



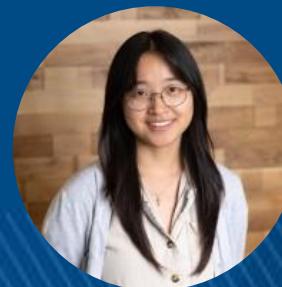
Pocket AI and IoT:

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



Armando Garcia

Senior Applications Engineer – Education

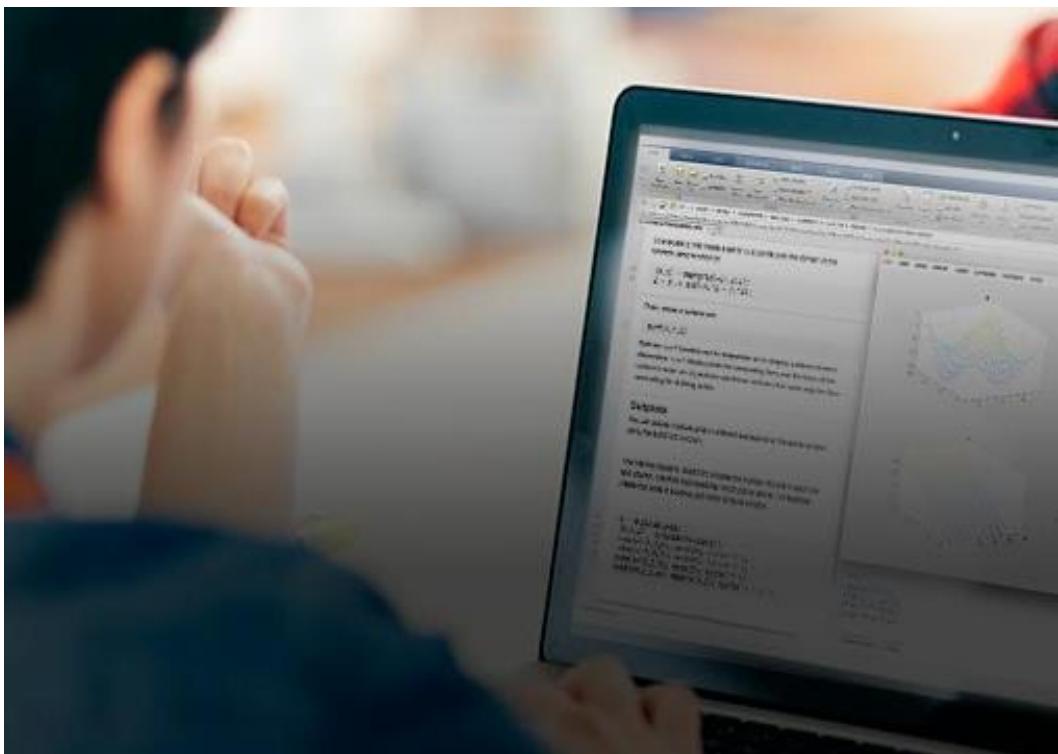


Grace Wang

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

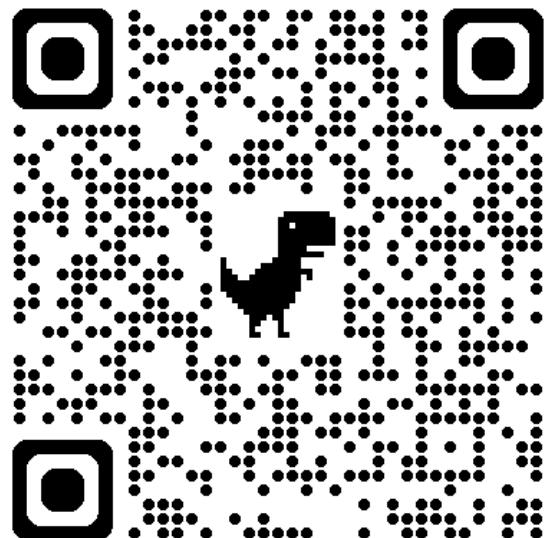
Fitness Tracker MATLAB Model	Points (70)
Creativity - Innovative, creative, and original work	10
Difficulty and Mastery - Level of MATLAB knowledge demonstrated in executing the tasks	10
Functionality - Error-free and runs without issues	10
Readability - Clean, organized and easy to comprehend	10
Data 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](https://www.instagram.com/rice.matlab)



Instagram

rice.matlab Follow Message ...

11 posts 499 followers 971 following

MATLAB @ Rice
@mathworks at Rice University! 🏫 🎓
🔗 github.com/mathworks/awesome-matlab-students

events! giveaways!

POSTS REELS TAGGED

The screenshot shows the Instagram profile for 'rice.matlab'. At the top, there's a bio for 'MATLAB @ Rice' with links to their GitHub page. Below the bio are two circular icons labeled 'events!' and 'giveaways!'. The main feed displays several posts: one about a MATLAB Onramp event on September 12, another with a MATLAB surface plot and text 'I will have a good semester', and a photo of a person smiling outdoors. A navigation bar at the bottom includes 'POSTS', 'REELS', and 'TAGGED' buttons.

Also Follow and Like!

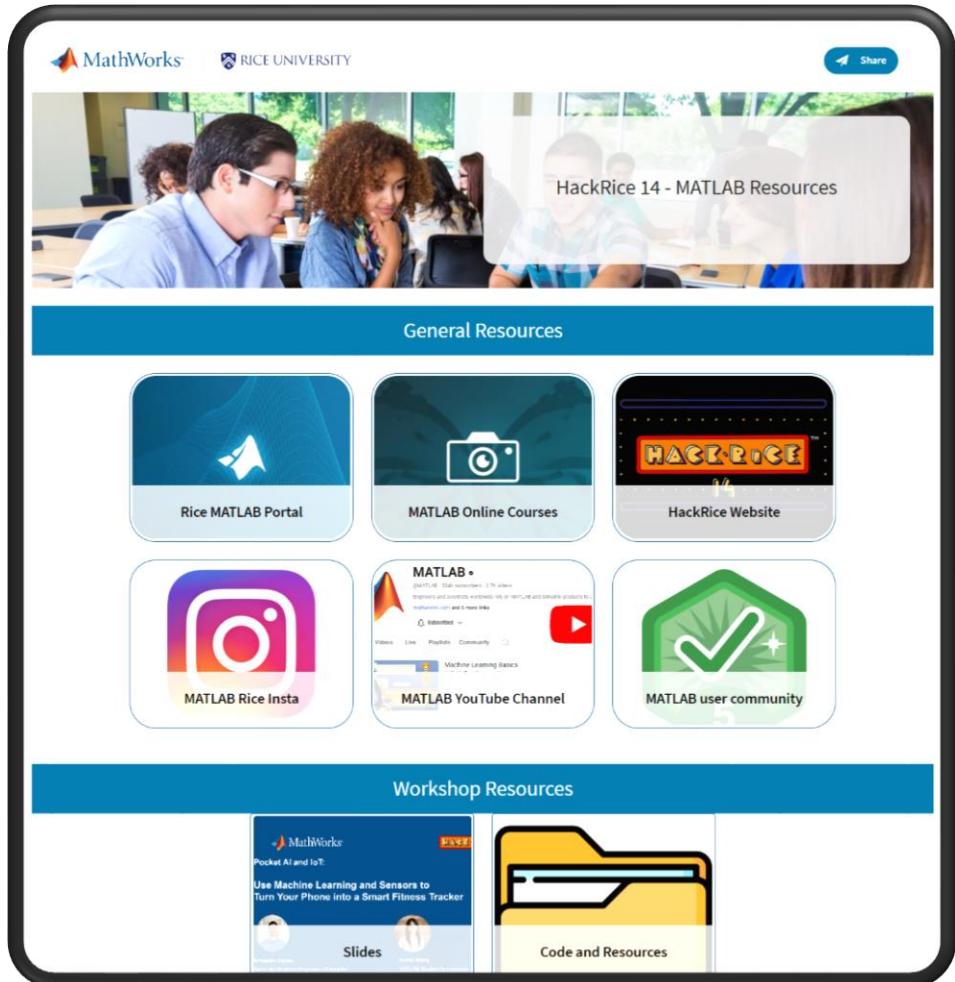
MATLAB Onramps

I will have a good semester

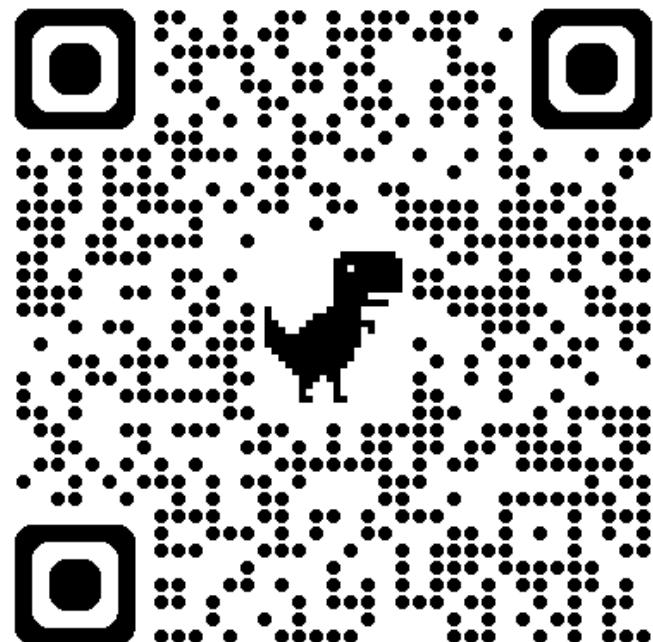
I will attend Rice MATLAB events

MATLAB Onramps

HackRice 14 Competition Smart Page



tinyurl.com/4t2xyzsa



What's in it for you?

Special prizes for the best use of MATLAB



Certificates of participation and place in the competition

Selected projects posted on our website!

