Fraud Detector

Machine Learning Project:

From Model To Production

Table of Contents

Introduction

The Goal :

- 1. To build simple Fraud Detection Model using Python.
- 2. To train, test, check basic statistical measure of the Model.
- 3. To package the model in API such as Flask or MLFlow.
- 4. To monitor performance of predictive model using MLFlow.
- 5. To manage security of data and access control list.
- 6. To automate, trigger the training once per-month, or if the datasets exceed certain quantity.
- 7. To describe challenges and constraints during the project.

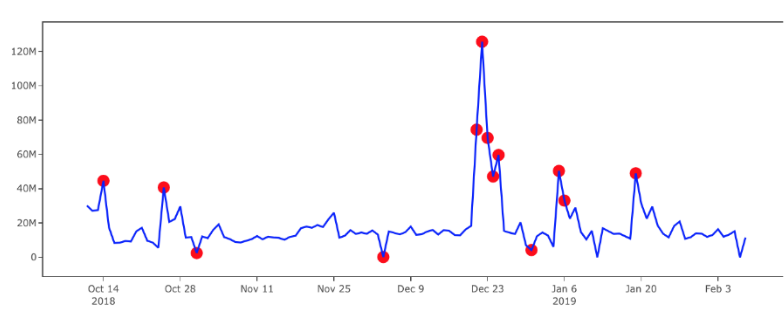
Data source (Fictional sample dataset):

- fraud_detector.csv

Code link:

- https://github.com/hennypurwadi/mlflow_mlop

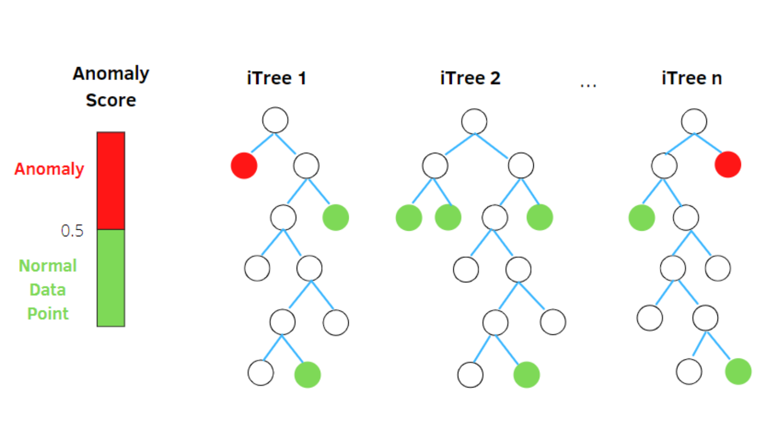
Fraud Detection Machine Learning Model



To detect Fraud is to identify anomaly.

Anomaly is set of data that differ significantly from the rest of others.

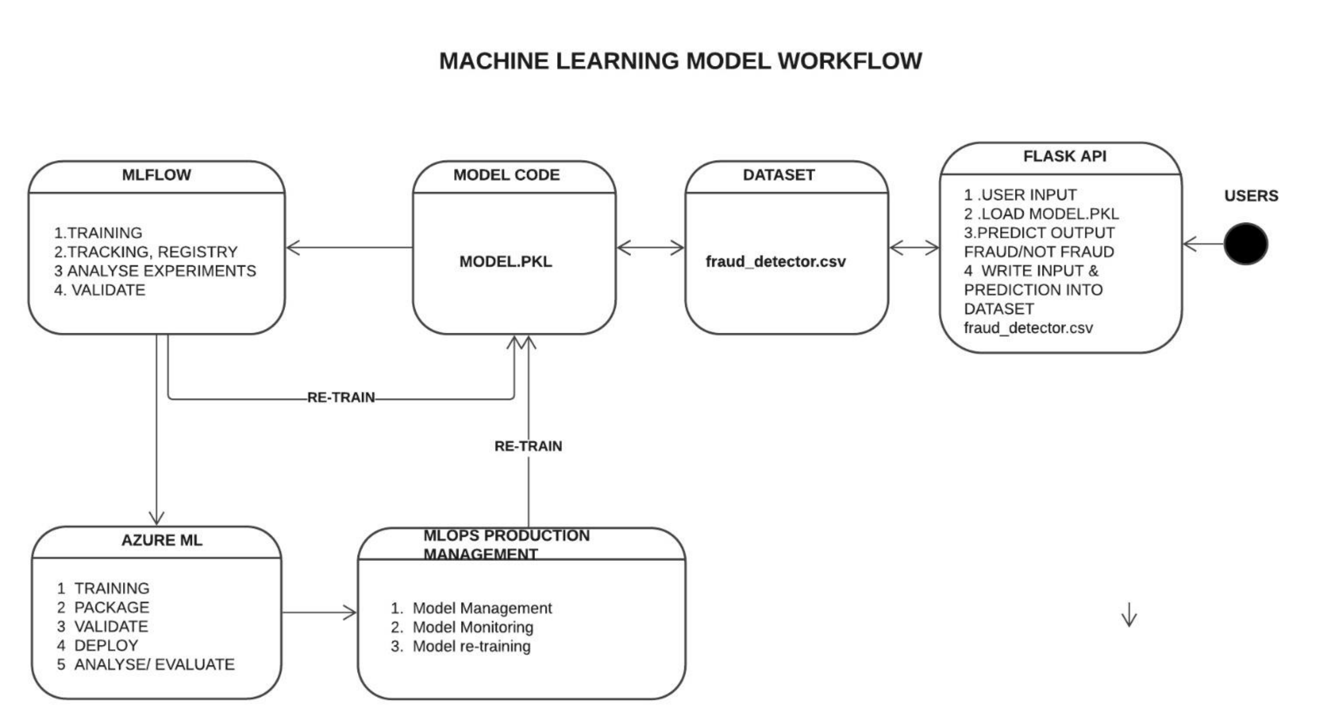
Anomaly pattern detection is identified automatically by algorithm of Machine Learning.



ISOLATION FOREST

We are identifying anomalies using sklearn’s **Isolation Forest**. Isolation forest builds an ensemble of Isolation Trees for dataset.

Anomalies are the point which have shorter average path lengths on the trees, compared to normal ones.



MACHINE LEARNING MODEL WORKFLOW

MLFLOW

1.TRAINING
2.TRACKING, REGISTRY
3 ANALYSE EXPERIMENTS
4. VALIDATE

MODEL CODE

MODEL.PKL

DATASET

fraud_detector.csv

FLASK API

1 .USER INPUT
2 .LOAD MODEL.PKL
3.PREDICT OUTPUT FRAUD/NOT FRAUD
4 WRITE INPUT & PREDICTION INTO DATASET fraud_detector.csv

USERS

RE-TRAIN

RE-TRAIN

AZURE ML

1 TRAINING
2 PACKAGE
3 VALIDATE
4 DEPLOY
5 ANALYSE/ EVALUATE

MLOPS PRODUCTION MANAGEMENT

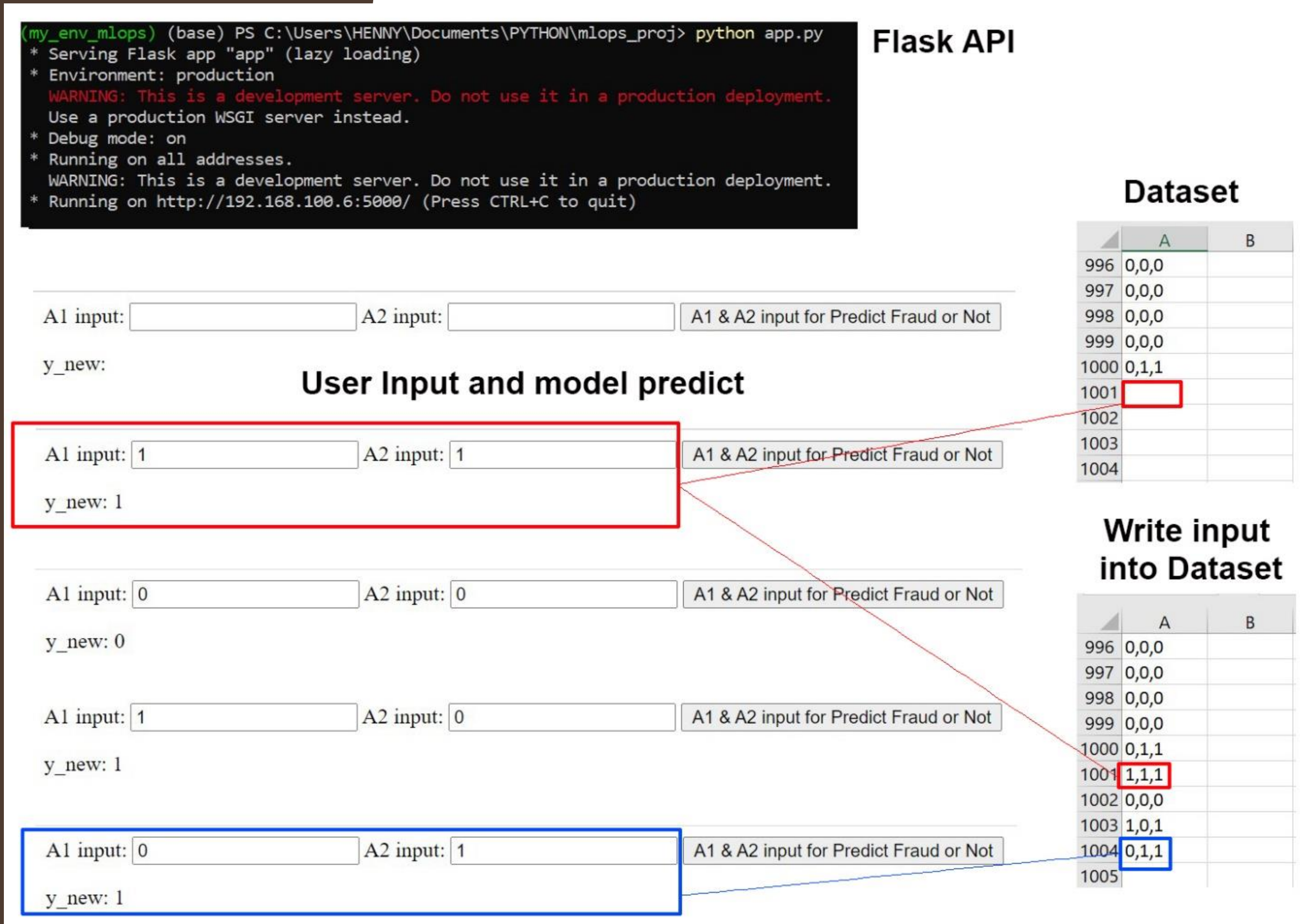
1. Model Management
2. Model Monitoring
3. Model re-training

Conceptual architecture of Data input, storage processing, prediction model as a service

- FLASK API AND DOCKER

- USER INPUT,
- FRAUD PREDICTION

WITH FLASK API



Flask API

```
(my_env_mlops) (base) PS C:\Users\HENNY\Documents\PYTHON\mlops_proj> python app.py
 * Serving Flask app "app" (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Running on all addresses.
   WARNING: This is a development server. Do not use it in a production deployment.
 * Running on http://192.168.100.6:5000/ (Press CTRL+C to quit)
```

User Input and model predict

A1 input: A2 input:

y_new:

A1 input: 1 A2 input: 1

y_new: 1

A1 input: 0 A2 input: 0

y_new: 0

A1 input: 1 A2 input: 0

y_new: 1

A1 input: 0 A2 input: 1

y_new: 1

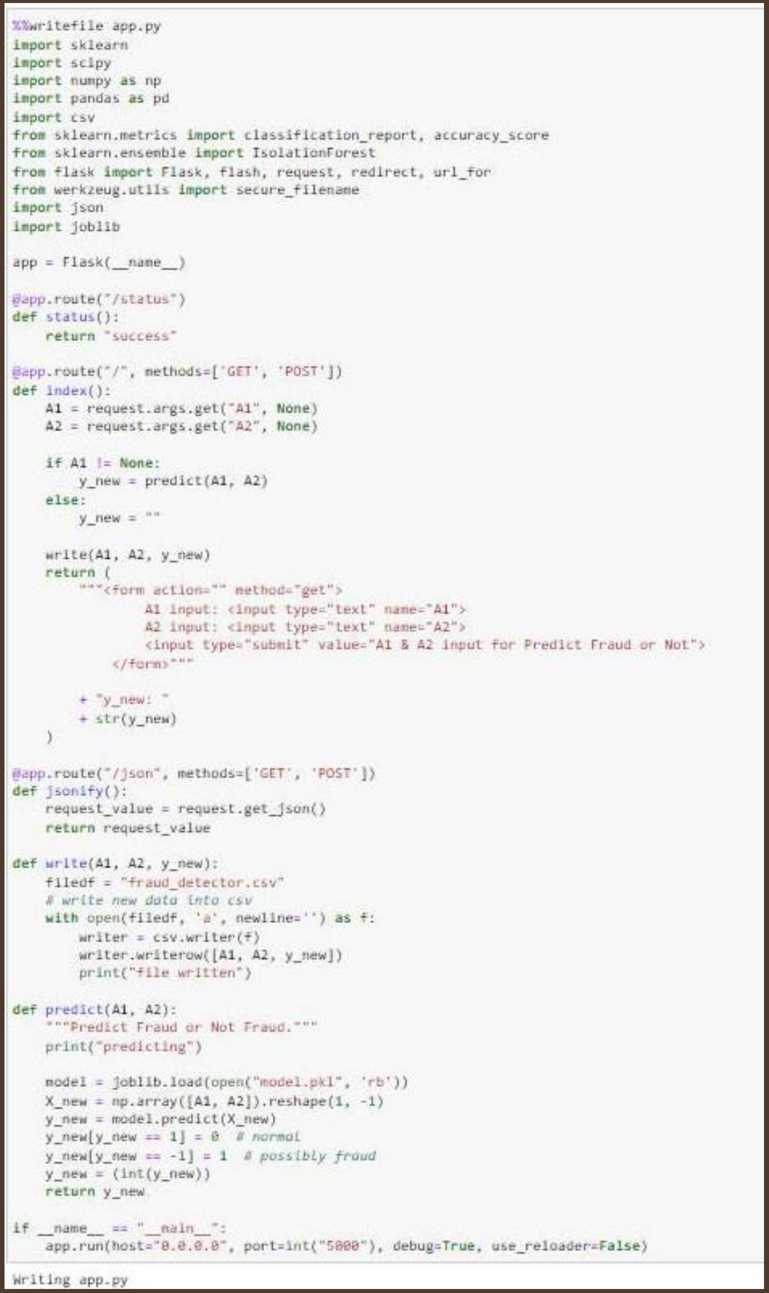
A1 & A2 input for Predict Fraud or Not
A1 & A2 input for Predict Fraud or Not
A1 & A2 input for Predict Fraud or Not
A1 & A2 input for Predict Fraud or Not
A1 & A2 input for Predict Fraud or Not

Dataset

	A	B
996	0,0,0	
997	0,0,0	
998	0,0,0	
999	0,0,0	
1000	0,1,1	
1001		
1002		
1003		
1004		

Write input into Dataset

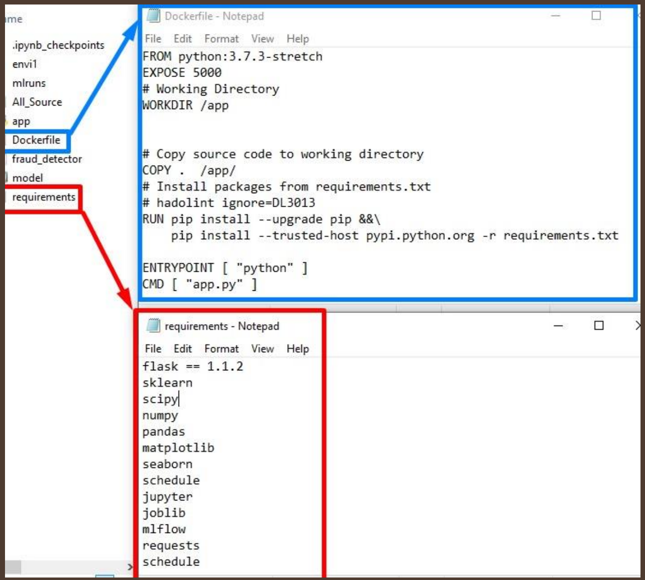
	A	B
996	0,0,0	
997	0,0,0	
998	0,0,0	
999	0,0,0	
1000	0,1,1	
1001	1,1,1	
1002	0,0,0	
1003	1,0,1	
1004	0,1,1	
1005		



```
%%writefile app.py
import sklearn
import scipy
import numpy as np
import pandas as pd
import csv
from sklearn.metrics import classification_report, accuracy_score
from sklearn.ensemble import IsolationForest
from flask import Flask, flash, request, redirect, url_for
from werkzeug.utils import secure_filename
import json
import joblib

app = Flask(__name__)

@app.route("/status")
def status():
    return "success"

@app.route("/", methods=['GET', 'POST'])
def index():
    A1 = request.args.get("A1", None)
    A2 = request.args.get("A2", None)

    if A1 != None:
        y_new = predict(A1, A2)
    else:
        y_new = ""

    write(A1, A2, y_new)
    return (
        """<form action="" method="get">
                A1 input: <input type="text" name="A1">
                A2 input: <input type="text" name="A2">
                <input type="submit" value="A1 & A2 input for Predict Fraud or Not">
            </form>"""

        + "y_new: "
        + str(y_new)
    )

@app.route("/json", methods=['GET', 'POST'])
def jsonify():
    request_value = request.get_json()
    return request_value

def write(A1, A2, y_new):
    filedf = "fraud_detector.csv"
    # write new data into csv
    with open(filedf, 'a', newline='') as f:
        writer = csv.writer(f)
        writer.writerow([A1, A2, y_new])
        print("file written")

def predict(A1, A2):
    """Predict Fraud or Not Fraud."""
    print("predicting")

    model = joblib.load(open("model.pkl", 'rb'))
    X_new = np.array([A1, A2]).reshape(1, -1)
    y_new = model.predict(X_new)
    y_new[y_new == 1] = 0  # normal
    y_new[y_new == -1] = 1  # possibly fraud
    y_new = (int(y_new))
    return y_new

if __name__ == "__main__":
    app.run(host="0.0.0.0", port=int("5000"), debug=True, use_reloader=False)
```

```
Writing app.py
```

