Predictive Analytics with Amazon SageMaker

Steve Shirkey
Specialist SA, AWS (Singapore)
Explosion in AI and ML Use Cases

- Image recognition and tagging for photo organization
- Object detection, tracking and navigation for Autonomous Vehicles
- Speech recognition & synthesis in Intelligent Voice Assistants
- Algorithmic trading strategy performance improvement
- Sentiment analysis for targeted advertisements
Welcome to Amazon.com Books!

One million titles, consistently low prices.

(If you explore just one thing, make it our personal notification service. We think it's very cool!)

~1997

SPOTLIGHT! -- August 16th
These are the books we love, offered at Amazon.com low prices. The spotlight moves EVERY day so please come often.

ONE MILLION TITLES
Search Amazon.com's million title catalog by author, subject, title, keyword, and more... Or take a look at the books we recommend in over 20 categories... Check out our customer reviews and the award winners from the Hugo and Nebula to the Pulitzer and Nobel... and bestsellers are 30% off the publishers list...

EYES & EDITORS, A PERSONAL NOTIFICATION SERVICE
Like to know when that book you want comes out in paperback or when your favorite author releases a new title? Eyes, our tireless, automated search agent, will send you mail. Meanwhile, our human editors are busy previewing galleys and reading advance reviews. They can let you know when especially wonderful works are published in particular genres or subject areas. Come in, meet Eyes, and have it all explained.

YOUR ACCOUNT
Check the status of your orders or change the email address and password you have on file with us. Please note that you do not need an account to use the store. The first time you place an order, you will be given the opportunity to create an account.
Thousands of Amazon Engineers Focused on Machine Learning

Fulfillment & logistics  
Search & discovery  
Existing products  
New products  
At AWS
Over 20 years of AI at Amazon…

- Applied research
- Core research
- Alexa
- Demand forecasting
- Risk analytics
- Search
- Recommendations
- AI services

- Q&A systems
- Supply chain optimization
- Advertising
- Machine translation
- Video content analysis
- Robotics
- Lots of computer vision…
- NLP/NLU
ML @ AWS

OUR MISSION

Put machine learning in the hands of every developer and data scientist
Customers Running Machine Learning On AWS Today
The Amazon Machine Learning Stack

**APPLICATION SERVICES**
- Rekognition
- Transcribe
- Translate
- Polly
- Comprehend
- Lex

**PLATFORM SERVICES**
- Amazon SageMaker
- Amazon EMR (Spark ML)
- Amazon Mechanical Turk
- AWS DeepLens

**FRAMEWORKS & INTERFACES**
- AWS Deep Learning AMIs
- Caffe2
- CNTK
- Apache MXNet
- PyTorch
- TensorFlow
- Chainer
- Keras
- Gluon
Let’s Review the ML Process
The Machine Learning Process

- Business Problem
- ML problem framing
- Data Collection
  - Data Integration
  - Data Preparation & Cleaning
  - Data Visualization & Analysis
- Feature Engineering
- Model Training & Parameter Tuning
- Model Evaluation
- Are Business Goals met?
  - Yes
    - Model Deployment
  - No
    - Feature Augmentation
    - Data Augmentation
    - Re-training
- Monitoring & Debugging
- Predictions
Business Problem – ML problem framing

Data Collection → Data Integration
Data Integration → Data Preparation & Cleaning
Data Preparation & Cleaning → Data Visualization & Analysis

Data Augmentation:
- Help formulate the right questions
  - Domain Knowledge

Feature Engineering → Model Training & Parameter Tuning
Model Training & Parameter Tuning → Model Evaluation
Model Evaluation → Are Business Goals met?

Yes: Model Deployment
No: Re-training

Monitoring & Debugging → Predictions
Integration: The Data Architecture

1. Business Problem –
   - ML problem framing

2. Data Collection
   - Data Integration
     - Data Preparation & Cleaning
       - Data Visualization & Analysis
         - Feature Augmentation

3. Feature Engineering
   - Model Training & Parameter Tuning
     - Model Evaluation
       - Are Business Goals met?
         - Yes: Model Deployment
         - No: Retraining

4. Build the data platform:
   - Amazon S3
   - AWS Glue
   - Amazon Athena
   - Amazon EMR
   - Amazon Redshift
   - Spectrum

5. Monitoring & Debugging
   - Predictions
Why We built Amazon SageMaker: Model Training Undifferentiated Heavy Lifting

- Setup and manage Notebook Environments
- Setup and manage Training Clusters
- Write Data Connectors
- Scale ML algorithms to large datasets
- Distribute ML training algorithm to multiple machines
- Secure Model artifacts
Why We built Amazon SageMaker: **Model Deployment Undifferentiated Heavy Lifting**

