H2O.ai

Productionizing H2O Models using Apache Spark

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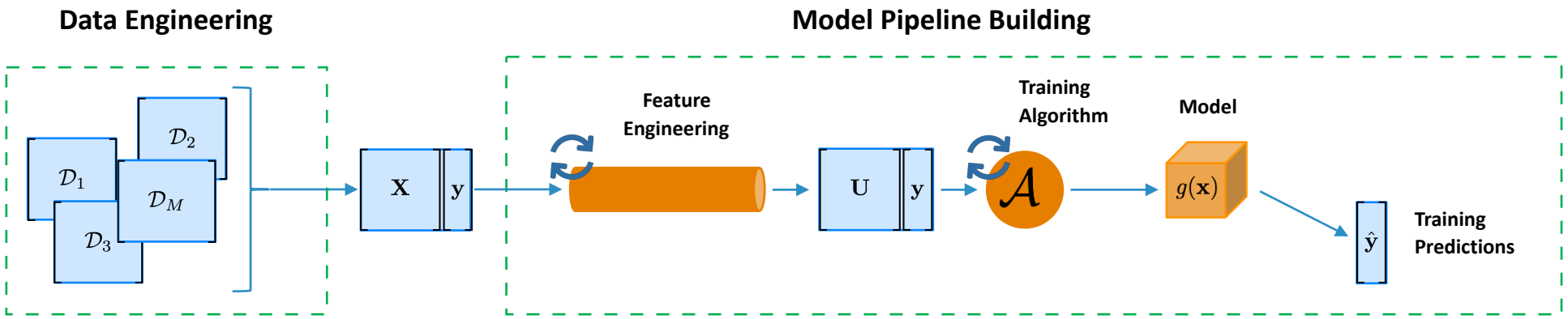
Who Are We?

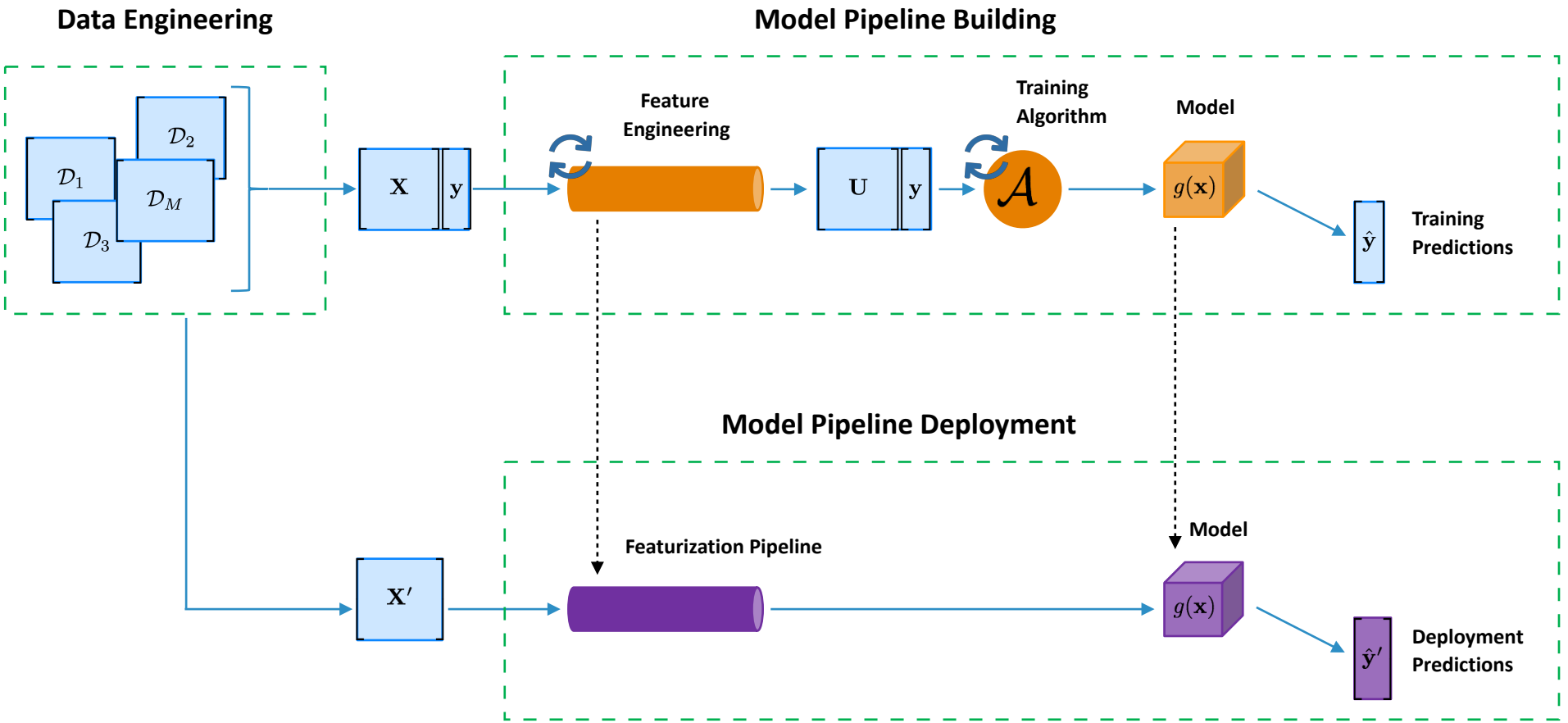
- **Kuba**
  - Senior Software engineer at H2O.ai - Core Sparkling Water
  - Master's at Charles University (CZ)
  - Implemented high-performance cluster monitoring tool for JVM based languages (JNI, JVMTI, instrumentation)
- **Michal**
  - VP of Engineering at H2O.ai
  - Creator of Sparkling Water
  - Ph.D at Charles University (CZ), PostDoc at Purdue (US)

