INTERNSHIP REPORT

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1.1 Introduction

This internship report is based on my experience as an intern in Fraunhofer Institute for Manufacturing Engineering and Automation for 4 months starting at 1st February 2019 and ends in 31st May 2019. This internship program is part of my joint degree program in Technische Universität Ilmenau.I worked in the Household and Assistive robots section where the main focus is in the development of service robots for everyday tasks in order to help and assisting elderly or disabled people. My main task is to improve an existing service robots (MobiKa Robot) software in terms of functionality and features. The robot is based on ROS (Robot Operating System) framework and programming language that is used is C++ and Python Programming Language. MobiKa Robot, the robot that i have been working on in Fraunhofer IPA is shown in Figure 1.2

Figure 1.2: MobiKa Robot [4]

1.2 Job Description

The main purpose of the existing service robot that I worked on is to help people, especially elderly people. So there are a lot of components and part of the robot that can be improved and automated or even added a new components to enhance the robot,for instance one of my task is to detect a charging station and dock the robot properly in the station. This feature is used to enhance and automate the robot, as most of electric devices needs electric charge to keep them running. This feature is one of the example of improvement that can be done to the robot. All the task that i have done in this internship :

- Marker detection : The purpose of this task is to detect a specific type of a marker and publish its TF in 2d space. This marker is used to determine the exact position and orientation of a charging station to charge the robot.

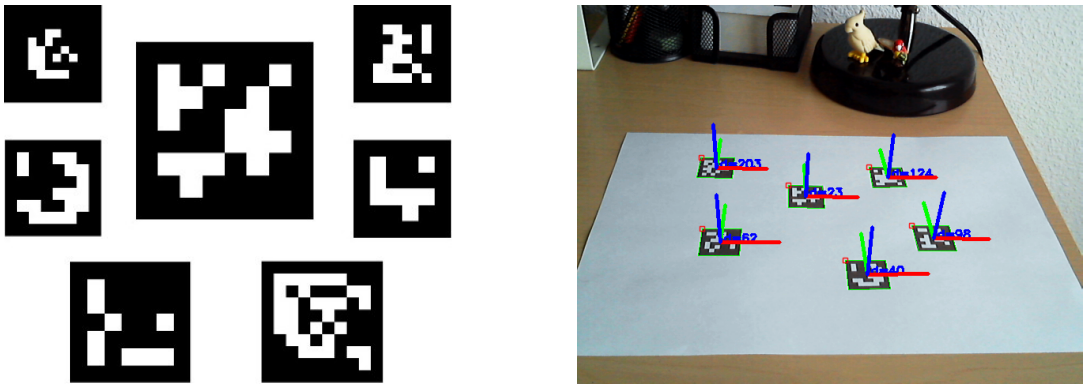


Figure 1.3: (a) Aruco Marker (b) Marker detection [2]

- Charging station docking: This task is the continuation of the marker detection. After the marker is detected the robot should be able to docked to the charging station.

- Camera Pose Initialization and Detection : This task is based on Hough Circle detection with OpenCV library. This library also available to be downloaded in the internet and also comes for the ROS platform. The main idea is to detect one of object in the robot (the lidar) which is in circular shape, and as the position of the lidar is fixed and will not changed, it is used to determine the pose of the camera, then we can rotate camera to a desired initialization angle.

