TU/e Faculty of Mechanical Engineering
Embedded motion control
Quartile 4, 2020/2021

Design Document

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1.1 Requirements and Specifications

Requirements and Specifications: General

- 1. The PICO must be safe around humans.
  - 1.A Max speed 0.5 m/s translational, 1.2 rad/s rotational.
  - 1.B The PICO must be able to be stopped at anytime.
  - 1.C The PICO must report its actions to the operator.
- 2. The PICO must not bump into walls or objects.
  - 2.A The PICO must be able to detect walls and objects, and present them in the world model.
  - 2.B The PICO must keep a minimum distance of 0.2 m from walls and objects.
  - 2.C The PICO preferably keeps a minimum distance of 0.6 m from dynamic objects. If a dynamic object is within 0.6 m the PICO has to stand still.
  - 2.D The PICO should always be driving in the direction of the Laser Range Finder range: -2 to 2 rad.
- 3. The software should easily be updated, compiled using "cmake" and "make", only one executable has to be called when starting.
- 4. The PICO should not remain in idle position for longer than 30 seconds.
  - 4.A After 30 seconds in a idle position a recovery behaviour should be started.

Requirements and Specifications: Escape Room

- 1. The PICO should be able to escape from a arbitrary rectangular chamber, without prior knowledge of the map of the chamber.
  - 1.A The PICO should be able to identify the exit.
  - 1.B The PICO should be able to detect when the finish line is crossed.
  - 1.C The PICO should be able to escape the chamber from any starting point within the chamber.
  - 1.D The PICO should be able to escape the chamber as fast as possible, but within 5 minutes.

Requirements and Specifications: Hospital Challenge

- 1. When PICO "picks up" or "drop offs" medicine it must make a clear sound signal to simulate the delivery.
- 2. A snapshot of the laserdata, in front of each cabinet should be saved.
- 3. The PICO should be able to navigate despite the presence of (moving) obstacles, not present in the map.
  - 3.A the PICO should be able to detect static and dynamic objects.
  - 3.B The PICO should be able to update the planned path based on obstacles and barriers.
- 4. The PICO should be able to correct for differences in the measured features and provided map caused by slipping.
- 5. The PICO should be able to sequentially visit all required cabinets in order, where the cabinets and there order are only known at the start of the challenge.
  - 5.A The PICO should be able to plan a route through the known map to visit all cabinets
  - 5.B The PICO should be able to identify a cabinet based on provided map.
- 6. The PICO should complete the task within 10 minutes.

1.2 Hardware Specifications

- 1. **Laser scanner:** Angular sensing range of distance sensor is ± 2 rad from the normal direction, with increments of 0.004004 rad. Range from 0.01m to 10 m.
- 2. **Camera** The camera on the PICO has a 170° view.
- 3. **Holonomic base:** Maximum velocity: 0.5 m/s translational, 1.2 rad/s rotational.
- 4. **Speaker:** The PICO has a speaker to communicate to humans.

1.3 Functions

Input data processing

- Laser range finder interpretation
  PICO should know what to do with the laser data that it is generating, containing information about distance and angle with respect to an object. For example, PICO should be able to detect the current wall clearance.
- Odometer interpretation
  The odometer on the PICO contains the displacement and rotation of the robot since the moment it has been put on. This data can be used, together with the laser range finder, for mapping the environment.
- Sensor fusion
  The LRF and odometer data should be combined to make a reliable position estimate.
- Vector-map data interpretation This function structures the data obtained from the provided map of the (test) environment. This will play a role in the hospital challenge, where this will be used for decision making on path planning.

Localization

- Environment comparison and localization
  With this function, PICO will localize itself in the room using the LRF data and in case of the hospital challange compare this to the vector map. Thu function returns the estimated position of PICO.
- Position estimation
  Odometrie data is used to validate the localization in the previous function. Once this has been executed PICO will decide its next action by means of a new path.
- Obstacle recognition
  PICO should be able to recognize obstacles, either static and dynamical. Note that both have different specifications.

Control

- Path planning
  Every time the environment changes, PICO will call this function to determine the next action. The environment changes whenever the new data is collected about the surrounding, using the LRF sensor. If this happens the PICO will calculate the optimal path for fulfilling its task. When necessary it will alter its reference path and start a new action. An example of this is when a wall is detected, the robot should then align itself with that wall before continuing to drive.
- Translating and rotating
  Here the defined path will be translated to input for the controller of the base of PICO, so that it actually moves towards the next set target.

