Probabilistic Robotics Course

Robots and Sensors MARRTino & Orazio

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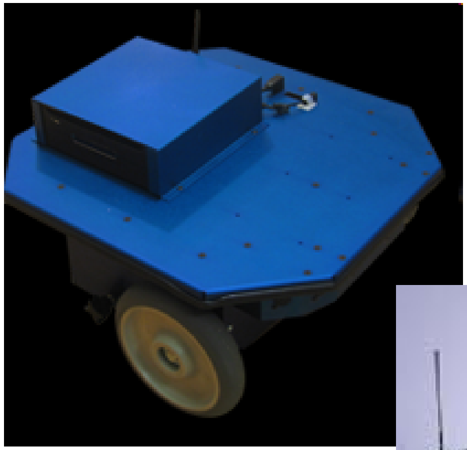
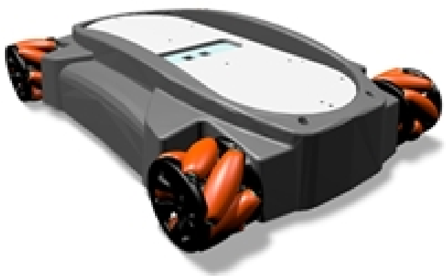
Outline

- Robot Devices
  - Overview of Typical sensors and Actuators
- Mobile Bases
- MARRTino/Orazio
  - Hardware
  - Firmware

Mobile Base

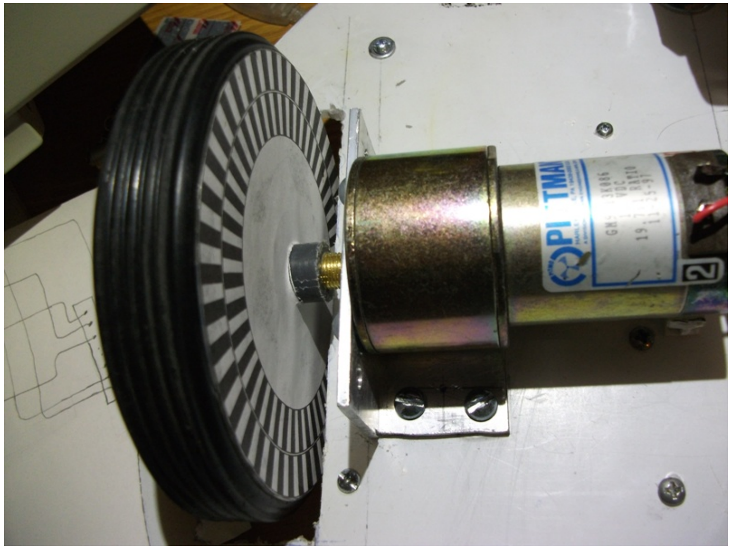
- A mobile platform is a device capable of moving in the environment and carrying a certain load (sensors and actuators)
- At low level the inputs are the desired velocities of the joints, and the output is the state of the joints
- At high level it can be controlled with linear/angular velocity, and provides the relative position of the mobiel base w.r.t. an initial instant, obtained by integrating the joint’s states (odometry).




Sensors for Ego-Motion

- Wheel encoders mounted on the wheels
- IMU:
  - Accelerometers
  - Gyros
- The estimate of ego-motion is obtained by ***integrating*** the sensor measurements of these devices. This results in an accumulated drift due to the noise affecting the measurement
- In absence of an external reference there is ***no way*** to recover from these errors



Measuring the Environment

Perception of the environment

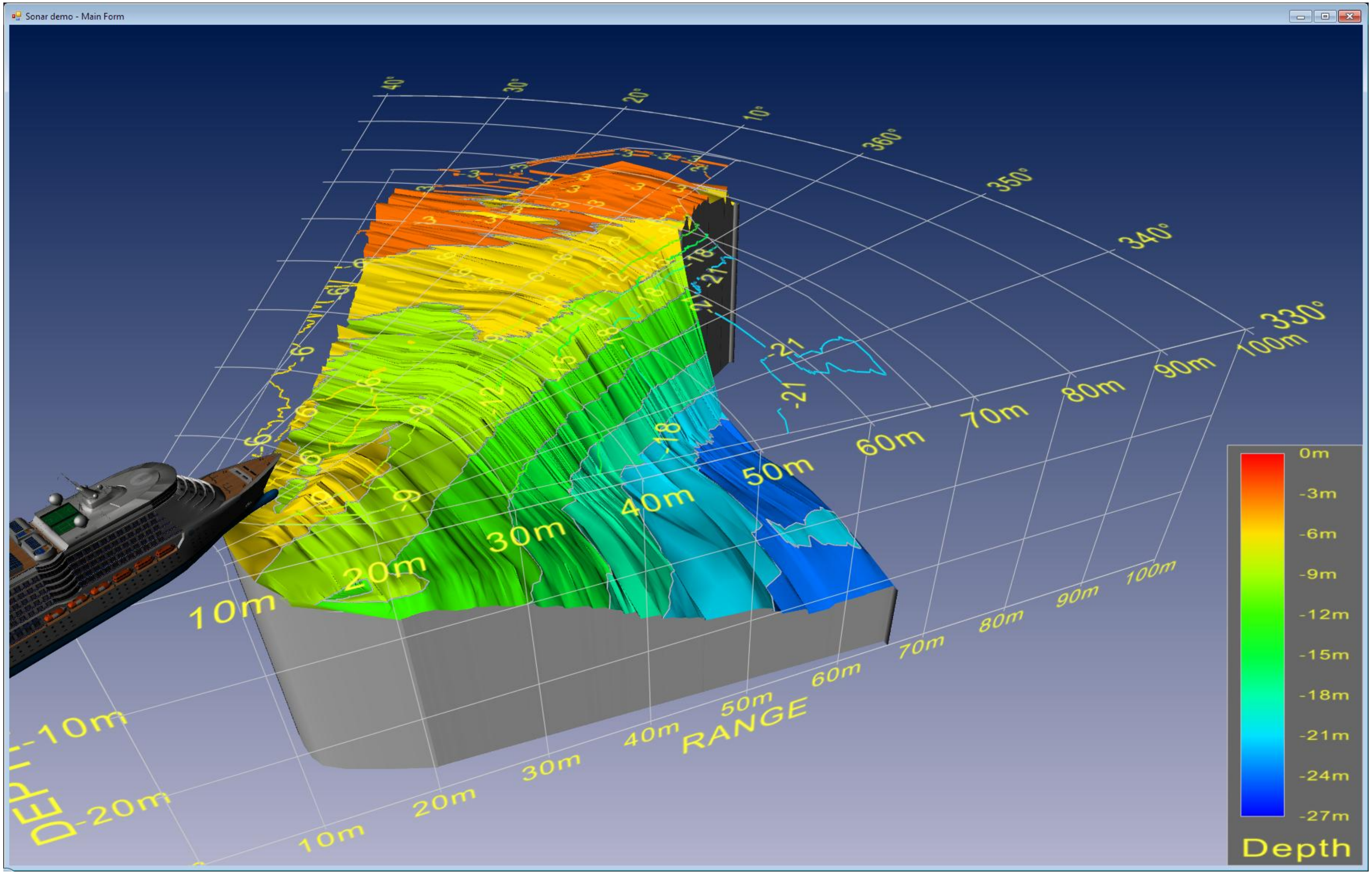
Active:

- Ultrasound
- Laser range finder
- Structured-light cameras
- Infrared

Passive:

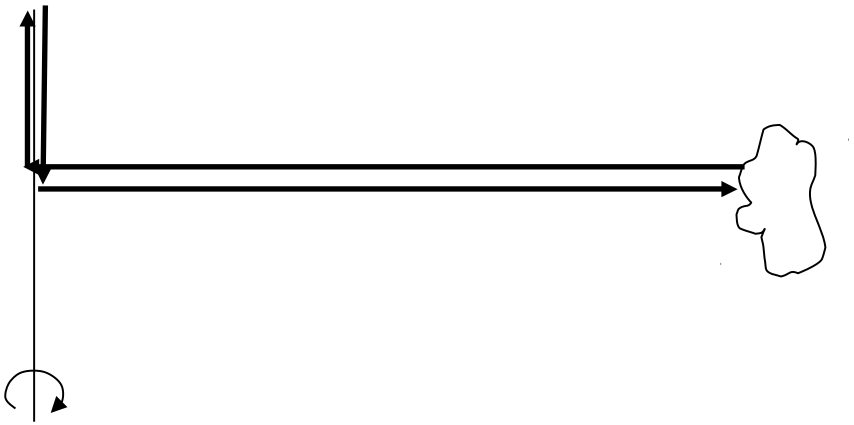
- RGB Cameras
- Tactiles

Sonars
(SOund Navigation And Ranging)



