore" tab is active, displaying a preview of the data. The data table has 21 columns and 50 rows. The columns are: id, age, job, marital, education, default, housing, loan, contact, month, day_of_week, duration, and campaign. The data includes various categories like "entrepreneur", "technician", "self-employed", etc., and binary values like "yes" or "no".

3) Notebook and Compute VM for Notebook Created

Screenshot 50:

The screenshot shows the Microsoft Azure Machine Learning interface with a notebook titled "aml-pipelines-with-automated-machine-learning-step.ipynb" open. The notebook is running on a compute instance named "automlcomputevm". The code cell contains the following imports:

```
[1]: 1 import logging
2 import os
3 import csv
4
5 from matplotlib import pyplot as plt
```

4) All Runs Completed Notebook

https://github.com/ashishsomvanshi/operationalizing_azureml/blob/main/aml-pipelines-with-automated-machine-learning-step.ipynb

5) Experiment Seen as Completed

Screenshot 51: (Run 4, Run 1 auto failed without human intervention as recorded in screencast)

The screenshot shows the Microsoft Azure Machine Learning Studio interface. The main view displays a summary of experiment runs. At the top, there are filters for 'Run status' (Running, Completed, Failed, Other), 'recall_score_micro' (No data), and 'accuracy' (No data). Below this is a table of runs:

Run	Run ID	Status	Submitted time	Duration	Submitted by	Compute target	Run type	Last(recall_score_micro)	Last(accuracy)	Tags
Run 4	4c5d132d-47f4-410d-8b54-2e534fb63d...	Completed	Jan 10, 2021 7:02 AM	44m 35s	ODL_User 134165	Pipeline				azureml.pipeline[...]
Run 1	d50d19bb-6306-431b-a14a-39143073a3...	Failed	Jan 10, 2021 6:54 AM	2m 42s	ODL_User 134165	Pipeline				azureml.pipeline[...]

At the bottom of the interface, there is a 'swagger.json' file tab and a taskbar with various application icons.

6) Best Model Auto selected (Screenshots 52 to 56)

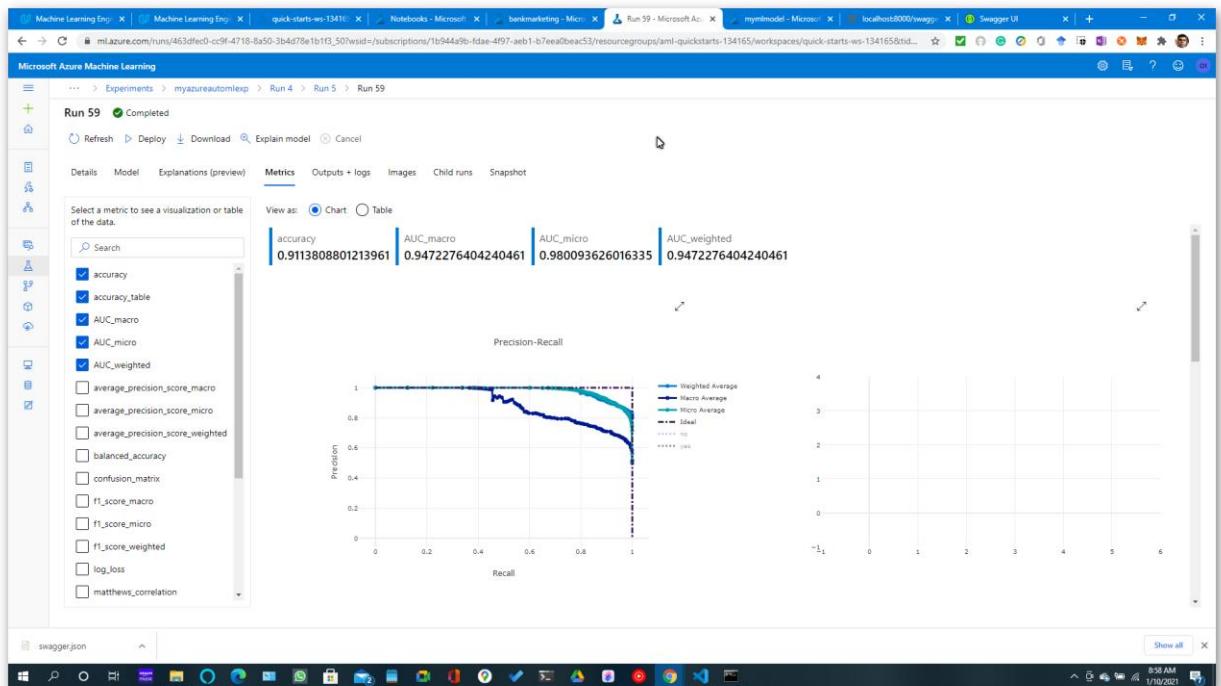
Screenshot 52:

This screenshot shows the Microsoft Azure Machine Learning Studio interface. The main title bar reads "Machine Learning Env" and "Machine Learning Env". The URL in the address bar is "ml.azure.com/runs/463dfe0-cc9f-4718-8a50-3b4d78e1b1f3?wsid=...". The page displays a "Run 5" entry under the "Experiments > myazureautomlexp > Run 4" path. The status is "Completed". The "Properties" section includes fields like "Status" (Completed), "Created" (Jan 10, 2021 7:02 AM), "Started" (Jan 10, 2021 7:03 AM), "Duration" (42m 18.87s), "Compute target" (myazuremlcomp), "Run ID" (463dfe0-cc9f-4718-8a50-3b4d78e1b1f3), "Run number" (5), and "Script name" (--). The "Input datasets" and "Output datasets" sections are shown as grayed-out boxes. The "Best model summary" section lists the algorithm as "VotingEnsemble" with an AUC weighted of 0.94723. The "Run summary" section shows the task type as "Classification", primary metric as "AUC weighted", and run status as "Completed". The "Experiment name" is "myazureautomlexp". The bottom navigation bar includes a "swagger.json" link and a "Show all" button.

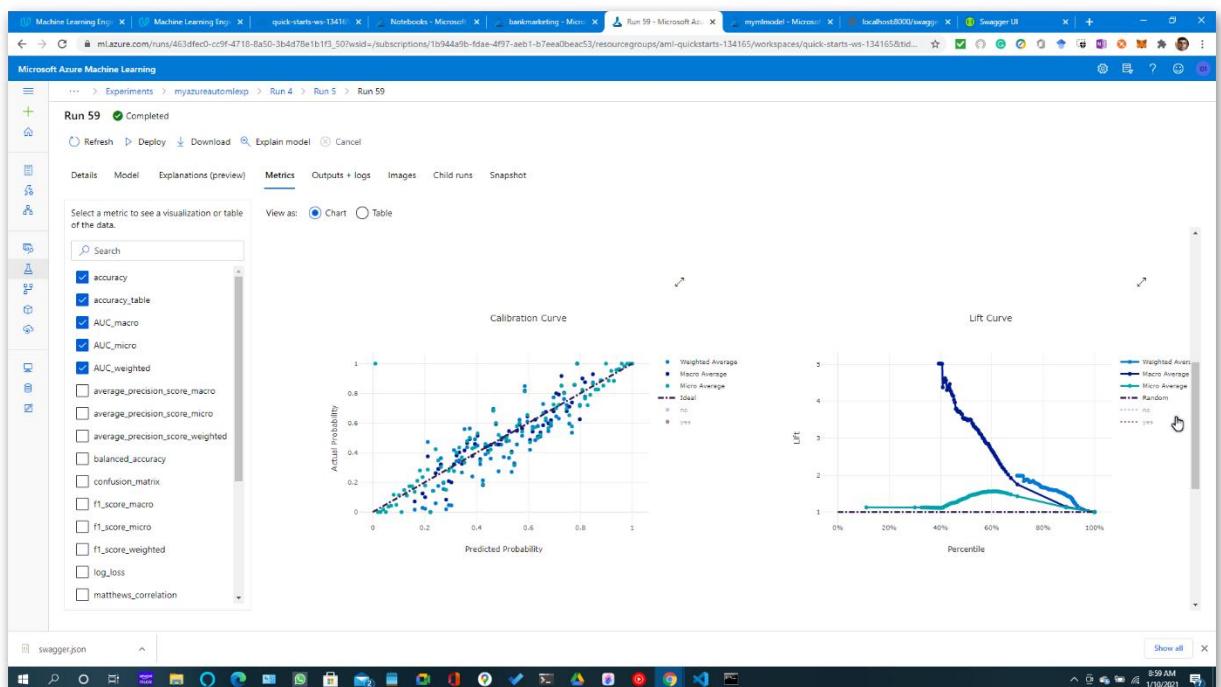
Screenshot 53:

This screenshot shows the Microsoft Azure Machine Learning Studio interface, similar to the previous one but for a different run. The main title bar reads "Machine Learning Env" and "Machine Learning Env". The URL in the address bar is "ml.azure.com/runs/463dfe0-cc9f-4718-8a50-3b4d78e1b1f3_50?wsid=...". The page displays a "Run 59" entry under the "Experiments > myazureautomlexp > Run 4 > Run 5 > Run 59" path. The status is "Completed". The "Model summary" section includes fields like "Algorithm name" (VotingEnsemble), "AUC weighted" (0.94723), "Sampling" (100.00 %), and "Registered models" (463dfe0-cc9f47150:1). The "Deploy status" section is shown as a grayed-out box. The bottom navigation bar includes a "swagger.json" link and a "Show all" button.

