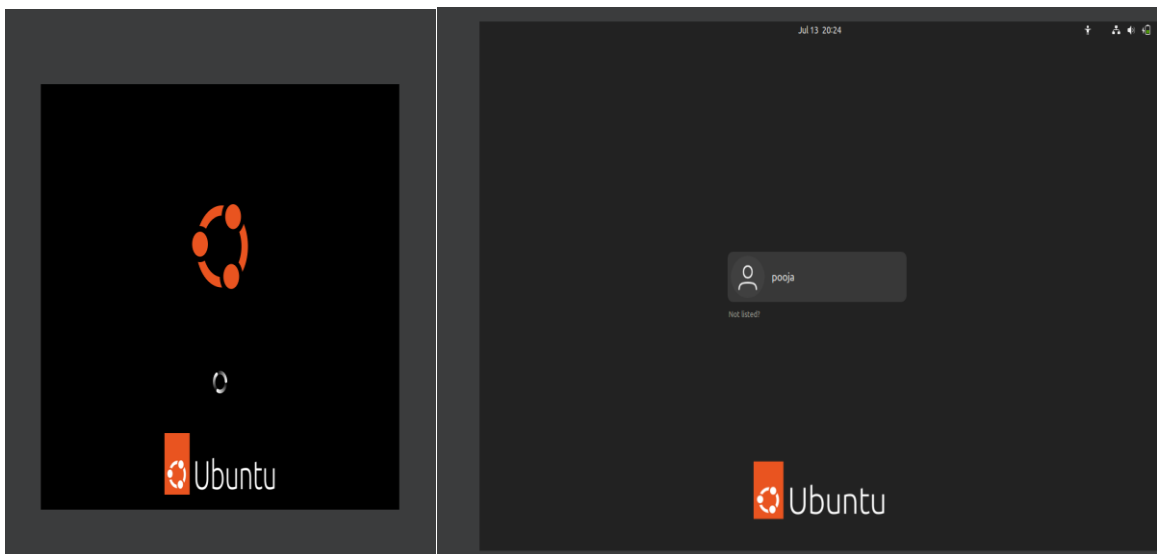


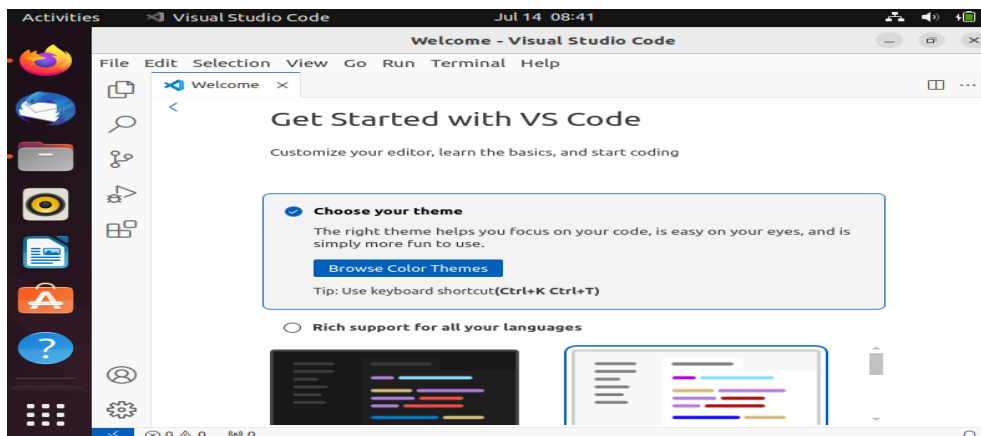
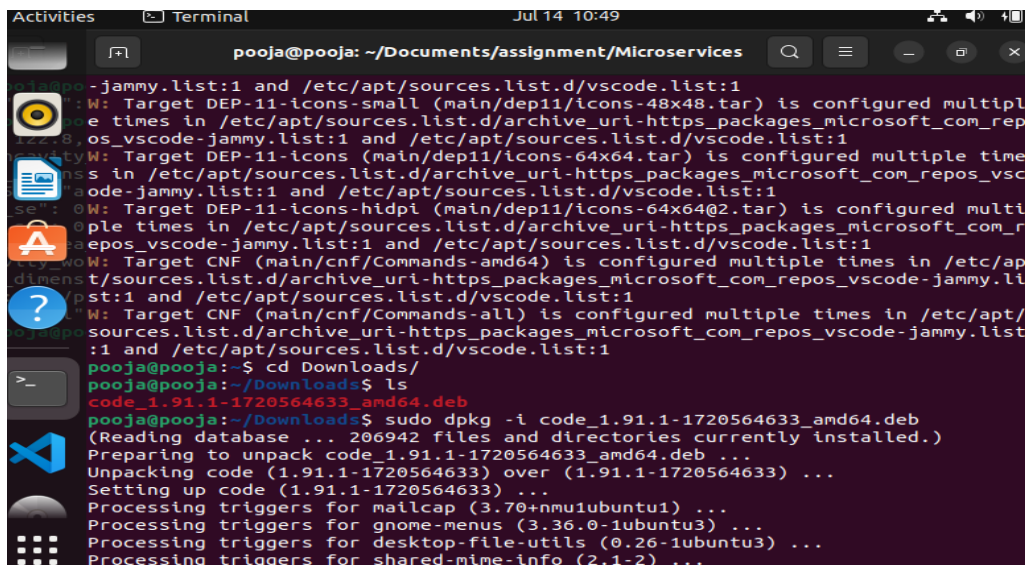
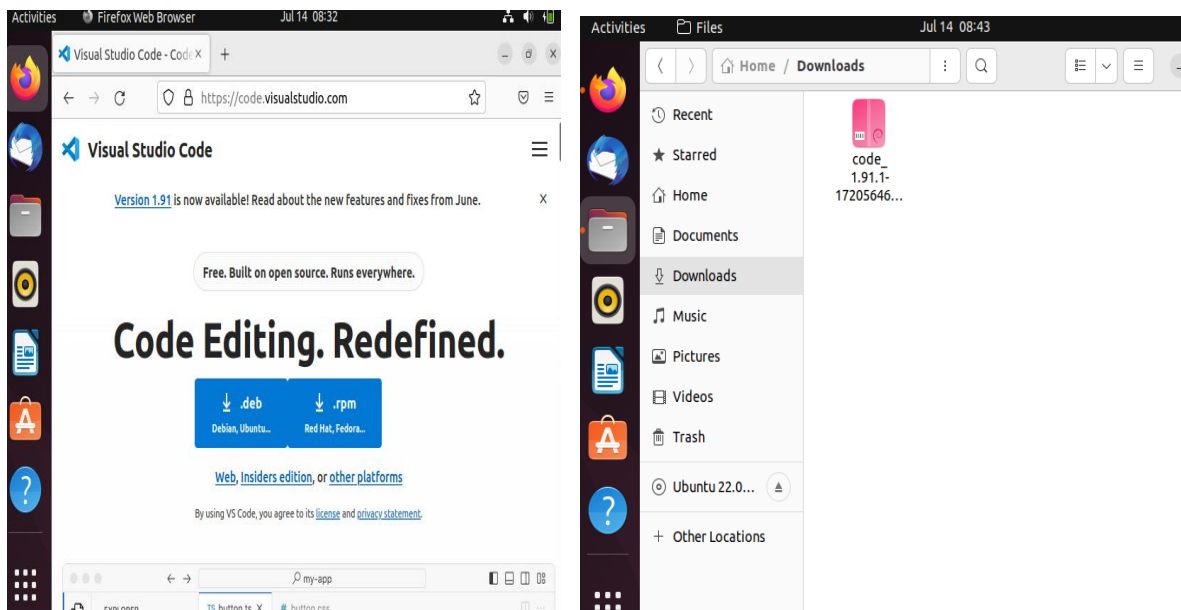
Assignment

Objective: Implementing a microservice using the Python Flask framework on an Ubuntu virtual machine to serve a machine learning prediction model.

