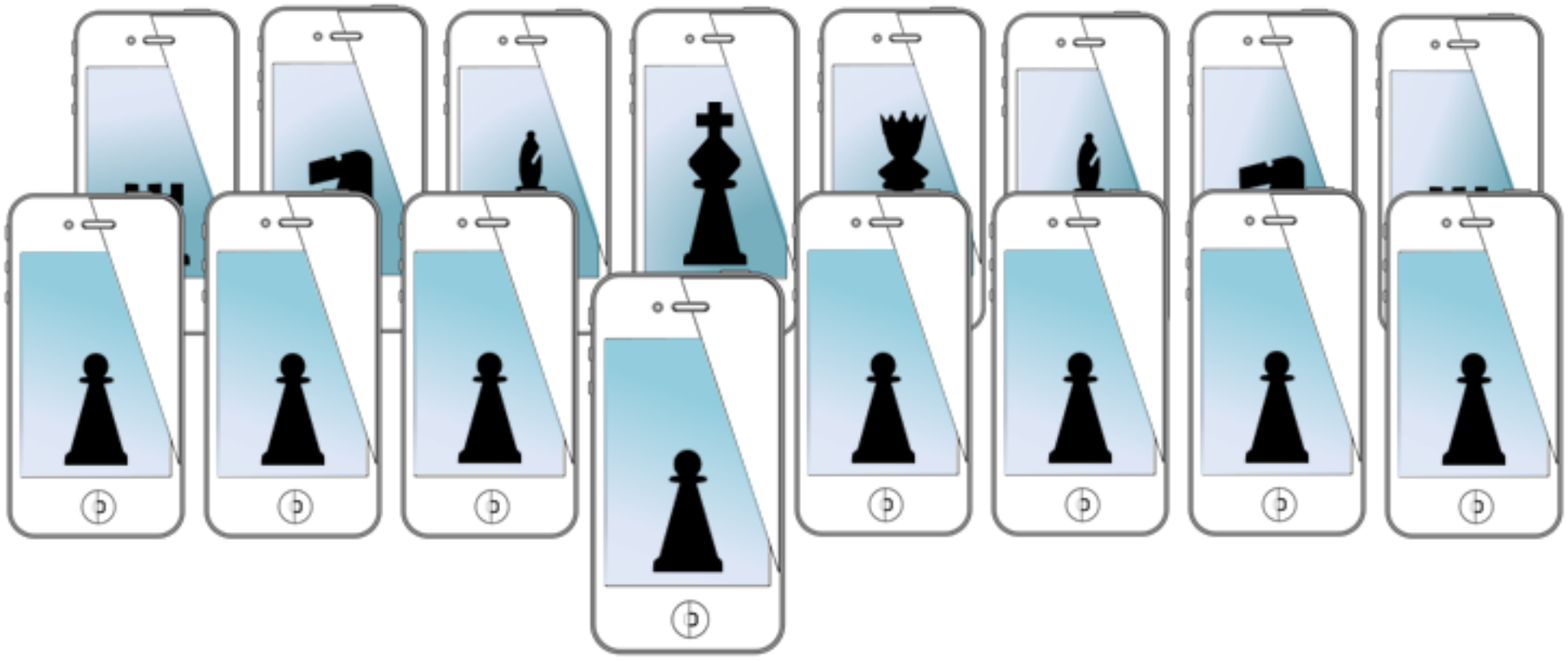
MOBILE SENSING LEARNING



CS5323 & 7323

Mobile Sensing and Learning

machine learning with Apple

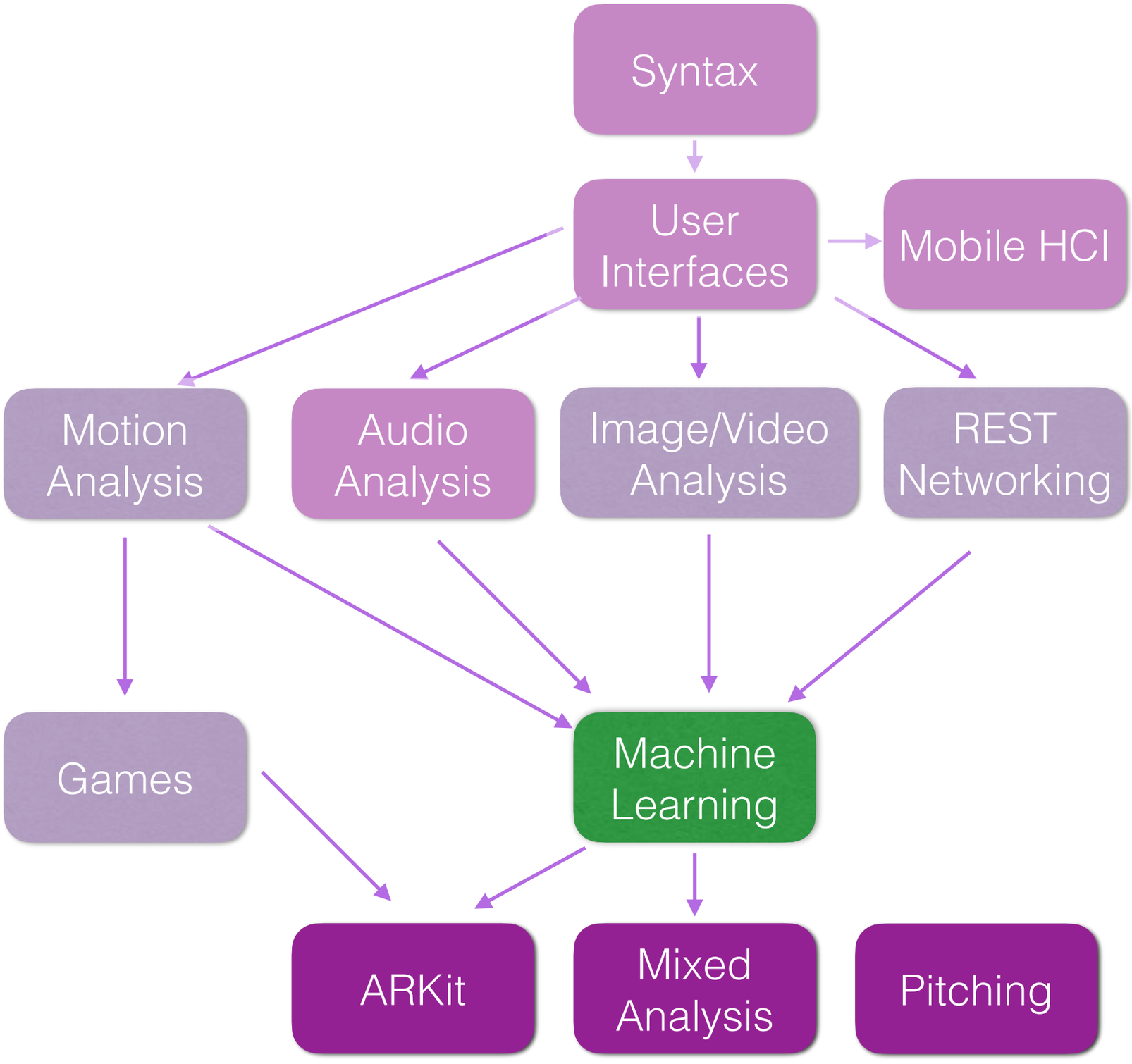
Eric C. Larson, Lyle School of Engineering,
Computer Science, Southern Methodist University

