UNIVERSITÄT DUISBURG-ESSEN
FAKULTÄT FÜR WIRTSCHAFTSWISSENSCHAFTEN
INSTITUT FÜR INFORMATIK UND WIRTSCHAFTSINFORMATIK
LEHRSTUHL FÜR PERVASIVE COMPUTING

Masterarbeit

ORIGNIAL FORMAT for the title of the work

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Zeitraum: 1.Januar 2010 - 1.Juni 2010

Inhaltsverzeichnis

Abstract

The function of the abstract is to summarize, in one or two paragraphs, the major aspects of the entire bachelor or master thesis. It is usually written after writing most of the chapters.

It should include the following:

- Definition of the problem (the question(s) that you want to answer) and its purpose (Introduction).
- Methods used and experiments designed to solve it. Try to describe it basically, without covering too many details.
- Quantitative results or conclusions. Talk about the final results in a general way and how they can solve the problem (how they answer the question(s)).

Even if the Title can be a reference of the work's meaning, the Abstract should help the reader to understand in a quick view, the full meaning of the work. The abstract length should be around 300 words.

Abstracts are protected under copyright law just as any other form of written speech is protected. However, publishers of scientific articles invariably make abstracts publicly available, even when the article itself is protected by a toll barrier. For example, articles in the biomedical literature are available publicly from MEDLINE which is accessible through PubMed. It is a common misconception that the abstracts in MEDLINE provide sufficient information for medical practitioners, students, scholars and patients[citation needed]. The abstract can convey the main results and conclusions of a scientific article but the full text article must be consulted for details of the methodology, the full experimental results, and a critical discussion of the interpretations and conclusions. Consulting the abstract alone is inadequate for scholarship and may lead to inappropriate medical decisions[2].

An abstract[IGM97, Lev65, MAdR02, Sal89] allows one to sift through copious amounts of papers for ones in which the researcher can have more confidence that they will be relevant to his research. Once papers are chosen based on the abstract, they must be read carefully to be evaluated for relevance. It is commonly surmised that one must not base reference citations on the abstract alone, but the entire merits of a paper.

Kapitel 1

Introduction

[You should answer the question: What is the problem?]

This paragraph should establish the context of the reported work. To do that, authors discuss over related literature (with citations[1]) and summarize the knowledge of the author in the investigated problem.

ToDo: how to make citations

An introduction should answer (most of) the following questions:

- What is the problem that I want to solve?
- Why is it a relevant question?
- What is known before the study?
- How can the study improve the current solutions?

To write it, use if possible active voice:

- We are going to watch a film tonight (Active voice).
- A film is going to be watched by us tonight (Passive voice).

The use of the first person is accepted.

1.1 Motivation

A good introduction usually starts presenting a general view of the topic and continues focusing on the problem studied. Begin it clarifying the subject area of interest and establishing the context (remember to support it with related bibliography).

[1]To cite a work in latex

1.2 Problem definition

Additionally, focuses the text on the relevant points of your investigation and problems that you want to solve, relating them with the first part.

1.3 Thesis/Diplom/Bachelor/Master Structure

Present your work to the reader giving a brief overview of what is going to cover every chapter. Write only general concepts, no more than one or two sentences per chapter should be necessary.

Kapitel 2

Materials and Methods

This section is to clarify the pre-existing tools, defining what was developed in this field until now, and why this tool was used instead of others.

The general structure is the following:

- Definition of the specific tool(s) studied (robots, sensor nodes, smart-phones). When relevant, pre-existing experiments.
- Definition of the context of use (indoor/outdoor, humans/animals/robots, with/without connection).
- Definition of used protocols (How the data are collected, when, etc.)

Kapitel 3

Approach

In our system there are a multiple robots that must handle various tasks. For example, visiting given rooms. To tackele this problem, a communication efficient task scheduling system is designed. This system allicate task according to system resources, including enviroment factors and robot available battery. Once these information is attained, the task scheduling system assign robot a set of task.

- *Robot.* The robot is responssible for executing tasks as well as listen to sensors on its way. It has a rechargeable battery. Robot battery level drops as its moves and rotates.

- *Tasks.* The tasks include two part. The first part is moving to a given position and the second part is either finding a person or recharge itself.

- *Enviroment.* The enviroment is an office area that contains a corridor along the central x axis and 16 rooms located around the corridor. The enviroment model is shown in Figure 3.1. The enviroment factors, such as room location and occupancy possibility help task allocation.

3.1 Architecture Design

As shown is Figure 3.2, the architecture of the system consist of several parts: centralized pool, robot controller, navigation stack, charging station and system enviroment.