Machine Learning (ML) Lifecycle

Basic ML Lifecycle



Basic ML Lifecycle



Example Implementations

Model Building | Model Deployment

Data Engineering	Feature Engineering	Training Algorithm	Deployment Pipeline	Model
Spark		H2O	Spark	H2O MOJO
Spark	H2O Driverless AI		Spark	H2O Driverless AI MOJO

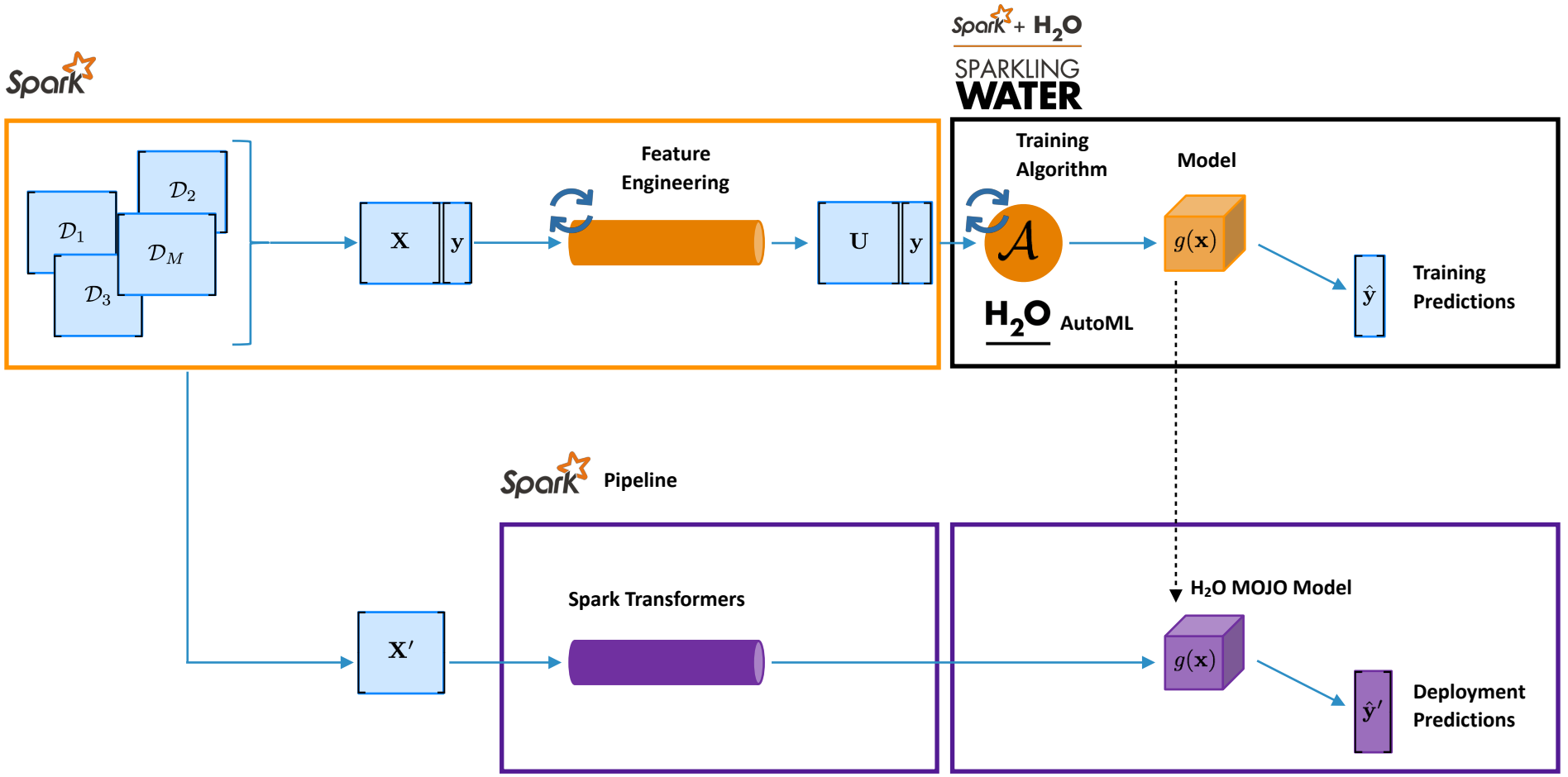
H2O + Spark = Sparkling Water

H2O + Spark

- H2O
  - Machine Learning Library
  - Distributed Algorithms
  - For ML experts

- **Sparkling Water**
  - Integrates H2O & Spark Ecosystems
  - Transparent for Spark users
  - Based on Spark pipelines & H2O

Basic ML Lifecycle: Sparkling Water



Example: Spark Pipeline

Start Sparkling Water

```
# Necessary PySparkling imports
from pysparkling import *
from pysparkling.ml import *
```

```
# Start H2O Context
hc = H2OContext.getOrCreate(spark)
```

```
Connecting to H2O server at http://172.30.43.36:54321... successful.
```

Create the Pipeline

```
# Filter out the outliers
from pyspark.ml.feature import SQLTransformer
removeOutliers = SQLTransformer(
    statement="SELECT * FROM __THIS__ WHERE nrows_train > 100")
```

```
# Define the H2O AutoML pipeline stage for Spark pipeline
from pysparkling.ml import *
algoStage = H2OAutoML(
                  maxRuntimeSecs=60, # 1 minute
                  seed=1,
                  convertUnknownCategoricalLevelsToNa=True,
                  predictionCol="t_total")
```

```
# Define the Spark pipeline
from pyspark.ml import Pipeline, PipelineModel
pipeline = Pipeline(stages=[removeOutliers, algoStage])
```

Export the Pipeline

```
# Convert data to Spark frame from H2O frame
train_spark_frame = hc.as_spark_frame(fr)
train_spark_frame
```

```
DataFrame[GPU: string, sys_CPU: tinyint, sys_GPU: tinyint, config_accu: tinyint, config_time: tinyint, config_MLI: ti
nyint, nrows_train: int, ncols_train: smallint, target_binary_dist: double, target_nclasses: smallint, recipe_individ
uals: tinyint, train_data_size: bigint, weight: tinyint, t_total: double]
```

```
# Train the pipeline model
model = pipeline.fit(train_spark_frame)
```

