Control Thymio Robot thru Hand Gestures

YOLO! Detect my hand gesture to control my Thymio robot.

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# Abstract

With the help of Deep Learning, we all know that the field of Computer Vision has proliferated in the last decade. As a result, so many prevalent computers vision problems like image classification, object detection, and segmentation having real industrial use-case started to achieve accuracy like never. A new benchmark was set every year from 2012. And today, we will look at object detection from a practical perspective.

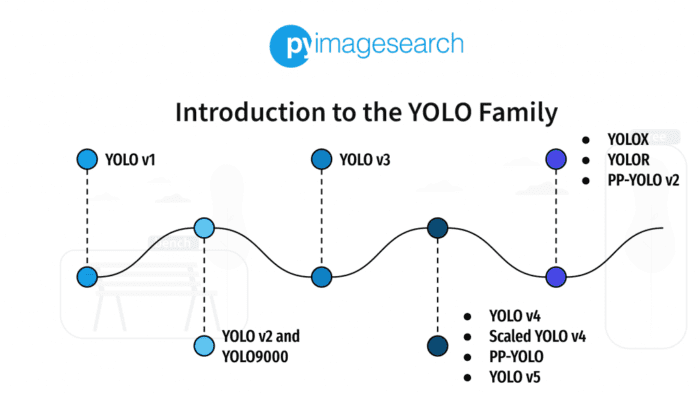
This proof of concept is combining a wireless Thymio II with a python software on computer to control the movements of the robot via hand gestures. Python software based on YOLOV5 is running on the computer to detect hand gestures via a camera. Once the python application recognizes new hand gesture, the python script decides what command to send to the Thymio robot. For example, hand gesture of one means "move forward", hand gesture of "five" means "stop", hand gesture of "fist" means "speed up", and so on.

# Introduction

Object detection is one of the most crucial subjects in computer vision. Most computer vision problems involve detecting visual object categories like pedestrians, cars, buses – mainly for autonomous cars, faces, hand gestures – mainly for augmented reality and virtual reality use cases, etc. It is one such field that is widely used in both academia and real-world business use case in domains like video surveillance, healthcare, in-vehicle sensing, autonomous driving. And in this paper, we will demonstrate integration of hand gestures to control educational robot called Thymio. Let’s see the main two components that composing this PoC.

## YOLO V5

Many use cases, require good accuracy and real-time inference speed. Hence, choosing an Object Detector that fits the bill for both speed and accuracy becomes essential. YOLO (You Only Look Once) is a single-stage object detector introduced to achieve both goals (i.e., speed and accuracy). And today, we will give use case of integrating YOLOV5 with custom data to control educational robot called Thymio.