course logistics and agenda

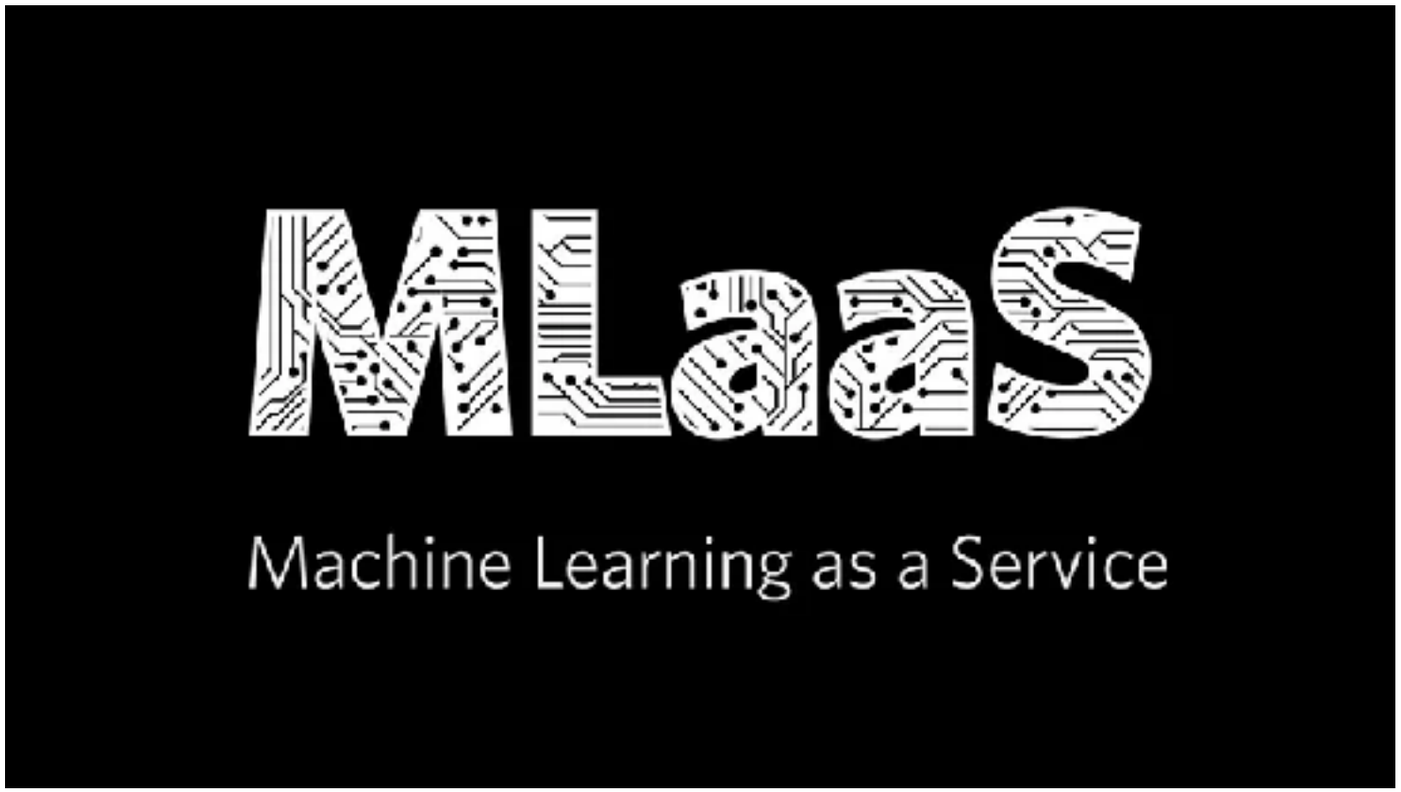
- logistics:
  - grading update
  - final flipped module (next time!!!)
  - **A5** is due soon-ish, try to make it a first draft of your final project!

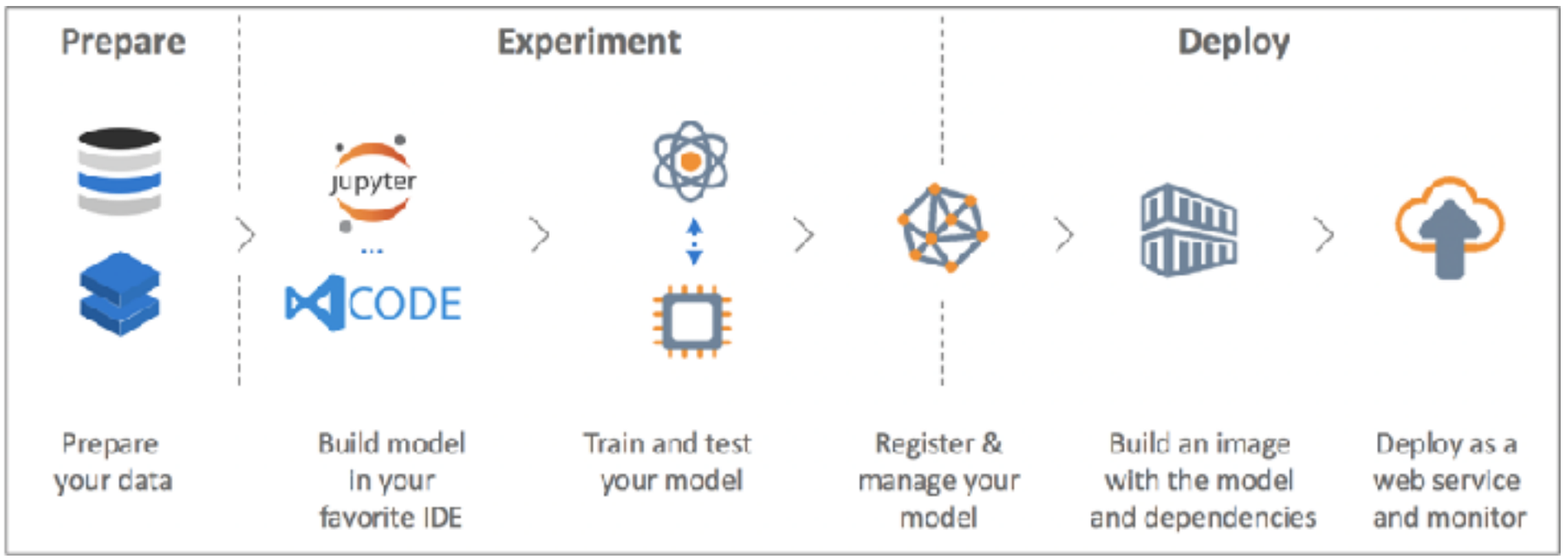
- Agenda
  - CoreML/CreateML
  - **final project proposal** is also due at same time
    - today: talk about old projects!

