

CI/CD AND ENVIRONMENT CONFIGURATION

A PROJECT REPORT

**SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
AWARD OF THE DEGREE
OF**

**MASTER OF TECHNOLOGY
IN
INFORMATION TECHNOLOGY**

Submitted by:

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CERTIFICATE

We hereby certify that the Project titled “CI/CD and Environment Configuration” which is submitted by Ishan Mangal (24/ISY/05), Muheet Alam (24/ISY/09), Paras Chandra (24/ISY/13), Keshu Shukla (24/ISY/15), Ujjawal Tomar (24/ISY/25), Department of Information Technology, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge, this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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OBJECTIVE

The primary goal of this project is to automate the setup and deployment of a Machine Learning (ML) environment using **Docker** and **Ansible**, ensuring reproducibility, ease of collaboration, and consistency across systems. Specifically, this project implements a pipeline that:

- Uses **Ansible** to automate environment setup both **locally** and **remotely**.
- Uses **Docker** to containerize the ML training workflow.
- Publishes a **working Docker image** to **DockerHub**: `alamsaim/fakenews-model:latest`.

Deliverables:

- `playbook-local.yml` and `playbook-remote.yml` for local and portable environment setup respectively.
- `Dockerfile` and associated Docker image containing all ML training logic and dependencies.
- Trained model artifacts (`model.pkl` and `vectorizer.pkl`) saved to `/opt/ml/output` after container execution.

INTRODUCTION

In the modern era of software and machine learning (ML) development, the need for automation, consistency, and reliability in deployment has become critical. This project focuses on simplifying and automating the deployment of a machine learning pipeline using DevOps tools like **Docker**, **Ansible**, and **DockerHub**. It encapsulates environment provisioning and application containerization to ensure that the ML workflow can be deployed and executed consistently, regardless of the host system. The core of this implementation lies in creating a seamless **Continuous Integration and Continuous Deployment (CI/CD)** workflow and automating the environment setup for scalable, reproducible deployment.

Abstract of Implementation:

The ML training script (`train.py`) was designed to detect fake news using TF-IDF vectorization and a `PassiveAggressiveClassifier`. This script, along with its dependencies (`pandas`, `scikit-learn`, `nltk`), is run inside a Docker container that is automatically built and executed using Ansible playbooks.

Importance of Automation:

Automation plays a critical role in the success of ML workflows:

- It removes manual errors during environment setup.
- It ensures every team member can replicate the training environment effortlessly.
- It aligns with real-world MLOps practices.

Tools Used in This Project:

- **Docker**: To containerize the ML pipeline.
- **Ansible**: To automate system provisioning.
- **DockerHub**: To store and share the working Docker image.

TECHNOLOGY STACK

1. Python 3.9

- Python is a high-level, interpreted programming language widely used in scripting, data science, machine learning, and automation.
- Used to write the `train.py` script that loads `train.csv` and `test.csv`, vectorizes the text data, trains a fake news classifier, and saves output models.

2. Docker

- Docker is a platform that allows applications to be packaged and run in containers — lightweight, standalone, and executable environments that include everything needed to run the software. Containers ensure that applications run the same regardless of where they are deployed.
- The `Dockerfile` in `/app` builds an image with Python and ML libraries, copies source code, installs dependencies, and runs training on container start. Final image: `alamsaim/fakenews-model:latest`.

3. Ansible

- Ansible is an open-source IT automation tool that automates configuration management, application deployment, and task execution across servers. Using YAML-based playbooks, Ansible can install software, configure systems, and manage infrastructure, making deployments repeatable and error-free.
- Two playbooks were created:
 - i. `playbook-local.yml`: Sets up environment locally.
 - ii. `playbook-remote.yml`: Sets up environment remotely or in cloud VMs.

4. DockerHub

- DockerHub is a cloud-based repository where Docker images can be stored, shared, and pulled for use. It acts like GitHub for Docker containers, allowing developers to automate the build and deployment process directly through CI/CD pipelines.
- The trained and tested image was pushed to DockerHub for public reuse. The image runs the model training and saves artifacts to `/opt/ml/output`.

