

## Robot - Proof of concept

In this chapter, we will present the realization of a robot presented as a "Proof of concept". This robot contains a maximum of the components developed in the framework, and is composed of two main parts: the robot (part 1) and a "joystick remote" (part 2). The part 1 (on the left in figure E.1) combines a Raspberry Pi 2, a BrickPi, some LEGO Mindstorms NXT sensors and motors, and a set of additional components. The part 2 (on the right in figure E.1) combines a Raspberry Pi 2 and a joystick.

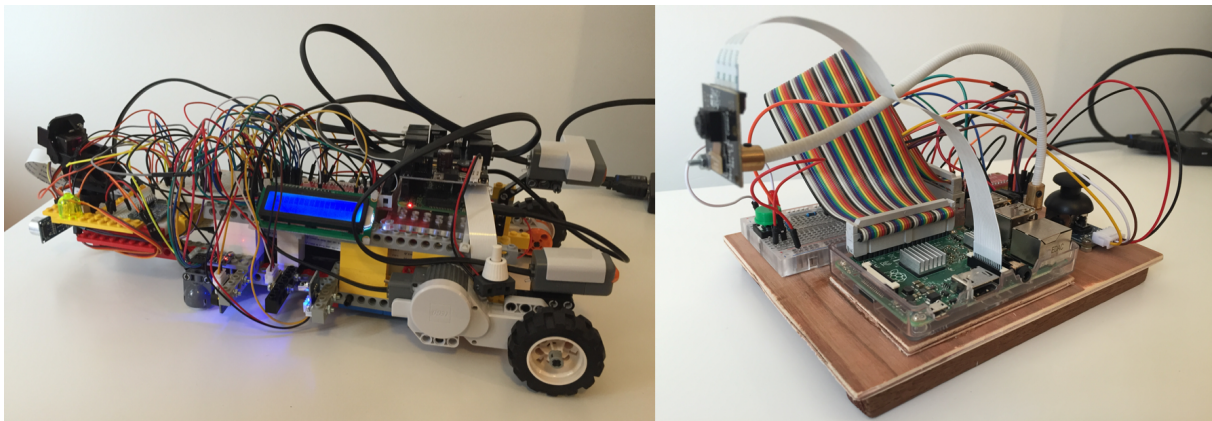


Figure E.1: Proof of concept: robot on the left (part 1); joystick remote on the right (part 2).

The operating principle is the following: the joystick part (part 2) of the project is used to control the robot (part 1) through the network, as a remote control. To do so, part 2 is used to create a WiFi hotspot. Part 1 will automatically connect to this hotspot, so that both sides are part of the same network, and can communicate together. There are two different modes for the joystick. The first mode controls the movements of the robot (by sending commands to control the two motors) while the second one controls the orientation of the camera support (by sending commands to control the two servomotors composing the camera support - the robot contains a camera support which is able to rotate along x and y axis (horizontally and vertically), via two servomotors (see figure E.5)). The communications between the joystick remote and the robot are performed by using a MessageLikeSocketServer on part 1 to deal with commands received from part 2. They respect the related specific protocol as presented in the network part of this report. From the joystick, it is possible to switch from one mode to another by pressing the green button (visible on the breadboard in right part of figure E.1). When the LED is ON: the movements of the robot are controlled; when the LED is OFF: the camera support is controlled. As presented earlier, the joystick is an analog component: we used an ADC to convert analog signals coming from the joystick into digital commands.

Regarding the robot part of the project, it has a lot of sensors and actuators. As you can see on the left part of figure E.1, there are a lot of cables, and the complete robot seems really tricky. It is not as complex as one could think. Each component simply requires its little electrical circuit. With about 30 components (sensors, motors and actuators), it is unavoidable to have a lot of electric cables. To facilitate the assemblies, we decided to mount two breadboard directly on the robot. The structure of the robot is only made of LEGO building blocks. We just use some screws with nuts and a few colsons to fix the additional components to LEGO Technic building blocks. The robot is composed of two floors:

the first one is used to hold batteries (a power bank for the Raspberry Pi, a 6x1.5V battery holder for the BrickPi and a 4x1.5V battery holder for the servomotors controlling the camera support) and the second one is used for the breadboards, the Raspberry Pi, the BrickPi, etc. An LCD display (see figure E.8) is present on the robot. It is used to display some information coming from some sensors such as the thermistor, the photoresistor, etc. The information shown on the display can be switched by using a simple infrared media remote, via an infrared receiver placed under the LCD display.