class overview

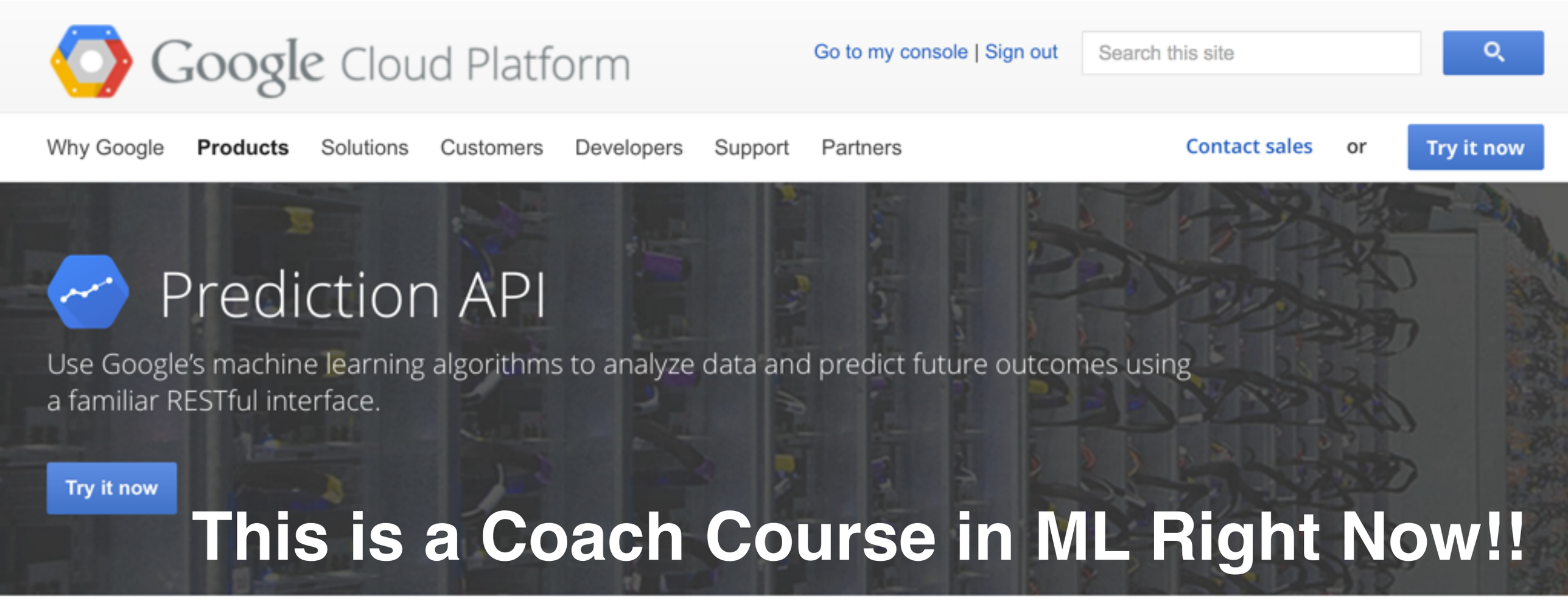


lab five town hall



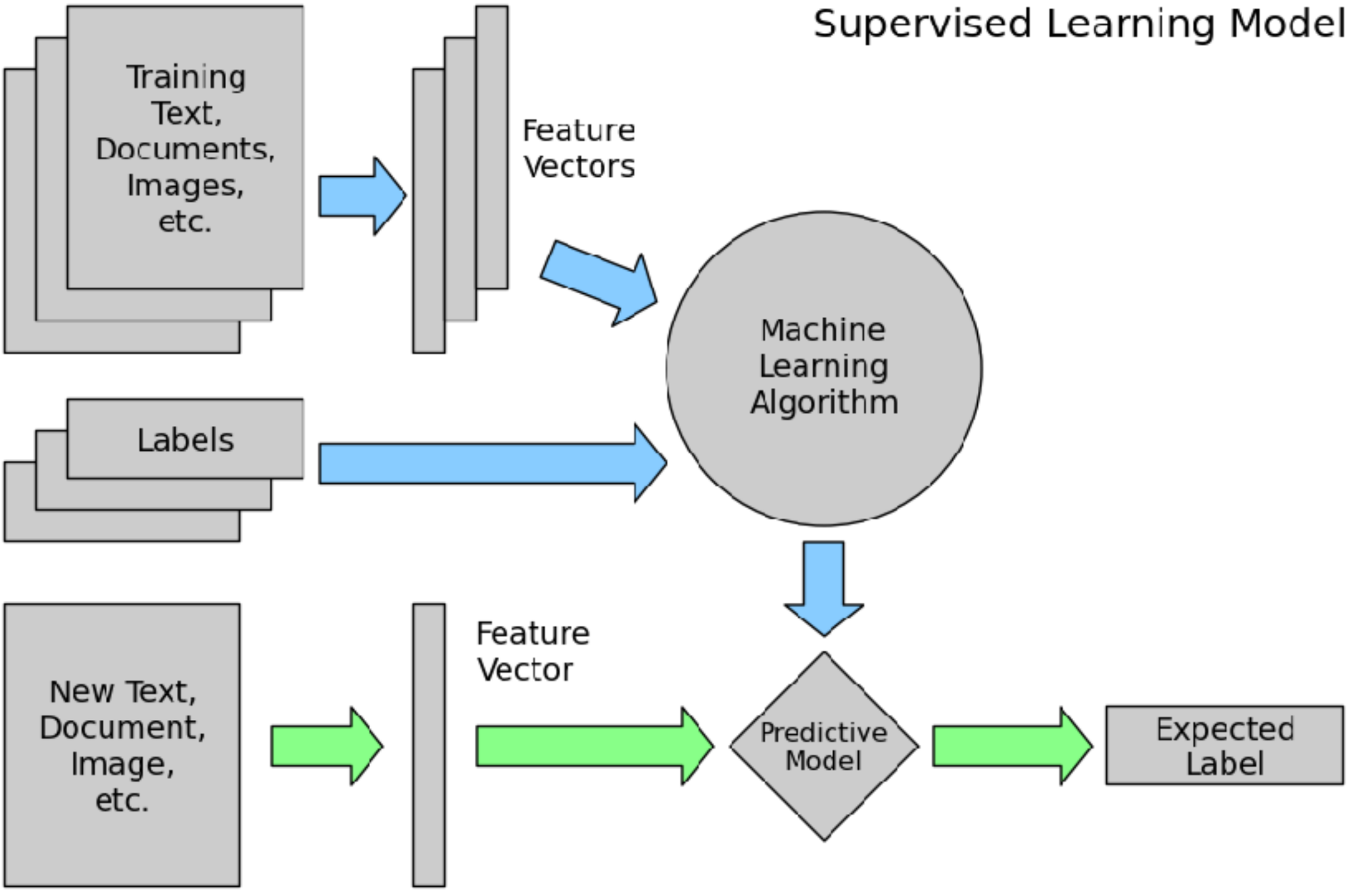


machine learning



This is a Coach Course in ML Right Now!!

machine learning models



types of data

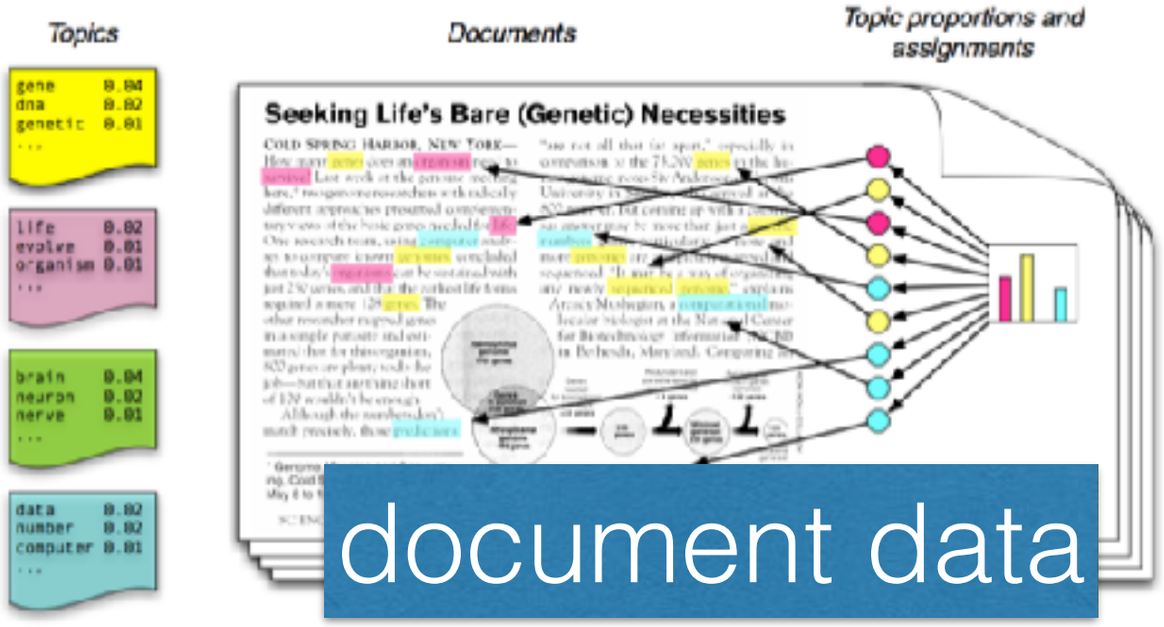


Figure source: Blei, D. M. (2012). Probabilistic topic models. *Communications of the ACM*, 55(4), 77-84.

