# Contents

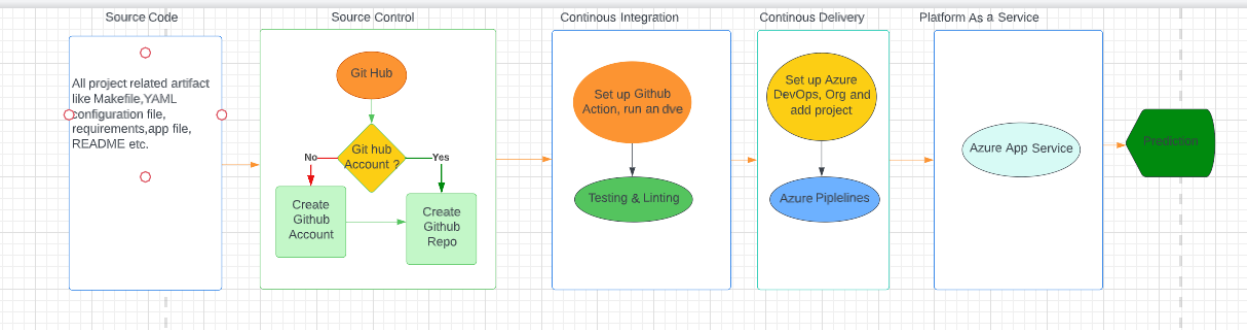
# 1. Azure DevOps Principles and Practices

## 1.1. Project Plan

### 1.1.1 An overview of the project

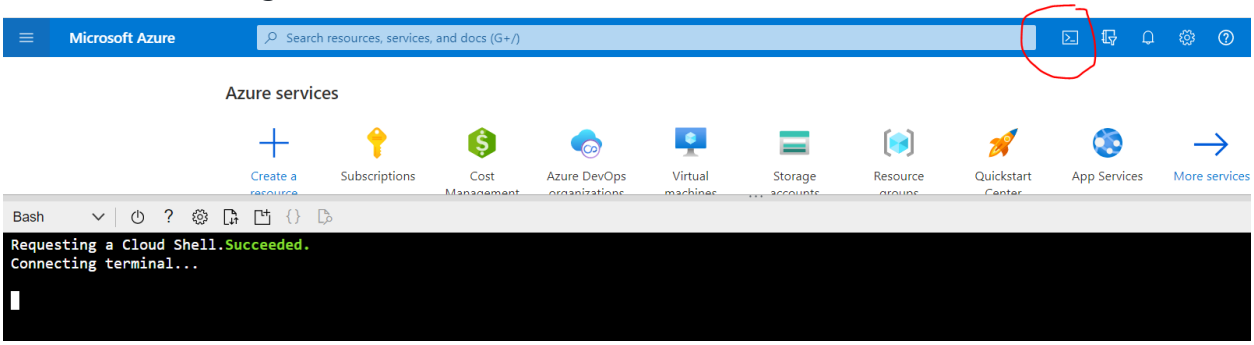
This project is a Python flask app that serves out predictions (inference) about housing prices through API calls which can be extended to any pre-trained machine learning model, such as those for image recognition and data labeling. The project provides pre-trained, sklearn model that has been trained to predict housing prices in Boston according to several features, such as average rooms in a home and data about highway access, teacher-to-pupil ratios, and so on. I will build a Github repository from scratch and create a scaffolding that will assist me in performing both Continuous Integration and Continuous Delivery of this project. I will use Github Actions along with a Makefile, requirements.txt and application code to perform an initial lint, test, and install cycle and then integrate this project with Azure Pipelines to enable Continuous Delivery to Azure App Service

## 1.2. Architectural Diagram



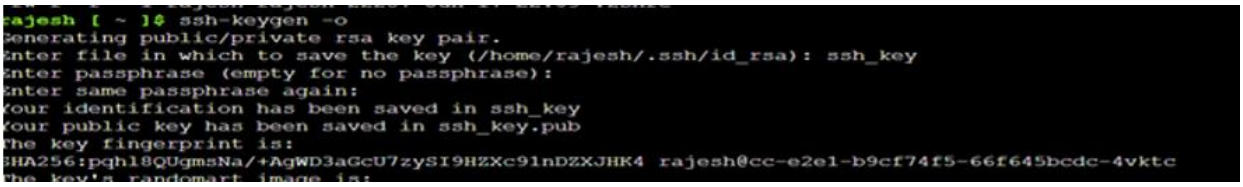

## 1.3. Instructions for running the Python project

1.3.1. Login into azure portal and click on Azure cloud shell (>). This will prompt to create a storage account and file share for first time, this is required to store Azure cloud shell related setting and metadata.

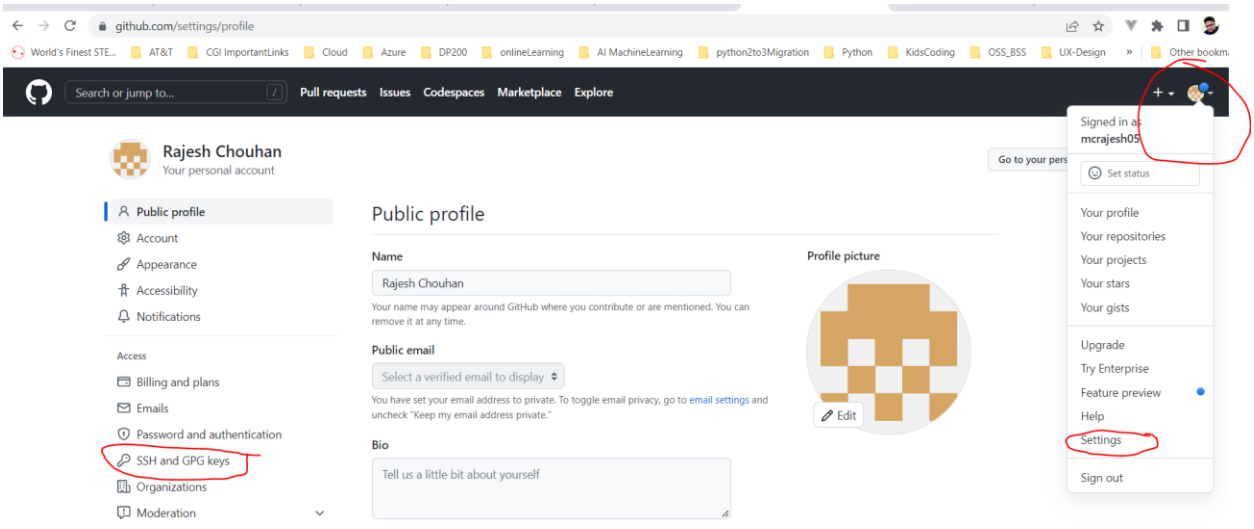



1.3.2. Create ssh-key and upload the public key GitHub account to facilitate secure password less communication.

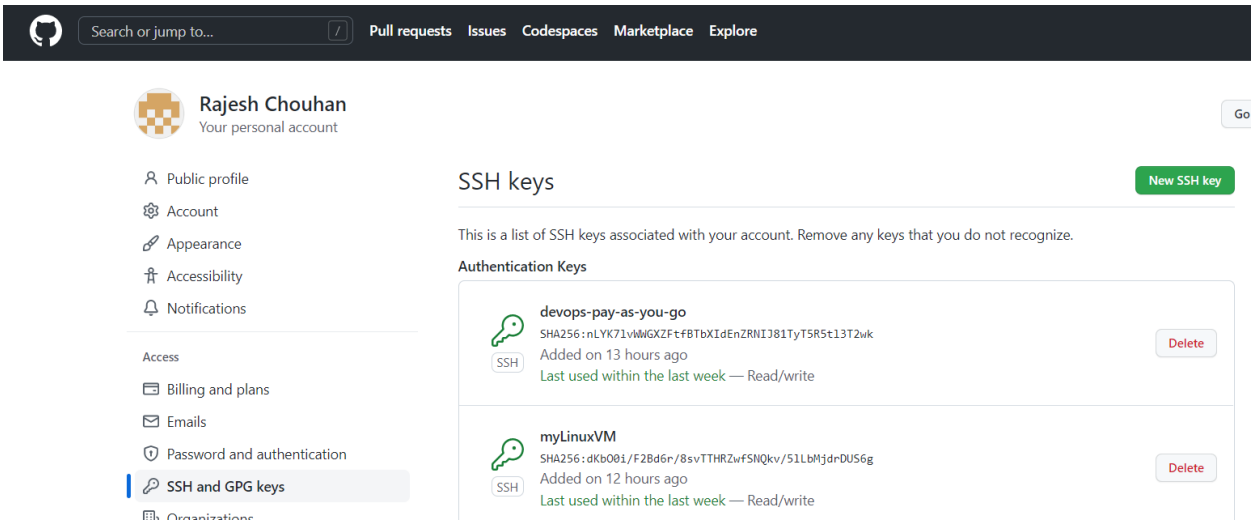
Use command ssh-keygen



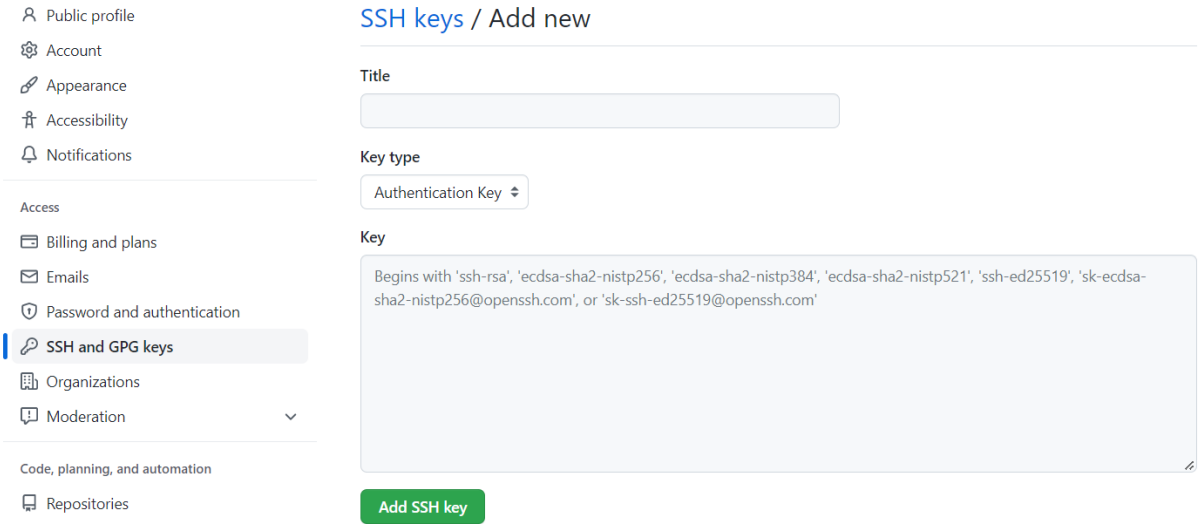

To Upload the public key GitHub account, login to GitHub account and click on profile and setting as shown below.