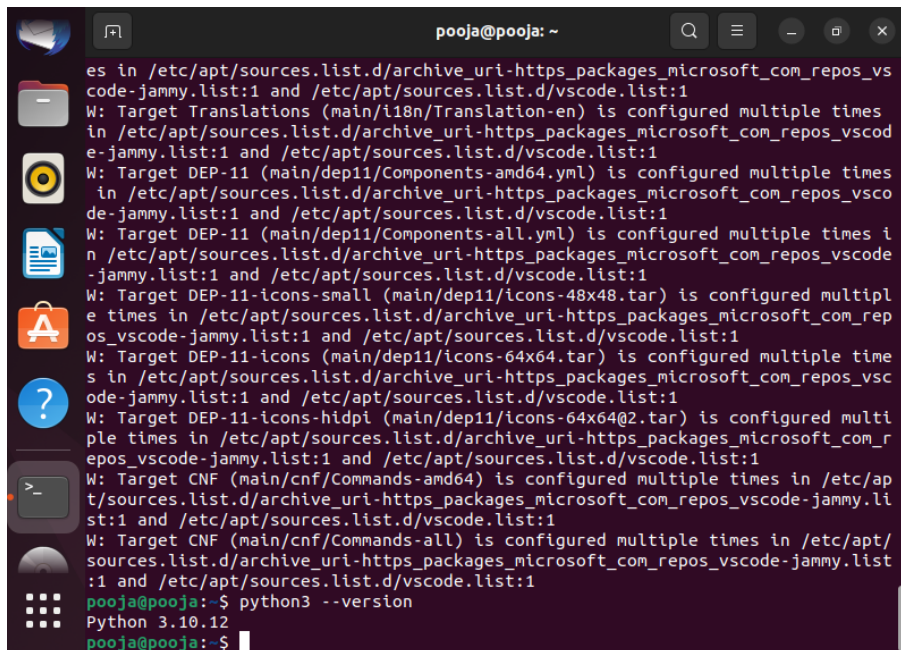
STEP 1: Host an Ubuntu Virtual Machine using Oracle VM Virtual Box.



STEP 2: Set up Visual Studio code on Ubuntu VM.

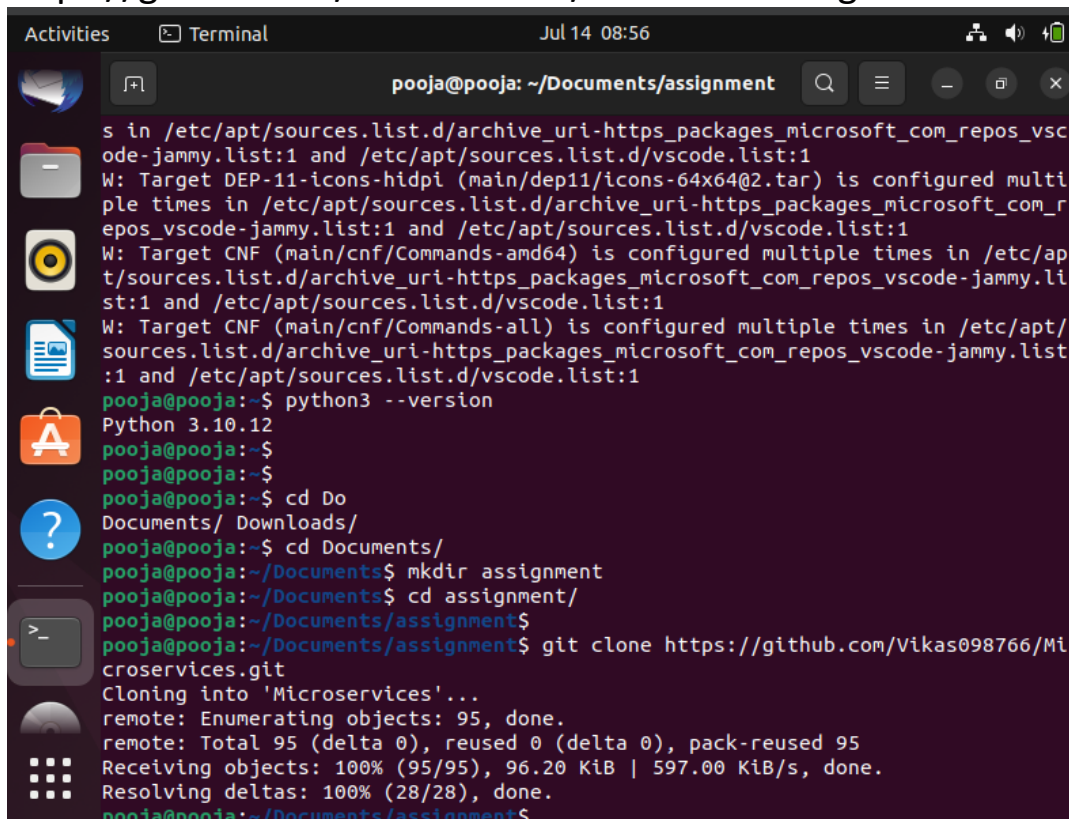


STEP 3: Set up Python.



