

Assignment 02: Experiment Tracking and Model Lifecycle Management with MLFlow

AI545 - W26

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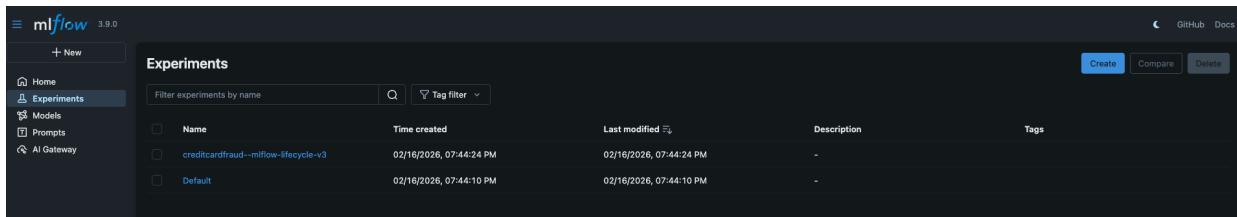
1 Part A: Experiment Design and Setup

Problem Definition: The modeling task is a binary classification to detect fraudulent credit card transactions. The goal is to identify the minority class (Fraud = 1) within a highly imbalanced dataset containing European cardholder transactions from September 2013.

Dataset: We are using the Kaggle Credit Card Fraud Detection dataset. It contains 284,807 transactions, where only 492 (0.172%) are fraudulent. The features include 'Time', 'Amount', and 28 principal components.

Hyperparameters: To optimize the Random Forest model, we will tune four specific hyperparameters:

- *n_estimators*: The number of trees in the forest (controls variance).
- *max_depth*: The maximum depth of the tree (controls overfitting).
- *min_samples_split*: The minimum samples required to split an internal node.
- *min_samples_leaf*: The minimum samples required to be at a leaf node (smooths the model).



The screenshot shows the MLflow interface with the title 'mlflow 3.9.0'. On the left, there's a sidebar with links for Home, Experiments (which is selected), Models, Prompts, and AI Gateway. The main area is titled 'Experiments' and contains a table with two rows of data. The columns are 'Name', 'Time created', 'Last modified', 'Description', and 'Tags'. The first row has a checkbox next to 'Name', which is checked for 'creditcardfraud--mlflow-lifecycle-v3'. The second row has a checkbox next to 'Name', which is checked for 'Default'. Both rows show the same timestamp for creation and modification: '02/16/2026, 07:44:24 PM' and '02/16/2026, 07:44:10 PM'. There are also 'Create', 'Compare', and 'Delete' buttons at the top right of the table.

Name	Time created	Last modified	Description	Tags
creditcardfraud--mlflow-lifecycle-v3	02/16/2026, 07:44:24 PM	02/16/2026, 07:44:24 PM	-	
Default	02/16/2026, 07:44:10 PM	02/16/2026, 07:44:10 PM	-	

Figure 1: MLFlow Experiments

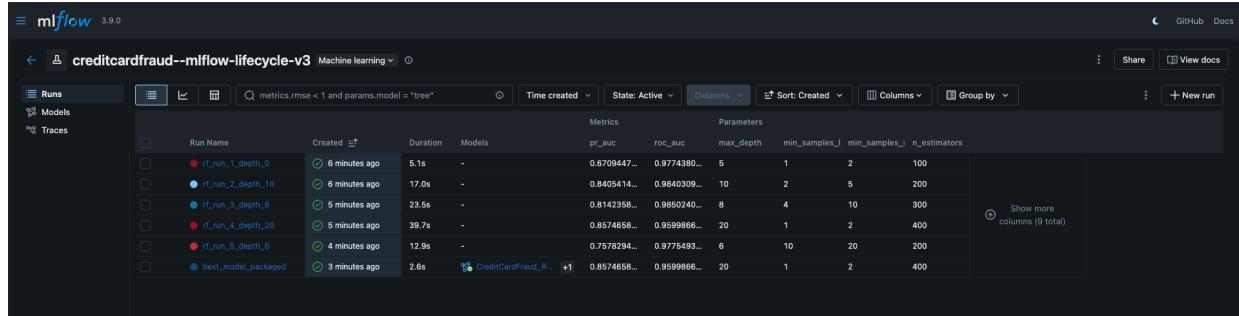


Figure 2: Details of an Experiment

2 Part B: MLflow Tracking

Artifacts: Confusion Matrix and Precision-Recall Curve.