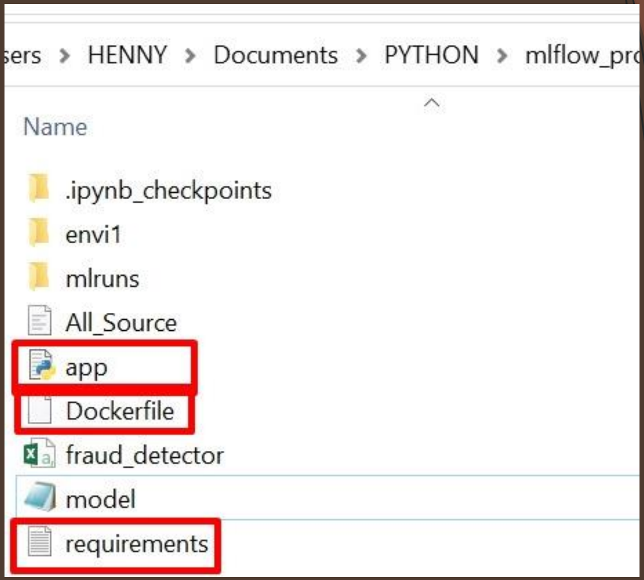
Flask codes



.ipynb_checkpoints
envi1
mlruns
All_Source
app
Dockerfile
fraud_detector
model
requirements

```
FROM python:3.7.3-stretch
EXPOSE 5000
# Working Directory
WORKDIR /app


# Copy source code to working directory
COPY .  /app/
# Install packages from requirements.txt
# hadolint ignore=DL3013
RUN pip install --upgrade pip &&\
    pip install --trusted-host pypi.python.org -r requirements.txt

ENTRYPOINT [ "python" ]
CMD [ "app.py" ]
```

```
flask == 1.1.2
sklearn
scipy
numpy
pandas
matplotlib
seaborn
schedule
jupyter
joblib
mlflow
requests
schedule
```



.ipynb_checkpoints
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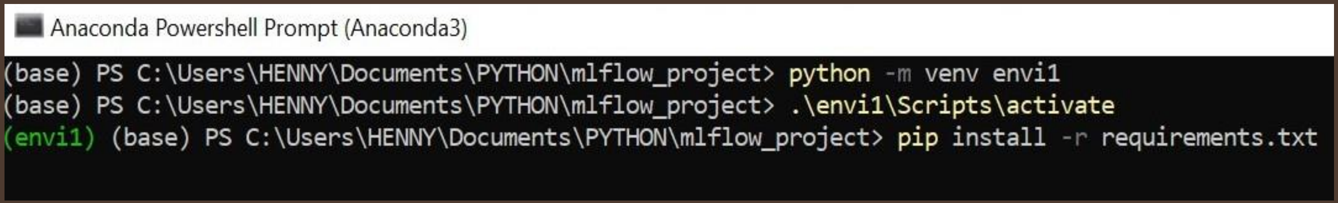
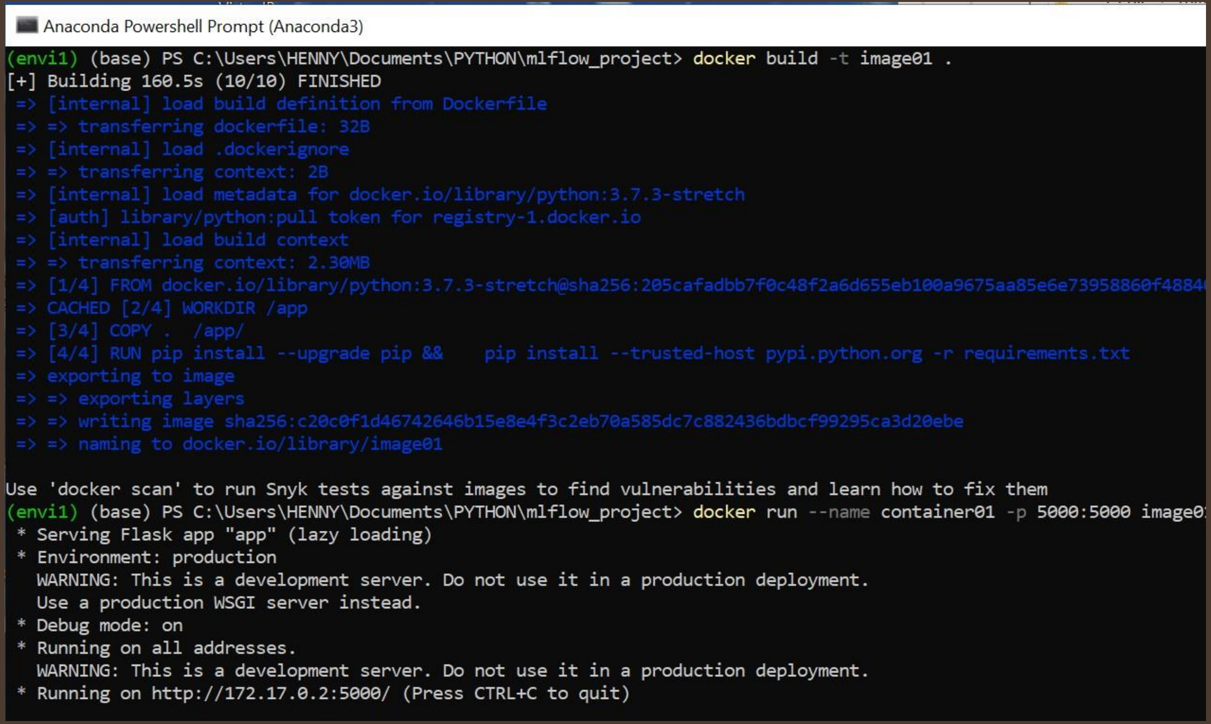


```
(base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> python -m venv envi1
(base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> .\envi1\Scripts\activate
(envi1) (base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> pip install -r requirements.txt
```

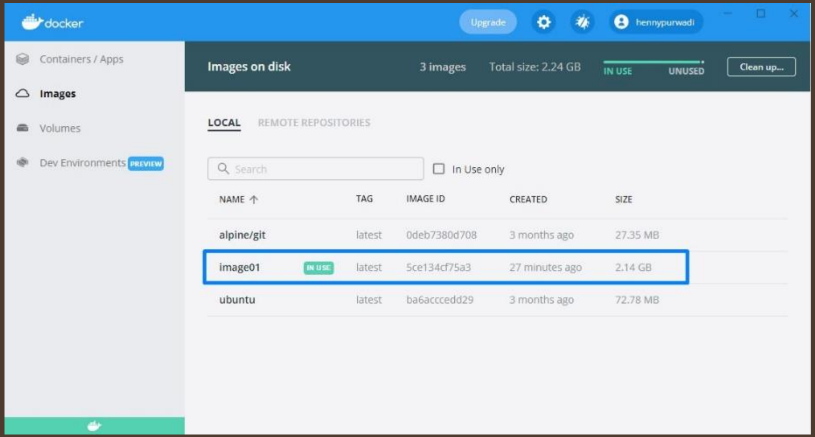
Create Docker Image and Container



```
(envi1) (base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> docker build -t image01 .
[+] Building 160.5s (10/10) FINISHED
 => [internal] load build definition from Dockerfile
 => => transferring dockerfile: 32B
 => [internal] load .dockerignore
 => => transferring context: 2B
 => [internal] load metadata for docker.io/library/python:3.7.3-stretch
 => [auth] library/python:pull token for registry-1.docker.io
 => [internal] load build context
 => => transferring context: 2.30MB
 => [1/4] FROM docker.io/library/python:3.7.3-stretch@sha256:205cafadbb7f0c48f2a6d655eb100a9675aa85e6e73958860f4884
 => CACHED [2/4] WORKDIR /app
 => [3/4] COPY .  /app/
 => [4/4] RUN pip install --upgrade pip &&    pip install --trusted-host pypi.python.org -r requirements.txt
 => exporting to image
 => => exporting layers
 => => writing image sha256:c20c0f1d46742646b15e8e4f3c2eb70a585dc7c882436bdbcf99295ca3d20ebe
 => => naming to docker.io/library/image01

Use 'docker scan' to run Snyk tests against images to find vulnerabilities and learn how to fix them
(envi1) (base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> docker run --name container01 -p 5000:5000 image0
 * Serving Flask app "app" (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Running on all addresses.
   WARNING: This is a development server. Do not use it in a production deployment.
 * Running on http://172.17.0.2:5000/ (Press CTRL+C to quit)
```

Build image and container from Terminal/ Cmd

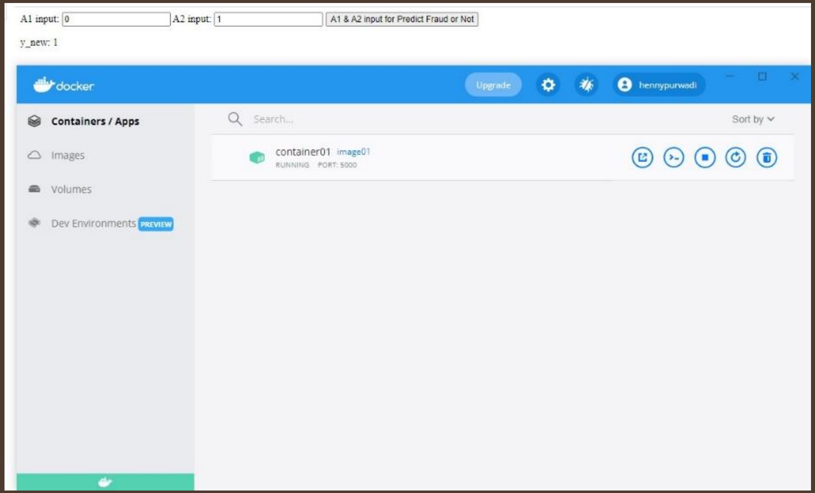
Docker apps



Images on disk 3 images Total size: 2.24 GB IN USE UNUSED

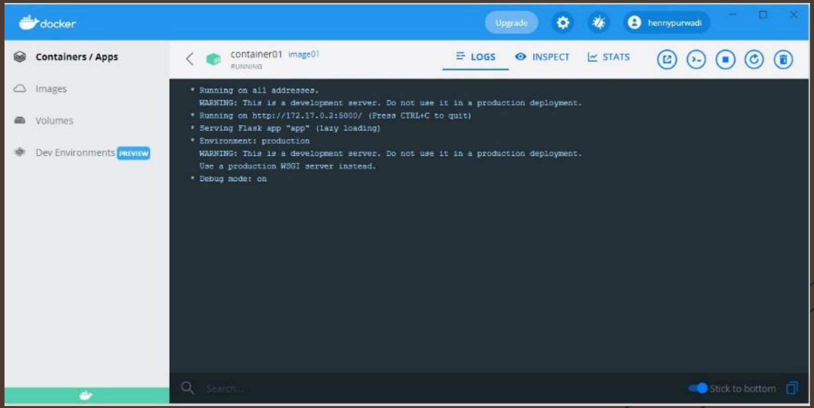
□ In Use only

NAME ↑		TAG	IMAGE ID	CREATED	SIZE
alpine/git		latest	0deb7380d708	3 months ago	27.35 MB
image01	IN USE	latest	5ce134cf75a3	27 minutes ago	2.14 GB
ubuntu		latest	ba6acccedd29	3 months ago	72.78 MB


A1 input: 0 A2 input: 1 A1 & A2 input for Predict Fraud or Not

y_new: 1

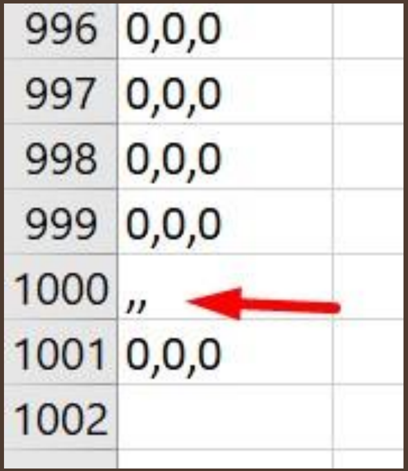
container01 image01
RUNNING PORT: 5000



container01 image01
RUNNING

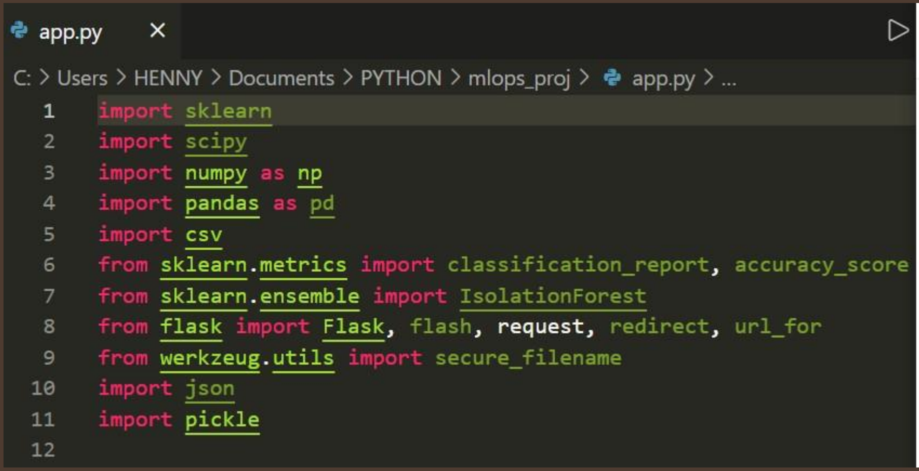
```
* Running on all addresses.
  WARNING: This is a development server. Do not use it in a production deployment.
* Running on http://172.17.0.2:5000/ (Press CTRL+C to quit)
* Serving Flask app "app" (lazy loading)
* Environment: production
  WARNING: This is a development server. Do not use it in a production deployment.
  Use a production WSGI server instead.
* Debug mode: on
```

Challenge and constraint, errors when building Docker image and Docker run:

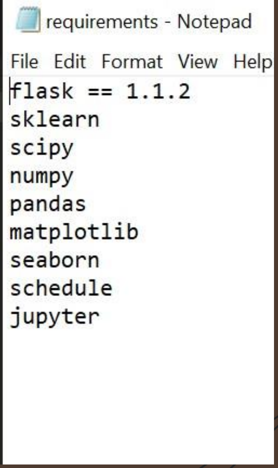


996	0,0,0
997	0,0,0
998	0,0,0
999	0,0,0
1000	,,
1001	0,0,0
1002	

1. Make sure dataset is not opening manually when the code trying to open and write automatically.
2. NaN empty row can cause error in overwrite dataset.
3. Make sure all dependencies in the code are listed in requirements.txt.