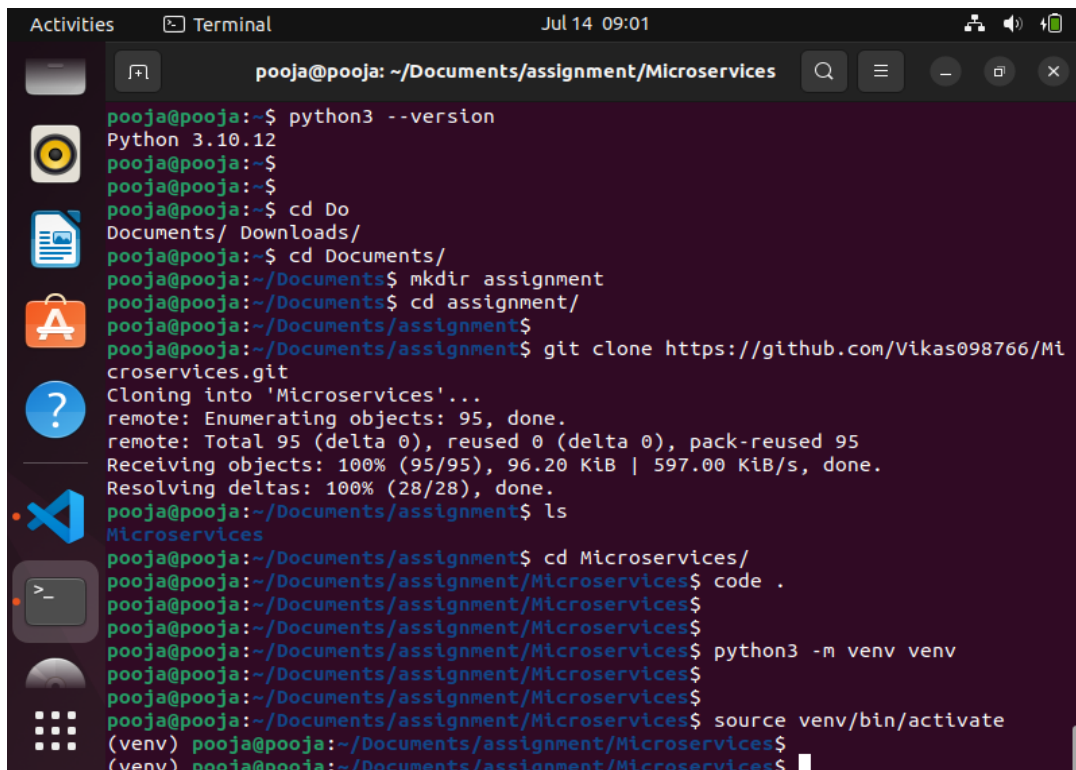
```
pooja@pooja: ~  
es in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vsc  
code-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target Translations (main/i18n/Translation-en) is configured multiple times  
in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscod  
e-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target DEP-11 (main/dep11/Components-amd64.yml) is configured multiple times  
in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscod  
e-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target DEP-11 (main/dep11/Components-all.yml) is configured multiple times i  
n /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscod  
e-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target DEP-11-icons-small (main/dep11/icons-48x48.tar) is configured multipl  
e times in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_rep  
os_vscode-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target DEP-11-icons (main/dep11/icons-64x64.tar) is configured multiple time  
s in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vsc  
ode-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target DEP-11-icons-hidpi (main/dep11/icons-64x64@2.tar) is configured multi  
ple times in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_r  
epos_vscode-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target CNF (main/cnf/Commands-amd64) is configured multiple times in /etc/ap  
t/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscode-jammy.li  
st:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target CNF (main/cnf/Commands-all) is configured multiple times in /etc/ap  
t/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscode-jammy.li  
st:1 and /etc/apt/sources.list.d/vscode.list:1  
pooja@pooja: $ python3 --version  
Python 3.10.12  
pooja@pooja: $
```

STEP 4: Clone this Github repository - <https://github.com/Vikas098766/Microservices.git>



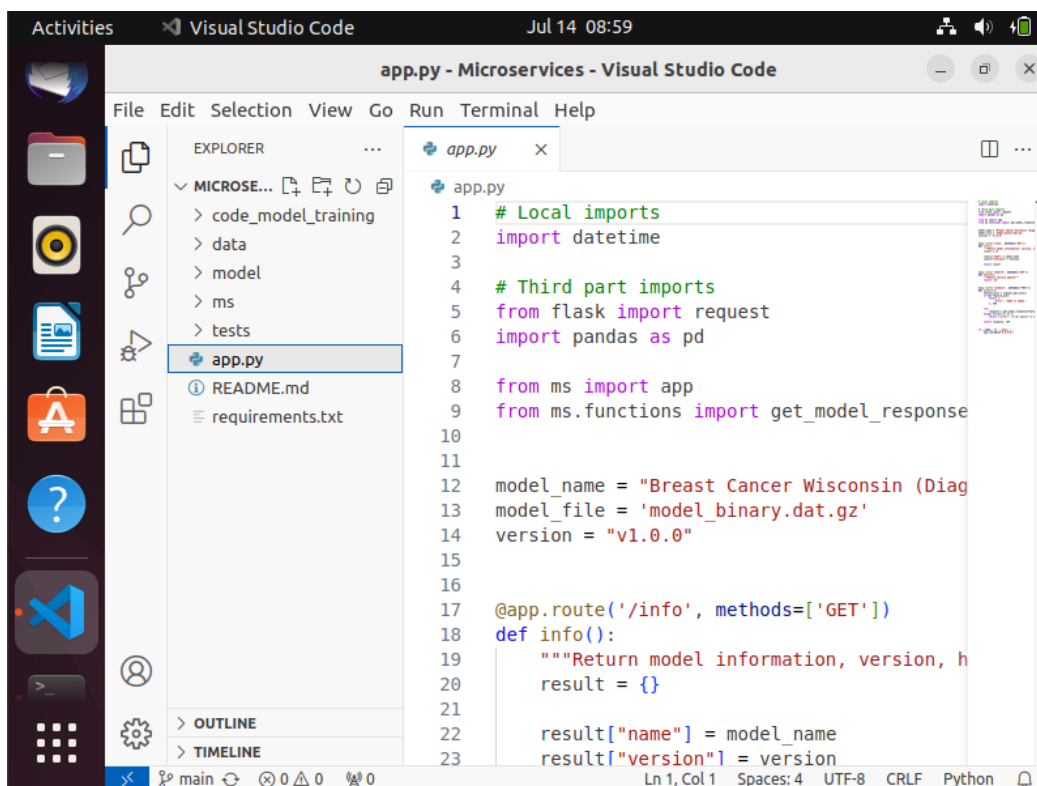
```
Activities Terminal Jul 14 08:56  
pooja@pooja: ~/Documents/assignment  
s in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vsc  
ode-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target DEP-11-icons-hidpi (main/dep11/icons-64x64@2.tar) is configured multi  
ple times in /etc/apt/sources.list.d/archive_uri-https_packages_microsoft_com_r  
epos_vscode-jammy.list:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target CNF (main/cnf/Commands-amd64) is configured multiple times in /etc/ap  
t/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscode-jammy.li  
st:1 and /etc/apt/sources.list.d/vscode.list:1  
W: Target CNF (main/cnf/Commands-all) is configured multiple times in /etc/ap  
t/sources.list.d/archive_uri-https_packages_microsoft_com_repos_vscode-jammy.li  
st:1 and /etc/apt/sources.list.d/vscode.list:1  
pooja@pooja:~$ python3 --version  
Python 3.10.12  
pooja@pooja:~$  
pooja@pooja:~$  
pooja@pooja:~$ cd Do  
Documents/ Downloads/  
pooja@pooja:~$ cd Documents/  
pooja@pooja:~/Documents$ mkdir assignment  
pooja@pooja:~/Documents$ cd assignment/  
pooja@pooja:~/Documents/assignment$  
pooja@pooja:~/Documents/assignment$ git clone https://github.com/Vikas098766/Mi  
croservices.git  
Cloning into 'Microservices'...  
remote: Enumerating objects: 95, done.  
remote: Total 95 (delta 0), reused 0 (delta 0), pack-reused 95  
Receiving objects: 100% (95/95), 96.20 KiB | 597.00 KiB/s, done.  
Resolving deltas: 100% (28/28), done.  
pooja@pooja:~/Documents/assignment$
```

STEP 5: Create a Virtual Environment.