We present here an almost complete list of material used to build part 1 and part 2, and a series of pictures to help to understand the robot. We wanted the robot to be as generic as possible to be able to test the components in different use cases. Indeed, combining a thermistor with a camera, an LCD display and a buzzer does not necessarily make sense.

When developing the framework, we tried a lot of electrical components. Among them, we found an almost complete kit of sensors sold by Sunfounder<sup>1</sup>. The main advantage of this kit is the fact that each sensor/actuator is already soldered on a small PCB. This avoids having to weld the components by ourselves. In the photos presented after, we can observe some blue LEDs next to some components. Indeed, sometimes, Sunfounder simply added a LED that lights up when the component is powered.

The complete code regarding the implementation of this proof of concept robot is available in the example part of the Raspoid framework.

## (Almost) Complete list of material

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### Part 1 - The robot:

- Raspberry Pi 2
- BrickPi
- LEGO Mindstorms NXT:
  - Ultrasound sensor
  - Touch sensor
  - Color sensor
  - Motor (x2)
  - Cable (x5)
- Breadboard
- GPIO Extension board
- Additional components:
  - Camera Pi
  - Servomotor (x2 + Pan/Tilt camera support<sup>2</sup>)
  - MPU6050 Accelerometer & gyroscope
  - Passive buzzer
  - IR receiver
  - BMP180 Barometer
  - LCM1602 LCD display
  - HCSR04 Ultrasound sensor
  - Photoresistor
  - Thermistor
  - PCF8591 ADC
  - LM358 Sound sensor
  - PCA9685 16 PWM channels
  - 220 Ohm Resistor

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<sup>1</sup>37 Modules Sensor Kit V2.0 for Raspberry Pi: <http://www.sunfounder.com/rpi2-sensorv2.html>

<sup>2</sup><http://www.amazon.fr/dp/B00BUBDSMA>

- LED
- Electrical cables
- LEGO Idle wheel (x2)
- LEGO Technic blocks
- Power supply 5V 2A micro usb
- Powerbank 6400 mAh 5V/2.4A<sup>3</sup>
- Battery holder for 6xAA batteries<sup>4</sup>
- Battery holder for 4xAA batteries
- Electrical switch (x2)
- Edimax EW-7811UN WiFi usb key

### Part 2 - The joystick remote:

- Raspberry Pi 2
- Breadboard
- GPIO Extension board
- Joystick
- PCF8591 ADC
- 220 Ohm Resistor
- LED
- Button
- Edimax EW-7811UN WiFi usb key
- Power supply 5V 2A micro usb

## Photos

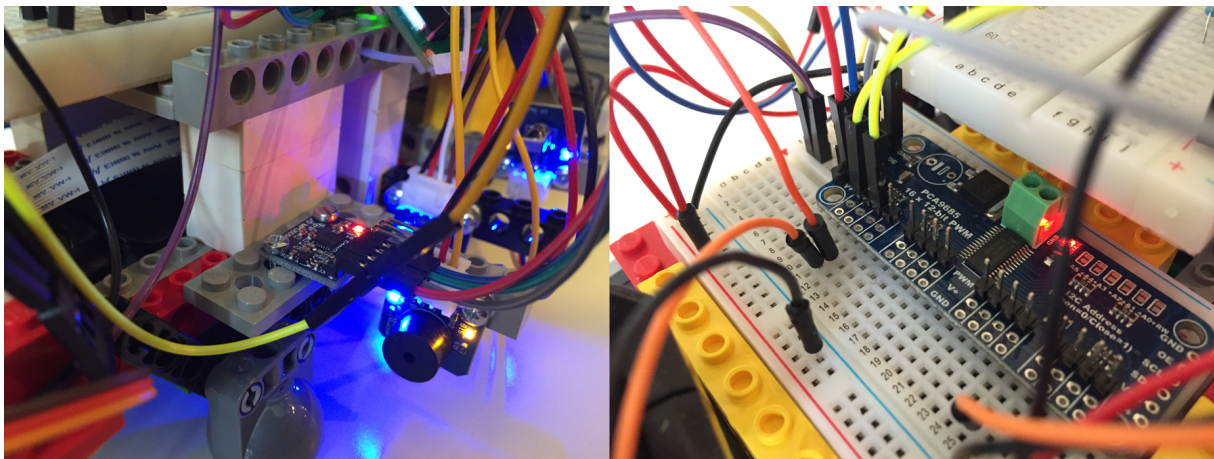


Figure E.2: Left part: the MPU6050 and the passive buzzer; Right part: the PCA9685 with 16 PWM output channels.