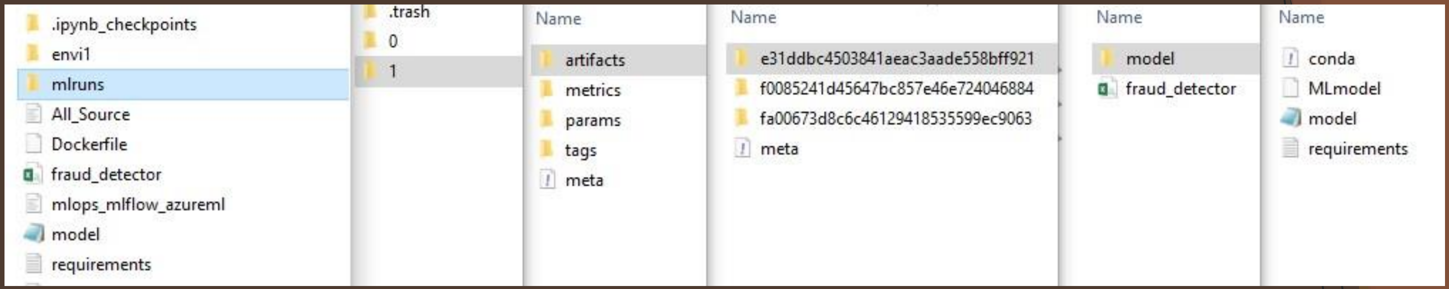

app.py ×
C: > Users > HENNY > Documents > PYTHON > mlops_proj > app.py > ...

```python
import sklearn
import scipy
import numpy as np
import pandas as pd
import csv
from sklearn.metrics import classification_report, accuracy_score
from sklearn.ensemble import IsolationForest
from flask import Flask, flash, request, redirect, url_for
from werkzeug.utils import secure_filename
import json
import pickle

```



```
flask == 1.1.2
sklearn
scipy
numpy
pandas
matplotlib
seaborn
schedule
jupyter
```

- MLFlow tracking, monitoring, automate triggered training



.ipynb_checkpoints
envi1
mlruns
All_Source
Dockerfile
fraud_detector
mlops_mlflow_azureml
model
requirements

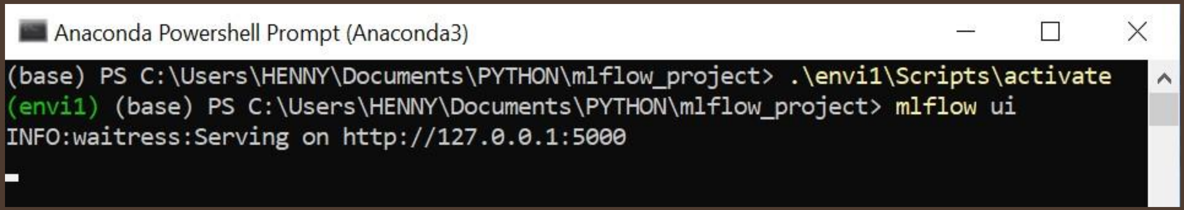
.trash
0
1

Name
artifacts
metrics
params
tags
meta

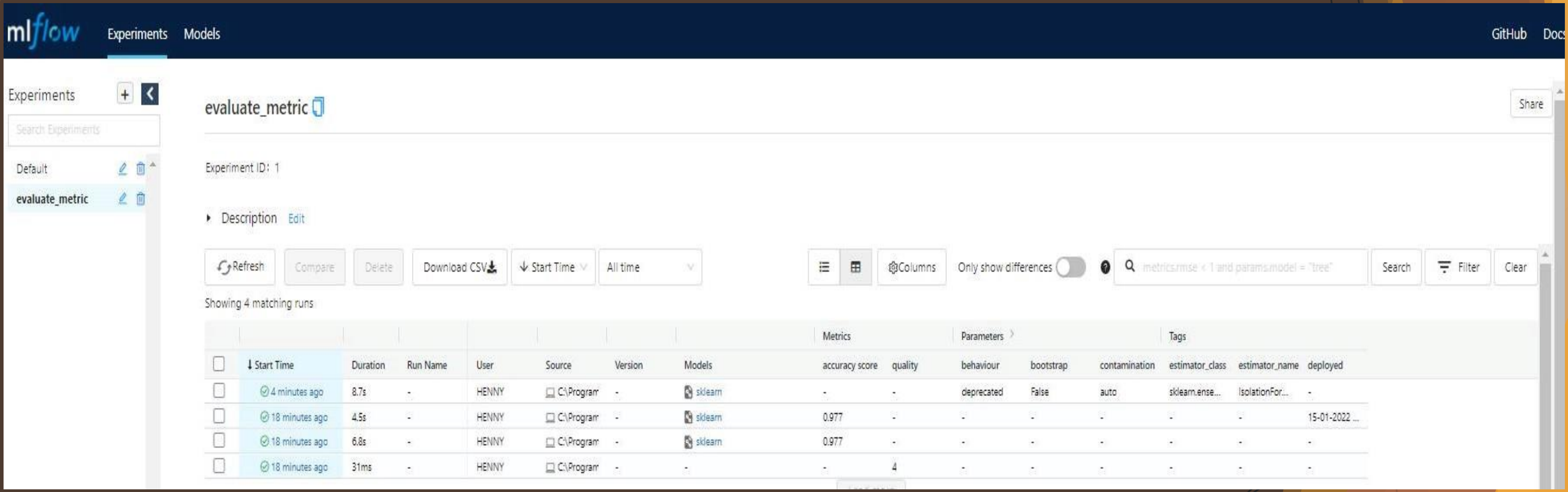
Name
e31ddbc4503841aeac3aade558bff921
f0085241d45647bc857e46e724046884
fa00673d8c6c46129418535599ec9063
meta

Name
model
fraud_detector

Name
conda
MLmodel
model
requirements



```
(base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> .\envi1\Scripts\activate
(envi1) (base) PS C:\Users\HENNY\Documents\PYTHON\mlflow_project> mlflow ui
INFO:waitress:Serving on http://127.0.0.1:5000
```



evaluate_metric

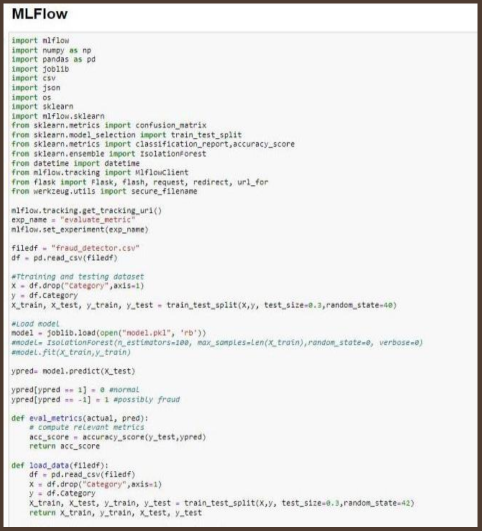
Experiment ID: 1

Showing 4 matching runs

								Metrics		Parameters			Tags		
☐	Start Time	Duration	Run Name	User	Source	Version	Models	accuracy score	quality	behaviour	bootstrap	contamination	estimator_class	estimator_name	deployed
☐	4 minutes ago	8.7s	-	HENNY	C:\Program	-	sklearn	-	-	deprecated	False	auto	sklearn.ense...	IsolationFor...	-
☐	18 minutes ago	4.5s	-	HENNY	C:\Program	-	sklearn	0.977	-	-	-	-	-	-	15-01-2022 ...
☐	18 minutes ago	6.8s	-	HENNY	C:\Program	-	sklearn	0.977	-	-	-	-	-	-	-
☐	18 minutes ago	31ms	-	HENNY	C:\Program	-	-	-	4	-	-	-	-	-	-

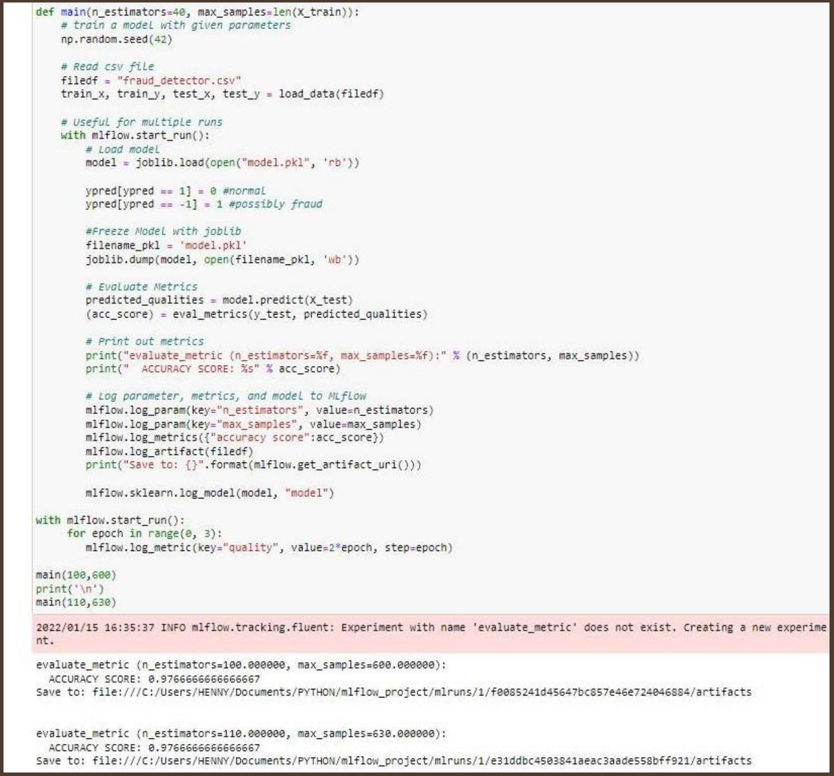
Model tracking with mlflow

Mlflow codes



MLFlow

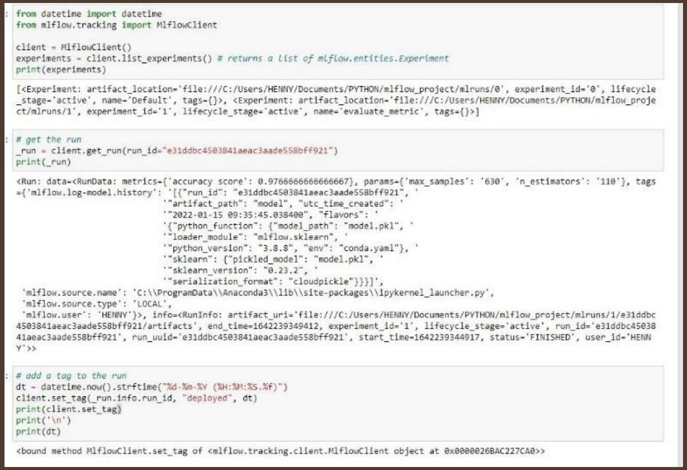
```
import mlflow
import numpy as np
import pandas as pd
import joblib
import csv
import json
import os
import sklearn
import mlflow.sklearn
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report,accuracy_score
from sklearn.ensemble import IsolationForest
from datetime import datetime
from mlflow.tracking import MlflowClient
from flask import Flask, flash, request, redirect, url_for
from werkzeug.utils import secure_filename

mlflow.tracking.get_tracking_uri()
exp_name = "evaluate_metric"
mlflow.set_experiment(exp_name)

filedf = "fraud_detector.csv"
df = pd.read_csv(filedf)

#Ttraining and testing dataset
X = df.drop("Category",axis=1)
y = df.Category
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.3,random_state=40)

#Load model
model = joblib.load(open("model.pkl", 'rb'))
#model= IsolationForest(n_estimators=100, max_samples=len(X_train),random_state=0, verbose=0)
#model.fit(X_train,y_train)

ypred= model.predict(X_test)

ypred[ypred == 1] = 0 #normal
ypred[ypred == -1] = 1 #possibly fraud

def eval_metrics(actual, pred):
    # compute relevant metrics
    acc_score = accuracy_score(y_test,ypred)
    return acc_score

def load_data(filedf):
    df = pd.read_csv(filedf)
    X = df.drop("Category",axis=1)
    y = df.Category
    X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.3,random_state=42)
    return X_train, y_train, X_test, y_test
```



```
def main(n_estimators=40, max_samples=len(X_train)):
    # train a model with given parameters
    np.random.seed(42)

    # Read csv file
    filedf = "fraud_detector.csv"
    train_x, train_y, test_x, test_y = load_data(filedf)

    # Useful for multiple runs
    with mlflow.start_run():
        # Load model
        model = joblib.load(open("model.pkl", 'rb'))

        ypred[ypred == 1] = 0 #normal
        ypred[ypred == -1] = 1 #possibly fraud

        #Freeze Model with joblib
        filename_pkl = 'model.pkl'
        joblib.dump(model, open(filename_pkl, 'wb'))

        # Evaluate Metrics
        predicted_qualities = model.predict(X_test)
        (acc_score) = eval_metrics(y_test, predicted_qualities)

        # Print out metrics
        print("evaluate_metric (n_estimators=%f, max_samples=%f):" % (n_estimators, max_samples))
        print("  ACCURACY SCORE: %s" % acc_score)

        # Log parameter, metrics, and model to MLflow
        mlflow.log_param(key="n_estimators", value=n_estimators)
        mlflow.log_param(key="max_samples", value=max_samples)
        mlflow.log_metrics({"accuracy score":acc_score})
        mlflow.log_artifact(filedf)
        print("Save to: {}".format(mlflow.get_artifact_uri()))

        mlflow.sklearn.log_model(model, "model")

with mlflow.start_run():
     for epoch in range(0, 3):
        mlflow.log_metric(key="quality", value=2*epoch, step=epoch)

main(100,600)
print('\n')
main(110,630)
```

```
2022/01/15 16:35:37 INFO mlflow.tracking.fluent: Experiment with name 'evaluate_metric' does not exist. Creating a new experime
nt.
```

```
evaluate_metric (n_estimators=100.000000, max_samples=600.000000):
  ACCURACY SCORE: 0.9766666666666667
Save to: file:///C:/Users/HENNY/Documents/PYTHON/mlflow_project/mlruns/1/f0085241d45647bc857e46e724046884/artifacts


evaluate_metric (n_estimators=110.000000, max_samples=630.000000):
  ACCURACY SCORE: 0.9766666666666667
Save to: file:///C:/Users/HENNY/Documents/PYTHON/mlflow_project/mlruns/1/e31ddbc4503841aeac3aade558bff921/artifacts
```



```
: from datetime import datetime
  from mlflow.tracking import MlflowClient

  client = MlflowClient()
  experiments = client.list_experiments() # returns a list of mlflow.entities.Experiment
  print(experiments)
```

```
[<Experiment: artifact_location='file:///C:/Users/HENNY/Documents/PYTHON/mlflow_project/mlruns/0', experiment_id='0', lifecycle
_stage='active', name='Default', tags={}>, <Experiment: artifact_location='file:///C:/Users/HENNY/Documents/PYTHON/mlflow_proje
ct/mlruns/1', experiment_id='1', lifecycle_stage='active', name='evaluate_metric', tags={}>]
```

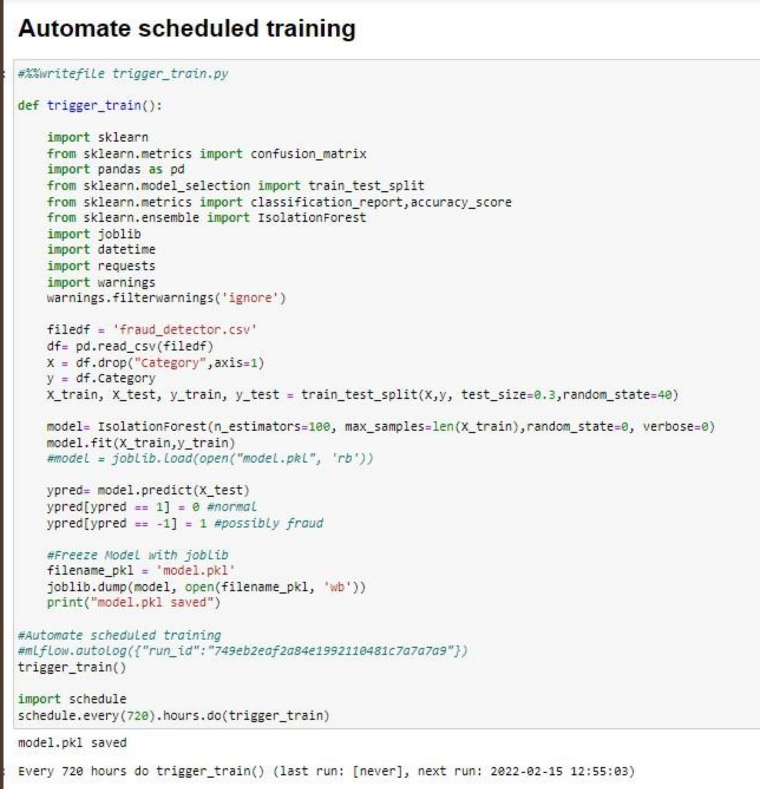
```
: # get the run
  _run = client.get_run(run_id="e31ddbc4503841aeac3aade558bff921")
  print(_run)
```

```
<Run: data=<RunData: metrics={'accuracy score': 0.9766666666666667}, params={'max_samples': '630', 'n_estimators': '110'}, tags
={'mlflow.log-model.history': '[{"run_id": "e31ddbc4503841aeac3aade558bff921", '
                              '"artifact_path": "model", "utc_time_created": '
                              '"2022-01-15 09:35:45.038400", "flavors": '
                              '{"python_function": {"model_path": "model.pkl", '
                              '"loader_module": "mlflow.sklearn", '
                              '"python_version": "3.8.8", "env": "conda.yaml"}, '
                              '"sklearn": {"pickled_model": "model.pkl", '
                              '"sklearn_version": "0.23.2", '
                              '"serialization_format": "cloudpickle"}}}]',
 'mlflow.source.name': 'C:\\ProgramData\\Anaconda3\\lib\\site-packages\\ipykernel_launcher.py',
 'mlflow.source.type': 'LOCAL',
 'mlflow.user': 'HENNY'}>, info=<RunInfo: artifact_uri='file:///C:/Users/HENNY/Documents/PYTHON/mlflow_project/mlruns/1/e31ddbc
4503841aeac3aade558bff921/artifacts', end_time=1642239349412, experiment_id='1', lifecycle_stage='active', run_id='e31ddbc45038
41aeac3aade558bff921', run_uuid='e31ddbc4503841aeac3aade558bff921', start_time=1642239344917, status='FINISHED', user_id='HENN
Y'>>
```

```
: # add a tag to the run
  dt = datetime.now().strftime("%d-%m-%Y (%H:%M:%S.%f)")
  client.set_tag(_run.info.run_id, "deployed", dt)
  print(client.set_tag)
  print('\n')
  print(dt)
```

```
<bound method MlflowClient.set_tag of <mlflow.tracking.client.MlflowClient object at 0x0000026BAC227CA0>>
```