A terminal window titled 'pooja@pooja: ~/Documents/assignment/Microservices' showing the following commands and output:

```
pooja@pooja:~$ python3 --version
Python 3.10.12
pooja@pooja:~$ 
pooja@pooja:~$ 
pooja@pooja:~$ cd Do
Documents/ Downloads/
pooja@pooja:~$ cd Documents/
pooja@pooja:~/Documents$ mkdir assignment
pooja@pooja:~/Documents$ cd assignment/
pooja@pooja:~/Documents/assignment$ 
pooja@pooja:~/Documents/assignment$ git clone https://github.com/Vikas098766/Microservices.git
Cloning into 'Microservices'...
remote: Enumerating objects: 95, done.
remote: Total 95 (delta 0), reused 0 (delta 0), pack-reused 95
Receiving objects: 100% (95/95), 96.20 KiB | 597.00 KiB/s, done.
Resolving deltas: 100% (28/28), done.
pooja@pooja:~/Documents/assignment$ ls
Microservices
pooja@pooja:~/Documents/assignment$ cd Microservices/
pooja@pooja:~/Documents/assignment/Microservices$ code .
pooja@pooja:~/Documents/assignment/Microservices$ 
pooja@pooja:~/Documents/assignment/Microservices$ python3 -m venv venv
pooja@pooja:~/Documents/assignment/Microservices$ 
pooja@pooja:~/Documents/assignment/Microservices$ source venv/bin/activate
(venv) pooja@pooja:~/Documents/assignment/Microservices$ 
(venv) pooja@pooja:~/Documents/assignment/Microservices$
```



A Visual Studio Code window titled 'app.py - Microservices - Visual Studio Code' showing the following code in 'app.py':

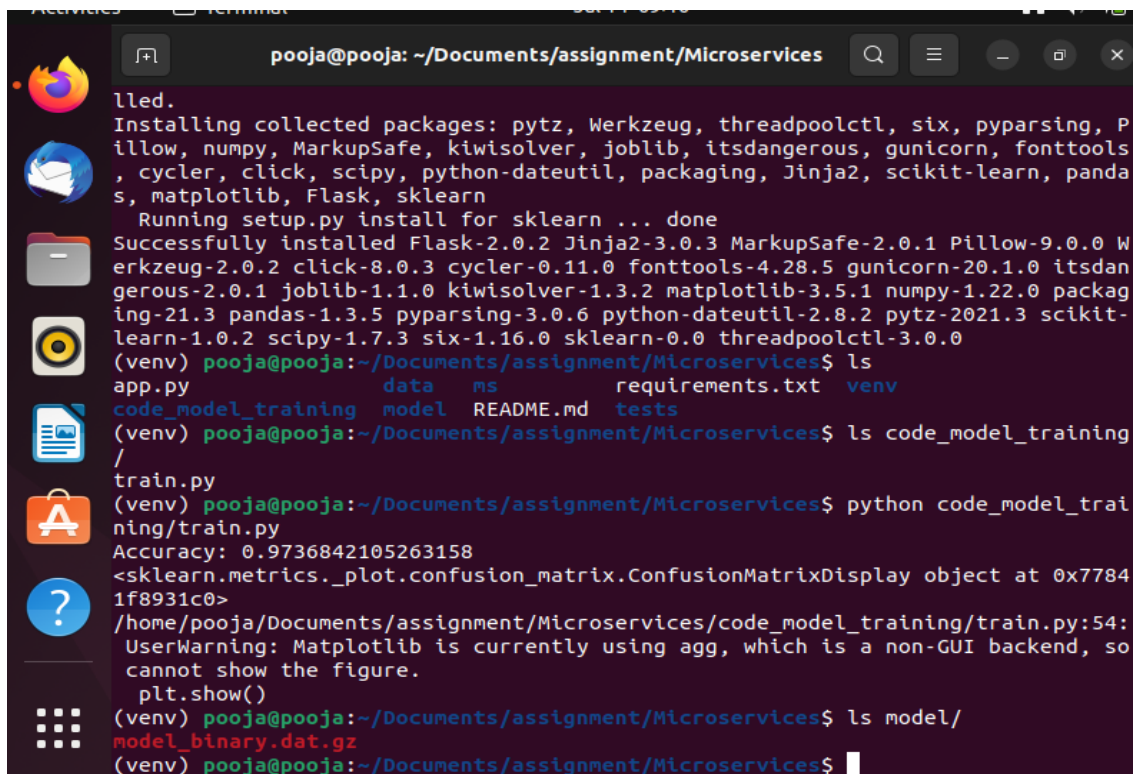
```
1 # Local imports
2 import datetime
3
4 # Third part imports
5 from flask import request
6 import pandas as pd
7
8 from ms import app
9 from ms.functions import get_model_response
10
11
12 model_name = "Breast Cancer Wisconsin (Diagnostic)"
13 model_file = 'model_binary.dat.gz'
14 version = "v1.0.0"
15
16
17 @app.route('/info', methods=['GET'])
18 def info():
19     """Return model information, version, history"""
20     result = {}
21
22     result["name"] = model_name
23     result["version"] = version
```

STEP 6: Install the dependencies from requirements.txt file.

```
pooja@pooja: ~/Documents/assignment/Microservices
Resolving deltas: 100% (28/28), done.
pooja@pooja:~/Documents/assignment$ ls
Microservices
pooja@pooja:~/Documents/assignment$ cd Microservices/
pooja@pooja:~/Documents/assignment/Microservices$ code .
pooja@pooja:~/Documents/assignment/Microservices$
pooja@pooja:~/Documents/assignment/Microservices$ python3 -m venv venv
pooja@pooja:~/Documents/assignment/Microservices$
pooja@pooja:~/Documents/assignment/Microservices$ source venv/bin/activate
(venv) pooja@pooja:~/Documents/assignment/Microservices$
(venv) pooja@pooja:~/Documents/assignment/Microservices$ pip install -r require
ments.txt
Collecting click==8.0.3
  Using cached click-8.0.3-py3-none-any.whl (97 kB)
Collecting cycycler==0.11.0
  Using cached cycycler-0.11.0-py3-none-any.whl (6.4 kB)
Collecting Flask==2.0.2
  Using cached Flask-2.0.2-py3-none-any.whl (95 kB)
Collecting fonttools==4.28.5
  Using cached fonttools-4.28.5-py3-none-any.whl (890 kB)
Collecting gunicorn==20.1.0
  Using cached gunicorn-20.1.0-py3-none-any.whl (79 kB)
Collecting itsdangerous==2.0.1
  Using cached itsdangerous-2.0.1-py3-none-any.whl (18 kB)
Collecting Jinja2==3.0.3
  Using cached Jinja2-3.0.3-py3-none-any.whl (133 kB)
Collecting joblib==1.1.0
```