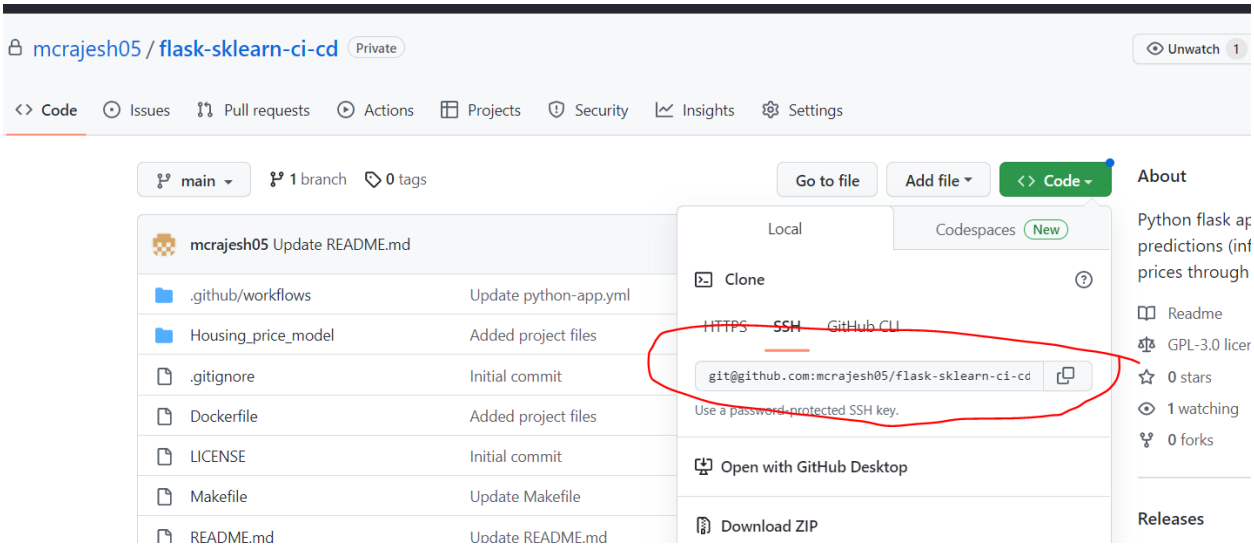

Click on SSH and GPG and New SSH key




Fill the title with appropriate and copy the public key form cloud shell and past into key field. Save it.



1.3.4. Clone the project into cloud shell. Grab the ssh URL.




In azure cloud shell type as shown the screen shot.

```
rajesh [ ~ ]$ git clone git@github.com:mcrajesh05/flask-sklearn-ci-cd.git
Cloning into 'flask-sklearn-ci-cd'...
The authenticity of host 'github.com (20.207.73.82)' can't be established.
ED25519 key fingerprint is SHA256:+DiY3wvvV6TuJJhbpZisF/zLDA0zPMSvHdkr4UvCOqU.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'github.com' (ED25519) to the list of known hosts.
remote: Enumerating objects: 84, done.
remote: Counting objects: 100% (84/84), done.
remote: Compressing objects: 100% (74/74), done.
remote: Total 84 (delta 33), reused 20 (delta 5), pack-reused 0
Receiving objects: 100% (84/84), 242.30 KiB | 386.00 KiB/s, done.
Resolving deltas: 100% (33/33), done.
rajesh [ ~ ]$ ls -la
total 64
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:45 .
drwxrwxrwx 3 root   root    4096 Nov 15 05:27 
drwx------ 5 rajesh rajesh  4096 Nov 15 05:28 .azure
-rw------- 1 rajesh rajesh   322 Nov 15 05:45 .bash_history
-rw-r--r-- 1 rajesh rajesh   178 Apr 23  2022 .bash_logout
-rw-r--r-- 1 rajesh rajesh   645 Apr 23  2022 .bash_profile
-rw-r--r-- 1 rajesh rajesh   741 Nov 15 05:27 .bashrc
lrwxrwxrwx 1 rajesh rajesh    22 Nov 15 05:27 clouddrive -> /usr/csuser/clouddrive
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:45 flask-sklearn-ci-cd
drwx------ 2 rajesh rajesh  4096 Nov 15 05:45 .ssh
-rw-r--r-- 1 rajesh rajesh    42 Nov 15 05:27 .tmux.conf
```

1.3.5. Create and virtual environment and activate it.

- **Use command**

  python3 -m venv venv310

```
Python 3.9.14
rajesh [ ~ ]$ python3 -m venv .devops
```

- **Use command to activate**

source ./ venv310/bin/activate

```
-rw-r--r-- 1 rajesh rajesh 22287 Jun 17 22:09 .zshrc
rajesh [ ~ ]$ source ./.devops/bin/activate
(.devops) rajesh [ ~ ]$
```

### 1.3.6. Navigate to cloned project folder. Run “make all” . This will install all the necessary python libraries

### 1.3.7. To test locally run: python app.py

- Open new cloud shell and run: ./make_prediction.sh

```
rajesh [ ~ ]$ source ./.devops/bin/activate
(.devops) rajesh [ ~ ]$ cd flask-sklearn-ci-cd
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$ ./make_prediction.sh
Port: 5000
{
  "prediction": [
    20.353731771344123
  ]
}
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$
```

### 1.3.7. To deploy and test.

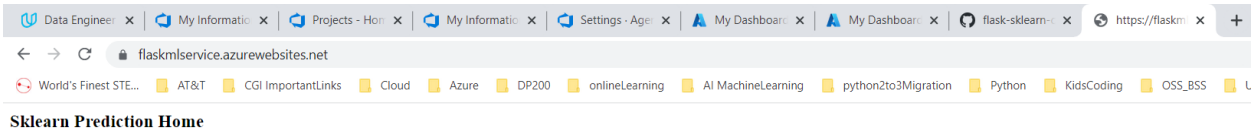
- Run the following command to deploy the app.

  az webapp up --name flaskmlservice --resource-group devops --runtime "PYTHON:3.10" --sku B

- Once the deployment is completed. Get the URL something like

  https://flaskmlservice.azurewebsites.net/

- open browser and open this URL. Verify if you get output as shown below.




Once you see the above output then run the command as shown below to see prediction.

```
-rwxrwxrwx 1 rajesh rajesh   358 Nov 15 05:45 run_kubernetes.sh
-rwxrwxrwx 1 rajesh rajesh   417 Nov 15 05:45 test_hello.py
-rwxrwxrwx 1 rajesh rajesh   333 Nov 15 05:45 upload_docker.sh
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$ ./make_predict_azure_app.sh
Port: 443
{"prediction":[20.353731771344123]}
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$
```

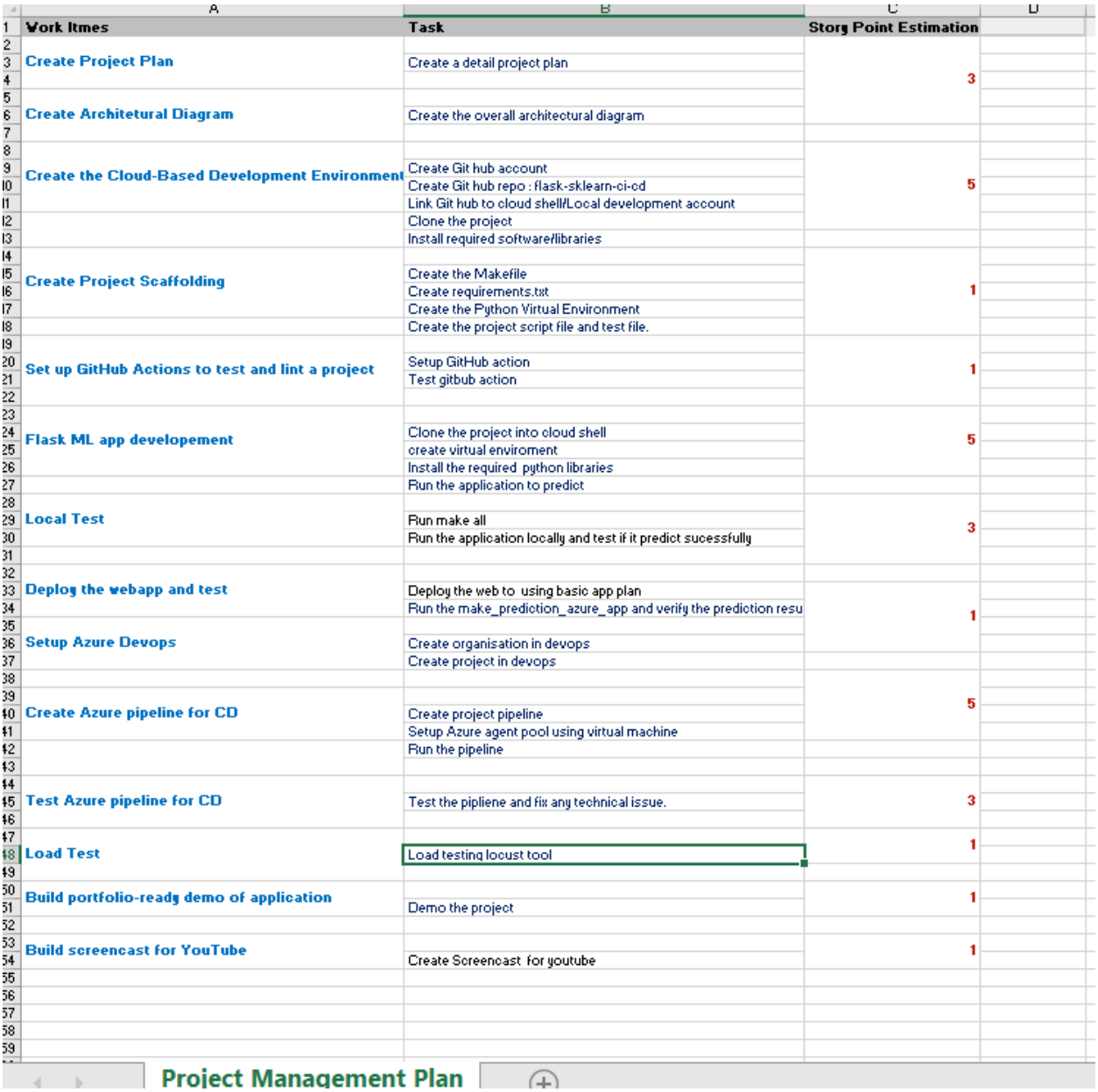
# 1.4. Short description of how to improve the project in the future.

This entire project can work as scaffold for new any pre-trained machine learning model project. We just need to provide trained memory object to read and predict. For example, image recognition and data labeling, credit risk forecast, Predict net promoter score etc.

# 1.5. Screenshots demonstrating key steps

The screen shots are provided in 1, 2 and 3 section of this document along with explanation.

