VILNIUS UNIVERSITY
FACULTY OF MATHEMATICS AND INFORMATICS
INSTITUTE OF COMPUTER SCIENCE
INFORMATION TECHNOLOGIES STUDY PROGRAM

Problem-Based Project

Technical specification

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1 Overview

1.1 Project overview

The goal of the project is to design an autonomous robot, which would be able to detect, avoid and follow objects in an indoor environment. The rover should be able to roam around the area freely and remember the layout. We will need to use sensors to detect objects and determine how to react. We use sensors to map the environment and find a path through the area. We use a micro-controller to control the motors and receive input from the sensors.

1.2 Hardware diagram

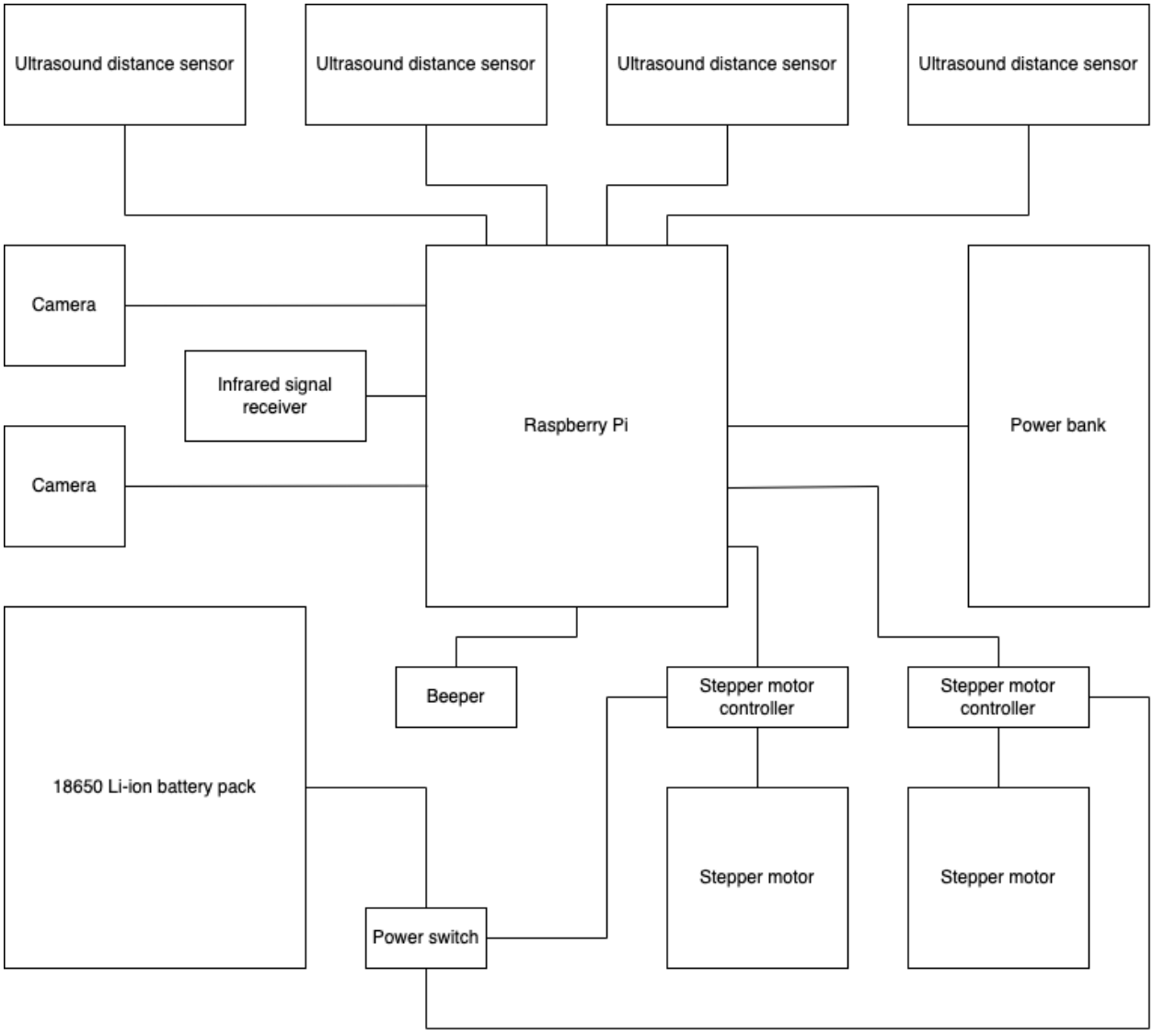

Figure 1. Hardware diagram

1.3 Context diagram

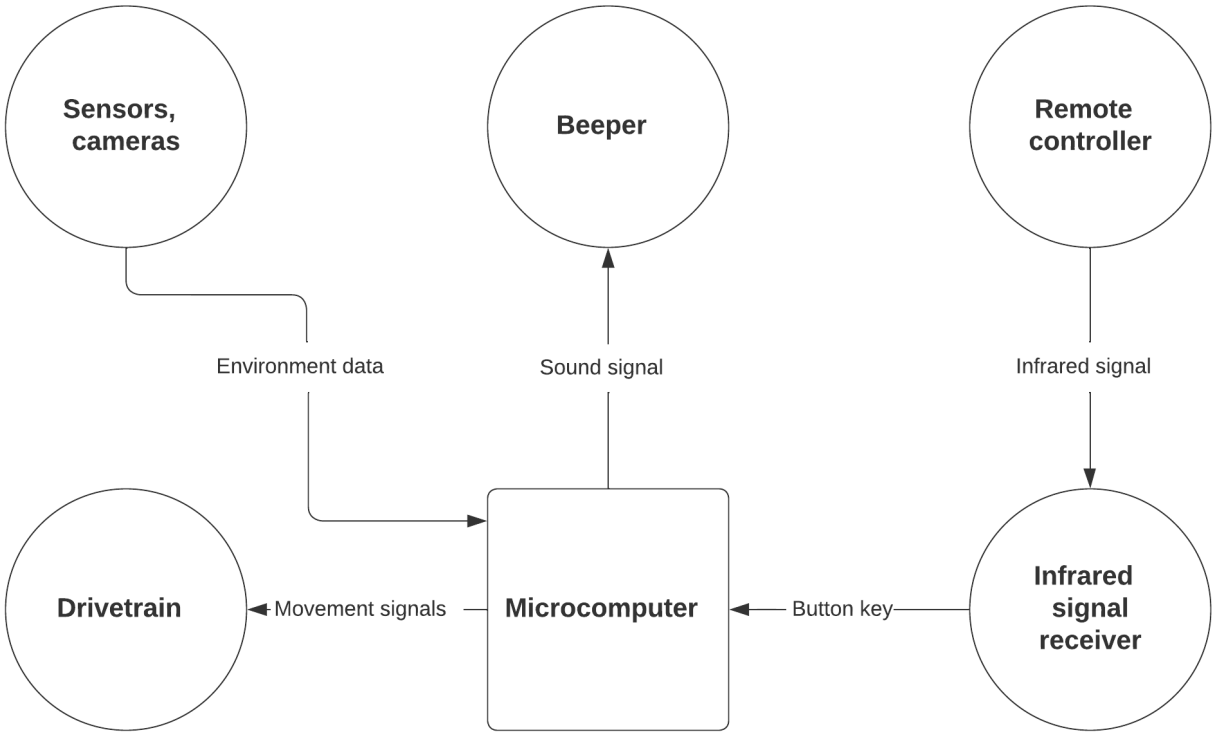

Figure 2. Context diagram

1.4 UML deployment diagram

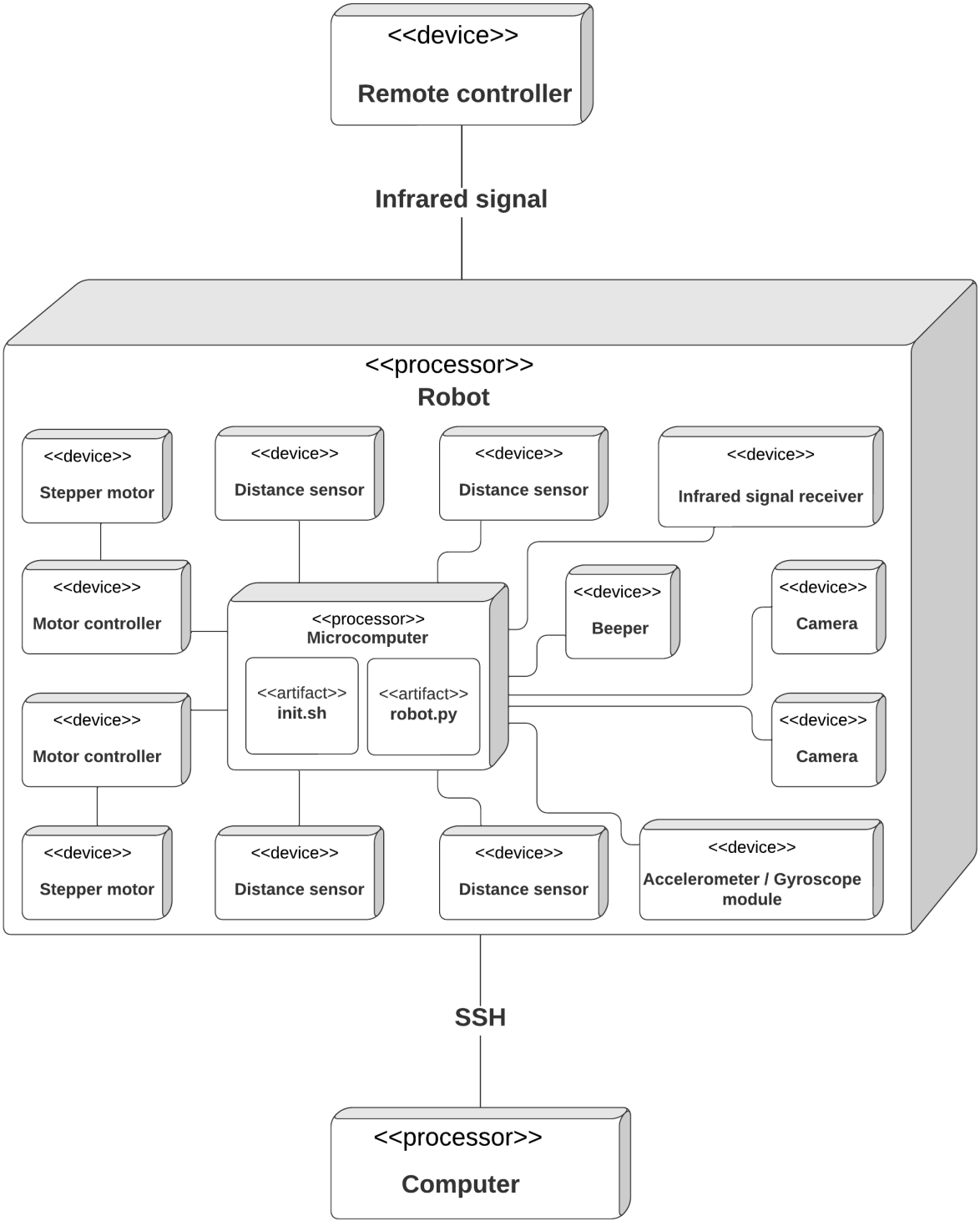

Figure 3. Deployment diagram

2 Deliverable internals

2.1 Structural aspects

The main components of the robot are the Raspberry Pi, cameras and sensors, motors, infrared signal sensor and the beeper. The cameras and sensors will be used to detect the robot's surroundings, the motors will be used to move the robot. The infrared signal sensor will be used to read the signals from the remote. The beeper will be used to warn the user of errors and events, and the Raspberry Pi will be used to execute the required code.

The Raspberry Pi will run on Linux OS, and BASH will be used to run any required scripts on startup. The code for the robot will be written using python, OpenCV libraries will be used for computer vision.

2.2 Dynamic aspects

