MATLAB EXPO 2018

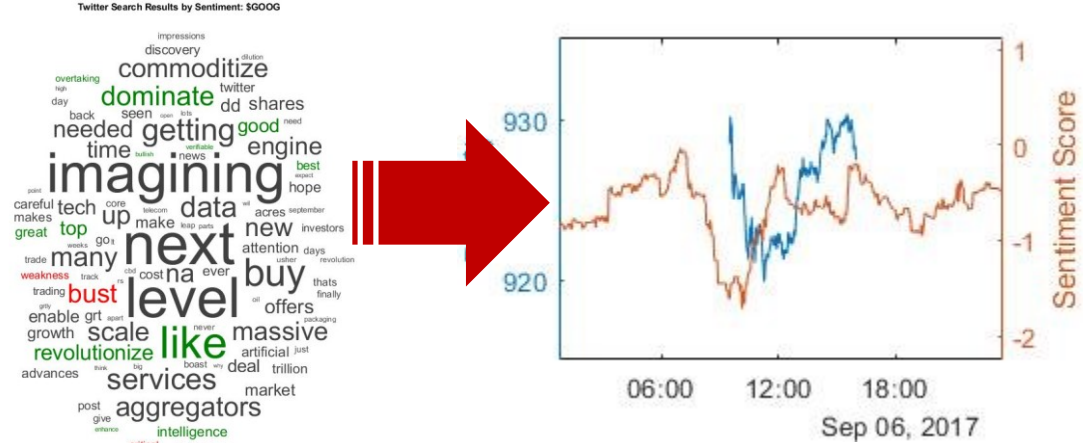## Unlocking the Power of Machine Learning
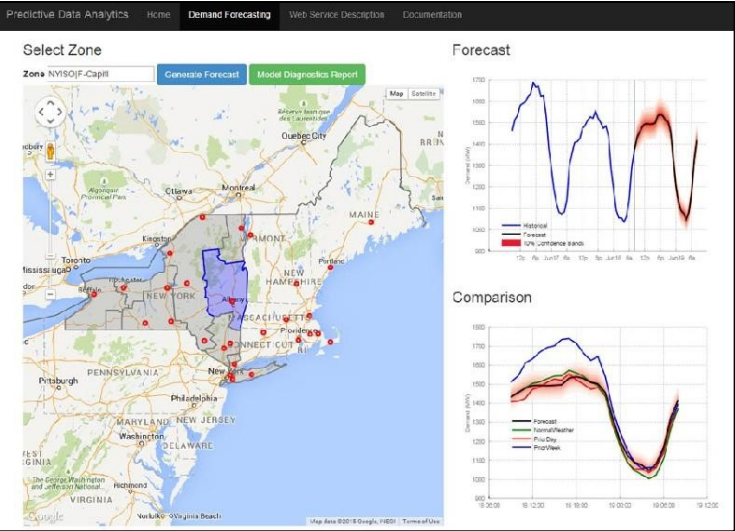
Antti Löytynoja