# 1.6. Project Estimate Document

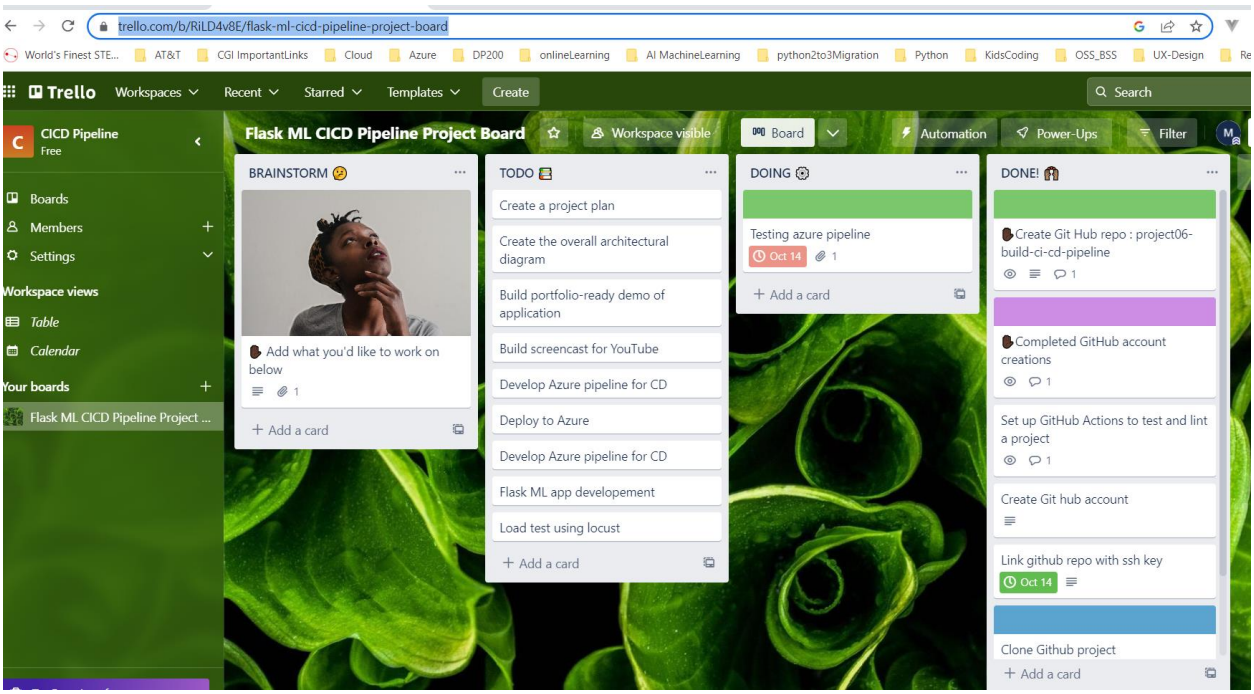


| Work Itmes | Task | Storg Point Estimation |
|---|---|---|
| Create Project Plan | Create a detail project plan | 3 |
| Create Architetural Diagram | Create the overall architectural diagram | |
| Create the Cloud-Based Development Environment | Create Git hub account | 5 |
| | Create Git hub repo : flask-sklearn-ci-cd | |
| | Link Git hub to cloud shell/Local development account | |
| | Clone the project | |
| | Install required software/libraries | |
| Create Project Scaffolding | Create the Makefile | 1 |
| | Create requirements.txt | |
| | Create the Python Virtual Environment | |
| | Create the project script file and test file. | |
| Set up GitHub Actions to test and lint a project | Setup GitHub action | 1 |
| | Test gitbub action | |
| Flask ML app developement | Clone the project into cloud shell | 5 |
| | create virtual enviroment | |
| | Install the required python libraries | |
| | Run the application to predict | |
| Local Test | Run make all | 3 |
| | Run the application locally and test if it predict sucessfully | |
| Deplog the webapp and test | Deploy the web to using basic app plan | 1 |
| | Run the make_prediction_azure_app and verify the prediction resu | |
| Setup Azure Devops | Create organisation in devops | |
| | Create project in devops | |
| Create Azure pipeline for CD | Create project pipeline | 5 |
| | Setup Azure agent pool using virtual machine | |
| | Run the pipeline | |
| Test Azure pipeline for CD | Test the pipliene and fix any technical issue. | 3 |
| Load Test | Load testing locust tool | 1 |
| Build portfolio-ready demo of application | Demo the project | 1 |
| Build screencast for YouTube | Create Screencast for youtube | 1 |

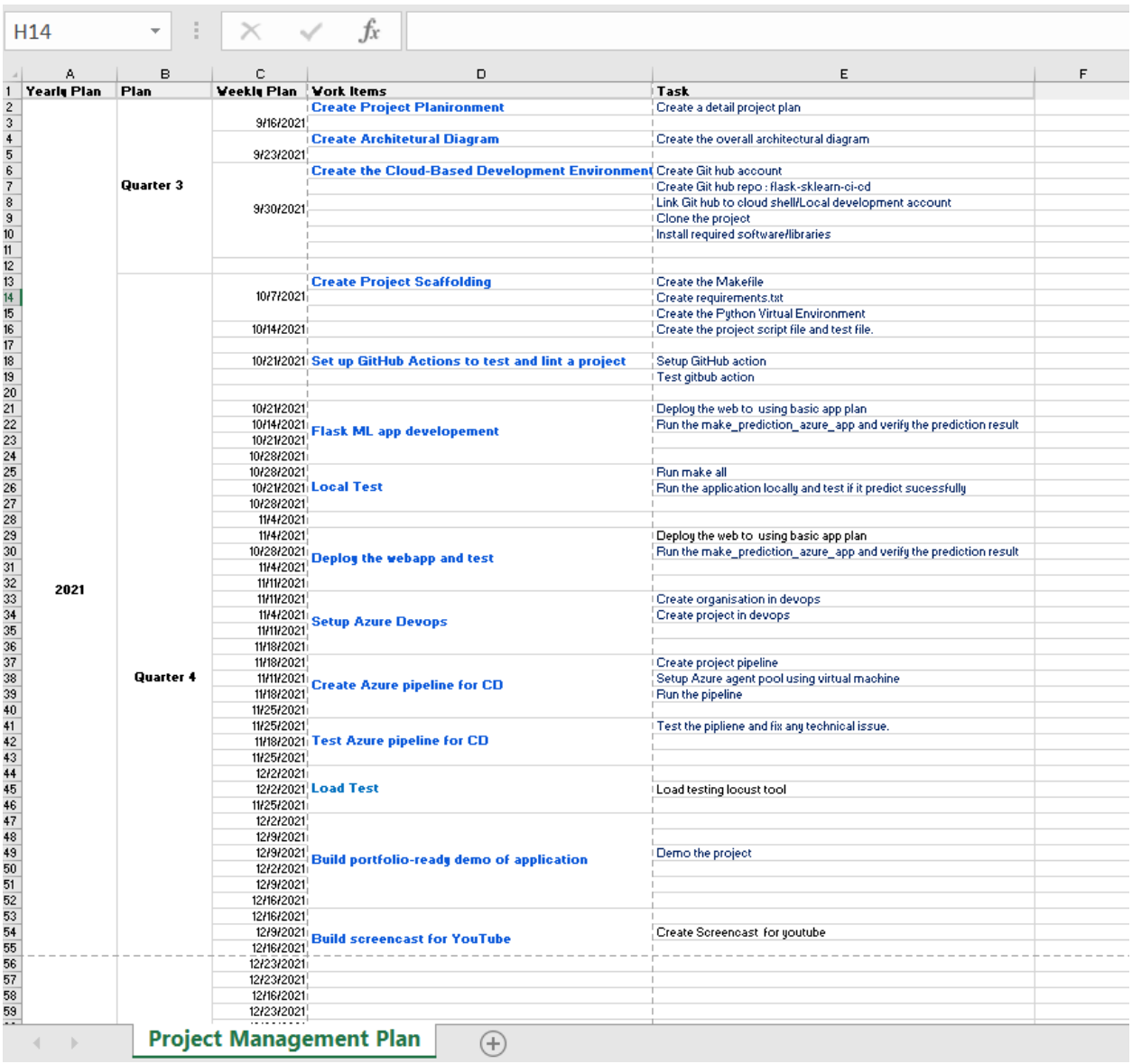
Project Management Plan

## 1.7. A link to a Trello board for the project

[https://trello.com/b/RiLD4v8E/flask-ml-cicd-pipeline-project-board](https://trello.com/b/RiLD4v8E/flask-ml-cicd-pipeline-project-board)




# 1.8. A link to a spreadsheet that includes the original and final project plan



| Yearly Plan | Plan | Weekly Plan | Work Items | Task |
|---|---|---|---|---|
| 2021 | Quarter 3 | 9/16/2021 | Create Project Planironment | Create a detail project plan |
| | | 9/23/2021 | Create Architetural Diagram | Create the overall architectural diagram |
| | | 9/30/2021 | Create the Cloud-Based Development Environment | Create Git hub account |
| | | | | Create Git hub repo : flask-sklearn-ci-cd |
| | | | | Link Git hub to cloud shell/Local development account |
| | | | | Clone the project |
| | | | | Install required software/libraries |
| | Quarter 4 | 10/7/2021 | Create Project Scaffolding | Create the Makefile |
| | | | | Create requirements.txt |
| | | | | Create the Python Virtual Environment |
| | | 10/14/2021 | | Create the project script file and test file. |
| | | 10/21/2021 | Set up GitHub Actions to test and lint a project | Setup GitHub action |
| | | | | Test gitbub action |
| | | 10/21/2021 | Flask ML app developement | Deploy the web to using basic app plan |
| | | 10/14/2021 | | Run the make_prediction_azure_app and verify the prediction result |
| | | 10/21/2021 | | |
| | | 10/28/2021 | | |
| | | 10/28/2021 | Local Test | Run make all |
| | | 10/21/2021 | | Run the application locally and test if it predict sucessfully |
| | | 10/28/2021 | | |
| | | 11/4/2021 | Deploy the webapp and test | |
| | | 11/4/2021 | | Deploy the web to using basic app plan |
| | | 10/28/2021 | | Run the make_prediction_azure_app and verify the prediction result |
| | | 11/4/2021 | | |
| | | 11/11/2021 | Setup Azure Devops | |
| | | 11/11/2021 | | Create organisation in devops |
| | | 11/4/2021 | | Create project in devops |
| | | 11/11/2021 | | |
| | | 11/18/2021 | Create Azure pipeline for CD | |
| | | 11/18/2021 | | Create project pipeline |
| | | 11/11/2021 | | Setup Azure agent pool using virtual machine |
| | | 11/18/2021 | | Run the pipeline |
| | | 11/25/2021 | Test Azure pipeline for CD | |
| | | 11/25/2021 | | Test the pipliene and fix any technical issue. |
| | | 11/18/2021 | | |
| | | 11/25/2021 | Load Test | |
| | | 12/2/2021 | | Load testing locust tool |
| | | 12/2/2021 | Build portfolio-ready demo of application | |
| | | 11/25/2021 | | |
| | | 12/2/2021 | | |
| | | 12/9/2021 | | Demo the project |
| | | 12/9/2021 | | |
| | | 12/2/2021 | Build screencast for YouTube | |
| | | 12/9/2021 | | Create Screencast for youtube |
| | | 12/16/2021 | | |
| | | 12/16/2021 | | |
| | | 12/23/2021 | | |
| | | 12/23/2021 | | |
| | | 12/16/2021 | | |
| | | 12/23/2021 | | |



# 1.9. Professional, portfolio-ready demo of an Azure DevOps application.

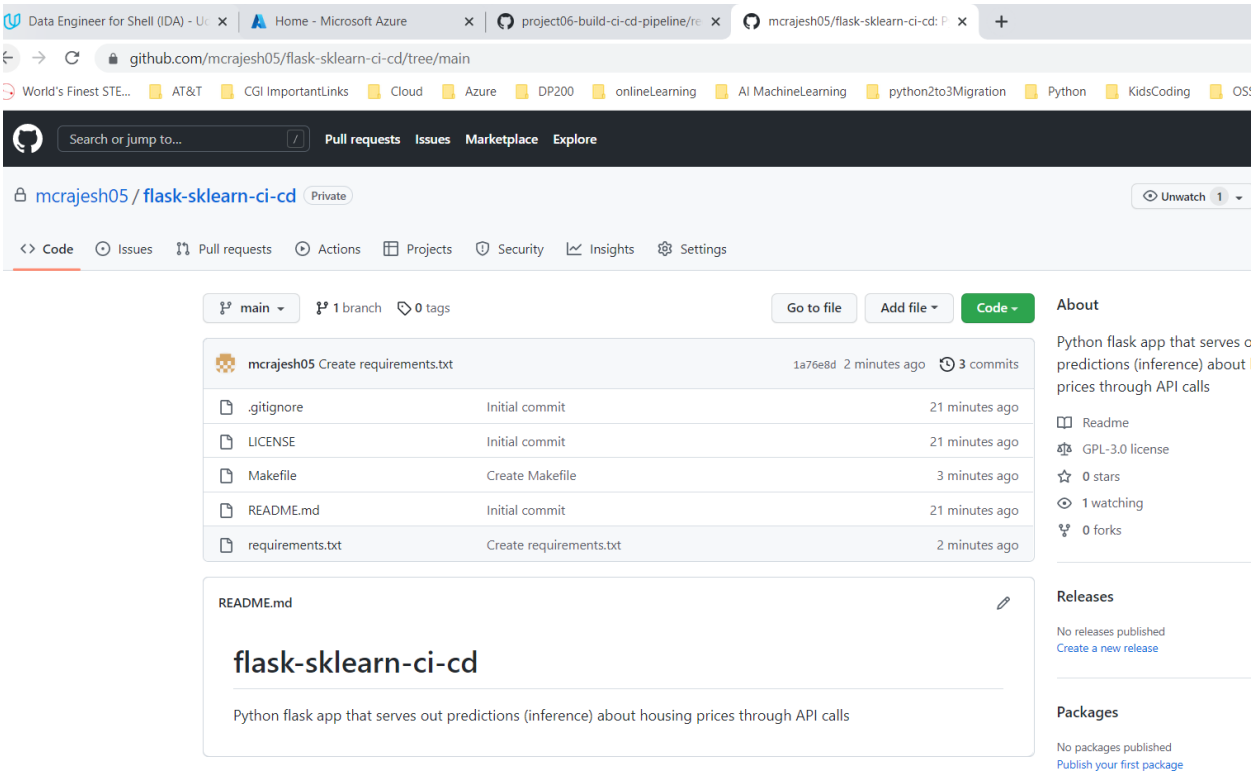
# 1.10. A link to the screencast on YouTube