Tags: run_purpose, model_family, and problem_type.

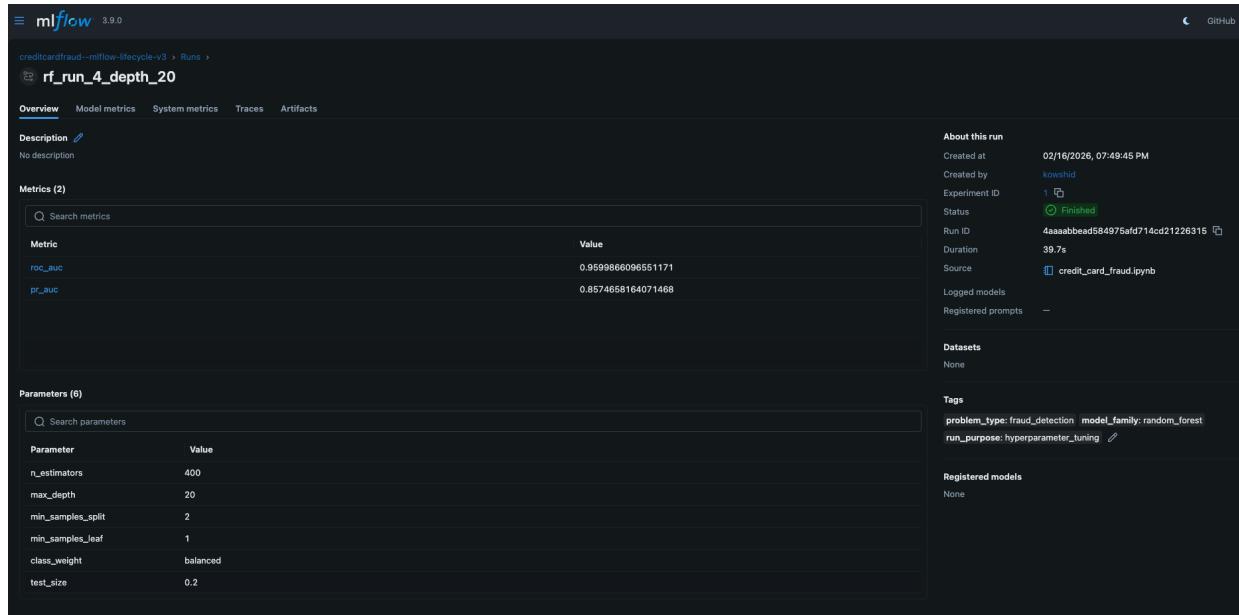


Figure 3: A Run Information

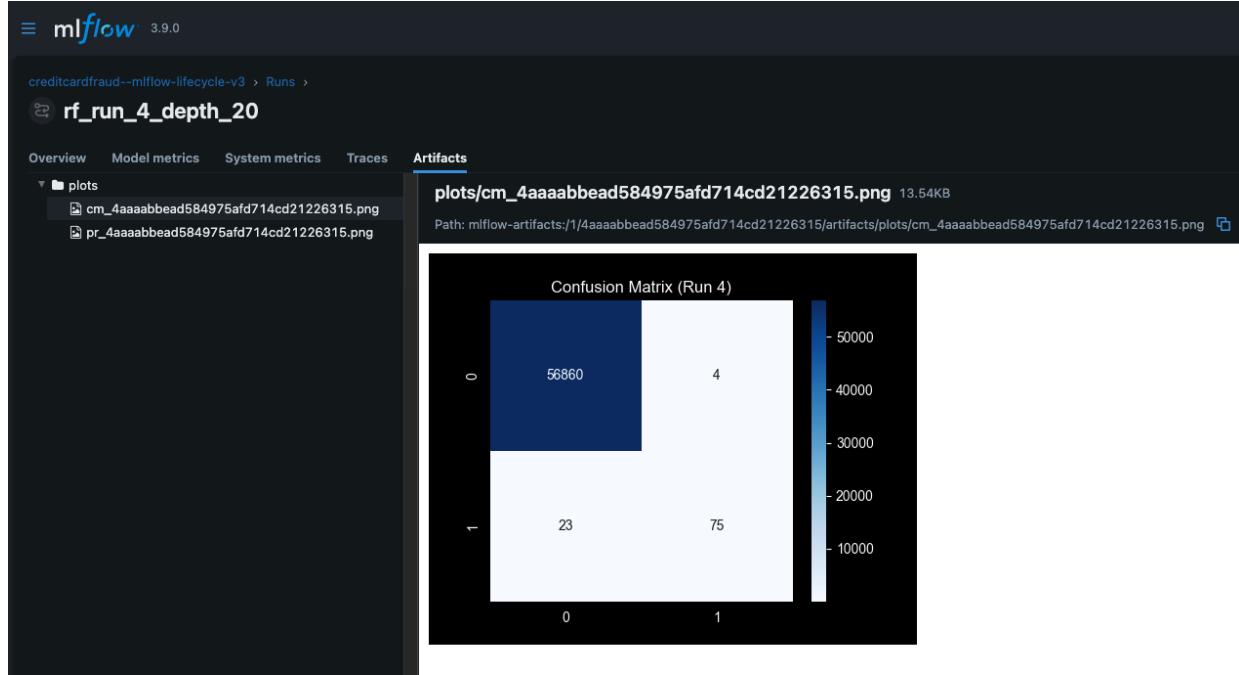


Figure 4: Confusion Matrix of a Run



Figure 5: Precision-Recall Curve of a Run

3 Part C: Experiment Comparison and Analysis

Best Model: The best performing model was the run 4 with $n_estimators = 400$, $max_depth = 20$, $min_samples_leaf = 1$, and $min_samples_split = 2$. This is achieved by sorting by pr_auc (Average Precision).

This model achieved the highest Precision-Recall, indicating it maintains high Precision (few false alarms) while capturing a significant portion of fraud cases (high Recall).

