MathWorks®

HACK·RICE

Pocket AI and IoT:

Use Machine Learning and Sensors to Turn Your Phone into a Smart Fitness Tracker

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Senior Applications Engineer – Education

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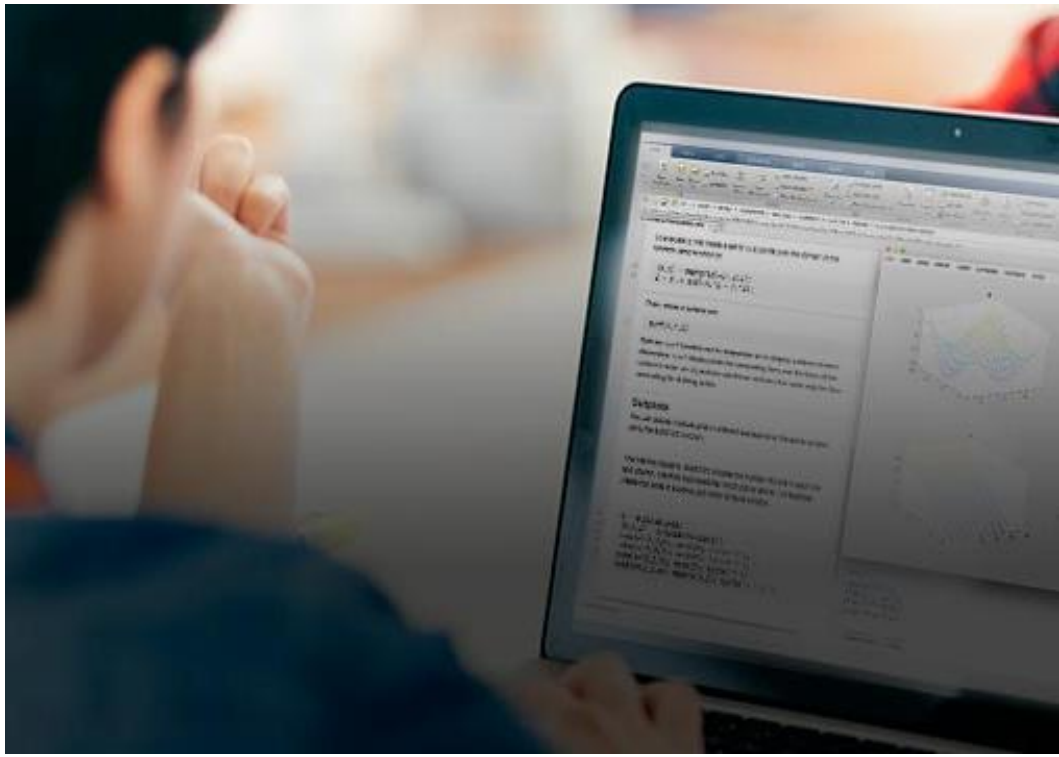
MATLAB Student Ambassador

Agenda

- Challenge description & instructions
- Workshop
  - Step counting with MATLAB Mobile, Machine Learning and ThingSpeak



Problem Statement

Fitness trackers are useful and relatively low-tech

Challenge: use MATLAB® and MATLAB Mobile® to make your own fitness tracker

- **Collect sensor data** with your phone
- **Create a model** (ideally **machine or deep learning**) to turn these data (calories burned, steps taken, flights climbed, etc.) into usable information
- **Present data to users** in an easy-to-understand manner

Judging

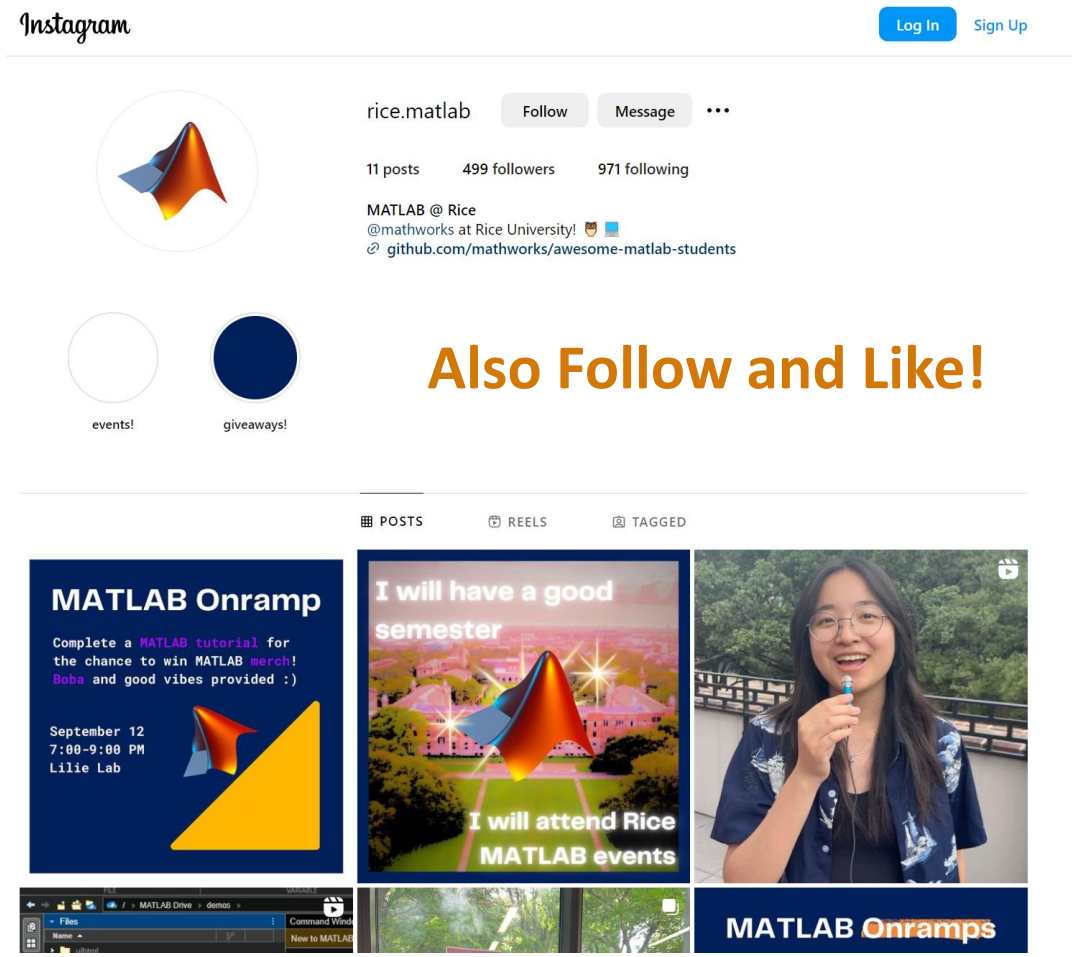
Fitness Tracker MATLAB Model	Points (70)
Creativity - Innovative, creative, and original work	10
Difficulty and Mastery - Level of MATLAB knowledge demonstrated in executing the tasks	10
Functionality - Error-free and runs without issues	10
Readability - Clean, organized and easy to comprehend	10
Data Visualization - Clear and insightful graphics	10
Model Making - Transitioned between model ideas into a viable model implementation	10
Advanced Model Making - Use of Machine or Deep Learning Techniques in model	10

Presenting Results - Report, Presentation or Video	Points (30)
Creativity - Interesting delivery methods, innovative and informative	10
Quality - Technical execution of material and attention to detail	10
Concept - Engaging, coherent and appropriate	10
Clarity - Message is clear and well-communicated	10

Questions during the competition?