# 2. Continuous Integration

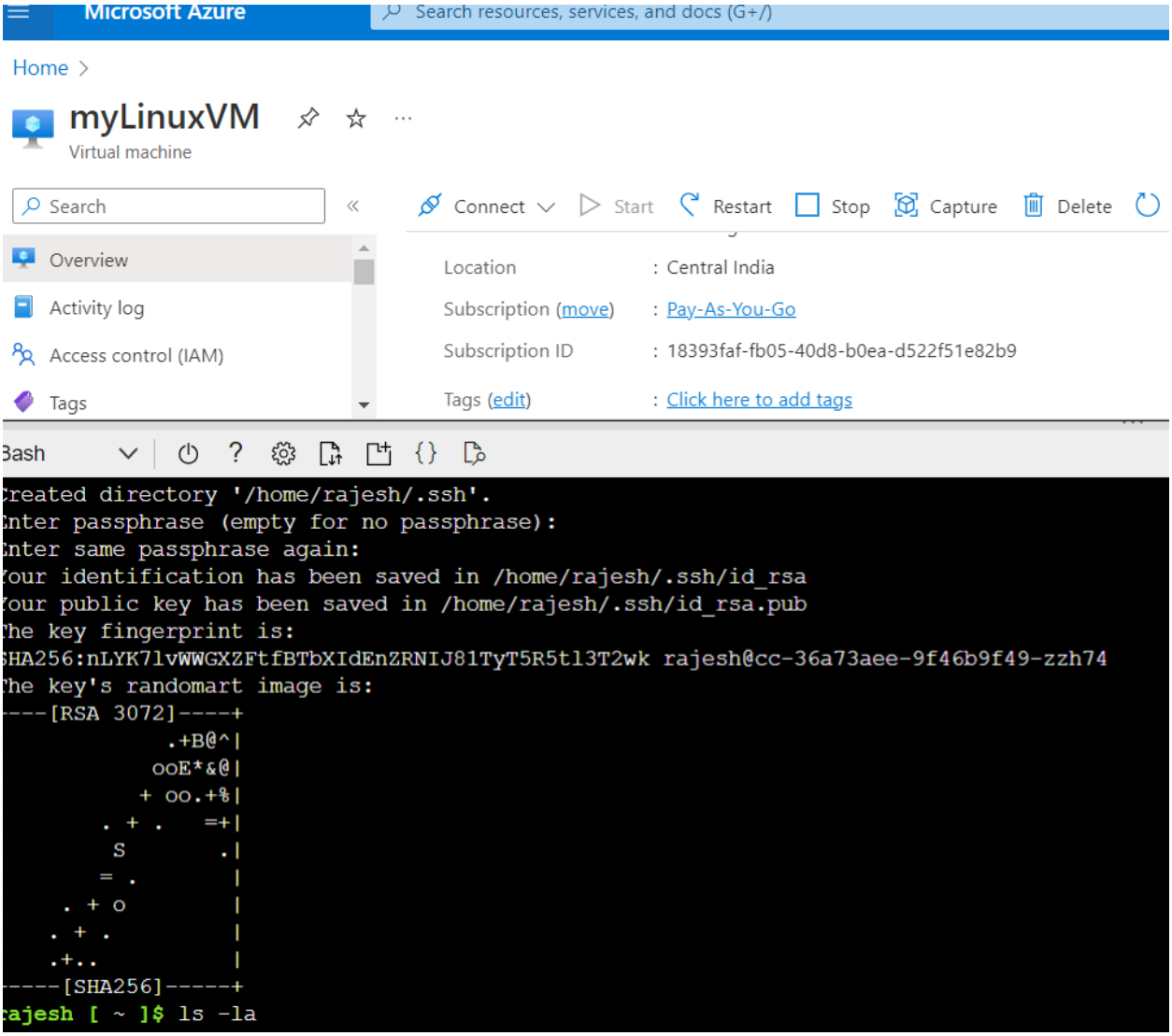
## 2.1. Setup Azure Cloud Shell and clone application inside of Azure Cloud Shell.

### 2.1.1. Create the Cloud-Based Development Environment

#### *2.1.1.1. Create a GIT repo*




#### *2.1.1.2. Setup SSH key*




*2.1.1.3. A screenshot showing the project[flask-sklearn-ci-cd] cloned into Azure Cloud Shell.*

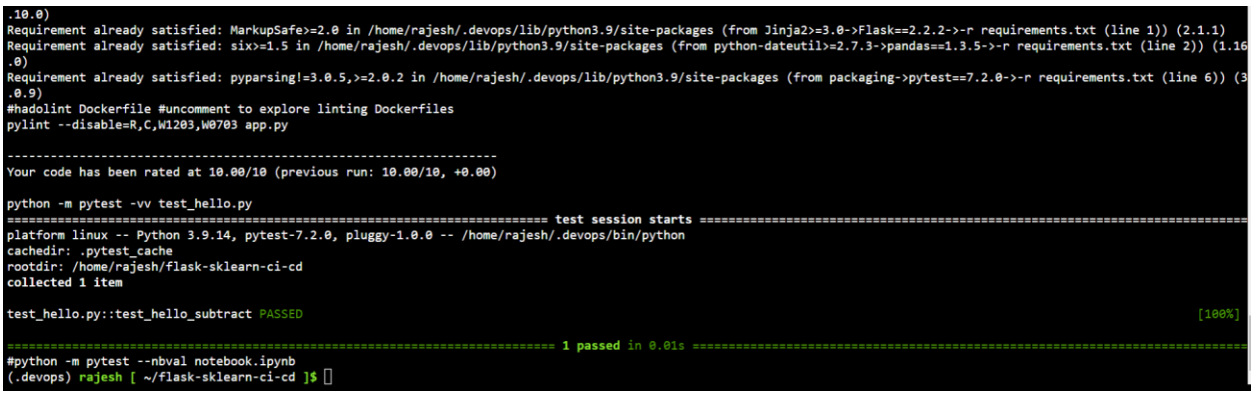
```
rajesh [ ~ ]$ git clone git@github.com:mcrajesh05/flask-sklearn-ci-cd.git
Cloning into 'flask-sklearn-ci-cd'...
The authenticity of host 'github.com (20.207.73.82)' can't be established.
ED25519 key fingerprint is SHA256:+DiY3wvvV6TuJJhbpZisF/zLDA0zPMSvHdkr4UvCOqU.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'github.com' (ED25519) to the list of known hosts.
remote: Enumerating objects: 84, done.
remote: Counting objects: 100% (84/84), done.
remote: Compressing objects: 100% (74/74), done.
remote: Total 84 (delta 33), reused 20 (delta 5), pack-reused 0
Receiving objects: 100% (84/84), 242.30 KiB | 386.00 KiB/s, done.
Resolving deltas: 100% (33/33), done.
rajesh [ ~ ]$ ls -la
total 64
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:45 .
drwxrwxrwx 3 root   root    4096 Nov 15 05:27 
drwx------ 5 rajesh rajesh  4096 Nov 15 05:28 .azure
-rw------- 1 rajesh rajesh   322 Nov 15 05:45 .bash_history
-rw-r--r-- 1 rajesh rajesh   178 Apr 23  2022 .bash_logout
-rw-r--r-- 1 rajesh rajesh   645 Apr 23  2022 .bash_profile
-rw-r--r-- 1 rajesh rajesh   741 Nov 15 05:27 .bashrc
lrwxrwxrwx 1 rajesh rajesh    22 Nov 15 05:27 clouddrive -> /usr/csuser/clouddrive
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:45 flask-sklearn-ci-cd
drwx------ 2 rajesh rajesh  4096 Nov 15 05:45 .ssh
-rw-r--r-- 1 rajesh rajesh    42 Nov 15 05:27 .tmux.conf
```

### *2.1.1.4. A screenshot showing creating virtual env and activating it*

```
rajesh [ ~ ]$ python --version
Python 3.9.14
rajesh [ ~ ]$ python3 -m venv .devops
rajesh [ ~ ]$ ls -la
total 68
drwxr-xr-x 6 rajesh rajesh  4096 Nov 15 05:50 .
drwxrwxrwx 3 root   root    4096 Nov 15 05:27 
drwx------ 5 rajesh rajesh  4096 Nov 15 05:28 .azure
-rw------- 1 rajesh rajesh   386 Nov 15 05:50 .bash_history
-rw-r--r-- 1 rajesh rajesh   178 Apr 23  2022 .bash_logout
-rw-r--r-- 1 rajesh rajesh   645 Apr 23  2022 .bash_profile
-rw-r--r-- 1 rajesh rajesh   741 Nov 15 05:27 .bashrc
lrwxrwxrwx 1 rajesh rajesh    22 Nov 15 05:27 clouddrive -> /usr/csuser/clouddrive
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:50 .devops
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:45 flask-sklearn-ci-cd
drwx------ 2 rajesh rajesh  4096 Nov 15 05:45 .ssh
-rw-r--r-- 1 rajesh rajesh    42 Nov 15 05:27 .tmux.conf
-rw-r--r-- 1 rajesh rajesh 22287 Jun 17 22:09 .zshrc
rajesh [ ~ ]$ source ./.devops/bin/activate
(.devops) rajesh [ ~ ]$ 
```

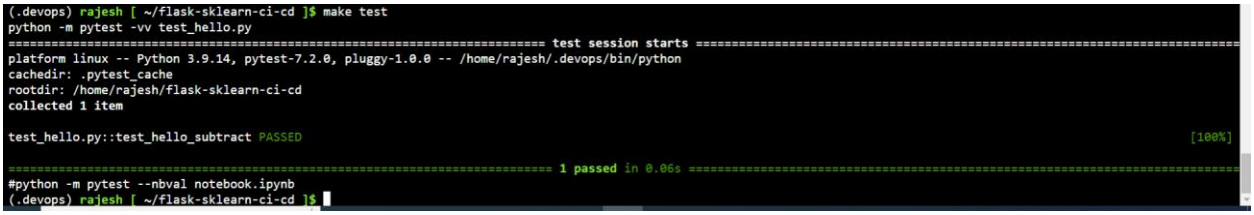
*2.1.1.5. A screenshot showing the passing tests that are displayed after running the test*