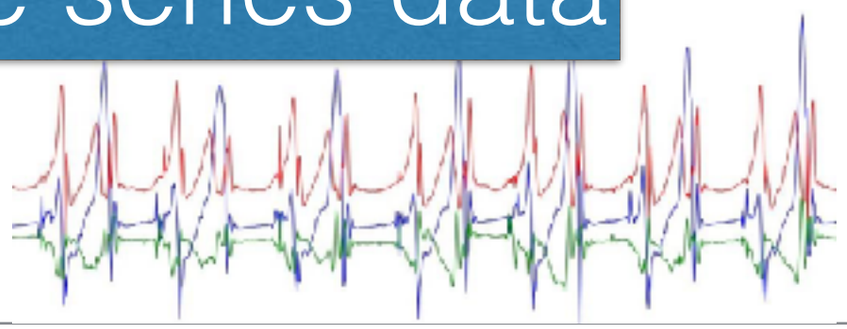
table data

Attributes, columns, variables, fields, characteristics, **Features**

Objects, records, rows, points, **samples**, cases, entities, **instances**

TID	Pregnant	BMI	Age	Diabetes
1	Y	33.6	41-50	positive
2	N	26.6	31-40	negative
3	Y	23.3	31-40	positive
4	N	28.1	21-30	negative
5	N	43.1	31-40	positive
6	Y	25.6	21-30	negative
7	Y	31.0	21-30	positive
8	Y	35.3	21-30	negative
9	N	30.5	51-60	positive
10	Y	37.6	51-60	positive

time series data



features and labels

- actually, feature vectors
- **classic example**: the iris dataset—table data

setosa versicolor virginica

- 4 features
  - sepal length in cm
  - sepal width in cm
  - petal length in cm
  - petal width in cm

```
[5.1,  3.5,  1.4,  0.2] setosa
[5.7,  2.8,  4.5,  1.3] versicolor
[7.6,  3. ,  6.6,  2.1] virginica
```

50 examples each

features

- most common is numeric and categorical
- vector quantization (numeric to categories)
- text:
  - bag of words
  - term frequency inverse document frequency
  - text embeddings from neural nets
- graphs
  - used to quantize

take data mining!
or python machine learning!

common ML algorithms

nonparametric

- nearest neighbor
- k-nearest neighbor (KNN)
- kernel density estimator

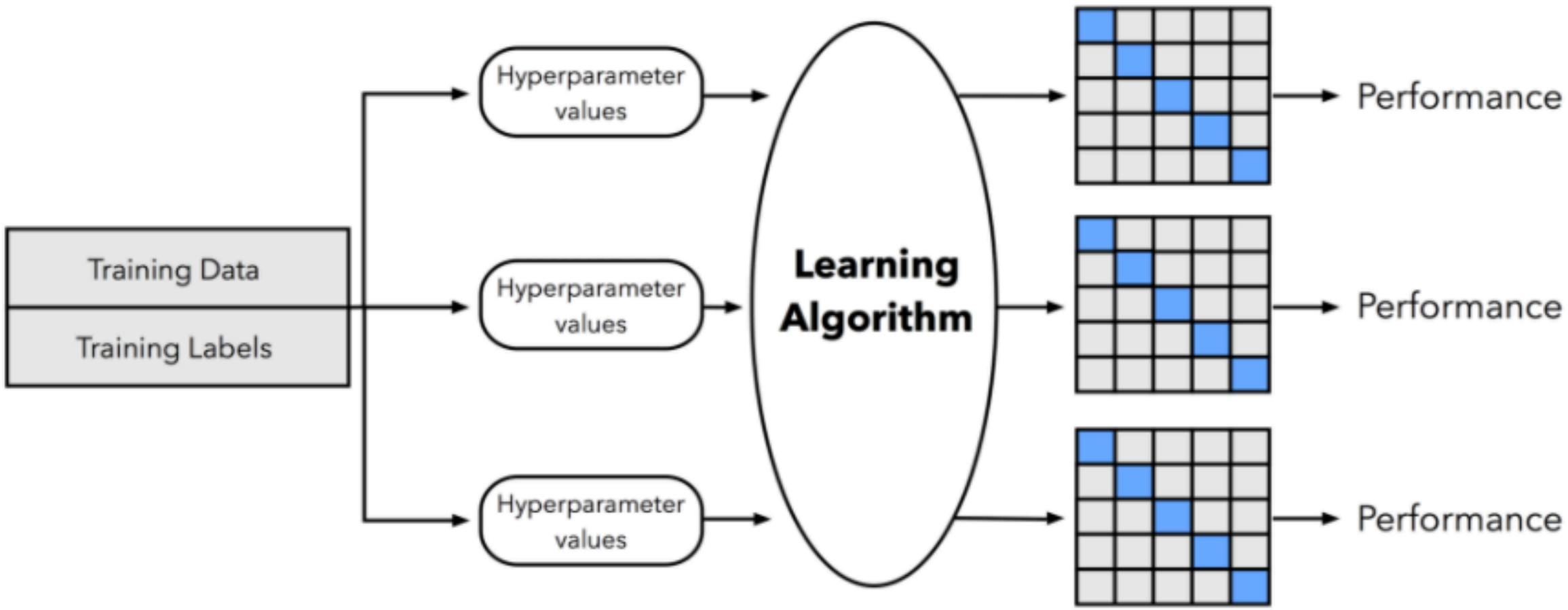
parametric

- decision tree
- random forest/boosted trees
- logistic regression
- neural networks
- gaussian mixtures

- support vector machines
- and many many more…

finding the best ML model

- try a bunch of stuff until it works well enough

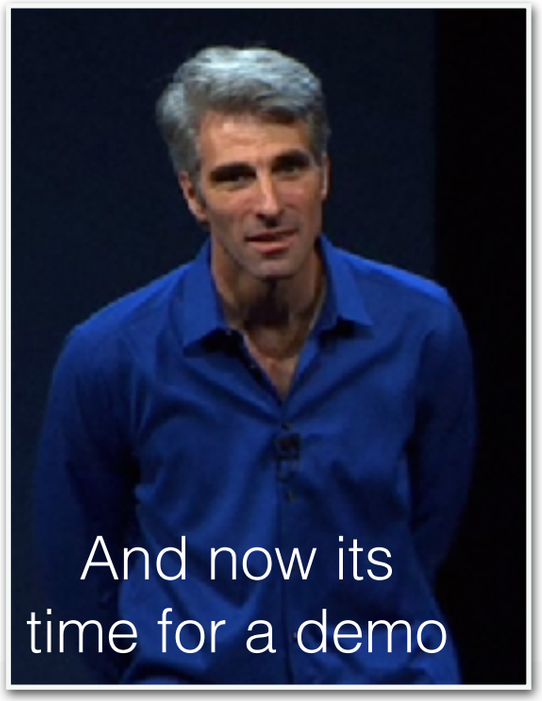


http://ethen8181.github.io/machine-learning/model_selection/model_selection.html

turi create demo, with SFrame

Carlos Guestrin · 2nd

Senior Director of AI and Machine Learning at Apple & Amazon Professor of Machine Learning at University of Washington




```
python_short_examples >
    TuriExample.ipynb
```