DM our MATLAB Rice Instagram account

instagram.com/rice.matlab



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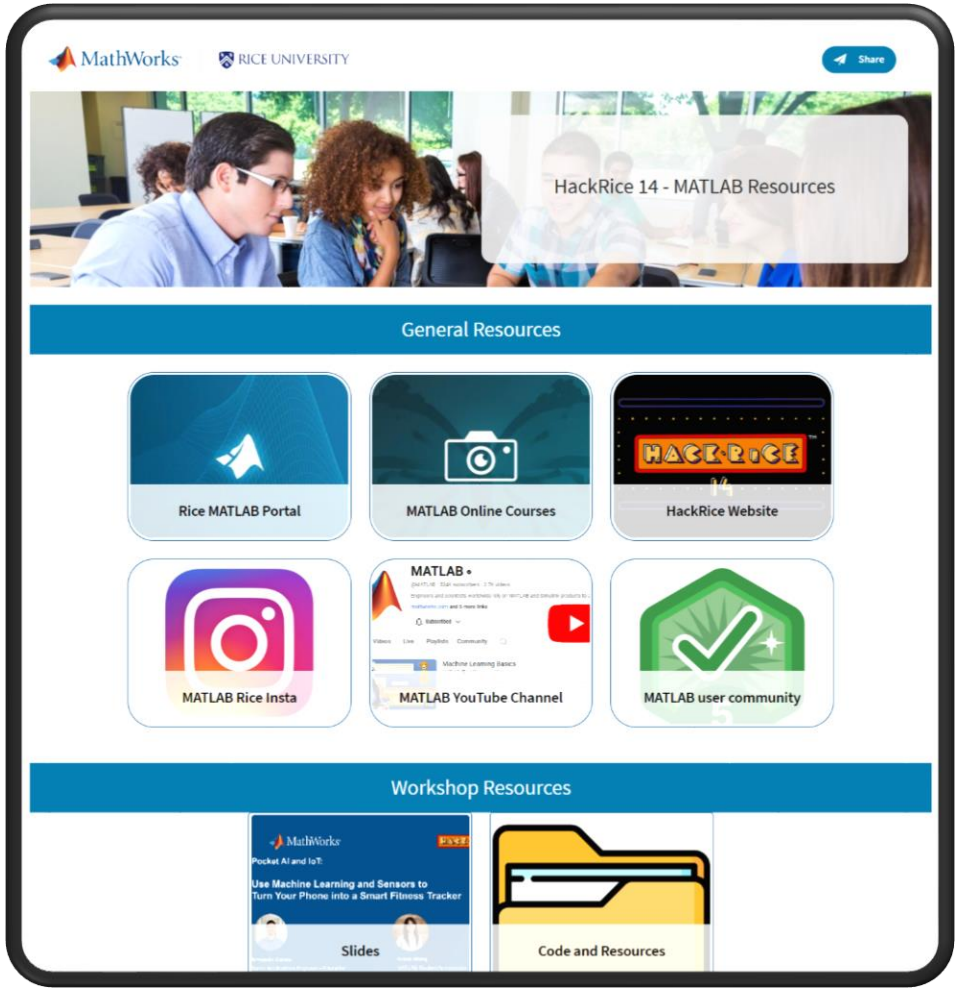
HackRice 14 Competition Smart Page



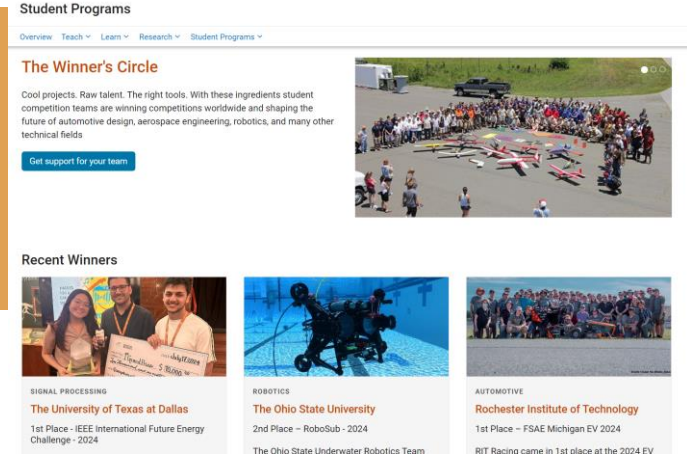
tinyurl.com/4t2xyzsa

What's in it for you?

Special prizes for best use of MATLAB

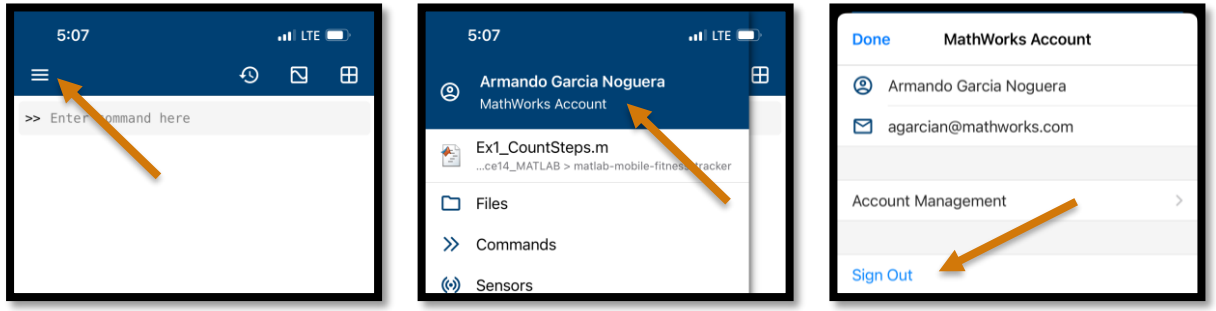
Certificates of participation and place in the competition

Selected projects posted on our website!



Prework

- Hardware and Software Requirements: Requires Android 8.0 or Requires iOS 13
- MATLAB Mobile installed? **Sign out**



Step 1. Create a MathWorks Account and activate your license (Skip to step 2 if you already have an account)

Step 2. Access the workshop files

HackRice14_MATLAB Public

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Guidelines and Handouts	Add files via upload	17 minutes ago
matlab-mobile-fitness-tracker	Delete matlab-mobile-fitness-tracker/TakeHome/Prework_M...	17 hours ago
README.md	Update README.md	17 hours ago

