What is MLflow?
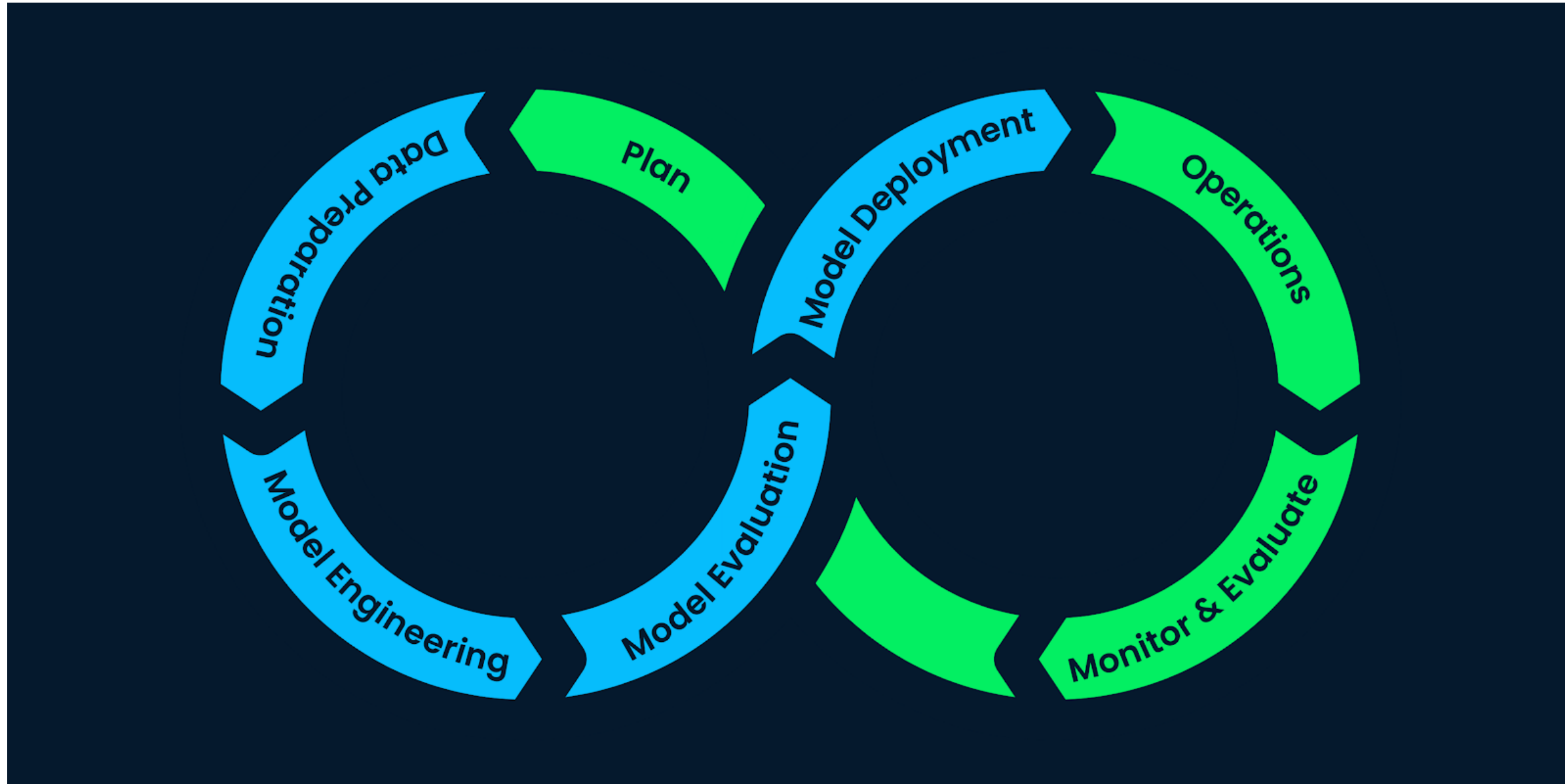
INTRODUCTION TO MLFLOW

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The machine learning lifecycle

Difficulties of machine learning

- **Tracking:**
  - Models and model metrics

- **Reproducibility:**
  - Platforms, environments and workspaces

- **Deployment:**
 - So many options and no standards

What is MLflow?