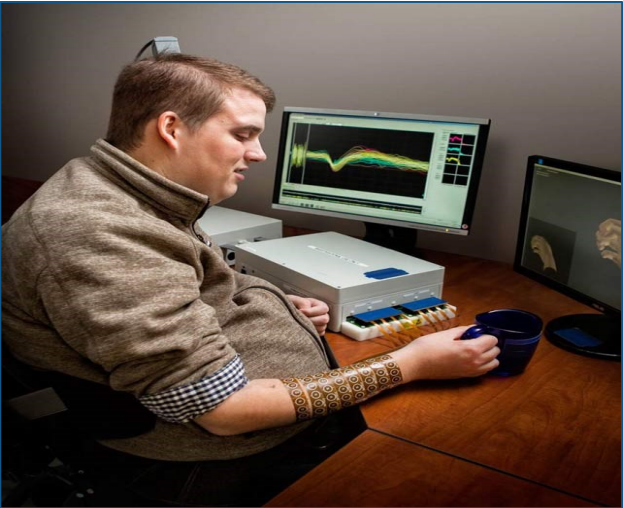# Machine Learning has driven Innovation

Robots mimic complex human behaviors

Sentiment Analysis in Finance

Electric Grid Load Forecasting

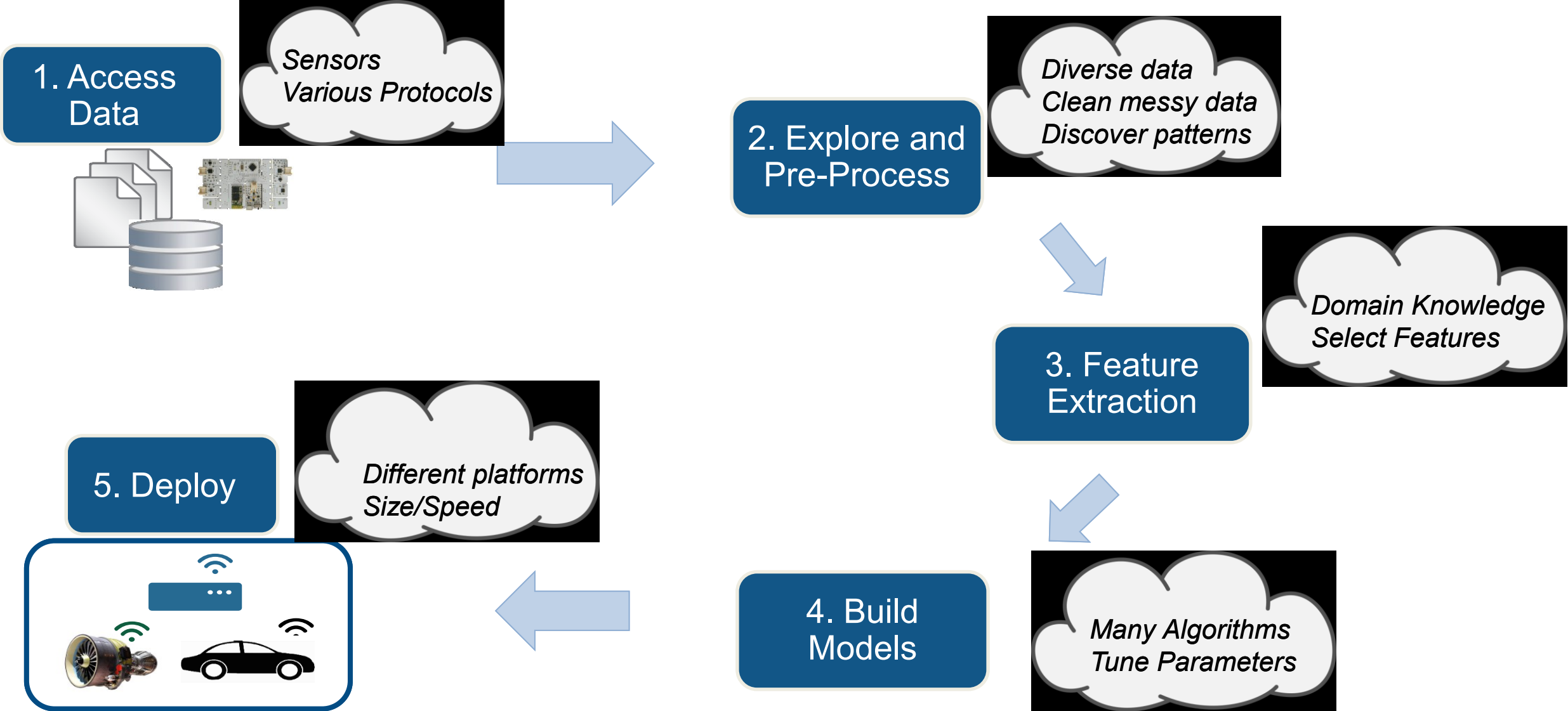Restore Arm Control for Quadriplegic

Outline

- Machine Learning workflow and its challenges
- Overview of Types of Machine Learning
- Developing a Heart Sound Classifier

Key takeaways

- – Cover complete workflow (exploration to deployment)
- – Make data exploration easy
- – Make machine learning easy