Student Programs

Overview Teach ▾ Learn ▾ Research ▾ Student Programs ▾

The Winner's Circle

Cool projects. Raw talent. The right tools. With these ingredients student competition teams are winning competitions worldwide and shaping the future of automotive design, aerospace engineering, robotics, and many other technical fields

Get support for your team



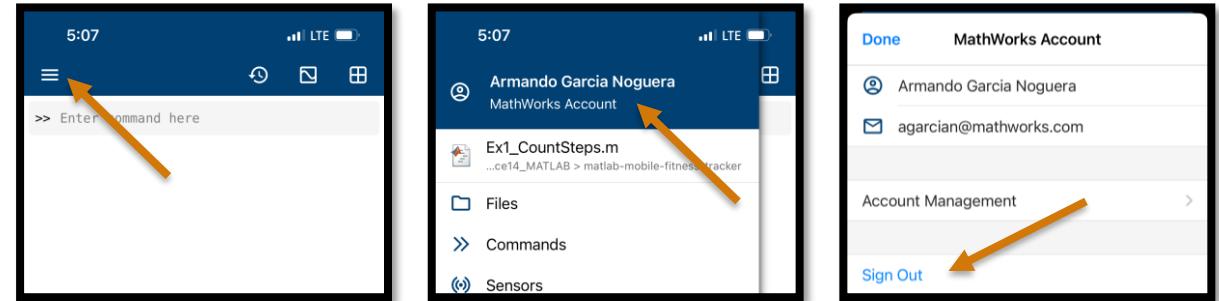
Recent Winners

 SIGNAL PROCESSING The University of Texas at Dallas 1st Place - IEEE International Future Energy Challenge - 2024	 ROBOTICS The Ohio State University 2nd Place – RoboSub - 2024	 AUTOMOTIVE Rochester Institute of Technology 1st Place – FSAE Michigan EV 2024
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RIT Racing came in 1st place at the 2024 FV

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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master

1 Branch 0 Tags

Go to file

Add file

Code

armandogarcia17 Add files via upload

05a30dd · 17 minutes ago 25 Commits

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



[Open in MATLAB Online](#)



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!

YouTl Whats Inbox Bixby ChatG ChatG Feed: \$26m Home Login Christ ERS v5 ers v5 Arman MathV MATL HackR Farms App B Total U The W Renew Educ 2024 Edit A M Henry How to - X

matlab.mathworks.com

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HOME PLOTS APPS

New Script New Live Script Go to File New Open Find Files Import Data Save Workspace New Variable Open Variable Clean Data Clear Workspace Favorites Commands Simulink Layout Set Path Add-Ons Parallel Preferences Help Learn MATLAB RESOURCES

FILE VARIABLE CODE SIMULINK ENVIRONMENT

MATLAB Drive > Repositories > AnalysisDeDatos Applied-Linear-Algebra Beam-Bending-and-Deflection calculus-derivatives Courseware-on-Finite-Element-Methods DC-Circuit-Analysis Deep-Learning-Updated Deep-Learning-Updated-2 deep-learning-workshop Descriptive-Stats-and-Probability Descriptive-Stats-and-Probability-2 Digital-Signal-Processing ElectromagneticsTextbookCode EXPO-2023-Apps-Grader-Live-Scripts-in-MATLAB Fluid-Mechanics Low-code-Data-Analysis-with-MATLAB---Tsunami-Data matlabexamples microgrid-on-mars-activity Numerical-Methods-with-Applications Probability-Theory Regression-Basics

Workspace

Name Value Size Class

Command Window

Open Repository

To open https://github.com/aramdogarcia17/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.

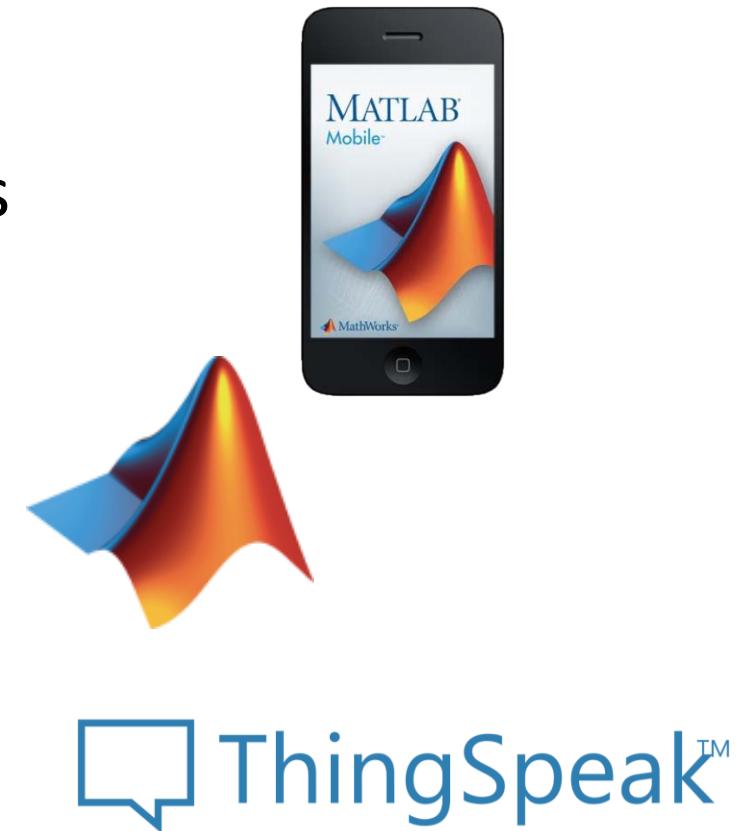
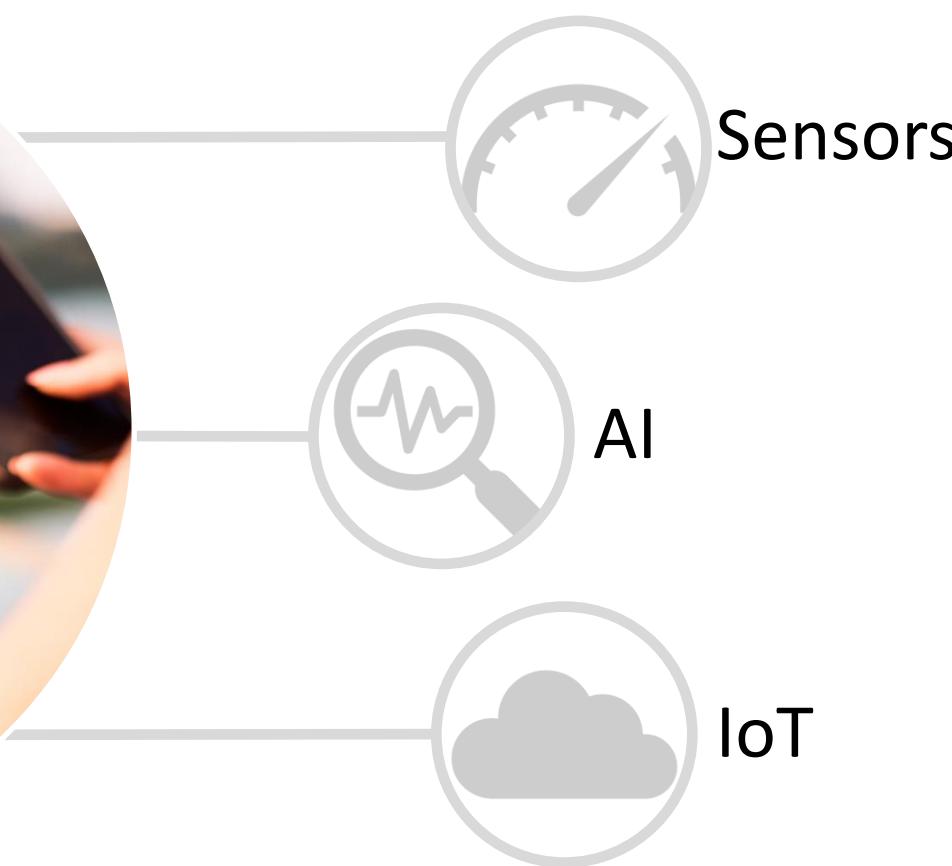
A fitness tracker uses sensors, Artificial Intelligence (AI), and Internet of Things (IoT)