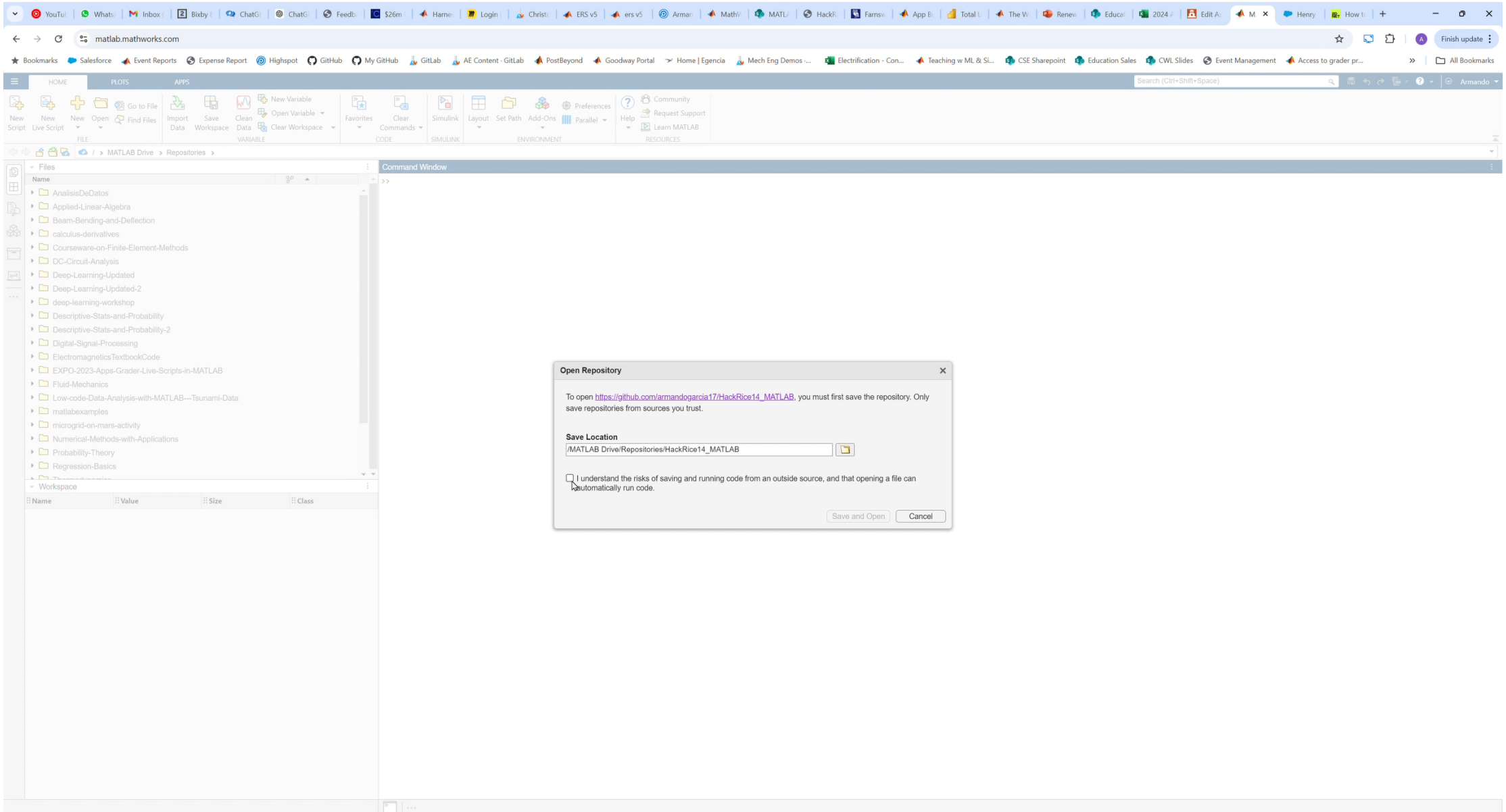
README

HackRice14

Resources for the MATLAB Fitness Tracker Challenge

Create Your Own Fitness Tracker with MATLAB® Online™ and MATLAB® Mobile™

This repository contains code and instructions to help you create your own fitness tracker with MATLAB Online and MATLAB Mobile for a Hackathon!


matlab.mathworks.com
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Command Window
Workspace
Open Repository
To open https://github.com/armandogarcia17/HackRice14_MATLAB, you must first save the repository. Only save repositories from sources you trust.
Save Location
/MATLAB Drive/Repositories/HackRice14_MATLAB
I understand the risks of saving and running code from an outside source, and that opening a file can automatically run code.
Save and Open
Cancel

Prework

- Hardware and Software Requirements: Requires Android 8.0 or Requires iOS 13
- MATLAB Mobile installed? **Sign out**

Step 1. Create a MathWorks Account and activate your license (Skip to step 2 if you already have an account)

Step 2. Access the workshop files

Step 3. Download and connect to MATLAB Mobile

- ✓ **On your device**, go to mathworks.com/products/matlab-mobile
- ✓ Click the Google Play or App Store link and **install the app**
- ✓ Open the app and click **'Connect to MathWorks Cloud'**
- ✓ **Log in** using the MathWorks Account you created.

A fitness tracker uses sensors, Artificial Intelligence (AI), and Internet of Things (IoT)

Get ready to cut through the hype and build a smart fitness tracker!

Exercise 1

Exercise 2

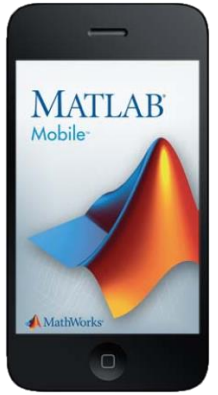
Exercise 3

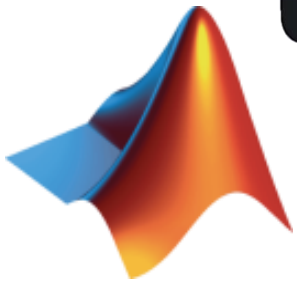
These are the technologies we will use

Sensors

AI

IoT



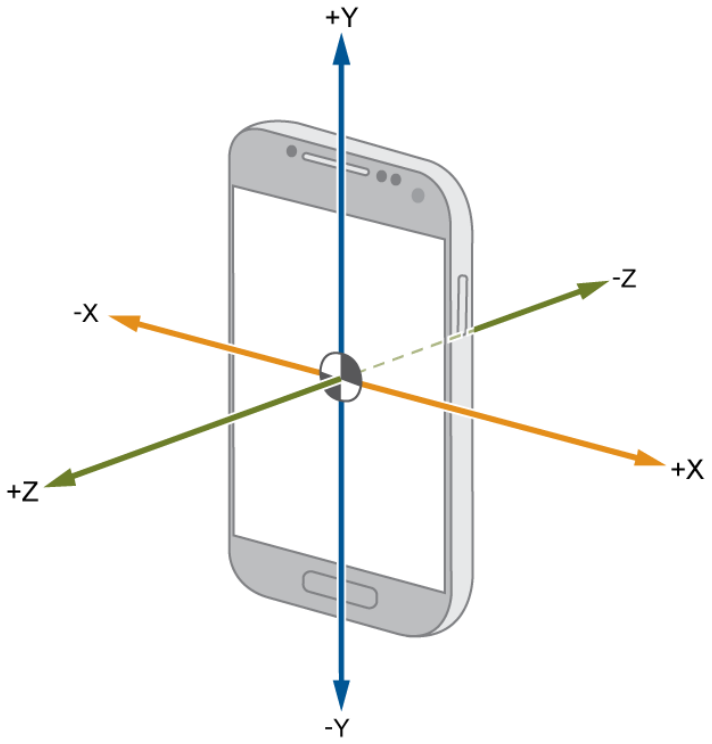


ThingSpeak™

Let's start with sensors

Sensors are everywhere!