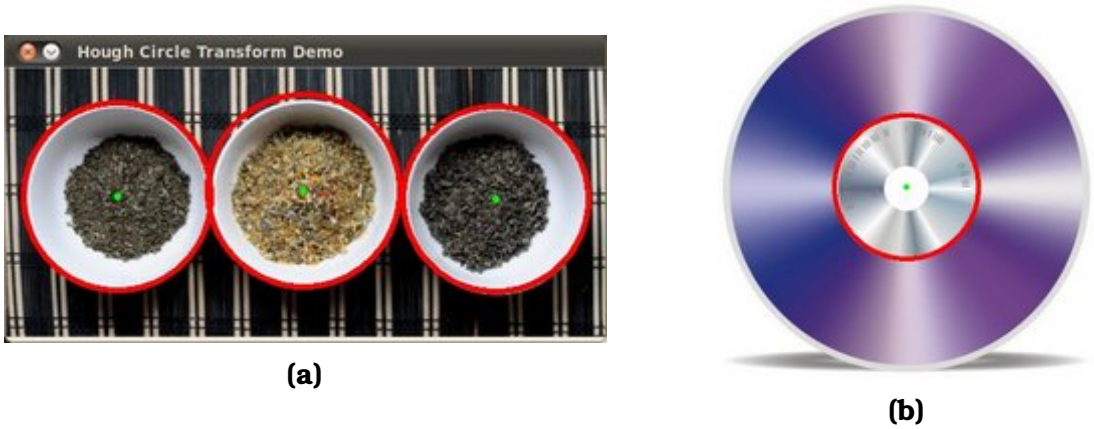


Figure 1.4: Hough circle detection [3]

- Tablet Height Control : The main idea of the tablet height control is the tablet needs to be in several different height (i.e person while sitting, standing is in different height) for people to interact with the tablet. So with many different situation, the tablet needs to be controlled and can be set into a specific height.

- Bag file analysis and visualization : This task is mainly about analyzing an existing bag file which is recorded from a simulation of the robot approaching human and from that bag file, the performance of the robot

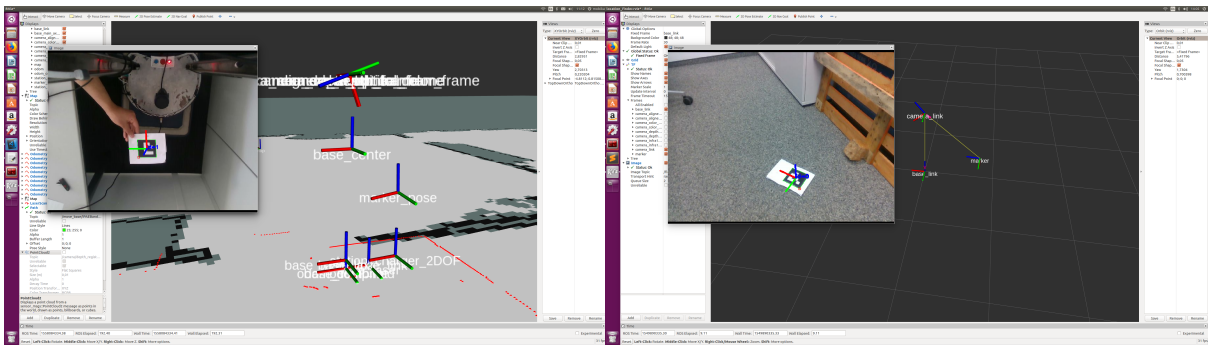
is analyzed and processed in form of csv file and then visualized in form of a graph. A bag file is a format of file which can store data in ROS [5], so all the topics , TF , nodes that is running when the experiment is done, can be stored and analyzed later on separately.

- Speech Recognition : With speech recognition, the robot is expected to be able to interact with people as it is the one of the main purpose of the robot. It can be used as a conversation partner or to asked the robot to do something.

1.3 Project Report

In this section, the detailed description about the problem occured and the solution that performed is explained.

- Marker detection : This is the first task that I worked on in Fraunhofer IPA. The marker is detected using the standard aruco marker package which also provided for ROS platform that can be downloaded from the internet. But the problem is the standard marker detection is in 6-DOF space and the desired requirements is in 2-DOF space. In this case simple python script is made which listen to the TF from the base of the robot (in this case called base link) and the pose of the marker in the 6-DOF space. With this method, a pose in 2D space is obtained and then we can publish the TF.