- *Centralized Pool.* A centralized pool consist of serveral modules: multi-robot task allocation module, system enviroment state, database, execution and mornitoring. The database contains the room information such as occupancy possible and the tasks. The multirobot task allocation module assign task to robots according to both robot status and system enviroment.

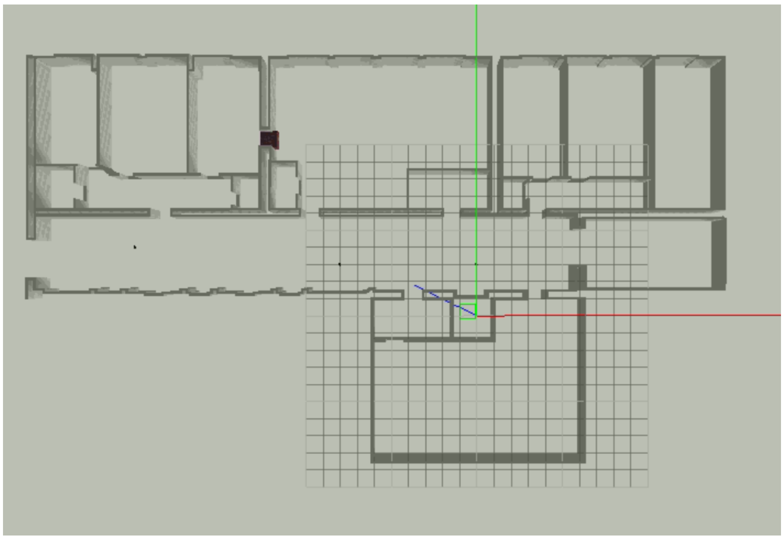


Abbildung 3.1: Gazebo Model

- *Robot Controller.* A robot controller contains serveral modules: execute module and robot action. The execute module receive commands from centralized pool and decide when and which task the robot should perform. During performing a task,a robot can send enviroment information to centralized pool.

- *Navigation stack.* The move_base node provides a ROS interface for configuring, running, and interacting with the navigation stack on a robot. It make robot move to desired positions using the navigation stack. Its advantages includes optionally performing recovery behaviors when the robot perceives itself as stuck.

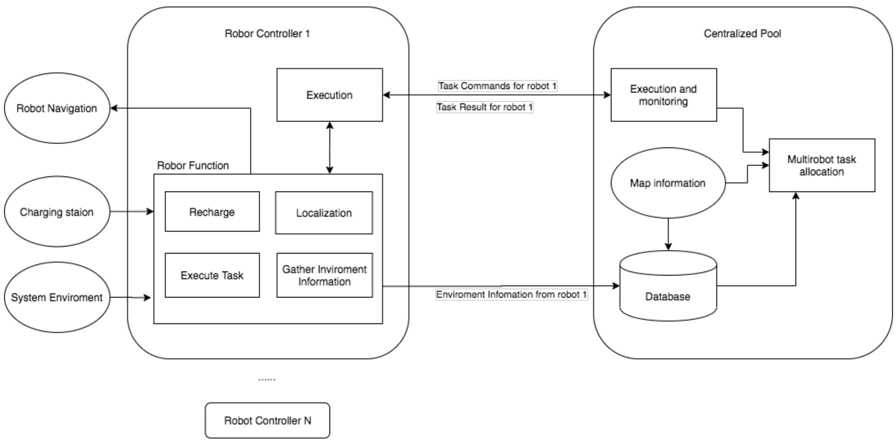


Abbildung 3.2: System architecture

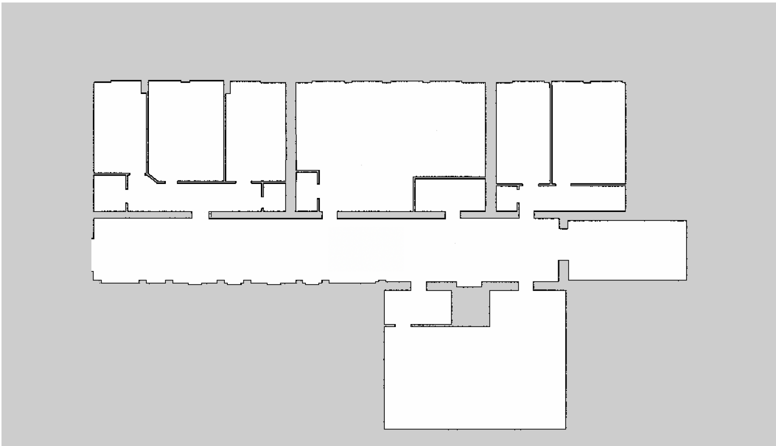


Abbildung 3.3: Enviroment occupancy grid

3.2 System Environment

The system enviroment is an office area. A 3D Gazebo module shown in 3.1, and an occupancy grid is shown in 3.3. The write area is unoccupied, which is the corridor and rooms. The black line is occuppied area, which is the wall. anything else is gray. Following are important objects in system enviroment that interact with robot.