An accelerometer detects acceleration, vibration, and tilt



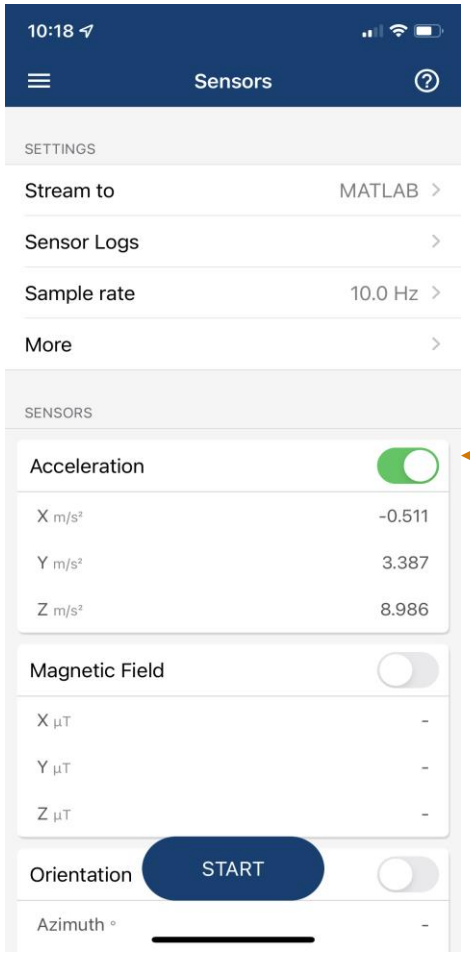
You will use your phone's accelerometer to count steps

Sensors
Exercise 1

AI
Exercise 2

IoT
Exercise 3

You will use MATLAB Mobile to record and analyze your accelerometer data



Accelerometer

Android 8 or later

iOS 13 or later

It is simple to navigate and run code

Collect the accelerometer data as you walk

CollectData.m

```
m = mobiledev;
m.AccelerationSensorEnabled = true;
m.Logging = true;
```

We will count steps by finding peaks in our acceleration data

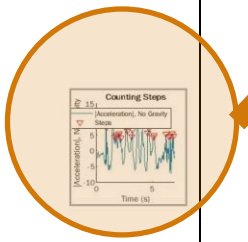
Ex1_CountSteps.m

```
[a, t] = accellog(m);
mag = sqrt(sum(x.^2 + y.^2 + z.^2,2));
[pks, locs] = findpeaks(magNoG,...
    'MINPEAKHEIGHT',
numSteps = numel(pks);
```

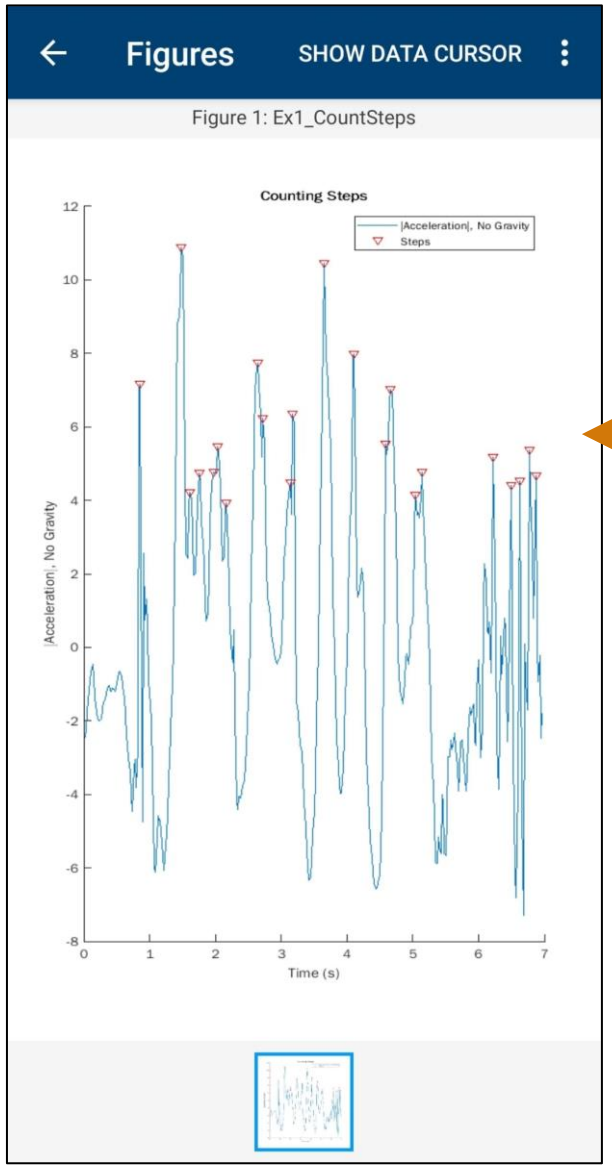
The command window displays your step count

```
>> Ex1_CountSteps

Start your activity in 5 secs
     5

     4

     3

     2

     1

Start your activity(walk,run,idle) for 20
secs
Data collection complete.

numSteps =

    22

>>
```

Step Count



Click



Peak = Step

Exercise 1: Let's calculate your step count
Get ready to walk!

1. Open **`Ex1_CountSteps.m`** and press Run
2. Wait for the prompt to start walking
3. WALK for 20 seconds
4. View your step count

If you have time, try again and review the code

Did you get the results you expected?

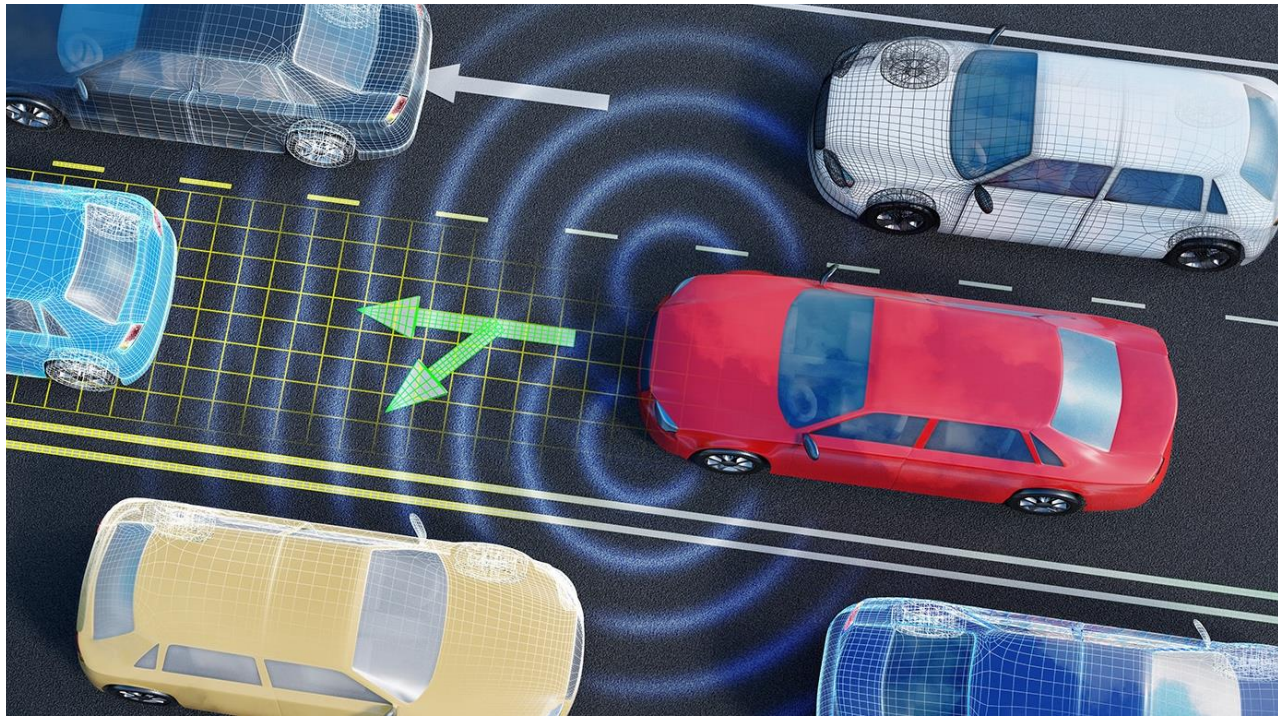
- How accurate were your results?
- If they were not accurate, why?
- What are some other sensors you could collect data from?

