Lab n° 4
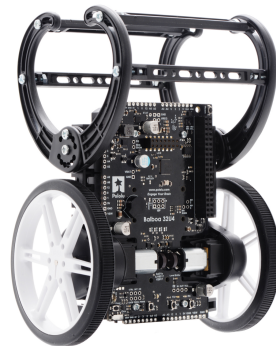
Balance control
for the two-wheeled Balboa mobile robot

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Lab 4

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The Balboa 32U4 is a highly integrated balancing robot that is both programmable and customizable.

The Balboa 32U4 control board is built around a USB-enabled Atmel ATmega32U4 AVR microcontroller, and it ships preloaded with an Arduino-compatible bootloader. The control board features two H-bridge motor drivers, as well as quadrature encoders and a complete inertial measurement unit (IMU) which includes an accelerometer, a gyro, and a magnetometer that allows it to determine its orientation, essential for balancing.

1.1   Objectives and layout of the Lab

This lab is structured into three main parts:

1. The construction a two-wheeled Balboa robot from the provided kit;

2. The development of a balance control program for the Balboa robot from Pololu;

3. The development of a control algorithm for line following

1.2   Hardware required

Figure 1.1: Balboa 32U4 robot from Pololu and its main components

The required hardware for this section includes:

- a Balboa 32U4 Robot in kit from Pololu as shown in Figure 1.1;

- a USB A to Micro-B cable to connect the robot to your computer for programming and debugging. The USB connection can be used to transmit and receive data from the computer and program the board over USB;

- Six rechargeable AA NiMH batteries;

- a test track.

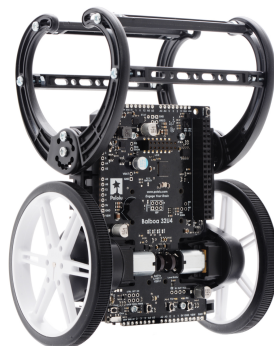## 1.3   Assembling two-wheeled Balboa robot

Figure 1.2: Assembled Balboa 32U4 robot

By using the user guide available at: `www.pololu.com/docs/0J70`, build your own Balboa mobile robot from the provided kit to get the assembled robot as shown in Figure 1.2.

1.4 Operating system and software required

1.4.1 Operating System required

The Balboa 32U4 robot can be programmed from a computer using any operating system that supports the Arduino environment. This includes Microsoft Windows 10, 8.1, 8, 7, Vista, XP (with Service Pack 3), Linux, and Mac OS X.

1.4.2 Software required

To get started with your Balboa robot, follow the instructions given below. They are more detailed in Section **5. Programming the Balboa 32U4** of the Balboa robot user guide which can be downloaded from `www.pololu.com/docs/0J70`.

1. If necessary, download and install on your PC the Arduino compiler from `www.arduino.cc/en/Main/Software`.

2. To help interface with all the on-board hardware on the Balboa 32U4, Pololu has provided the Balboa32U4 library. Follow carefully all the instructions given in `www.pololu.com/docs/0J70/5.2` to install the Balboa 32U4 Arduino library.
Depending on your Arduino version, you can also try the following: from Arduino, go to the "Sketch" menu, select "Include Library", then "Manage Libraries...", then search for "Balboa32U4" and install the library.

3. Several example sketches are available that show how to use the Balboa robot with the library. You can access the example codes available from the Arduino IDE by opening the "File" menu, selecting "Examples", and then selecting "Balboa32U4". If you cannot find these examples, the library was probably installed incorrectly and you should retry the installation instructions above. Another option is to download and copy the folders including the code examples for Pololu's Arduino-based Balboa 32U4 robot from `https://github.com/pololu/balboa-32u4-arduino-library`.

1.5 Balancing the two-wheeled Balboa robot

Balancing a two-wheeled robot like the Balboa is a classical problem in control theory, known as the "inverted pendulum", and there are many approaches to solving it. A simple balancing technique is given in the Balboa Balancer example, which uses feedback from the Balboa's gyroscope and encoders to keep the robot upright.

If you need a refresher about IMU, watch the excellent video on this topic from Brian Douglas !
`www.youtube.com/watch?v=0rlvvYgmTvIt=467s`

From the given example code, figure out the control method used to balance the Balboa robot: cascaded PID-based or state-space model-based control.

1.6 Control algorithm for line following with the balanced Balboa mobile robot

If a 5-Channel Reflectance Sensor Array (for identifying changes in reflectance on the ground directly underneath the Balboa (like detecting or following a black line on a white background))

is present in the kit, adapt the line following control algorithm you developed for the 3pi+ robot to the Balboa Robot.

1.7   Summary and reflections

Summarize and reflect on what you have seen and learned during this lab.