Run make all



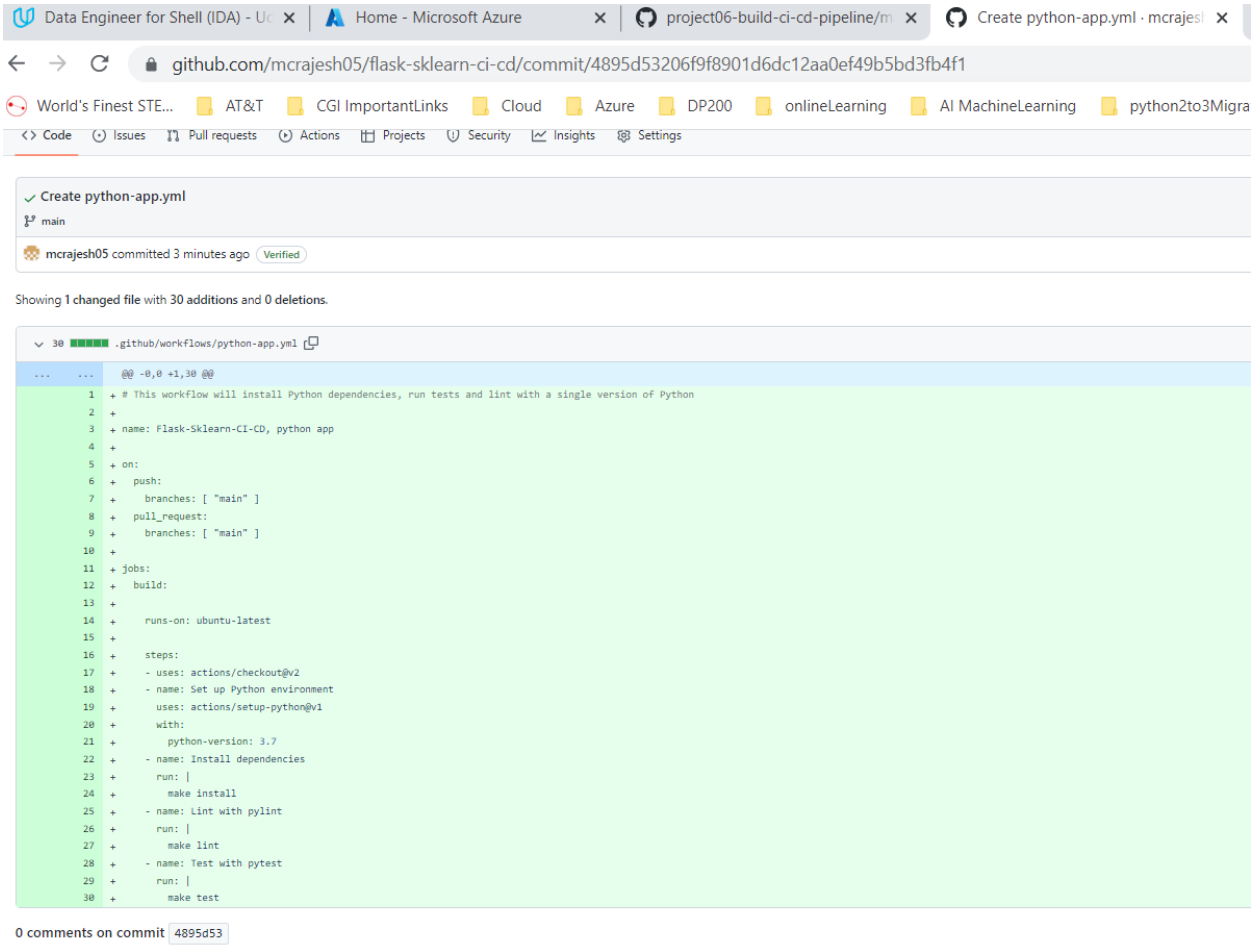

# 2.2. Conduct a test run on an application in Azure Cloud Shell.

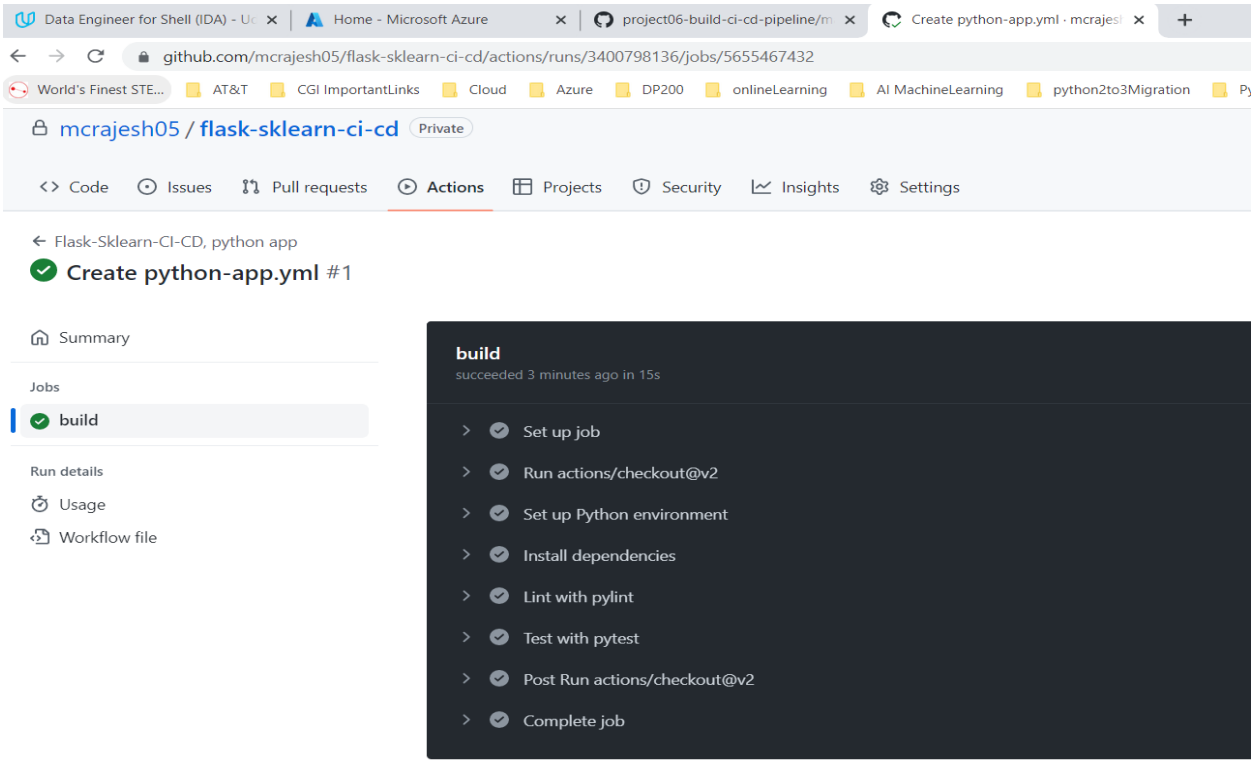
2.2.1. A screenshot showing the output of a test run.



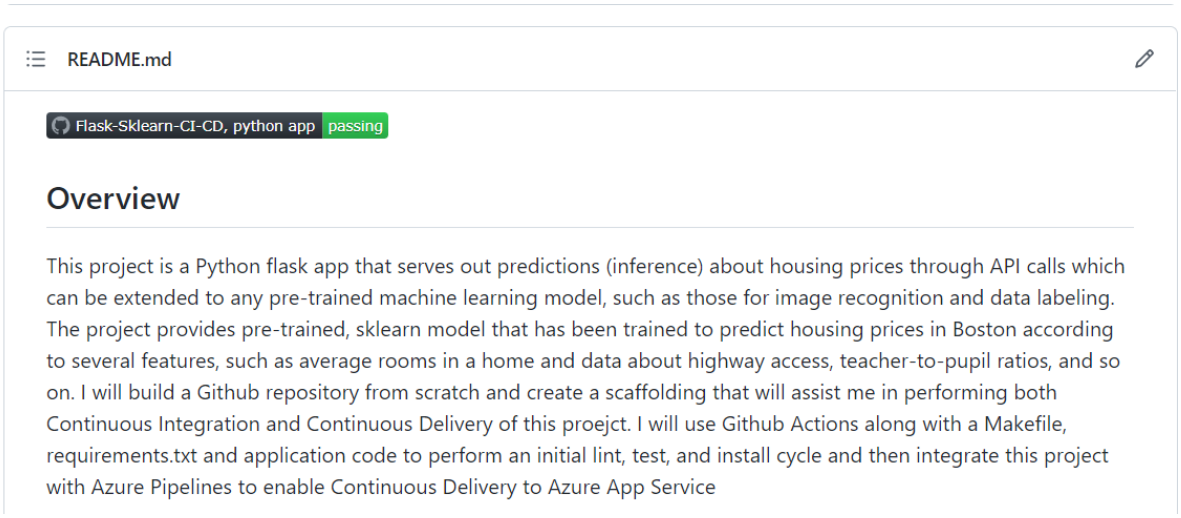

# 2.3. Use GitHub Actions to test and lint a project while writing code.

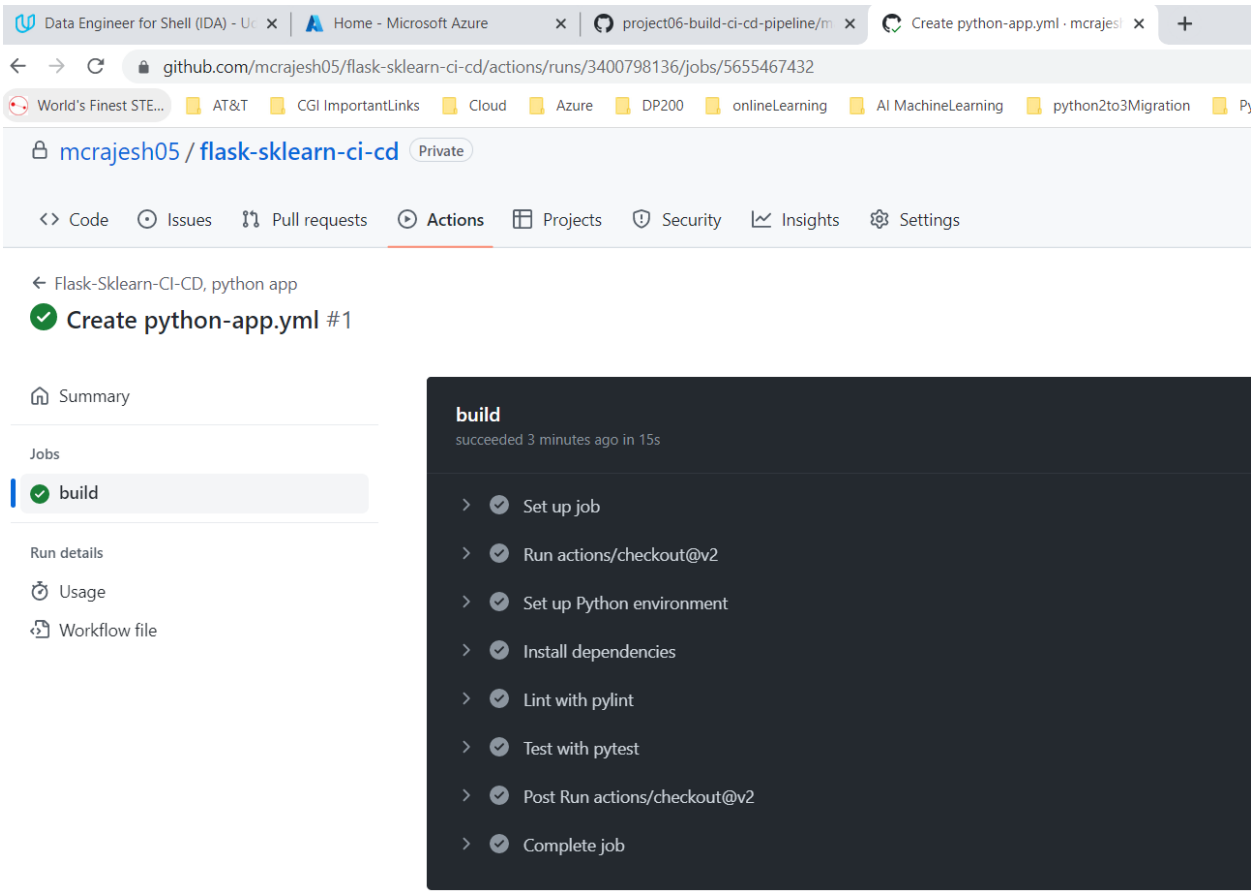
## 2.3.1. The GitHub repo contains the GitHub Actions YAML file