"An open source platform for the machine learning lifecycle" - **MLflow.org**

[1] www.mlflow.org

Components of MLflow

- **MLflow Tracking:**
  - Record metrics and parameters from training runs
  - Query data from experiments
  - Store models, artifacts and code

- **Model Registry:**
  - Store and version ML models
  - Load and deploy ML models

- **MLflow Models:**
  - Standardize models for deployment
  - Build customized models

- **MLflow Projects:**
  - Package ML code for reproducibility
  - Package ML code for repeatability

Integrations with:
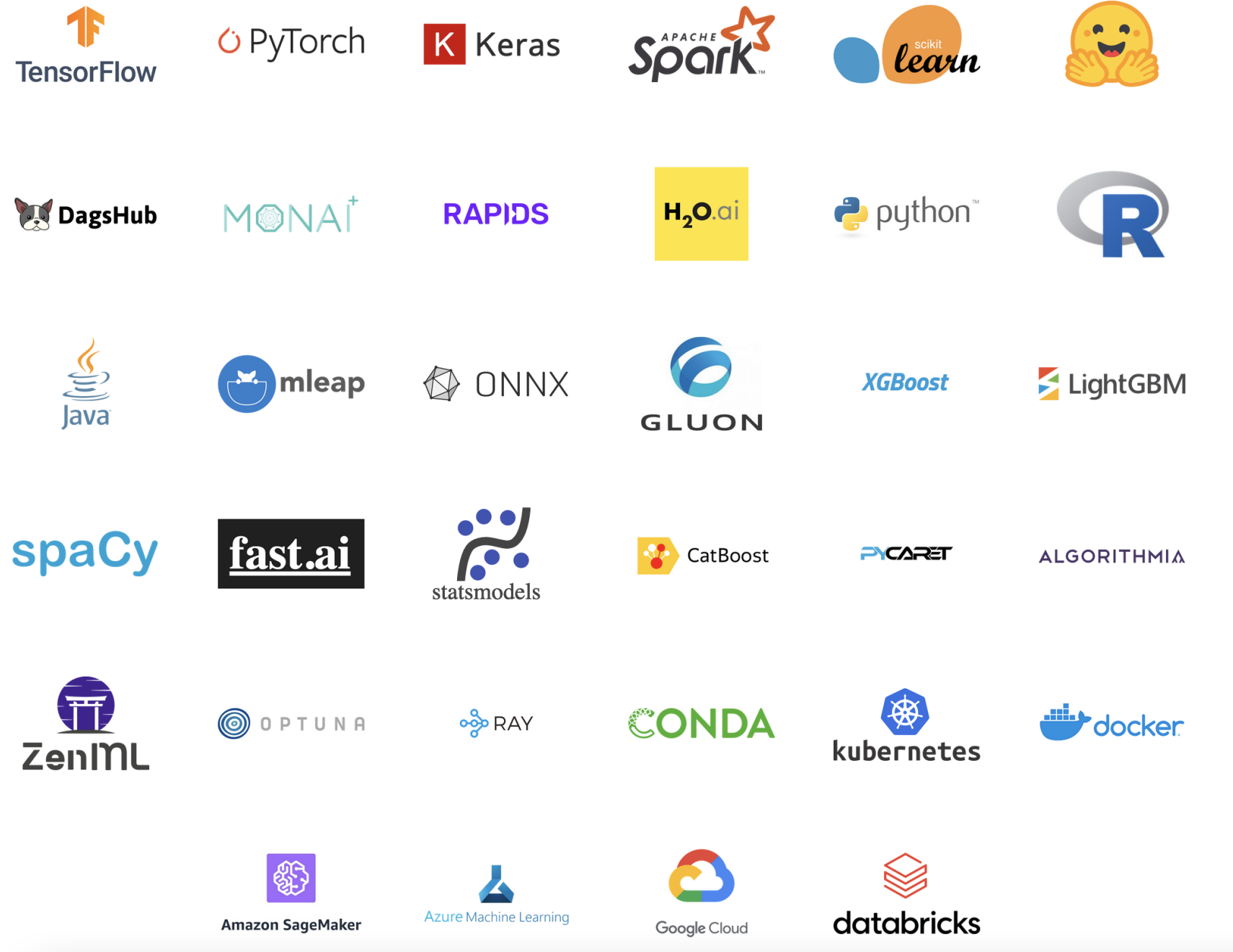
MLflow experiments

Experiments

Search Experiments

- ☑ **Default**
- ☐ Scores Experiment
- ☐ Scores
- ☐ Unicorn Experiment
- ☐ Unicorn
- ☐ Unicorn Model
- ☐ 5
- ☐ Test
- ☐ 7
- ☐ Test 2
- ☐ 9
- ☐ Test 3
- ☐ 11

