Prototyping the Useless Butler: Machine Learning for IoT Designers

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Introductions

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> … and you?

Experience with Arduino, ML, Wekinator?

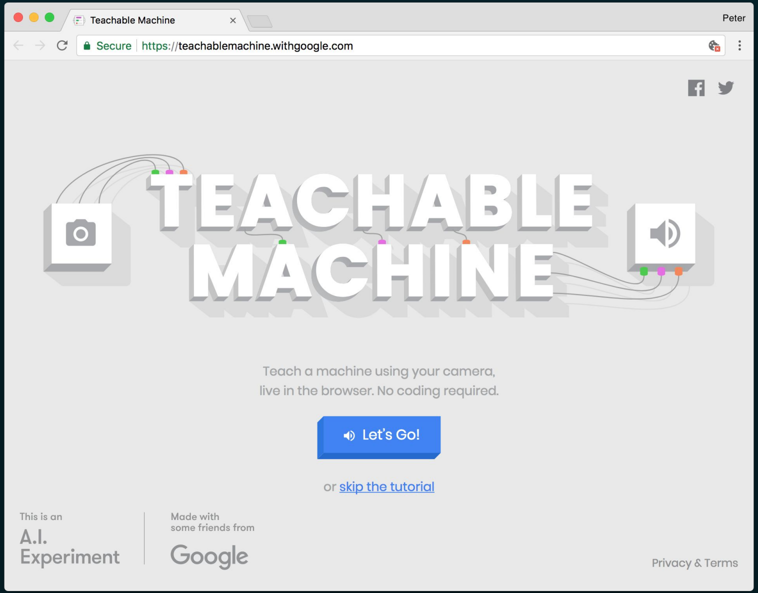
Overview

1. Brief introduction to machine learning
2. Overview of the toolchain: Wekinator, MKR1000, OSC
3. Exercises: regression, classification, dynamic time warping
4. Playtime
5. Discussion and close-out

Machine learning

Machine learning

https://teachablemachine.withgoogle.com/



Teach a machine using your camera, live in the browser. No coding required.

or skip the tutorial

Machine learning

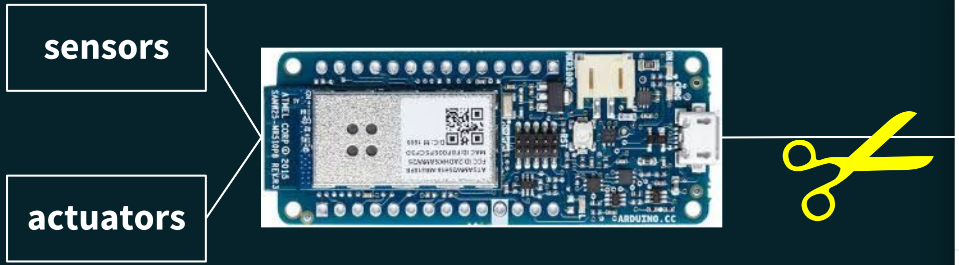
if	train
then	learn
else	run

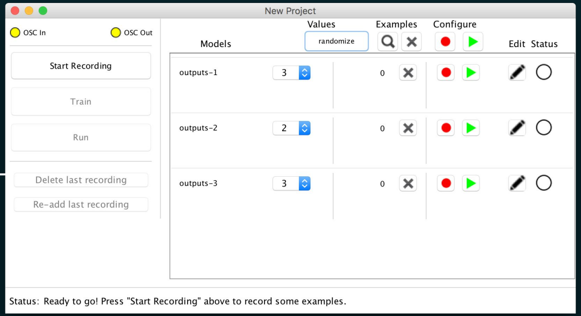
Machine learning

All these are just interfaces (abstractions) for ML algorithms.
The Wekinator as well.

Toolchain

Toolchain





Models	Values	Examples	Configure	Edit	Status
outputs-1	3	0			○
outputs-2	2	0			○
outputs-3	3	0			○

Status: Ready to go! Press "Start Recording" above to record some examples.