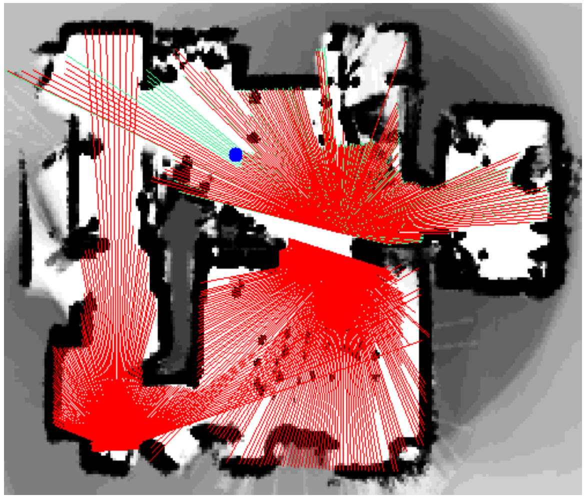
- Extensive FOV

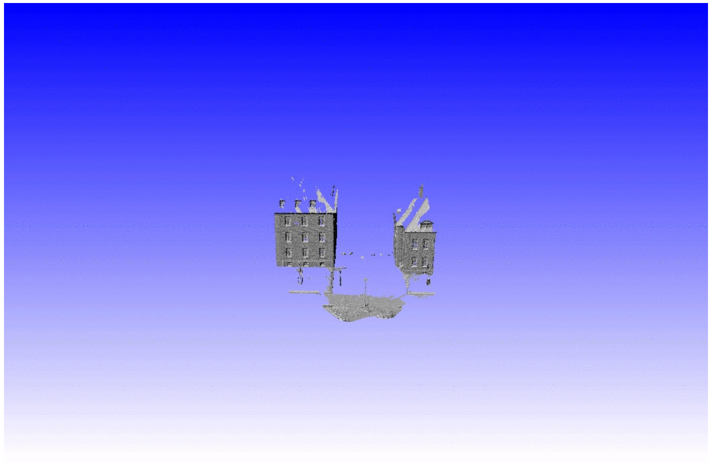
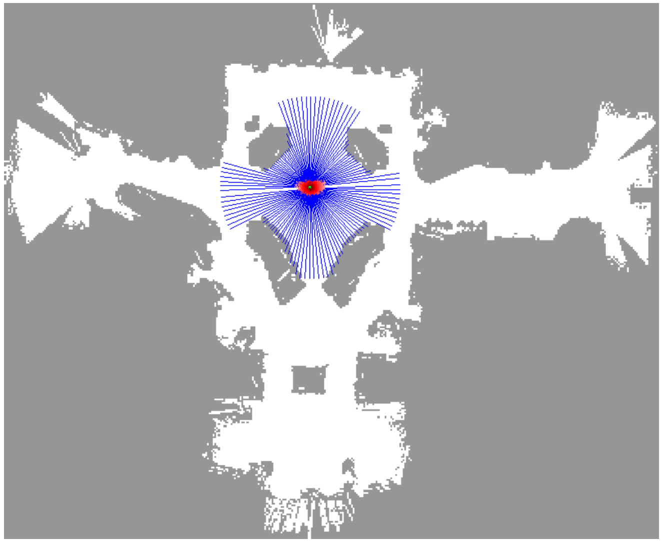
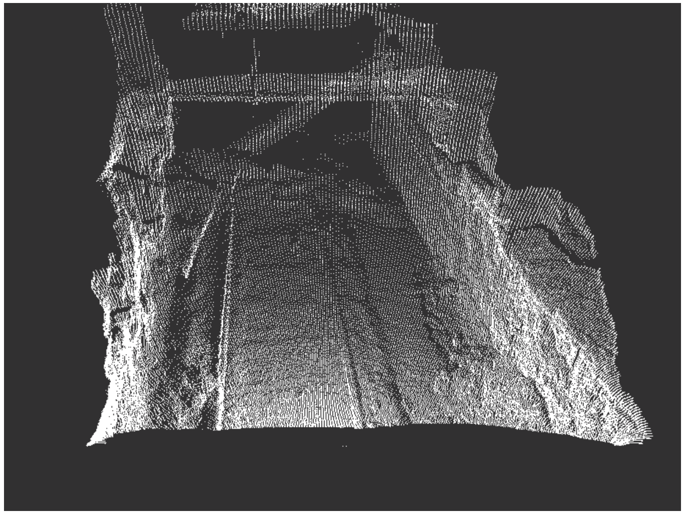
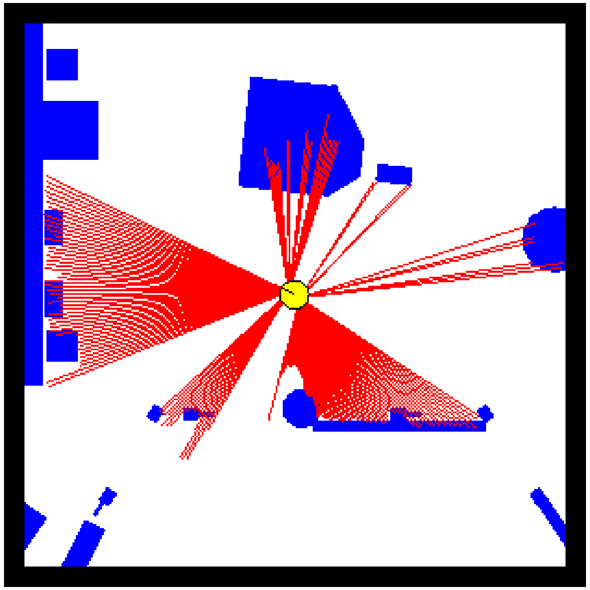
Laser Scanner



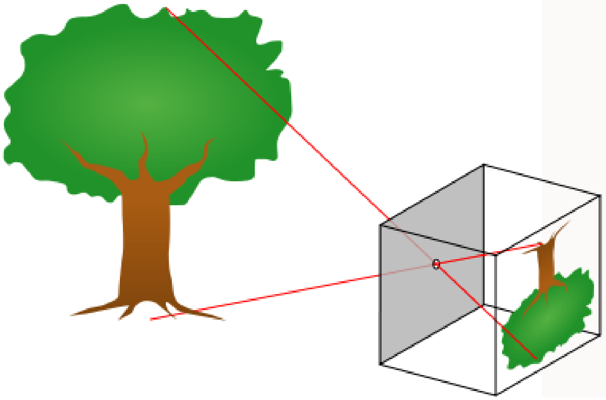
- Wide FOV
- Highly Accurate
- Approved security for collision detection