Default

Share

ℹ **Track machine learning training runs in experiments. Learn more** ✕

Experiment ID: 0   Artifact Location: ./mlruns/0

> **Description** Edit

🔍 metrics.rmse < 1 and params.model = "tree"   ℹ

⋮   🔄 Refresh

⇅ Sort: Created ⌄   ☰ Columns ⌄

Time created: All time ⌄   State: Active ⌄   Showing 3 matching runs

	Run Name	Created		Duration	metric_1	metric_2
					Metrics	
☐	rumbling-deer-742	✓ 3 months ago		2.0s	0.872	1.824
☐	receptive-kit-255	✓ 3 months ago		2.0s	0.86	1.356
☐	bright-gnu-469	✓ 3 months ago		2.0s	0.242	1.263

Working with experiments

MLflow Client

- Create Experiments

```
client.create_experiment("Name")
```

- Tag Experiments

```
client.set_experiment_tag("Name",
k, v)
```

- Delete Experiments

```
client.delete_experiment("Name")
```

MLflow module

- Create Experiments

```
mlflow.create_experiment("Name")
```

- Tag Experiments

```
mlflow.set_experiment_tag(k, v)
```

- Delete Experiments

```
mlflow.delete_experiment("Name")
```

- Set Experiment

```
mlflow.set_experiment("Name")
```

Starting a new experiment

```python
import mlflow
# Create new Experiment
mlflow.create_experiment("My Experiment")
# Tag new experiment
mlflow.set_experiment_tag("scikit-learn", "lr")
# Set the experiment
mlflow.set_experiment("My Experiment")
```

Let's practice!

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MLflow Tracking

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Tracking data about models
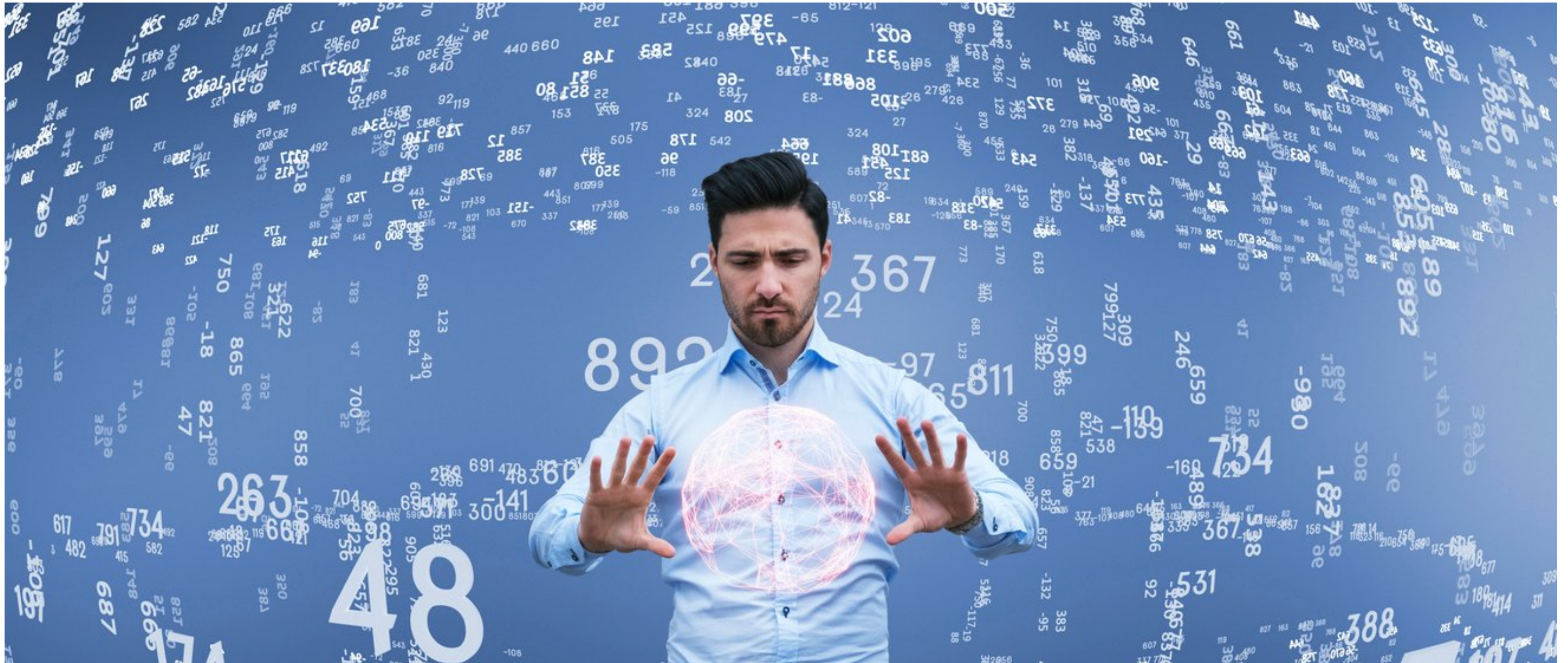
What is MLflow Tracking?