Now that you've collected data, how can you analyze it?


amazon


Luke Skywalker
94.5%


ВЫХОД В ГОРОД
ACCESS TO CITY



Artificial Intelligence

The capability of a machine to imitate intelligent human behavior

Artificial Intelligence

The capability of a machine to match or exceed intelligent human behavior

Artificial Intelligence Today

The capability of a machine to match or exceed intelligent human behavior

by training a machine to learn the desired behavior

There are two ways to get a computer to do what you want

Traditional Programming

There are two ways to get a computer to do what you want

Machine Learning

Artificial Intelligence

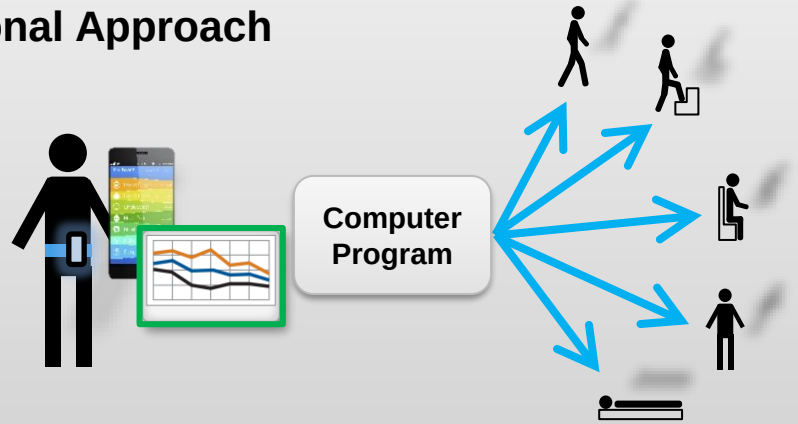
Machine Learning

What is Machine Learning?