- *Room.* As is shown in Fgure 3.4, the restrict area(the write area in Figure 3.4) is divided into rectangles. The rectangle is used to let the system clearly distinguish which room robot is in.

- *Door.* In 3D Model there are no original doors. However in order to simulate an enviroment, a few simulated sensors are created. Those coordinate of sensors are the same as corresponding doors positions (D1-D17 in Figure 3.5). Additionally one simulated door sensor is created on the door position. Each simulated door sensors brocasts door status periodically. The broadcast message are received by all robot within its range, including both robots enter the room and robots in corridor passing by the door. Figure 3.5 shows the distribution of doors.

- Charging Station. The battery decrease is also considered. Three simulated charging stations are located in the corridor. Figure 3.5 shows the distribution of charging stations. When robot get a charging task, it would move to one of the charging station and wait until fully charged. The details of robot charging is shown in Section .

ToDo: Robot charging

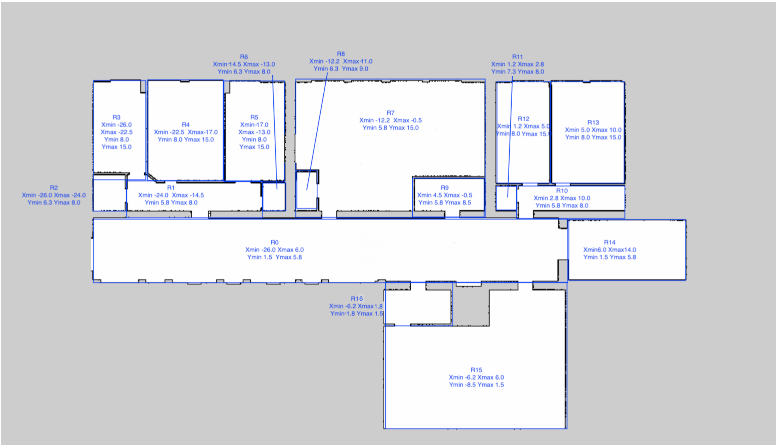


Abbildung 3.4: Room division

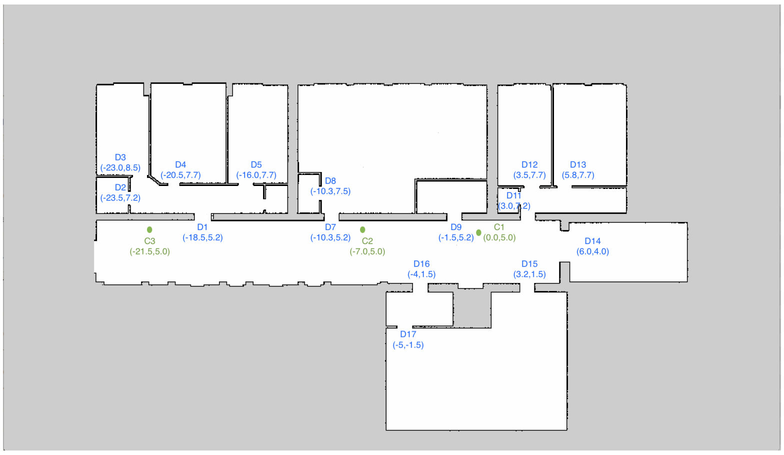


Abbildung 3.5: Doors and Charging Stations

3.3 Task allocation

3.3.1 Task explanation

In order to improving overall execution efficiency. One single robot can carry either small task, which make robot move to one position, or large task, which consist of multiple small task. On one hand, to make robot work long hours in office enviroment, recharging is necessary. On the other hand, a robot should gather enviroment information as much as possible, which centralized pool would learn from and make better decision. Therefore, three types of task are defined, which are shown in Table 3.6.

Type Name	Target	Task size	Dependency	Priority	Generator	Handle faile
GatherEnviromentInfo	Door	Small task only	No	1	Centralized pool node	Put task into tabl
Execute task	Any point	Small task or large task	Dependent on execute task (alternative)	2,3,4	SQL database Task generator node	Put task into tab
Charging	Charging station	Small task only	No	5	Centralized pool node SQL database	Put task into ta

Abbildung 3.6: Comparision of task types

- *Task size.* One single robot is able to carry out one charging task or gather inviroment information task, but can carry multiple execute task, thereby These tasks with dependencies also referred to as small task. Those small tasks form a dependency chain, also referred to as a large task.
- *Priority.*

3.3.2 Task factor

3.3.3 Enviroment factors

- textslRoom occupancy.