(a) **(b)**

Figure 1.5: (a) 2DOF marker transformation (b) Marker detection result

- Charging station docking: In this task I was studying another colleague code and try to modified is so it can worked with the code that I have been developed (Marker Detection). In this task is I used the Husky Simulator as first step before use the actual robot because this is include the robot to move around. The result worked quite well with the simulator and worked as expected. But when tested with the real robot, there are couple of problem that come up. First, because the marker detection is in a different computer with the robot, there are some time synchronization problem. Then I tried to compile most of the code in the same computer so the problem can be minimized. Then there is also problem for detecting the marker, while lightning condition also influence the result, so sometimes the marker is not detected. Another problem is the docking code produce a very slow speed in order to get a very precise result, but the robot is not capable to move in such slow speed, so the result is not as precised as what the code is intended to produce.

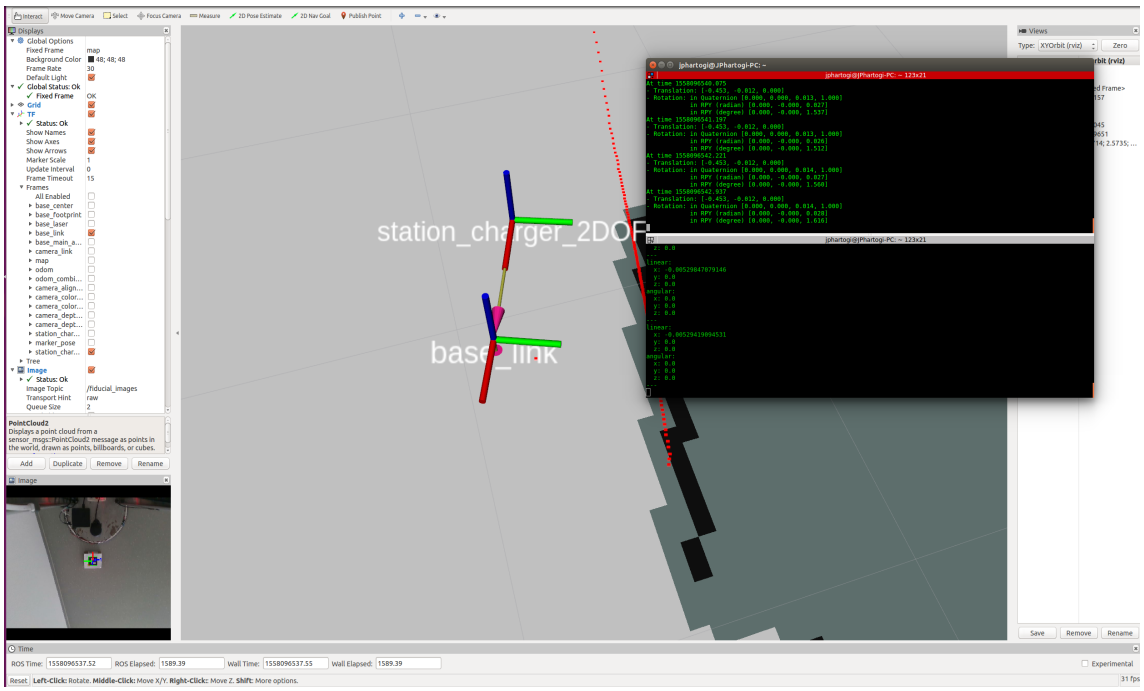


Figure 1.6: Result of the docking process

- Camera Pose Initialization and Detection : The main goal for this task is to initialize camera angle to a desired angle. This specific camera angle is used as a parameter for the charging mode camera pose and an accurate camera pose is required to determine the location of the charging station which will be detected by marker detection phase. Hough Circle Transform which explain in [1], is used for detecting the circle shape features in the robot which is the Lidar.By placing some reference with pythagoras theorem (using the distance from the base to the camera as an y and base to the lidar as an x) we can place an reference angle for the camera and then we can determine the pose of the camera.