Machine learning uses **data** and produces a **model** to perform a **task**

Task: Human Activity Detection

Traditional Approach



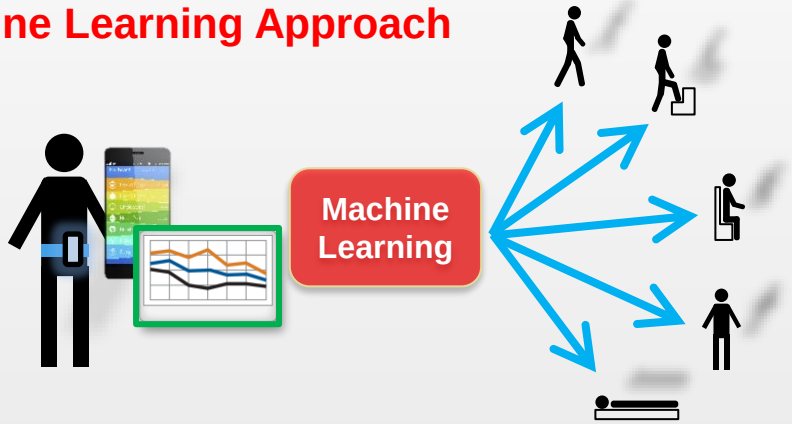
Handwritten Program

If X_acc > 0.5
then "SITTING"
If Y_acc < 4 and Z_acc > 5
then "STANDING"
…

Formula or Equation

$$Y_{activity} = \beta_1 X_{acc} + \beta_2 Y_{acc} + \beta_3 Z_{acc} + \ldots$$

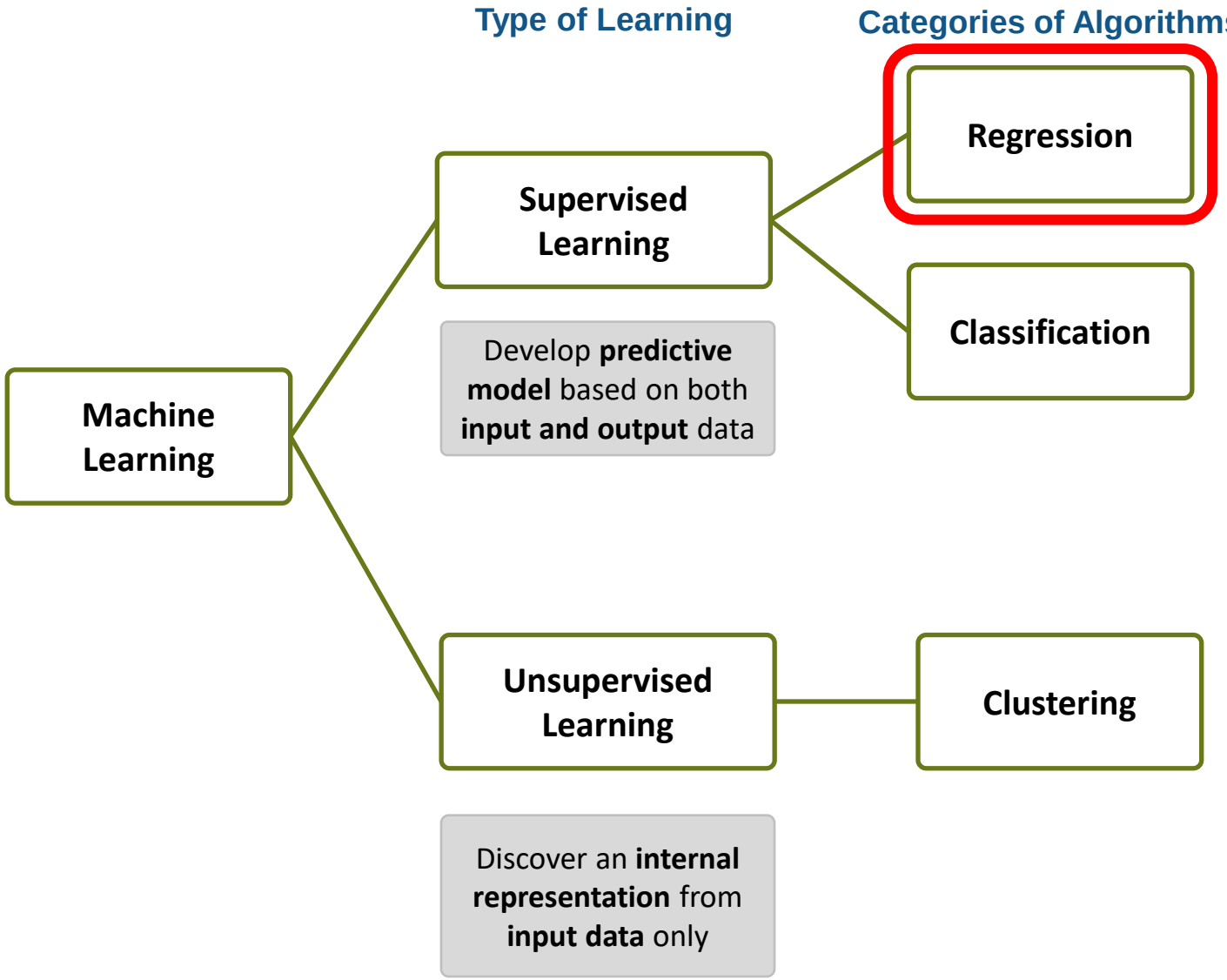
Machine Learning Approach



$model$: Inputs → Outputs

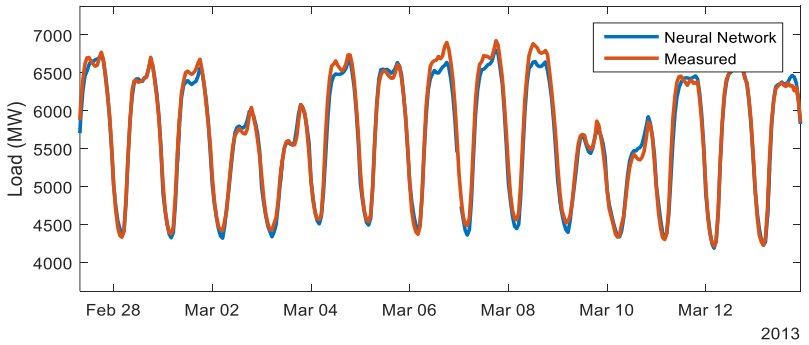
$$model = <\begin{matrix}\textbf{Machine}\\ \textbf{Learning}\\ \textbf{Algorithm}\end{matrix}>(sensor\_data, activity)$$

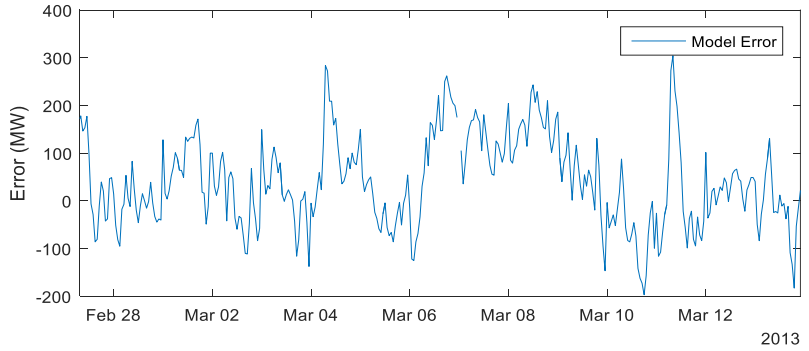
Types of Machine Learning



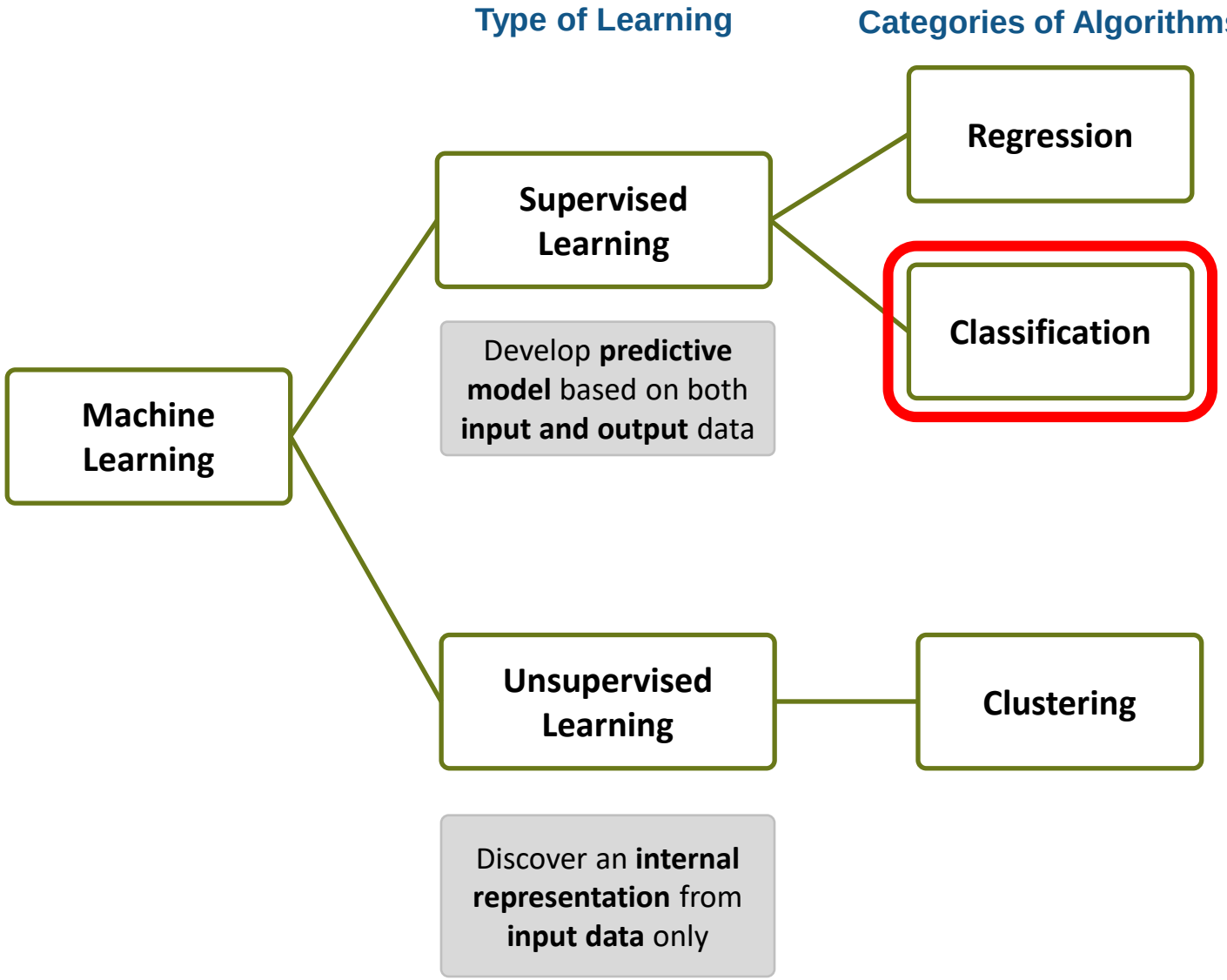
Objective:

Easy and accurate computation of day-ahead system load forecast





Types of Machine Learning



Objective:

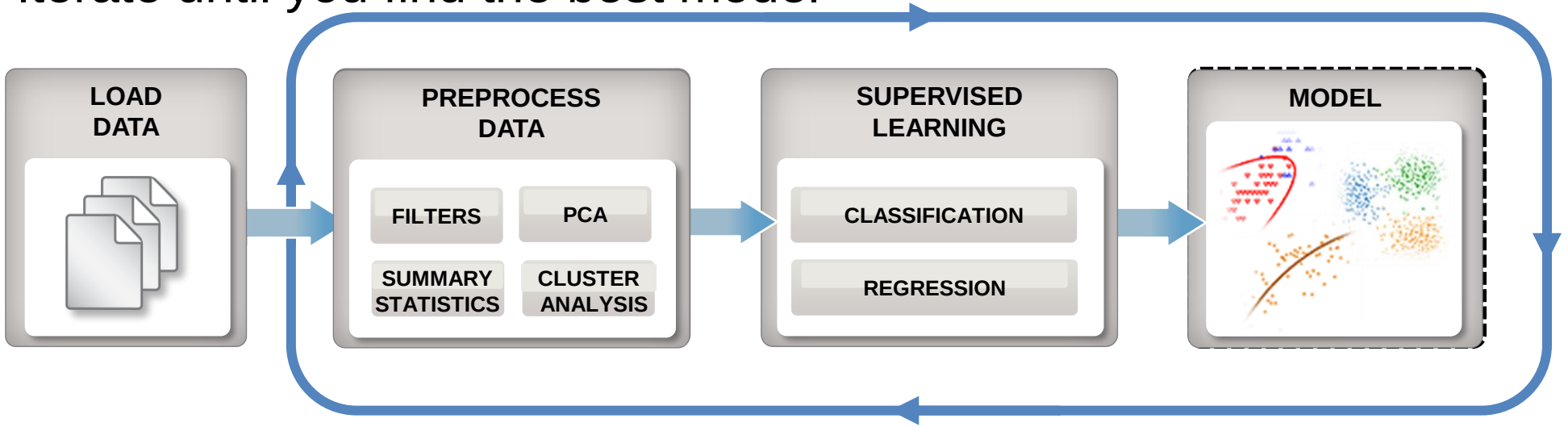
Train a classifier to classify human activity from sensor data

Data:

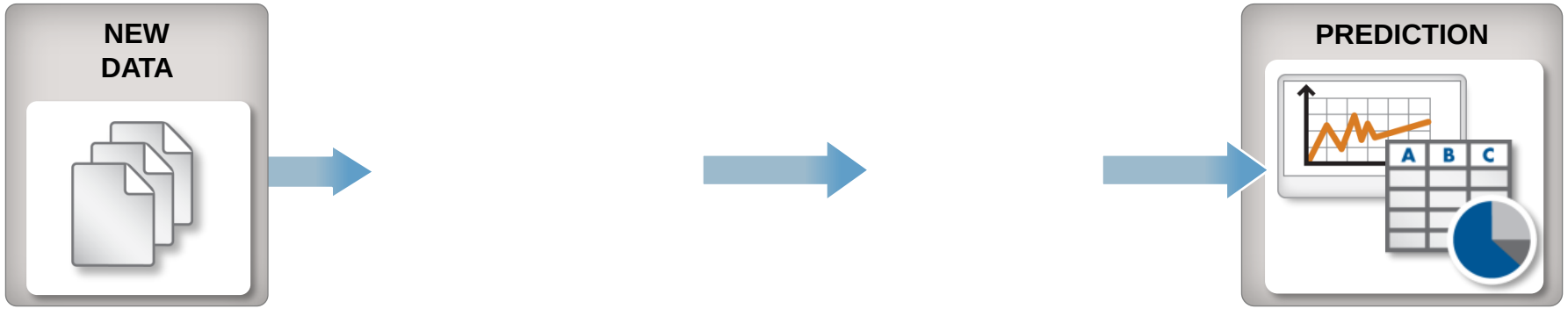
Inputs	3-axial Accelerometer 3-axial Gyroscope 
Outputs	

Supervised Learning Workflow

Train: Iterate until you find the best model

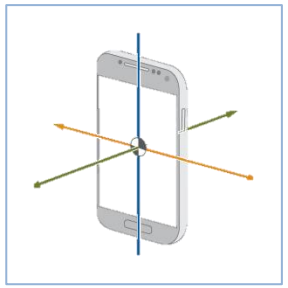


Predict: Integrate trained models into applications



Machine learning teaches a model to do a task using data

DATA



KNN

CLASSIFICATION

We will use machine learning to classify your activity

Sensors
Exercise 1

AI
Exercise 2

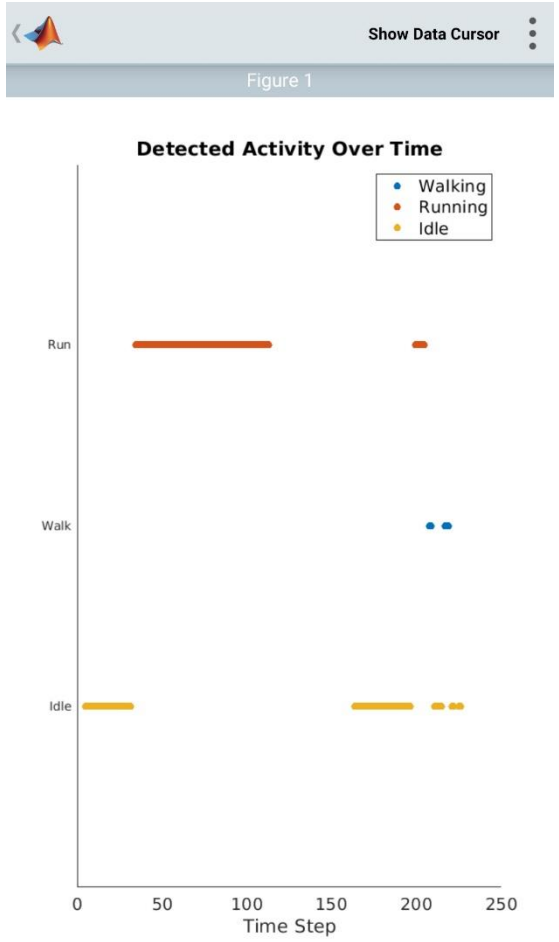
IoT
Exercise 3

We will use training data to build a k-nearest neighbors model for classification

Ex2_ClassifyActivity.m

```
[X,Y,dataMin,dataRange] = getTrainingData();


mdl = fitcknn(X,Y);
knnK = 10; %num of nearest neighbors
mdl.NumNeighbors = knnK;
[frameActivity,frameScore] = ...
    predict(mdl, frameFeatures);
```

Click on the plot to see a breakdown



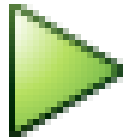
Run

Walk

Idle

Time

Exercise 2: Let's use machine learning to classify your activity

1. Open  **`Ex2_ClassifyActivity.m`** and press Run 

2. Wait for the prompt to start your activity

3. MOVE (Walk, Run, Idle) for 30 seconds

4. View the breakdown of your fitness activity

If you have time, try again and review the code

Did you get the results you expected?

- How do you think you could improve the accuracy?

- Data
- Features
- Model
- Sensors

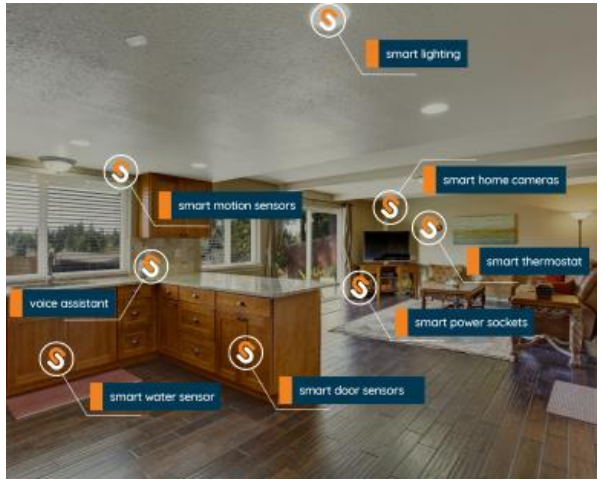
How can we aggregate our activity to the cloud?