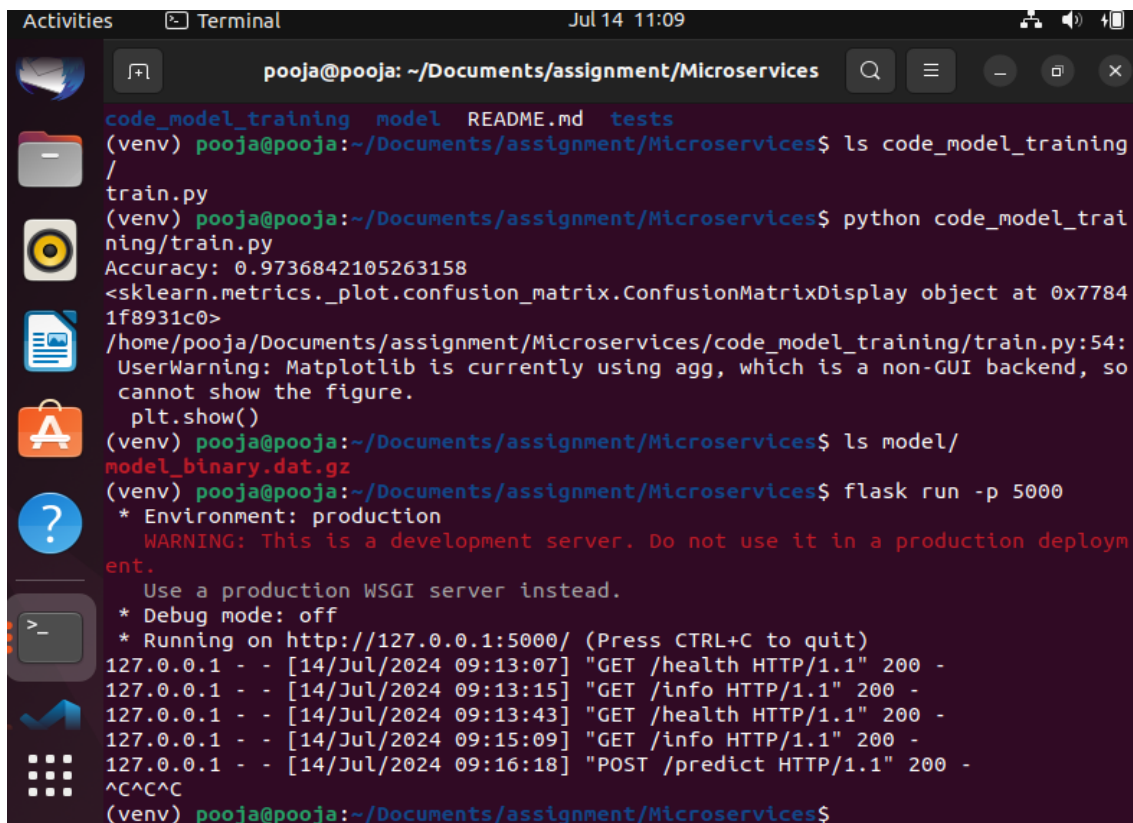
```
Activities Terminal Jul 14 09:05
pooja@pooja: ~/Documents/assignment/Microservices
  Using cached scikit_learn-1.0.2-cp310-cp310-manylinux_2_17_x86_64.manylinux20
14_x86_64.whl (26.5 MB)
Collecting scipy==1.7.3
  Using cached scipy-1.7.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_
64.whl (39.9 MB)
Collecting six==1.16.0
  Using cached six-1.16.0-py2.py3-none-any.whl (11 kB)
Collecting sklearn==0.0
  Using cached sklearn-0.0.tar.gz (1.1 kB)
  Preparing metadata (setup.py) ... done
Collecting threadpoolctl==3.0.0
  Using cached threadpoolctl-3.0.0-py3-none-any.whl (14 kB)
Collecting Werkzeug==2.0.2
  Using cached Werkzeug-2.0.2-py3-none-any.whl (288 kB)
Requirement already satisfied: setuptools>=3.0 in ./venv/lib/python3.10/site-pa
ckages (from gunicorn==20.1.0->-r requirements.txt (line 5)) (59.6.0)
Using legacy 'setup.py install' for sklearn, since package 'wheel' is not insta
lled.
Installing collected packages: pytz, Werkzeug, threadpoolctl, six, pyparsing, P
illow, numpy, MarkupSafe, kiwisolver, joblib, itsdangerous, gunicorn, fonttools
, cycycler, click, scipy, python-dateutil, packaging, Jinja2, scikit-learn, panda
s, matplotlib, Flask, sklearn
Running setup.py install for sklearn ... done
Successfully installed Flask-2.0.2 Jinja2-3.0.3 MarkupSafe-2.0.1 Pillow-9.0.0 W
erkzeug-2.0.2 click-8.0.3 cycycler-0.11.0 fonttools-4.28.5 gunicorn-20.1.0 itsdan
gerous-2.0.1 joblib-1.1.0 kiwisolver-1.3.2 matplotlib-3.5.1 numpy-1.22.0 packag
ing-21.3 pandas-1.3.5 pyparsing-3.0.6 python-dateutil-2.8.2 pytz-2021.3 scikit-
learn-1.0.2 scipy-1.7.3 six-1.16.0 sklearn-0.0 threadpoolctl-3.0.0
(venv) pooja@pooja:~/Documents/assignment/Microservices$
```