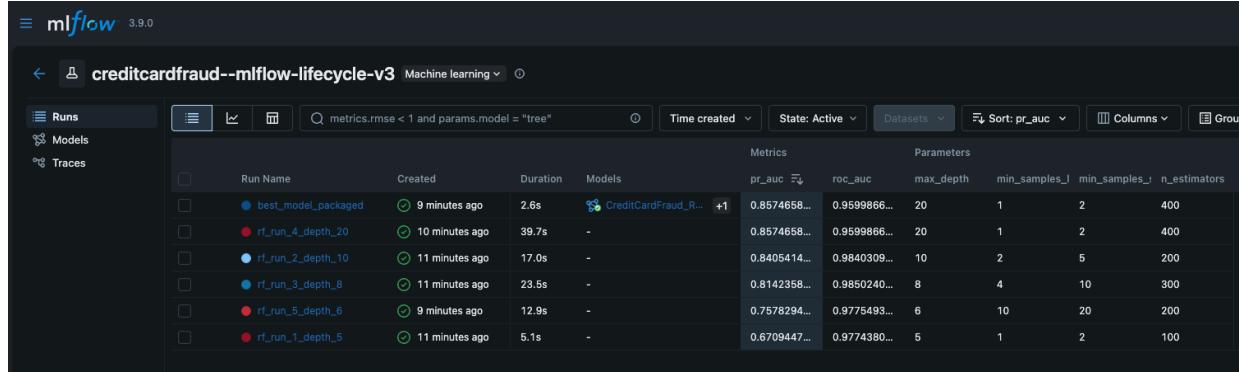


Figure 6: Runs Sorted by Precision-Recall

4 Part D: Model Packaging and Signatures

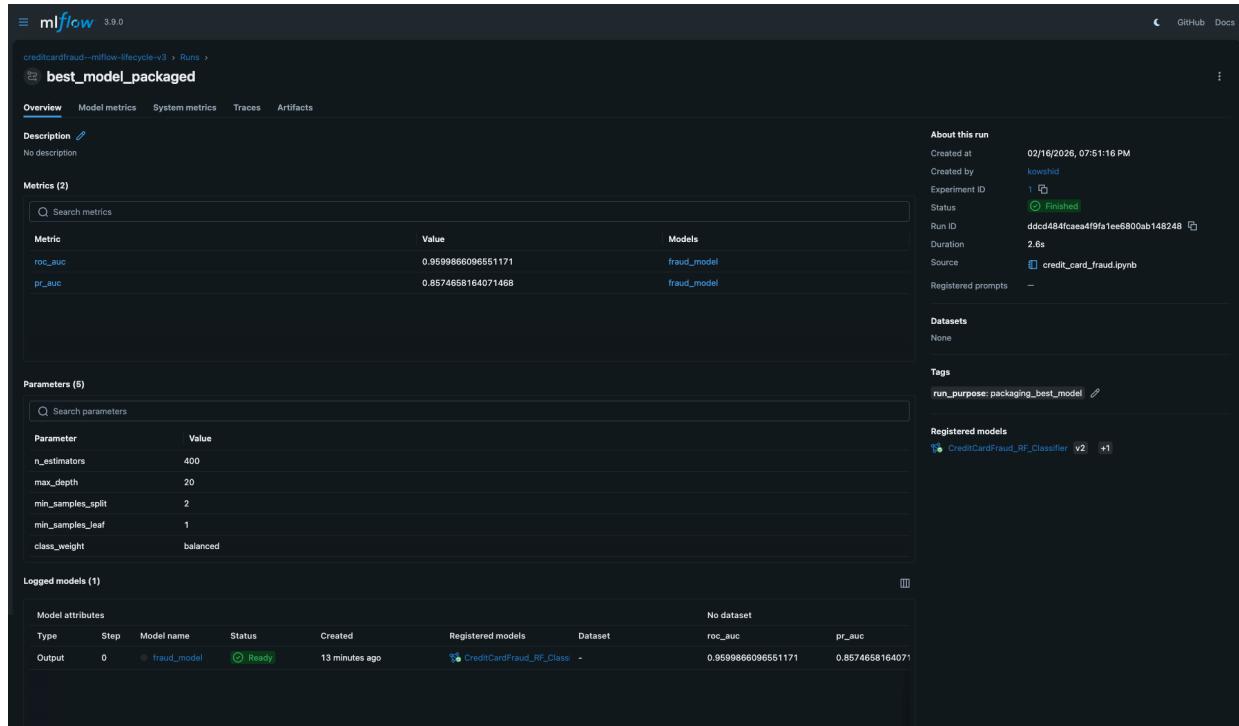


Figure 7: Overview of Best Model

4.1 Model Signature

```
artifact_path: mlflow-artifacts:/1/models/m-c85e74fe975545f29d26173583ce1183/artifacts
flavors:
  python_function:
    env:
      conda: conda.yaml
      virtualenv: python_env.yaml
    loader_module: mlflow.sklearn
    model_path: model.pkl
    predict_fn: predict
    python_version: 3.11.14
  sklearn:
    code: null
    pickled_model: model.pkl
    serialization_format: cloudpickle
    sklearn_version: 1.8.0
    skops_trusted_types: null
  is_signature_from_type_hint: false
  mlflow_version: 3.9.0
model_id: m-c85e74fe975545f29d26173583ce1183
model_size_bytes: 12958248
model_uuid: m-c85e74fe975545f29d26173583ce1183
prompts: null
run_id: ddcd484fccea4f9fa1ee6800ab148248
saved_input_example_info:
  artifact_path: input_example.json
  pandas_orient: split
  serving_input_path: serving_input_example.json
  type: dataframe
signature:
  inputs: '[{"type": "double", "name": "Time", "required": true}, {"type": "double", "name": "V1", "required": true}, {"type": "double", "name": "V2", "required": true}, {"type": "double", "name": "V3", "required": true}, {"type": "double", "name": "V4", "required": true}, {"type": "double", "name": "V5", "required": true}, {"type