turicreate.SFrame

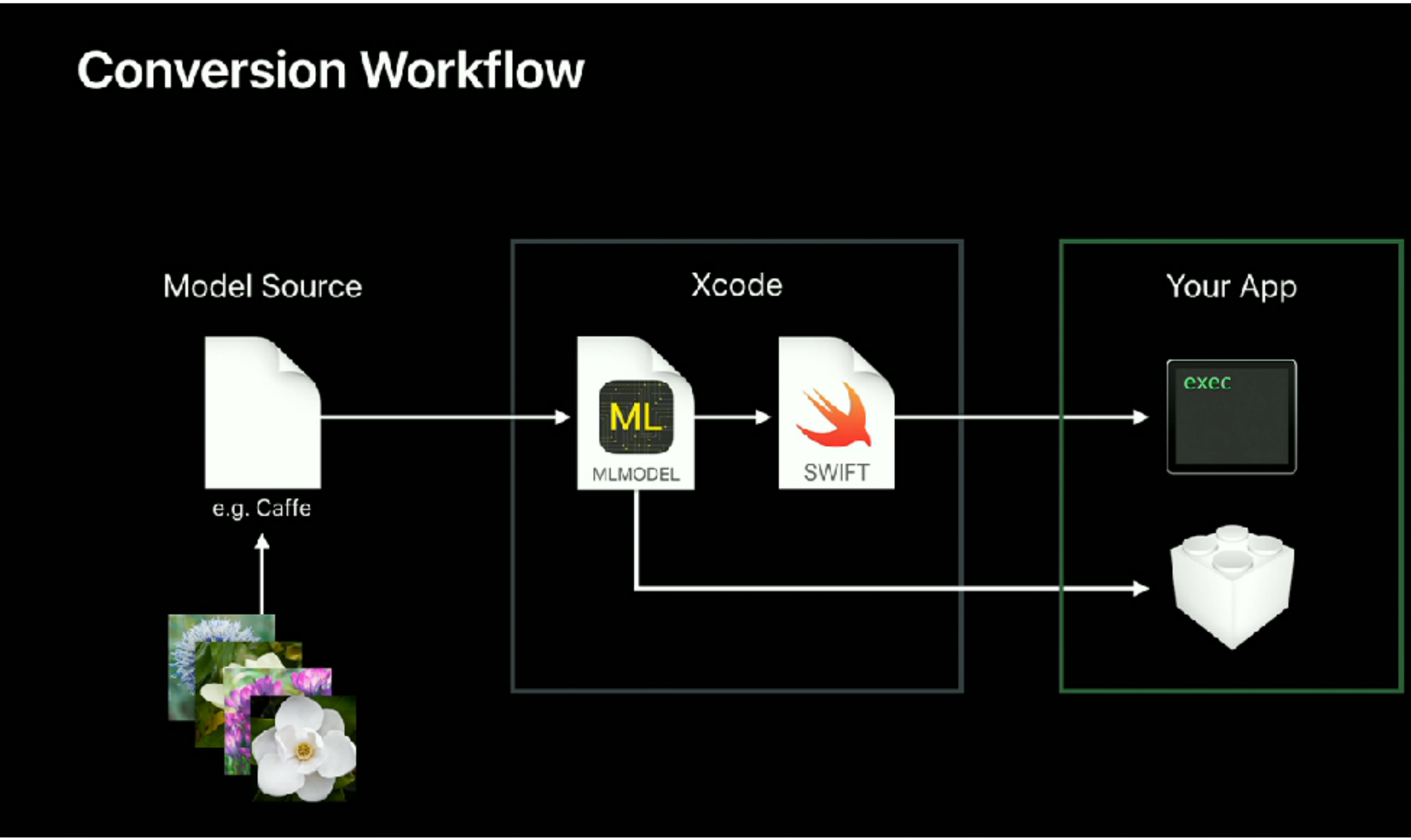
class `turicreate.` `SFrame` ***(data=None, format='auto', _proxy=None)***

SFrame means scalable data frame. A tabular, column-mutable dataframe object that can scale to big data. The data in SFrame is stored column-wise, and is stored on persistent storage (e.g. disk) to avoid being constrained by memory size. Each column in an SFrame is a size-immutable `SArray`, but SFrames are mutable in that columns can be added and subtracted with ease. An SFrame essentially acts as an ordered dict of SArrays.

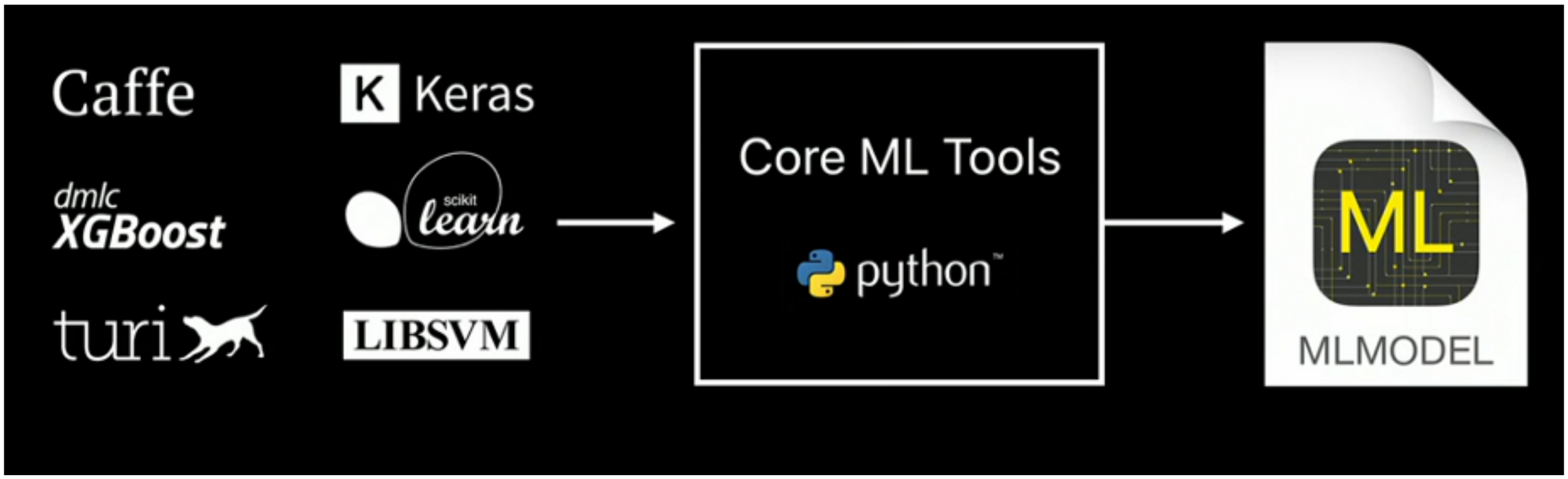
Currently, we support constructing an SFrame from the following data formats:

- csv file (comma separated value)
- sframe directory archive (A directory where an sframe was saved previously)
- general text file (with csv parsing options, See `read_csv()`)
- a Python dictionary
- pandas.DataFrame
- JSON

CoreML


Conversion Workflow
Model Source
Xcode
Your App
e.g. Caffe
ML
MLMODEL
SWIFT
exec

CoreML


Caffe
Keras
dmlc
XGBoost
scikit
learn
turi
LIBSVM
Core ML Tools
python
ML
MLMODEL

but… we want more than **pre-trained** models

installing CoreMLTools

- built into **TuriCreate**
  `model.export_coreml("MyModel.mlmodel")`
- also available for other libraries, like **sklearn**: so create a conda environment and install coremltools
  - `conda install sklearn numpy (+others) …`
  - `pip install coremltools`

```
clf = RandomForestClassifier(n_estimators=50)
print("Training Model", clf)

clf.fit(X,y)

print("Exporting to CoreML")

coreml_model = coremltools.converters.sklearn.convert(
    clf,
    ["accelX"]*50+["accelY"]*50+["accelZ"]*50, # feature names (optional)
    "Direction") # label name (optional)

# save out as a file
coreml_model.save('rf.mlmodel')
```

using CoreML

- drag into project

Machine Learning Model

Name	RandomForestAccel
Type	Tree Ensemble Classifier
Size	28 KB
Author	unknown
Description	description not included
License	unknown