<sup>3</sup><http://www.amazon.fr/dp/B00D8DDI50>

<sup>4</sup><http://www.amazon.fr/dp/B000L1MBUU>

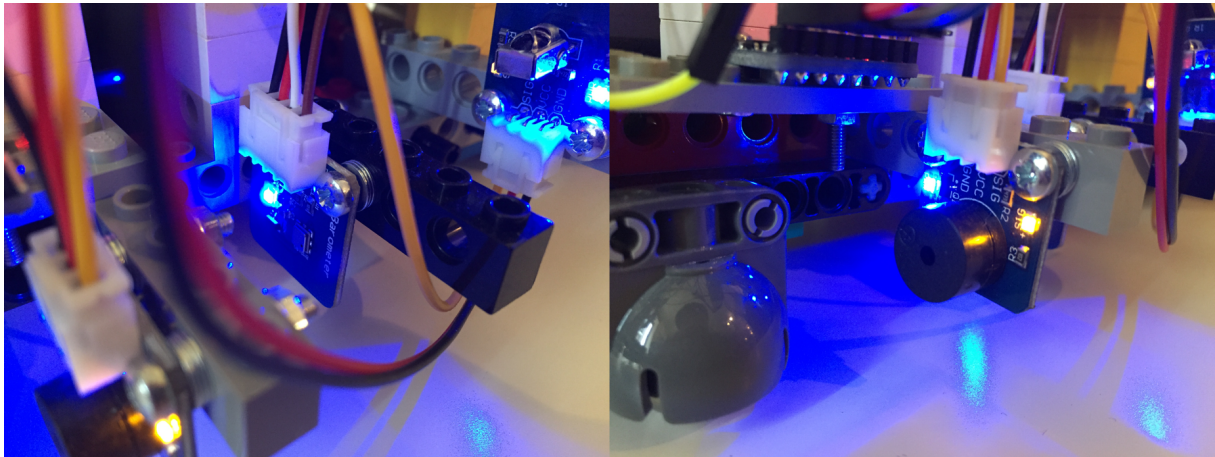


Figure E.3: Left part: BMP180 barometer; Right part: passive buzzer.

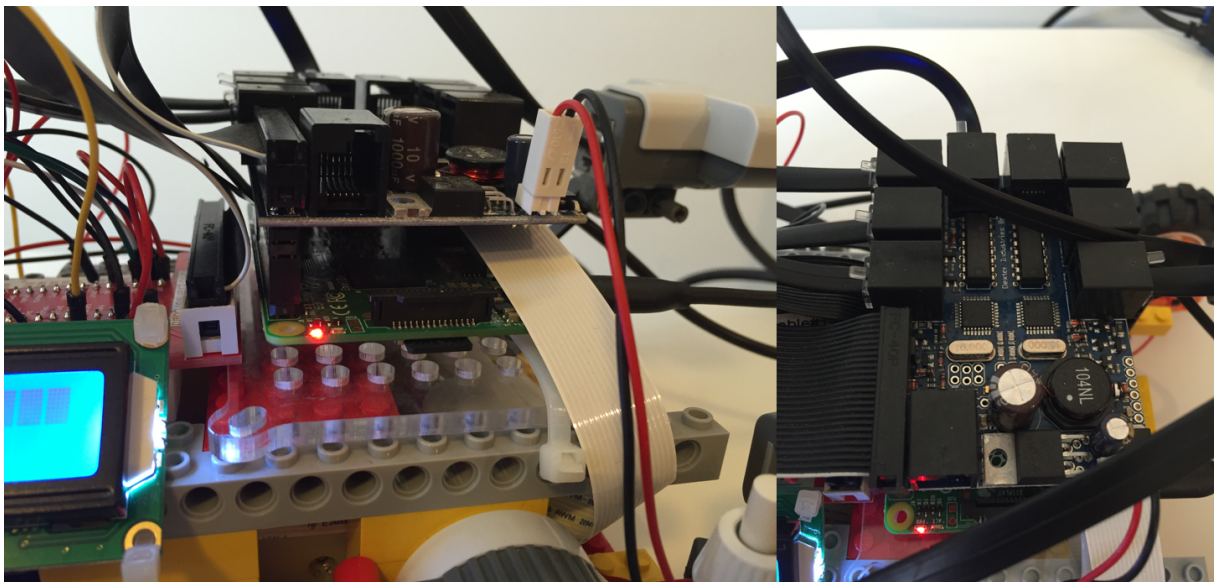


Figure E.4: Left part: Raspberry Pi with BrickPi; Right part: BrickPi, from the top.