": "double", "name": "V6", "required": true}, {"type": "double", "name": "V7", "required": true}, {"type": "double", "name": "V8", "required": true}, {"type": "double", "name": "V9", "required": true}, {"type": "double", "name": "V10", "required": true}, {"type": "double", "name": "V11", "required": true}, {"type": "double", "name": "V12", "required": true}, {"type": "double", "name": "V13", "required": true}, {"type": "double", "name": "V14", "required": true}, {"type": "double", "name": "V15", "required": true}, {"type": "double", "name": "V16", "required": true}, {"type": "double", "name": "V17", "required": true}, {"type": "double", "name": "V18", "required": true}, {"type": "double", "name": "V19", "required": true}, {"type": "double", "name": "V20", "required": true}, {"type": "double", "name": "V21", "required": true}, {"type": "double", "name": "V22", "required": true}, {"type": "double", "name": "V23", "required": true}, {"type": "double", "name": "V24", "required": true}, {"type": "double", "name": "V25", "required": true}, {"type": "double", "name": "V26", "required": true}, {"type": "double", "name": "V27", "required": true}, {"type": "double", "name": "V28", "required": true}, {"type": "double", "name": "Amount", "required": true}]'
  outputs: '[{"type": "tensor", "tensor-spec": {"dtype": "float64", "shape": [-1]}}]'
  params: null
type_hint_from_example: false
```