STEP 7: Train and save the model



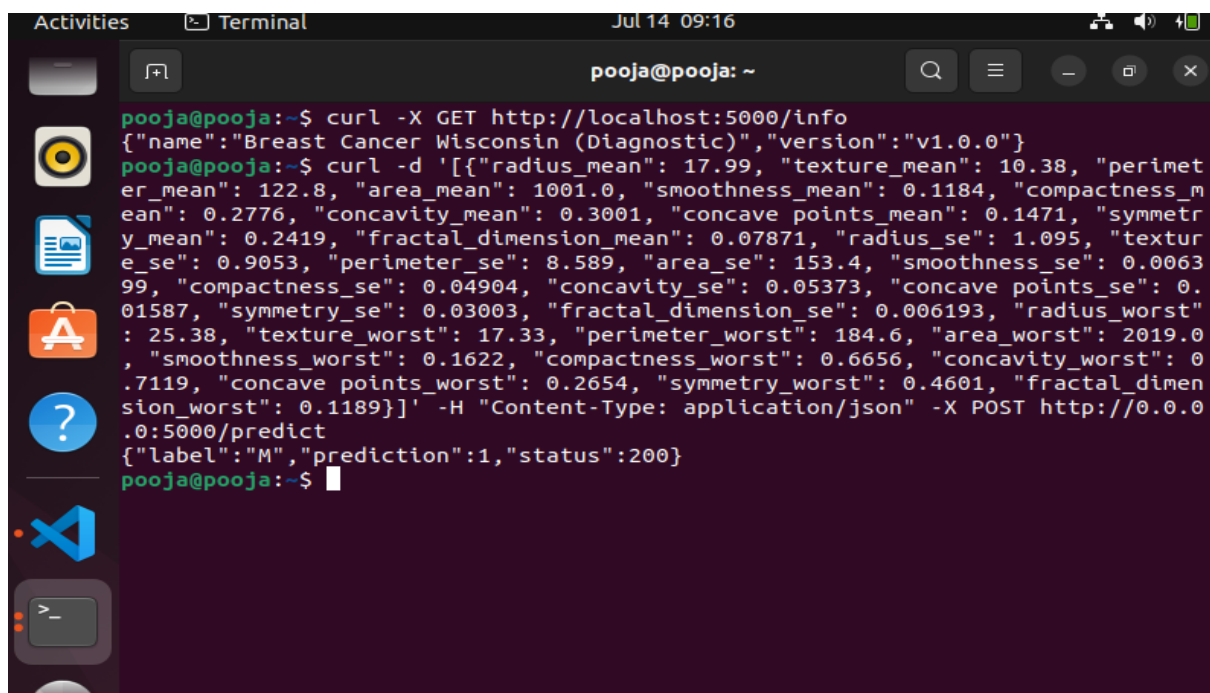
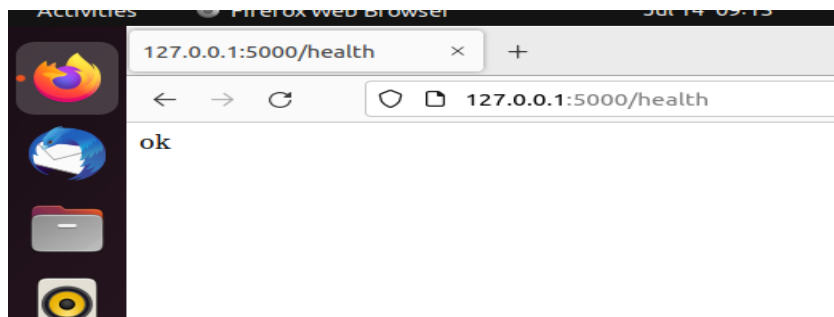
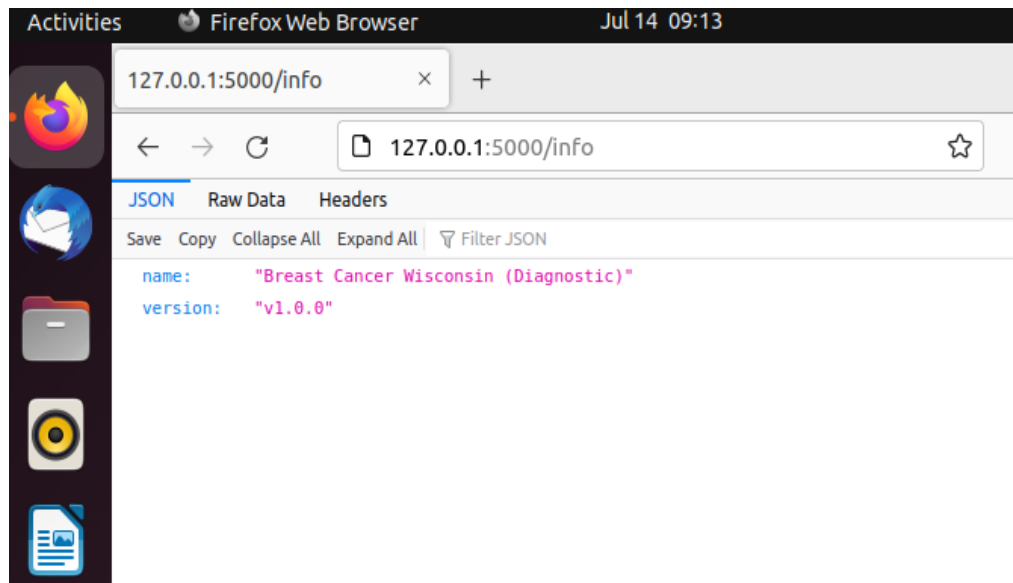
```
pooja@pooja: ~/Documents/assignment/Microservices
Installing collected packages: pytz, Werkzeug, threadpoolctl, six, pyparsing, Pillow, numpy, MarkupSafe, kiwisolver, joblib, itsdangerous, gunicorn, fonttools, click, scipy, python-dateutil, packaging, Jinja2, scikit-learn, pandas, matplotlib, Flask, sklearn
Running setup.py install for sklearn ... done
Successfully installed Flask-2.0.2 Jinja2-3.0.3 MarkupSafe-2.0.1 Pillow-9.0.0 Werkzeug-2.0.2 click-8.0.3 cyclical-0.11.0 fonttools-4.28.5 gunicorn-20.1.0 itsdangerous-2.0.1 joblib-1.1.0 kiwisolver-1.3.2 matplotlib-3.5.1 numpy-1.22.0 packaging-21.3 pandas-1.3.5 pyparsing-3.0.6 python-dateutil-2.8.2 pytz-2021.3 scikit-learn-1.0.2 scipy-1.7.3 six-1.16.0 sklearn-0.0 threadpoolctl-3.0.0
(venv) pooja@pooja:~/Documents/assignment/Microservices$ ls
app.py  data  ms  requirements.txt  venv
code_model_training  model  README.md  tests
(venv) pooja@pooja:~/Documents/assignment/Microservices$ ls code_model_training/
train.py
(venv) pooja@pooja:~/Documents/assignment/Microservices$ python code_model_training/train.py
Accuracy: 0.9736842105263158
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay object at 0x77841f8931c0>
/home/pooja/Documents/assignment/Microservices/code_model_training/train.py:54:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so cannot show the figure.
plt.show()
(venv) pooja@pooja:~/Documents/assignment/Microservices$ ls model/
model_binary.dat.gz
(venv) pooja@pooja:~/Documents/assignment/Microservices$
```

STEP 8: Test the Flask web application.