- Model Metrics
  - F1, Recall, Accuracy, MSE, etc...

- Parameters
  - library specific

- code
  - `train.py`

- other artifacts
  - tokenizers, pickle, etc...

Training runs

- How MLflow is organized

- New run equals new model training

- A run is placed within an experiment

- Invoked via `mlflow.start_run()`

[1] unsplash.com

Starting a training run

```python
import mlflow

# Start a run
mlflow.start_run()
```

```
<ActiveRun: >
```

```python
# End a run
mlflow.end_run()
```

Setting a training run variable

```python
import mlflow
# Set experiment
mlflow.set_experiment("My Experiment")
# Start a run
run = mlflow.start_run()
# Print run info
run.info
```

```
<RunInfo: artifact_uri='./mlruns/0/9de5df4d19994546b03dce09aefb58af/artifacts',
    end_time=None, experiment_id='31', lifecycle_stage='active',
    run_id='9de5df4d19994546b03dce09aefb58af', run_name='big-owl-145',
    run_uuid='9de5df4d19994546b03dce09aefb58af', start_time=1676838126924,
    status='RUNNING', user_id='user'>
```

Logging to MLflow Tracking

- **Metrics**
  - `log_metric("accuracy", 0.90)`

  - `log_metrics({"accuracy": 0.90, "loss": 0.50})`

- **Parameters**
  - `log_param("n_jobs", 1)`

  - `log_params({"n_jobs": 1, "fit_intercept": False})`

- **Artifacts**
  - `log_artifact("file.py")`

  - `log_artifacts("./directory/")`

Logging a run

```python
import mlflow
# Set Experiment
mlflow.set_experiment("LR Experiment")

# Start a run
mlflow.start_run()

# Model Training Code here
lr = LogisticRegression(n_jobs=1)

# Model evaluation Code here
lr.fit(X, y)

score = lr.score(X, y)
```

```python
# Log a metric
mlflow.log_metric("score", score)

# Log a parameter
mlflow.log_param("n_jobs", 1)

# Log an artifact
mlflow.log_artifact("train_code.py")
```

Open MLflow UI

```
# Open MLflow Tracking UI
mlflow ui
```

Go to: **http://localhost:5000**

Tracking UI experiment view

LR Experiment ⧉   Share

Experiment ID: 37   Artifact Location: ./mlruns/37

> Description Edit

🔍 metrics.rmse < 1 and params.model = "tree"   ⓘ   ⇅ Sort: Created ⌄

☰ Columns ⌄   ⋮   ↻ Refresh

Time created: All time ⌄   State: Active ⌄   Showing 1 matching run

				Metrics	Parameters
				---	---
	Run Name	**Created** ⇅	**Models**	**score**	**n_jobs**
☐	**silent-slug-662**	✓ 1 minute ago	-	0.951	1

Tracking UI run view

silent-slug-662

Run ID: a410480d4ccc4601904085b5651483b4   Date: 2023-02-20 08:14:05   Source: 💻

User: weston   Duration: 1.5min   Status: FINISHED

Lifecycle Stage: active

› Description Edit

∨ Parameters (1)

Name	Value
n_jobs	1

∨ Metrics (1)

Name	Value
score 📈	0.951

› Tags

∨ Artifacts

📄 train_code.py

Let's practice!