3.3.4 Robot factors

The decrease amount of robot battery is related to robot trajectory. If a robot get a Large execute task that contains n small task, Equation 3.1 can be used to calculate battery consumption.

$$
\begin{aligned}
& B : Battery\_Consumption \\
& W : Weight \\
B_{large\_task} &= \sum_{task_0}^{task_n} B_{trajectory} \\
&= \sum_{task_0}^{task_N} \sum_{point_0}^{pont_M} [W_{position} \times position\_variation + W_{angle} \times angle\_variation] \\
&= \sum_{t=task_0}^{task_N} \sum_{p=point_0}^{point_M} [W_{position} \times \sqrt{(x_p - x_{p-1})^2 + (y_p - y_{p-1})^2} \\
&+ W_{angle} \times 2 \times \arccos(w_p)]
\end{aligned}
\tag{3.1}
$$

3.3.5 Cost function

A. Cost function for Execute task that contains n small tasks is shown in Equation 3.2.

$$
\begin{aligned}
Cost_{Large\_execute\_task} = & \frac{W_{battery} \times Battery\_consum}{n} + W_{waiting} \times Waiting\_time \\
& + W_{possibility} \times \prod_{i=1}^{n} Open\_possibility + W_{priority} \times priority
\end{aligned}
\tag{3.2}
$$

The robot

3.4 Procedure

The process of

Kapitel 4

Implementation

Explain what you did to implement your solution, problems that occurred and how you fixed them. If they are interesting, include some relevant parts of the implementation (most relevant pieces of code and so on).

4.1 Program Structure

each robot autonomously request task from the centralized pool and centralized pool response with a set of suitable tasks.

4.1.1 Robot Components

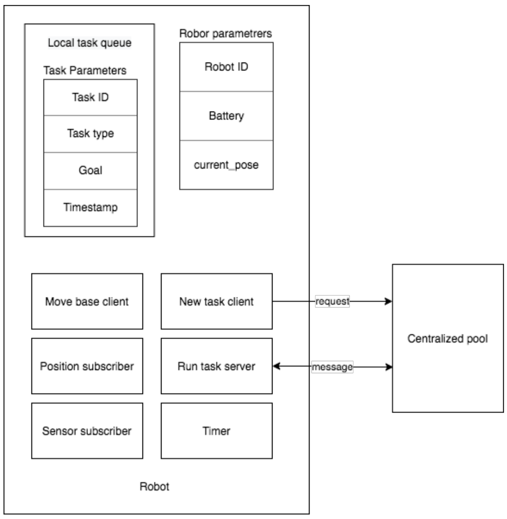


Abbildung 4.1: Robot Components

- *Robot ID.* Robot ID is a unique identification for each robot.
- *Battery level.* Battery level drops as the robot moves and rotates.
- *Task type.* Robots perform different tasks such as "Charging", Ëxecute Task", "Gather Enviroment Information". For details please refer to Section **??**
- *Local task queue.* Local task queue keeps a list of tasks that a robot will run sequentially. Once a task is finished, it would be removed from task queue. Once this queue become empty, the robot send task result to centralized pool.
- *New task client.* Once all task are finished, the new task client send request to new task server.
- *Run task server.* The run task server receive tasks and send task feedback and task result.
- *Timer.* To prevent robot to be hanged by one task forever, the timer check the robot moving state periodically.
- *Move base client.* The move_base node provides a ROS interface for configuring, running, and interacting with the navigation stack on a robot. The move_base client send a goal to move_base node to tracking their status
- *Position subscriber.* The position subscriber get robot current position from navigation stack. The robot send its current location to centralized pool to request a new task.
- *Sensor subscriber.* The Sensor subscriber listen to sensor data within the range.

4.1.2 Centralized Pool Components

- *Map Information.* Map information contains information such as the door list that the robot will pass through when moving to target position.
- *Cost calculator.* Cost calculator calculate the cost for doors, rooms and charging stations.
- *Task manager.* Task manager can construct, sort and allocate tasks.

4.2 Communication Protocols

Since centralized pool and robots need to share task information with each other, the communication protocals are required. Four types of message are defined: (1) task request message; (2) task goal messages; (3) task feedback; (4) task result. The comparation of task type and examples of each type are shown in Figure 4.3.