Automate scheduled/ triggered monthly training

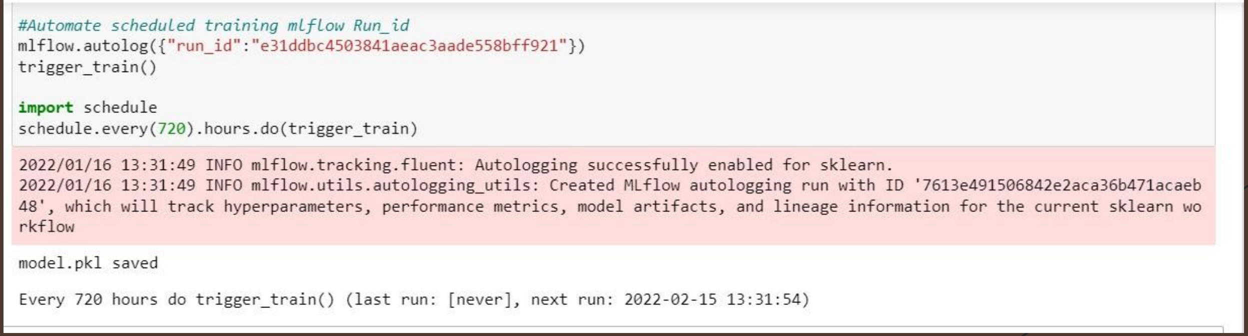


Automate scheduled training

```
#%%writefile trigger_train.py

def trigger_train():

    import sklearn
    from sklearn.metrics import confusion_matrix
    import pandas as pd
    from sklearn.model_selection import train_test_split
    from sklearn.metrics import classification_report,accuracy_score
    from sklearn.ensemble import IsolationForest
    import joblib
    import datetime
    import requests
    import warnings
    warnings.filterwarnings('ignore')

    filedf = 'fraud_detector.csv'
    df= pd.read_csv(filedf)
    X = df.drop("Category",axis=1)
    y = df.Category
    X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.3,random_state=40)

    model= IsolationForest(n_estimators=100, max_samples=len(X_train),random_state=0, verbose=0)
    model.fit(X_train,y_train)
    #model = joblib.load(open("model.pkl", 'rb'))

    ypred= model.predict(X_test)
    ypred[ypred == 1] = 0 #normal
    ypred[ypred == -1] = 1 #possibly fraud

    #Freeze Model with joblib
    filename_pkl = 'model.pkl'
    joblib.dump(model, open(filename_pkl, 'wb'))
    print("model.pkl saved")

#Automate scheduled training
#mlflow.autolog({"run_id":"749eb2eaf2a84e1992110481c7a7a7a9"})
trigger_train()

import schedule
schedule.every(720).hours.do(trigger_train)
```

```
model.pkl saved

Every 720 hours do trigger_train() (last run: [never], next run: 2022-02-15 12:55:03)
```

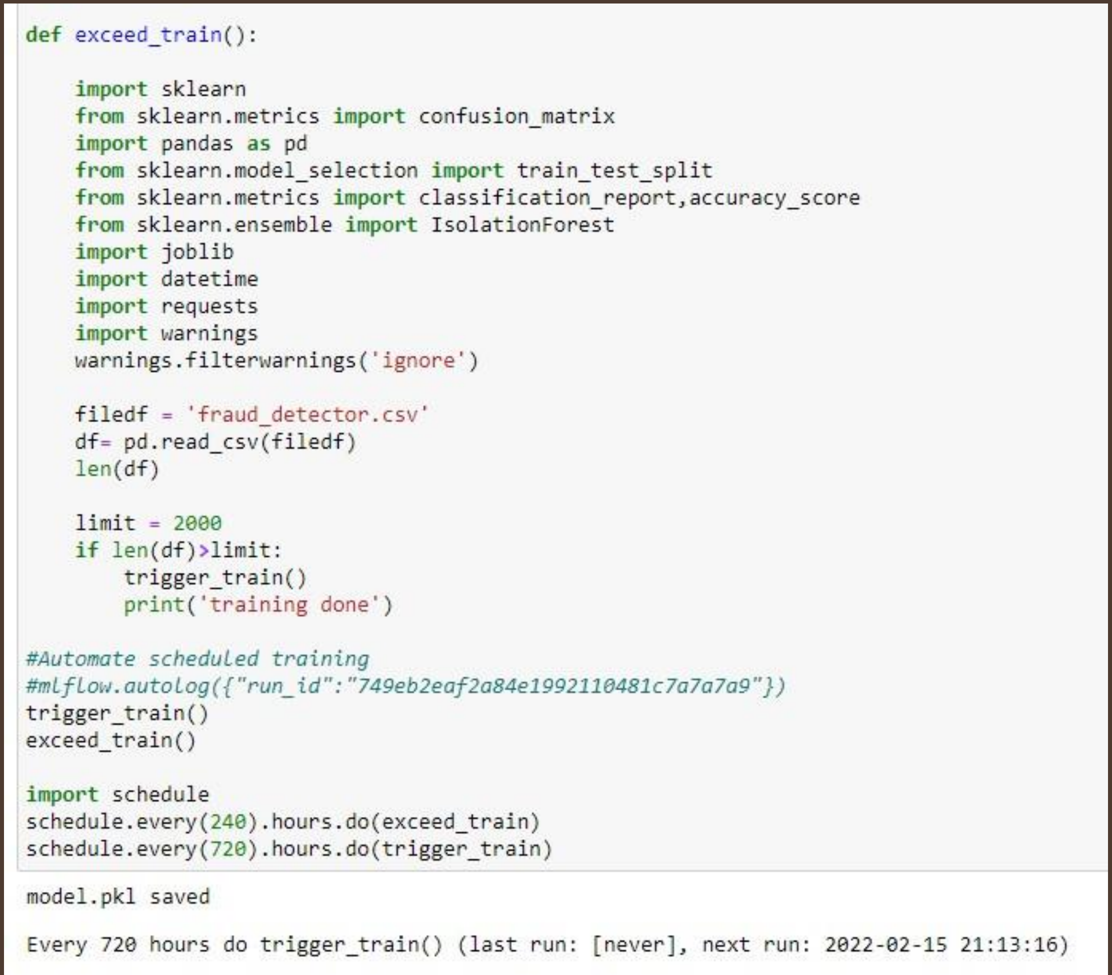
Automate mlflow **Run_id** scheduled/ triggered monthly training



```
#Automate scheduled training mlflow Run_id
mlflow.autolog({"run_id":"e31ddbc4503841aeac3aade558bff921"})
trigger_train()

import schedule
schedule.every(720).hours.do(trigger_train)
```

```
2022/01/16 13:31:49 INFO mlflow.tracking.fluent: Autologging successfully enabled for sklearn.
2022/01/16 13:31:49 INFO mlflow.utils.autologging_utils: Created MLflow autologging run with ID '7613e491506842e2aca36b471acaeb
48', which will track hyperparameters, performance metrics, model artifacts, and lineage information for the current sklearn wo
rkflow

model.pkl saved

Every 720 hours do trigger_train() (last run: [never], next run: 2022-02-15 13:31:54)
```

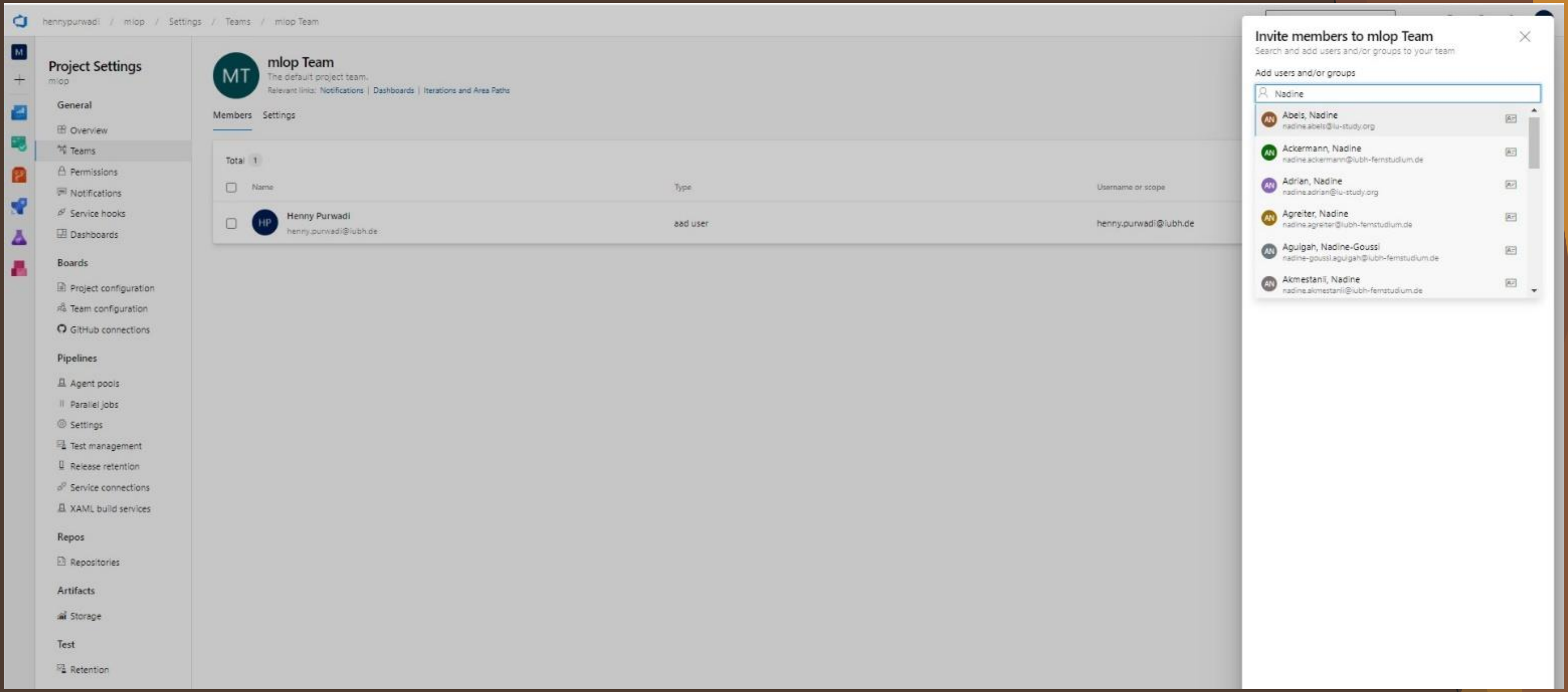
Automate training when quantity of datasets exceed certain numbers



```
def exceed_train():

    import sklearn
    from sklearn.metrics import confusion_matrix
    import pandas as pd
    from sklearn.model_selection import train_test_split
    from sklearn.metrics import classification_report,accuracy_score
    from sklearn.ensemble import IsolationForest
    import joblib
    import datetime
    import requests
    import warnings
    warnings.filterwarnings('ignore')

    filedf = 'fraud_detector.csv'
    df= pd.read_csv(filedf)
    len(df)

    limit = 2000
    if len(df)>limit:
        trigger_train()
        print('training done')

#Automate scheduled training
#mlflow.autolog({"run_id":"749eb2eaf2a84e1992110481c7a7a7a9"})
trigger_train()
exceed_train()

import schedule
schedule.every(240).hours.do(exceed_train)
schedule.every(720).hours.do(trigger_train)
```

```
model.pkl saved

Every 720 hours do trigger_train() (last run: [never], next run: 2022-02-15 21:13:16)
```

MLOps with Azure DevOps



MT mlop Team

The default project team.

Relevant links: Notifications | Dashboards | Iterations and Area Paths

Total 1

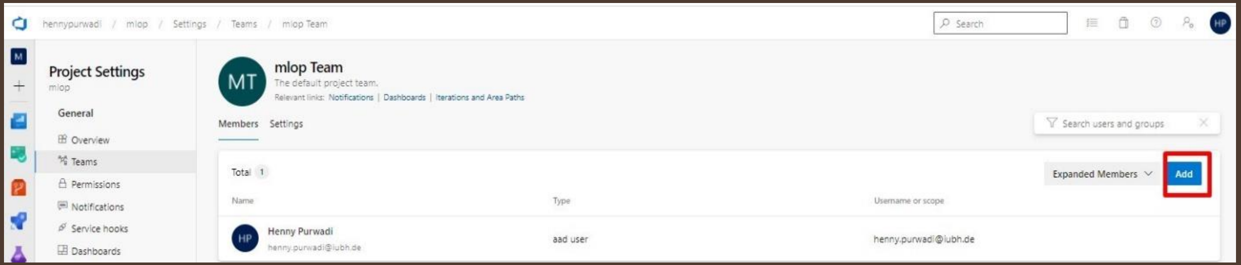
Name	Type	Username or scope
Henny Purwadi henny.purwadi@iubh.de	aad user	henny.purwadi@iubh.de

Invite members to mlop Team

Search and add users and/or groups to your team

Add users and/or groups: Nadine

- Abels, Nadine — nadine.abels@iu-study.org
- Ackermann, Nadine — nadine.ackermann@iubh-fernstudium.de
- Adrian, Nadine — nadine.adrian@iu-study.org
- Agreiter, Nadine — nadine.agreiter@iubh-fernstudium.de
- Aguigah, Nadine-Goussi — nadine-goussi.aguigah@iubh-fernstudium.de
- Akmestanli, Nadine — nadine.akmestanli@iubh-fernstudium.de



MT mlop Team

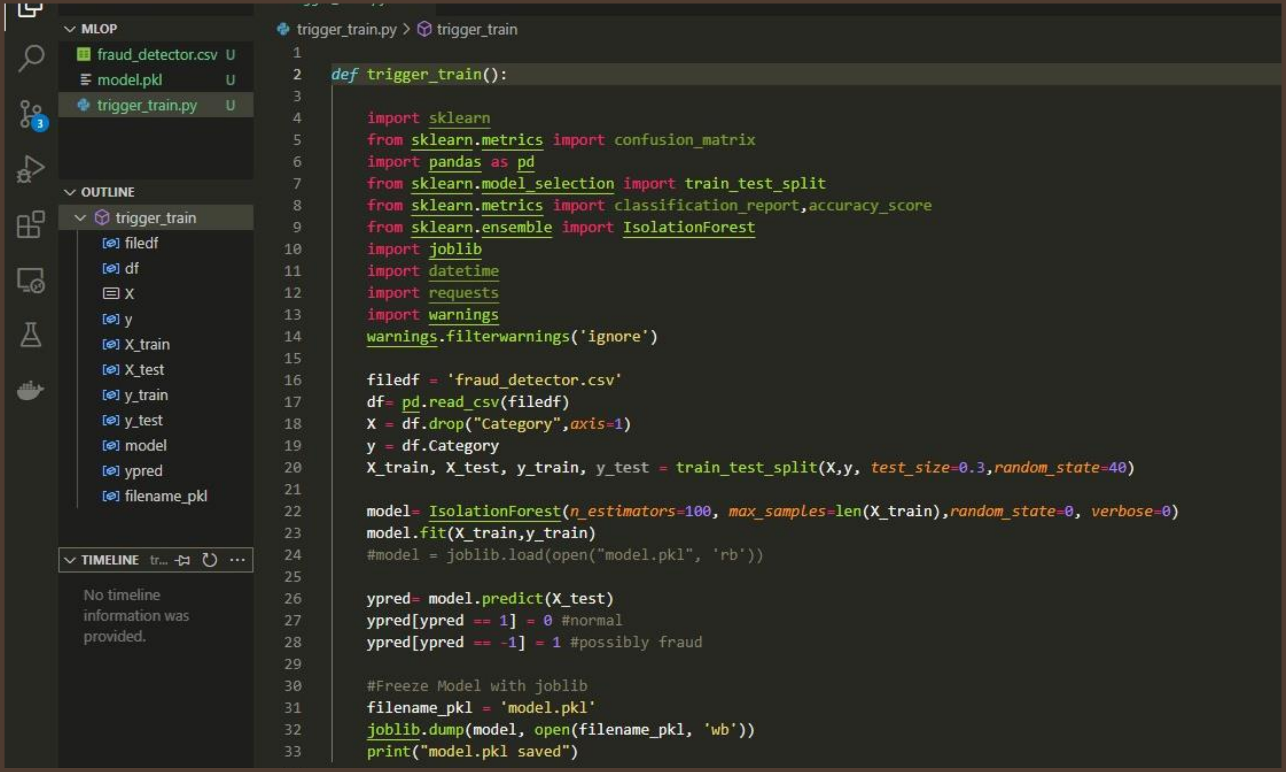
The default project team.