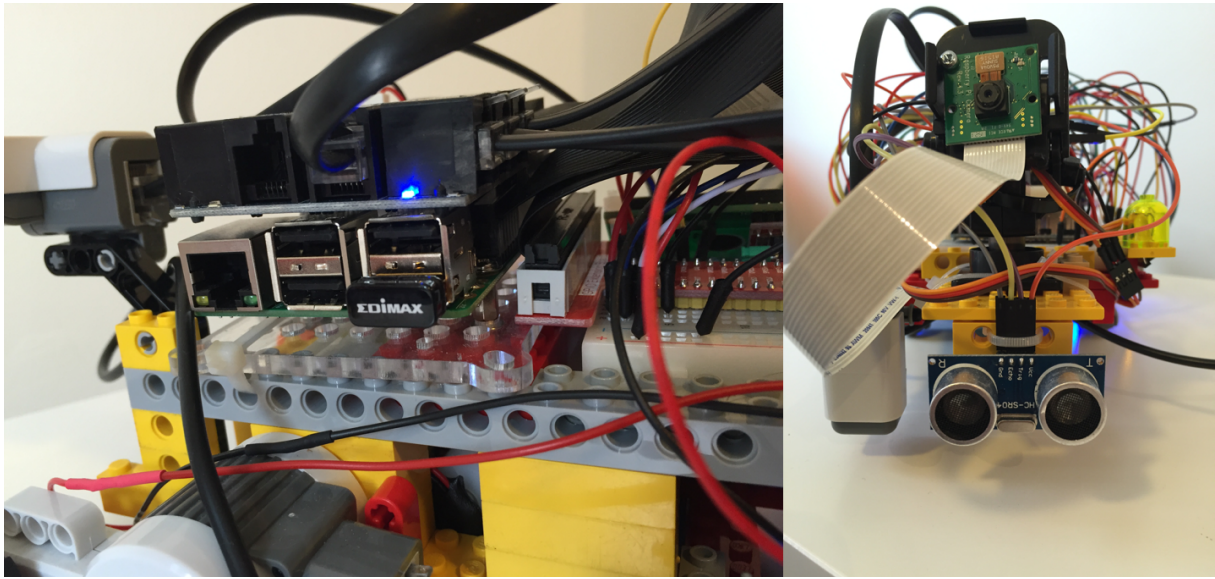


Figure E.5: Left part: Raspberry Pi, BrickPi and Edimax WiFi usb key; Right part: camera support, Camera Pi and ultrasonic sensor.