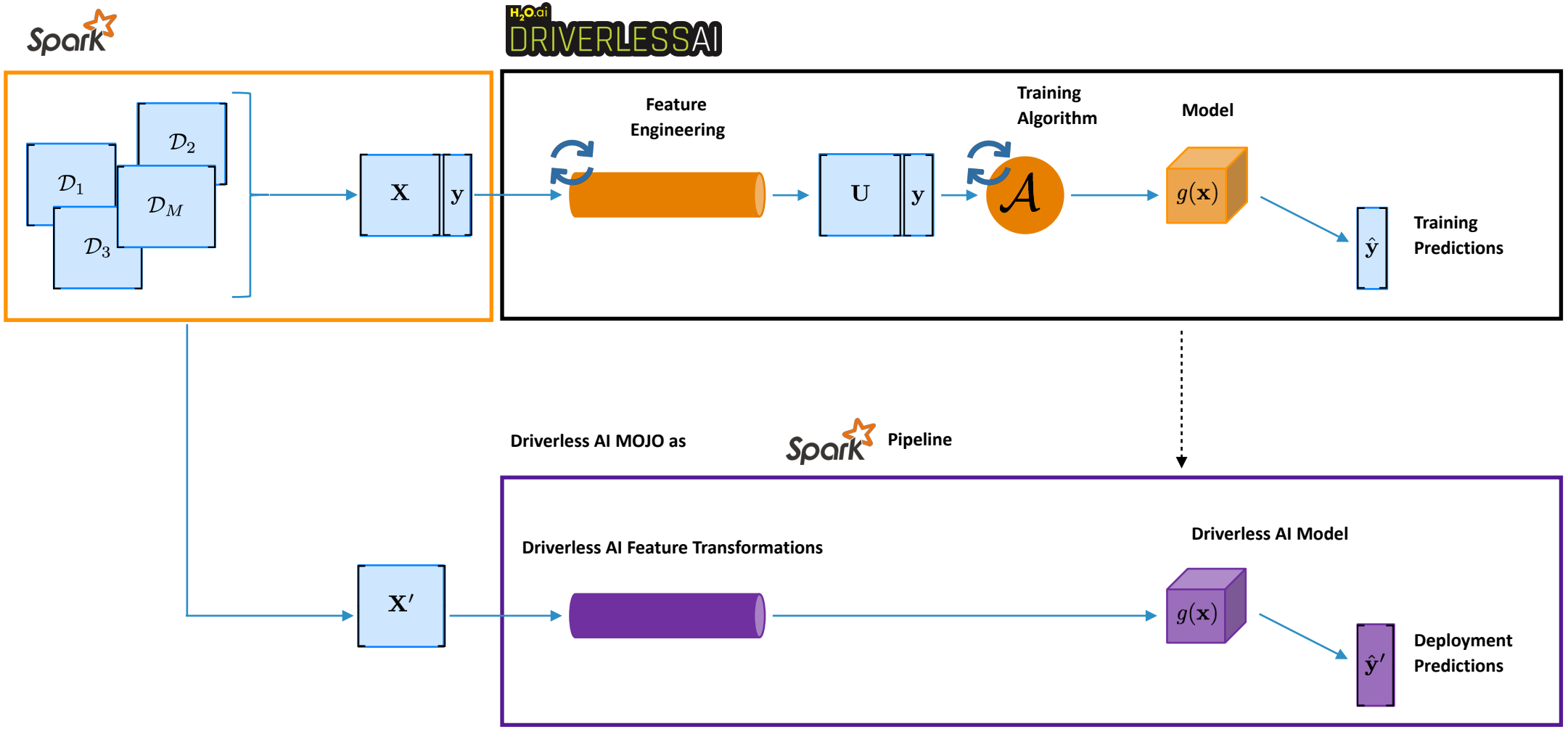
```
# Export the Pipeline Model
model.write().overwrite().save("spark.pipeline")
```

H2O Driverless AI

H2O Driverless AI

- What if I’m not expert ?
  - H2O Driverless AI
- H2O Driverless AI
  - No expert knowledge required
  - Automatic **Feature Engineering** & ML

Basic ML Lifecycle: Driverless AI



Example: Driverless AI as Spark Pipeline

H2O.ai Experiment

DRIVERLESS AI 1.1.3 — AI TO DO AI
Licensed to H2O.ai (SN21647)

What do these settings mean?

ACCURACY
- Training data size: **4,000 rows, 25 cols** (sampled)
- Feature evolution: **XGBoost**, **1/3 validation split, 2 reps**
- Final pipeline: **XGBoost, 4-fold CV**

TIME
- Feature evolution: **8 individuals**, up to **500 iterations**
- Early stopping: After **50** iterations of no improvement

INTERPRETABILITY
- Feature pre-pruning strategy: None
- Monotonicity constraints: disabled
- Feature engineering search space (where applicable):
['Clustering', 'Date', 'FrequencyEncoding', 'Identity', 'Interactions', 'TargetEncoding', 'Text', 'TruncatedSVD', 'WeightOfEvidence']

XGBoost models to train:
- Feature evolution: **4024**
- Final pipeline: **1**

Estimated max. total memory usage:
- Feature engineering: **8.0MB**
- GPU XGBoost: **1.2GB**

Estimated runtime: **20 minutes**

TRAINING DATA

DATASET
train.csv

ROWS	COLUMNS	DROPPED COLS	VALIDATION DATASET	TEST DATASET
24K	25	--	--	--

TARGET COLUMN
default payment next

FOLD COLUMN
--

WEIGHT COLUMN
--

TIME COLUMN
[OFF]

TYPE	COUNT	UNIQUE	TARGET FREQ
int	23999	2	18630

EXPERIMENT SETTINGS HELP

CLASSIFICATION | REPRODUCIBLE | ENABLE GPUS

SCORER
GINI
MCC
F05
F1
F2
ACCURACY
LOGLOSS
AUC
AUCPR

LAUNCH EXPERIMENT

H2O.ai Experiment wavuliwu

DRIVERLESS AI 1.5.4 – AI TO DO AI
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TRAINING DATA

ASSISTANT

DATASET
Engine_6988_494b344516674125abd1b4673ff39b

ROWS	COLUMNS	DROPPED COLS	VALIDATION DATASET	TEST DATASET
24K	25	0	--	Yes
				Engine_6988_9c1a007

TARGET COLUMN
default payment next

FOLD COLUMN
--

WEIGHT COLUMN
--

TIME COLUMN
[OFF]