Relevant links: Notifications | Dashboards | Iterations and Area Paths

Total 1

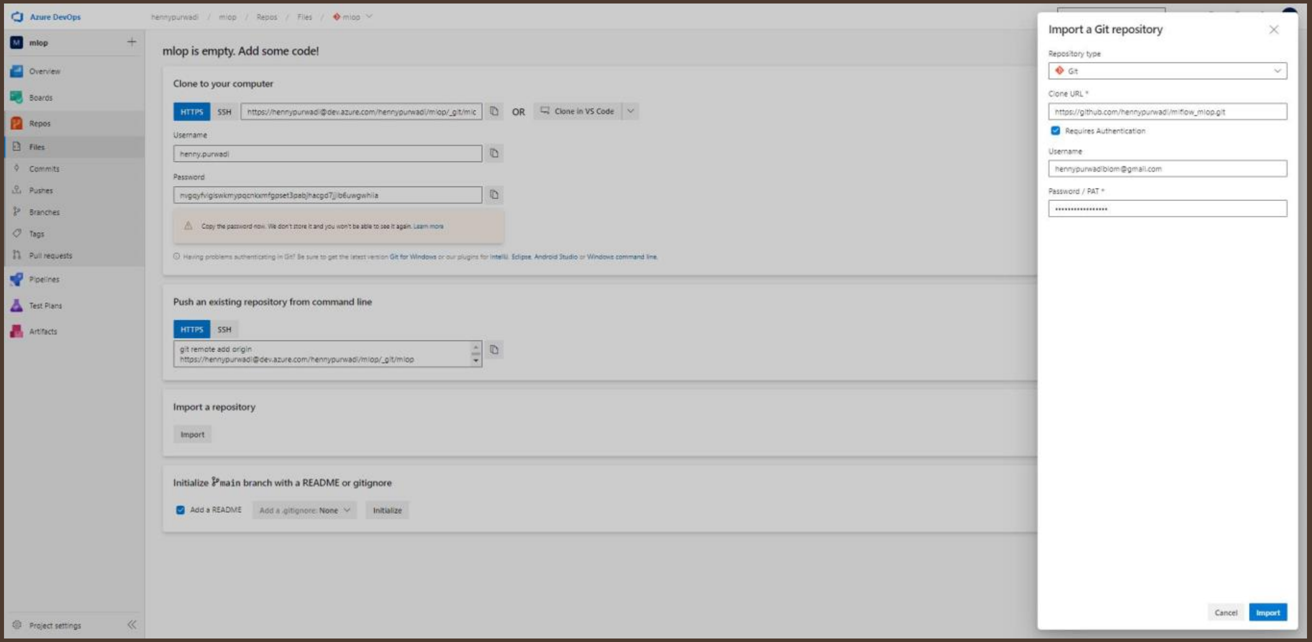
Name	Type	Username or scope
Henny Purwadi henny.purwadi@iubh.de	aad user	henny.purwadi@iubh.de

Invite members to Project in Azure DevOps



```python

def trigger_train():

    import sklearn
    from sklearn.metrics import confusion_matrix
    import pandas as pd
    from sklearn.model_selection import train_test_split
    from sklearn.metrics import classification_report,accuracy_score
    from sklearn.ensemble import IsolationForest
    import joblib
    import datetime
    import requests
    import warnings
    warnings.filterwarnings('ignore')

    filedf = 'fraud_detector.csv'
    df= pd.read_csv(filedf)
    X = df.drop("Category",axis=1)
    y = df.Category
    X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.3,random_state=40)

    model= IsolationForest(n_estimators=100, max_samples=len(X_train),random_state=0, verbose=0)
    model.fit(X_train,y_train)
    #model = joblib.load(open("model.pkl", 'rb'))

    ypred= model.predict(X_test)
    ypred[ypred == 1] = 0 #normal
    ypred[ypred == -1] = 1 #possibly fraud

    #Freeze Model with joblib
    filename_pkl = 'model.pkl'
    joblib.dump(model, open(filename_pkl, 'wb'))
    print("model.pkl saved")
```

Azure DevOps linked with VS Code



mlop is empty. Add some code!

Clone to your computer

HTTPS SSH https://hennypurwadi@dev.azure.com/hennypurwadi/mlop/_git/mlc OR Clone in VS Code

Username: henny.purwadi

Password: nvgqyfvigiswkmypqcnkxmfgpset3pebjhacgd7jjb6uwgwhila

Copy the password now. We don't store it and you won't be able to see it again. Learn more

Having problems authenticating in Git? Be sure to get the latest version Git for Windows or our plugins for IntelliJ, Eclipse, Android Studio or Windows command line.

Push an existing repository from command line

HTTPS SSH

```
git remote add origin
https://hennypurwadi@dev.azure.com/hennypurwadi/mlop/_git/mlop
```

Import a repository

Import

Initialize main branch with a README or gitignore

☑ Add a README   Add a .gitignore: None   Initialize

Import a Git repository

Repository type: Git

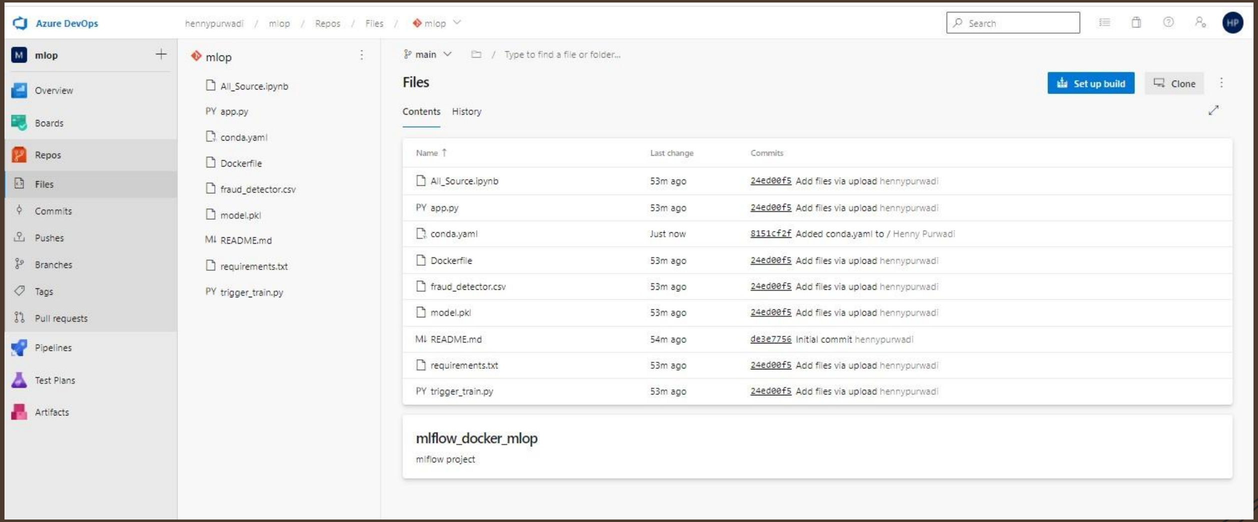
Clone URL *: https://github.com/hennypurwadi/mlflow_mlop.git

☑ Requires Authentication

Username: hennypurwadibiom@gmail.com

Password / PAT *: ••••••••••••••••••

Cancel   Import



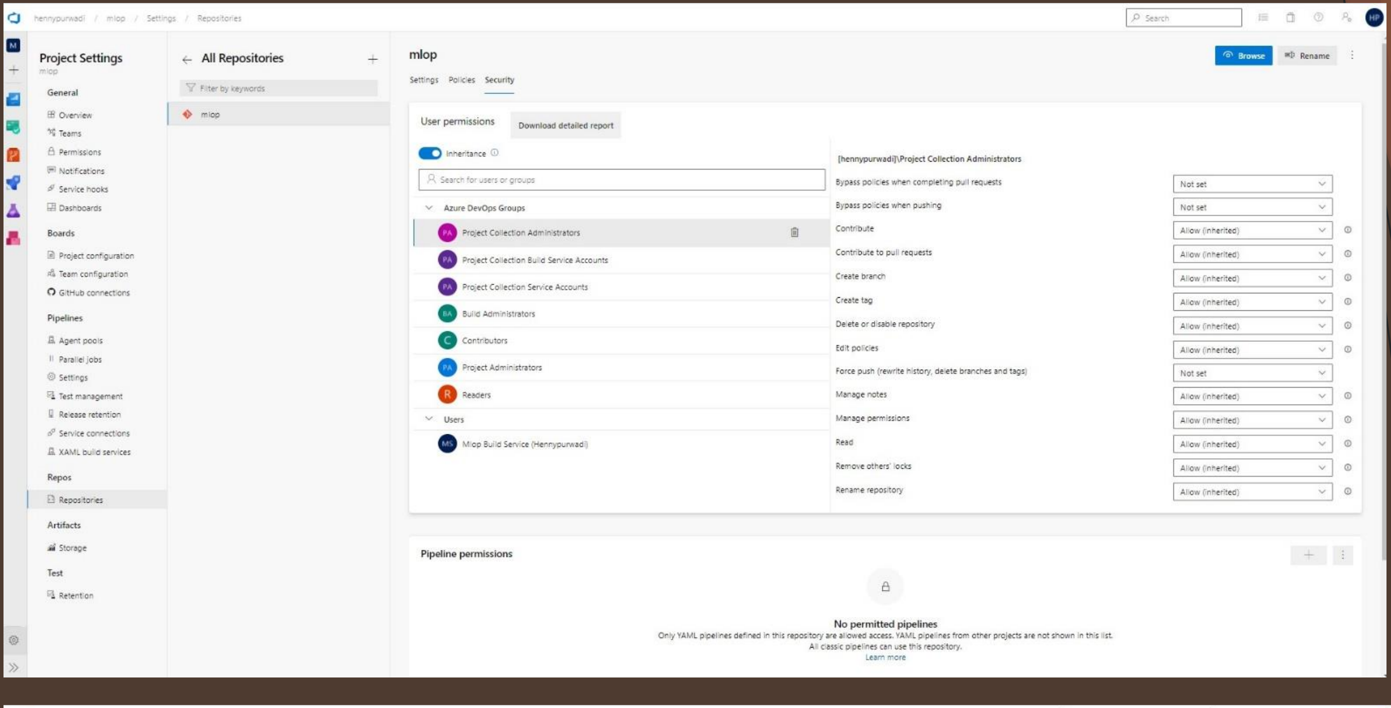
Files

Name ↑	Last change	Commits
All_Source.ipynb	53m ago	24ed00f5 Add files via upload hennypurwadi
app.py	53m ago	24ed00f5 Add files via upload hennypurwadi
conda.yaml	Just now	8151cf2f Added conda.yaml to / Henny Purwadi
Dockerfile	53m ago	24ed00f5 Add files via upload hennypurwadi
fraud_detector.csv	53m ago	24ed00f5 Add files via upload hennypurwadi
model.pkl	53m ago	24ed00f5 Add files via upload hennypurwadi
README.md	54m ago	de3e7756 Initial commit hennypurwadi
requirements.txt	53m ago	24ed00f5 Add files via upload hennypurwadi
trigger_train.py	53m ago	24ed00f5 Add files via upload hennypurwadi

mlflow_docker_mlop

mlflow project

Azure DevOps linked with Github repository



hennypurwadi / mlop / Settings / Repositories

Project Settings
mlop

General
- Overview
- Teams
- Permissions
- Notifications
- Service hooks
- Dashboards

Boards
- Project configuration
- Team configuration
- GitHub connections

Pipelines
- Agent pools
- Parallel jobs
- Settings
- Test management
- Release retention
- Service connections
- XAML build services

Repos
- Repositories

Artifacts
- Storage

Test
- Retention

All Repositories

Filter by keywords

mlop

mlop

Settings Policies Security

User permissions   Download detailed report

Inheritance

Search for users or groups

Azure DevOps Groups
- PA Project Collection Administrators
- PA Project Collection Build Service Accounts
- PA Project Collection Service Accounts
- BA Build Administrators
- C Contributors
- PA Project Administrators
- R Readers

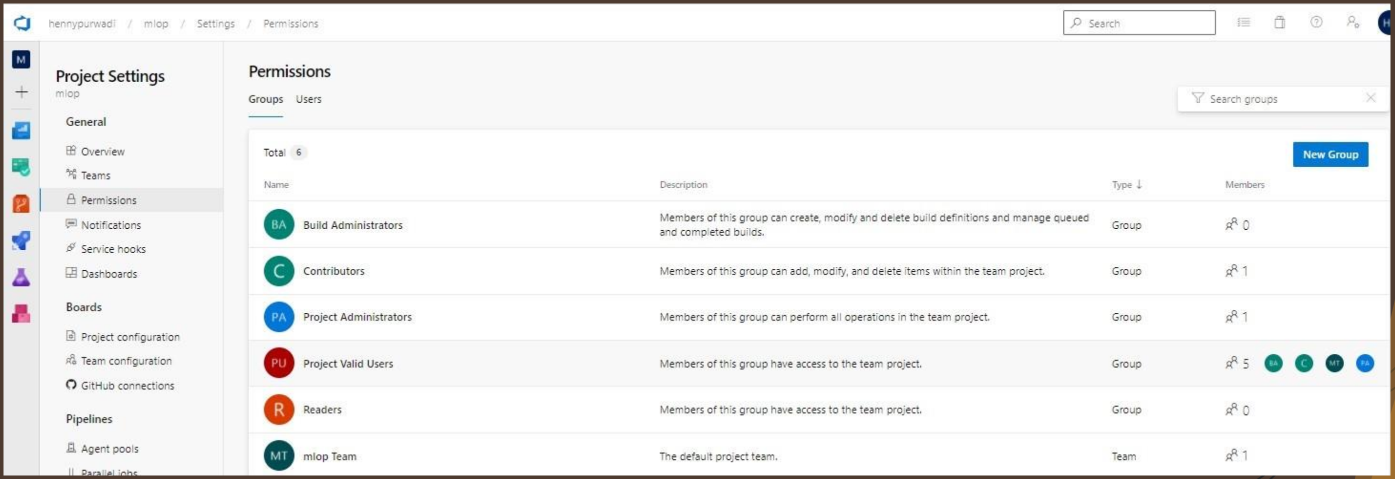
Users
- MS Mlop Build Service (Hennypurwadi)

[hennypurwadi]\Project Collection Administrators

Bypass policies when completing pull requests	Not set
Bypass policies when pushing	Not set
Contribute	Allow (inherited)
Contribute to pull requests	Allow (inherited)
Create branch	Allow (inherited)
Create tag	Allow (inherited)
Delete or disable repository	Allow (inherited)
Edit policies	Allow (inherited)
Force push (rewrite history, delete branches and tags)	Not set
Manage notes	Allow (inherited)
Manage permissions	Allow (inherited)
Read	Allow (inherited)
Remove others' locks	Allow (inherited)
Rename repository	Allow (inherited)

Pipeline permissions

No permitted pipelines
Only YAML pipelines defined in this repository are allowed access. YAML pipelines from other projects are not shown in this list.
All classic pipelines can use this repository.
Learn more



hennypurwadi / mlop / Settings / Permissions

Project Settings
mlop

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Pipelines
- Agent pools
- Parallel jobs