Challenges in Developing Machine Learning Applications

1. Access Data

Sensors
Various Protocols

2. Explore and Pre-Process

Diverse data
Clean messy data
Discover patterns

3. Feature Extraction

Domain Knowledge
Select Features

4. Build Models

Many Algorithms
Tune Parameters

5. Deploy

Different platforms
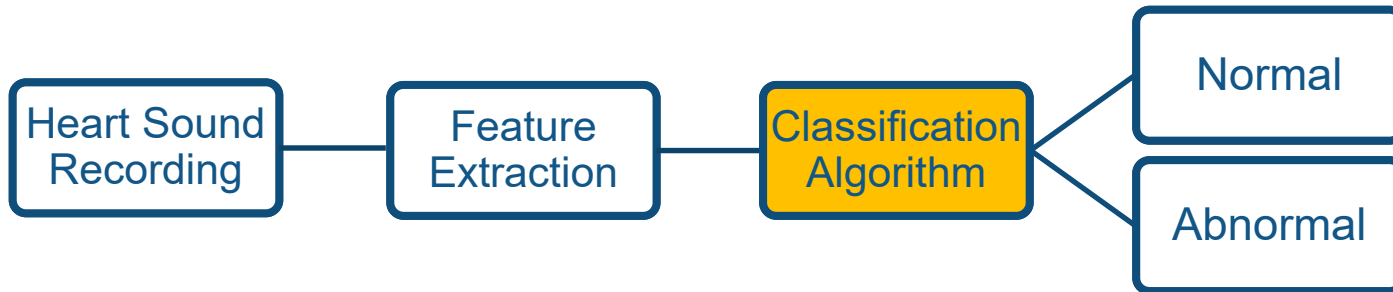*Size/Speed*

MATLAB EXPO 2018

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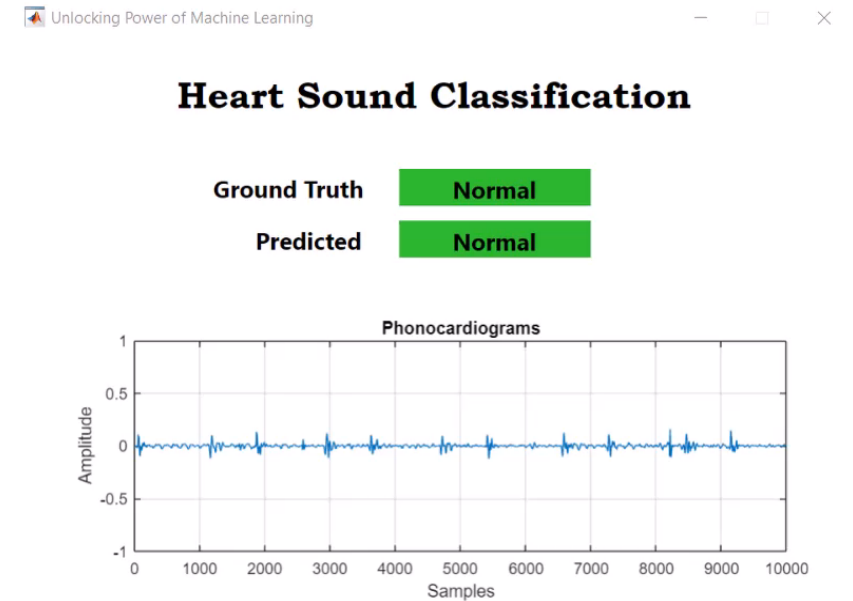# Case Study: Heart Sound Classifier

Motivation

– Heart sounds require trained clinicians for diagnosis

– Lowered FDA requirements renewed interest

– Digital Health applications

Goal: build a classifier and deploy in portable device

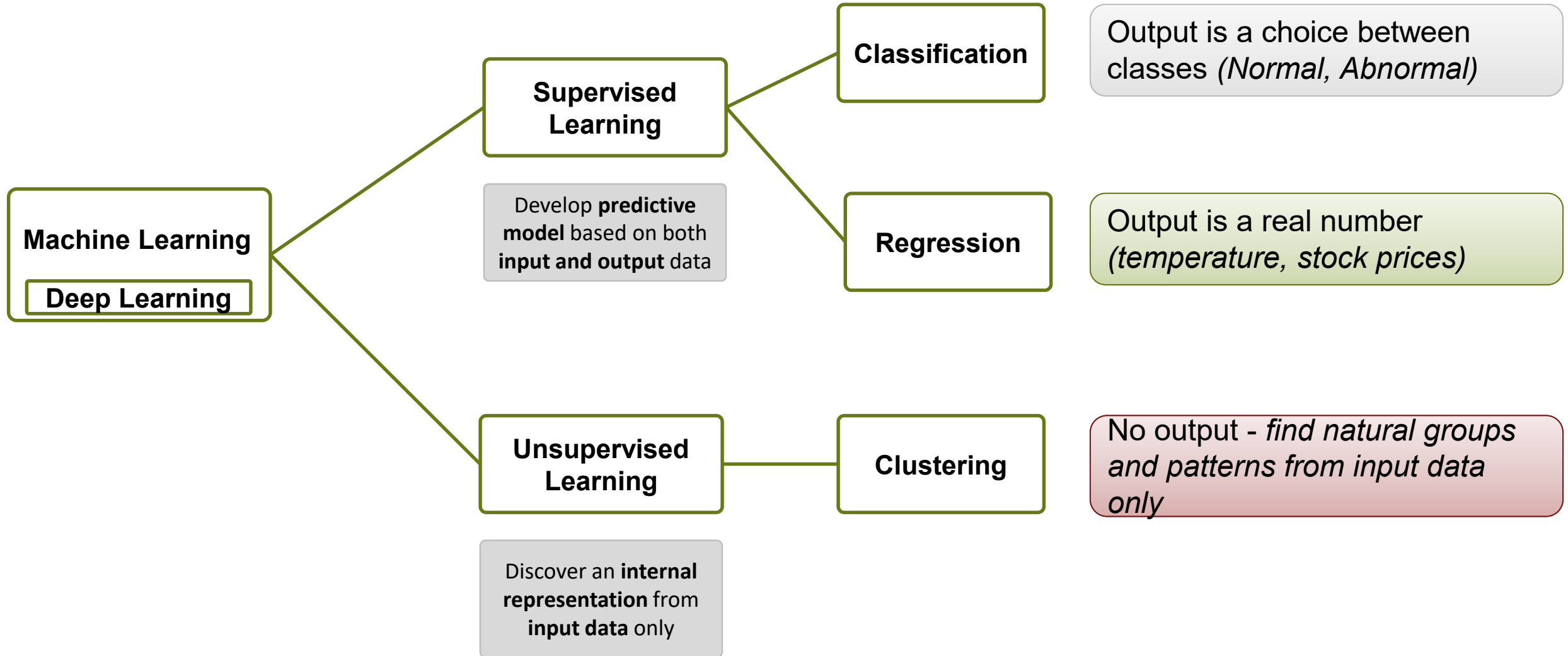

Data: Heart sound recordings (phonocardiogram):