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



These are the technologies we will use



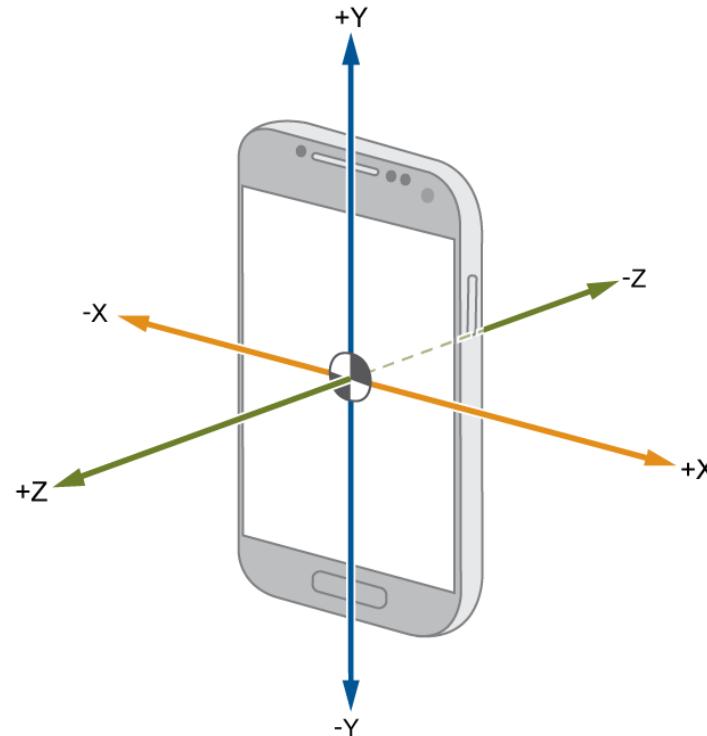
Let's start with sensors



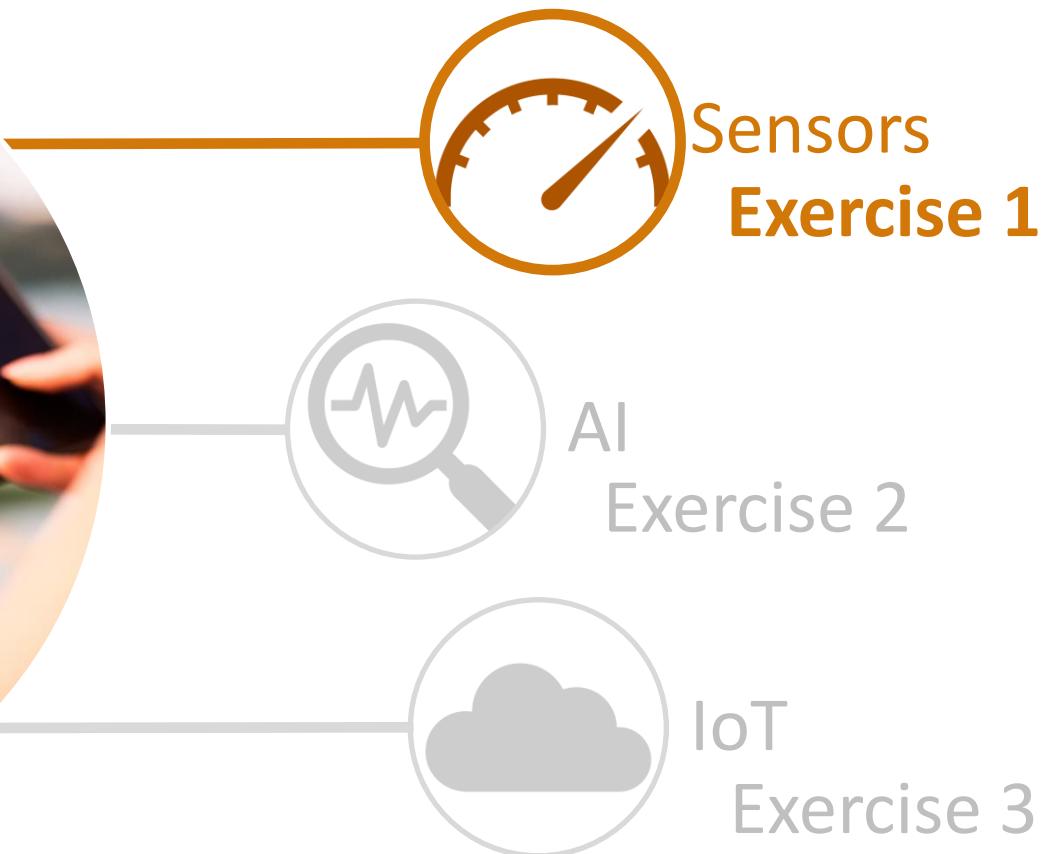
Sensors are everywhere!



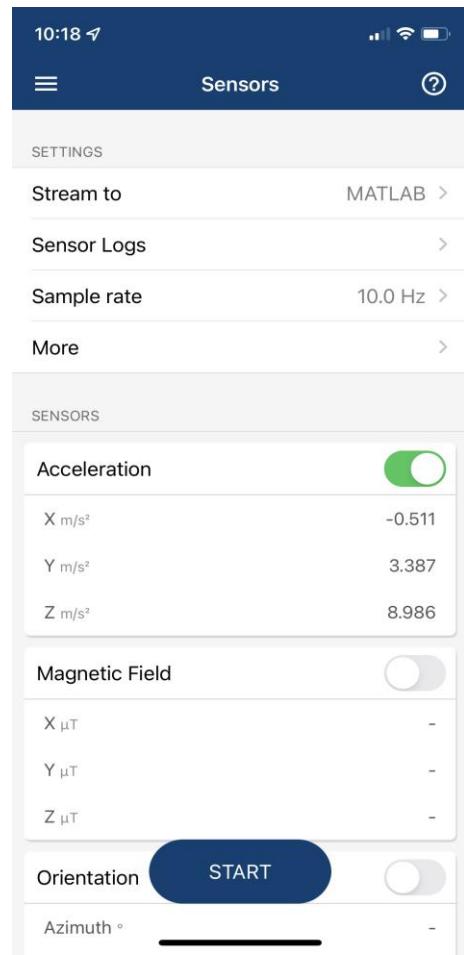
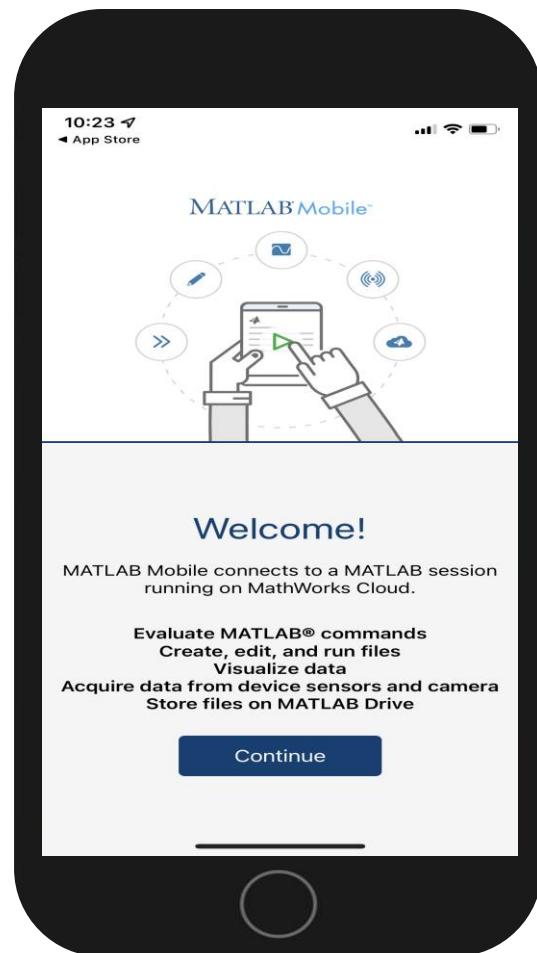
An accelerometer detects acceleration, vibration, and tilt



You will use your phone's accelerometer to count steps



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

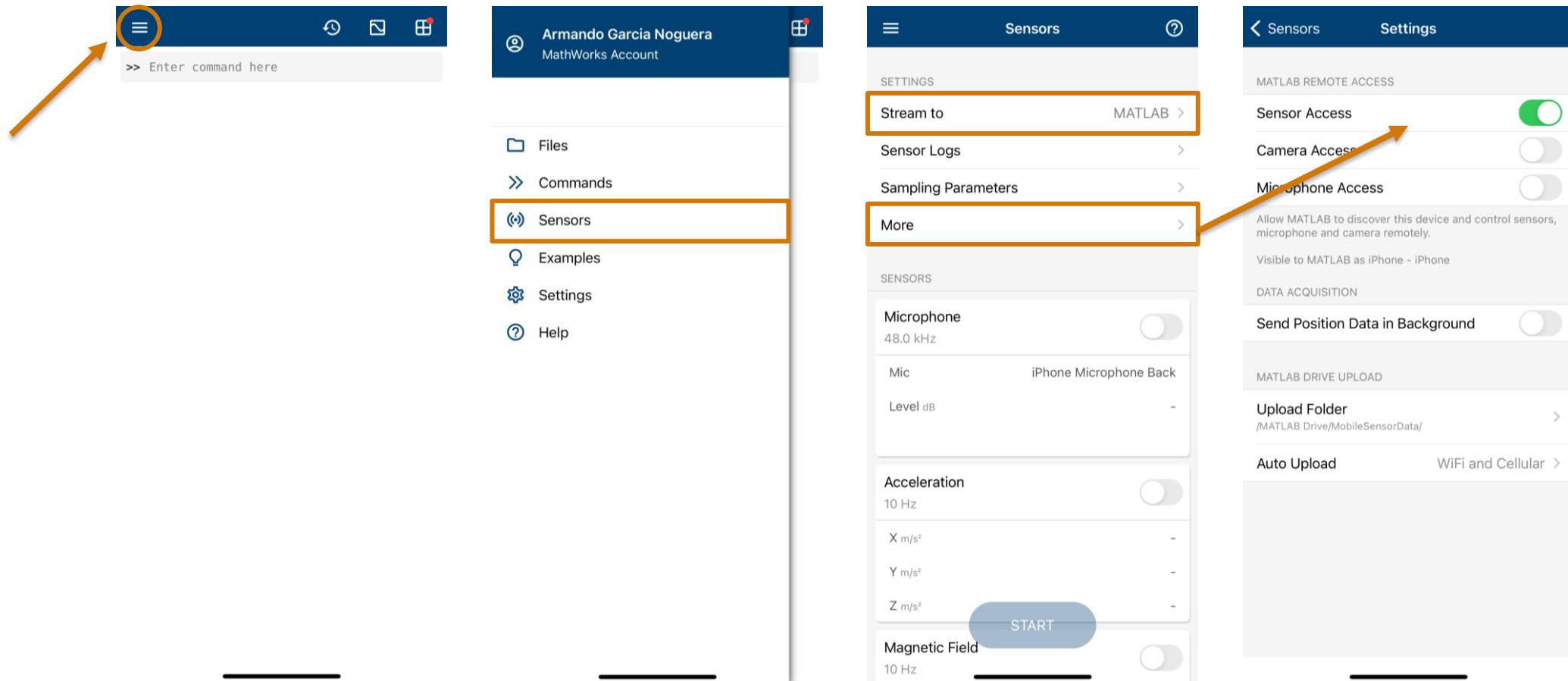


Accelerometer

Android 8 or later

iOS 13 or later

Initial Sensor Access Setup



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

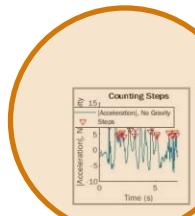
```
[a, t] = acceloga(m);  
mag = sqrt(sum(x.^2 + y.^2 + z.^2, 2));  
[pks, locs] = findpeaks(magNoG, ...  
    'MTNPKEAKHETGHT');  
numSteps = numel(pks);  
    %ITTCARTEYR,
```