2.3.2. The GitHub actions badge is shown in the README, like in this screenshot.

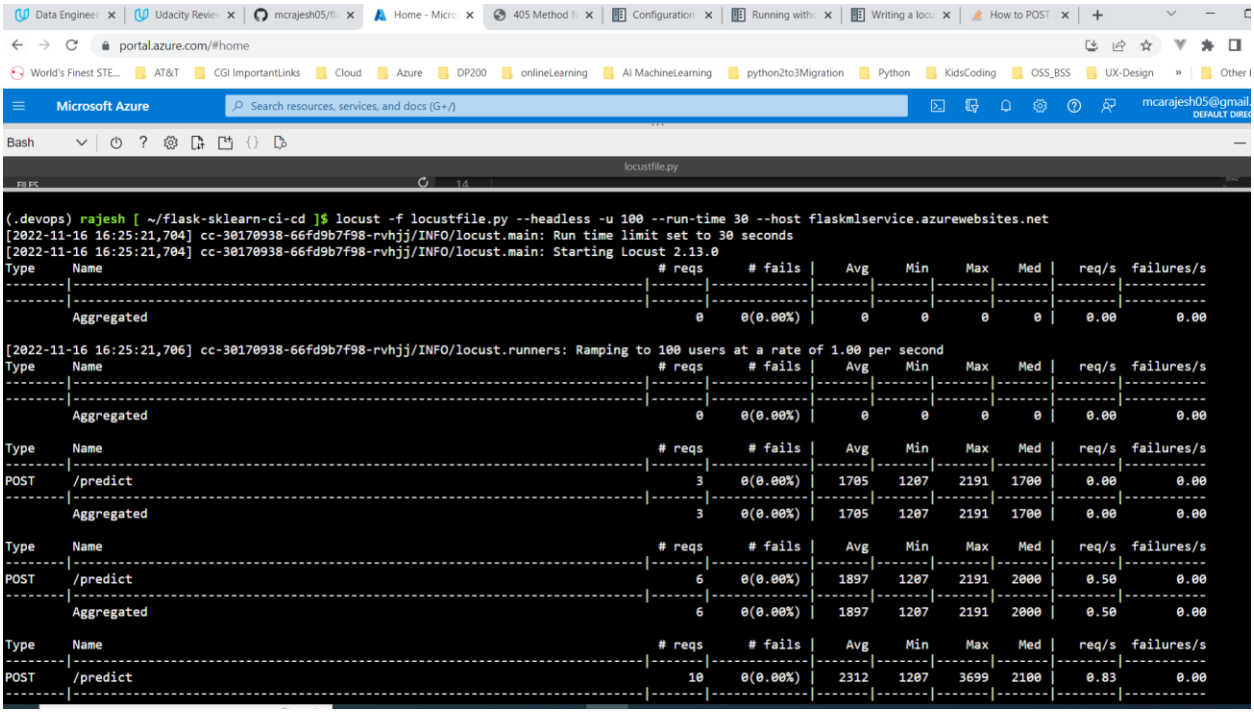


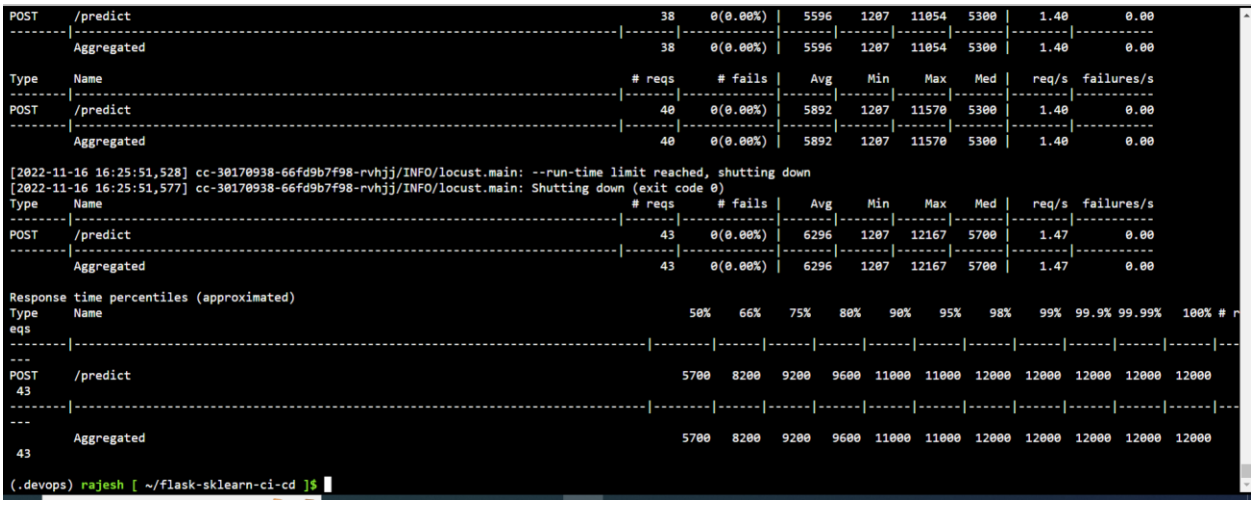

Data Engineer for Shell (IDA) - U
Home - Microsoft Azure
project06-build-ci-cd-pipeline/m
Create python-app.yml · mcrajesh
github.com/mcrajesh05/flask-sklearn-ci-cd/actions/runs/3400798136/jobs/5655467432
World's Finest STE...
AT&T
CGI ImportantLinks
Cloud
Azure
DP200
onlineLearning
AI MachineLearning
python2to3Migration
mcrajesh05 / flask-sklearn-ci-cd
Private
Code
Issues
Pull requests
Actions
Projects
Security
Insights
Settings
Flask-Sklearn-CI-CD, python app
Create python-app.yml #1
Summary
Jobs
build
Run details
Usage
Workflow file
build
succeeded 3 minutes ago in 15s
Set up job
Run actions/checkout@v2
Set up Python environment
Install dependencies
Lint with pylint
Test with pytest
Post Run actions/checkout@v2
Complete job

# 3. Continuous Delivery

## 3.1. Load test an application using Locust.

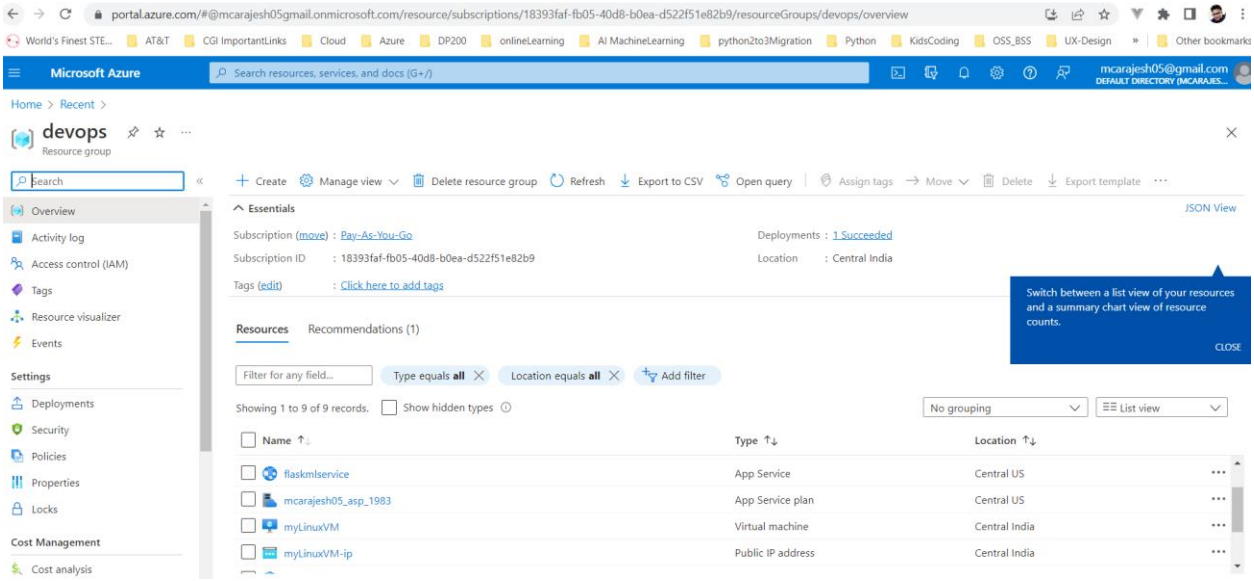
### 3.1.1 A screenshot of the application running against a load test with locust