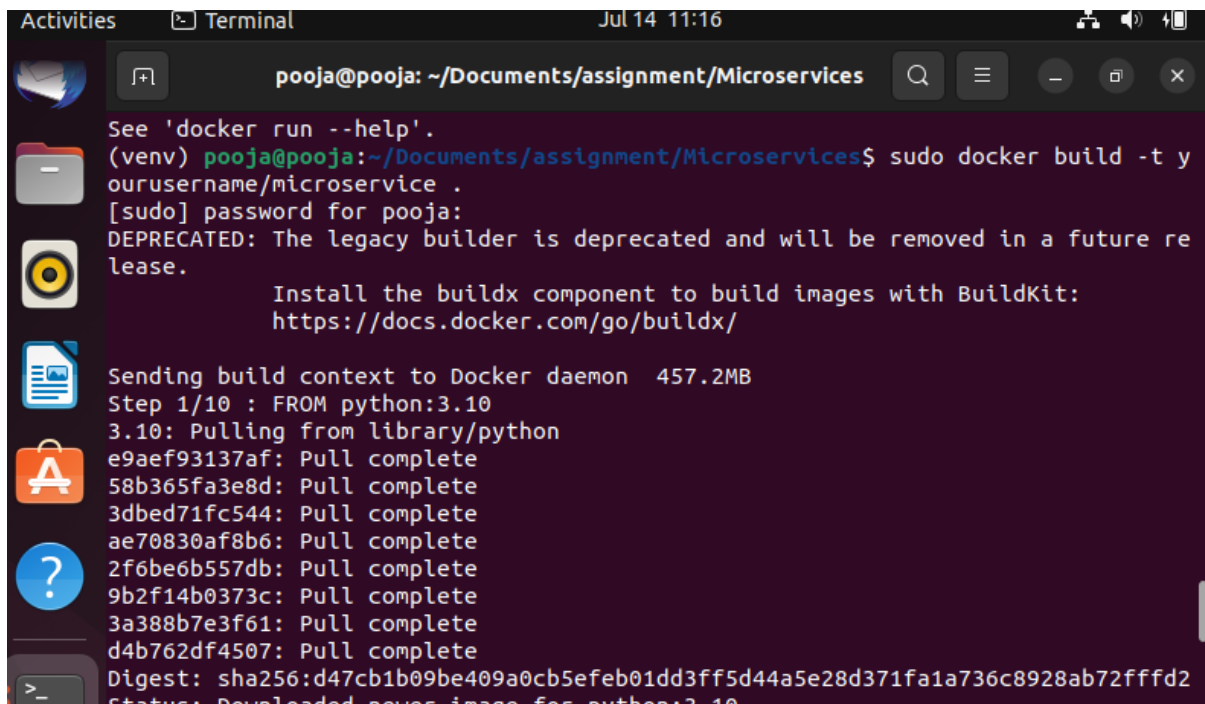


```
pooja@pooja: ~/Documents/assignment/Microservices
code_model_training  model  README.md  tests
(venv) pooja@pooja:~/Documents/assignment/Microservices$ ls code_model_training/
train.py
(venv) pooja@pooja:~/Documents/assignment/Microservices$ python code_model_training/train.py
Accuracy: 0.9736842105263158
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay object at 0x77841f8931c0>
/home/pooja/Documents/assignment/Microservices/code_model_training/train.py:54:
UserWarning: Matplotlib is currently using agg, which is a non-GUI backend, so cannot show the figure.
plt.show()
(venv) pooja@pooja:~/Documents/assignment/Microservices$ ls model/
model_binary.dat.gz
(venv) pooja@pooja:~/Documents/assignment/Microservices$ flask run -p 5000
* Environment: production
WARNING: This is a development server. Do not use it in a production deployment.
Use a production WSGI server instead.
* Debug mode: off
* Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
127.0.0.1 - - [14/Jul/2024 09:13:07] "GET /health HTTP/1.1" 200 -
127.0.0.1 - - [14/Jul/2024 09:13:15] "GET /info HTTP/1.1" 200 -
127.0.0.1 - - [14/Jul/2024 09:13:43] "GET /health HTTP/1.1" 200 -
127.0.0.1 - - [14/Jul/2024 09:15:09] "GET /info HTTP/1.1" 200 -
127.0.0.1 - - [14/Jul/2024 09:16:18] "POST /predict HTTP/1.1" 200 -
^C^C^C
(venv) pooja@pooja:~/Documents/assignment/Microservices$
```

STEP 9: Test the application and make predictions using the example calls available in the folder /tests.



STEP 10: Create a docker image containing everything needed to run the application.