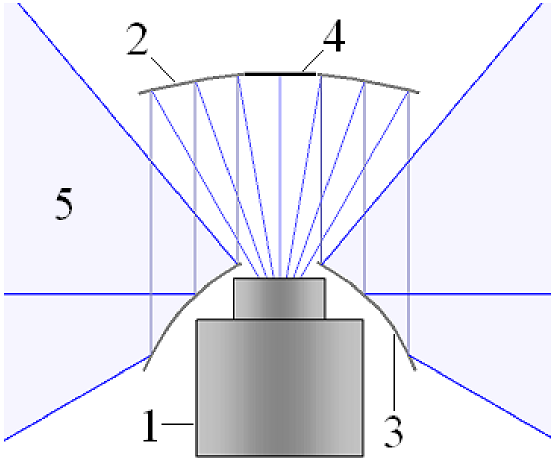
Typical Scans



RGB Monocular Camera

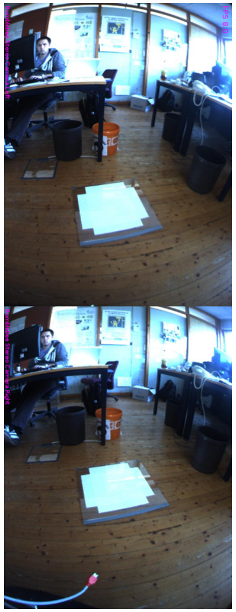


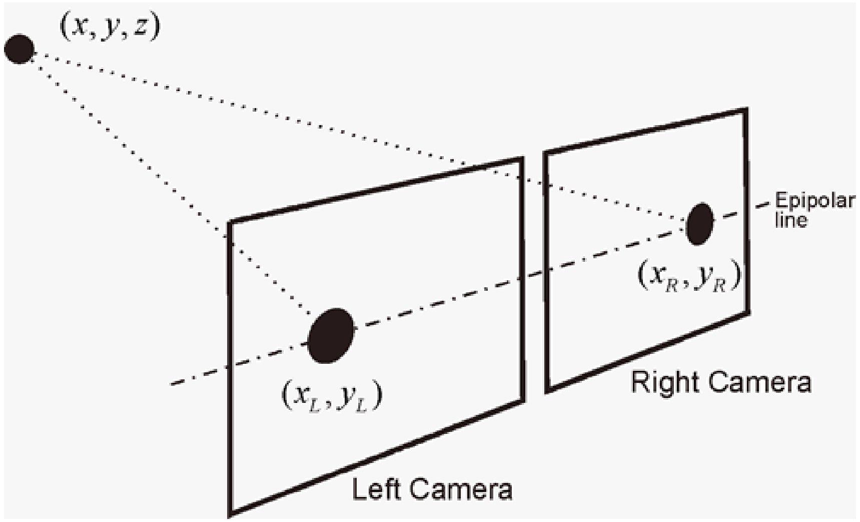


RGB Monocular Camera

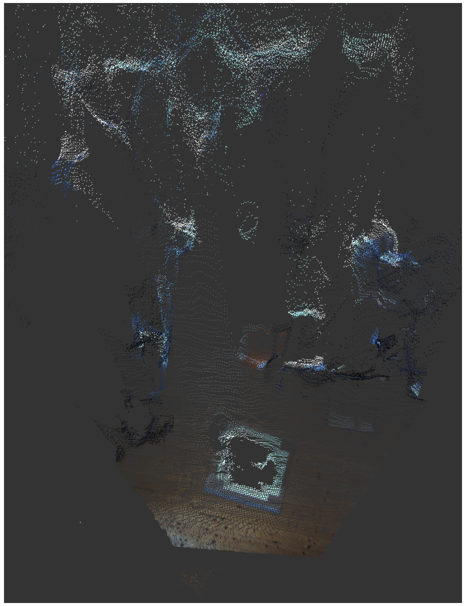
- Cameras measure the intensity of the light projected onto a (typically planar) ccd through a system of lenses and/or mirrors
- Provide a lot of information
- Project 3D onto 2D, which results in the unobservability of the depth
- The scene can be reconstructed by multiple images (see SfM)

RGB Stereo Camera





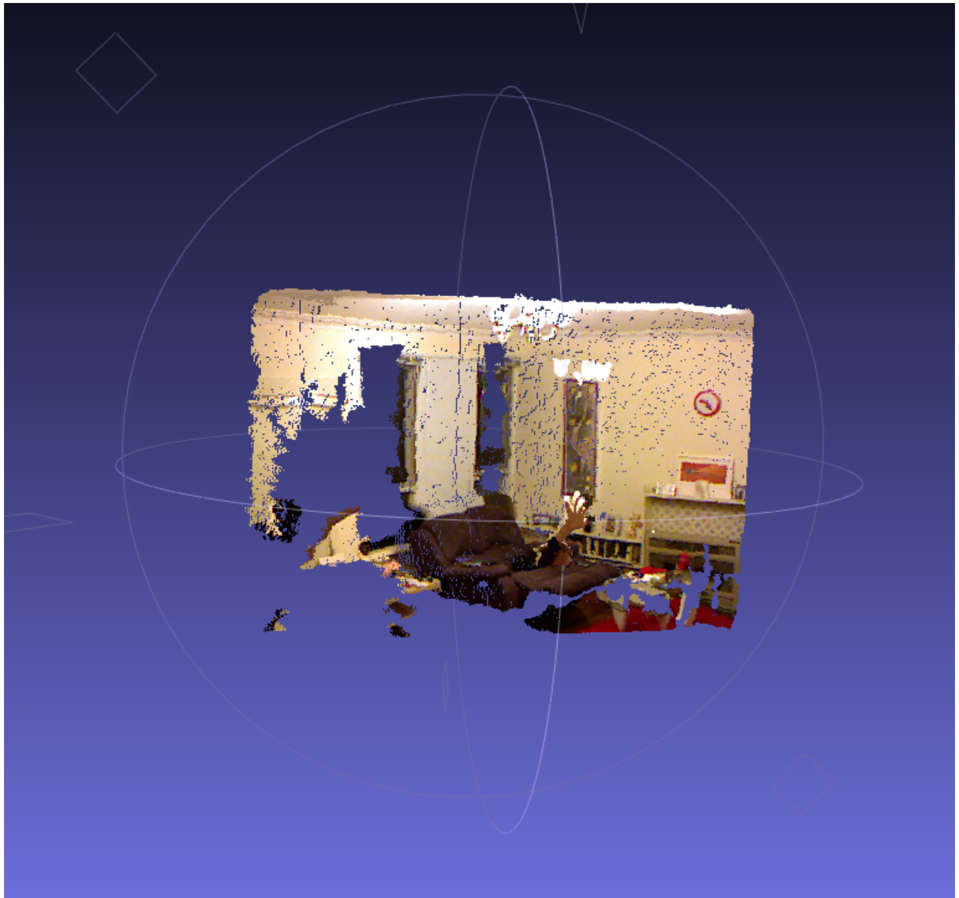
reconstruction from top



- Stereo cameras are combination of 2 monocular cameras that allow triangulation, given a known geometry.
- If the corresponding points in the images are known, we can reconstruct the 3D scene.
- Error in the depth depends on the distance!
- Sensible to lack of texture

RGB-D Cameras

- Cameras that are able to sense the color and the depth even with poor/no texture
- Use an active light source and retrieve the depth either
  - via stereo triangulation (emitter and source are in different positions)
  - Time of flight (emitter and source are in the same position)
- Environment conditions should allow to sense the emitted light.
- Typically OK indoors