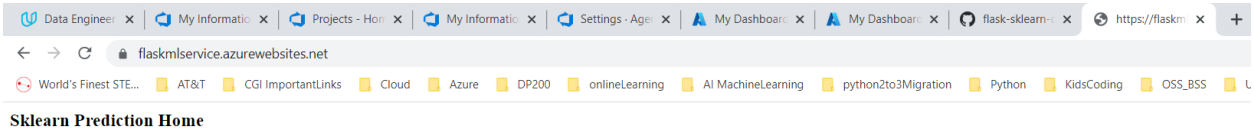


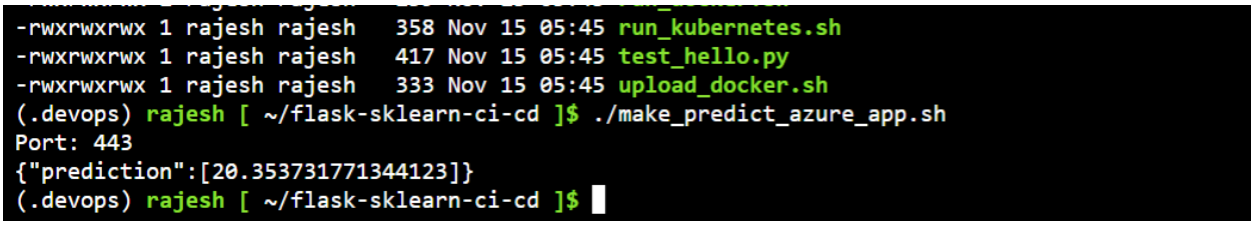

## 3.2. Deploy an application using Azure Pipelines into Azure App Services

## 3.2.1. A screenshot of Azure App Service

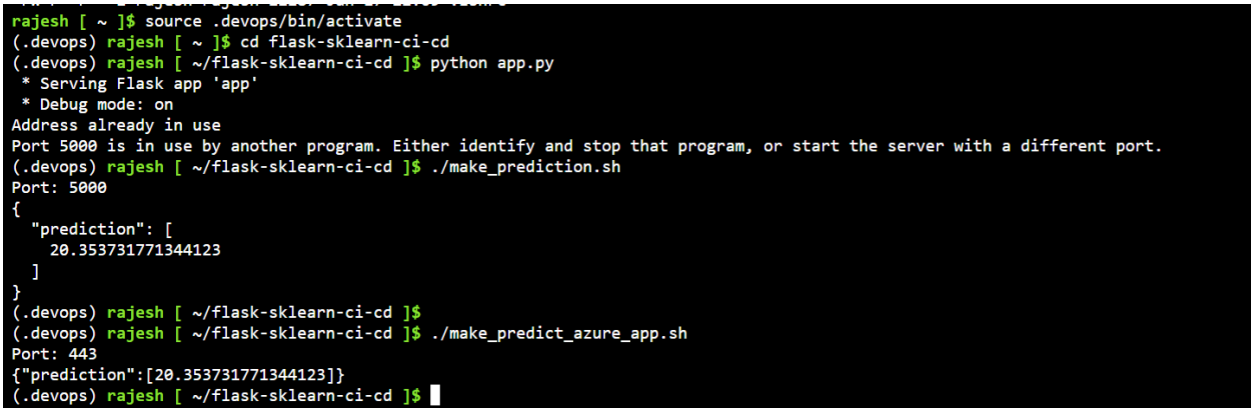


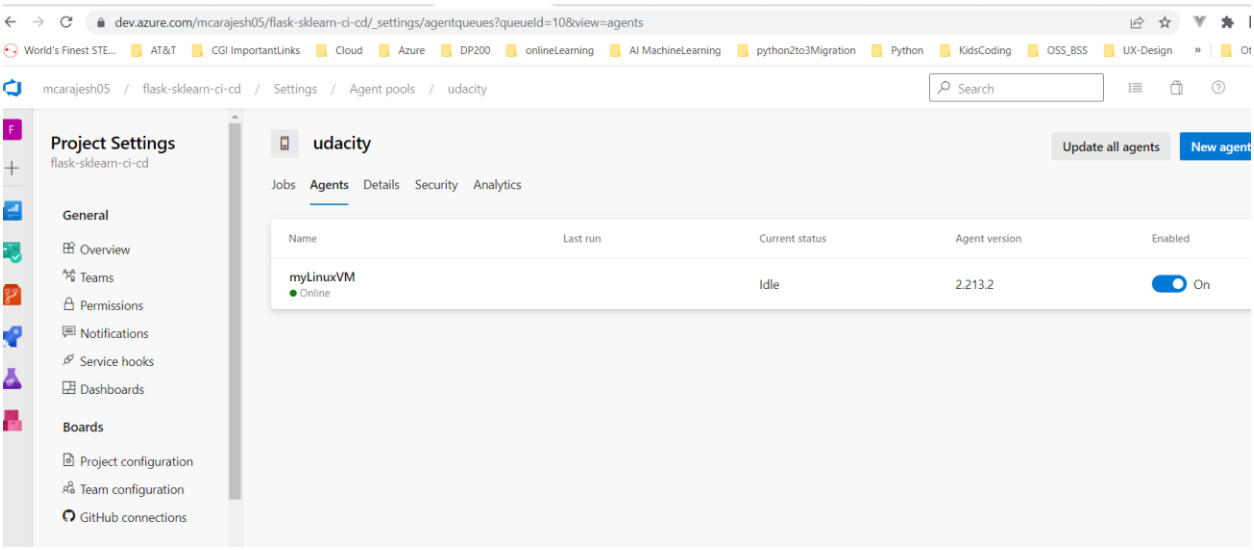

## 3.2.2. A screenshot of a successful prediction in Azure Cloud Shell

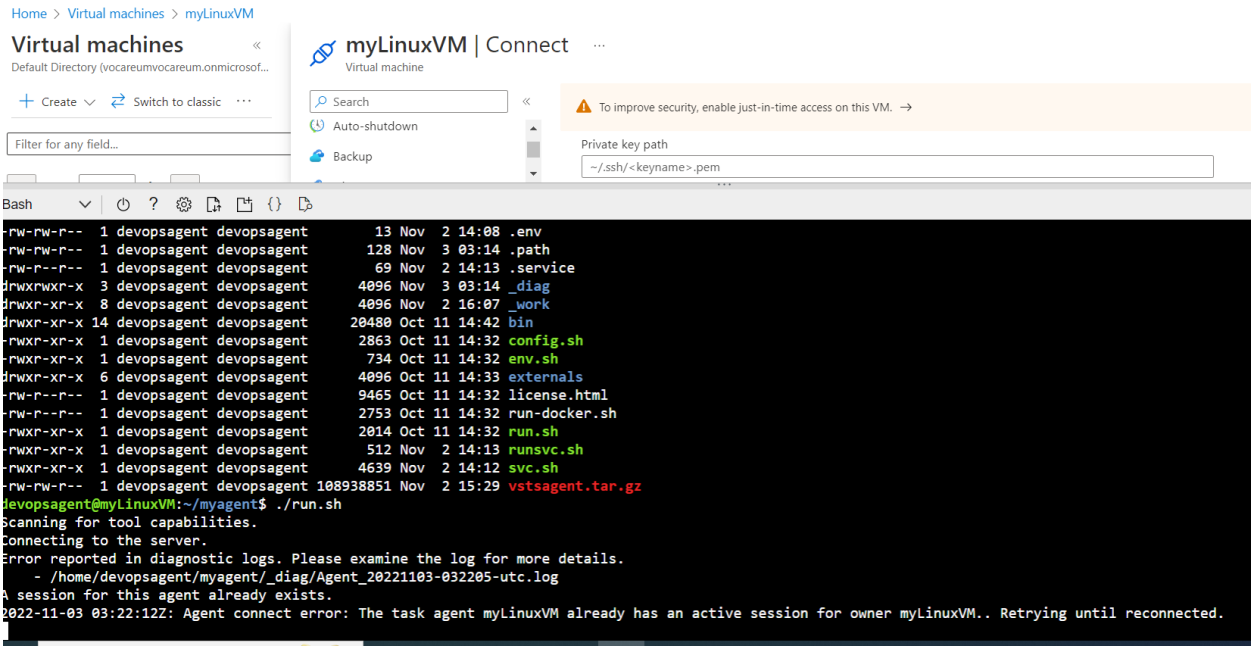



Prediction from Local setup

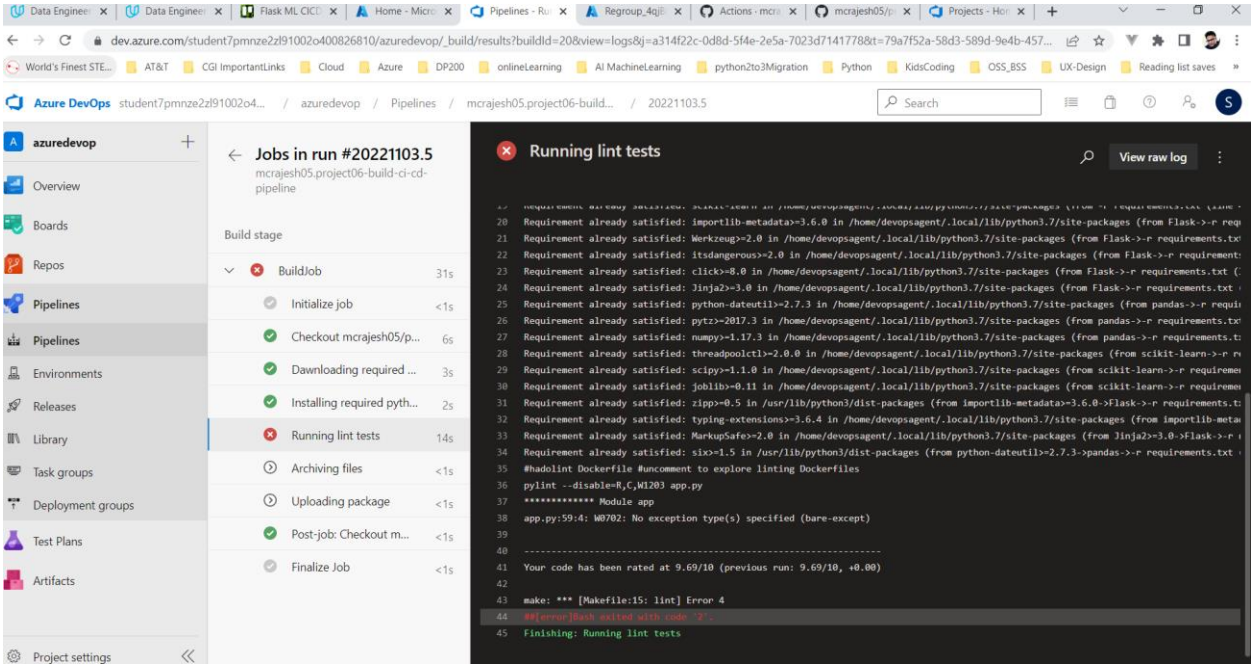


Agent Pool

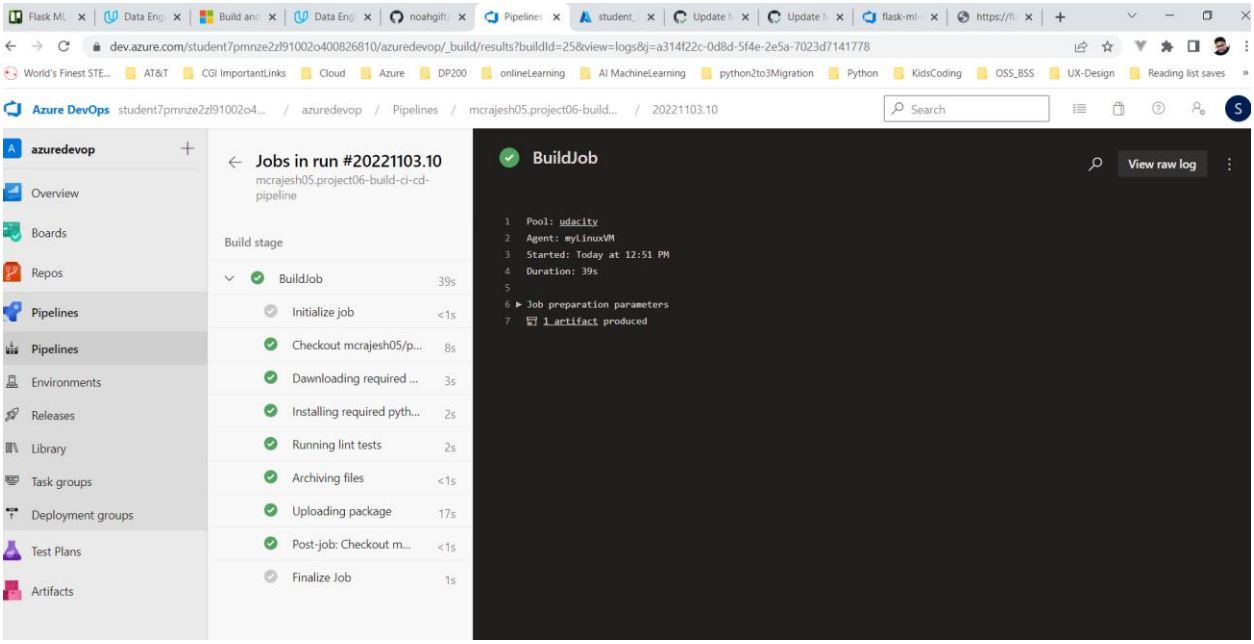



Lint Test




Successful build




--NEW screen shots

Local prediction

```
rajesh [ ~ ]$ source ./.devops/bin/activate
(.devops) rajesh [ ~ ]$ cd flask-sklearn-ci-cd
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$ ./make_prediction.sh
Port: 5000
{
  "prediction": [
    20.353731771344123
  ]
}
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$
```