Model Class

RandomForestAccel

Automatically generated Swift model class

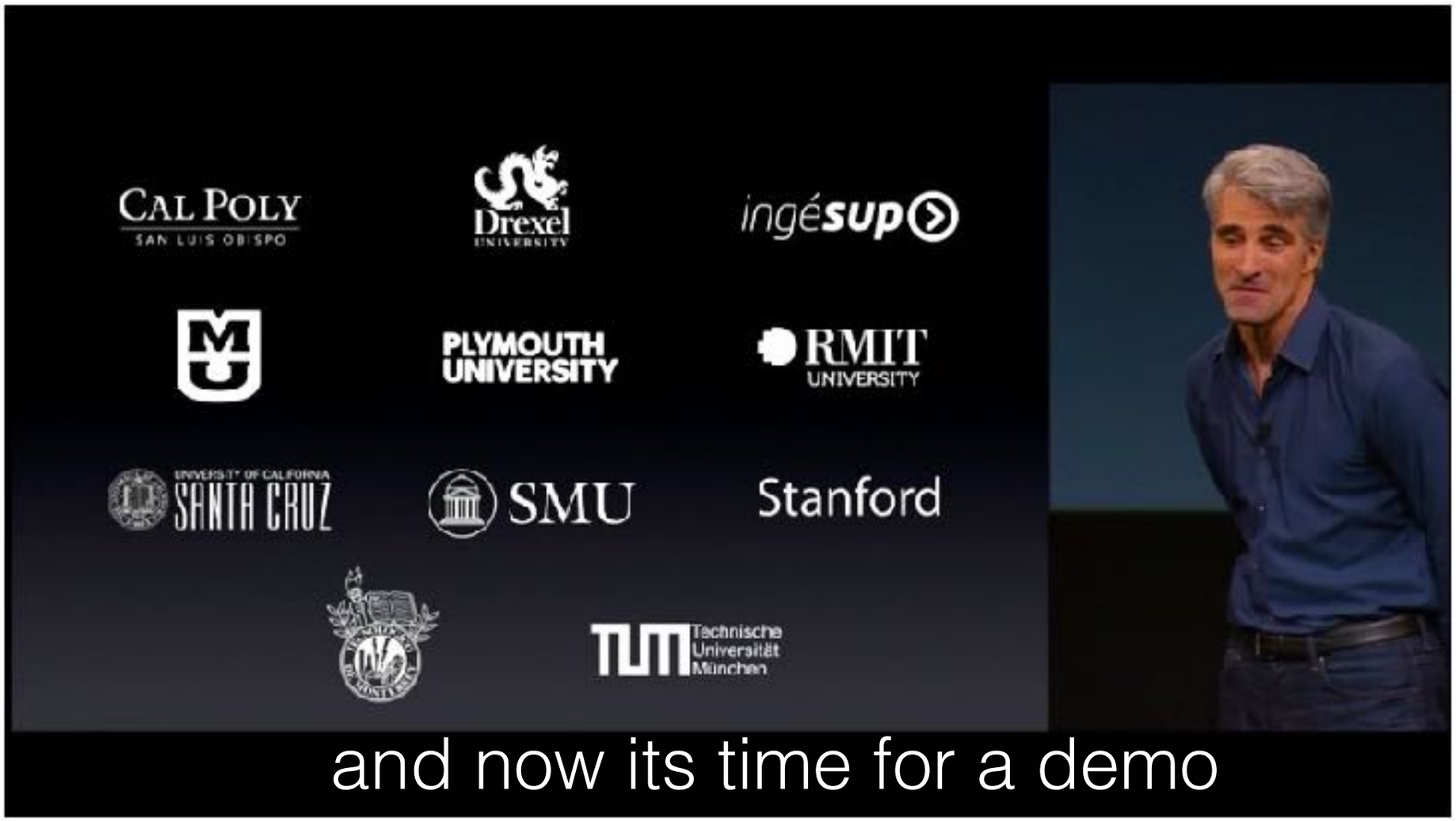
Model Evaluation Parameters

Name	Type	Desc
inputs		
input	MultiArray (Double 150)	
outputs		
classLabel	String	
classProbability	Dictionary (String → Double)	

```
/// Class for model loading and prediction
@available(macOS 10.13, iOS 11.0, tvOS 11.0, watchOS 4.0, *)
class RandomForestAccel {
    var model: MLModel

    /**
        Construct a model with explicit path to mlmodel file
        - parameters:
           - url: the file url of the model
           - throws: an NSError object that describes the problem
    */
    init(contentsOf url: URL) throws {
        self.model = try MLModel(contentsOf: url)
    }

    /// Construct a model that automatically loads the model from th
    convenience init() {
        let bundle = Bundle(for: RandomForestAccel.self)
        let assetPath = bundle.url(forResource: "RandomForestAccel",
        try! self.init(contentsOf: assetPath!)
    }

    /**
        Make a prediction using the structured interface
        - parameters:
           - input: the input to the prediction as RandomForestAccel
        - throws: an NSError object that describes the problem
        - returns: the result of the prediction as RandomForestAccel
    */
    func prediction(input: RandomForestAccelInput) throws -> RandomF
```

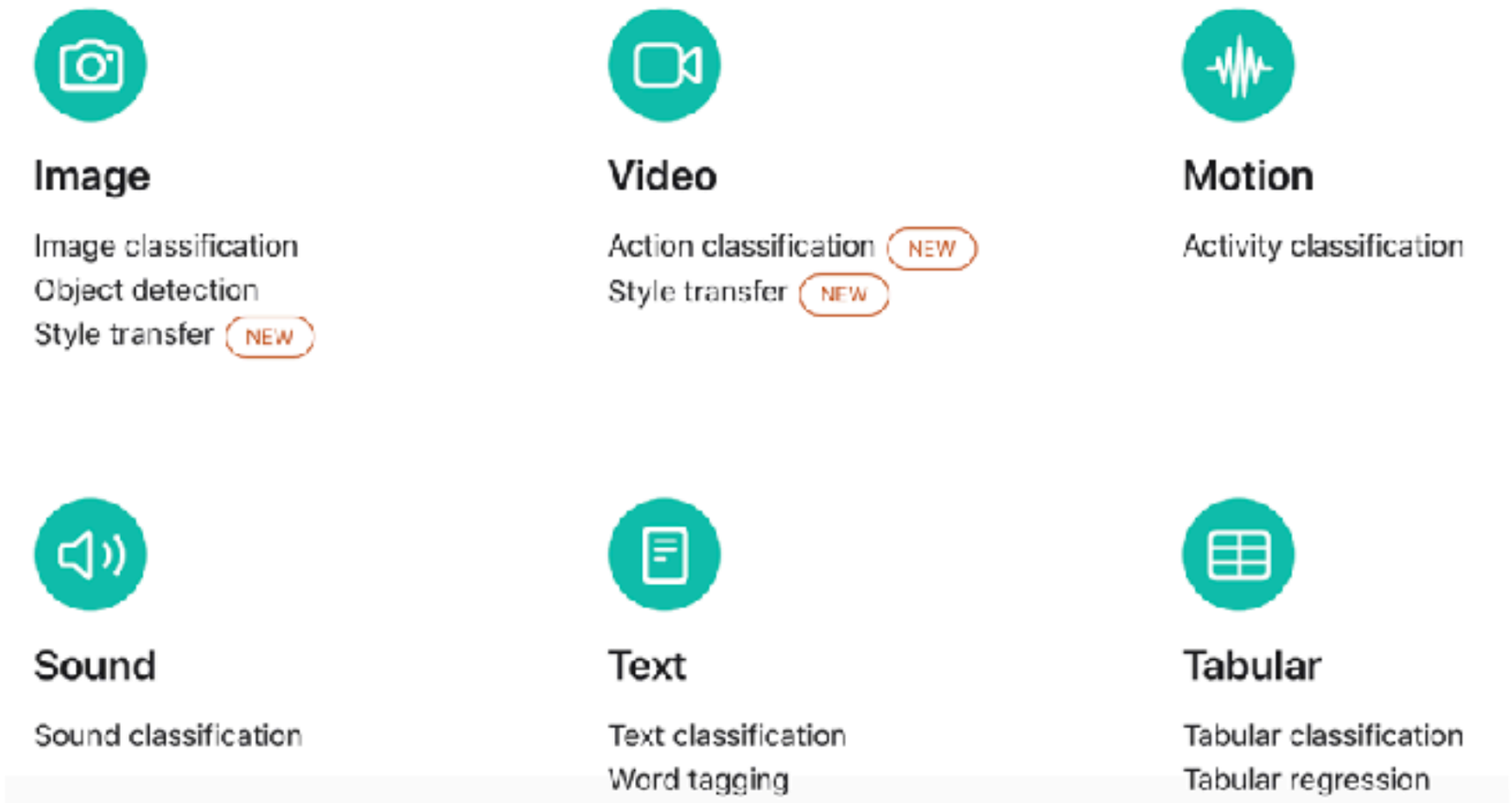
CoreML

- assumes some understanding of **final flipped module**
- combining our web server, mongo, iOS, CoreML