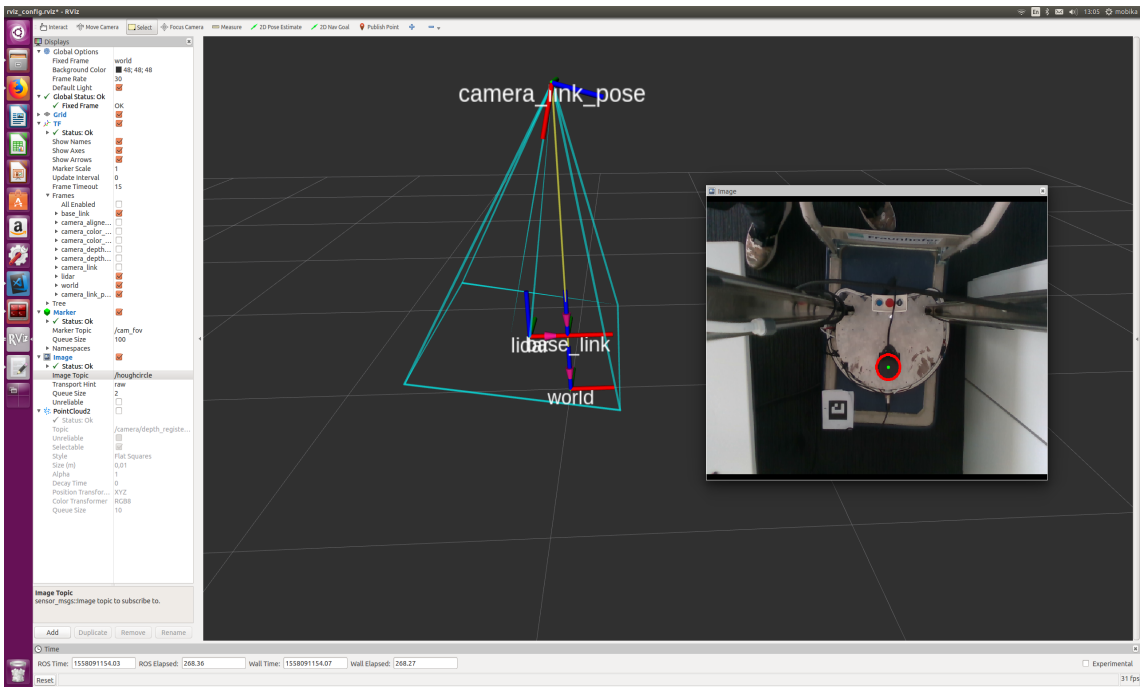


Figure 1.7: Circle detection

Problems that occured during the circle detection is determine the best parameter for detecting the circle. According to [3], parameter that is need to be determine is

cv::HoughCircles(a, b, c, d, e, f, g, h, i);

- b = Vector type values which publishing x , y and the radius of the circle
- c = Define the detection method.
- d = The inverse ratio of resolution
- e = Minimum distance between detected centers
- f = Upper threshold for the internal Canny edge detector

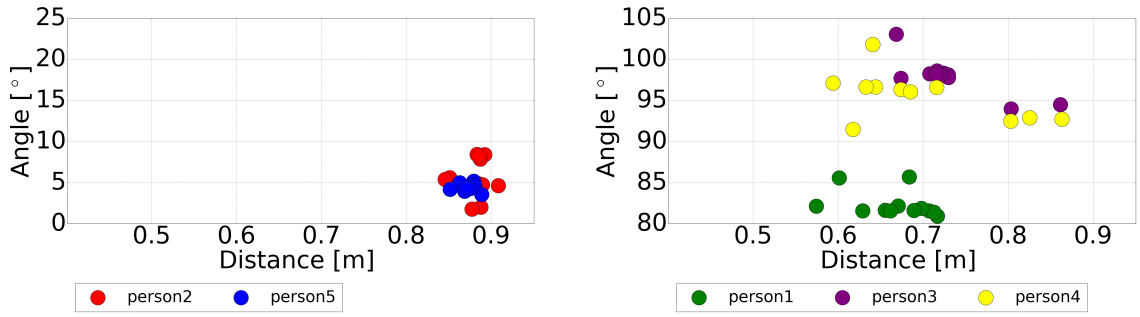
- g = Threshold for center detection
- h = Minimum radius to be detected
- i = Maximum radius to be detected