**Business Problem** –

- Setup and manage Model Inference Clusters
- Manage and Scale Model Inference APIs
- Monitor and Debug Model Predictions
- Models versioning and performance tracking
- Automate New Model version promotion to production (A/B testing)
Amazon SageMaker
Amazon SageMaker

Easily build, train, and deploy machine learning models

1. Collect and prepare training data
2. Choose and optimize your ML algorithm
3. Set up and manage environments for training
4. Train and tune model (trial and error)
5. Deploy model in production
6. Scale and manage the production environment

© 2018 Amazon Web Services, Inc. or its Affiliates. All rights reserved.
Amazon SageMaker

Easily build, train, and deploy machine learning models

BUILD

- Pre-built notebooks for common problems
- Built-in, high performance algorithms
- Set up and manage environments for training
- Train and tune model (trial and error)
- Deploy model in production
- Scale and manage the production environment
Training ML Models Using Amazon SageMaker

SageMaker Built-in Algorithms

- k-Means Clustering
- PCA
- Neural Topic Modelling
- Factorisation Machines
- Linear Learner
- XGBoost
- Latent Dirichlet Allocation
- Image Classification
- Seq2Seq
- DeepAR Forecasting
- BlazingText (word2vec)
- Random Cut Forest
- k-Nearest Neighbor
- Object Detection
Training ML Models Using Amazon SageMaker

SageMaker Built-in Algorithms
- K-means Clustering
- PCA
- Neural Topic Modelling
- Factorisation Machines
- Linear Learner – Regression
- XGBoost
- Latent Dirichlet Allocation
- Image Classification
- Seq2Seq
- Linear Learner – Classification
- DeepAR Forecasting

Bring Your Own Algorithms
- ML Algorithms
- R
- MXNet
- TensorFlow
- Caffe
- PyTorch
- Keras
- CNTK
- ...

© 2018 Amazon Web Services, Inc. or its Affiliates. All rights reserved.
Training ML Models Using Amazon SageMaker

**SageMaker Built-in Algorithms**
- K-means Clustering
- PCA
- Neural Topic Modelling
- Factorisation Machines
- Linear Learner – Regression
- XGBoost
- Latent Dirichlet Allocation
- Image Classification
- Seq2Seq
- Linear Learner – Classification
- DeepAR Forecasting

**Bring Your Own Algorithms**
- ML Algorithms
- R
- MXNet
- TensorFlow
- Caffe
- PyTorch
- Keras
- CNTK
- ...

**SageMaker Framework SDKs**
- TensorFlow SDK
- MXNet (Gluon) SDK
- Chainer SDK
- PyTorch SDK

© 2018 Amazon Web Services, Inc. or its Affiliates. All rights reserved.
## Training ML Models Using Amazon SageMaker

### SageMaker Built-in Algorithms
- K-means Clustering
- PCA
- Neural Topic Modelling
- Factorisation Machines
- Linear Learner – Regression
- XGBoost
- Latent Dirichlet Allocation
- Image Classification
- Seq2Seq
- Linear Learner – Classification
- DeepAR Forecasting

### Bring Your Own Algorithms
- ML Algorithms
- R
- MXNet
- TensorFlow
- Caffe
- PyTorch
- Keras
- CNTK
- ...

### SageMaker Framework SDK
- TensorFlow SDK
- MXNet (Gluon) SDK
- Chainer SDK
- PyTorch SDK

### Apache Spark Estimator
- Apache Spark Python library
- Apache Spark Scala library

---

© 2018 Amazon Web Services, Inc. or its Affiliates. All rights reserved.
Amazon SageMaker

Easily build, train, and deploy machine learning models

**BUILD**

- Pre-built notebooks for common problems
- Built-in, high performance algorithms

**TRAIN**

- One-click training
- Hyperparameter tuning

**Deploy model in production**

**Scale and manage the production environment**
Amazon SageMaker

Easily build, train, and deploy machine learning models

**BUILD**
- Pre-built notebooks for common problems

**TRAIN**
- Built-in, high performance algorithms
- One-click training
- Hyperparameter tuning

**DEPLOY**
- One-click deployment
- Fully managed hosting with auto-scaling
Reference Architecture

**Prepare**
- SageMaker Notebooks
  - Raw Data
  - Prepared Data
- Amazon S3
  - Training Data

**Train & Optimise**
- Training Algorithm
  - HPO
- Algorithm Container
  - Trained Model
- SageMaker Training
  - Trained Model
- Amazon S3
  - Trained Model

**Deploy**
- Inference requests
- SageMaker Hosting
  - AWS Lambda
  - API Gateway
- User Interactions
Walkthrough: SageMaker Console
Amazon SageMaker Architecture
Model Training (on EC2)