MARRtino

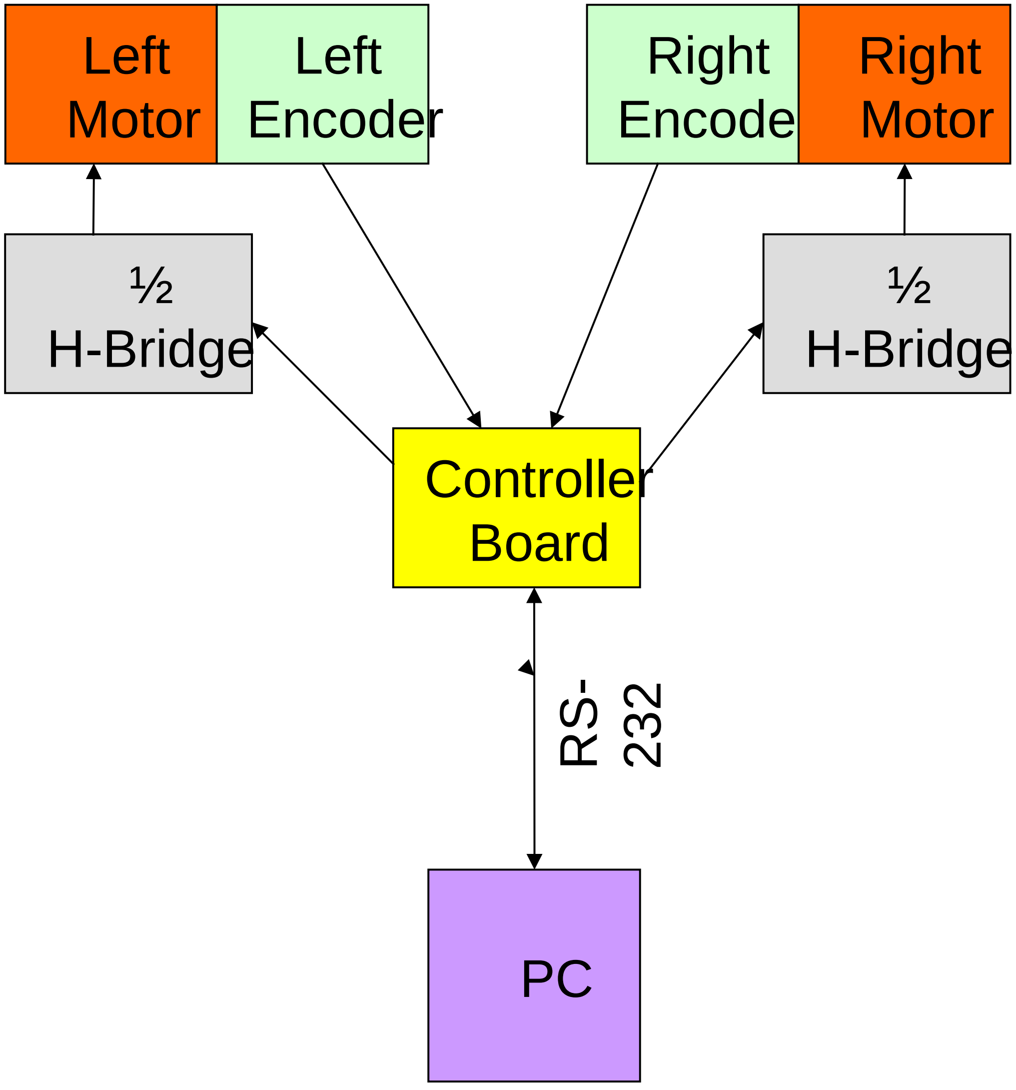
- Is a simple but complete mobile base designed to be used in the MARR course.
- The cost of the parts is around 300 euro
- It is entirely open source
- It is integrated in ROS through a simple node that publishes/subscribes standard topics

Orazio

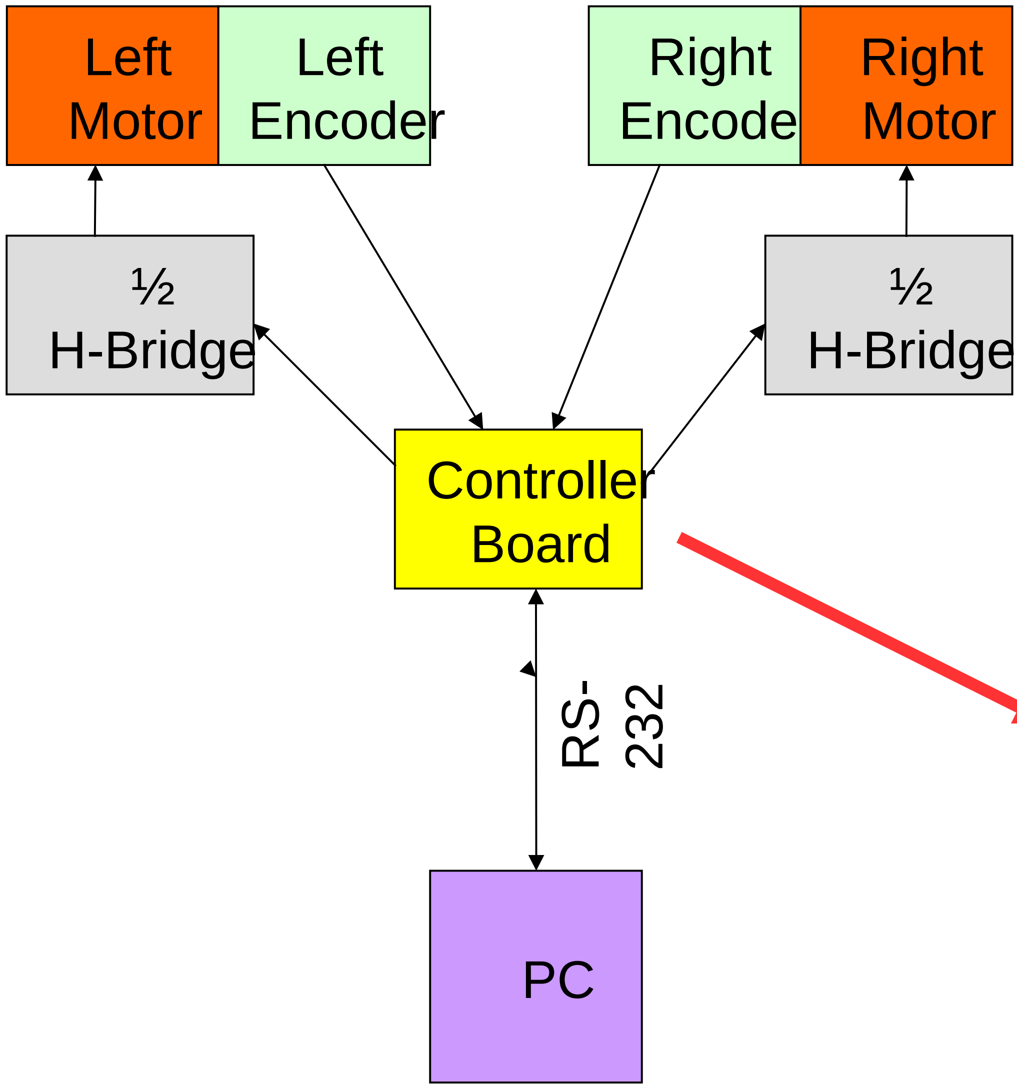
- Is a simplified yet complete redesign of MARRtino, with the goals of
  - Using easy-to-find hardware (Arduino)
  - Reducing the assembly time (2 hours for non skilled users)
- It is entirely open source
- It is integrated in ros through a simple node that publishes/subscribes standard topics