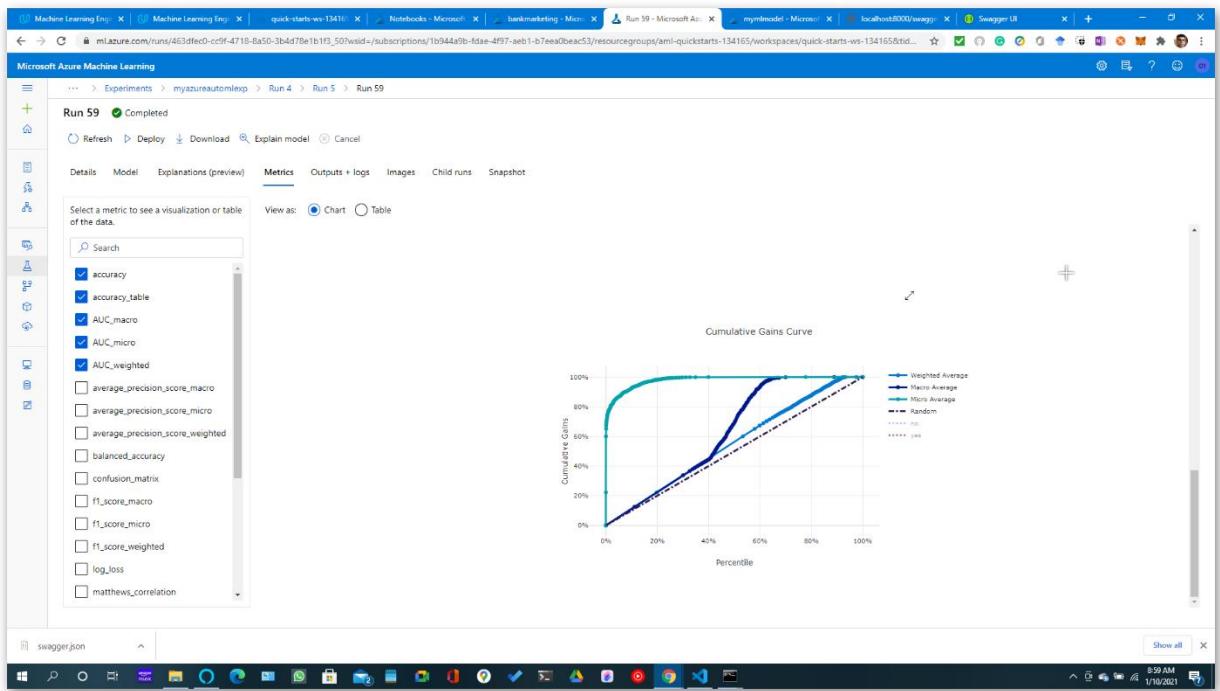
Screenshot 54:



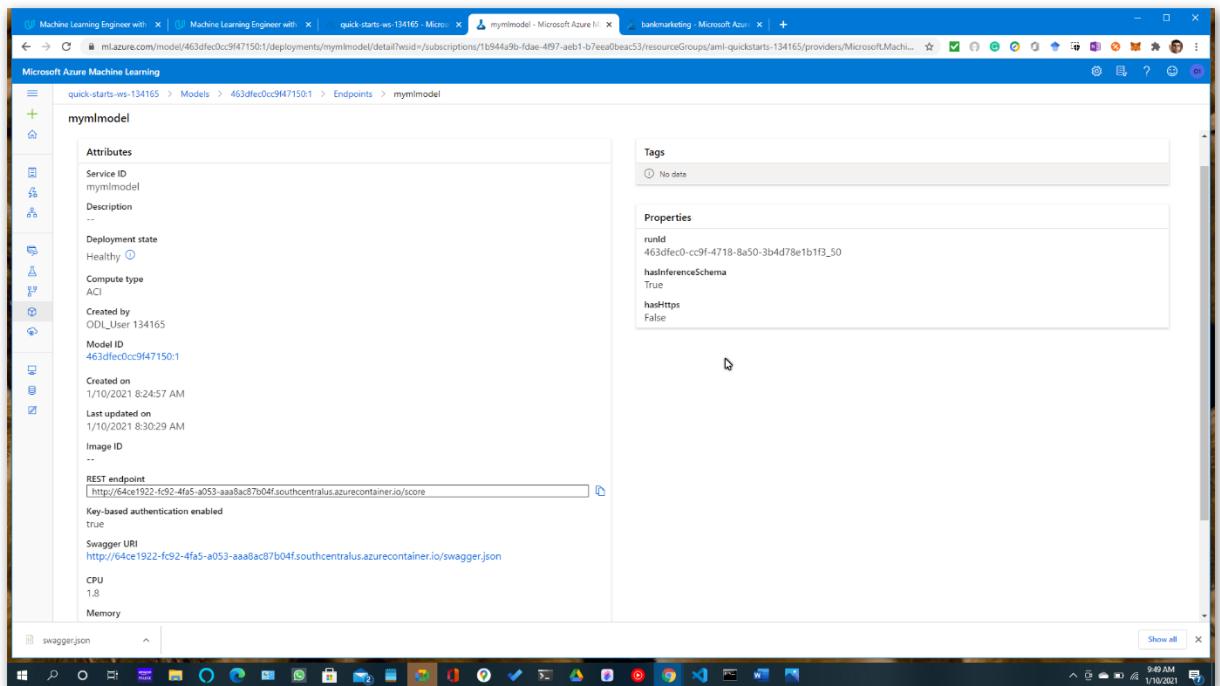
Screenshot 55:



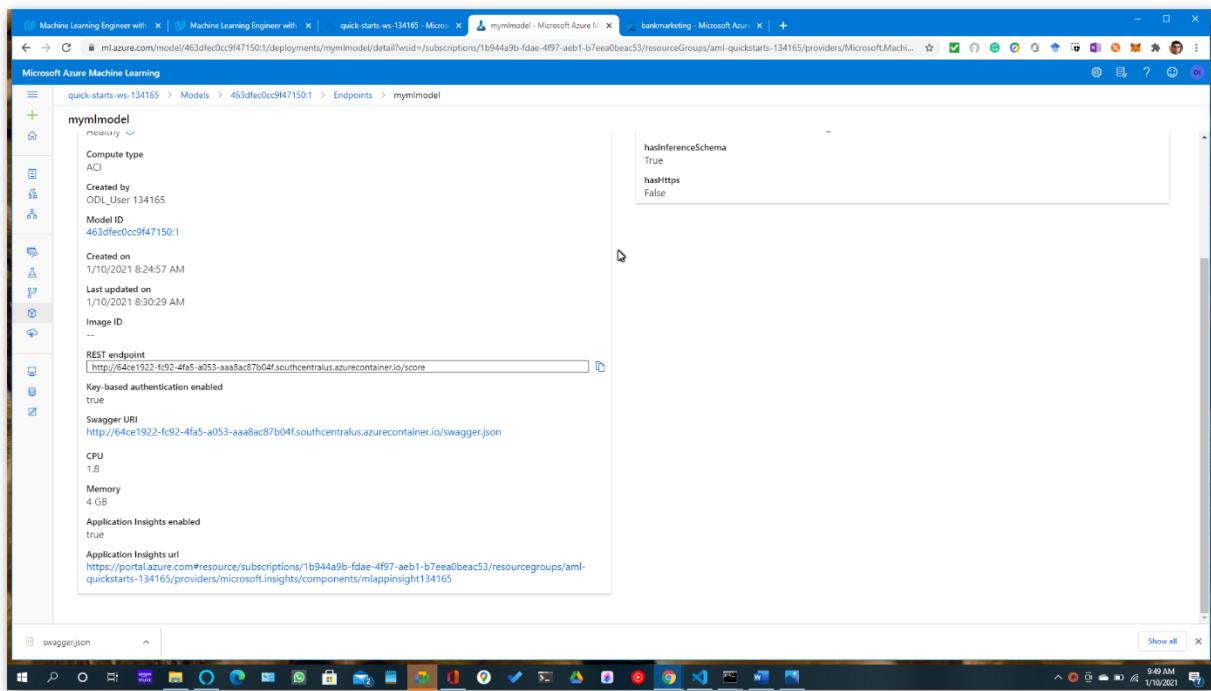
Screenshot 56:



- 7) Endpoint details of published model with Application Insights enabled and output of logs.py
- Screenshot 57:**



Screenshot 58:

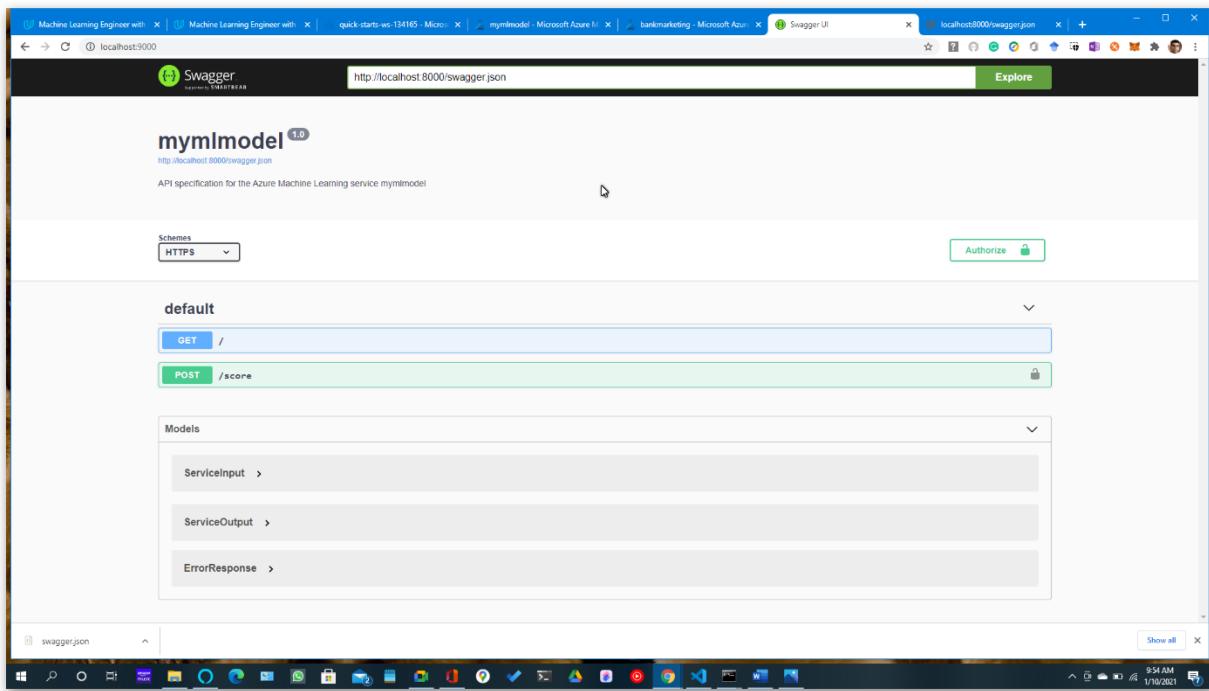


8) swageer.sh output

Screenshot 59:

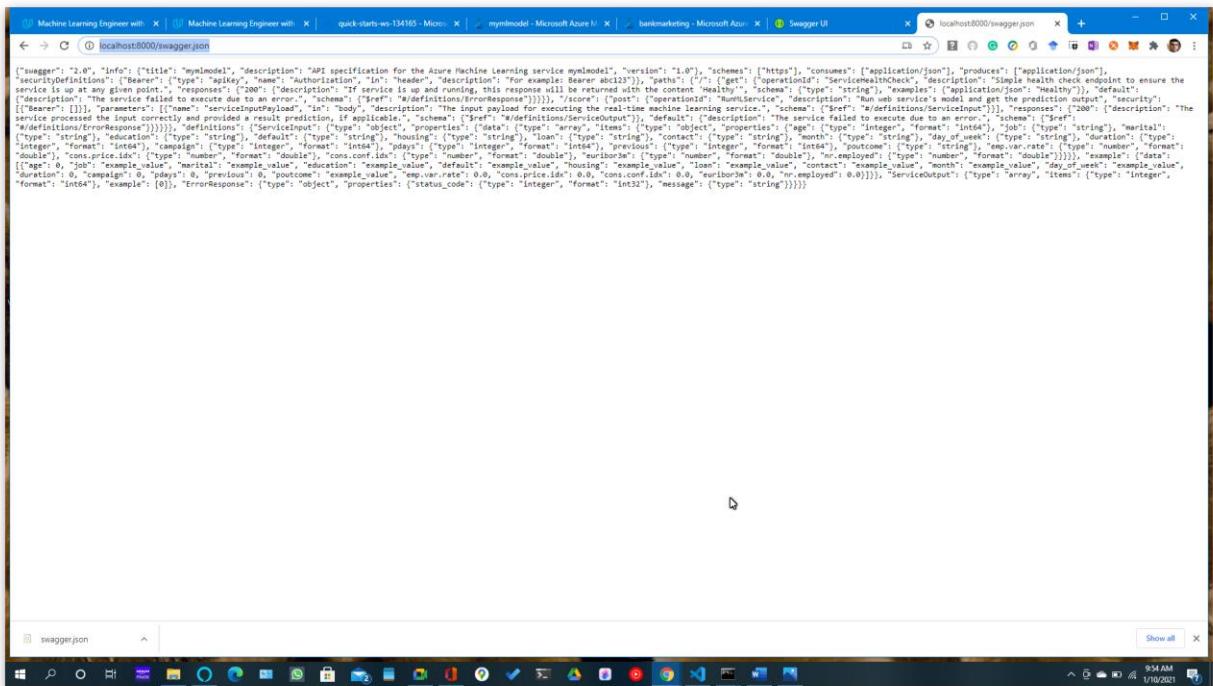
9) swagger ui running with swagger.json

Screenshot 60:



10) swagger.json

Screenshot 61:



11) endpoint.py (ran as endpoints.py) and ab benchmark ran as benchbark.sh

Screenshot 62:

```

MINGW64 /c/Users/Ashish/OneDrive/Desktop/azlattest
$ ./azlattest
$ python endpoints.py
[{"result": "no", "no": ""}]

MINGW64 /c/Users/Ashish/OneDrive/Desktop/azlattest
This is ApacheBench, Version 2.3 (Revision: 1879490 >)
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking 64ce1922-fc92-4fa5-a053-aaa8ac87b04f.southcentralus.azurecontainer.io (be patient)...INFO: POST header ==
POST /score HTTP/1.0
Content-Type: application/json
Authorization: Bearer 93c08e85zshJpQayyxdShIKJZNoV7Z
Host: 64ce1922-fc92-4fa5-a053-aaa8ac87b04f.southcentralus.azurecontainer.io
User-Agent: ApacheBench/2.3
Accept: */*

...
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:47 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: c6d92a5a-0009-4951-9751-9ccf44cb793
X-Ms-Run-Function-Failed: False
[{"result": "\\"no\\", "\\"no\\"]}
LOG: Response code = 200
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:47 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: 031b4980-95ec-4ac2-84ec-13bb1507617f
X-Ms-Run-Function-Failed: False
[{"result": "\\"no\\", "\\"no\\"]}
LOG: Response code = 200
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:48 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: 3103e3b-alexa-4f39-9ad3-99864372e85
X-Ms-Run-Function-Failed: False
[{"result": "\\"no\\", "\\"no\\"]}
LOG: Response code = 200
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:49 GMT
Server: nginx/1.10.3 (Ubuntu)
X-Ms-Request-Id: 43164-11-69a9-4717-a74e-a32dfb66061
X-Ms-Run-Function-Failed: False
[{"result": "\\"no\\", "\\"no\\"]}
LOG: Response code = 200
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:50 GMT
...