TYPE	COUNT	UNIQUE	TARGET FREQ
bool	24000	2	5265

STATUS: COMPLETE

- INTERPRET THIS MODEL
- DIAGNOSE MODEL ON NEW DATASET...
- SCORE ON ANOTHER DATASET
- TRANSFORM ANOTHER DATASET...
- DOWNLOAD PREDICTIONS
- DOWNLOAD PYTHON SCORING PIPELINE
- BUILD MOJO SCORING PIPELINE
- DOWNLOAD EXPERIMENT SUMMARY
- DOWNLOAD LOGS

EXPERIMENT SETTINGS

EXPERT SETTINGS

ACCURACY	TIME	INTERPRETABILITY
1	1	10

CLASSIFICATION | REPRODUCIBLE | ENABLE GPUS

SCORER: GINI | MCC | F05 | F1 | F2 | ACCURACY | LOGLOSS | AUC | AUCPR

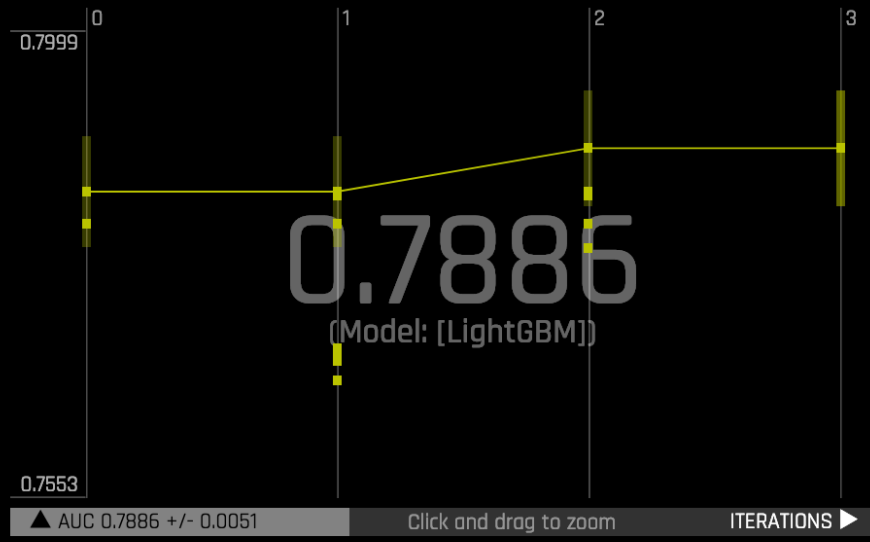
CPU / MEMORY

Notifications Log Trace

CPU

MEM

ITERATION DATA - VALIDATION



VARIABLE IMPORTANCE

4_Freq:PAY_0	1.00
21_PAY_0	0.88
44_Freq:PAY_0:PAY_2	0.68
22_PAY_2	0.41
38_CVTE:PAY_2.0	0.31
12_BILL_AMT1	0.30
23_PAY_3	0.29
19_LIMIT_BAL	0.24
27_PAY_AMT1	0.24
29_PAY_AMT3	0.22
43_CVCatNumEnc:LIMIT_BAL:PAY_AMT5.sd	0.21
28_PAY_AMT2	0.20
34_CVTE:PAY_4.0	0.20
14_BILL_AMT3	0.20

ROC P-R LIFT GAINS K-S SUMMARY

Experiment: wavuliwu, 2019-02-21 02:24, 1.5.4
Settings: 1/1/10, seed=265172352, GPUs enabled
Train data:
Engine_6988_494b344516674125abd1b4673ff39b13_.daiplugin.csv (24000, 25)
Validation data: N/A
Test data:
Engine_6988_9c1a0076c6d2491b898c5f1a5ab4566a_.daiplugin.csv (5700, 24)
Target column: default payment next month (binary, 21.938% target class)
System specs: Docker/Linux, 240 GB, 32 CPU cores, 4/4 GPUs
Max memory usage: 1.52 GB, 1.49 GB GPU
Recipe: AutoDL (2 iterations, 8 individuals)
Validation scheme: stratified, 1 internal holdout
Feature engineering: 87 features scored (32 selected)
Timing:
Data preparation: 2.70 secs
Model and feature tuning: 5.42 secs (4 models trained)
Feature evolution: 15.43 secs (11 of 18 models trained)
Final pipeline training: 7.05 secs (1 model trained)
Python / MOJO scorer building: 11.53 secs / 0.00 secs
Validation score: AUC = 0.78451 +/- 0.0051346 (baseline)
Validation score: AUC = 0.78865 +/- 0.0050898 (final pipeline)