utc_time_created: '2026-02-17 00:51:16.334083'

The screenshot shows the mlflow UI interface. At the top, there's a navigation bar with 'mlflow' logo, GitHub link, and Docs link. Below it, a breadcrumb navigation shows 'creditcardfraud--mlflow-lifecycle-v3 > Runs > best_model_packaged'. On the left, there's a sidebar with 'Overview', 'Model metrics', 'System metrics', and 'Traces' tabs. The 'Artifacts' tab is selected, showing a list of files: 'MLmodel', 'conda.yaml', 'input_example.json', 'model.pkl', 'python_envyaml', 'requirements.txt', and 'serving_input_example.json'. The main content area is titled 'MLmodel 2.83KB' and displays the contents of the 'MLmodel' file. The file content is a JSON object with various fields like 'env', 'sklearn', 'signature', 'inputs', 'outputs', and 'params'. The 'signature' field contains a detailed definition of input and output types. The 'inputs' field lists 15 double-type variables named V1 through V15. The 'outputs' field specifies a single tensor output of type float64 with shape [-1]. The 'params' field is null.

Figure 8: MLmodel Details

4.2 Input Example

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5 Part E: Model Registry and Lifecycle Management

Model name	Status	Created	Logged from	Source run	Registered models	No dataset	Parameters
fraud_model	Ready	43 minutes ago	credit_card_fraud.ipynb	best_model_packaged	CreditCardFraud_RF_Classifi	0.8574658164071468	max_depth: 20 min_samples_leaf: 1

Figure 9: Models from Run

The screenshot shows the mlflow UI interface. At the top, there's a navigation bar with links for GitHub and Docs. Below it, the main header says "creditcardfraud--mlflow-lifecycle-v3 > Models > fraud_model". On the left, there are tabs for Overview, Traces, and Artifacts, with Overview selected. Under Overview, there's a "Description" section with a note that "No description". Below that is a "Metrics (2)" section with two rows of data:

Metric	Dataset	Source run	Value
roc_auc	-	best_model_packag...	0.9599866096551...
pr_auc	-	best_model_packag...	0.8574658164071...

Further down are sections for "Parameters (5)", "Runs", and "Artifacts". On the right side, there's a sidebar titled "About this logged model" with details like "Created at 44 minutes ago", "Status Ready", and "Model ID m-c85e74fe975545f29d2...". There's also a "Datasets used" section indicating "None" and a "Model versions" section showing "CreditCardFraud_RF_Classifier v1 +3".

