Unlocking the power of Machine Learning

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AI will change the way we do things

- Everybody will have a virtual assistant, and they’re going to be pretty smart
- All your voice-based gadgets will work together (and may get confused)

- Facial recognition will be the new credit card
- Your boss is going to start to talk about AI

- Artificial intelligence will generate media specific to your personal preferences
- Artificial intelligence will write news and market reports tailored specifically for you

- Your computer will become empathetic
- Your doctor is going to use AI
Machine Learning has driven Innovation

Robots mimic complex human behaviors

Sentiment Analysis in Finance

Electric Grid Load Forecasting

Restore Arm Control for Quadriplegic
Battelle Neural Bypass Technology Restores Movement to a Paralyzed Man’s Arm and Hand

Challenge
Restore arm and hand control to a quadriplegic man by processing signals from an electrode array implanted in his brain

Products Used
• MATLAB + Wavelet Toolbox

Approach
• Used MATLAB to analyze signal samples
• Generated compact feature vectors using wavelets – wavelets allowed the researchers to extract the important information from the signals for classification.
• Applied machine learning to classify patterns mapped to movements, and
• Generate actuation signals for a neuromuscular electrical stimulator

Results
▪ Control over paralyzed hand and arm restored
▪ Real-time processing performance achieved

“The algorithms we developed using MATLAB gave the participant back basic control of his arm and hand. By the end of the study, he could grip a bottle, pour out its contents, and set it down, as well as pick up a stir stick and execute a stirring motion.”

David Friedenberg
Battelle

Link to full user story
Outline

Machine Learning and its challenges

Developing a Heart Sound Classifier

Going beyond Machine Learning
Key takeaways

Empower engineers to be productive in data science!

- Cover complete workflow (exploration to deployment)
- Apps for Machine Learning
- Support for Deep Learning
Developing Machine Learning Applications

1. Access Data

   - Sensors
   - Various Protocols

2. Explore and Pre-Process

   - Diverse data
   - Clean messy data
   - Discover patterns

3. Extract Features

   - Domain Knowledge
   - Select Features

4. Train Models

   - Many Algorithms
   - Tune Parameters

5. Deploy

   - Different platforms
   - Size/Speed

MATLAB EXPO 2018
Outline

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Case Study: Heart Sound Classifier

Motivation

- Heart sounds require trained clinicians for diagnosis
- Lowered FDA requirements renewed interest

Goal: build a classifier and deploy in portable device

Data: Heart sound recordings (phonocardiogram):

- From PhysioNet Challenge 2016
- 5 to 120 seconds long audio recordings
Different Types of Learning

Machine Learning

Supervised Learning

Classification
Output is a choice between classes (Normal, Abnormal)

Regression
Output is a real number (temperature, stock prices)

Unsupervised Learning

Clustering
No output - find natural groups and patterns from input data only

Unsupervised Learning
Step 1: Access & Explore Data

Challenges
- Different sampling rates
- Signal Management
- Large datasets ("big data")

Easy Exploration of Data
- Time domain
- Frequency domain
- Time-Frequency domain

Signal Analyzer: Visual Data Exploration
Step 2: Pre-process Signals

Challenges
- Preserving sharp features
- Overlap of signal and noise spectra

Automatic Denoising

Generate MATLAB code
Step 3: Extract Features

Challenges
– Find features for non-stationary signals
– Features occurring at different scales
– Feature selection

Spectral features
– Mel-Frequency Cepstral
– Octave band decomposition with Wavelets
Step 4: Train Models

Challenges
- Knowledge of machine learning algorithms
- Scale to large data sets

Quickly train model in App
- Define cross-validation
- Try all popular algorithms
- Analyze performance 93% on test data

Scale to large data sets without recoding, “Tall” arrays

Model Training with Classification Learner
Step 4 Cont’d: Optimize Model

Challenges:
- Manual parameter tuning tedious
- Identify additional improvements
- Imbalanced data

<table>
<thead>
<tr>
<th>Class</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>75%</td>
</tr>
<tr>
<td>Abnormal</td>
<td>25%</td>
</tr>
</tbody>
</table>

Iterative Model Optimization
- Bayesian Optimization of parameters
- Visually analyze performance
- Adjust for imbalances (data or severity of misclassifications)
Step 5: Deploy

MATLAB

MATLAB Compiler
MATLAB Compiler SDK
MATLAB Coder

Enterprise Systems

Embedded Hardware

MATLAB EXPO 2018
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Beyond Machine Learning: Deep Learning

Supervised Classification using Neural Nets with many layers

1. Convolutional Neural Networks (CNN)
   - A versatile and flexible approach for Deep Learning
   - Apply to signals by converting to time-frequency representation:

2. Long short-term memory networks (LSTM)
Apply Deep Learning to Heart Sound Classifier

Steps
- Signal ➔ Time-Frequency
- Continuous Wavelet Transform
- Transfer Learning with GoogLeNet

Results
- Achieves 90% accuracy
- Just 10 lines of code
Summary: Making Machine Learning Easier

1. Access Data
   Support for industrial sensors, phones, etc.

2. Explore and Pre-Process
   Visual Exploration

3. Extract Features
   Wavelets Feature Selection

4. Train Models
   Automatically compare models in App
   Automatically tune parameters
   Explore Deep Learning

5. Deploy
   Automatically Generate C/CUDA Code
Learn More

Complete user story for Battelle’s “NeuroLife” system

Download Heart Sounds Classification application from File Exchange

Watch “Machine Learning Using Heart Sound Classification”

Read:

– Machine Learning with MATLAB
– What is Deep Learning?
Key takeaways

Empower engineers to be productive in data science!

- Cover complete workflow (exploration to deployment)
- Make machine learning easy
- Support for Deep Learning