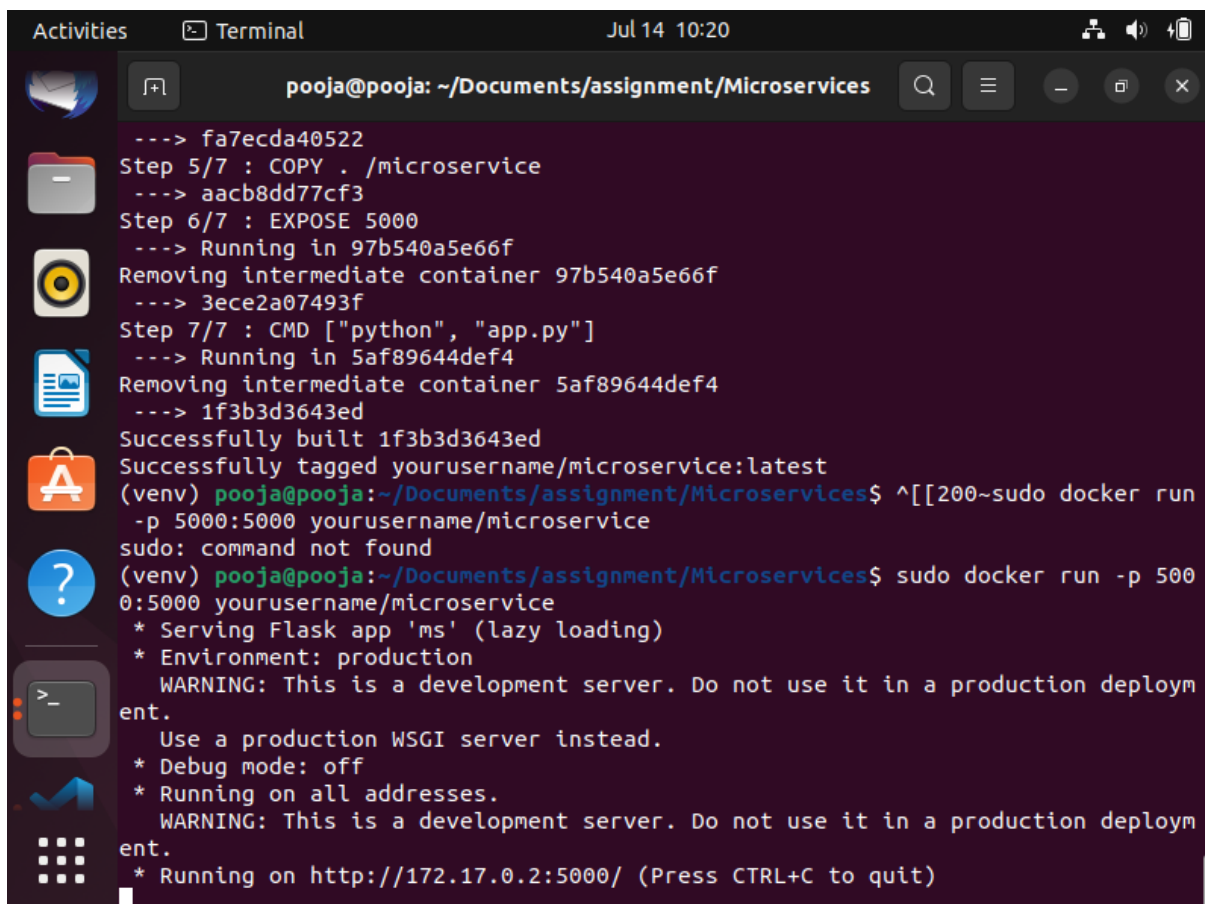


A terminal window titled 'pooja@pooja: ~/Documents/assignment/Microservices' showing the execution of the 'docker build' command. The terminal output includes a warning about the deprecated legacy builder, a message to install the buildx component, and the progress of building the Docker image 'yourusername/microservice' from the 'python:3.10' base image. The build context is sent to the Docker daemon (457.2MB), and the image is pulled from the library/python repository. The final digest is sha256:d47cb1b09be409a0cb5efeb01dd3ff5d44a5e28d371fa1a736c8928ab72fffd2.

```
See 'docker run --help'.
(venv) pooja@pooja:~/Documents/assignment/Microservices$ sudo docker build -t yourusername/microservice .
[sudo] password for pooja:
DEPRECATED: The legacy builder is deprecated and will be removed in a future release.

                Install the buildx component to build images with BuildKit:
                https://docs.docker.com/go/buildx/

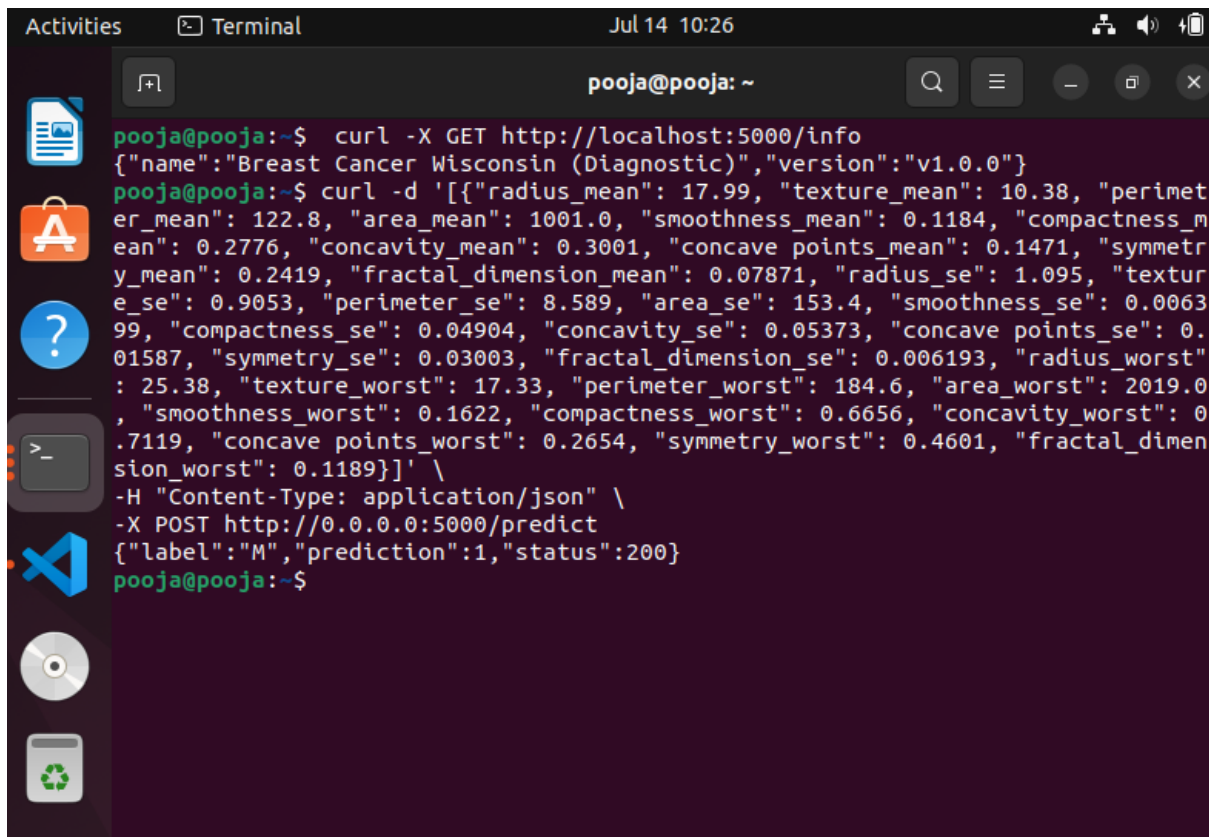
Sending build context to Docker daemon  457.2MB
Step 1/10 : FROM python:3.10
3.10: Pulling from library/python
e9aef93137af: Pull complete
58b365fa3e8d: Pull complete
3dbed71fc544: Pull complete
ae70830af8b6: Pull complete
2f6be6b557db: Pull complete
9b2f14b0373c: Pull complete
3a388b7e3f61: Pull complete
d4b762df4507: Pull complete
Digest: sha256:d47cb1b09be409a0cb5efeb01dd3ff5d44a5e28d371fa1a736c8928ab72fffd2
Status: Downloaded newer image for python:3.10
```



A terminal window titled 'pooja@pooja: ~/Documents/assignment/Microservices' showing the execution of the 'docker run' command. The terminal output includes the steps of running the container, removing intermediate containers, and the final state of the container. The container is successfully built and tagged 'yourusername/microservice:latest'. The command 'sudo docker run -p 5000:5000 yourusername/microservice' is executed, and the output shows the Flask app 'ms' (lazy loading) running on http://172.17.0.2:5000/.

```
---> fa7ecda40522
Step 5/7 : COPY . /microservice
---> aacb8dd77cf3
Step 6/7 : EXPOSE 5000
---> Running in 97b540a5e66f
Removing intermediate container 97b540a5e66f
---> 3ecec2a07493f
Step 7/7 : CMD ["python", "app.py"]
---> Running in 5af89644def4
Removing intermediate container 5af89644def4
---> 1f3b3d3643ed
Successfully built 1f3b3d3643ed
Successfully tagged yourusername/microservice:latest
(venv) pooja@pooja:~/Documents/assignment/Microservices$ sudo docker run -p 5000:5000 yourusername/microservice
* Serving Flask app 'ms' (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: off
* 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)
```


STEP 11: Run the containerized application as a prediction service and test it locally by passing some example calls and get the prediction.



```
Activities Terminal Jul 14 10:26
pooja@pooja: ~
pooja@pooja:~$ curl -X GET http://localhost:5000/info
{"name":"Breast Cancer Wisconsin (Diagnostic)","version":"v1.0.0"}
pooja@pooja:~$ curl -d '[{"radius_mean": 17.99, "texture_mean": 10.38, "perimeter_mean": 122.8, "area_mean": 1001.0, "smoothness_mean": 0.1184, "compactness_mean": 0.2776, "concavity_mean": 0.3001, "concave points_mean": 0.1471, "symmetry_mean": 0.2419, "fractal_dimension_mean": 0.07871, "radius_se": 1.095, "texture_se": 0.9053, "perimeter_se": 8.589, "area_se": 153.4, "smoothness_se": 0.006399, "compactness_se": 0.04904, "concavity_se": 0.05373, "concave points_se": 0.01587, "symmetry_se": 0.03003, "fractal_dimension_se": 0.006193, "radius_worst": 25.38, "texture_worst": 17.33, "perimeter_worst": 184.6, "area_worst": 2019.0, "smoothness_worst": 0.1622, "compactness_worst": 0.6656, "concavity_worst": 0.7119, "concave points_worst": 0.2654, "symmetry_worst": 0.4601, "fractal_dimension_worst": 0.1189}]" \
-H "Content-Type: application/json" \
-X POST http://0.0.0.0:5000/predict
{"label":"M","prediction":1,"status":200}
pooja@pooja:~$
```