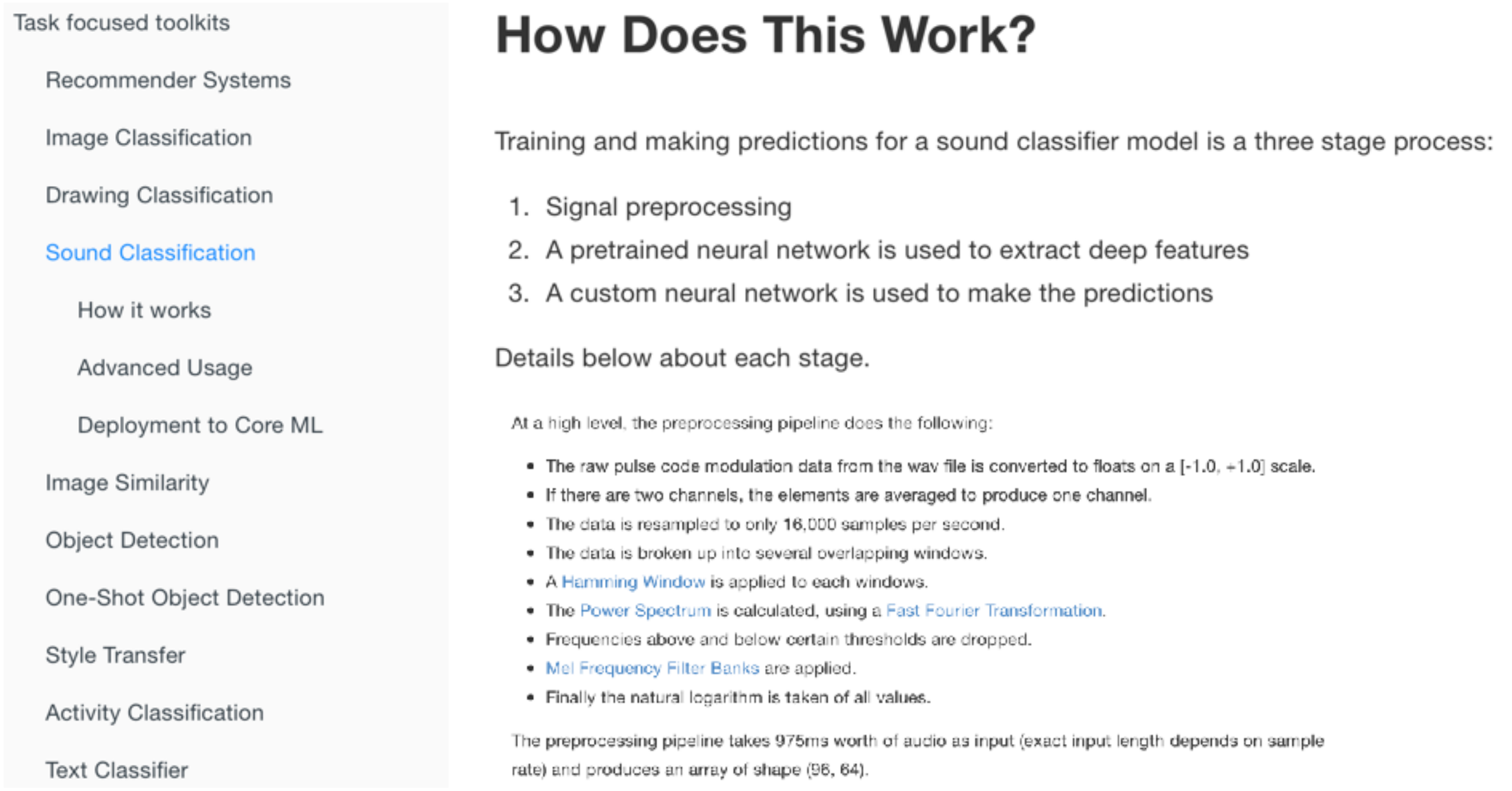
Create ML

making machine learning easy to use for developers that are not data scientists



these are also built into TuriCreate!

could be good for final projects!!!



Task focused toolkits

- Recommender Systems
- Image Classification
- Drawing Classification
- Sound Classification
  - How it works
  - Advanced Usage
  - Deployment to Core ML
- Image Similarity
- Object Detection
- One-Shot Object Detection
- Style Transfer
- Activity Classification
- Text Classifier

How Does This Work?

Training and making predictions for a sound classifier model is a three stage process:

1. Signal preprocessing
2. A pretrained neural network is used to extract deep features
3. A custom neural network is used to make the predictions

Details below about each stage.

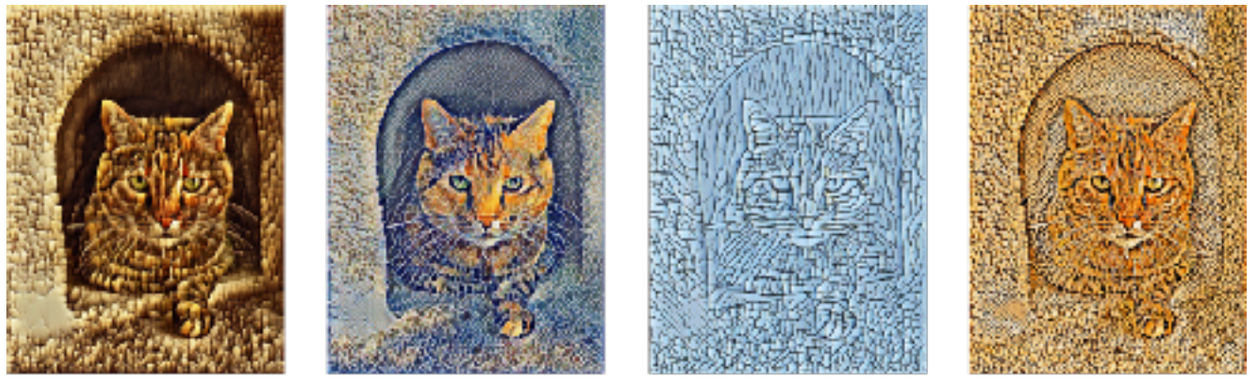
At a high level, the preprocessing pipeline does the following:

- The raw pulse code modulation data from the wav file is converted to floats on a [-1.0, +1.0] scale.
- If there are two channels, the elements are averaged to produce one channel.
- The data is resampled to only 16,000 samples per second.
- The data is broken up into several overlapping windows.
- A Hamming Window is applied to each windows.
- The Power Spectrum is calculated, using a Fast Fourier Transformation.
- Frequencies above and below certain thresholds are dropped.
- Mel Frequency Filter Banks are applied.
- Finally the natural logarithm is taken of all values.

The preprocessing pipeline takes 975ms worth of audio as input (exact input length depends on sample rate) and produces an array of shape (96, 64).

https://apple.github.io/turicreate/docs/userguide/sound_classifier/

could be good for final projects!!!



Style transfer model

The technique used in Turi Create is based on *"A Learned Representation For Artistic Style"*. The model is compact and fast and hence can run on mobile devices like an iPhone. The model consists of 3 convolutional layers, 5 residual layers (2 convolutional layers in each) and 3 upsampling layers each followed by a convolutional layer. There are a total of 16 convolutional layers.

There are three aspects about this technique that are worth noting:

- It is designed to be incredibly fast at stylizing images, allowing deployment on device. As a trade off, the model creation takes longer.
- A single model can incorporate a large number of styles without any significant increase in the size of the model.
- The model can take input of any size and output a stylized image of the same size.