Permissions

Groups Users

Search groups

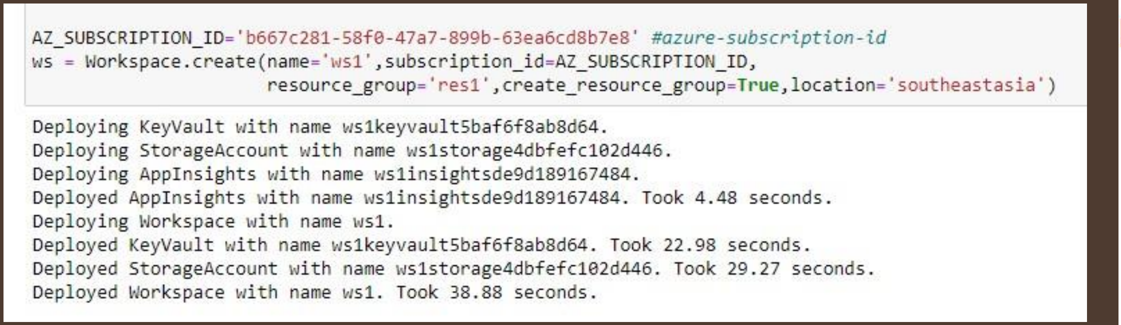
Total 6

New Group

Name	Description	Type	Members
BA Build Administrators	Members of this group can create, modify and delete build definitions and manage queued and completed builds.	Group	0
C Contributors	Members of this group can add, modify, and delete items within the team project.	Group	1
PA Project Administrators	Members of this group can perform all operations in the team project.	Group	1
PU Project Valid Users	Members of this group have access to the team project.	Group	5 BA C MT PA
R Readers	Members of this group have access to the team project.	Group	0
MT mlop Team	The default project team.	Team	1

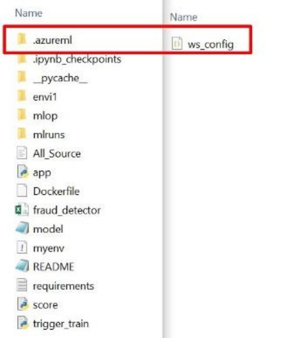
Azure DevOps Permissions

- Deploy Model into Azure ML

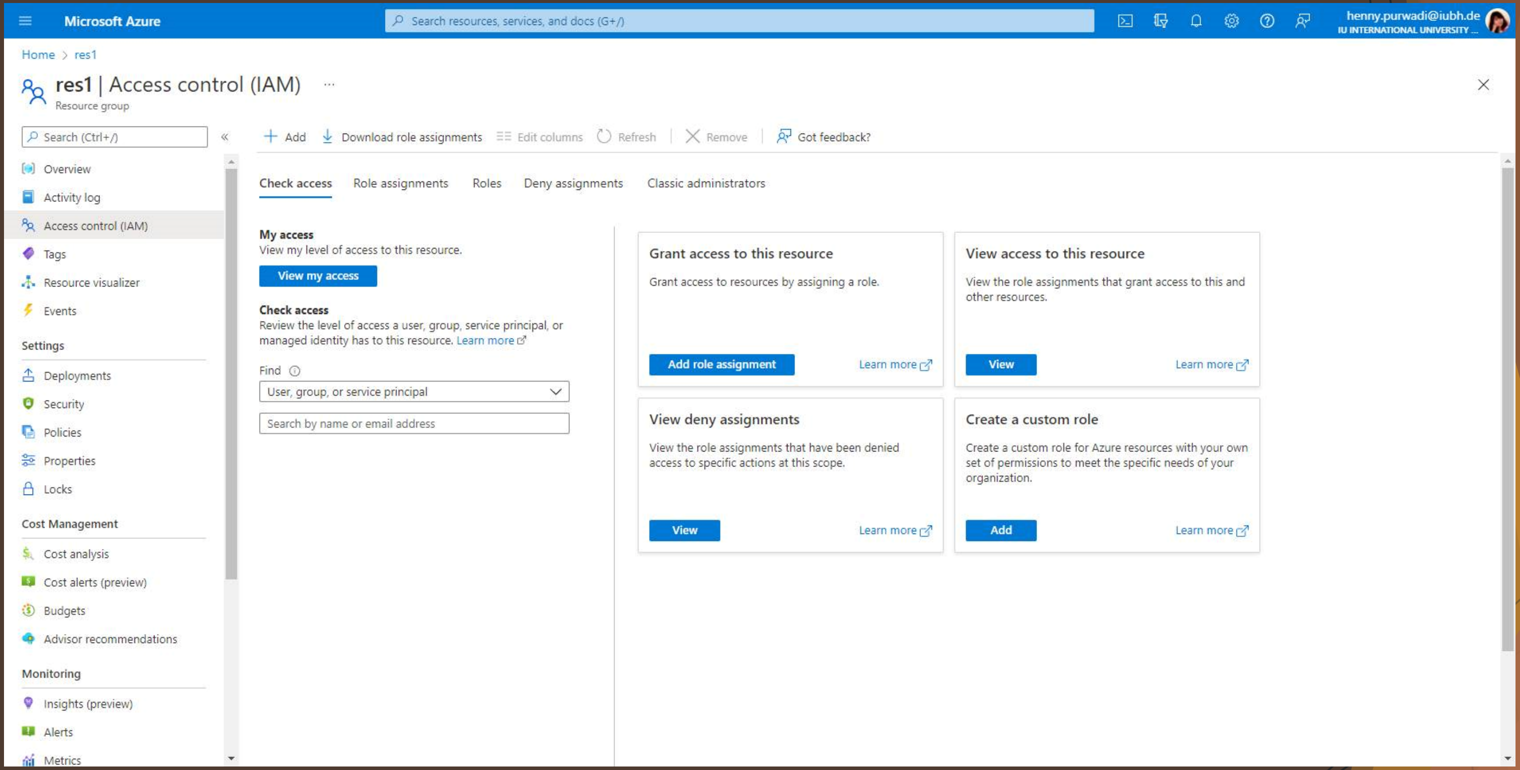


```
AZ_SUBSCRIPTION_ID='b667c281-58f0-47a7-899b-63ea6cd8b7e8' #azure-subscription-id
ws = Workspace.create(name='ws1',subscription_id=AZ_SUBSCRIPTION_ID,
                      resource_group='res1',create_resource_group=True,location='southeastasia')
```

```
Deploying KeyVault with name ws1keyvault5baf6f8ab8d64.
Deploying StorageAccount with name ws1storage4dbfefc102d446.
Deploying AppInsights with name ws1insightsde9d189167484.
Deployed AppInsights with name ws1insightsde9d189167484. Took 4.48 seconds.
Deploying Workspace with name ws1.
Deployed KeyVault with name ws1keyvault5baf6f8ab8d64. Took 22.98 seconds.
Deployed StorageAccount with name ws1storage4dbfefc102d446. Took 29.27 seconds.
Deployed Workspace with name ws1. Took 38.88 seconds.
```



Name	Name
.azureml	ws_config
.ipynb_checkpoints	
__pycache__	
envi1	
mlop	
mlruns	
All_Source	
app	
Dockerfile	
fraud_detector	
model	
myenv	
README	
requirements	
score	
trigger_train	



My access

View my level of access to this resource.

View my access

Check access

Review the level of access a user, group, service principal, or managed identity has to this resource. Learn more

Find

User, group, or service principal

Search by name or email address

Grant access to this resource

Grant access to resources by assigning a role.

Add role assignment — Learn more

View access to this resource

View the role assignments that grant access to this and other resources.

View — Learn more

View deny assignments

View the role assignments that have been denied access to specific actions at this scope.

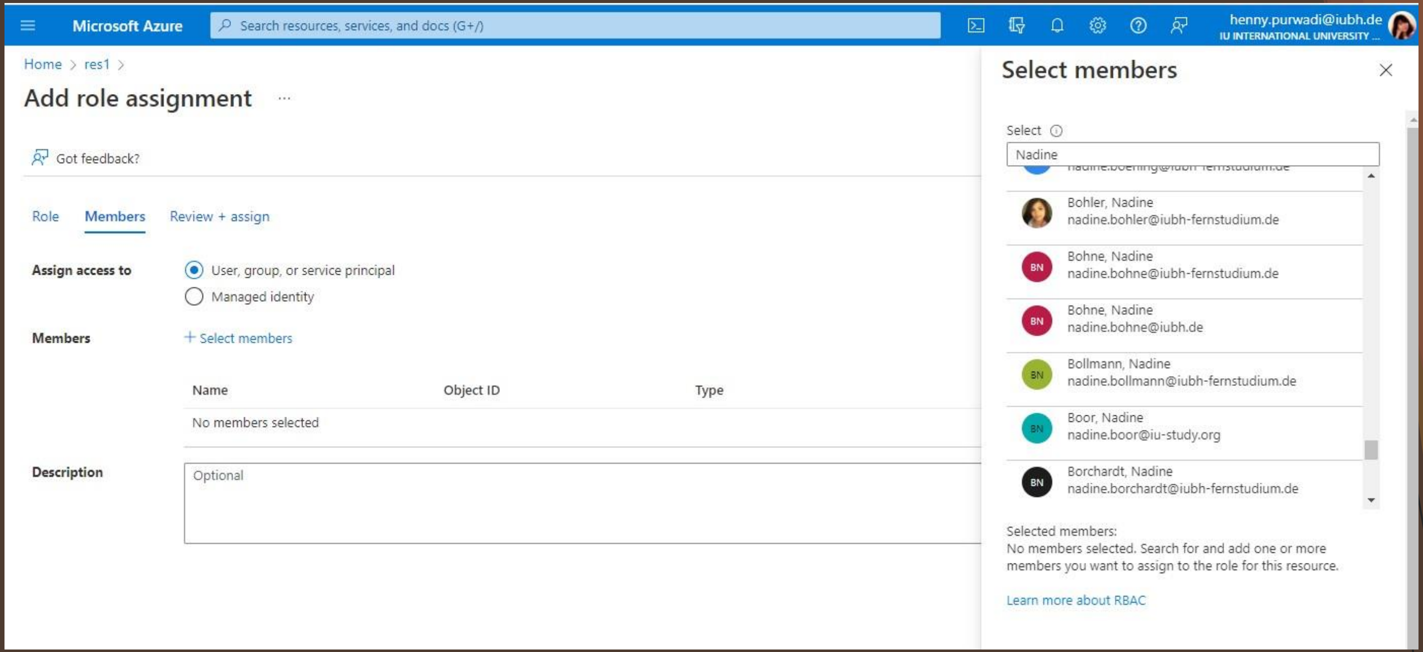
View — Learn more

Create a custom role

Create a custom role for Azure resources with your own set of permissions to meet the specific needs of your organization.

Add — Learn more

AzureML resource and workspace creation and access control



Add role assignment

Assign access to
● User, group, or service principal
○ Managed identity

Members
+ Select members

Name	Object ID	Type
No members selected		

Description
Optional

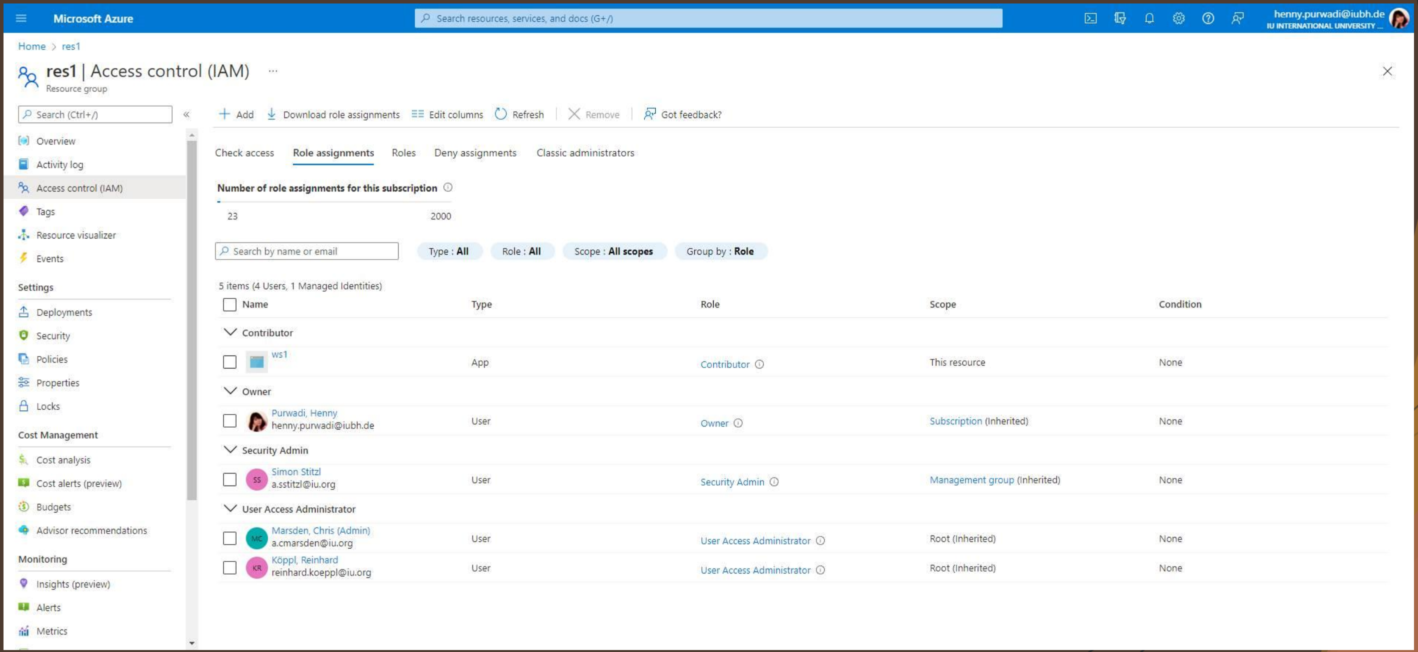
Select members

Select ⓘ
Nadine

Bohler, Nadine nadine.bohler@iubh-fernstudium.de
BN Bohne, Nadine nadine.bohne@iubh-fernstudium.de
BN Bohne, Nadine nadine.bohne@iubh.de
BN Bollmann, Nadine nadine.bollmann@iubh-fernstudium.de
BN Boor, Nadine nadine.boor@iu-study.org
BN Borchardt, Nadine nadine.borchardt@iubh-fernstudium.de

Selected members:
No members selected. Search for and add one or more members you want to assign to the role for this resource.

Learn more about RBAC



res1 | Access control (IAM)
Resource group

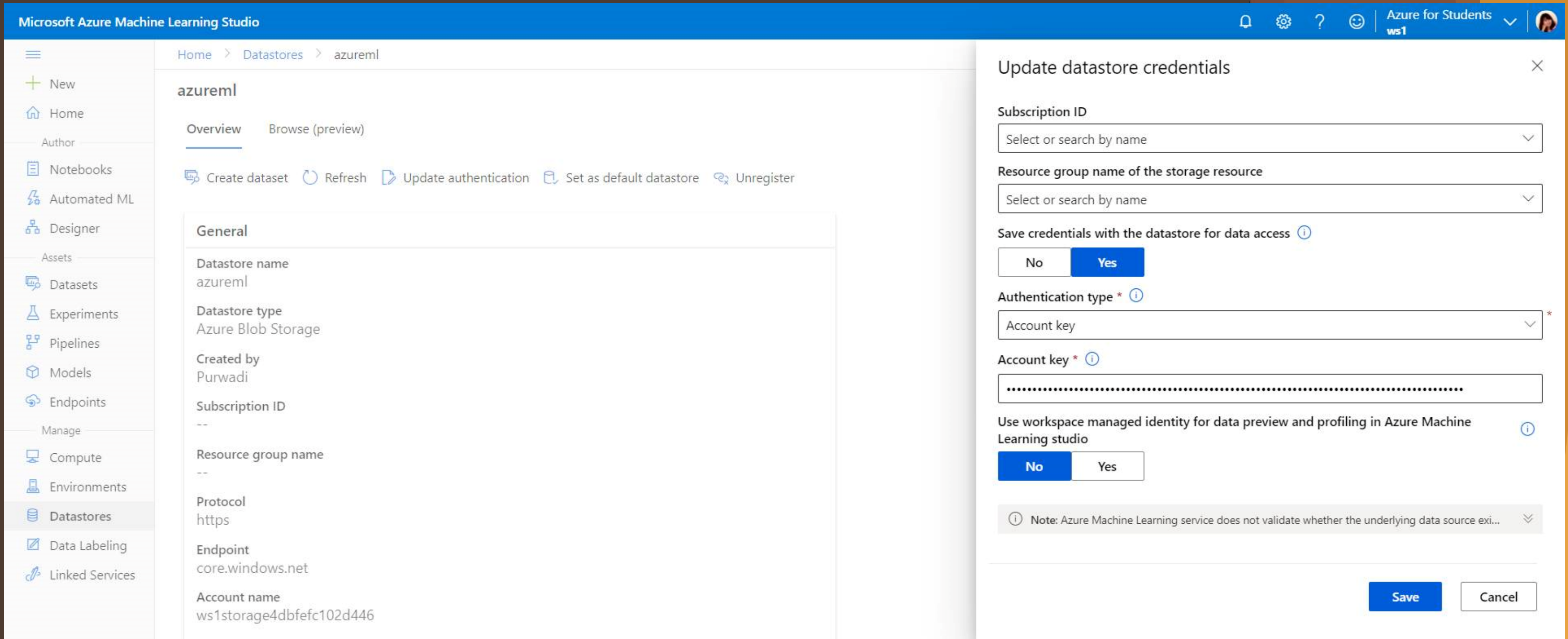
Number of role assignments for this subscription ⓘ
23 2000