Client application

Amazon SageMaker

Amazon ECR

Training data

Training code

Helper code

Model Training (on EC2)
Model Training (on EC2)

Amazon SageMaker

Amazon ECR

Training data

Model artifacts

Client application

Training code

Helper code

Inference code

© 2018 Amazon Web Services, Inc. or its Affiliates. All rights reserved.
Hyperparameter Tuning
# Hyperparameters

You can use hyperparameters to finely control training. We've set default hyperparameters for the algorithm you've chosen. [Learn more](#)

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mode</td>
<td>skipgram</td>
</tr>
<tr>
<td>min_count</td>
<td>5</td>
</tr>
<tr>
<td>window_size</td>
<td>5</td>
</tr>
<tr>
<td>negative_samples</td>
<td>5</td>
</tr>
<tr>
<td>epochs</td>
<td>5</td>
</tr>
<tr>
<td>vector_dim</td>
<td>100</td>
</tr>
<tr>
<td>batch_size</td>
<td>11</td>
</tr>
<tr>
<td>learning_rate</td>
<td>0.05</td>
</tr>
<tr>
<td>sampling_threshold</td>
<td>0.0001</td>
</tr>
<tr>
<td>evaluation</td>
<td>true</td>
</tr>
</tbody>
</table>
Option 1: Grid Search
#hyperparameter optimization

for C in C_values:
    for gamma in gamma_values:
        # train the model for every hyperparameter value pair
        svc = svm.SVC(C=C, gamma=gamma)
        svc.fit(X, y)
        score = svc.score(Xval, yval)

        # rate accuracy of the model using each hyperparam value pair
        if score > best_score:
            best_score = score
            best_params['C'] = C
            best_params['gamma'] = gamma
Option 2: Random Search

“Compared with neural networks configured by a pure grid search, we find that random search over the same domain is able to find models that are as good or better within a small fraction of the computation time.”

Bergstra, Bengio, “Random Search for Hyper-Parameter Optimization”
https://dl.acm.org/citation.cfm?id=2188395
# for a preset number of iterations
for i in range(10):
    # try random values for each hyperparameter
    svc = svm.SVC(C=randint(0, 9), gamma=randint(0, 3))
    svc.fit(X, y)
    score = svc.score(Xval, yval)

    if score > best_score:
        best_score = score
        best_params['C'] = C
        best_params['gamma'] = gamma
Option 3: Bayesian Optimization Papers

• A Tutorial on Bayesian Optimization of Expensive Cost Functions, with Application to Active User Modeling and Hierarchical Reinforcement Learning (https://arxiv.org/abs/1012.2599)


Hyperparameter Tuning in Amazon SageMaker

Amazon SageMaker’s Hyperparameter Tuning feature is based on an implementation of Bayesian Optimization, along with some additional optimizations.
Walkthrough: Hyperparameter Tuning
Additional Resources
Next Steps with Amazon SageMaker

• Getting started with Amazon SageMaker:
  • https://aws.amazon.com/sagemaker/

• Use the Amazon SageMaker SDK:
  • For Python: https://github.com/aws/sagemaker-python-sdk
  • For Spark: https://github.com/aws/sagemaker-spark

• SageMaker Code Samples / Workshops:
  • https://github.com/awslabs/amazon-sagemaker-examples
  • https://github.com/awslabs/amazon-sagemaker-workshop
Amazon ML Solutions Lab

Leverage Amazon experts with decades of ML experience with technologies like Amazon Echo, Amazon Alexa, Prime Air and Amazon Go

Amazon ML Solutions Lab provides ML expertise

Brainstorming  Modeling  Teaching
Make your data driven decisions count, and make a career in Big Data on AWS. Follow the Big Data Specialty learning path and become a specialist in Big Data:

- Implement core AWS Big Data services according to best practices
- Design and maintain Big Data
- Leverage tools to automate data analysis

Who should attend

- Enterprise solutions architects
- Big Data solutions architects
- Data scientists
- Data analysts

Visit www.aws.training to find out more

AWS Certified Big Data - Specialty

Big Data on AWS – 3-day Classroom Training

Free AWS digital training: Big Data Technology Fundamentals

Certified Cloud Practitioner

Associate-level Certification

Free AWS digital training: Foundational knowledge
Thank You For Attending
AWS Data Driven Decisions Webinar Series.

We hope you found it interesting! A kind reminder to complete the survey. Let us know what you thought of today’s event and how we can improve the event experience for you in the future.

aws-apac-marketing@amazon.com
twitter.com/AWSCloud
facebook.com/AmazonWebServices

google.com/user/AmazonWebServices
slideshare.net/AmazonWebServices
twitch.tv/aws