Arduino
MKR1000

OpenSoundControl
Through UDP

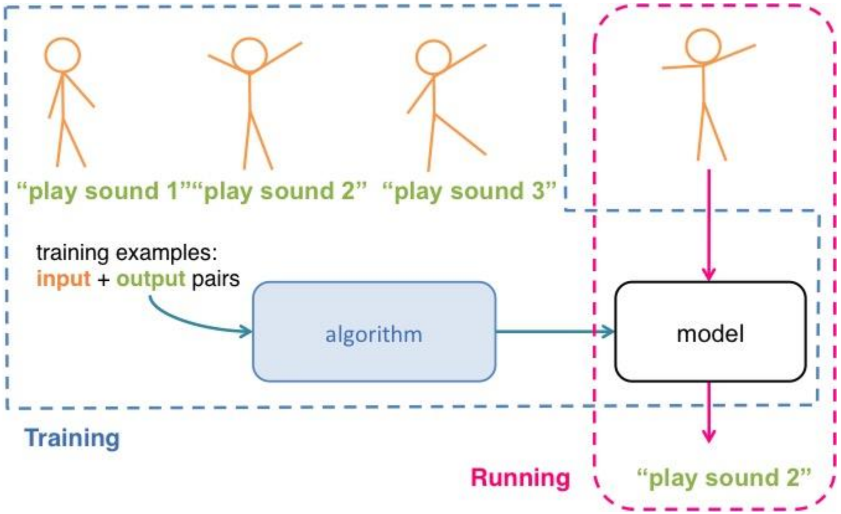
Wekinator

Toolchain – Rationale

- Get first-hand feel for ML
- Few moving parts
- Prototype interactive ML products
- Automate wizard of oz
- Modules and components with embedded ML on the horizon

Toolchain – Wekinator

The Wekinator is free, open source software originally created in 2009 by [Rebecca Fiebrink](). The Wekinator allows users to build new interactive systems by demonstrating human actions and computer responses, instead of writing programming code.



Toolchain – MKR1000

Arduino MKR1000 is a powerful board that combines the functionality of the Zero and the Wi-Fi Shield. It is the ideal solution for makers wanting to design IoT projects with minimal previous experience in networking.

Zero is a simple and powerful 32-bit extension of the platform established by the Uno. This board aims to provide a platform for innovative projects in smart IoT devices, wearable technology, high-tech automation, crazy robotics, and much more.

Toolchain – OSC

Open Sound Control (OSC) is a protocol for communication among computers, sound synthesizers, and other multimedia devices that is optimized for modern networking technology.

We use an Arduino and Teensy library implementation of OSC. It was developed at CNMAT (The Center for New Music and Audio Technologies at UC Berkeley) where OSC was invented.

Exercises

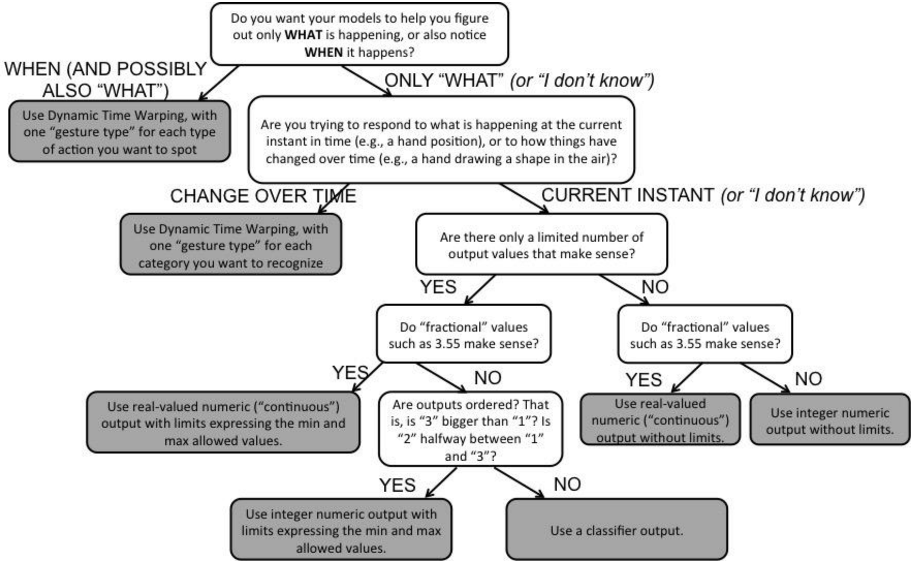
Before we get started…

Download and install all the things!

http://bit.ly/useless-butler

Three types of output

1. Regression
2. Classification
3. Dynamic Time Warping (DTW)



Do you want your models to help you figure out only **WHAT** is happening, or also notice **WHEN** it happens?