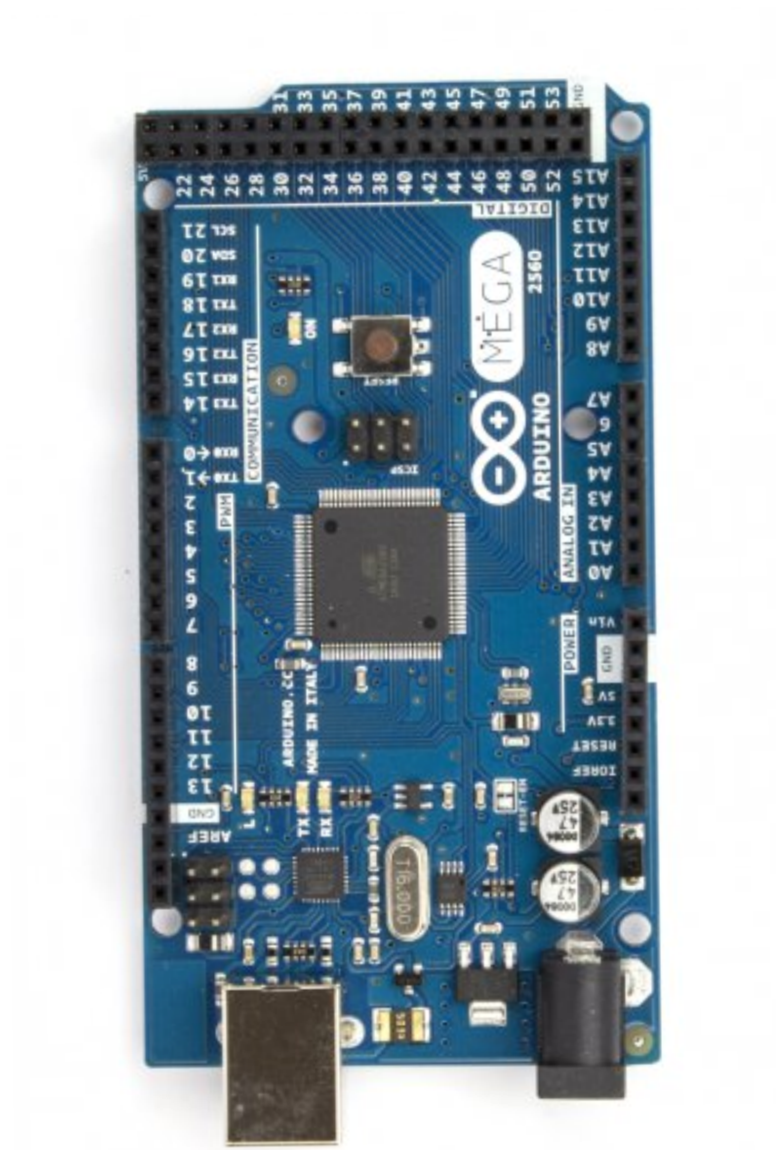
Firmware at `https://gitlab.com/srrg-software/srrg_orazio_core`