The command window displays your step count

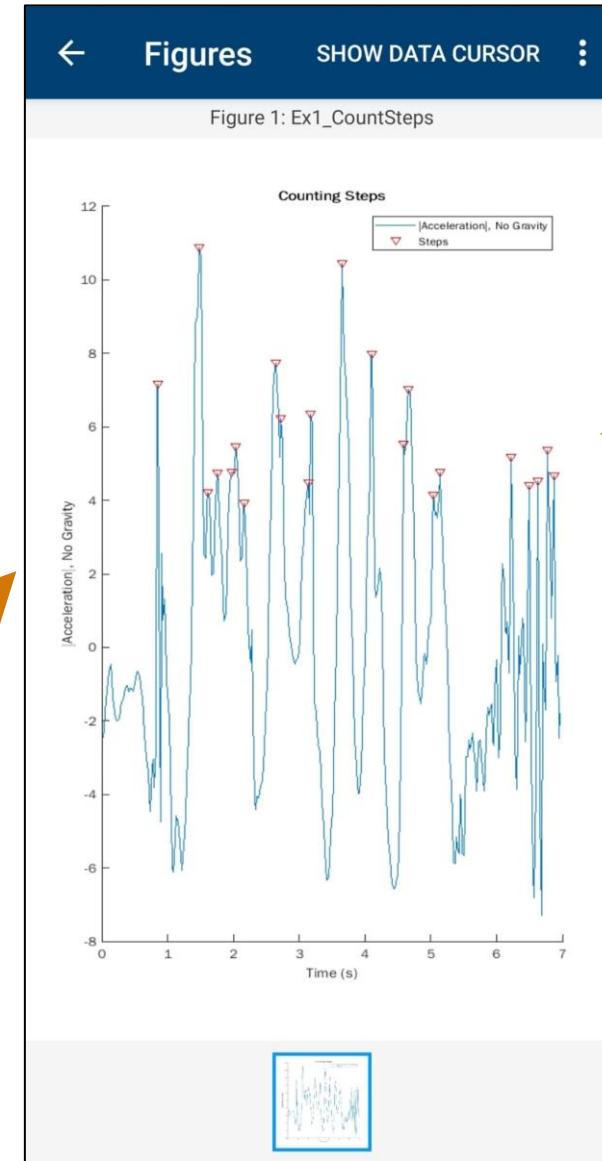
**Step
Count**

```
>> 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
>>
```



Click



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

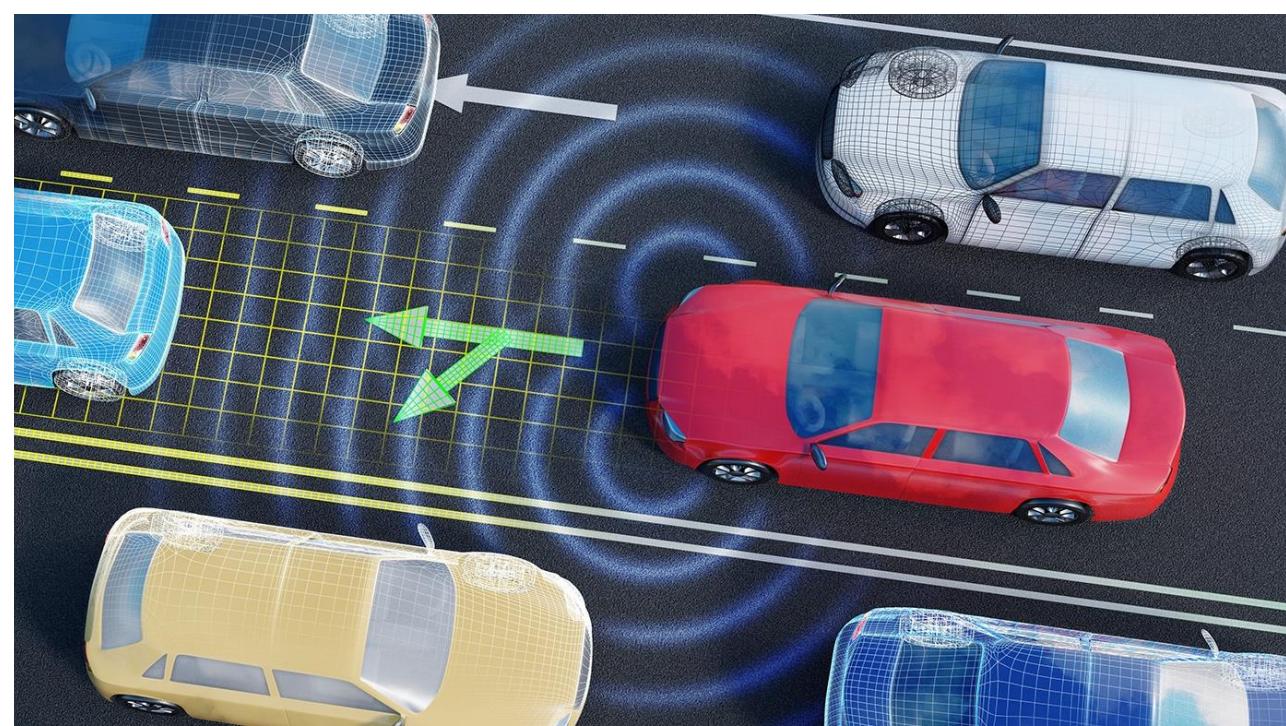
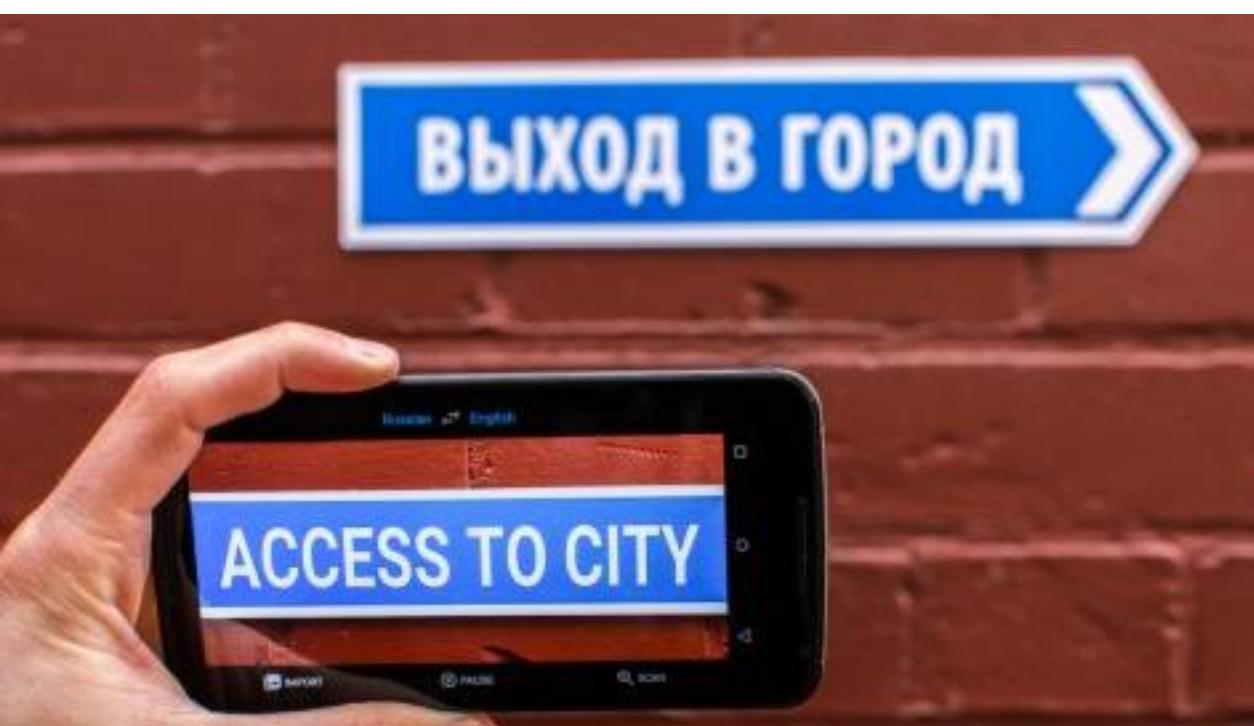


Did you get the results you expected?

- 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?