Figure 10: Overview of Model

This screenshot shows the "Registered Models" page. The left sidebar has a "Models" tab selected. The main area displays a table of registered models:

Name	Latest version	Aliased versions	Created by	Last modified	Tags
CreditCardFraud_RF_Classifier	Version 2	@challenger; Version 2 +1		02/16/2026, 07:51:...	-

Figure 11: Registered Model

This screenshot shows the details of a registered model. The left sidebar has a "Models" tab selected. The main area shows the model's creation time (02/16/2026, 07:51:18 PM) and last modified time (02/16/2026, 07:51:22 PM). It includes sections for "Description" (with an "Edit" link), "Tags", and "Versions". The "Versions" section lists two entries:

Version	Registered at	Created by	Tags	Aliases	Description
Version 2	02/16/2026, 07:51:20 PM		stage: staging	@ challenger	Best model challenger version 2
Version 1	02/16/2026, 07:51:18 PM		stage: production	@ champion	Best model version 1

Figure 12: Registered Model Details

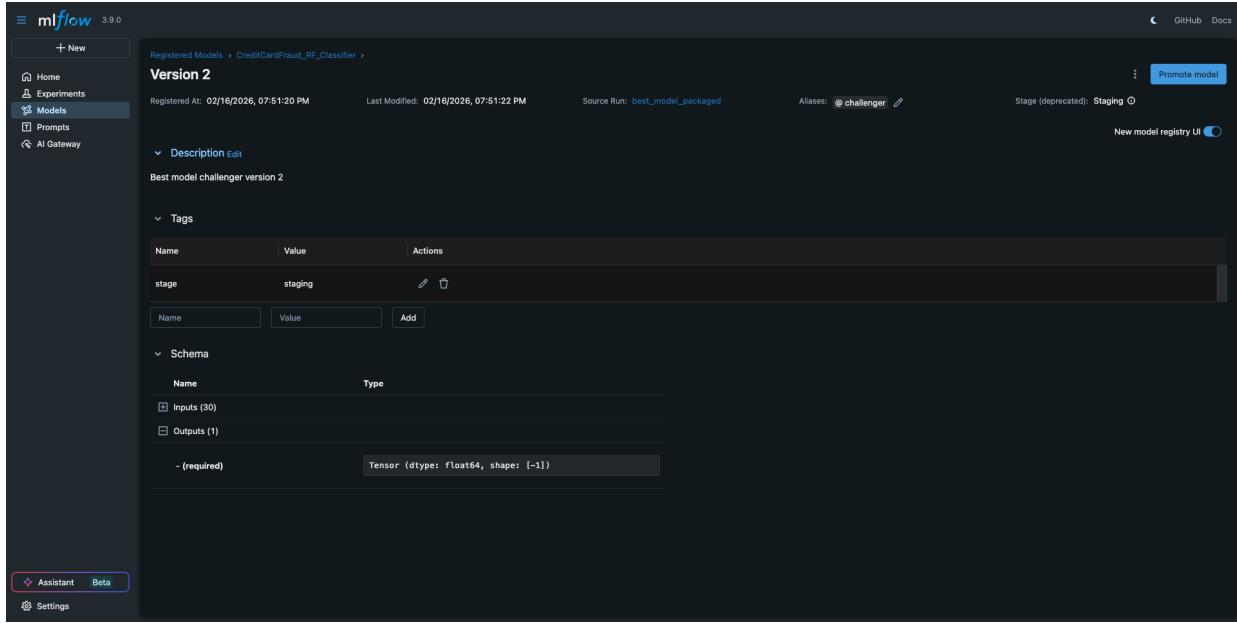


Figure 13: Registered Model Version Details

6 Part F: Reflection

MLflow solves practical problems in real ML systems by providing a single system of record for experiment runs, hyperparameters, metrics, artifacts, and packaged models, which improves reproducibility and team collaboration. It also supports governance through the Model Registry, where versions can be staged and promoted with documented rationale.

However, mistakes can still happen: data leakage, incorrect train/test splits, mislabeled data can occur even if everything is logged. Teams can also log incorrect/incomplete metadata and still lose reproducibility.

MLflow integrates well with DVC by using DVC for data version control while MLflow tracks run metadata and artifacts. We can log the DVC commit hash as a tag in MLflow, linking the exact data version to the experiment results. In a CI/CD pipeline, a change request could trigger a script that trains a model, logs it to MLflow, and compares its metrics against the current *Production* model. If the new model's metrics are better, the CI pipeline can automatically register it and move it to *Staging*. This makes promotion decisions auditable and automatic.