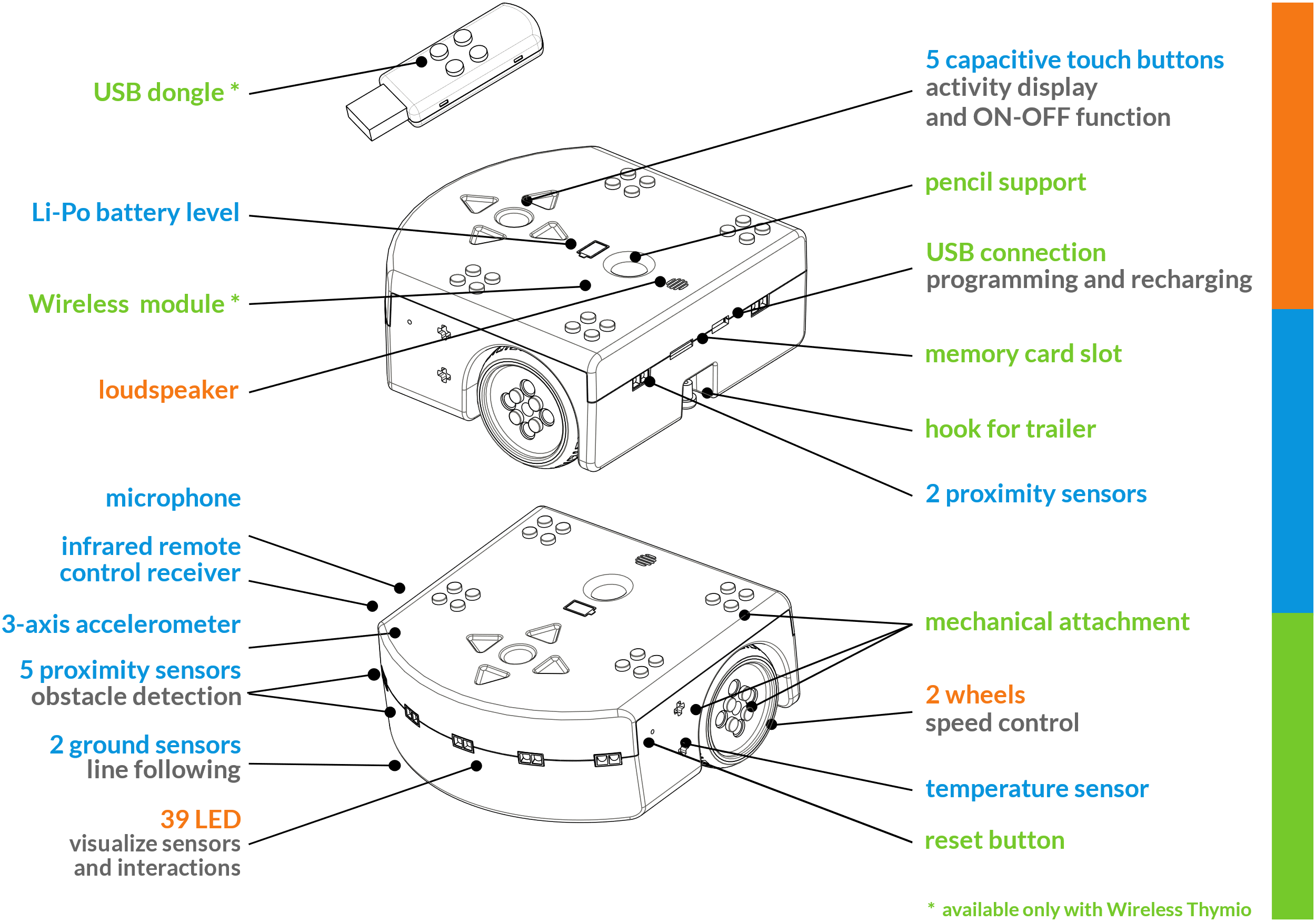
## Yolov5 History

Before we start, a little story of the YOLOv5 birth controversy. YOLO was first created by Joseph Redmon in May 2016. That was a revolution in real-time object detection. Please notice that it was Joseph Redmon that came with this so-good name. The code has been updated with associations with Ali Farhadi for the 3 first versions. From there, the pioneers give Alexey Bochkovskiy their benediction via Twitter to take the lead of YOLO institution. Joseph Redmon’s tweet states that it isn’t his anymore. Alexey Bochkovskiy introduced YOLOv4 in April 2020.

## What Thymio is?

Thymio is an open-source educational robot designed by researchers from the EPFL, in collaboration with ECAL, and produced by Mobsya, a nonprofit association whose mission is to offer comprehensive, engaging STEAM journeys to learners of all ages. For more information, visit the official web site at: <https://www.thymio.org/>

# What is Thymio composed of?[[1]](#footnote-1)



## Python

Python is a computer programming language often used to build websites and software, automate tasks, and conduct data analysis. Python is a general-purpose language, meaning it can be used to create a variety of different programs and isn’t specialized for any specific problems. This versatility, along with its beginner-friendliness, has made it one of the most-used programming languages today. A survey conducted by industry analyst firm RedMonk found that it was the second-most popular programming language among developers in 2021. (Coursera, 2022).

Python, one of the most popular programming languages in the world, has created everything from Netflix’s recommendation algorithm to the software that controls self-driving cars. Python is a general-purpose language, which means it’s designed to be used in a range of applications, including data science, software and web development, automation, and generally getting stuff done.

# Demo

You may view our demo in YouTube [Control Thymio by Hand Gesture](https://youtube.com/shorts/no3g03PY0nw) (link: <https://youtube.com/shorts/no3g03PY0nw> )

# Prepare Development environment

Thanks to Davies for his great online blog on Weights & Biases (Davies, 2022).

We will detail the steps to prepare the development environment to allow training and detecting hand gestures.

## Setup Environment to Run the Demo

To prepare an environment for running the demo on your end, you need the following:

### Hardware:

You need to have a computer; we will install on it all the needed software.

You need to have a camera connected to the computer (built in camera or external one).