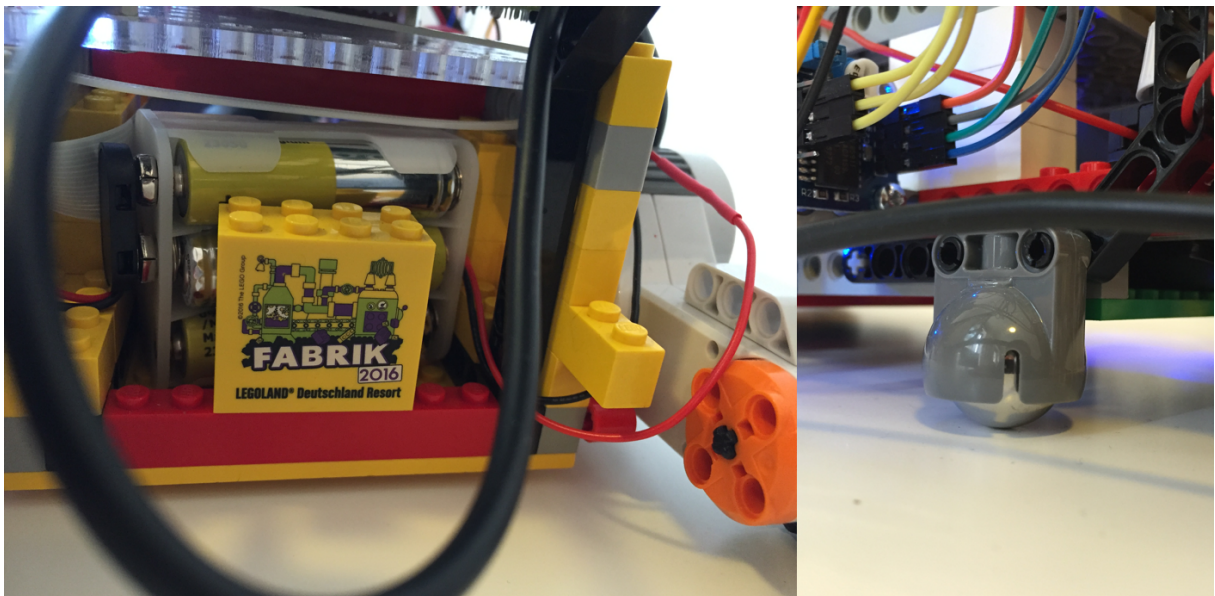


Figure E.6: Left part: battery holder for 6x1.5V AA batteries; Right part: LEGO idle wheel.

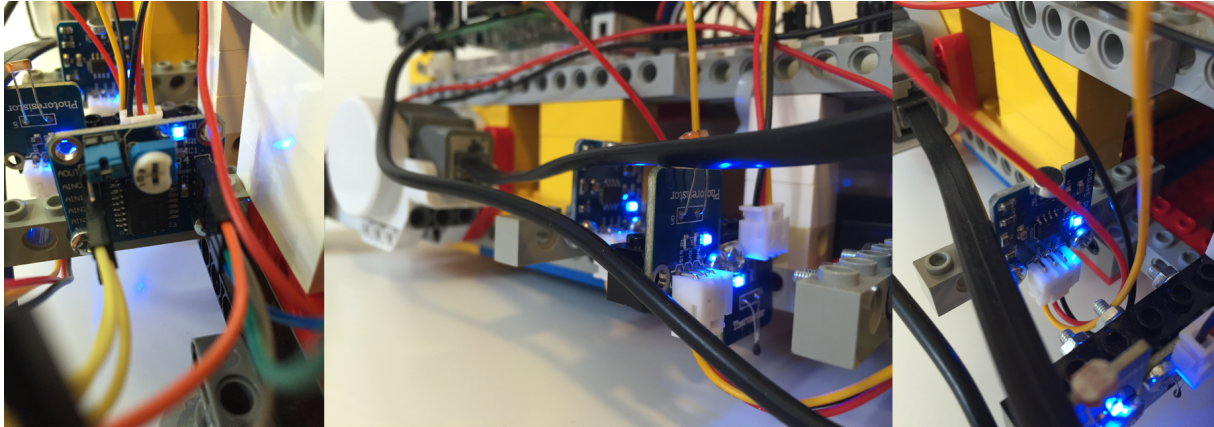


Figure E.7: Left part: PCF8591 ADC; Middle part: photoresistor and thermistor; Right part: sound sensor.

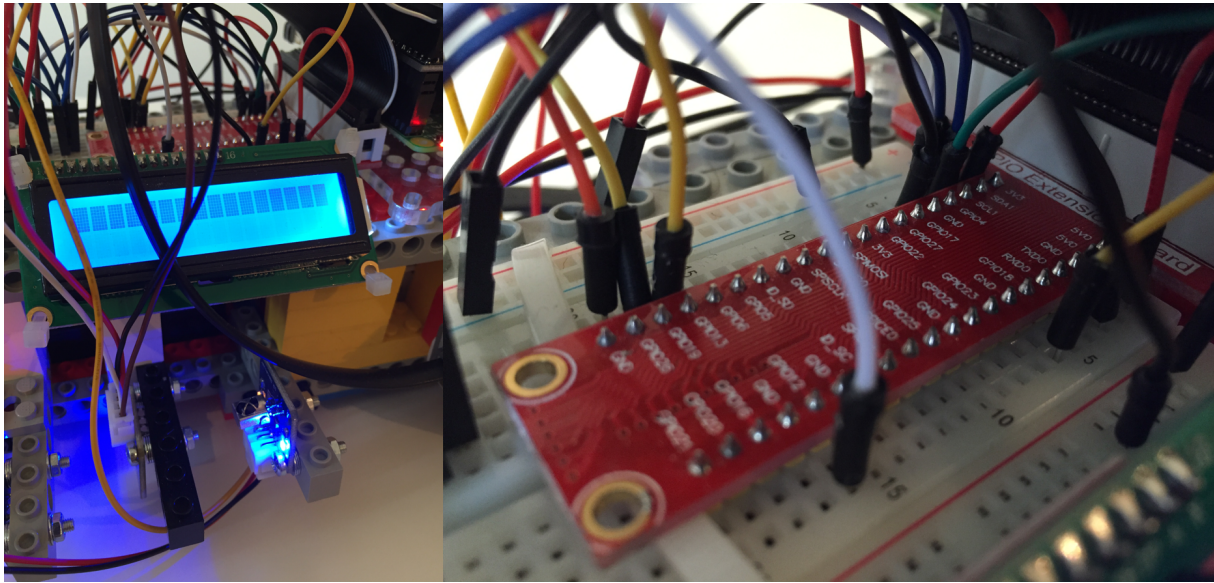


Figure E.8: Left part: LCD display and infrared receiver (in the bottom); Right part: a GPIO extension board.