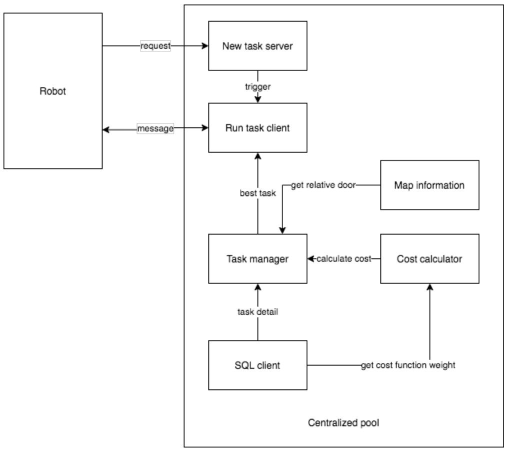
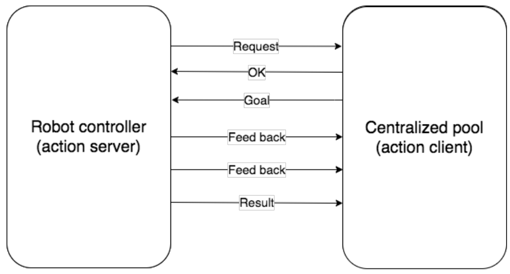


Abbildung 4.2: Centralized Pool Components



1. Request Message

Structure

Battery	Pose	Robot id

Example

93	(2,4)	1

2. Goal Message

Structure

Task id[]	Task type	Target id	Goal[]

Example

1	Gather Enviroment Info	9	(-1.5,5.2) 2020-06-01 9:00:00
[3,4]	Execute task	21, 22	(-24.0,12.0), 2020-06-01 9:02:00 (-21.0,12.0) 2020-06-01 9:02:00
5	Charging	17	(0.0,5.0), 2020-06-01 9:04:00

3. Feedback Message

Structure

Robor id	Door id	Measurement time	Measurement result

Example

1	3	2020-06-01 9:00:03	Door open

3. Result Message

Structure

Task id	Task type	Result

Example

1	Gather Enviroment Info	Success

Abbildung 4.3: Communication Protocols

Kapitel 5

Evaluation

In this chapter you should describe the previous (if possible) and final experiments performed on the implementation.

Every single experiment should be explained individually, providing to the reader information about the meaning of the experiment, the expected (theoretical) results, the final results, the comparison between them and others (if possible) and the conclusions.

Each experiment should include a description, covering (when possible) the following information:

- Significant physical features (obstacles present on the environment, human presence, temperature, humidity, possible noise sources, computational speed of the machine, etc.)
- The precise location of the experiment (latitude and longitude, room number or citation to a description of the used laboratory).
- Sampling design (variable(s) measured, transformation performed to the data, samples collected, replication, comparative with a Ground Truth system, collecting data protocol).
- Analysis design (how the data are processed, statistical procedures used, statistical level to determine significance).

The provided information should be sufficient to allow other scientists to repeat your experiment in the same conditions. Thus, the use of standard and well-known equipment could only be represented by a simple sentence, but the non-standard equipment should be described in detail, citing the source (vendor) and most important characteristics.

To write it, try to use the third person when describing the experiments and results. Avoid to use first person. Past tense should be the dominant conjugation (the work is done and was performed in the past).

Note: Graphics represent really well data, use them! (Matlab or Octave could be useful for that).

Kapitel 6

Discussion

The meaning of this paragraph is to interpret the results of the performed work. It will always connect the introduction, the postulated hypothesis and the results of the thesis/bachelor/master.

It should answer the following questions:

- Could your results answer your initial questions?
- Did your results agree with your initial hypothesis?
- Did you close your problem, or there are still things to be solved? If yes, what will you do to solve them?

Kapitel 7

Acknowledgements

(This part is optional, and it could be completely excluded by deleting
\include {content/chapters/chapter7}
from the Firstname_Lastname_Diplom_Master_arbeit.tex file)

This paragraph could mention people or institutions that supported you to some extent with your work or friends and relatives that supported you during your study period.

Literaturverzeichnis

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German

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English

I hereby declare that I have written this Bachelor (Master) thesis - except for the guidance of the supervisor - independently, using no other than the specified sources and resources, and that all quotations have been indicated. I declare that I have reported to the best of my knowledge all the relevant information, that it is true and that I concealed nothing. I am aware that a false declaration will be punished according to §156 and §163 par. 1 of the criminal code with a prison sentence or a monetary penalty.

Essen, 20. September 2020
(Ort, Datum)

First Name Second Name