```

Screenshot 63:

```

MINGW64 /c/Users/Ashish/OneDrive/Desktop/azlattest
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:52 GMT
Server: nginx/1.10.3
X-Ms-Request-Id: 43164-11-69a9-4717-a74e-a32dfb66061
X-Ms-Run-Function-Failed: False
[{"result": "\\"no\\", "\\"no\\"]}
LOG: Response code = 200
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jan 2021 03:12:53 GMT
Server: nginx/1.10.3
X-Ms-Request-Id: c41fe1e1-96a9-4cd0-b5b4-580bd631e2aF
X-Ms-Run-Function-Failed: False
[{"result": "\\"no\\", "\\"no\\"]}
LOG: Response code = 200
...done

Server Software:      nginx/1.10.3
Server Hostname:     64ce1922-fc92-4fa5-a053-aaa8ac87b04f.southcentralus.azurecontainer.io
Server Port:          80
Document Path:        /score
Document Length:     32
Connection Level:    1
Time taken for tests:  6.703 seconds
Complete requests:   10
Avg. byte sent per transaction:  2590 bytes
Total transferred:   10640 bytes
HTML transferred:   10640 bytes
Requests per second: 1.49 [#/sec] (mean)
Time per request:   0.676 [ms] (mean)
Time per request:   0.70268 [ms] (mean), across all concurrent requests
Transfer rate:       0.38 [kbytes/sec] received
                         1.15 [kbytes/sec] sent
                         1.93 kb/s total

Connection Times (ms)
              min  mean[+/-sd] median  max
Connect:   53  672  102  222
Processing: 354  276  23.2  363  414
Waiting:   351  374  22.6  360  410
Total:    640  670  26.6  674  705

Percentage of the requests served within a certain time (ms)
  50% 672
  66% 692
  75% 703
  80% 702
  90% 705
  95% 705
  99% 705
100% 705 (longest request)