– From PhysioNet Challenge 2016

– 5 to 120 seconds long audio recordings

Different Types of Learning

Type of Learning

Categories of Algorithms

Machine Learning

Deep Learning

Supervised Learning

Develop **predictive model** based on both **input and output** data

Classification

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

Regression

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

Unsupervised Learning

Discover an **internal representation** from **input data** only

Clustering

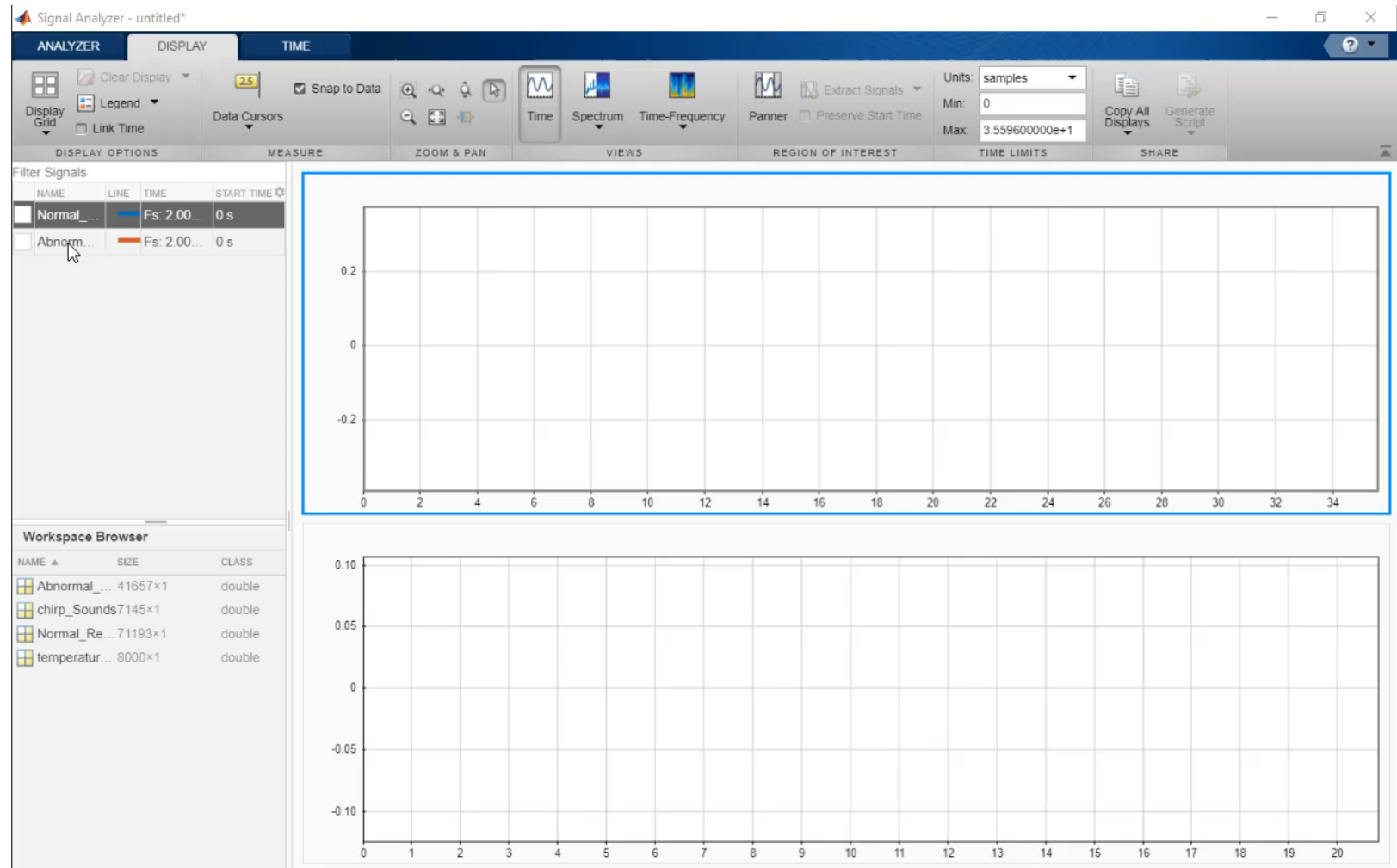No output - *find natural groups and patterns from input data only*