WHEN (AND POSSIBLY ALSO "WHAT")

Use Dynamic Time Warping, with one "gesture type" for each type of action you want to spot

ONLY "WHAT" *(or "I don't know")*

Are you trying to respond to what is happening at the current instant in time (e.g., a hand position), or to how things have changed over time (e.g., a hand drawing a shape in the air)?

CHANGE OVER TIME

Use Dynamic Time Warping, with one "gesture type" for each category you want to recognize

CURRENT INSTANT *(or "I don't know")*

Are there only a limited number of output values that make sense?

YES

Do "fractional" values such as 3.55 make sense?

YES

Use real-valued numeric ("continuous") output with limits expressing the min and max allowed values.

NO

Are outputs ordered? That is, is "3" bigger than "1"? Is "2" halfway between "1" and "3"?

YES

Use integer numeric output with limits expressing the min and max allowed values.

NO

Use a classifier output.

NO

Do "fractional" values such as 3.55 make sense?

YES

Use real-valued numeric ("continuous") output without limits.

NO

Use integer numeric output without limits.

Regression

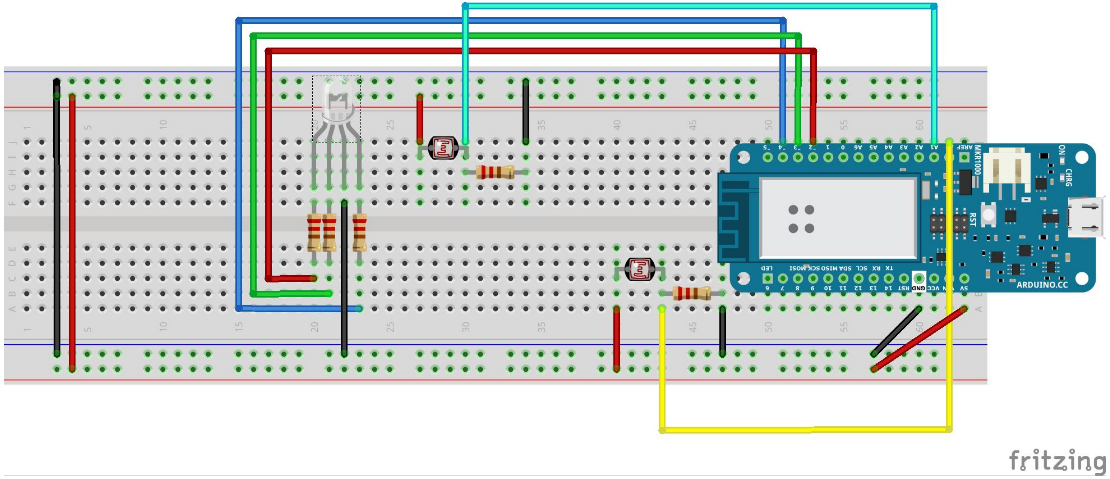
Real-valued (“continuous”) numeric outputs can take on any number value (possibly limited to a certain range). For example, you might want to control “audio gain” with a real-valued output limited between 0 and 1. This is the default output type in Wekinator.

Think of this as a smart slider.

