Eindhoven University of Technology
Embedded Motion Control

Design Report

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Introduction

In this document, the basic principles to be used in the autonomous robot 'PICO' are presented. PICO must successfully complete the Escape Room challenge, where the task is to find the exit of a rectangular room under certain constraints. In the next assignment, called the Hospital challenge, it must visit several rooms while dealing with obstacles that may obstruct its way. In the following chapters the architecture of the design is illustrated, which will serve as a guideline during the implementation phase.

Requirements

In order to successfully build a software that allows the execution of certain tasks, the requirements and demands must be well-defined. Some of them are imposed by the nature of the competition, while others are set by the team itself, to achieve a high-quality design:

- Competition requirements:
  - PICO must operate autonomously.
  - It must detect walls and exits.
  - PICO must not bump into walls.
  - It must exit the room as fast as possible but within 5 minutes.
  - It must not stand still for longer than 30 seconds.
  - PICO has exited the room when its rear wheel has passed the finish line.
  - It must stop after crossing the finish line.
  - It must avoid obstacles by either stopping or circumventing them.
- Quality-of-design requirements:
  - Software must be easy to set-up.
  - Avoid deadlocks or infinite executions.
  - A mapping of the room must be created as the robot moves and recognizes its surroundings.
  - Adhere generally to the good practices of robotic software architecture.

Functions

In order to achieve the project requirements, a series of functions must be implemented in the PICO software. The functions can be divided in three categories, depending on the level of abstraction:

The **low-level** functions are basis building blocks for controlling the sensors and the actuators. They are described as follows:

Motion:

- Start moving
- Rotate left or right
- Stop moving/rotating

Sensing:

- Obtain laser data
- Obtain encoder data

These basic tasks can be combined to form **mid-level** functions. These are called by the high-level and are executed via the low-level functions. Parts of the mid-level functions are:

Bundled tasks:

- Identify position in the room
- Path generation and following (e.g. move parallel to wall)
- Recognize walls and exit
- Recognize obstacles and perform actions to avoid them (stop or go around)
- Turn to corridor starting point
- Move to corridor starting point

In the most abstract level lie the **high-level** functions. The most important ones are written down below:

Planning:

- Initialize sensors
- Escape the room
- Mediation (Stop and do checks when data contradicts each other)
- Monitor progress (compare actual behavior to expected behavior)
- Mapping
- Stop and shut down

Components

During the course of the project the PICO robot will be used, that will utilize the following components to achieve the necessary tasks:

- Actuators:
  - Holonomic base with three omni-wheels, that enables the translational and rotational movement of PICO
  - Pan-tilt unit for head
- Sensors:
  - Laser range finder (LRF): Detects the distance and the direction of objects in the surrounding environment of PICO.
  - Wheel encoders: Together with the control effort they allow the determination of the robot's position and orientation, taking into account possible inaccuracies due to error accumulation.
- Computer
  - Ubuntu 16.04
  - Intel i7

Specifications

The specifications of the provided equipment and of the environment are the following:

- The maximum transitional velocity of PICO is 0.5 m/s.
- The maximum rotational velocity of PICO is 1.2 rad/s.
- The field of view of the Laser Range Finder is from -2 to 2 rad, with a resolution of 0.004004 rad.
- The range of the Laser Range Finder has to be determined.
- The initial position of PICO inside the room is random.
- The shape of the room is approximately rectangular (not perfectly perpendicular or parallel walls).
- The width of the corridor and the openings in the walls are between 0.5 and 1.5 m.
- The finish line is located more than 3 m after the beginning of the exit corridor.

Interfaces

This section illustrates how the elements of the designed mentioned previously communicate and interact. Figure 1 presents this architecture of the design:

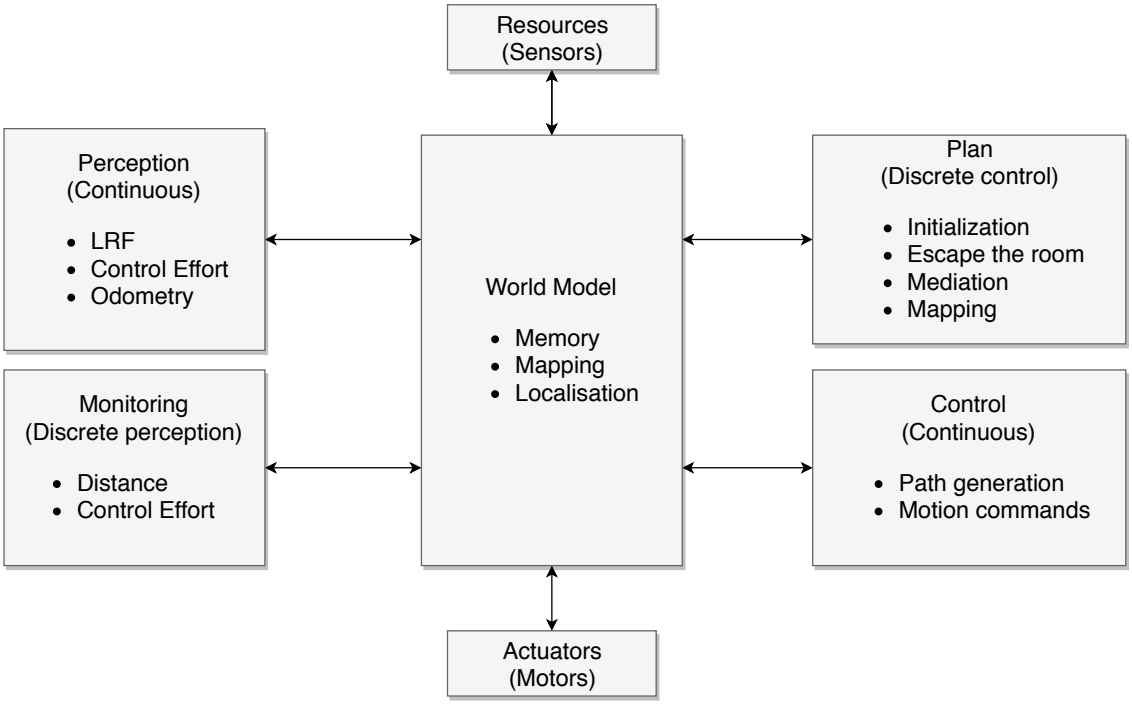

Figure 1: Initial Design of Interfaces and system architecture