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

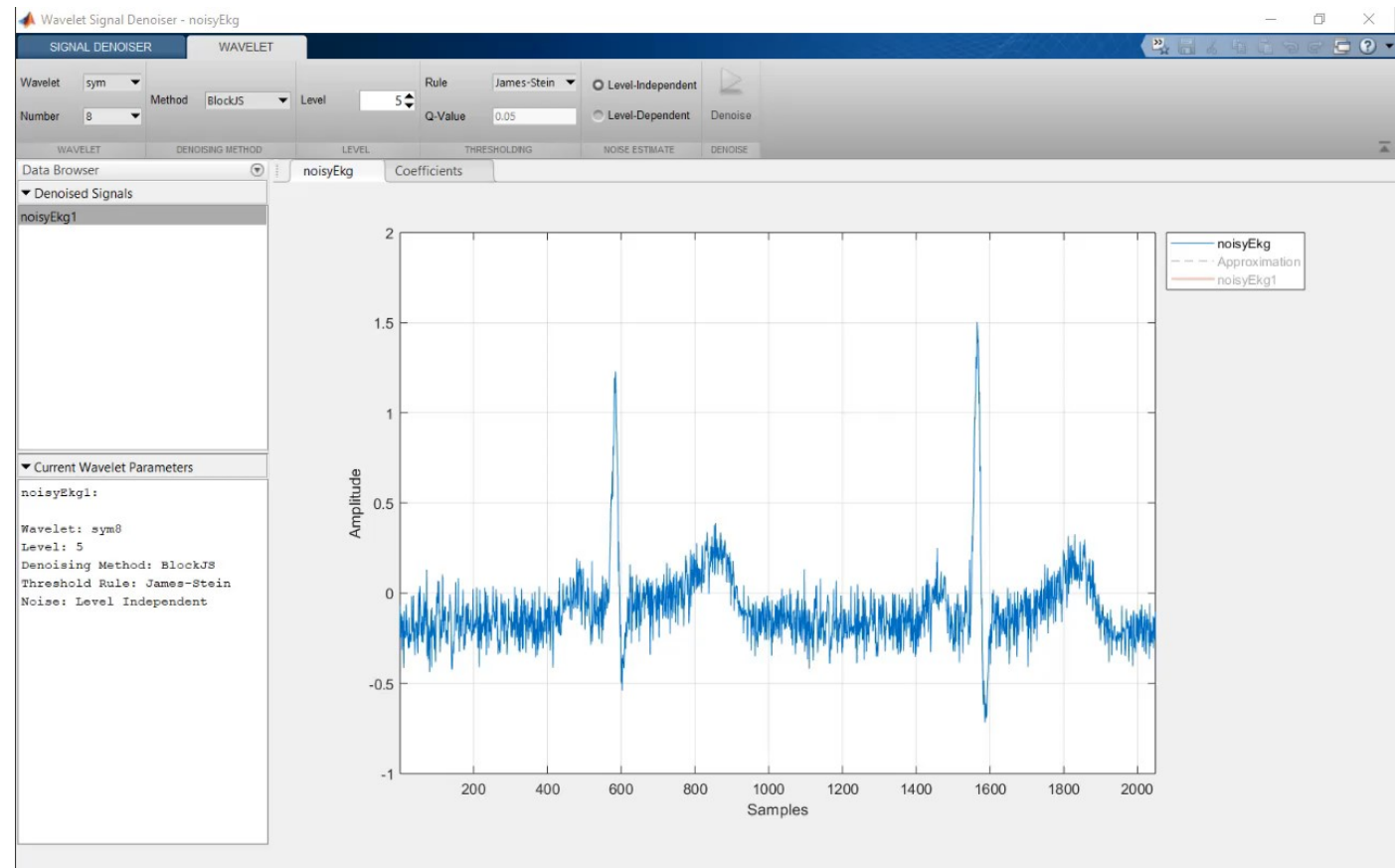*Signal Analyzer: Visual Data Exploration*

Step 2: Pre-process Signals

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

Automatic Denoising

Generate MATLAB code

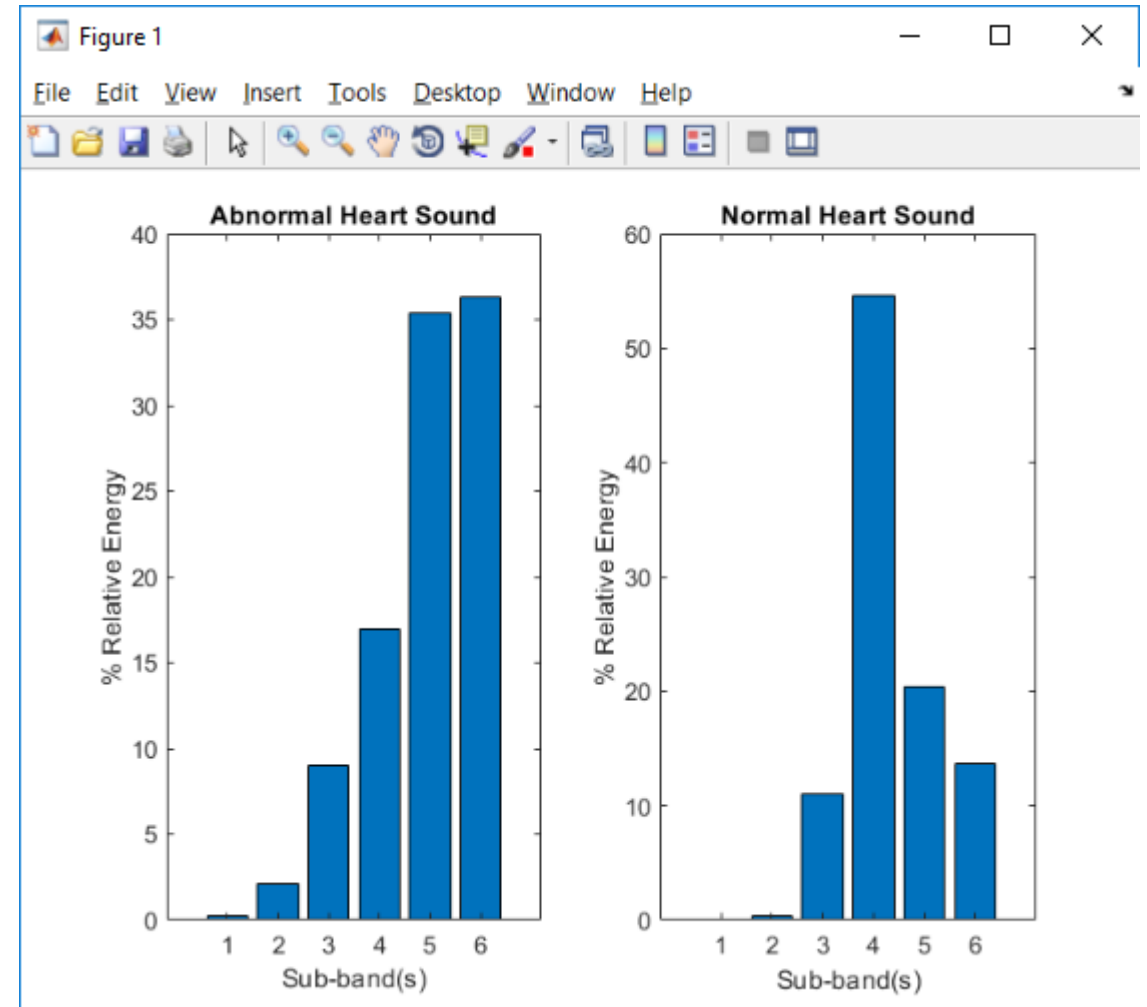*Signal Pre-processing without writing any code*