Regression – Circuit

- RGB LED on digital PWM pins 2, 3, 4
- Two photoresistors on analog pins A0, A1

Note: Cathode RGB LED goes to 5V instead of ground

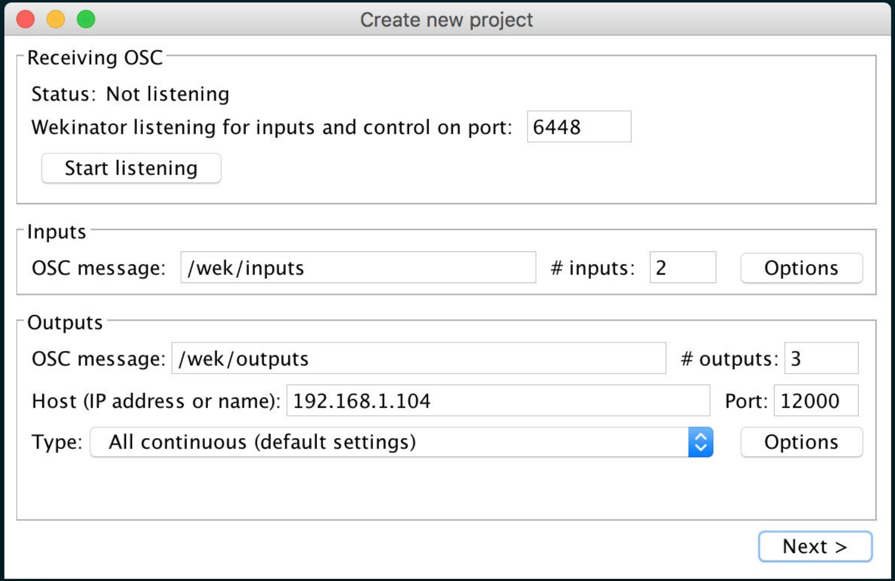


Regression – Code

1. Download example code from GitHub
2. Open ‘regressionExample’
3. Copy config_sample.h and rename to config.h
4. Set SSID and password in config.h
5. Get laptop IP from network settings and set in Arduino IDE ‘outIp’
6. Upload sketch to MKR1000
7. Make note of MKR1000 IP in Arduino IDE serial monitor

Regression – Wekinator

- Two inputs
- Three outputs
- All continuous (default)
- Don’t forget to set your MKR1000’s IP under ‘host’
- Leave ports as they are
- Hit ‘next’ to start training



Receiving OSC

Status: Not listening

Wekinator listening for inputs and control on port: 6448

Inputs

OSC message: /wek/inputs # inputs: 2

Outputs

OSC message: /wek/outputs # outputs: 3

Host (IP address or name): 192.168.1.104 Port: 12000

Type: All continuous (default settings)

Regression – Training & Running

Classification

These are discrete categories, such as “Position 1”, “Position 2,” “Position 3.” You’ll need to tell Wekinator how many categories to use. Wekinator will send outputs as numbers, such as “1,” “2,” “3” for categories 1, 2, and 3. Wekinator will attempt to categorize every new input you send it.

Think of this as a smart switch.

Classification – Circuit

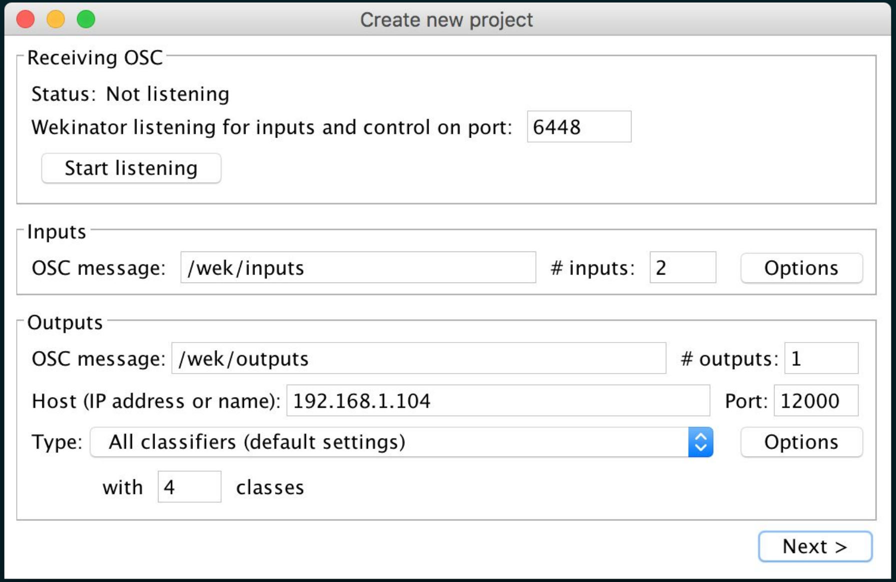
Same as regression

Classification – Code

1. Open ‘classificationExample’
2. Copy config_sample.h and rename to config.h
3. Set SSID and password in config.h
4. Get laptop IP from network settings and set in Arduino IDE ‘outIp’
5. Upload sketch to MKR1000
6. Make note of MKR1000 IP in Arduino IDE serial monitor