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Querying runs

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datacamp

Model data

Runs data

Insurnace Experiment ⧉

Experiment ID: 27   Artifact Location: ./mlruns/27

> Description Edit

🔍 metrics.rmse < 1 and params.model = "tree"	ⓘ	⇅ Sort: accuracy_score ⌄	☰ Columns ⌄

Time created: All time ⌄	State: Active ⌄

			Metrics						
☐	Run Name	Cr Models	accuracy_score	example_count	f1_score	false_negatives	false_positives	precision_scor	recall_score
☐	wise-mole-318	📄 shap, 1 mo	0.621	335	0.623	65	62	0.629	0.618
☐	invincible-lark-929	📄 shap, 1 mo	0.621	335	0.623	65	62	0.629	0.618
☐	sedate-fawn-631	📄 shap, 1 mo	0.621	335	0.623	65	62	0.629	0.618
☐	awesome-moth-449	📄 shap, 1 mo	0.621	335	0.623	65	62	0.629	0.618
☐	fun-grub-597	📄 shap, 1 mo	0.621	335	0.623	65	62	0.629	0.618

Searching runs

```
mlflow.search_runs()
```

Output format

```
#    Column                    Non-Null Count   Dtype
0    run_id                    6 non-null       object
1    experiment_id             6 non-null       object
2    status                    6 non-null       object
3    artifact_uri              6 non-null       object
4    start_time                6 non-null       datetime64[ns, UTC]
5    end_time                  5 non-null       datetime64[ns, UTC]
6    metrics.test              1 non-null       float64
7    metrics.metric_2          3 non-null       float64
8    metrics.metric_1          3 non-null       float64
9    params.param_1            3 non-null       object
10   params.random_state       3 non-null       object
11   params.n_estimators       3 non-null       object
12   tags.mlflow.user          6 non-null       object
13   tags.mlflow.runName       6 non-null       object
14   tags.mlflow.source.type   6 non-null       object
15   tags.mlflow.source.name   6 non-null       object
```

Filtering run searches

- `max_results` - maximum number of results to return.

- `order_by` - column(s) to sort in `ASC` ending or `DESC` ending order.

- `filter_string` - string based query.

- `experiment_names` - name(s) of experiments to query.

Tracking UI

Insurance Experiment ⧉

Experiment ID: 27   Artifact Location: ./mlruns/27

> Description Edit

| 🔍 metrics.rmse < 1 and params.model = "tree" | ⓘ | ⇅ Sort: accuracy_score ⌄ | ☰ Columns ⌄ |

| Time created: All time ⌄ | State: Active ⌄ | | | | | S |

				Metrics				
☐	Run Name	Created	Duration	accuracy_score⇅	f1_score	false_negative	false_positives	precision_score
☐	wise-mole-318	✓ 3 months ago	10.4s	0.621	0.623	65	62	0.629
☐	powerful-shoat-853	✓ 3 months ago	5.0s	0.621	0.623	65	62	0.629
☐	amazing-penguin-22	✓ 3 months ago	4.6s	0.537	0.485	97	58	0.557
☐	traveling-snipe-808	✓ 3 months ago	5.6s	0.537	0.485	97	58	0.557

Search runs example

```python
import mlflow

# Filter string

f1_score_filter = "metrics.f1_score > 0.60"

# Search runs

mlflow.search_runs(experiment_names=["Insurance Experiment"],
    filter_string=f1_score_filter,
    order_by=["metrics.precision_score DESC"])
```

```python
# Create a filter string for R-squared score
    = "metrics.r2_score > .70"# Search runs
        (
            =["Unicorn Sklearn
Experiments", "Unicorn Other Experiments"],
            =
        =["metrics.r2_score DESC"])
```

Example output

```python
# Search runs from Insurance Experiment
mlflow.search_runs(experiment_names=["Insurance Experiment"],
    filter_string=f1_score_filter,
    order_by=["metrics.precision_score DESC"])
```

```
                    run_id experiment_id  ... tags.mlflow.source.type tags.mlflow.user
0  90407e29a5aa4a31954bed874c7d4337            27  ...                    LOCAL             user
1  c335c0b16a5d4cf398aaa7189362b577            27  ...                    LOCAL             user
```

Let's practice!

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