What is the Internet of Things (IoT)?

- **Network of devices or things**
  - Embedded devices with sensors
  - Place to aggregate and analyze data
  - Access to data and algorithm development

IoT Applications

Smart Home



Smart Cities

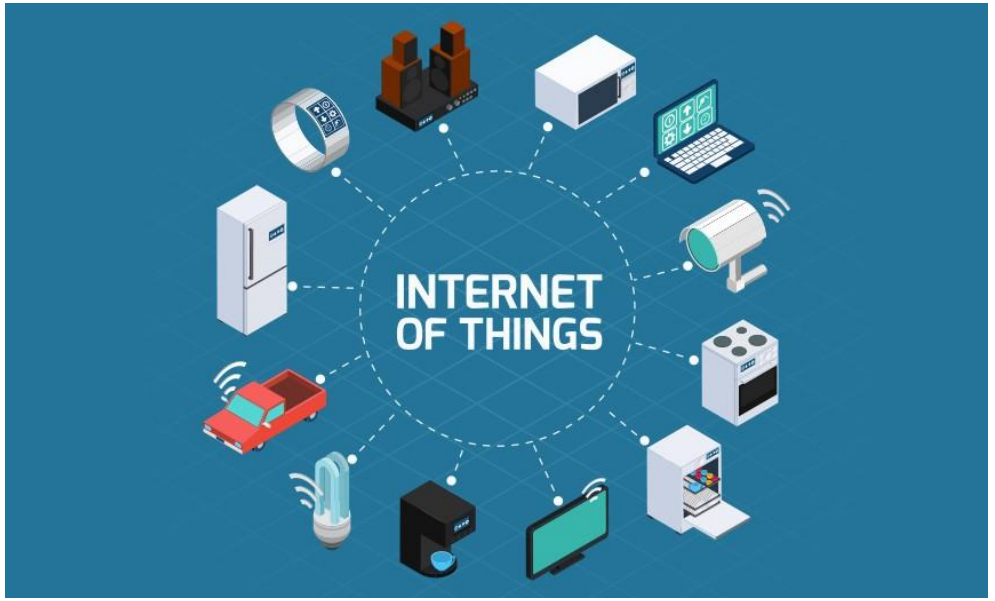
Smart Agriculture

Healthcare/Wearables

Industrial 4.0

Why IoT?

- **Do things better and smarter**
  - Efficiency
  - Automation
- **Do new things**
  - QoL improvements
  - Remote operations



We will collect our activity data on the cloud

Sensors
Exercise 1

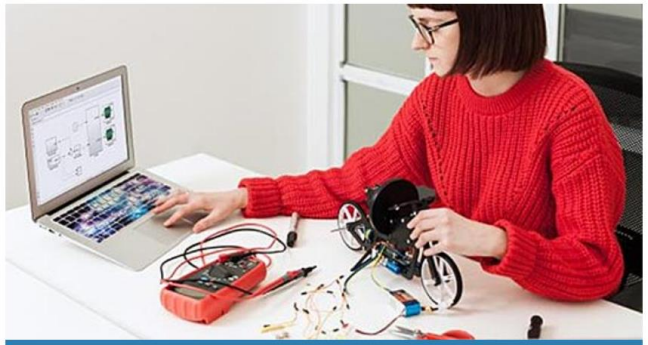
AI
Exercise 2

Collect — Data from mobile device

Analyze — Classify

Aggregate — Total steps per team

ThingSpeak is MATLAB's platform for IoT



ThingSpeak for Students and Educators

Implement IoT research projects quickly with built-in MATLAB data analysis tools and real-time sensor data collection

ThingSpeak for Environmental Monitoring

Build IoT services for remote monitoring of air quality sensors, and create MATLAB models to predict pollution levels

thingspeak.com

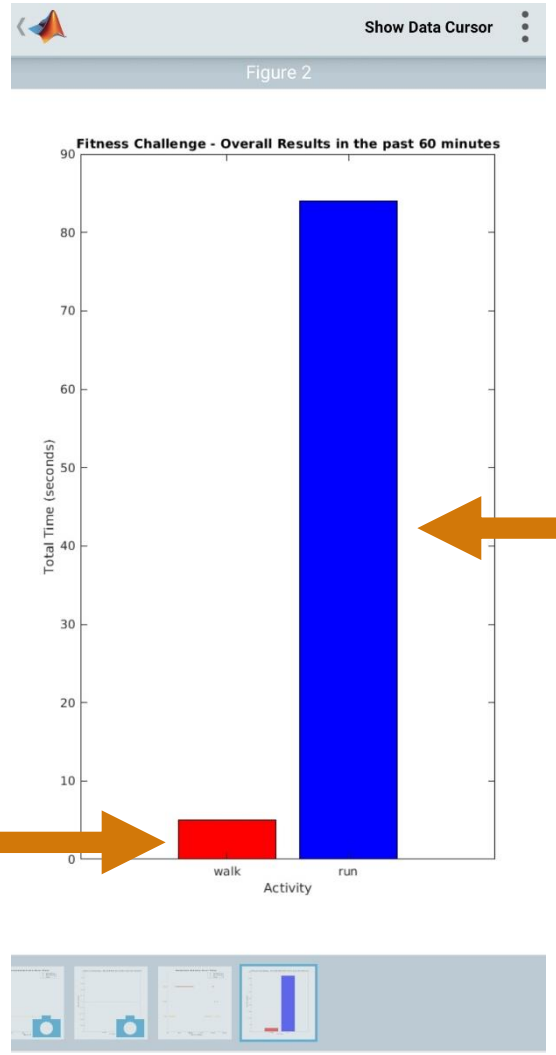
You will aggregate your team's activity time

Ex3_ThingSpeak_Fitness.m

```
thingSpeakWrite(fitnessChallengeChannelID,...
    {tWalkSum, tRunSum, tIdleSum, teamID},...
    'WriteKey',fitnessChallengeWriteAPIKey);
    fitnessChallengeChannelID,...
    'NumMinutes',numMins,...
y = [ThisData.WalkData ThisData.RunData];
b = bar(sum(y,1),'FaceColor','flat');
```


49

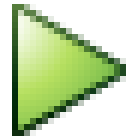
You can examine the figure to view everyone's combined time walking and running



Run

Walk

Exercise 3: Let's view your team's total active time

1. Open  **`Ex3_ThingSpeak_Fitness.m`** and press Run 
2. You will get assigned to a team (1-5)
3. MOVE (Walk, Run, Idle) for 30 seconds
4. View the fitness activity from all teams

If you have time, log more data!

Let's compare the classified activity states across teams…

Fitness Channel

Did you get the results you expected?

- What else could you do with the data you have aggregated?

- Can you think of other applications in your day-to-day life where you see machine learning and IoT come together?

Congratulations! You've cut through the hype and designed a fitness tracker!

YOU + Sensors + AI + IoT = Innovation!