SYSTEM REQUIREMENTS

1. OS Compatibility

- Ubuntu 20.04+ / WSL2 (for Windows)
- macOS

2. Required Software

Tool	Version	Purpose
Python	3.8+	Core scripting language
pip	21+	Package manager
Docker	20.10+	Containerisation
Ansible	2.9+	Automation & environment provisioning
DockerHub	-	Required to push and pull Docker images remotely.

3. Python Packages

Specified in `requirements.txt`:

- pandas
- scikit-learn
- numpy
- nltk

These are auto-installed during Docker image build or via Ansible.

FOLDER STRUCTURE OVERVIEW

```
project-2-mlops/  
├─ app/  
│   ├── train.py  
│   ├── Dockerfile  
│   ├── requirements.txt  
│   ├── train.csv (local only)  
│   └── test.csv (local only)  
└─ ansible/  
    ├── playbook-local.yml  
    └── playbook-remote.yml
```

Description of each file:

- `train.py`: Trains ML model, outputs `model.pkl` and `vectorizer.pkl`.
- `Dockerfile`: Builds an image to execute training automatically.
- `playbook-local.yml`: Sets up local system with Docker and required packages.
- `playbook-remote.yml`: Does the same on a remote host or VM.

KEY FUNCTIONALITIES

End-to-End Workflow:

1. Ansible playbook installs Python, pip, and Docker.
2. Ansible copies the `app/` folder to `/opt/ml`.
3. Docker image is built using `Dockerfile`.
4. Docker container is executed, running `train.py`.
5. Trained model artifacts are saved to `/opt/ml/output/`.

Sample Output:

- Accuracy: 93.97%
- Confusion Matrix:
[[583 42]
[34 601]]
- Model saved to `/opt/ml/output/model.pkl`
- Vectorizer saved to `/opt/ml/output/vectorizer.pkl`

DOCKERHUB INTEGRATION

➤ Docker Image Name:

```
docker pull alamsaim/fakenews-model:latest
```

➤ Push Steps:

```
docker tag fakenews-model alamsaim/fakenews-model:latest  
docker push alamsaim/fakenews-model:latest
```

➤ Usage:

```
docker run --rm -v $(pwd)/output:/opt/ml/output  
alamsaim/fakenews-model:latest
```

➤ Output:

Files saved to ./output directory on host machine.

EXECUTION INSTRUCTIONS

➤ **Local Execution:**

```
ansible-playbook ansible/playbook-local.yml
```

Performs setup, builds image, and runs container locally.

➤ **Remote Execution:**

```
ansible-playbook ansible/playbook-remote.yml
```

Runs same setup on a remote system with Ansible installed.

➤ **Docker Only:**

```
cd app
```

```
docker build -t fakenews-model .
```

```
docker run --rm -v $(pwd)/output:/opt/ml/output fakenews-model
```

SCREENSHOTS

1. Docker Build:

```
(base) muheetalam@Muheet-PC:~/DOML/project-2-mlops/app$ docker build -t fakenews-model .
failed to fetch metadata: fork/exec /usr/local/lib/docker/cli-plugins/docker-buildx: no such file or directory

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 21.64MB
Step 1/5 : FROM python:3.9-slim
--> 501f96d59d70
Step 2/5 : WORKDIR /app
--> Using cache
--> 0adb409e929f
Step 3/5 : COPY . /app
--> 2057aee9eaa8
Step 4/5 : RUN pip install --no-cache-dir -r requirements.txt
--> Running in 6661ac0c5e1c
Collecting pandas
  Downloading pandas-2.2.3-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (13.1 MB)
    13.1/13.1 MB 4.6 MB/s eta 0:00:00
Collecting scikit-learn
  Downloading scikit_learn-1.6.1-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (13.5 MB)
    13.5/13.5 MB 5.6 MB/s eta 0:00:00
Collecting numpy
  Downloading numpy-2.0.2-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (19.5 MB)
    19.5/19.5 MB 1.9 MB/s eta 0:00:00
Collecting nltk
  Downloading nltk-3.9.1-py3-none-any.whl (1.5 MB)
    1.5/1.5 MB 1.4 MB/s eta 0:00:00
Step 5/5 : CMD ["python", "train.py"]
--> Running in 56e33860c672
--> Removed intermediate container 56e33860c672
--> e4d12464230e
Successfully built e4d12464230e
Successfully tagged fakenews-model:latest
```