Electronics



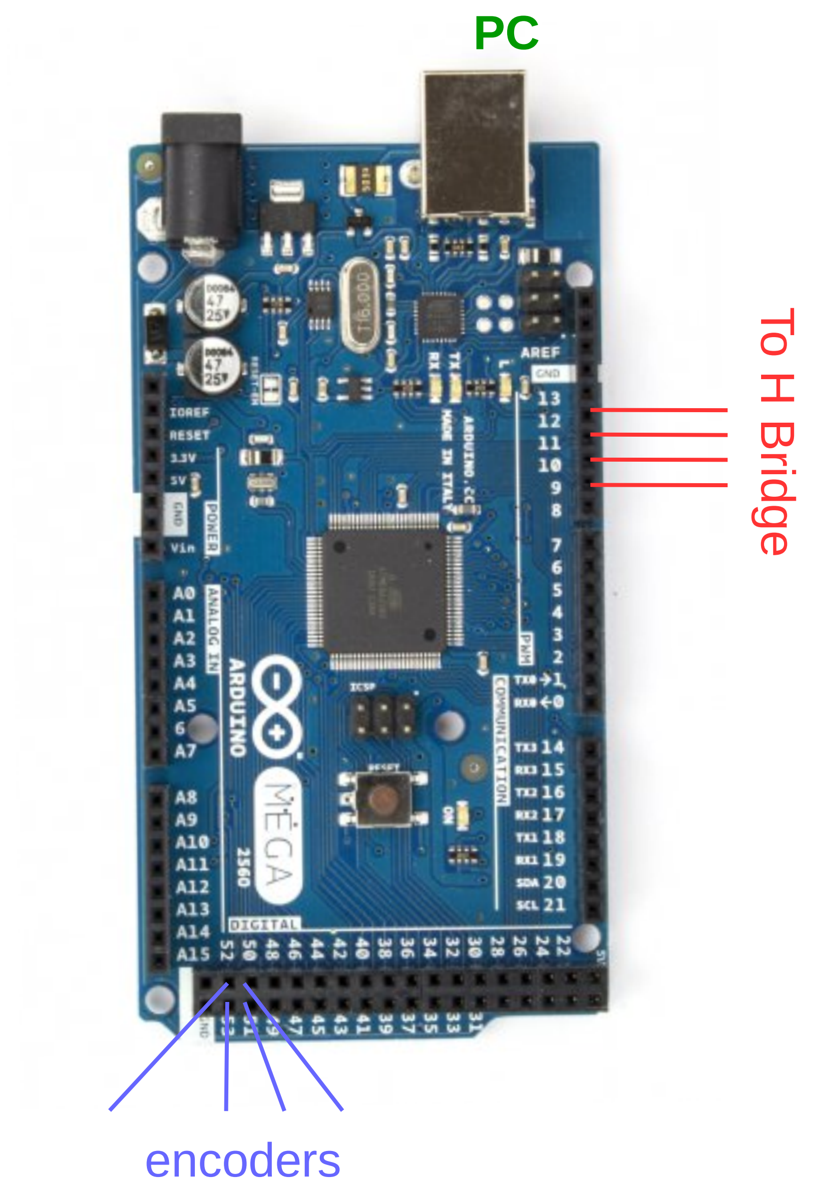
Electronics





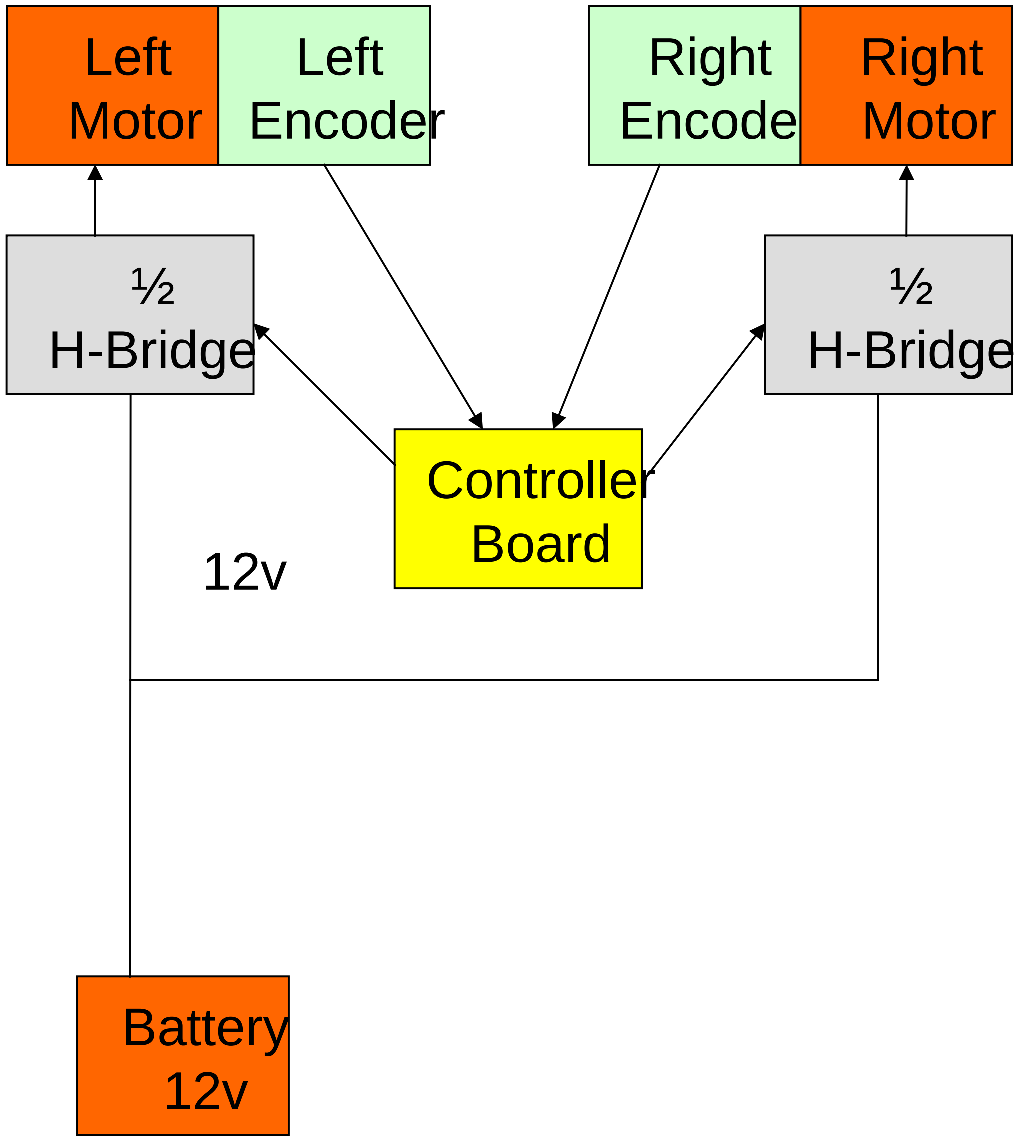
Electronics

- The PC communicates with arduino through USB
- Each encoder provides two signals
- Each PWM requires at least 2 wires
- The wiring of the PWM depends on the H-Bridge used