Classification – Wekinator

- Two inputs
- One output
- All classifiers
- Four classes
- Don’t forget to set your MKR1000’s IP under ‘host’
- Leave ports as they are
- Hit ‘next’ to start training



Create new project

Receiving OSC

Status: Not listening

Wekinator listening for inputs and control on port: 6448

Inputs

OSC message: /wek/inputs # inputs: 2

Outputs

OSC message: /wek/outputs # outputs: 1

Host (IP address or name): 192.168.1.104 Port: 12000

Type: All classifiers (default settings)

with 4 classes

Classification – Training & Running

Dynamic Time Warping (DTW)

Use this output type when you want Wekinator to recognize patterns over time. For instance, you might want to play one note every time you draw a circle in the air with your hand, and another note every time you draw a square. If you're not drawing either one, or if you're in the middle of drawing, you don't want anything to happen. That is, you want Wekinator to look for a particular pattern (or multiple patterns) of how the inputs are changing over time, and tell you when a pattern is spotted and which one it was.

Think of this as a smart button.

Dynamic Time Warping – Circuit

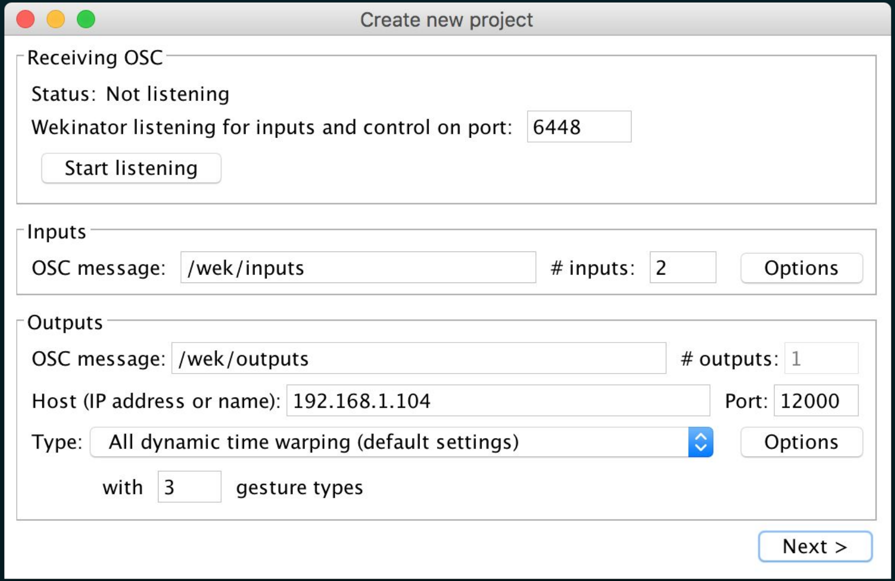
Same as previous exercises

Dynamic Time Warping – Code

1. Open ‘dtwExample’
2. Copy config_sample.h and rename to config.h
3. Set SSID and password in config.h
4. Get laptop IP from network settings and set in Arduino IDE ‘outIp’
5. Upload sketch to MKR1000
6. Make note of MKR1000 IP in Arduino IDE serial monitor

Dynamic Time Warping – Wekinator

- Two inputs
- One output
- All DTW
- Three gesture types
- Don’t forget to set your MKR1000’s IP under ‘host’
- Leave ports as they are
- Hit ‘next’ to start training



Create new project

Receiving OSC

Status: Not listening

Wekinator listening for inputs and control on port: 6448

Inputs

OSC message: /wek/inputs # inputs: 2

Outputs

OSC message: /wek/outputs # outputs: 1

Host (IP address or name): 192.168.1.104 Port: 12000

Type: All dynamic time warping (default settings)

with 3 gesture types

Dynamic Time Warping – Training & Running

Rename your outputs to “output/1”, “output/2” and “output/3” – underscores won’t work!

Playtime

Discussion

Thank you!