Fig 1. Successful image creation

2. Docker Run:

```
(base) muheetalam@Muheet-PC:~/DOML/project-2-mlops/app$ docker run --rm -v $(pwd)/output:/opt/ml/output fakenews-model
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data] Unzipping corpora/stopwords.zip.
✓ Accuracy: 94.13%
Confusion Matrix:
[[585  40]
 [ 34 601]]
👉 Model saved to /opt/ml/output/model.pkl
👉 Vectorizer saved to /opt/ml/output/vectorizer.pkl
```

Fig 2. Output in terminal with accuracy & confusion matrix

3. Output Files:

```
(base) muheetalam@Muheet-PC:~/DOML/project-2-mlops/app$ ls output
model.pkl  vectorizer.pkl
```

Fig 3(a). Screenshot of model.pkl and vectorizer.pkl listed inside /opt/ml/output

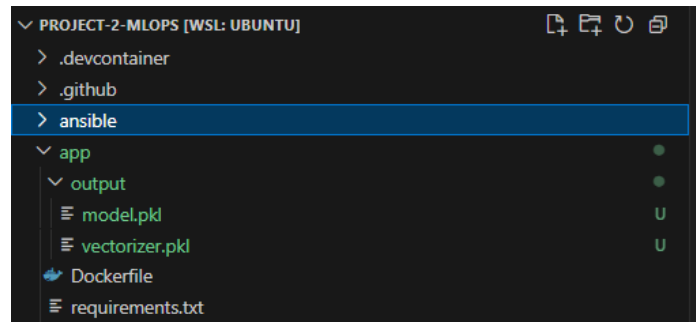


Fig 3(b). Screenshot of model.pkl and vectorizer.pkl inside /opt/ml/output

4. Ansible Local Playbook Execution:

```
• (base) muheestalam@Muheet-PC:~/DOML/project-2-mlops$ ansible-playbook ansible/playbook-local.yml --ask-become-pass
BECOME password:
[WARNING]: No inventory was parsed, only implicit localhost is available
[WARNING]: provided hosts list is empty, only localhost is available. Note that the implicit localhost does not match 'all'

PLAY [Setup ML environment locally] *****

TASK [Gathering Facts] *****
ok: [localhost]

TASK [Update APT packages] *****
ok: [localhost]

TASK [Install Python 3 and pip] *****
ok: [localhost] => (item=python3)
ok: [localhost] => (item=python3-pip)

TASK [Ensure Docker is running] *****
ok: [localhost]

TASK [Copy app folder to /opt/ml] *****
changed: [localhost]

TASK [Build Docker image] *****
changed: [localhost]

TASK [Run Docker container] *****
changed: [localhost]

PLAY RECAP *****
localhost : ok=7  changed=3  unreachable=0  failed=0  skipped=0  rescued=0  ignored=0
```

Fig 4. Ansible playbook execution locally.