Step 3: Extract Features

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

Spectral features:
- Mel-Frequency Cepstral Coefficients
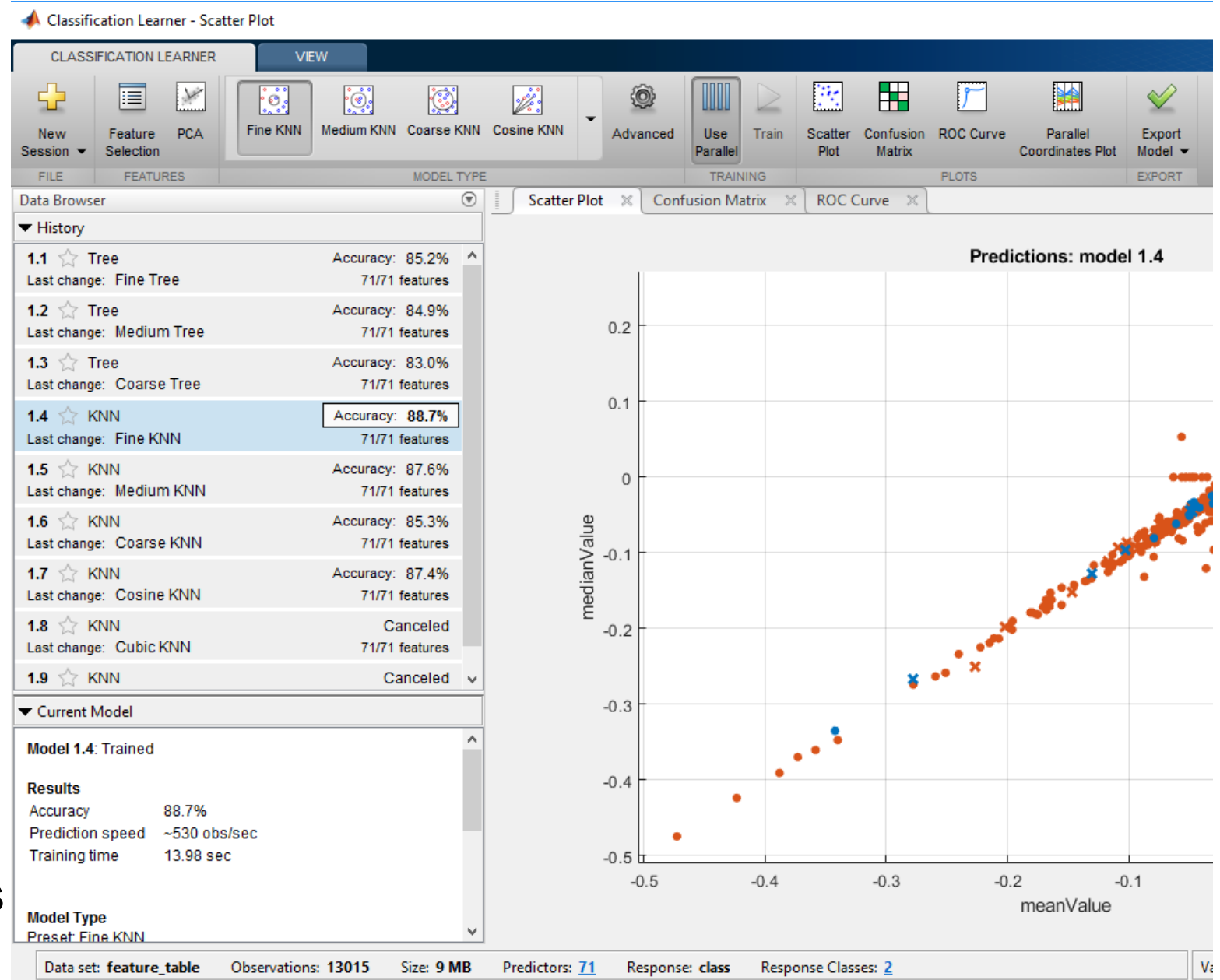- Octave band decomposition with Wavelets