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***

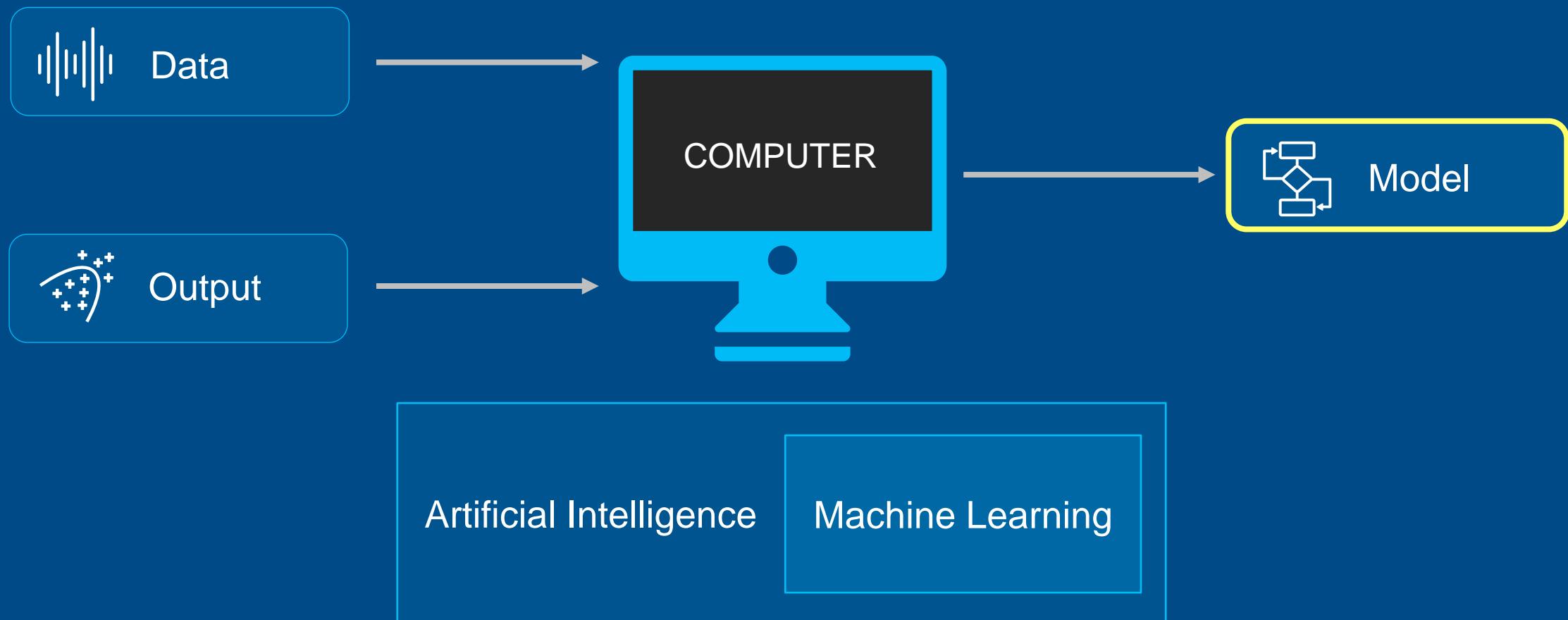
There are two ways to get a computer to do what you want

Traditional Programming



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

Machine Learning

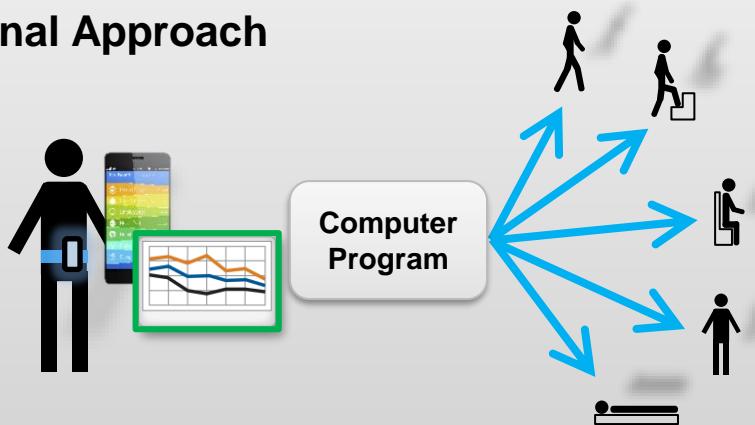


What is Machine Learning?

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

Task: Human Activity Detection

Traditional Approach



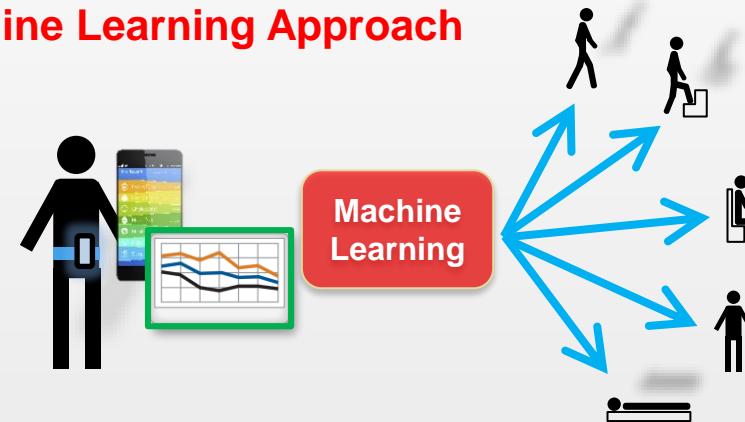
Handwritten Program

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

Formula or Equation

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

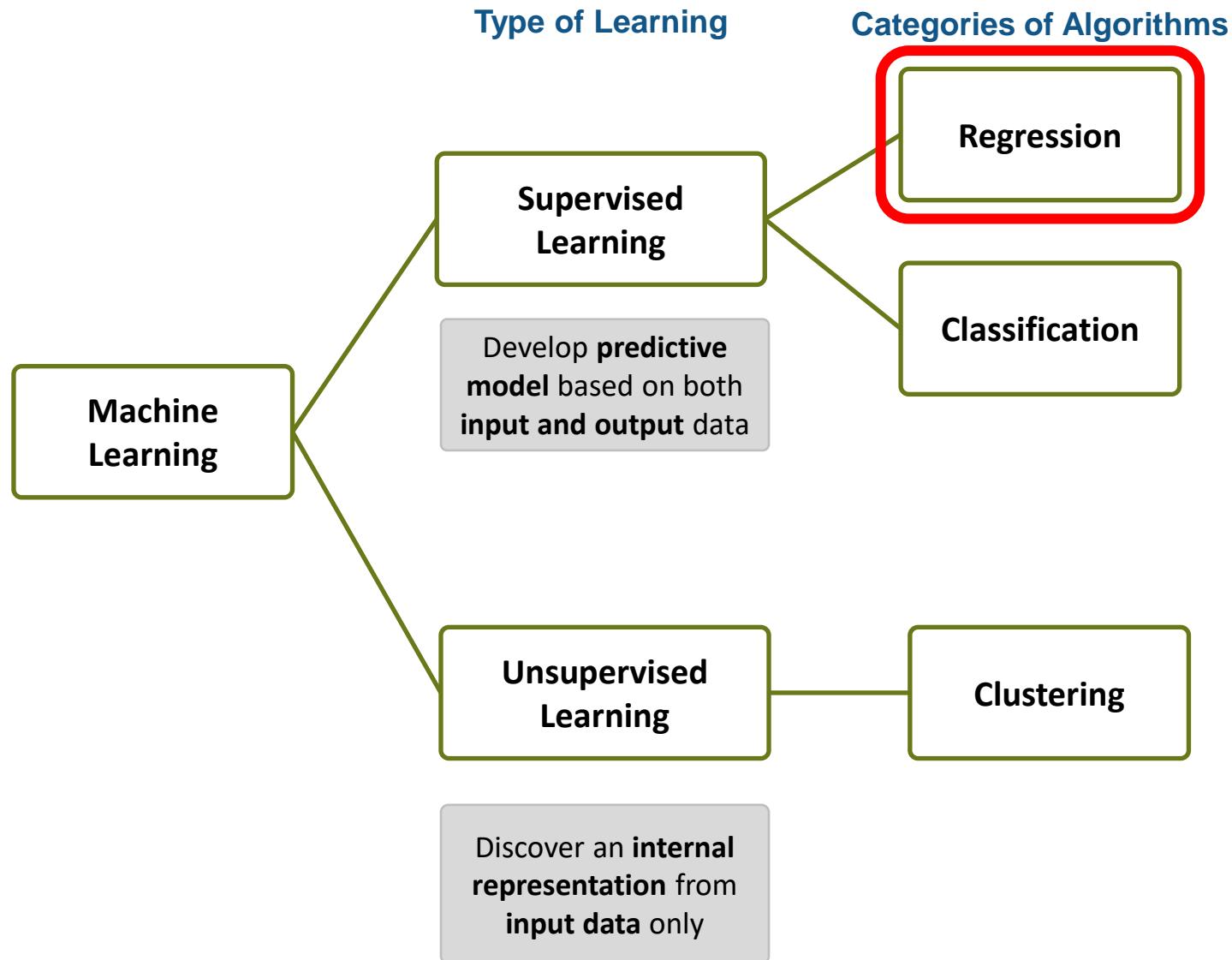
Machine Learning Approach



model: Inputs → Outputs

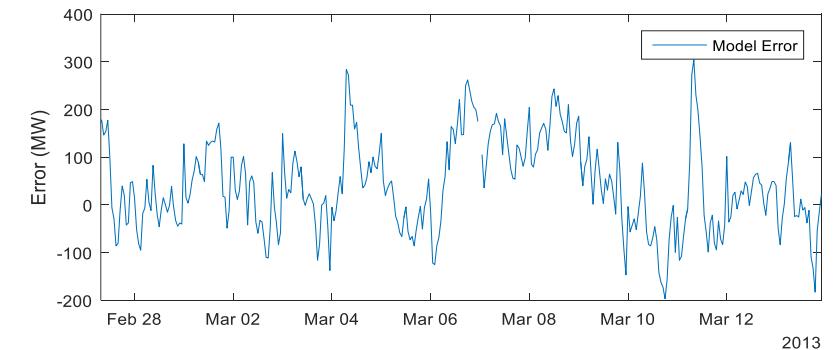
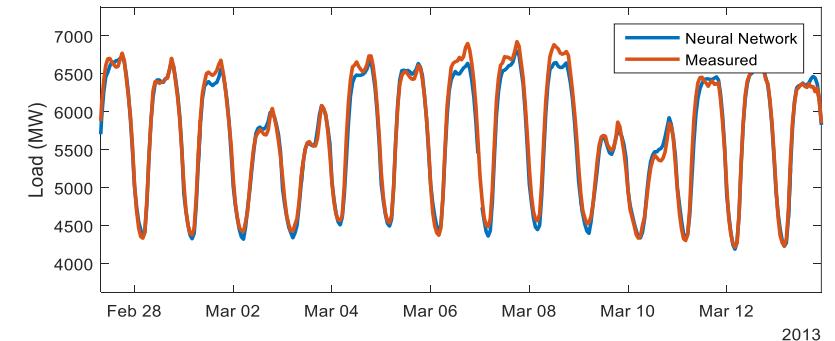
model = *Machine Learning* *Algorithm* (*sensor_data, activity*)