```

Screenshot 64:

```
MINGW64 ~/Users/Admin/OneDrive/Desktop/test.txt
Content-Length: 12
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:48 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 031b4960-95ec-4ac2-84ec-13bb1507617f
X-Ms-Run-Function-Failed: False

["result"], ["no"], ["no"]]

LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:48 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 3103e45b-a6ea-4f39-9ad3-998643723e85
X-Ms-Run-Function-Failed: False

["result"], ["no"], ["no"]]

LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:49 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 5af9e3e9-dac6-4d63-b3cb-ca059e558a9
X-Ms-Run-Function-Failed: False

["result"], ["no"], ["no"]]

LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:50 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 05d3488-41bf-4139-9038-ba02eb37472e
X-Ms-Run-Function-Failed: False

["result"], ["no"], ["no"]]

LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:50 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 8edcf306-5b7b-469a-b68c-303e27d961ac
X-Ms-Run-Function-Failed: False

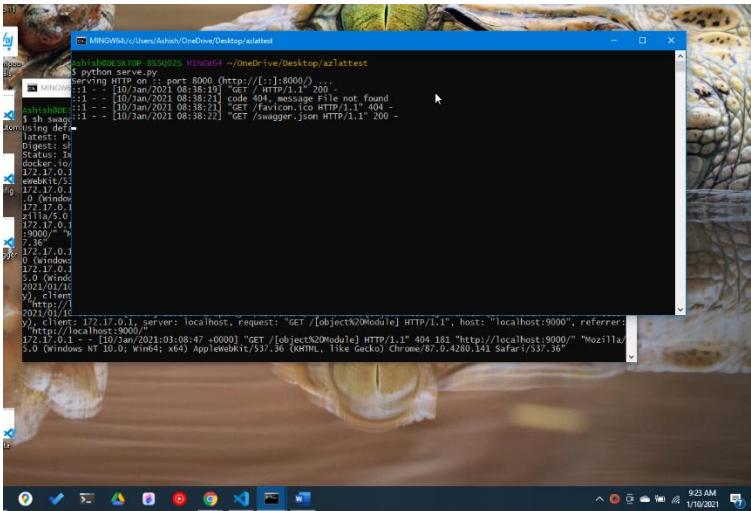
["result"], ["no"], ["no"]]

LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:51 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 8a2e6c35-cisc-f91a-81cf-54c2d0ea22c9
X-Ms-Run-Function-Failed: False

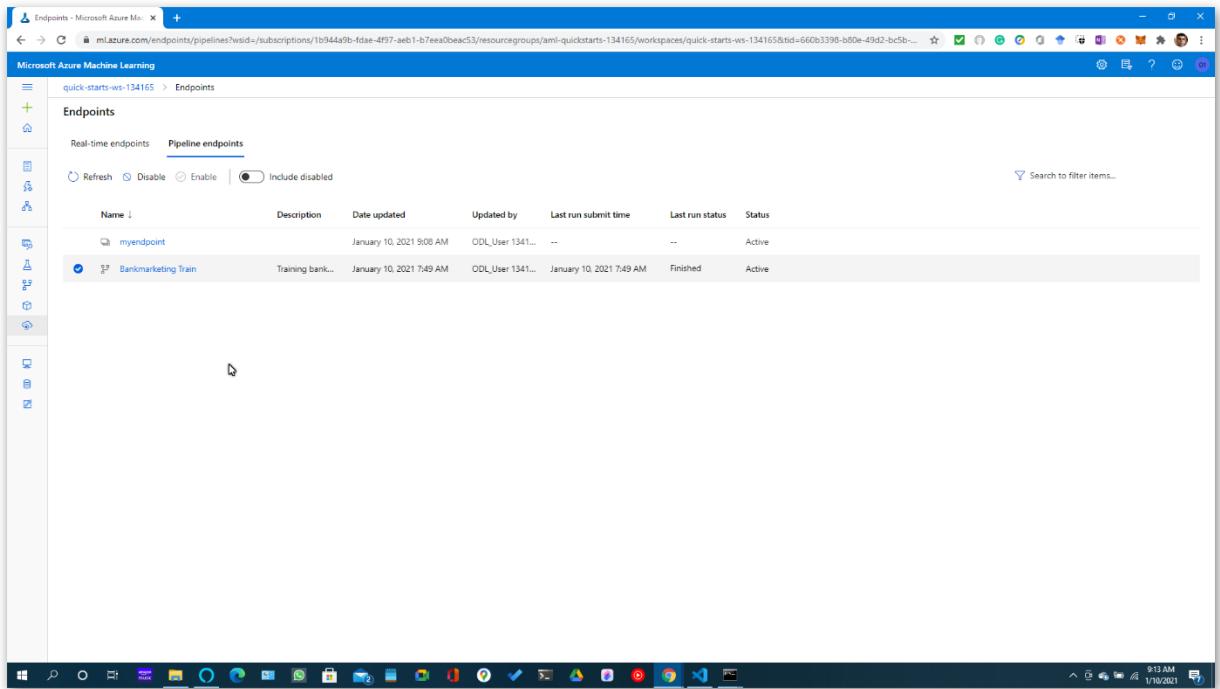
["result"], ["no"], ["no"]]

LOG: Response code: 200
LOG: header received:
HTTP/1.0 200 OK
Content-Length: 32
Content-Type: application/json
Date: Sun, 10 Jul 2021 03:12:52 GMT
Server: Microsoft-HTTPAPI/2.0 (Windows)
X-Ms-Request-Id: 2fc10747-5578-4c8b-8042-58dd48819754
X-Ms-Run-Function-Failed: False
```

12) serve.py running
Screenshot 65:

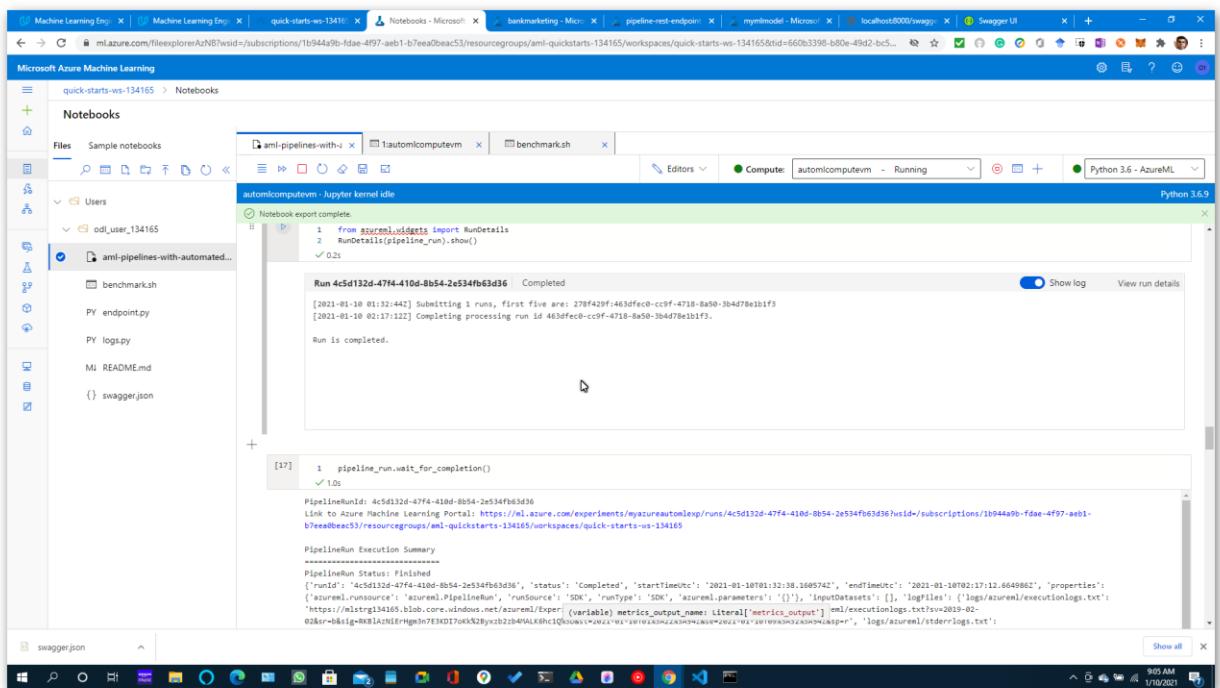


13) Active pipeline **Screenshot 66:**



- 14) Run details wizard output from python notebook (Screenshots 67-68)

Screenshot 67:



Screenshot 68:

```

[17] 1 pipeline_run.wait_for_completion()
    ✓ [1] Done
Link to Azure Machine Learning Portal: https://ml.azure.com/experiments/myazurautomlxp/runs/4c5d132d-47f4-410d-8b54-2e534fb63d36?sid=/subscriptions/1b944a9b-fdae-4f97-aeb1-b7ea0beac53/resourcegroups/aml-quickstarts-134165/workspaces/quick-starts-ws-134165&tid=660b3398-b80e-49d2-bc5...
PipelineRun Execution Summary
*****
PipelineRun Status: Finished
{
  "runId": "4c5d132d-47f4-410d-8b54-2e534fb63d36",
  "status": "Completed",
  "startTimeUtc": "2021-01-10T01:32:38.1605742",
  "endTimeUtc": "2021-01-10T02:17:12.6649862",
  "properties": {
    "azureml_runtask": "azureml_PipelineRun",
    "runsource": "Local"
  },
  "runType": "ScriptRun",
  "parameters": {
    "{'': ''}"
  },
  "inputDatasets": [],
  "logFiles": [
    "logs/azureml/executionlogs.txt"
  ],
  "outputs": [
    "outputs/aml-quickstarts-134165/aml-pipeline-run-134165-1b944a9b-fdae-4f97-aeb1-b7ea0beac53/aml-pipeline-run-134165-1b944a9b-fdae-4f97-aeb1-b7ea0beac53/resourcegroups/aml-quickstarts-134165/workspaces/quick-starts-ws-134165"
  ]
}
*****  

'Finished'

Examine Results
Retrieve the metrics of all child runs
Outputs of above run can be used as inputs of other steps in pipeline. In this tutorial, we will examine the outputs by retrieve output data and running some tests.
[18] 1 metrics_output = pipeline_run.get_pipeline_output('metrics_output')

```

Screen Recordings and Screenshots Captured

Link to all recordings and screenshots of almost all the major the activity done uploaded to the Microsoft OneDrive in Multiple files. Some activity was not recorded but I have tried to get them covered in screenshots.

For All activity:

Video Recordings: <https://1drv.ms/u/s!AqbnW4s20s0s0zi2cpE3OkK6sOy?e=VuBgXP>

Screenshots Captured:<https://1drv.ms/u/s!AqbnW4s20s0s1Dxi-uRuiH8xKwxg?e=QpXPkc>

Screencast For majority of the Python notebook run and related activities:

<https://1drv.ms/v/s!AqbnW4s20s0s1QPveG56A6RtfIAY>

Standout Suggestions

- 15) The optional Authentication step was also done including the deployment of Azure cli and azure machine learning extension to the azure cli as required and further authentication and another project related steps as in the project instructions.
- 16) Have tried to record all major activities done on video or screenshots.
- 17) Apache Benchmark (ab) was also executed and calculated.

Suggestions to improve further:

In future we can improve the best model by choosing different primary metrics and different classification methods and calculating and comparing the values of mean_squared_error, to study how our predictions have deviated from actual values and, we study mean absolute percent error (MAPE) in detail. We can also study the impact of increasing number of clusters used to study to get faster results. All these could help us in reducing error in our model and help us to study the model much faster. We can also add more data to the model, or we can add more columns. Also, we can make new columns with existing ones with future engineering and by applying our domain knowledge and obtain better results. Also, we can provide

a more user-friendly user interface while consuming the API's and the Swagger documentation. Lot of steps run on command-line can be ran directly from Jupyter notebook or could be automated in a single script.