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

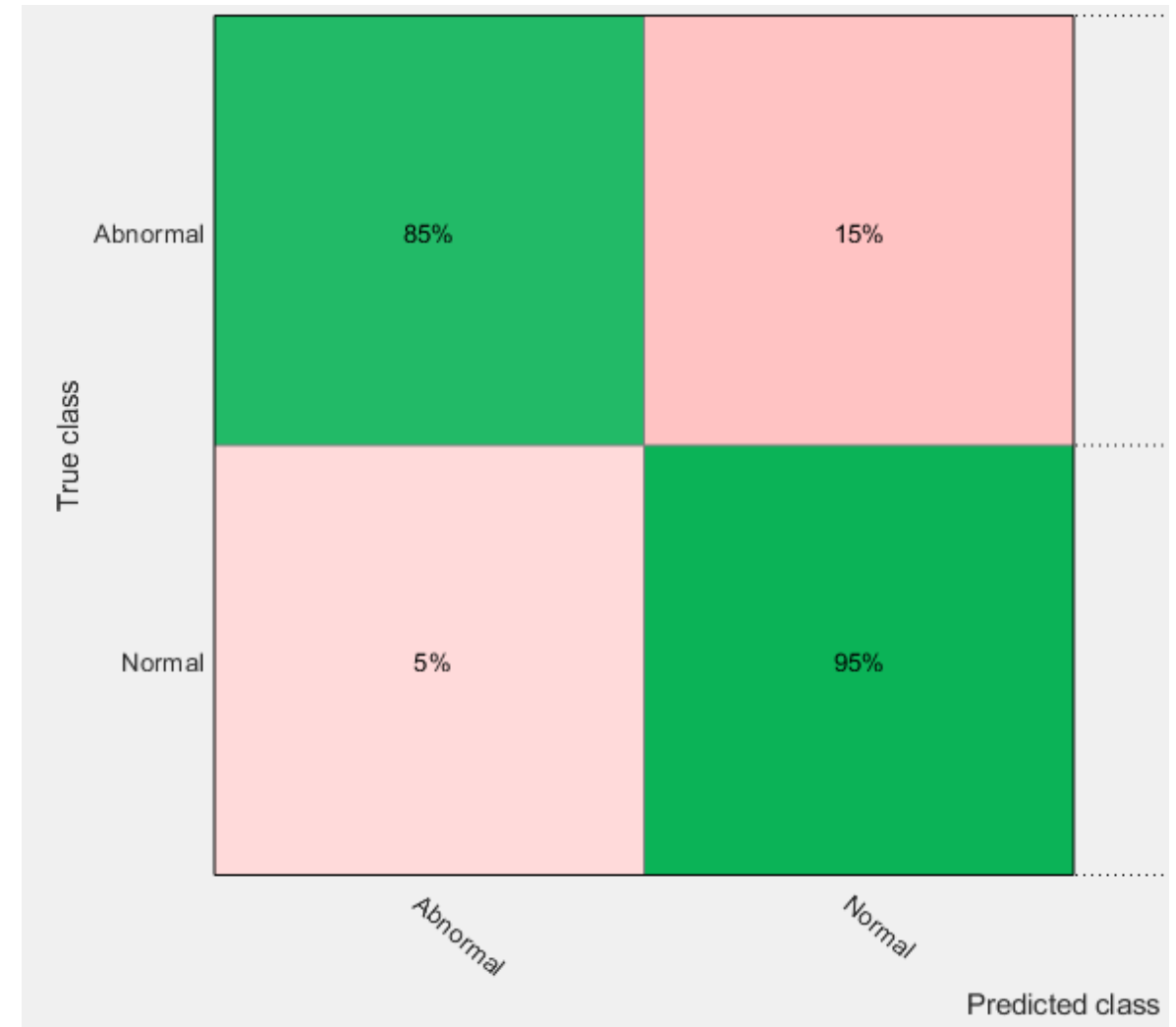# Step 4 Cont'd: Optimize Model

Challenges:
– Manual parameter tuning tedious
– Identify additional improvements

Iterative Model Optimization
– Bayesian Optimization of parameters
– Visually analyze performance
– Adjust for imbalances (data or severity of misclassifications)