5. Ansible Remote Playbook Execution:

```
(base) muheetalam@Muheet-PC:~$ ssh keshu17@192.168.85.106
Enter passphrase for key '/home/muheetalam/.ssh/id_rsa':
Welcome to Ubuntu 24.04.2 LTS (GNU/Linux 5.15.167.4-microsoft-standard-WSL2 x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/pro

System information as of Sun Apr 20 07:20:56 UTC 2025

System load:  0.17               Processes:            44
Usage of /:   0.3% of 1006.85GB   Users logged in:     1
Memory usage: 8%                IPv4 address for eth0: 172.28.100.238
Swap usage:   0%

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
   just raised the bar for easy, resilient and secure K8s cluster deployment.

https://ubuntu.com/engage/secure-kubernetes-at-the-edge
Last login: Sun Apr 20 07:19:32 2025 from 172.28.96.1
```

Fig 5. Establishing SSH connection.

```
(base) muheetalam@Muheet-PC:~/DOML/project-2-mlops$ ansible-playbook -i ansible/inventory.ini ansible/playbook-remote.yml --ask-become-pass
BECOME password:

PLAY [Setup ML environment on remote machine] *****

TASK [Gathering Facts] *****
Enter passphrase for key '/home/muheetalam/.ssh/id_rsa':
ok: [192.168.85.106]

TASK [Update APT packages] *****
ok: [192.168.85.106]

TASK [Install Python 3 and pip] *****
ok: [192.168.85.106] => (item=python3)
ok: [192.168.85.106] => (item=python3-pip)

TASK [Install Docker] *****
ok: [192.168.85.106]

TASK [Ensure Docker is running] *****
ok: [192.168.85.106]

TASK [Create app directory] *****
ok: [192.168.85.106]

TASK [Copy app folder contents to remote machine] *****
changed: [192.168.85.106]

TASK [Build Docker image] *****
changed: [192.168.85.106]

TASK [Run Docker container] *****
changed: [192.168.85.106]

TASK [Enable Docker BuildKit] *****
changed: [192.168.85.106]

PLAY RECAP *****
192.168.85.106      : ok=10  changed=4  unreachable=0  failed=0  skipped=0  rescued=0  ignored=0

(base) muheetalam@Muheet-PC:~/DOML/project-2-mlops$
```

Fig 6. Remote ML environment successfully set up using Ansible playbook with automated Docker deployment.


```

keshu17@DESKTOP-6VNP240:/opt/ml/output$ docker run -it --rm -v /opt/ml/output:/opt/ml/output 88c9246548f7 /bin/bash
root@9e9ced611f4b:/app# pip install -r requirements.txt
python train.py
Collecting pandas
  Downloading pandas-2.2.3-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (13.1 MB)
    13.1/13.1 MB 585.5 kB/s eta 0:00:00
Collecting scikit-learn
  Downloading scikit_learn-1.6.1-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (13.5 MB)
    13.5/13.5 MB 517.1 kB/s eta 0:00:00
Collecting numpy
  Downloading numpy-2.0.2-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (19.5 MB)
    19.5/19.5 MB 245.1 kB/s eta 0:00:00
Collecting nltk
  Downloading nltk-3.9.1-py3-none-any.whl (1.5 MB)
    1.5/1.5 MB 333.1 kB/s eta 0:00:00
Collecting pytz>=2020.1
  Downloading pytz-2025.2-py2.py3-none-any.whl (509 kB)
    509.2/509.2 kB 365.3 kB/s eta 0:00:00
Collecting python-dateutil>=2.8.2
  Downloading python_dateutil-2.9.0.post0-py3-none-any.whl (229 kB)
    229.9/229.9 kB 340.4 kB/s eta 0:00:00
Collecting tzdata>=2022.7
  Downloading tzdata-2025.2-py2.py3-none-any.whl (347 kB)
    347.8/347.8 kB 423.5 kB/s eta 0:00:00
Collecting scipy>=1.6.0
  Downloading scipy-1.13.1-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (38.6 MB)
    38.6/38.6 MB 737.2 kB/s eta 0:00:00
Collecting threadpoolctl>=3.1.0
  Downloading threadpoolctl-3.6.0-py3-none-any.whl (18 kB)
Collecting joblib>=1.2.0
  Downloading joblib-1.4.2-py3-none-any.whl (301 kB)
    301.8/301.8 kB 950.9 kB/s eta 0:00:00
Collecting tqdm
  Downloading tqdm-4.67.1-py3-none-any.whl (78 kB)
    78.5/78.5 kB 559.3 kB/s eta 0:00:00
Collecting click
  Downloading click-8.1.8-py3-none-any.whl (98 kB)
    98.2/98.2 kB 1.3 MB/s eta 0:00:00
Collecting regex>=2021.8.3
  Downloading regex-2024.11.6-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (780 kB)
    780.9/780.9 kB 1.1 MB/s eta 0:00:00
Collecting six>=1.5
  Downloading six-1.17.0-py2.py3-none-any.whl (11 kB)
Installing collected packages: pytz, tzdata, tqdm, threadpoolctl, six, regex, numpy, joblib, click, scipy, python-dateutil, nltk, scikit-learn, pandas
Successfully installed click-8.1.8 joblib-1.4.2 nltk-3.9.1 numpy-2.0.2 pandas-2.2.3 python-dateutil-2.9.0.post0 pytz-2025.2 regex-2024.11.6 scikit-learn-1.6.1