During training, we employ Transfer Learning. The model uses the visual semantics of an already trained VGG-16 network to understand and mimic stylistic elements.

https://apple.github.io/turicreate/docs/userguide/sound_classifier/

up

- forma
- organi
- organi
- train

ActivityClassification

MyActivityClassifier 〉 MyActivityClassifier 〉 ActivityClassification.mlmodel

▼ Machine Learning Model

Name	ActivityClassification
Type	Neural Network Classifier
Size	1 MB
Author	unknown
Description	description not included
License	unknown

▼ Model Class

ActivityClassification

Automatically generated Swift model class

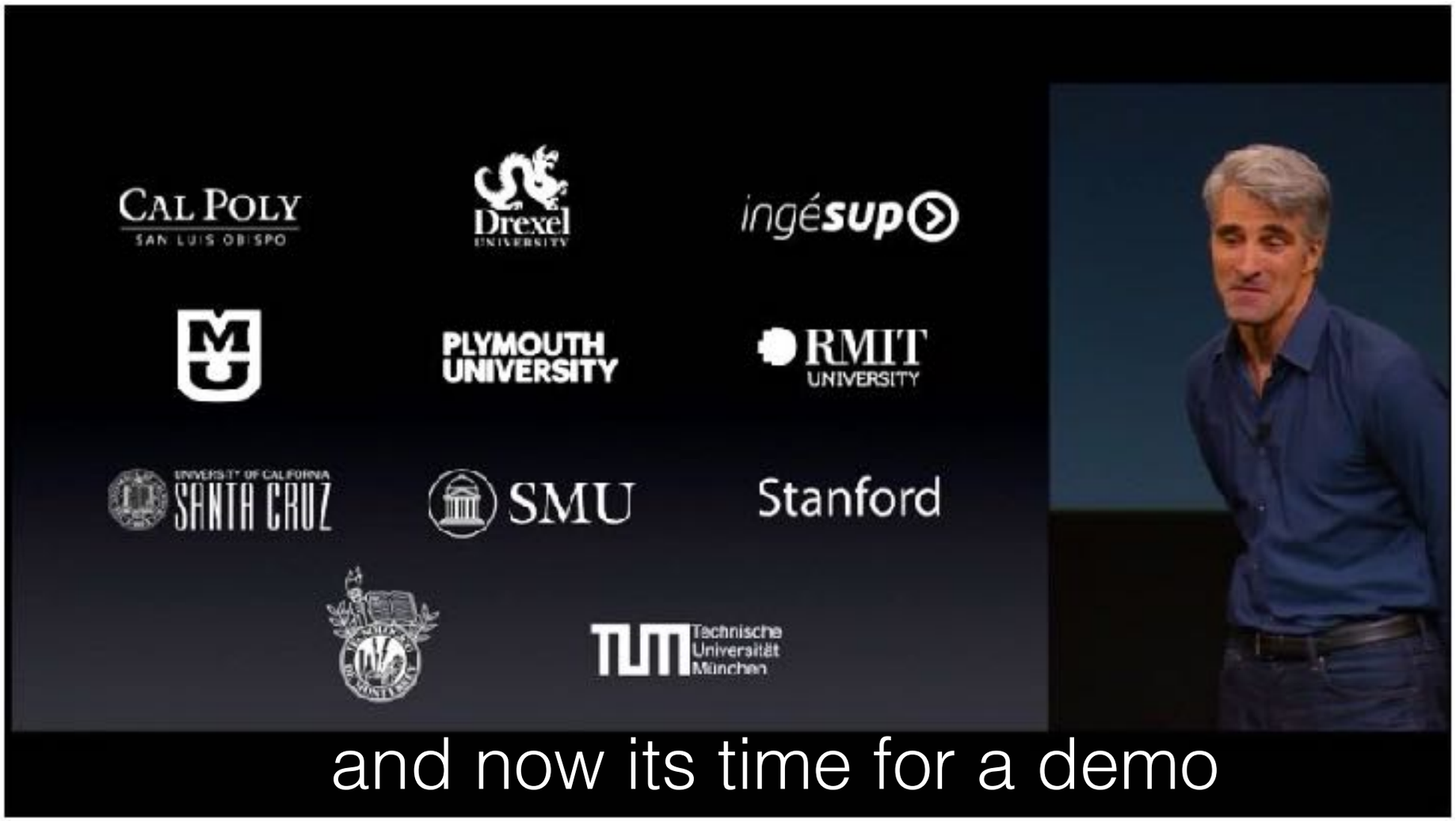
gyro_y	gyro_z
0.345444	0.038179
0.218995	0.046426
0.440128	-0.045815
0.503964	-0.206472
0.64263	-0.309709
-0.021075	0.034208
0.015272	-0.045815
0.009468	-0.094073
-0.039706	-0.094073
-0.142332	0.091324
-0.138972	0.055589
-0.124922	0.026878

```
// Perform model prediction
let modelPrediction = try!
    activityClassificationModel.prediction(acc_x: accelDataX, acc_y: accelDataY, acc_z: accelDataZ,
                                           gyro_x: gyroDataX, gyro_y: gyroDataY, gyro_z: gyroDataZ, stateIn: stateOutput)

// Update the state vector
stateOutput = modelPrediction.stateOut
```

stateIn	MultiArray (Double 400)	LSTM state input
▼ Outputs		
activityProbability	Dictionary (String → Double)	Activity prediction probabilities
activity	String	Class label of top prediction
stateOut	MultiArray (Double 400)	LSTM state output

CreateML

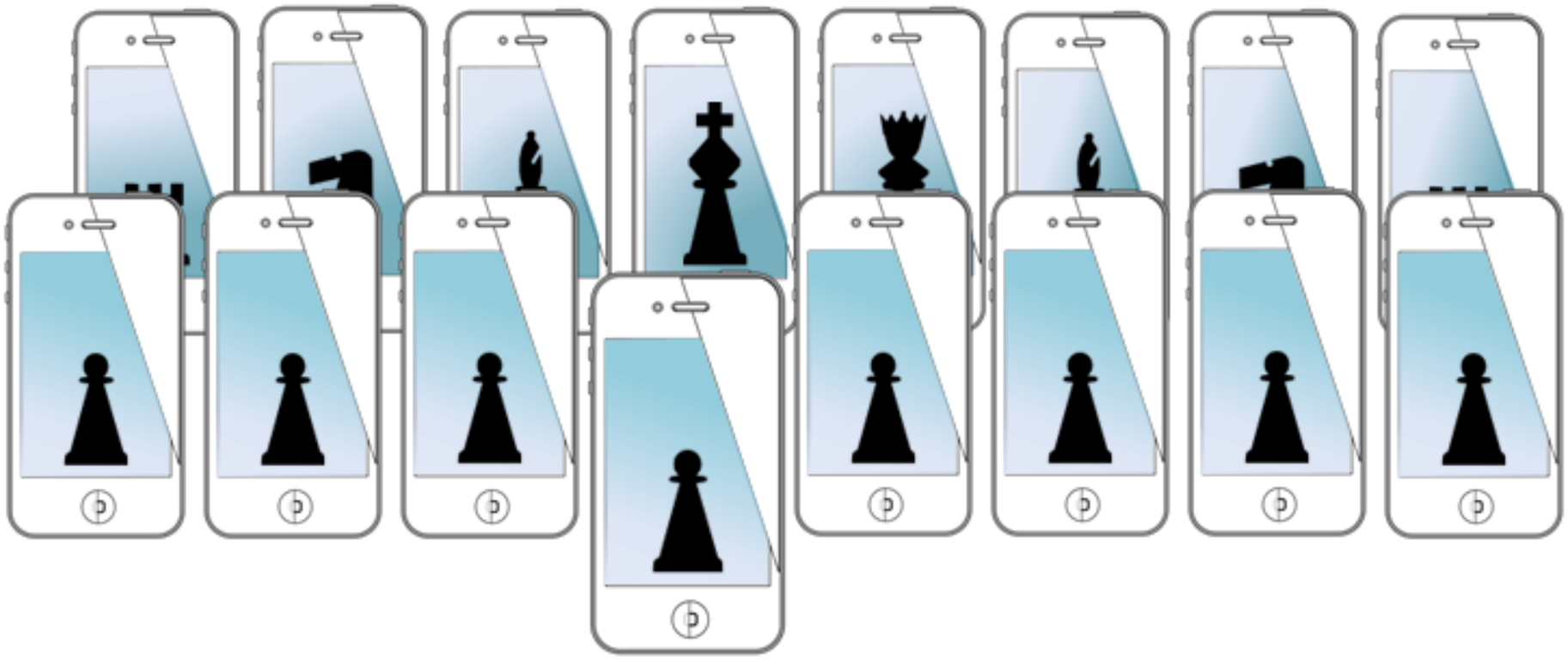
- extended demo from beginning to end
- combining our tornado, mongo, iOS, CoreML



And now…

- final project discussion
- and proposal!!

MOBILE SENSING LEARNING



CS5323 & 7323

Mobile Sensing and Learning

machine learning crash course

Eric C. Larson, Lyle School of Engineering,
Computer Science, Southern Methodist University