In order to accomplish the desired functionality, the robot's components will send data to the Raspberry Pi. The card sensor, when activated, will add a task to the robot's task queue. The stepper motors will make it possible for the robot to keep track of its location in the room, as well as move a specified distance.

Basic robot control: Remote controller will send an infrared signal to the infrared signal receiver. This will be the main way that user is going to interact with robot. The user will be able to send signals to start different tasks like roaming freely, finding a human, returning to starting position, stopping, using beeper, and similar tasks. Tasks received by remote controller can be added to the task list and will be executed sequentially.

The internal logic of USB cameras: Creating the "camera" class as an extension of the thread class to be able to keep cameras working together at the same time. Create a separate thread that will compare the view of the different cameras and calculate the disparity between different areas of the picture. Then, take the output of the disparity calculation, analyze if the path ahead is clear, and use it to update the 2D array representing the known map of the surrounding area. Then, calculate the next move the robot should make to get to the goal.

The known map will hold all data about the surrounding area: Each element in the array will represent the state associated with a particular area. The element will be an object with various state flags and additional information. It can hold states like: unknown, current rover position, obstacle, human, destination, starting position, and any additional useful info that could impact the decision-making of the rover. These elements will be held in 2D dynamic size array and new elements will be added if needed to represent new location.

Path finding: The path will be calculated using lightning algorithm, to find the shortest viable path. If such path does not exist the bot will analyze if path is still possible, possibly through unexplored area, and test it.

Threading: There will be 4 threads: 2 for camera input, 1 waiting for signals from infrared signal receiver, 1 main thread to analyze information provided by other treads, calculate appropriate response and execute it.

3 Testing

The robot will be tested using two methods:

3.1 Manually in an indoor environment

This is a reliable way to test the functionality of the code, especially when testing features that cannot be tested using a simulation, such as computer vision. Manual testing will be our preferred method.

3.2 Using simulation software "Webots"

This makes testing more accessible by sharing the code in a simulated environment. With these simulations we will test small features like movement or path finding.

4 Technologies and Tools

The following technologies will be used to build and test the robot, as well as maintain the required code.

4.1 Software used on Raspberry Pi

- Linux OS - operating system.
- Python - programming language.
- BASH - scripting language.
- OpenCV - computer vision libraries.

4.2 Software used for development

- Git and GitLab - version control.
- Webots - robot simulation environment.
- VSCode - development environment.

4.3 Software and hardware used to design and produce robot parts

- AutoCAD - 3D modeling.
- 3D printer - manufacturing of robot body parts.