Design Document

4SC020 - Embedded Motion Control

Group 3

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May 6, 2019

1 Introduction

This document describes the process of making the PICO robot succeed the Escape Room Competition and the Final Competition. The PICO robot is a telepresence robot that is capable of driving around while monitoring its environment. In the Escape Room Competition, the robot is placed somewhere inside a rectangular room with unknown dimensions with one doorway that leads to the finish line. Once the robot crosses the finish line without bumping into walls, the assignment is completed. The Final Competition involves a dynamic hospital-like environment, where the robot is assigned to approach a number of cabinets based on a known map, while avoiding obstacles.

2 Components

The PICO robot is a modified version of the *Jazz* robot, which is originally developed by Gostai, now part of Aldebaran. The key components of the robot that are relevant to this project are the drivetrain and the laser rangefinder. The drivetrain is holonomic, as it consists of three omni-wheels that allow the robot to translate in any direction without necessarily rotating. This adds the benefit of scanning the environment in a fixed orientation, while moving in any direction. The software framework allows the forward and sideways velocity to be set, as well as the horizontal angular velocity. The framework also approximates the relative position and angle from the starting position.

The laser rangefinder is a spatial measurement device that is capable of measuring the horizontal distance to any object within a fixed field of view. The software framework measures a finite number of equally distributed angles within the field of view and notifies when new measurement data is available. Using this data, walls and obstacles in the environment of the robot can be detected.

Lastly, the robot is fitted with loudspeakers and a WiFi connection according to the data sheet of the Jazz robot. This can be useful for interfacing during operation, as described in chapter 6. Whether the PICO robot actually has these speakers and the WiFi connectivity remains to be determined.

3 Requirements

Different requirement sets have been made for the Escape Room Competition and the Final Competition. The requirements are based on the course descriptions of the competitions and the personal ambitions of the project members. The final software is finished once all the requirements are met.

The requirements for the Escape Room Competition are as follows:

- The entire software runs on one executable on the robot.

- The robot is to autonomously drive itself out of the escape room.
- The robot may not 'bump' into walls, where 'bumping' is judged by the tutors during the competition.
- The robot may not stand still for more than 30 seconds.
- The robot has five minutes to get out of the escape room.
- The software will communicate when it changes its state, why it changes its state and to what state it changes.

The requirements for the Final Competition are as follows:

- The entire software runs on one executable on the robot.
- The robot is to autonomously drive itself around in the dynamic hospital.
- The robot may not 'bump' into objects, where 'bumping' is judged by the tutors during the competition.
- The robot may not stand still for more than 30 seconds.
- The robot can visit a variable number of cabinets in the hospital.
- The software will communicate when it changes its state, why it changes its state and to what state it changes.
- The robot navigates based on a provided map of the hospital and data obtained by the laser rangefinder and the odometry data.

4 Functions

A list of functions the robot needs to fulfil has been made. Some of these functions are for both competitions, while some are for either the Escape Room or Final Competition. The functions marked with (∗) are uniquely for the Escape Room Competition. The functions marked with (-) are designated to be used exclusively during the Final Competition. These functions are:

• Recognising spatial features;
• Preventing collision;
• Conditioning the odometry data;
• Conditioning the rangefinder data;
• Communicating the state of the software;
∗ Following walls;
∗ Detecting the end of the finish corridor;
- Moving to points on the map;
- Calculating current position on the map;
- Planning the trajectory to a point on the map;
- Approaching a cabinet based on its location on the map.

The key function in this project is recognising spatial features. The point of this function is to analyse the rangefinder data in order to detect walls, convex or concave corners, dead spots in the field of view, and gaps in the wall that could be a doorway. This plays a key role during the Escape Room Competition in order to detect the corridor with the finish line in it, and therefore has a priority during the realisation of the software. For this function to work reliably, it is essential that the rangefinder data is analysed for noise during the initial tests. If there is a significant amount of noise, the rangefinder data needs to be conditioned before it is fed into the spatial feature recognition function. As a safety measure, it is important to constantly monitor the spatial features in order to prevent collisions with unexpected obstacles.

Lastly, the trajectory planning function plays a major role during the Final Competition, as this determines the route that the robot needs to follow in order to get to a specified cabinet. This function needs to take obstacles into account, in case the preferred route is obstructed. This is possible, as the documentation about the Final Competition show a map in which multiple routes lead to a certain cabinet. One of these routes can be blocked, in which case the robot needs to calculate a different route.

5 Specifications

The specifications describe important dimensions and limitations of the hardware components of the robot that will be used during the competitions. For each component, the specifications of that components will be given, with a source of where this specification comes from.

The drivetrain of the robot can move the robot in the x and y directions and rotate the robot in the z direction. The maximum speed of the robot is limited to $\pm 0.5 m/s$ translation and $\pm 1.2 rad/s$ rotation. These values are from the Embedded Motion Control Wiki page. The centre of rotation of the drivetrain needs to be known in order to predict the translation of the robot after a rotation. This will be determined with a measurement.

The dimensions of the footprint of the robot need to be known in order to move the robot through corridors and doorways without collision. The footprint is $41cm$ wide and $35cm$ deep, according to the Jazz robot datasheet. A measurement will be made to check these dimensions.

The laser rangefinder will be used to detect and measure the distance to objects in the vicinity of the robot. The measurement distance range of the sensor is from $0.1m$ to $10.0m$ with a field of view of 229.2°. The range of the sensor is divided into 1000 parts. These values are determined with the PICO simulator and need to be verified with measurements on the real robot.

6 Interface

The interfacing of the robot determines how the project members interact with the robot in order to set it up for the competitions. It also plays a role during operation, in the way that it interacts with the spectators of the competitions. On the development level there is an Ethernet connection available to the robot. This allows a computer to be hooked up to the robot in order to download the latest version of the software using *git*, by connecting to the Gitlab repository of the project group. This involves using the `git pull` command, which downloads all the content from the repository, including the executable that contains the robot software.

On the operation level it is important for the robot to communicate the status of the software. This is useful for debugging the software, as well as clarifying the behaviour during the competitions. This can be made possible with the loudspeaker, by recording voice lines that explain what the robot currently senses and what the next step is that it will perform. Not only is this functionally important, but it can also add a human touch to the behaviour of the robot. In case that the PICO robot has been altered to not have loudspeakers, it needs to be determined during testing if the WiFi interface can be utilised in order to print messages in a terminal on a computer that is connected to the robot.