You also need Thymio II robot with wireless dongle (to be plugged in the computer)

### Software

Following are step by step instructions to prepare your computer with required software to run the demo:

* Install python v3 from <https://www.python.org/downloads/>, and make sure to have Python added to your system Path.
* Install the Thymio Suite from <https://www.thymio.org/download-thymio-suite/>
* You may run prepare\_env.bat under this repository to prepare the environment or follow below steps.
* Prepare new python environment - step by step:
  + From your command shell, run: C:\> mkdir c:\workdir\thymio
  + From your command shell, run: C:\> python -m venv c:\workdir\thymio
  + Activate the environment by typing in the command shell: c:\workdir\thymio\Scripts\Activate.bat
* Download and Setup YOLOV5:
  + Either:
    - Download YOLOV5 of Ultralytics from GitHub - <https://github.com/ultralytics/yolov5>
    - Copy the Ultralytics folder's content to: c:\workdir\thymio\yolov5
  + Or:
    - Run the following command from the shell: (thymio) c:\workdir\thymio>git clone https://github.com/ultralytics/yolov5 yolov5
  + From your command shell, from yolov5 sub-folder type: (thymio) c:\workdir\thymio\yolov5>pip install -r requirements.txt
* Download and Setup Control Thymio via Hand Gesture:
  + Either:
    - Download this repository to yolov5 folder, i.e., c:\workdir\thymio\yolov5
  + Or:
    - From your shell, type: (thymio) c:\workdir\thymio>git clone https://github.com/ahmad081177/control-thymio-via-hand-gesture .
    - Then copy/move files into yolov5 folder by typing: (thymio) c:\workdir\thymio>xcopy /E /Y /C control-thymio-via-hand-gesture\\* yolov5\.
  + Download Thymio requirements by typing: (thymio) c:\workdir\thymio\yolov5>pip install -r thymio\_req.txt
  + From your shell run: (thymio) c:\workdir\thymio\yolov5>python download\_models.py
* Prepare environment to detect hand gesture:
  + Locate detect.py in yolov5 subfolder and modify it as following:
    - Add the following lines at the beginning - before anything else.

import os, sys

#https://github.com/opencv/opencv/issues/17687

os.environ["OPENCV\_VIDEOIO\_MSMF\_ENABLE\_HW\_TRANSFORMS"] = "0"

* + - After all imports, add the following code:

from thymio import Thymio

* + - Locate run method, after "Load model" and before "Dataloader" place the following code:

\_thymio = None

print('start creating new Thymio interface')

\_thymio = Thymio()

r = \_thymio.start()

if r==True:

print('Thymio interface has been started successfully')

else:

\_thymio=None

print('Thymio interface could not be started')

* + - Locate "Print results" comment, and inside the loop, new the code should be:

for c in det[:, -1].unique():

#Start Modify - Ahmad

if \_thymio is not None:

print('Thymio on command: ', int(c), ' (',names[int(c)],')')

\_thymio.on\_command(names[int(c)])#int(c))

#End Modify - Ahmad

n = (det[:, -1] == c).sum() # detections per class

s += f"{n} {names[int(c)]}{'s' \* (n > 1)}, " # add to string

### Run the software:

* Make sure your camera is connected
* Make sure the Thymio robot is turned on and the wireless dongle is plugged in the computer
* In your shell, type: (thymio) c:\workdir\thymio\yolov5>run\_detect.bat

# References:

<https://towardsdatascience.com/yolov5-end-to-end-object-detector-project-on-custom-dataset-5d9cc2c95921>

<https://wandb.ai/onlineinference/YOLO/reports/YOLOv5-Object-Detection-on-Windows-Step-By-Step-Tutorial---VmlldzoxMDQwNzk4>

<https://www.coursera.org/articles/what-is-python-used-for-a-beginners-guide-to-using-python>

## Data:

The “Control Thymio Robot by Hand Gesture” demo was trained on hand gestures data by two phases. First, we used the “hand-gesture-recongition-yolo-v3” (link: <https://www.kaggle.com/datasets/abdullahmujahidali/hand-gesture-recongition-yolo-v3?select=102.txt>) from Kaggle website (<https://www.kaggle.com/>). Later, to improve the accuracy from one hand, and to add more classes (hand gesture types) from the other hand, we added more data to the dataset by creating our own pictures and labeling them using Label Image tool from python (<https://github.com/heartexlabs/labelImg>). The new dataset was uploaded to the public Kaggle dataset at the following link: <https://www.kaggle.com/datasets/ahmadgabari/hand-gestures-new>

1. Image from: <http://wiki.thymio.org/en:thymiospecifications> [↑](#footnote-ref-1)