The circle should easily detected because of the Lidar sensor which is the ciruclar part that needs to be detected is colored black and the base part (cover of the robot) is colored white which in RGB scale is very different ((255,255,255) vs (0,0,0) in RGB).But then the problem persist while the circle is detected is not as smooth as wanted, although tweaking the threshold in the code and using constrain the minimum radius and maximum radius increase the performance of the detection, but then I used also some limitation of the circle detection , in this case I created an Region Of Interest for the camera to detect, while the camera can only move in 1 axis and with that limitation the detection is much smoother.

- Tablet Height Control : The tablet height control was using an encoder from the motor to get the distance traveled by the motor and a limit switch as the indicator if the robot has reached its lowest position. The limit switch then used as the initialization point for the tablet as the 0 cm, then the distance traveled is calculated by the encoder.I also create a acceleration and deceleration mode so the robot motor is not suddenly start at a constant speed and end suddenly with 0 speed, instead it gradually increase its speed and also gradually decrease its speed until 0. There are also 2 mode, which is the automatic mode and manual mode.

Automatic mode is where we can just put some height (in cm) then the tablet will go to that desired height. In manual mode, we can use joystick to move the tablet up or down. The problem with this task is mainly because the hardware error that caused the code to crash. But in the end, i switched the USB cable that connect the encoder to the controller with USB cable with USB isolation adapter and it worked normally. And i got the conclusion that the noise from the motor is causing the error. There is also problem where the initialization part is not working as expected. This problem is not happened often, and could be caused by controller error when the tablet hit the limit switch.

- Bag file analysis and visualization : This task is using the library of matplotlib to visualize the data and python programming language to process the data and also import the data as a csv file. The data is extracted from the existing bag file, which recorded from the robot. The problem occured in this task is mainly because of the graph aesthetic in terms of size of the font, size of the point in the graph and scaling. With some trial and error method, the problem can be solved. Moreover, there also problem occured because the data can not be process directly as a raw data, as it needs to be adjust in some ways manually so it can be processed. For example, the angle data in the rosbag file is between person - reference and object - reference, so there is no direct angle data between the person and the object. In this case, the data needs to be processed further to get the wanted result.



(a) **(b)**

Figure 1.8: (a) Rosbag Data 1 (b) Rosbag Data 2

- Speech Recognition : With speech recognition, the robot is expected to be able to interact with people as it is the one of the main purpose of the robot. It can be used as a conversation partner or to asked the robot to do something. In this project, speech recognition library from google and sphinx is used. Speech recognition from google is online based version and the sphinx is the offline version. And the microphone that i used is the Respeaker microphone array, that also can detect the source location of the sound. The result of implementation speech recognition in offline version is not great, sometimes it can recognize speech correctly, but most of the times it does not. But then by using the speech recognition from google, the recognition is so much better compare to the offline version. The task using the speech recognition that I have done is to create some decision (yes or no) question for human to interact. And it also then improved, not only yes or no question but finding key words, for example ("come", "closer", "here") so when a person speak one of those words, the robot will listen and detect where the source location of the sound come and move towards the sound. The key words are still coded manually so

it has some limitation.