Power

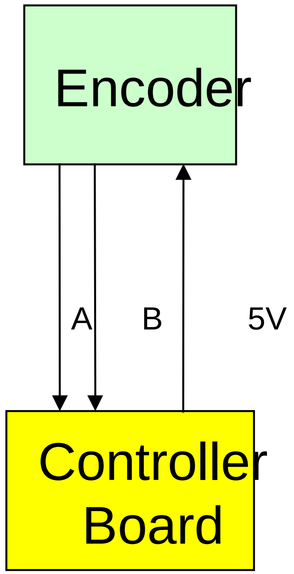
- Control Board: 6V from one of the batteries
- H bridges: 12 V from both batteries, 5V from logic
- The system can either charge the batteries or be powered ON.



Controller is powered through USB
Controller and H bridges share the GND

Encoders

- Each encoder has two signals (A, B) and requires a 5V voltage supplied by the controller board
- The encoders are managed by the Quadrature Encoder Module (QEI) of the controller, that takes care of counting ticks and direction



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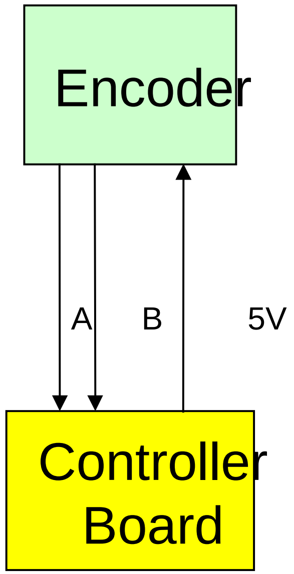
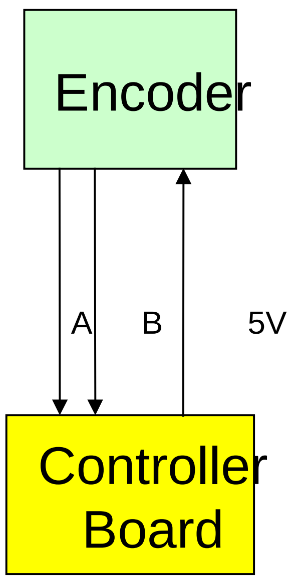
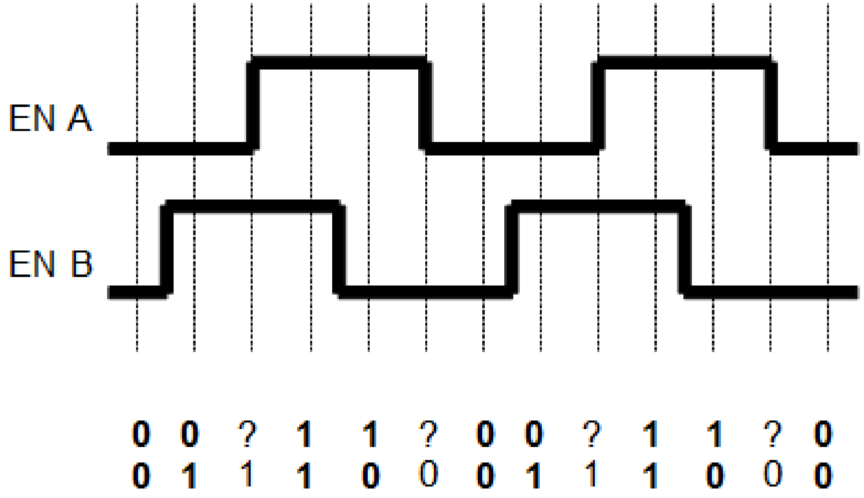


Encoders

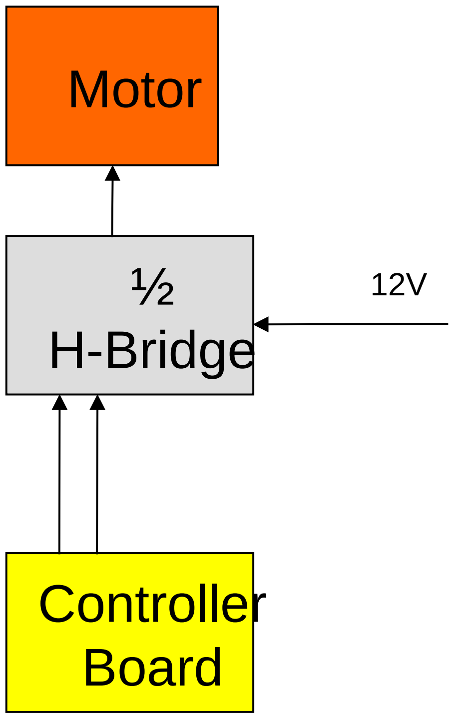
- Each encoder has two signals (A, B) and requires a 5V voltage supplied by the controller board
- The encoders are managed by interrupt on edges, that takes care of counting ticks and direction





H Bridge

- The motor is connected to the H Bridge, that provides the necessary voltage and current to drive it.
- The H bridge requires 12V power directly from the battery
- The board controls the H bridge by a set of wires. Three protocols are common
  - PWM/Dir: two pins, the first is a PWM signal controlling the voltage, the second controls the direction
  - Dual PWM: two pins, the first controls the voltage for one direction of rotation, the second pin for the opposite direction. The pins cannot be simultaneously “high”.
  - PWM/Phase: one pin, 50% of duty cicle means the motor is off. Values below 50% rotate in one direction, values above in the opposite direction



PC connection

- The robot communicates with the PC through an RS232 interface at TTL levels (0-5V)
- The TTL-RS232 is converted in USB through an FTDI chip
- The device is visible on Linux as /dev/ttyXXX