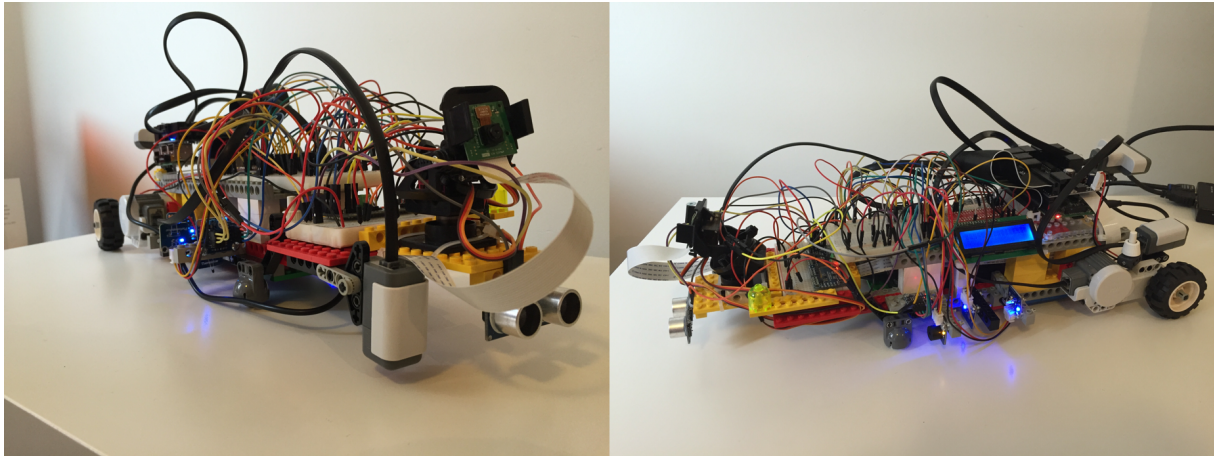


Figure E.9: Left part: the robot from the front; Right part: the robot from the top.

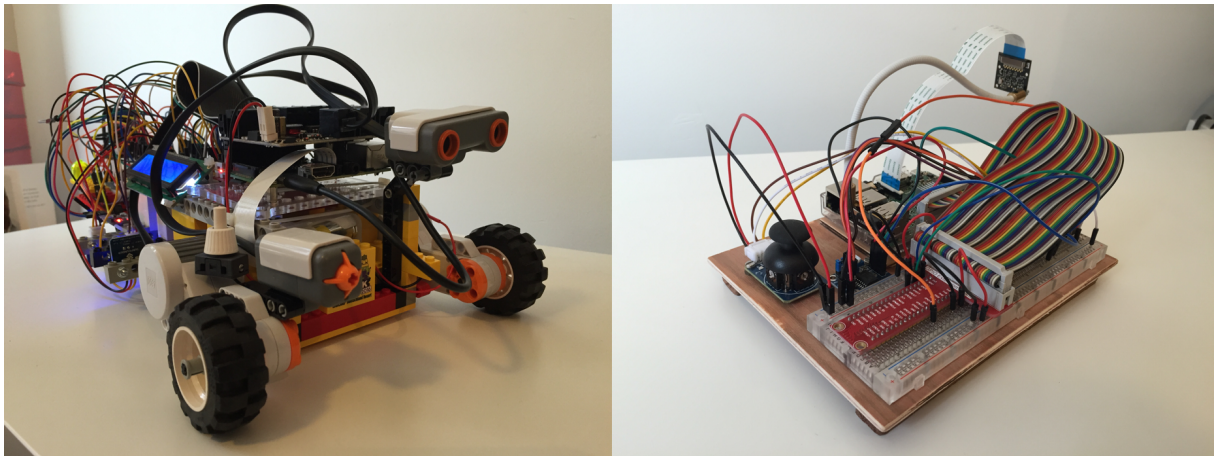


Figure E.10: Left part: robot from behind; Right part: joystick remote, from the top.