1.4 Components

Hardware

Sensors

PICO has two main sensors:

- Laser range finder (LRF)
  This sensor provides PICO on information about the environment with a 2D LIDAR.
- Camera
  This sensor will be used for object recognition and has a 170° wide view.
- Odometry
  This sensor provides PICO on information about the distance travel based on revolutions made by the wheels

Interface

- PICO needs to have a speaker which can be used to signal its actions to others in the same environment.
- PICO needs to have an emergency switch to turn down the robot completely in case the robot starts behaving unexpectedly or undesired.

Software

The hardware above also has to communicate with the users and itself via software which are described in multiple main functions. At start the software preferably initializes a room scan where the robot rotates in place or drives around to builds and/or updates the world model. Also the feed of the camera has to be processed to make sure it is able to recognize obstacles. The world model and obstacles then have to be pushed and used in the global and local path planner to create a path for the robot to follow which in turn will actuate the robot to an translational or rotational movement via the holonomic wheels. In case of the Hospital challenge the global path planning will also indicate when the robot has to communicate. As when the goal is reached it has to be communicated via sound with the help of the speaker.

1.5 Interfaces

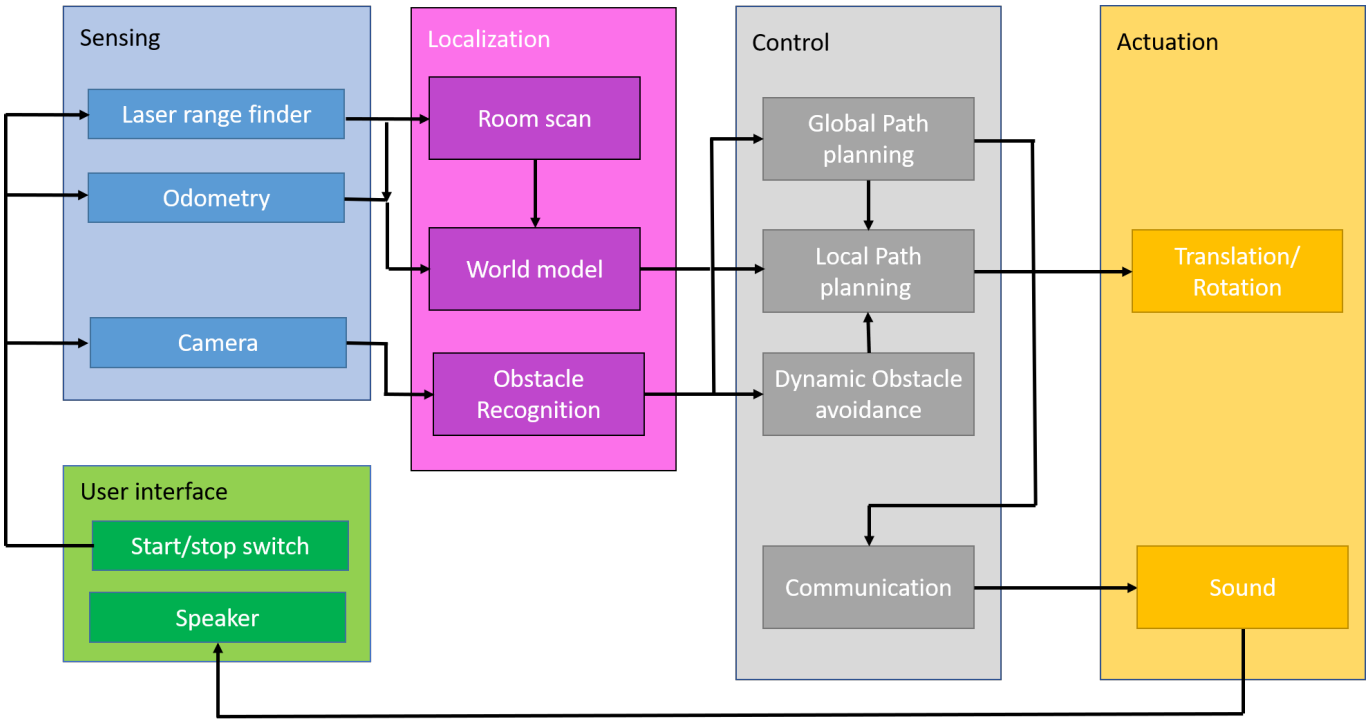

Figure 1.1: Interface schematic