Running MATLAB Machine Learning Jobs in Amazon SageMaker

Dr. Shun Mao, AWS
Gandharv Kashinath, MathWorks
Agenda

- Engineering applications and Machine Learning
- Designing a Pump Health Monitoring System
- Machine Learning using MATLAB in Amazon SageMaker (demo)
- Amazon Sagemaker Highlights
Agenda

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  - Designing a Pump Health Monitoring System
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Popular Machine Learning applications with MATLAB and Simulink

Solution is too complex for handwritten rules or equations

- Speech Recognition
- Object Recognition
- Engine Health Monitoring

learn complex non-linear relationships

Solution needs to adapt with changing data

- Weather Forecasting
- Energy Load Forecasting
- Stock Market Prediction

update as more data becomes available

Solution needs to scale

- IoT Analytics
- Taxi Availability
- Airline Flight Delays

learn efficiently from very large data sets
Typical Machine Learning Workflow

Access Input Data
- Files
- Databases
- Sensors

Pre-Processing
- Working with Messy Data
- Data Reduction/Transformation
- Feature Extraction

Model Training
- Model Creation e.g. Machine Learning
- Parameter Optimization
- Model Validation

Model deploy and testing
- Desktop Apps
- Enterprise Scale Systems
- Embedded Devices and Hardware
Agenda

- Engineering applications and Machine Learning

- Designing a Pump Health Monitoring System
  - Machine Learning using MATLAB in Amazon SageMaker (demo)

- Amazon Sagemaker Highlights
Designing a pump health monitoring system at a manufacturing facility

- Alex is an automation engineer working at a car manufacturing facility.
- He is tasked with producing a ML solution to monitor the health of the cooling system at the facility.
- One of the critical systems is a coolant pump, which has measurements of Pressure, Flow Rate, and Motor RPM.

Sensor outputs streaming over time.

Health status determined from outputs.

Cooling system

Pressure

Flow Rate

Motor RPM

Normal (No Fault)

Leak Fault

Blocking Fault

Bearing Fault

My job is to keep the factory cool.

My job is to keep the cooling system working.

Monitor, take action!
Coolant pump modeled in Simulink to create synthetic data for training a machine learning model to predict fault states.

**Simulink pump model**

**Numerical features extracted from time-series data**

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**Access Input Data**

**Pre-Processing**

**Model Training**

**Model deploy and testing**
Machine Learning models trained and tuned to predict fault codes using sensor measurements

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**Random Forest classification model**

Access Input Data

Pre-Processing

Model Training

Model deploy and testing

Pressure

Flow Rate

Motor RPM

Normal (No Fault)

Leak Fault

Blocking Fault

Bearing Fault
Using MATLAB in the Cloud via Amazon Sagemaker makes it easy to monitor the health of the cooling system

Sensor readings are uploaded to the cloud using kafka framework

Model is trained in SageMaker

Model is deployed to SageMaker end-point

Outputs cooling system health predictions to dashboard

Human in the loop annotates labels showing fault states, uploads latest labeled dataset

Access Input Data

Pre-Processing

Model Training

Model deploy and testing

Amazon S3

MATLAB WebApp Server

Apache kafka

Sensor readings are uploaded to the cloud using kafka framework
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DEMO

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## Amazon SageMaker

A comprehensive machine learning platform for virtually any data and ML use cases

<table>
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<tr>
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<th>Demand forecasting</th>
<th>Fraud detection</th>
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<tr>
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<td>Retail, consumer goods, manufacturing</td>
<td>Financial services, online retail</td>
</tr>
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<td>Credit risk prediction</td>
<td>Extract and analyze data from documents</td>
<td>Computer vision</td>
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<tr>
<td>Financial services, retail</td>
<td>Healthcare, legal, media/ent, education</td>
<td>Healthcare, pharma, manufacturing</td>
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<td>Autonomous driving</td>
<td>Personalized recommendations</td>
<td>Churn prediction</td>
</tr>
<tr>
<td>Automotive, transportation</td>
<td>Media and entertainment, retail, education</td>
<td>Retail, education, software and internet</td>
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Tens of thousands of customers use Amazon SageMaker
Amazon SageMaker Key feature tour

**Prepare Input Data**
- Geospatial: Visualize geospatial data
- Ground Truth: Create high quality datasets for ML
- Data Wrangler: Aggregate and prepare data for ML
- Feature Store: Store, catalog, search, and reuse features

**Processing**
- Studio Notebooks & Notebook Instances: Fully managed Jupyter notebooks with elastic compute
- Studio Lab: Free ML development environment
- Processing: Built-in Python, BYO R/Spark
- JumpStart: UI-based discovery, training, and deployment of models, solutions, and examples

**Model Training**
- Fully Managed Training: Broad hardware options, easy to setup and scale
- Distributed Training Libraries: High performance training for large datasets and models
- Training Compiler: Faster deep learning model training
- Automatic Model Tuning: Hyperparameter optimization
- Managed Spot Training: Reduce training cost by up to 90%
- Bring Your Own: Bring your own container and algorithms

**Model deploy and testing**
- Fully Managed Deployment: Ultra low latency, high throughput inference
- Real-Time Inference: For steady traffic patterns
- Serverless Inference: For intermittent traffic patterns
- Asynchronous Inference: For large payloads or long processing times
- Batch Transform: For offline inference on batches of large datasets
- Multi-Model Endpoints: Reduce cost by hosting multiple models per instance
- Multi-Container Endpoints: Reduce cost by hosting multiple containers per instance
- Shadow Testing: Validate model performance in production
- Inference Recommender: Automatically select compute instance and configuration
- Model Monitor: Maintain accuracy of deployed models

MLOps: Pipelines | Projects | Model Registry
Canvas: Generate accurate machine learning predictions—no code required
Studio | RStudio: Integrated development environment (IDE) for ML
Governance: Model Cards | Dashboard | Permissions

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Summary

- MATLAB is the best-in-class ML tool for engineering systems
- Amazon Sagemaker platform can be used for any ML and data use cases
- Leverage MATLAB in Amazon Sagemaker for your data and ML use cases
Reach out to us if you want to run MATLAB in Amazon SageMaker

cloud@mathworks.com

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Gandharv Kashinath, MathWorks
Thank you