Experiment Introduction

MSc Thesis: A knowledge graph-based interactive assistant to interpret robotics scenario information in a retail setting

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1 Pre-knowledge

ROS

Robot Operating System, better known as ROS [1], is a fully open-source operating system for robots. It is more of a meta operating system that helps to abstract the hardware from the software. Its main idea is to avoid continuously reinventing the wheel and provide standardized functionalities, so we save time on hardware abstraction from scratch because someone else has already done it. It provides an easy entry for hobbyists and non-professionals into the field of robot programming. As a middleware, it provides a way to connect a network of processes, including hardware abstraction, low-level device control, inter-process communication and package management, with a central or master hub, as shown in Figure 1.

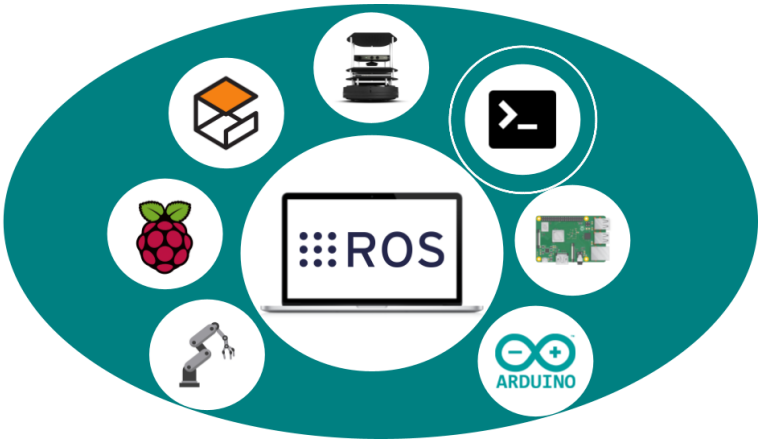

Figure 1: ROS support structure[2]

ROS has many useful tools, such as Gazebo [3] and Rviz [4], that let us mimic how the system will work in the real world. Gazebo allows us to create a simulation environment and generate experimental data during operation, while Rviz subscribes to these data and completes visual rendering, making it more intuitive. For example, Figure 3 shows that the TIAGo robot is moving to *Shelf_ 1* in the stimulated retail environment of Gazebo and Rviz. At the same time, execution information developers code about the action is printed to the Linux terminal (circled in white in Figure 1). Through the continuous terminal output shown in Figure 2, we could obtain detailed information on specific components when the stimulation is running. However, it is complex and sometimes challenging to comprehend messy information in real-time, requiring us to reaccess it after stimulation. Therefore, it comes to the motivation for this project, which will be mentioned later.