Types of Machine Learning

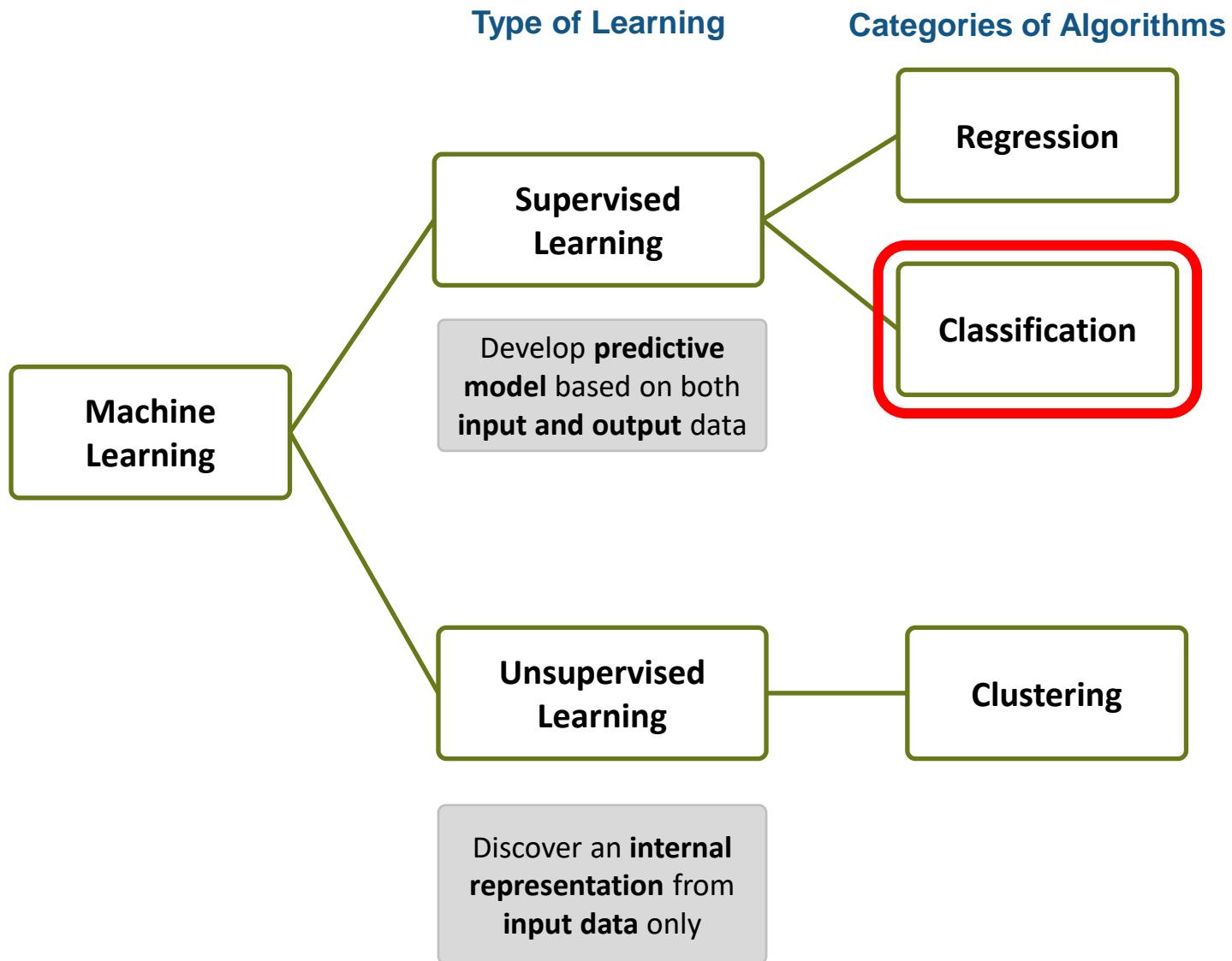


Objective:

Easy and accurate computation of day-ahead system load forecast



Types of Machine Learning



Objective:

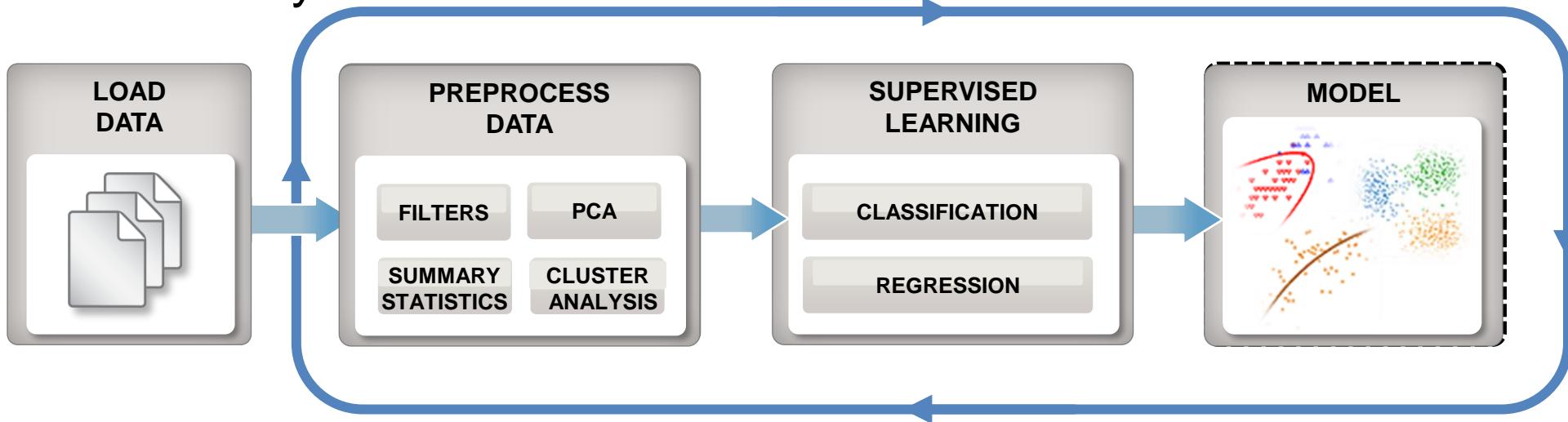
Train a classifier to classify human activity from sensor data

Data:

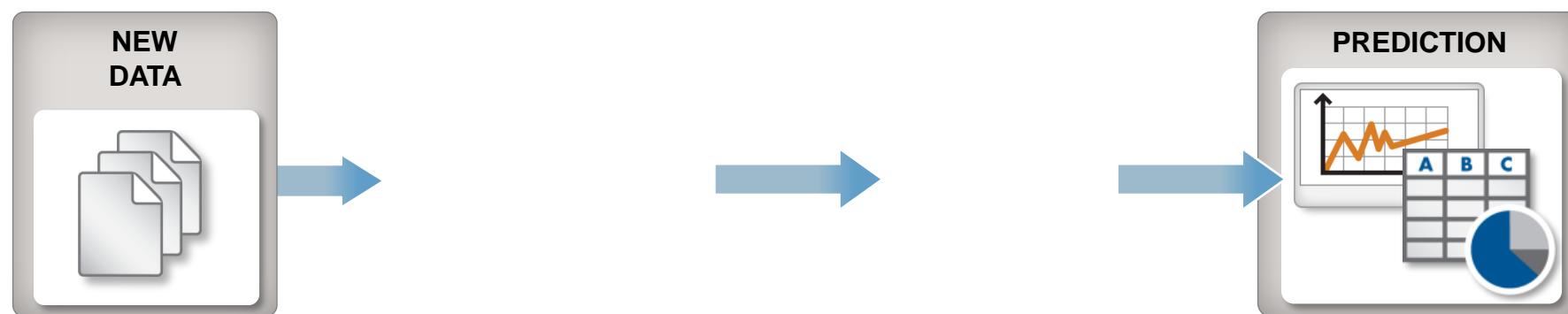
Inputs	3-axial Accelerometer 3-axial Gyroscope				
Outputs					

Supervised Learning Workflow

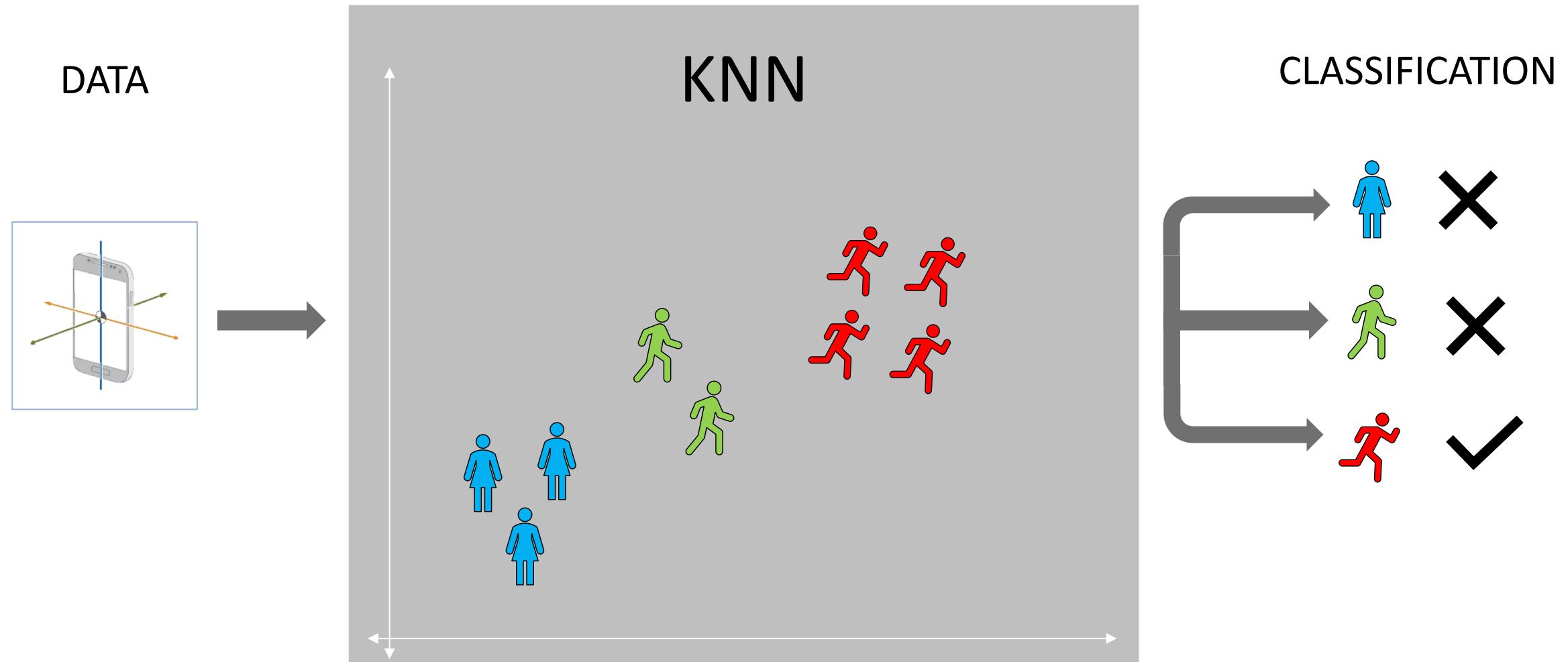
Train: Iterate until you find the best model