Search by name or email
Type : **All** Role : **All** Scope : **All scopes** Group by : **Role**

5 items (4 Users, 1 Managed Identities)

□ Name	Type	Role	Scope	Condition
Contributor				
□ ws1	App	Contributor ⓘ	This resource	None
Owner				
□ Purwadi, Henny henny.purwadi@iubh.de	User	Owner ⓘ	Subscription (Inherited)	None
Security Admin				
□ SS Simon Stitzl a.sstitzl@iu.org	User	Security Admin ⓘ	Management group (Inherited)	None
User Access Administrator				
□ MC Marsden, Chris (Admin) a.cmarsden@iu.org	User	User Access Administrator ⓘ	Root (Inherited)	None
□ KR Köppl, Reinhard reinhard.koeppl@iu.org	User	User Access Administrator ⓘ	Root (Inherited)	None

Datastore authentication



azureml

General

Datastore name
azureml

Datastore type
Azure Blob Storage

Created by
Purwadi

Subscription ID
--

Resource group name
--

Protocol
https

Endpoint
core.windows.net

Account name
ws1storage4dbfefc102d446

Update datastore credentials

Subscription ID
Select or search by name

Resource group name of the storage resource
Select or search by name

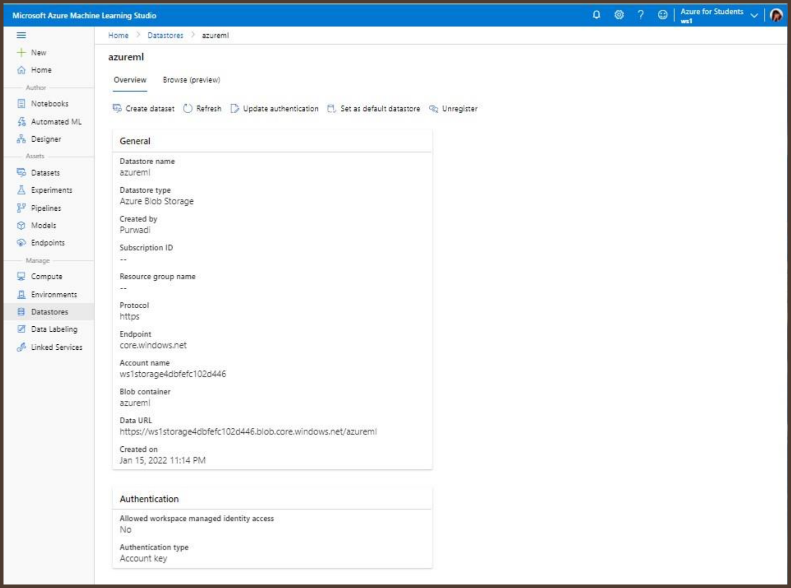
Save credentials with the datastore for data access
No [✓ Yes]

Authentication type *
Account key

Account key *
••

Use workspace managed identity for data preview and profiling in Azure Machine Learning studio
[✓ No] Yes

Note: Azure Machine Learning service does not validate whether the underlying data source exi...



azureml

General

Datastore name
azureml

Datastore type
Azure Blob Storage

Created by
Purwadi

Subscription ID
--

Resource group name
--

Protocol
https

Endpoint
core.windows.net

Account name
ws1storage4dbfefc102d446

Blob container
azureml

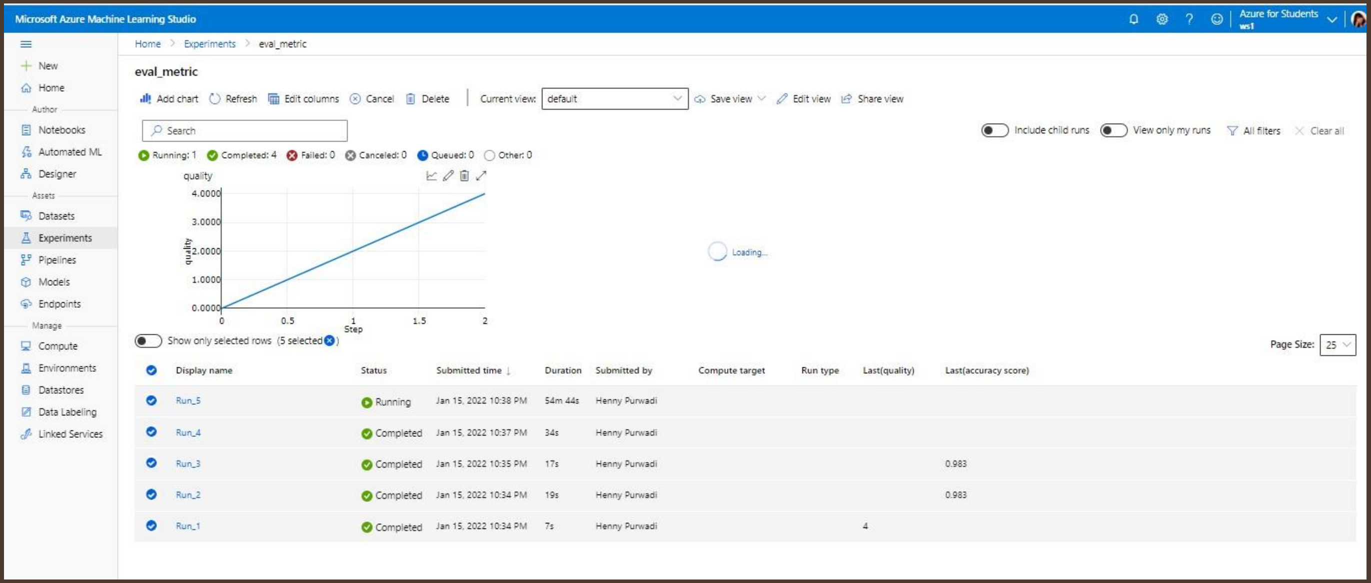
Data URL
https://ws1storage4dbfefc102d446.blob.core.windows.net/azureml

Created on
Jan 15, 2022 11:14 PM

Authentication

Allowed workspace managed identity access
No

Authentication type
Account key

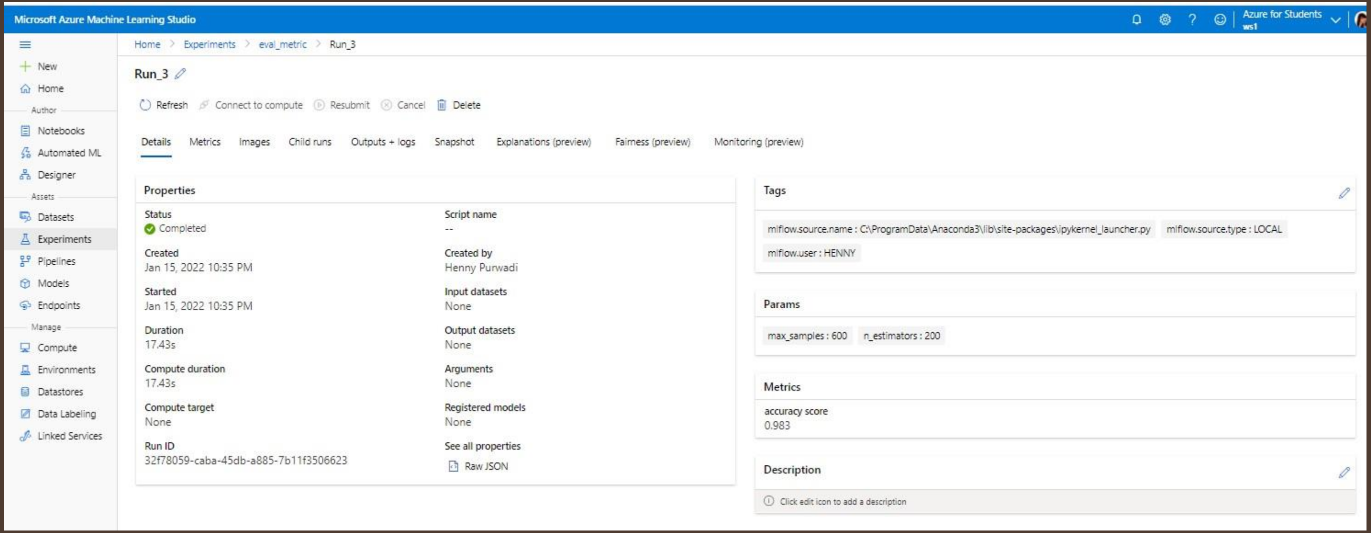


eval_metric

Current view: default

Running: 1 Completed: 4 Failed: 0 Canceled: 0 Queued: 0 Other: 0

Display name	Status	Submitted time ↓	Duration	Submitted by	Compute target	Run type	Last(quality)	Last(accuracy score)
Run_5	Running	Jan 15, 2022 10:38 PM	54m 44s	Henny Purwadi				
Run_4	Completed	Jan 15, 2022 10:37 PM	34s	Henny Purwadi				
Run_3	Completed	Jan 15, 2022 10:35 PM	17s	Henny Purwadi				0.983
Run_2	Completed	Jan 15, 2022 10:34 PM	19s	Henny Purwadi				0.983
Run_1	Completed	Jan 15, 2022 10:34 PM	7s	Henny Purwadi			4	



Run_3

Properties

Status
Completed

Script name
--

Created
Jan 15, 2022 10:35 PM

Created by
Henny Purwadi

Started
Jan 15, 2022 10:35 PM

Input datasets
None

Duration
17.43s

Output datasets
None

Compute duration
17.43s

Arguments
None

Compute target
None

Registered models
None

Run ID
32f78059-caba-45db-a885-7b11f3506623

See all properties
Raw JSON

Tags

mlflow.source.name : C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py
mlflow.source.type : LOCAL
mlflow.user : HENNY

Params

max_samples : 600
n_estimators : 200

Metrics

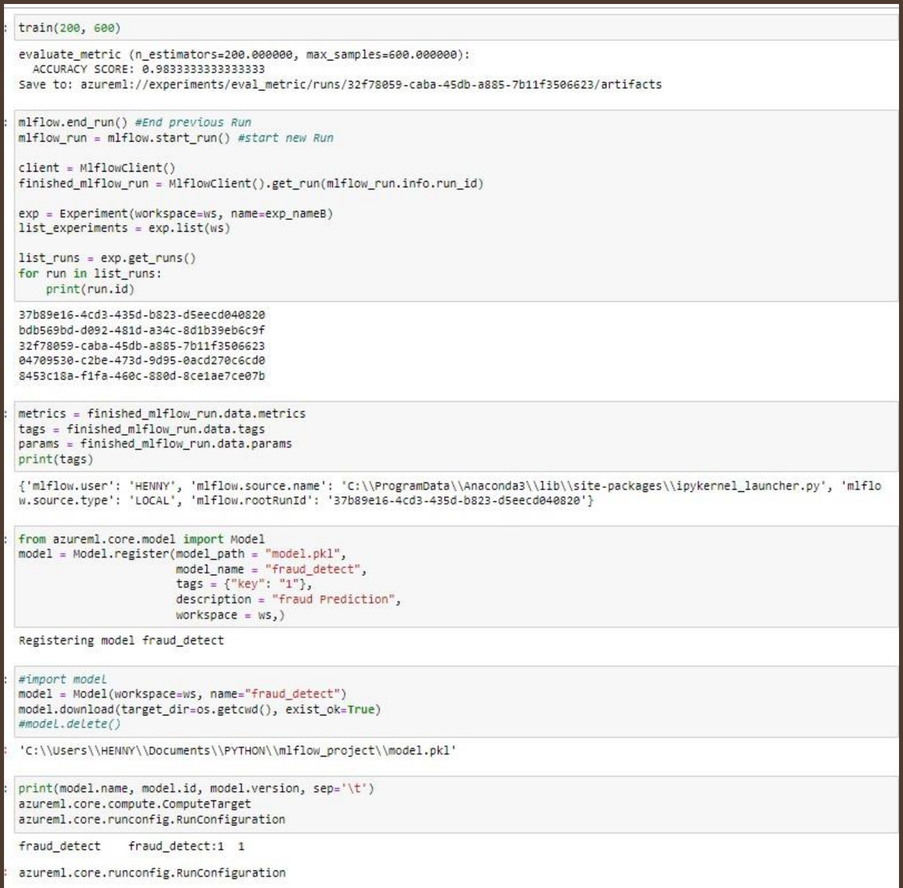
accuracy score
0.983

Description

Click edit icon to add a description

AzureML Experiments

AzureML codes



```
train(200, 600)
```

```
evaluate_metric (n_estimators=200.000000, max_samples=600.000000):
  ACCURACY SCORE: 0.9833333333333333
Save to: azureml://experiments/eval_metric/runs/32f78059-caba-45db-a885-7b11f3506623/artifacts
```

```
mlflow.end_run() #End previous Run
mlflow_run = mlflow.start_run() #start new Run

client = MlflowClient()
finished_mlflow_run = MlflowClient().get_run(mlflow_run.info.run_id)

exp = Experiment(workspace=ws, name=exp_nameB)
list_experiments = exp.list(ws)

list_runs = exp.get_runs()
for run in list_runs:
    print(run.id)
```

```
37b89e16-4cd3-435d-b823-d5eecd040820
bdb569bd-d092-481d-a34c-8d1b39eb6c9f
32f78059-caba-45db-a885-7b11f3506623
04709530-c2be-473d-9d95-0acd270c6cd0
8453c18a-f1fa-460c-880d-8ce1ae7ce07b
```

```
metrics = finished_mlflow_run.data.metrics
tags = finished_mlflow_run.data.tags
params = finished_mlflow_run.data.params
print(tags)
```

```
{'mlflow.user': 'HENNY', 'mlflow.source.name': 'C:\\ProgramData\\Anaconda3\\lib\\site-packages\\ipykernel_launcher.py', 'mlflo
w.source.type': 'LOCAL', 'mlflow.rootRunId': '37b89e16-4cd3-435d-b823-d5eecd040820'}
```

```
from azureml.core.model import Model
model = Model.register(model_path = "model.pkl",
                       model_name = "fraud_detect",
                       tags = {"key": "1"},
                       description = "fraud Prediction",
                       workspace = ws,)
```

```
Registering model fraud_detect
```

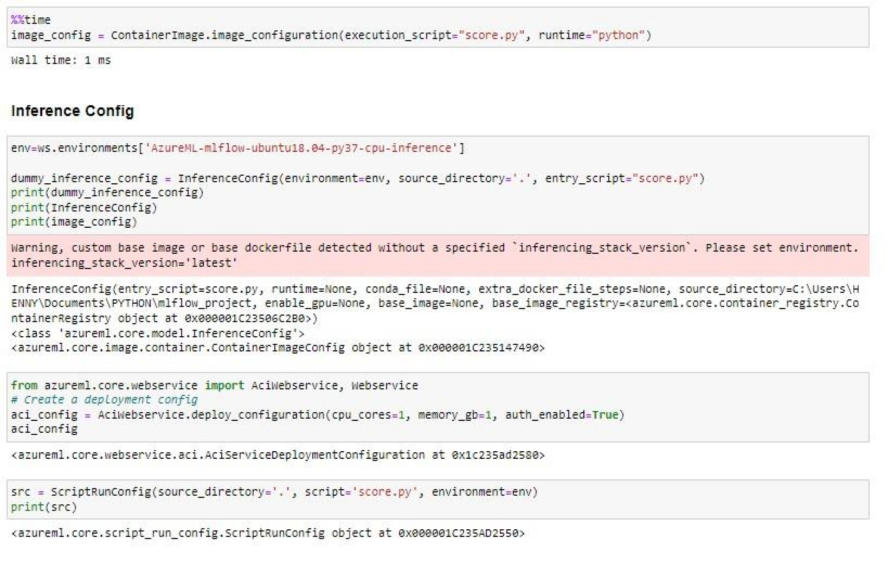
```
#import model
model = Model(workspace=ws, name="fraud_detect")
model.download(target_dir=os.getcwd(), exist_ok=True)
#model.delete()
```

```
'C:\\Users\\HENNY\\Documents\\PYTHON\\mlflow_project\\model.pkl'
```

```
print(model.name, model.id, model.version, sep='\t')
azureml.core.compute.ComputeTarget
azureml.core.runconfig.RunConfiguration
```

```
fraud_detect    fraud_detect:1  1
```

```
azureml.core.runconfig.RunConfiguration
```



```
%%time
image_config = ContainerImage.image_configuration(execution_script="score.py", runtime="python")
```

```
Wall time: 1 ms
```