H2O.ai Experiment wavuliwu

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TRAINING DATA

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TARGET COLUMN
default payment next

FOLD COLUMN
--

WEIGHT COLUMN
--

TIME COLUMN
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EXPERIMENT SETTINGS

EXPERT SETTINGS

ACCURACY	TIME	INTERPRETABILITY
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CLASSIFICATION | REPRODUCIBLE | ENABLE GPUS

SCORER: GINI, MCC, F05, F1, F2, ACCURACY, LOGLOSS, AUC, AUCPR

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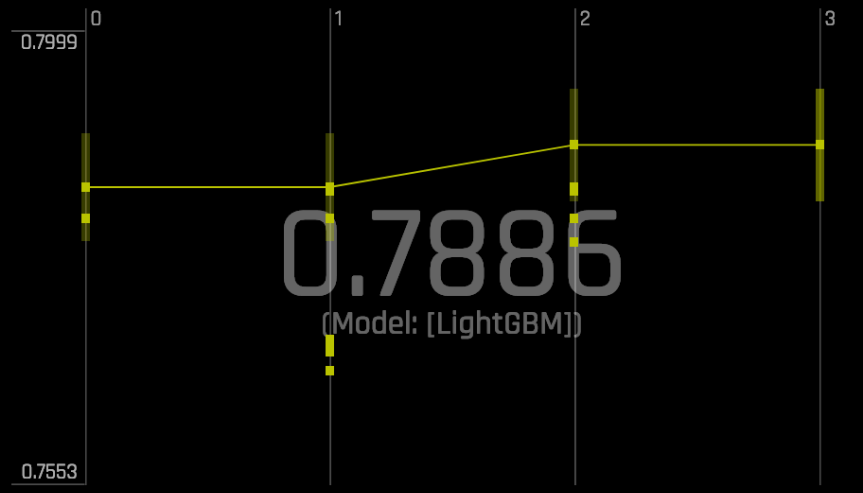
CPU