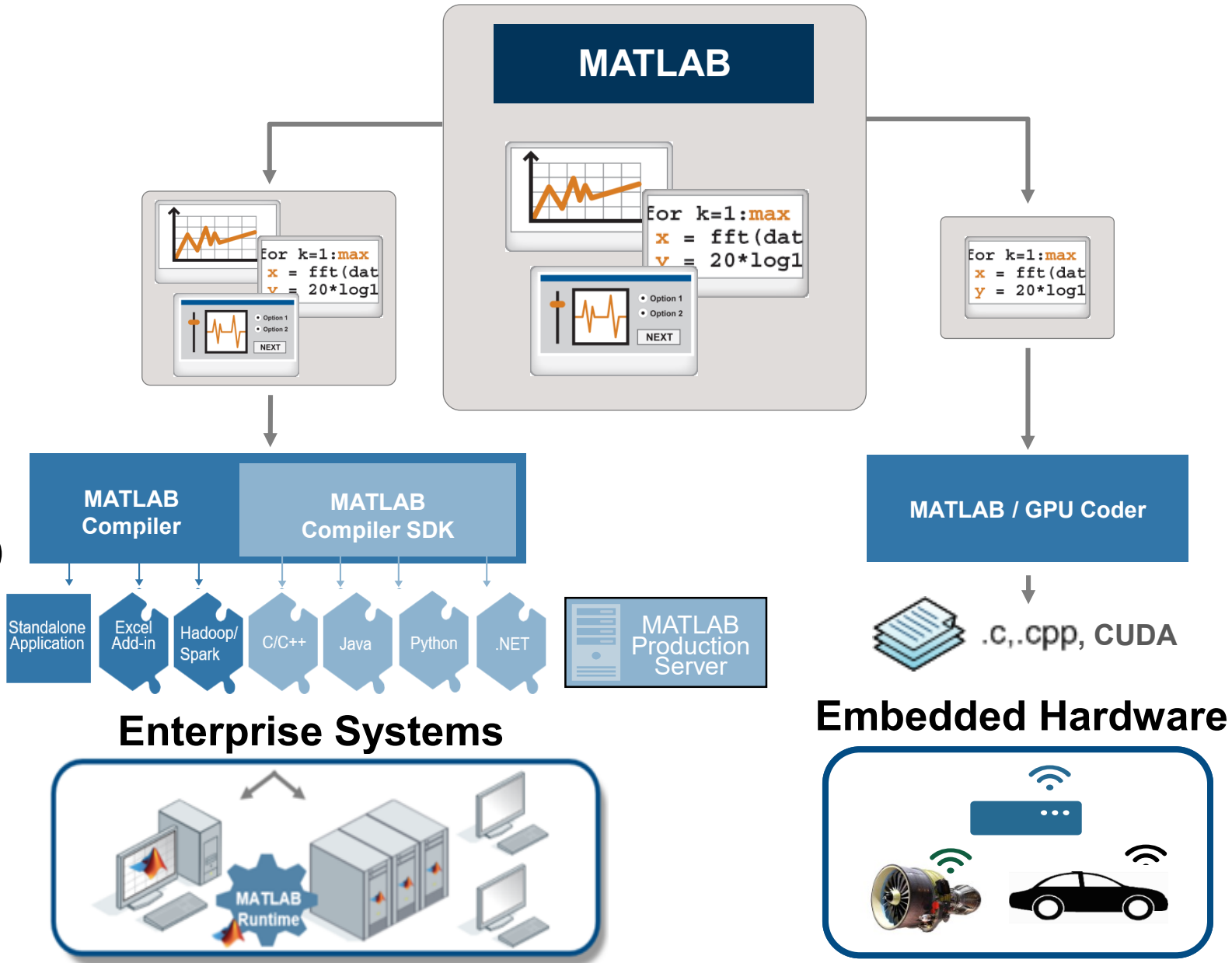| Class	Distribution
Normal	75%
Abnormal	25%

Step 5: Deploy

Challenges:

– Different target platforms

– Hardware requirements (Size, Speed, Fixed point, etc)

Deployment options:

– Generate Code (C, HDL, PLC) for Embedded System

– Compile MATLAB, scale using MPS for Enterprise systems

Apply automated feature selection to reduce model size

MATLAB

```
For k=1:max
x = fft(dat
y = 20*log1
```

- Option 1
- Option 2

NEXT

MATLAB Compiler

MATLAB Compiler SDK

Standalone Application | Excel Add-in | Hadoop/Spark | C/C++ | Java | Python | .NET

MATLAB Production Server

Enterprise Systems

MATLAB Runtime

MATLAB / GPU Coder

.c, .cpp, CUDA

Embedded Hardware

Summary: Making Machine Learning Easier

1. Access Data

Support for industrial sensors, phones, etc.

2. Explore and Pre-Process

Visual Exploration

3. Feature Extraction

Wavelets Feature Selection

4. Build Models

Quickly compare models in App Automatically tune parameters Explore Deep Learning

5. Deploy

Automatically Generate C/CUDA Code

Unlocking Power of Machine Learning

Heart Sound Classification

Ground Truth — Normal
Predicted — Normal

Phonocardiograms

Amplitude

Samples

Key takeaways

Empower engineers to be productive in data science!

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

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?](#)