Inference Config

```
env=ws.environments['AzureML-mlflow-ubuntu18.04-py37-cpu-inference']

dummy_inference_config = InferenceConfig(environment=env, source_directory='.', entry_script="score.py")
print(dummy_inference_config)
print(InferenceConfig)
print(image_config)
```

```
Warning, custom base image or base dockerfile detected without a specified `inferencing_stack_version`. Please set environment.
inferencing_stack_version='latest'
```

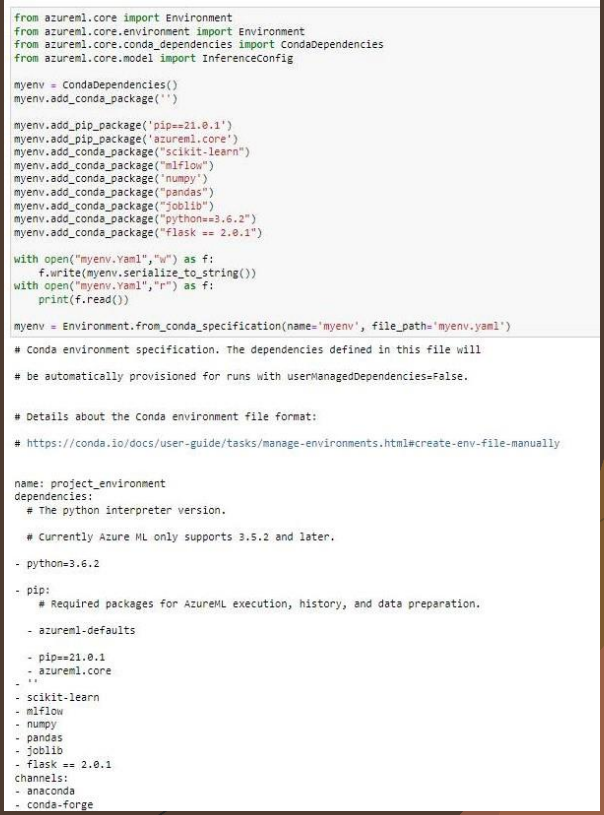
```
InferenceConfig(entry_script=score.py, runtime=None, conda_file=None, extra_docker_file_steps=None, source_directory=C:\Users\H
ENNY\Documents\PYTHON\mlflow_project, enable_gpu=None, base_image=None, base_image_registry=<azureml.core.container_registry.Co
ntainerRegistry object at 0x000001C23506C2B0>)
<class 'azureml.core.model.InferenceConfig'>
<azureml.core.image.container.ContainerImageConfig object at 0x000001C235147490>
```

```
from azureml.core.webservice import AciWebservice, Webservice
# Create a deployment config
aci_config = AciWebservice.deploy_configuration(cpu_cores=1, memory_gb=1, auth_enabled=True)
aci_config
```

```
<azureml.core.webservice.aci.AciServiceDeploymentConfiguration at 0x1c235ad2580>
```

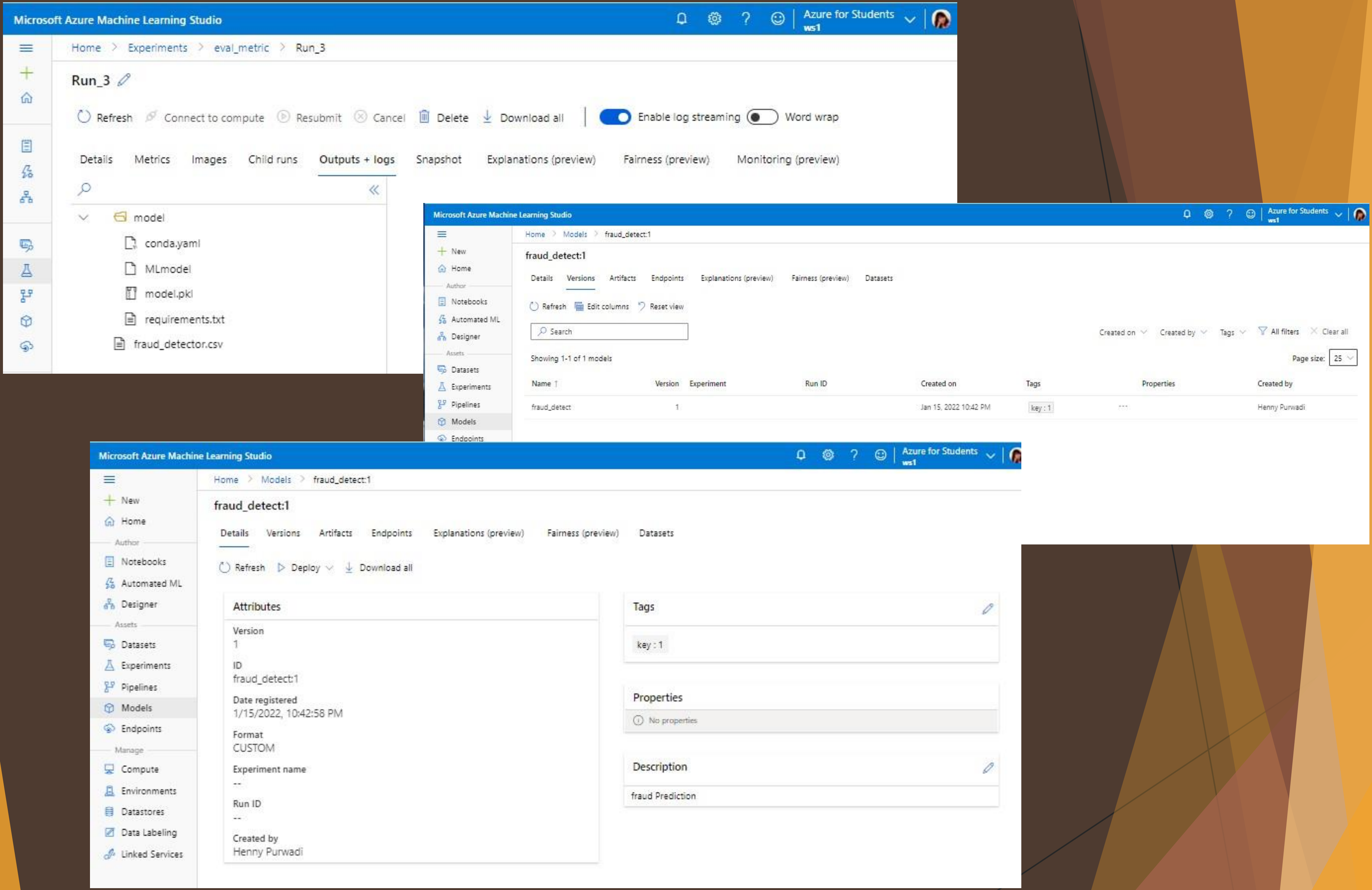
```
src = ScriptRunConfig(source_directory='.', script='score.py', environment=env)
print(src)
```

```
<azureml.core.script_run_config.ScriptRunConfig object at 0x000001C235AD2550>
```



```
from azureml.core import Environment
from azureml.core.environment import Environment
from azureml.core.conda_dependencies import CondaDependencies
from azureml.core.model import InferenceConfig

myenv = CondaDependencies()
myenv.add_conda_package('')

myenv.add_pip_package('pip==21.0.1')
myenv.add_pip_package('azureml.core')
myenv.add_conda_package("scikit-learn")
myenv.add_conda_package("mlflow")
myenv.add_conda_package('numpy')
myenv.add_conda_package("pandas")
myenv.add_conda_package("joblib")
myenv.add_conda_package("python==3.6.2")
myenv.add_conda_package("flask == 2.0.1")

with open("myenv.Yaml","w") as f:
    f.write(myenv.serialize_to_string())
with open("myenv.Yaml","r") as f:
    print(f.read())

myenv = Environment.from_conda_specification(name='myenv', file_path='myenv.yaml')
```

```
# Conda environment specification. The dependencies defined in this file will

# be automatically provisioned for runs with userManagedDependencies=False.


# Details about the Conda environment file format:

# https://conda.io/docs/user-guide/tasks/manage-environments.html#create-env-file-manually


name: project_environment
dependencies:
  # The python interpreter version.

  # Currently Azure ML only supports 3.5.2 and later.

- python=3.6.2

- pip:
    # Required packages for AzureML execution, history, and data preparation.

  - azureml-defaults

  - pip==21.0.1
  - azureml.core
- ''
- scikit-learn
- mlflow
- numpy
- pandas
- joblib
- flask == 2.0.1
channels:
- anaconda
- conda-forge
```



Microsoft Azure Machine Learning Studio

Home > Experiments > eval_metric > Run_3

Run_3

- model
  - conda.yaml
  - MLmodel
  - model.pkl
  - requirements.txt
- fraud_detector.csv

Microsoft Azure Machine Learning Studio

Home > Models > fraud_detect:1

fraud_detect:1

Showing 1-1 of 1 models

Page size: 25

Name ↑	Version	Experiment	Run ID	Created on	Tags	Properties	Created by
fraud_detect	1			Jan 15, 2022 10:42 PM	key : 1	···	Henny Purwadi

Microsoft Azure Machine Learning Studio

Home > Models > fraud_detect:1

fraud_detect:1

Attributes

Version
1

ID
fraud_detect:1

Date registered
1/15/2022, 10:42:58 PM

Format
CUSTOM

Experiment name
--

Run ID
--

Created by
Henny Purwadi

Tags

key : 1

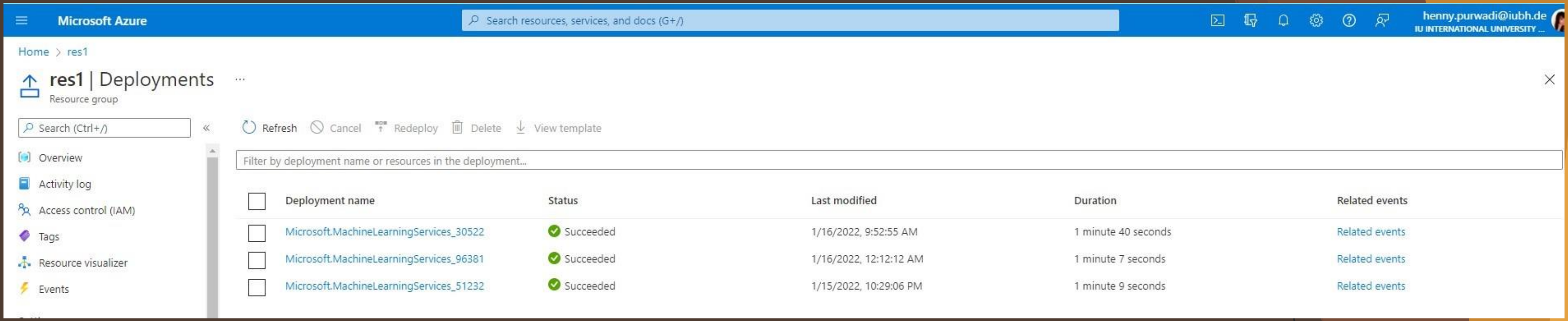
Properties

No properties

Description

fraud Prediction

AzureML Model registered

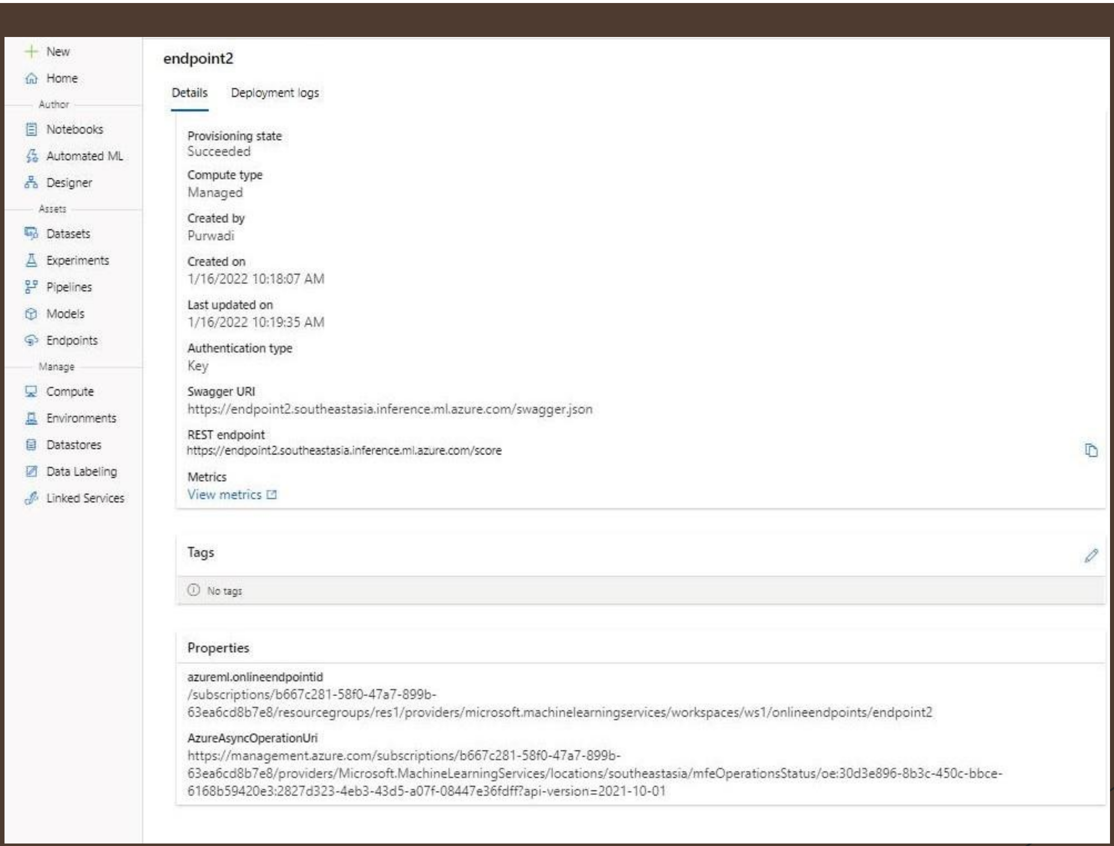


Microsoft Azure
Search resources, services, and docs (G+/)
henny.purwadi@iubh.de
IU INTERNATIONAL UNIVERSITY ...
Home > res1

res1 | Deployments

Resource group

□	Deployment name	Status	Last modified	Duration	Related events
□	Microsoft.MachineLearningServices_30522	✓ Succeeded	1/16/2022, 9:52:55 AM	1 minute 40 seconds	Related events
□	Microsoft.MachineLearningServices_96381	✓ Succeeded	1/16/2022, 12:12:12 AM	1 minute 7 seconds	Related events
□	Microsoft.MachineLearningServices_51232	✓ Succeeded	1/15/2022, 10:29:06 PM	1 minute 9 seconds	Related events



endpoint2

Provisioning state
Succeeded

Compute type
Managed

Created by
Purwadi

Created on
1/16/2022 10:18:07 AM

Last updated on
1/16/2022 10:19:35 AM

Authentication type
Key

Swagger URI
https://endpoint2.southeastasia.inference.ml.azure.com/swagger.json

REST endpoint
https://endpoint2.southeastasia.inference.ml.azure.com/score

Metrics
View metrics

Tags

No tags

Properties

azureml.onlineendpointid
/subscriptions/b667c281-58f0-47a7-899b-63ea6cd8b7e8/resourcegroups/res1/providers/microsoft.machinelearningservices/workspaces/ws1/onlineendpoints/endpoint2

AzureAsyncOperationUri
https://management.azure.com/subscriptions/b667c281-58f0-47a7-899b-63ea6cd8b7e8/providers/Microsoft.MachineLearningServices/locations/southeastasia/mfeOperationsStatus/oe:30d3e896-8b3c-450c-bbce-6168b59420e3:2827d323-4eb3-43d5-a07f-08447e36fdff?api-version=2021-10-01

AzureML Model deployed

Conclusion

Advantage of deploying Machine Learning model into MLFlow, AzureML, and MLOPs is to enables teams to easily maintaining, monitoring, training, tuning the model, in order to help us build, testing, and generate advanced analytics based on the data, and reproduce better versions of models.

List of Figure:

- Krishnan, Adithya. (2019). Anomaly Detection with Isolation Forest & Visualization. https://towardsdatascience.com/anomaly-detection-with-isolation-forest-visualization-23cd75c281e2

- Anello, Eugenia. (2021). **Anomaly Detection With Isolation Forest.**

- https://betterprogramming.pub/anomaly-detection-with-isolation-forest-e41f1f55cc6

Literature:

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  https://www.sciencedirect.com/science/article/abs/pii/S1474034620301105

- Natu Lauchande. (2021).Machine Learning Engineering with Mlflow. Packt Publishing

- Sridhar Alla, Suman Kalyan Adari . (2021). Beginning MLOps with MLFlow Deploy Models in AWS SageMaker, Google Cloud, and Microsoft Azure. Apress.