MEM

ITERATION DATA - VALIDATION



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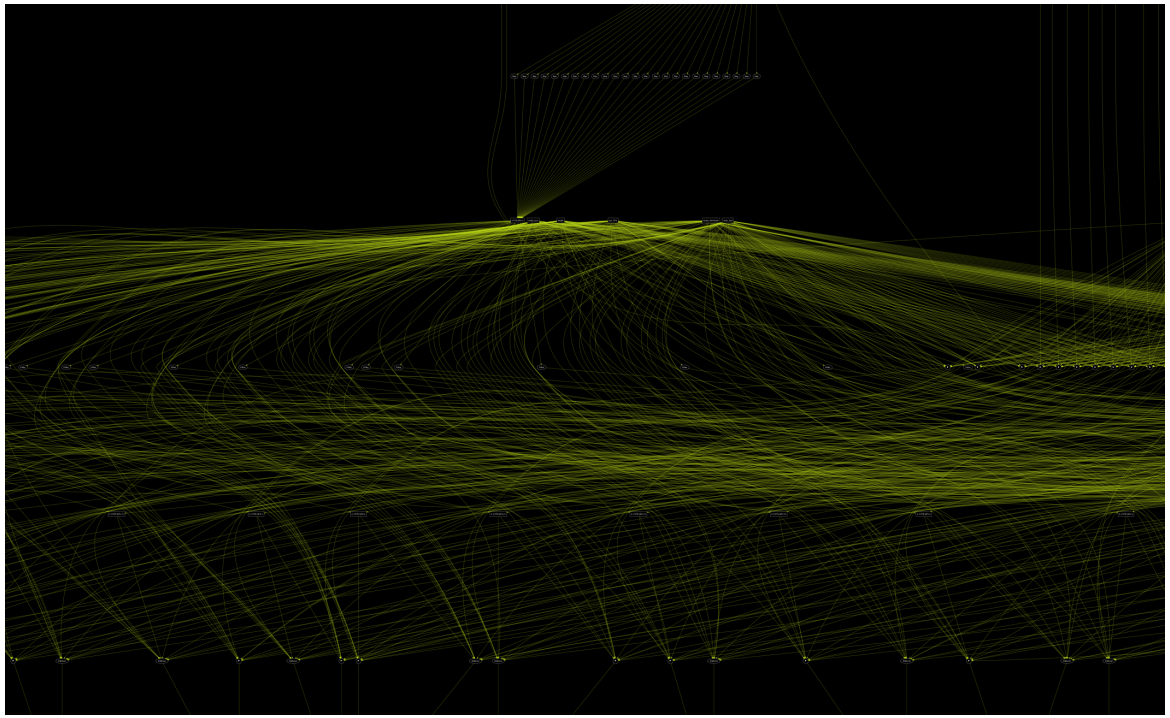
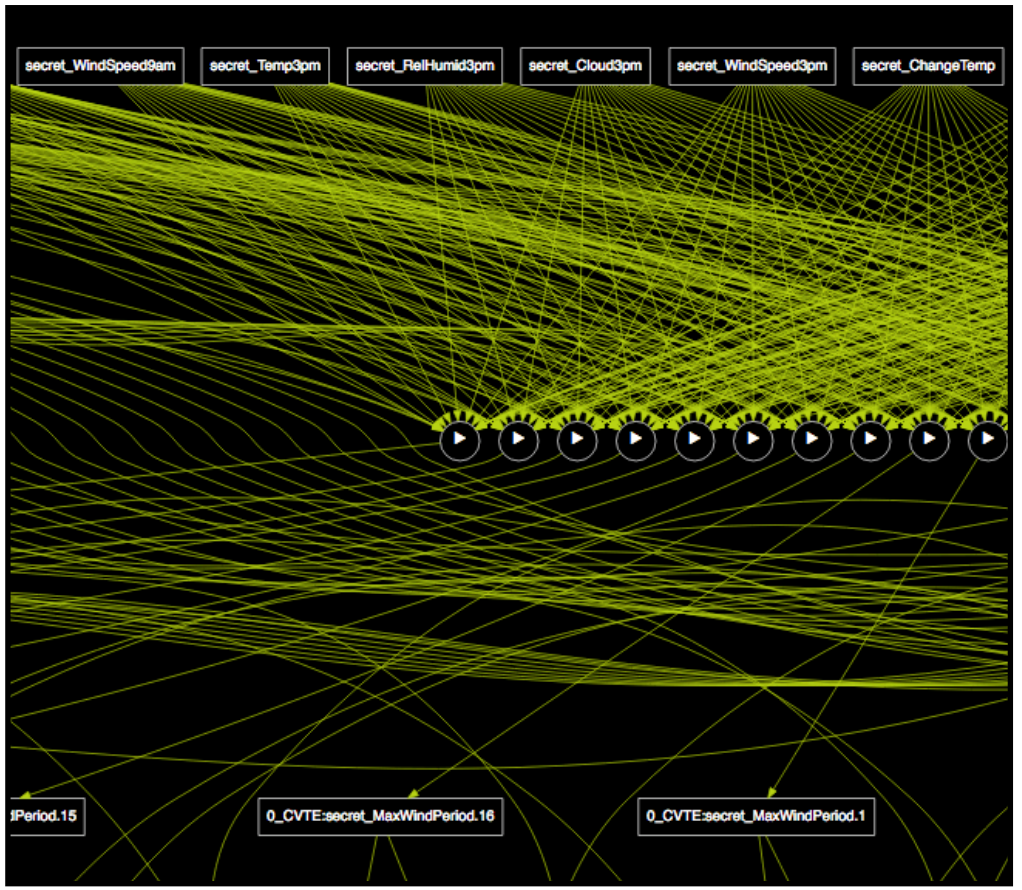
Driverless AI Pipeline





Example: Deployment

Load The MOJOs

```
spark = SparkSession.builder.getOrCreate()
spark.sparkContext.setLogLevel("OFF")

# Add sparkling water to all spark executors
Initializer.load_sparkling_jar(spark)

mojo1 = PipelineModel.load(sys.argv[2])
print("Spark Pipeline Loaded")

mojo2 = H2OMOJOPipelineModel.create_from_mojo(sys.argv[1])
print("Driverless AI as Spark Pipeline Loaded")
```

Define Schema

```
schema = StructType([
 StructField("ID", StringType(), True),
 StructField("GPU", StringType(), True),
 StructField("sys_CPU", DoubleType(), True),
 StructField("sys_GPU", DoubleType(), True),
 StructField("config_accu", DoubleType(), True),
 StructField("config_time", DoubleType(), True),
 StructField("config_MLI", DoubleType(), True),
 StructField("nrows_train", DoubleType(), True),
 StructField("ncols_train", DoubleType(), True),
 StructField("target_binary_dist", DoubleType(), True),
 StructField("target_nclasses", DoubleType(), True),
 StructField("recipe_individuals", DoubleType(), True),
 StructField("train_data_size", DoubleType(), True),
 StructField("weight", IntegerType(), True)])
```

Define Input Stream

```
input_data_stream = spark.readStream.schema(schema).csv("s3a://h2o-world-sf-streaming-data/*.csv")
```