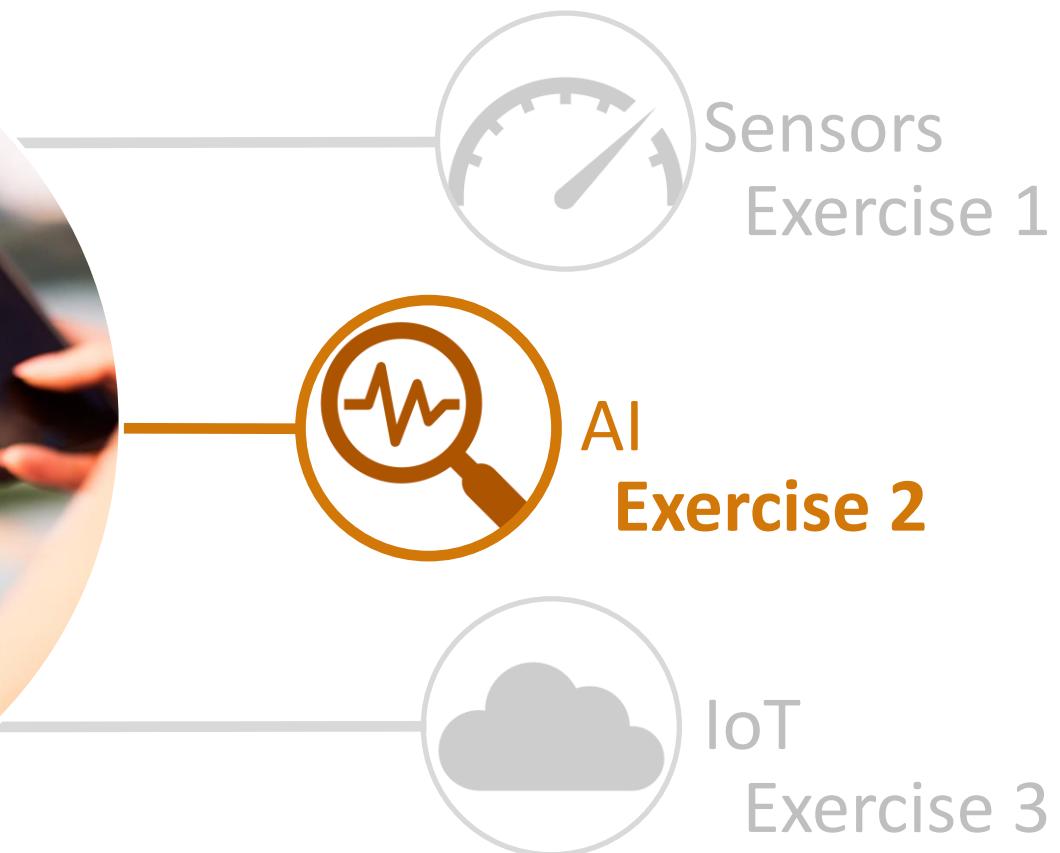
Predict: Integrate trained models into applications