Azure pipeline agent

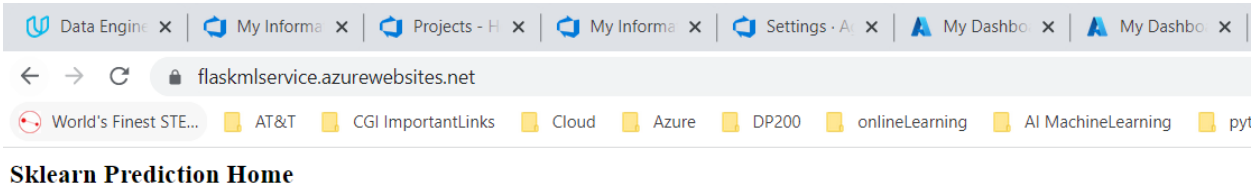
```
rajesh@myLinuxVM:~/myagent$ ./config.sh


  ___                      ______ _            _ _
 / _ \                     | ___ (_)          | (_)
/ /_\ \_____  _ _ __ ___   | |_/ /_ _ __   ___| |_ _ __   ___  ___
|  _  |_  / | | | '__/ _ \ |  __/| | '_ \ / _ \ | | '_ \ / _ \/ __|
| | | |/ /| |_| | | |  __/ | |   | | |_) |  __/ | | | | |  __/\__ \
\_| |_/___|\__,_|_|  \___| \_|   |_| .__/ \___|_|_|_| |_|\___||___/
                                    | |
        agent v2.213.2              |_|          (commit 4f90e68)


>> End User License Agreements:

Building sources from a TFVC repository requires accepting the Team Explorer Everywhere E
repositories.

A copy of the Team Explorer Everywhere license agreement can be found at:
  /home/rajesh/myagent/license.html

Enter (Y/N) Accept the Team Explorer Everywhere license agreement now? (press enter for N

>> Connect:

Enter server URL > https://dev.azure.com/mcarajesh05/
Enter authentication type (press enter for PAT) >
Enter personal access token > ******************************************************
Connecting to server ...
```

```
rajesh@myLinuxVM:~/myagent$ sudo ./svc.sh start

/etc/systemd/system/vsts.agent.mcarajesh05.udacity.myLinuxVM.service
● vsts.agent.mcarajesh05.udacity.myLinuxVM.service - Azure Pipelines Agent (mcarajesh05.udacity.myLinuxVM)
     Loaded: loaded (/etc/systemd/system/vsts.agent.mcarajesh05.udacity.myLinuxVM.service; enabled; vendor preset: enabled)
     Active: active (running) since Tue 2022-11-15 09:05:32 UTC; 19ms ago
   Main PID: 1887 (runsvc.sh)
      Tasks: 2 (limit: 472)
     Memory: 604.0K
     CGroup: /system.slice/vsts.agent.mcarajesh05.udacity.myLinuxVM.service
             └─1887 /bin/bash /home/rajesh/myagent/runsvc.sh

Nov 15 09:05:32 myLinuxVM systemd[1]: Started Azure Pipelines Agent (mcarajesh05.udacity.myLinuxVM).
rajesh@myLinuxVM:~/myagent$
```

Deploying app

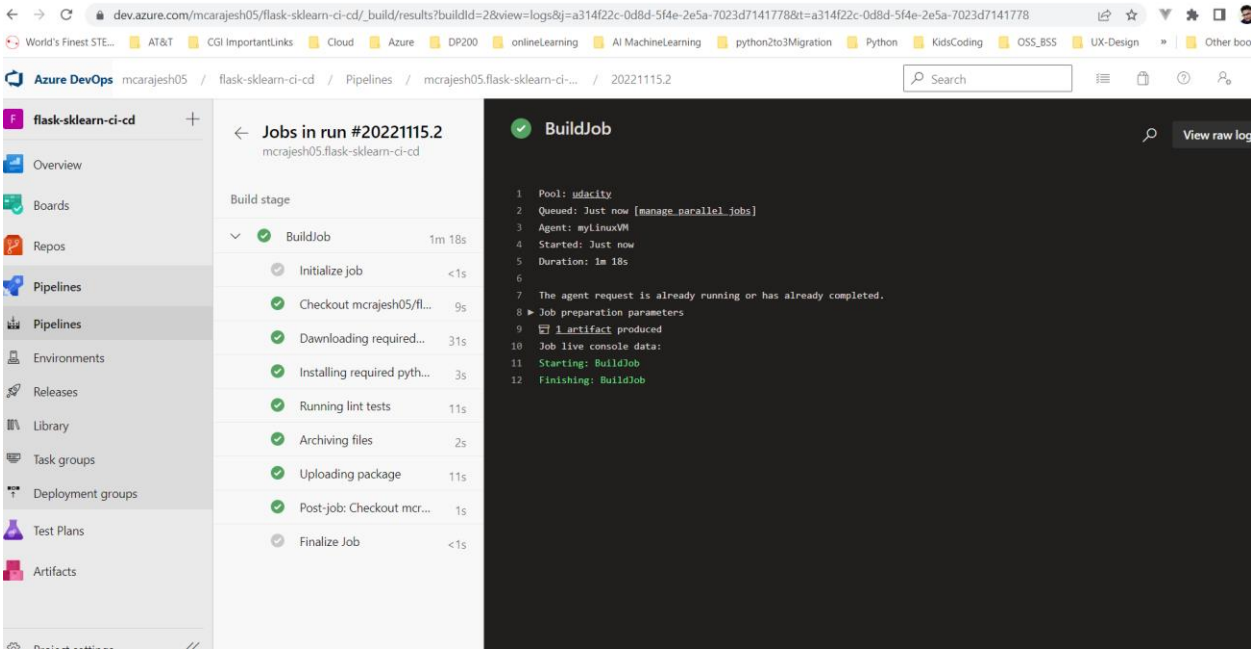
```
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$ az webapp up --name flaskmlservice --resource-group devops --runtime "PYTHON:3.10" --sku F1
The webapp 'flaskmlservice' doesn't exist
Creating AppServicePlan 'mcarajesh05_asp_1983' ...
Resource provider 'Microsoft.Web' used by this operation is not registered. We are registering for you.
Registration succeeded.
Creating webapp 'flaskmlservice' ...
Configuring default logging for the app, if not already enabled
Creating zip with contents of dir /home/rajesh/flask-sklearn-ci-cd ...
Getting scm site credentials for zip deployment
Starting zip deployment. This operation can take a while to complete ...
Deployment endpoint responded with status code 202
You can launch the app at http://flaskmlservice.azurewebsites.net
Setting 'az webapp up' default arguments for current directory. Manage defaults with 'az configure --scope local'
--resource-group/-g default: devops
--sku default: F1
--plan/-p default: mcarajesh05_asp_1983
--location/-l default: centralus
--name/-n default: flaskmlservice
{
  "URL": "http://flaskmlservice.azurewebsites.net",
  "appserviceplan": "mcarajesh05_asp_1983",
  "location": "centralus",
  "name": "flaskmlservice",
  "os": "Linux",
  "resourcegroup": "devops",
  "runtime_version": "PYTHON|3.10",
  "runtime_version_detected": "-",
  "sku": "FREE",
  "src_path": "//home//rajesh//flask-sklearn-ci-cd"
}
(.devops) rajesh [ ~/flask-sklearn-ci-cd ]$
```

App is running

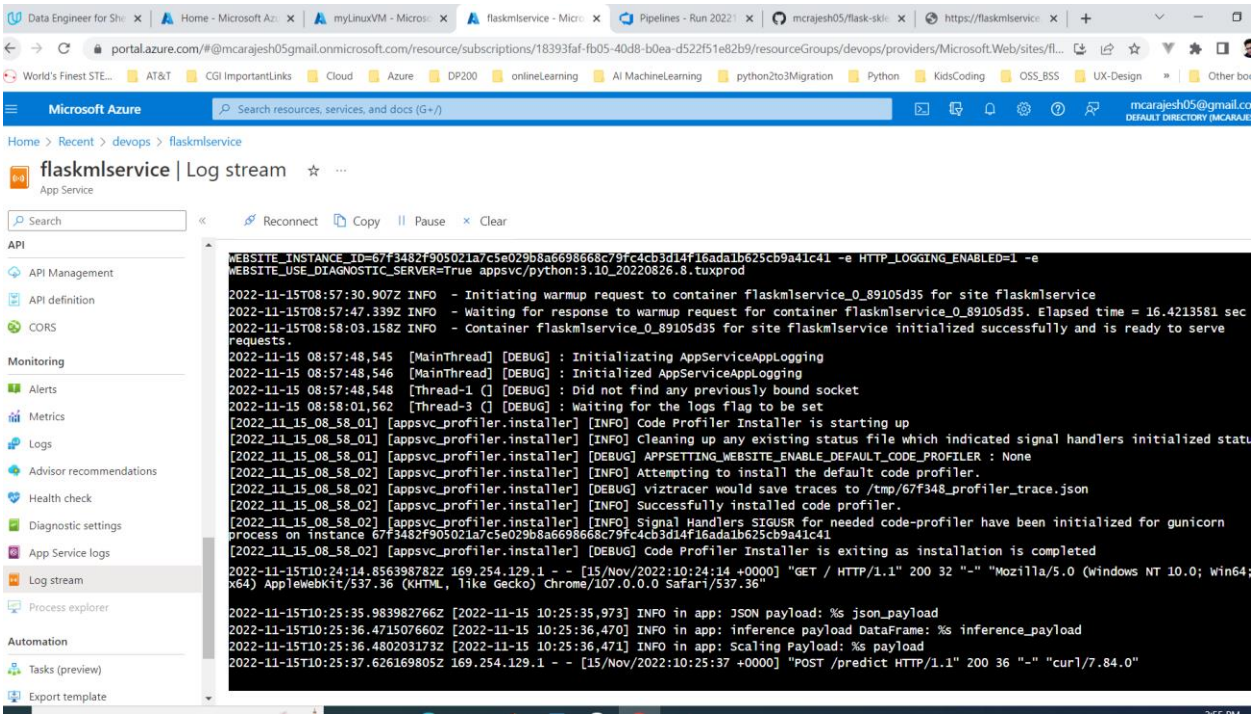



Prediction form deployed app

Azure pipeline




- Output of streamed log files from deployed application



Project running on app service

Git clone

```
(.devops) rajesh [ ~ ]$ ls -la
total 72
drwxr-xr-x 7 rajesh rajesh  4096 Nov 15 09:29 .
drwxrwxrwx 3 root   root    4096 Nov 15 09:29 ..
drwx------ 5 rajesh rajesh  4096 Nov 15 05:28 .azure
-rw------- 1 rajesh rajesh  1709 Nov 15 10:34 .bash_history
-rw-r--r-- 1 rajesh rajesh   178 Apr 23  2022 .bash_logout
-rw-r--r-- 1 rajesh rajesh   645 Apr 23  2022 .bash_profile
-rw-r--r-- 1 rajesh rajesh   741 Nov 15 05:27 .bashrc
drwxr-xr-x 4 rajesh rajesh  4096 Nov 15 06:40 .cache
lrwxrwxrwx 1 rajesh rajesh    22 Nov 15 09:29 clouddrive -> /usr/csuser/clouddrive
drwxr-xr-x 5 rajesh rajesh  4096 Nov 15 05:50 .devops
drwxrwxrwx 8 rajesh rajesh  4096 Nov 15 09:58 flask-sklearn-ci-cd
drwx------ 2 rajesh rajesh  4096 Nov 15 06:03 .ssh
-rw-r--r-- 1 rajesh rajesh    42 Nov 15 05:27 .tmux.conf
-rw-r--r-- 1 rajesh rajesh 22287 Jun 17 22:09 .zshrc
(.devops) rajesh [ ~ ]$
```