Run the Transformations

```
input_data_stream = spark.readStream.schema(schema).csv("s3a://h2o-world-sf-streaming-data/*.csv")
```

```
output_data_stream_1 = mojo1.transform(input_data_stream)
output_data_stream_2 = mojo2.transform(input_data_stream)
```

Store the Result

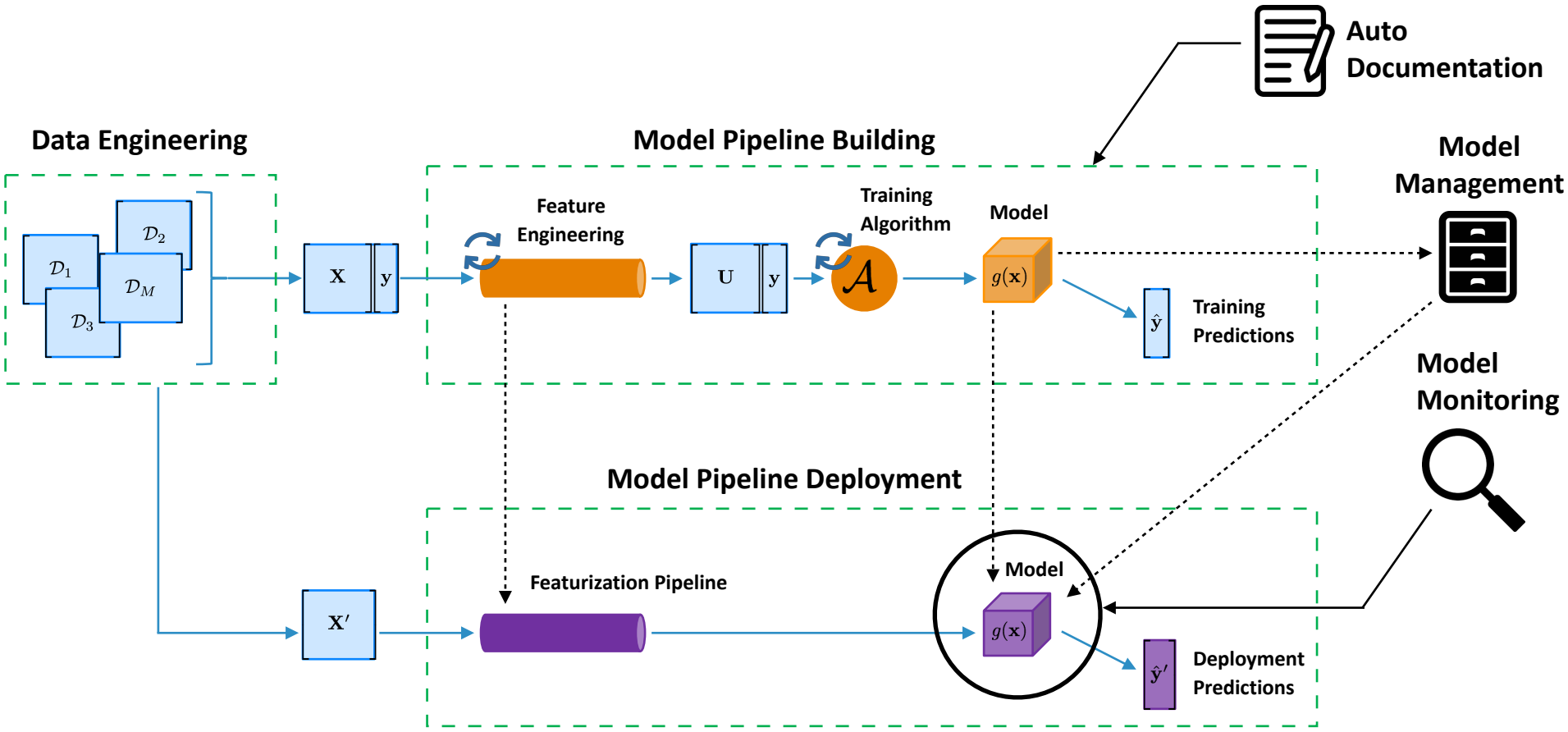
```
input_data_stream = spark.readStream.schema(schema).csv("s3a://h2o-world-sf-streaming-data/*.csv")
```

```
output_data_stream_1 = mojo1.transform(input_data_stream)
output_data_stream_2 = mojo2.transform(input_data_stream)
```

```
output_data_stream_1.writeStream.format("memory").queryName("spark").start()
output_data_stream_2.writeStream.format("memory").queryName("dai").start()
```

Governed ML Lifecycle

Governed ML Lifecycle



Materials

https://bit.ly/2RCStWM

Thank you!

Sparkling Water enables deployment of H2O ML models with Spark Pipelines