```

Fig 7. Installing ML project dependencies inside Docker container using requirements.txt.

```

[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data] Unzipping corpora/stopwords.zip.
✓ Accuracy: 93.81%
■ Confusion Matrix:
[[583  42]
 [ 38 591]]
● Model saved to /opt/ml/output/model.pkl
● Vectorizer saved to /opt/ml/output/vectorizer.pkl
root@9e9ced611f4b:/app#

```

Fig 8. Model trained with 93.81% accuracy; saved model.pkl and vectorizer.pkl for deployment.

```

keshu17@DESKTOP-6VNP240:/mnt/c/WINDOWS/system32$ ls -lh /opt/ml/output/
total 1.9M
-rw-r--r-- 1 root root 493K Apr 20 07:32 model.pkl
-rw-r--r-- 1 root root 1.4M Apr 20 07:32 vectorizer.pkl

```

Fig 9. Successfully accessed remote machine and verified presence of saved model and vectorizer files.

6. Dockerhub:

The screenshot shows the Docker Hub interface for the repository 'alamsaim/fakenews-model'. The left sidebar contains navigation links: Repositories, Settings, Default privacy, Notifications, Billing, Usage, Pulls, and Storage. The main content area displays the repository details, including a description, tags, and a table of image versions. The 'Tags' section shows one tag, 'latest', which was pushed 13 days ago. The 'Docker commands' section provides the command to push a new tag to the repository. The 'buildcloud' section promotes Docker Build Cloud for faster builds.

Repositories / fakenews-model / General

Using 0 of 1 private repositories. [Get more](#)

alamsaim/fakenews-model ⓘ
Last pushed 13 days ago

This Docker image contains all code and dependencies to train the fake news classifier. ⓘ

[MACHINE LEARNING & AI](#) [DEVELOPER TOOLS](#) ⓘ

General Tags Image Management BETA Collaborators Webhooks Settings

Tags ⓘ DOCKER SCOUT INACTIVE [Activate](#)

This repository contains 1 tag(s).

Tag	OS	Type	Pulled	Pushed
latest	linux	Image	3 days	13 days

[See all](#)

Docker commands [Public view](#)

To push a new tag to this repository:

```
docker push alamsaim/fakenews-model:tagname
```

buildcloud

Build with
Docker Build Cloud

Accelerate image build times with access to cloud-based builders and shared cache.

Docker Build Cloud executes builds on optimally-dimensioned cloud infrastructure with dedicated per-organization isolation.

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Fig 10. Dockerhub demonstration containing Docker Image

CONCLUSION

This project successfully automated an end-to-end ML workflow using Ansible and Docker. The containerized solution ensures reproducibility across environments, and the Ansible playbooks minimize manual setup. By pushing the Docker image to DockerHub, the model training process becomes easily shareable and executable by others without any configuration. This aligns with real-world MLOps practices and builds a strong foundation for more advanced automation and deployment workflows in machine learning systems.

REFERENCES

1. <https://docs.ansible.com/ansible/latest/index.html#>
2. <https://hub.docker.com/>
3. <https://www.docker.com/>
4. <https://github.com/>