Machine learning teaches a model to do a task using data



We will use machine learning to classify your activity



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

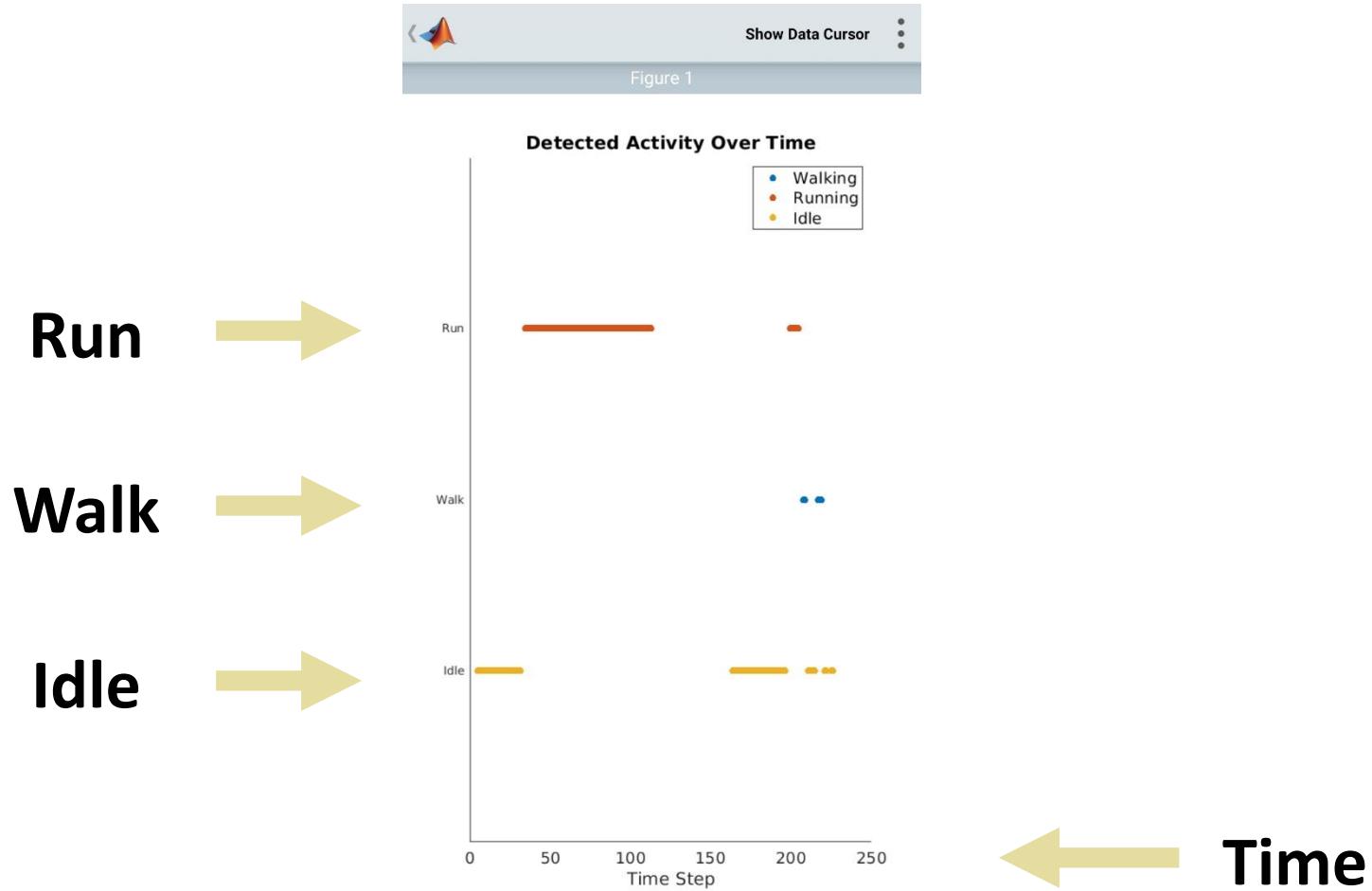


Ex2_ClassifyActivity.m

```
[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



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?



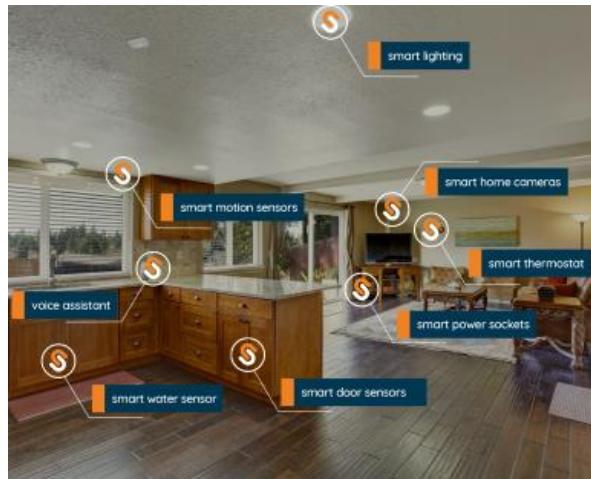
What is the Internet of Things (IoT)?

- **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

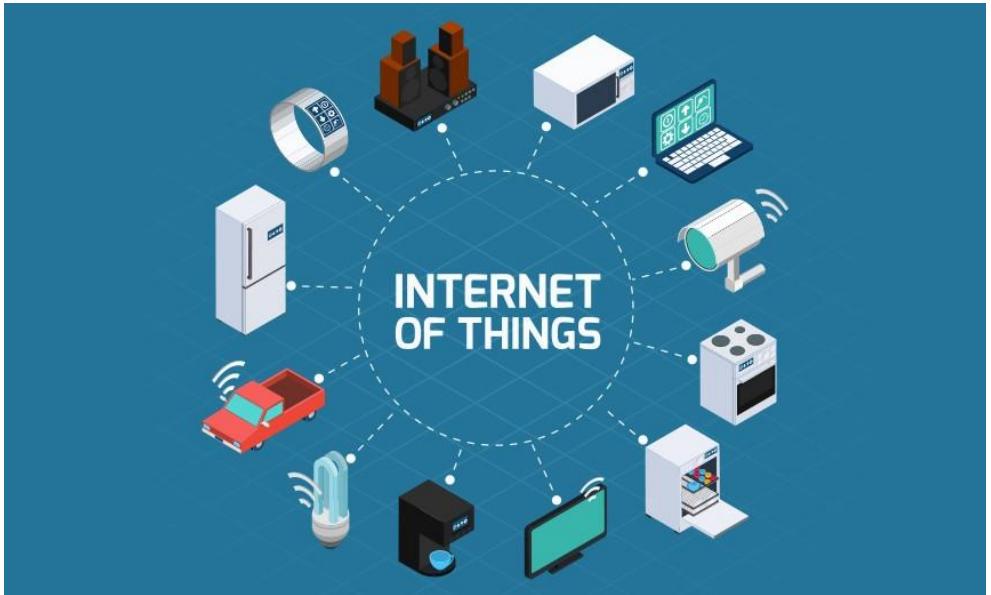


Industrial 4.0

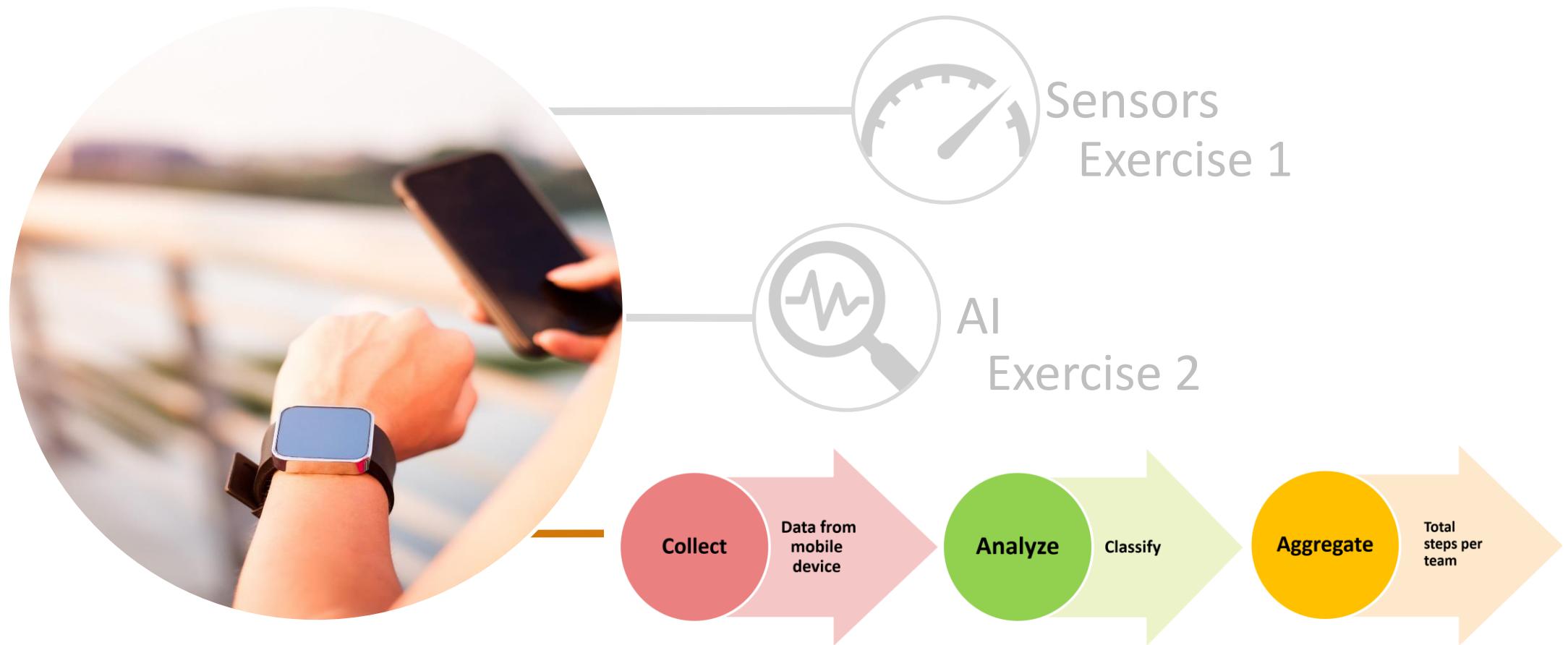


Why IoT?

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



We will collect our activity data on the cloud



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

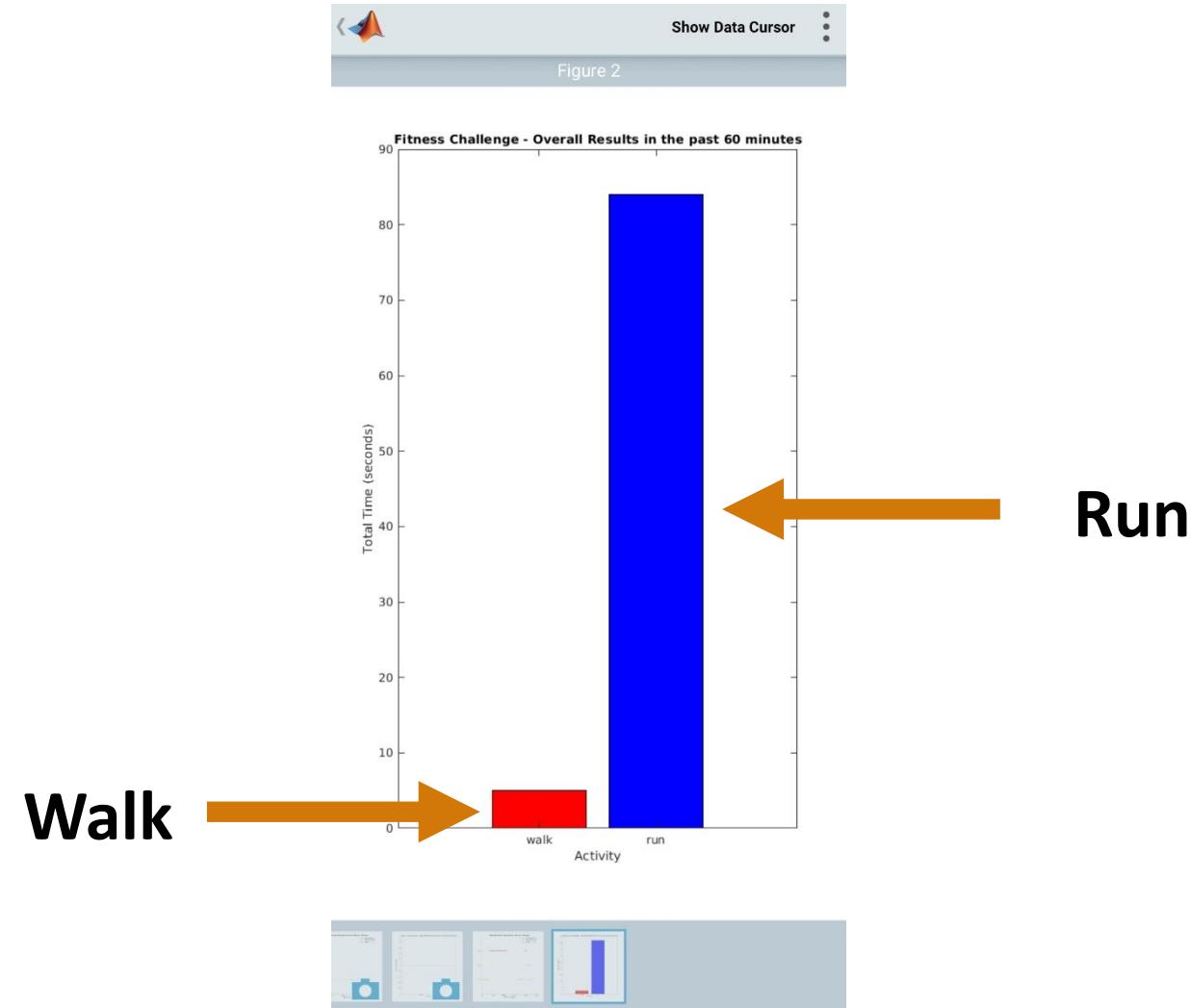
You will aggregate your team's activity time



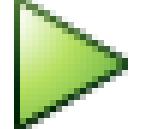
`Ex3_ThingSpeak_Fitness.m`

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

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



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!

What does it look like on ThingSpeak?

thingspeak.com/channels/858227

ThingSpeak™ Channels ▾ Apps ▾ Devices ▾ Support ▾ Commercial Use How to Buy AG Watch

Fitness Challenge

Channel ID: 858227 Author: [sarahmohamed](#) Access: Public

Export recent data

Fitness challenge at the Pocket AI and IoT workshop.

MATLAB Analysis MATLAB Visualization

Fitness Challenge

Fitness Challenge - past 60 minutes

A bar chart titled "Fitness Challenge - past 60 minutes". The y-axis is labeled "Total Time (seconds)" and ranges from 0 to 20. The x-axis is labeled "Team" and has two categories: "Walk" and "Run". The "Walk" bar is blue and reaches approximately 17 seconds. The "Run" bar is orange and reaches approximately 1 second. A legend in the top right corner identifies the colors.

Activity	Total Time (seconds)
Walk	~17
Run	~1

Fitness Challenge - Overall

Fitness Challenge - Overall Results in the past 60 minutes

A bar chart titled "Fitness Challenge - Overall Results in the past 60 minutes". The y-axis is labeled "Total Time (seconds)" and ranges from 0 to 20. The x-axis is labeled "Activity" and has two categories: "walk" and "run". The "walk" bar is red and reaches approximately 17 seconds. The "run" bar is black and reaches approximately 0 seconds. A legend in the top right corner identifies the colors.

Activity	Total Time (seconds)
walk	~17
run	~0

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!