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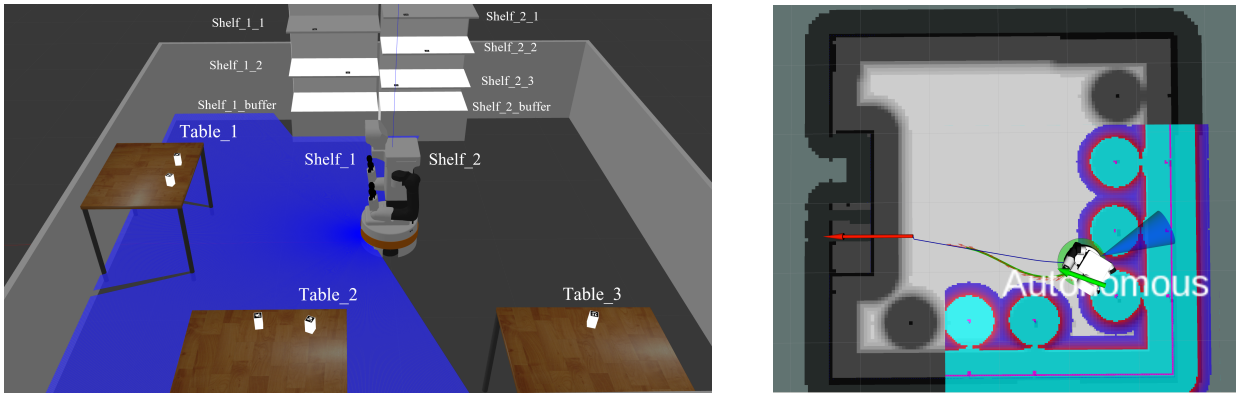
[/move_shelf_server] [INFO] [1623003124.635800, 873.907000]: The move_shelf_server is activated.
[/move_shelf_server] [INFO] [1623003124.644976, 873.910000]: Waiting for server...
[/move_shelf_server] [INFO] [1623003124.648442, 873.912000]: TIAGo moves to : left_shelf
[/move_shelf_server] [INFO] [1623003124.659980, 873.915000]: Sending move base goal...
[/move_shelf_server] [INFO] [1623003140.976547, 881.123000]: Navigation finished
```

Figure 2: Terminal output for the task: TIAGO moves to Shelf_1

[1] ROS Homepage
[2] Source: Open Cloudware Post
[3] Gazebo Homepage
[4] Rviz Wiki



(a) TIAGO running in Gazebo

(b) TIAGO running in Rviz

Figure 3: ROS & AIRLab

Knowledge Graph

A knowledge graph is a graph-based data structure consisting of nodes and edges, which represent certain relationships between entities in the real world. Knowledge graphs can effectively organize and represent knowledge so that it can be efficiently utilized in advanced applications. It has been performed on many different applications: smart question and answer, recommender systems, big data analytics and to name a few. Especially, it was implemented to increase the functionality of search engines by providing fully structured search results that reflected the interconnections of relevant information.

For example in Figure 4, four classes are displayed: {*Book, Author, Publisher, Location*} as well as six relationships: {*hasAuthor, hasPublisher, publishedInYear, isFollowedBy, worksWith, locatedIn*}. The red box marked part represents the information: *Book: To Kill a Mockingbird - has author → Author: Harper Lee.*

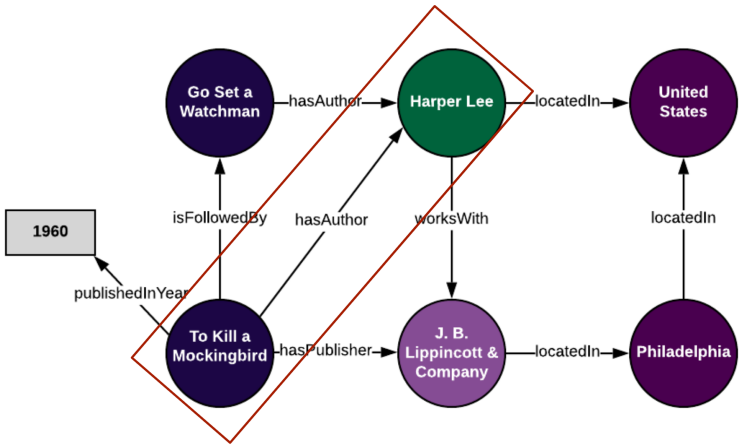


Figure 4: A knowledge graph example

2 Background

In AIRLab Delft [5], a robotic manipulator with a mobile base is used to perform stacking and picking tasks in a retail setting, shown in Figure 5. As you can see, there are several tables and shelves beside various prototype products.

In this project, an interactive assistant (hereinafter referred to as "chabot") is proposed as a communication channel between operators and robots, interpreting static environment information (i.e. properties of products) and dynamic execution information (i.e. the status of the undergoing task) in natural language to help operators understand robotic tasks in real-time. The experiment is designed to investigate the effectiveness of the chatbot's responses and generated knowledge graphs in enhancing operators' comprehension of robotics tasks in the ROS environment.

[5] AIRLab Delft homepage

Figure 5: The simulated retail environment in AIRLab Delft

3 Instruction

First, you'll go through a few different robotics tasks while the ROS simulation runs in the terminal. Then, you'll answer 10 questions about the tasks in a questionnaire. The time duration for interaction and questionnaire will be approximate **10** *mins* and **8** *mins*, respectively.

- **Step**:

  1, Please look at the knowledge graph generated after the experiment.

  Note: Try to obtain as much information as you want about the robot and the environment.

  Note: Try to understand and remember the robot's behaviours for each task.

  2, Fill out the questionnaire.