1.4 Technical Skills, General Knowledge and Professional Skills Developed

In Fraunhofer IPA, I have several type of task and challenge to be solved, from all of this task and challenge I have found new skills and developed the existing skills in me. First of all, I am now more adapt to a research type of task which there is no exact answer to the problem which need to be solved. So in this case I was "forced" and "trained" to be able to try and developed a new ideas or the best approached to solve the problem. And in this matter I also learn to be active in generating new ideas instead of asking an answer from my supervisor which I was doing when I was in the early week of my internship. I also have the opportunity to work with some of my colleagues and get a feedback or input from a different point of view to solve my problem.

For the technical skills, the first time I come to the Fraunhofer IPA, I was quite blind about ROS as general and also C++ and python because I have used them for some occasions in my university's project but most of the are a simple C++ code or python code that only used for simple task such as turn on an LED or read a digital data from a sensor. But in this internship, most of the task is not as simple as my previous task in university project. Especially in ROS part, because at my university, I was only using ROS to turn on the motor with a simple python script and I did not implement a strong basic understanding

about ROS, what ROS can do and all of the basic function (I.e subscribing, publishing, create a package, etc). And from this internship I have grown so much in terms of ROS and its function, but also the implementation in python and C++ on what on these two programming language can do. Moreover, even though ROS has already a lot of package available in the internet or I received some package from another colleague, unfortunately in most of cases, the code can not be implemented directly. Because there will be some adjustment and modification to the specification required. Because of this reason, I need and must understand the code and where I can modified to fulfill my needs, and from this method of learning, I learned from many types of code on how people write their program.

For the non-technical skills, in Fraunhofer IPA, I have met a lot of students and supervisors which comes from a different country and different culture. I can get to know a lot of new cultures that is hard to accepted at the beginning but as time goes by, I learn a lot from those diversity. I can then filter which is good and which is not suitable for me in order to develop a better me as a person in non-technical aspects.

1.5 Values

Through this internship, I learned a lot of precious values that improve myself as a better person as an engineer but also in general.

- Creativity : From this internship, I learned that in the real work life, there is no exact answer to a problem, instead there is a lot of approaches to solve a problem. As before I am doing this internship, when there is a problem, most of the time I will ask someone and follow his/her solution. But from this internship I also realize that someone's answer probably not the best approach or the most suitable solution to a specific problem, and in this case I need to use my creativity and think outside the box to generate the best approach to solve a problem. Although it is also good when we have a feedback or ideas from another colleague and take it into consideration to get the best approach to a specific goal.

- Initiative : In my previous experience and what I have been doing up until before the internship, I was lacking in initiative. I always wait for a task or a request and not thinking what is possible and come up with another ideas. And from this experience, I can not rely from another person to tell me what to do, and trying more active to generate new ideas in order to reach the specified goal.

- Persistence : In the world of engineering, we will always encounter problem or difficulties in our way. Sometimes the task seems something that we can not do with our own capabilities. In this internship, I also come up with such problems that is hard to solve. But as an engineer, running from a problem is not an option and based on this situation, I learned about persistence and not easily give up on a problem, rather try and researched on how to solve that problem.

1.6 Conclusion

Overall, I would describe my internship as a positive and instructive experience. The first week was not so effective and i need to adapt to many things in Fraunhofer. But then i became more adapt and finally feel comfortable and used to the environment at Fraunhofer IPA. I receive a lot of values and experience in technical and also non-technical terms that I can bring further in my career. I can also work closely with another colleagues which is a student, and know how they work and exchange ideas with them. Moreover i also learned from the expert in many fields here in Fraunhofer, where there are a lot of supervisor that have an extraordinary knowledge about what they are good about. In the end, i feel very lucky to have a chance to work in another country, to see and involved directly how engineer work done here in one of the country which is famous for their engineering capability.

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[4] *MobiKa - Low-Cost Mobile Robot for Human-Robot Interaction*. URL: https://www.groundai.com/project/mobika-low-cost-mobile-robot-for-human-robot-interaction/1.

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