ROS-Mobile: An Android™ application for the Robot Operating System

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Abstract

Controlling and monitoring complex autonomous and semi autonomous robotic systems is a challenging task. The Robot Operating System (ROS) was developed to act as a robotic middleware system running on Ubuntu Linux which allows, amongst others, hardware abstraction, message-passing between individual processes and package management. However, active support of ROS applications for mobile devices, such as smartphones or tablets, are missing. We developed a ROS application for Android, which comes with an intuitive user interface for controlling and monitoring robotic systems. Our open source contribution can be used in a large variety of tasks and with many different kinds of robots. Moreover, it can easily be customized and new features added. In this paper, we give an outline over the software architecture, the main functionalities and show some possible use-cases on different mobile robotic systems.

Keywords: ROS, Android, Robotics

Metadata

| Metadata       | Value                                                                 |
|----------------|----------------------------------------------------------------------|
| Current code version | 1.0                                                                 |
| Permanent link to code/repository | https://github.com/ROS-Mobile/ROS-Mobile-Android |
| Legal Code License       | The MIT License (MIT)                                                |
| Code versioning system used | git                                                                 |
| Software code languages, tools and services used | Java, XML, Gradle |
| Compilation Requirements and Dependencies | Linux or Windows with Android Studio Version 3.6.1 or higher |
| Developer Documentation | https://github.com/ROS-Mobile/ROS-Mobile-Android/wiki |
| User and developer support | rosmobile.info@gmail.com |

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1. Introduction

The Robot Operating System (ROS) [1] is a widely used framework at universities and companies for control and navigation of robotic systems. For example for controlling Unmanned Aerial Vehicle (UAV) using Model Predictive Control (MPC) methods [2] or mapping the environment with mobile robots using 2D Simultaneous Localization and Mapping (SLAM) techniques [3]. For visualizing robot data, setting marker positions or boundary perimeter the ROS Visualization (rviz) [4] can be used which comes with a full-desktop installation. However, rviz is not available for mobile devices running with Android on which 75% of all mobile devices operate, Figure 1a. Hence, to facilitate the interaction with different robotic systems, an Android application is required that on the one hand provides different control and visualization options similar to rviz and on the other hand is adaptable and intuitive to use. Moreover, it should include additional functionalities not available in rviz but provided by other ROS packages, e.g. teleoperational control [5]. Such an application allows the operator/user to efficiently control and supervise robots via smartphone or tablet which enables scientists to conduct easily outdoor experiments. All the more, since the share of mobile devices is steadily increasing which is shown in Figure 1b. For example, we use our application to control and monitor an autonomous lawn mower testing new mapping algorithms [6], a mobile agent mapping and navigating through unknown terrain for guiding patients through, for example, a hospital [7] or for education purposes.

1.1. Related Work

There have been different attempts and studies regarding remote control and monitoring of robots via Android mobile devices. For example, in [10], a low cost robot framework, controlled by two different Android applications based on ROSJava [11], was introduced. In [12], a remote control application for mobile robots built from Lego Mindstorms NXT kit was proposed. However, these applications are limited to specific robotic system (e.g. Lego Mindstorms NXT kit) or a specific robot configuration. Moreover, ROSJava is limited to...
older Android versions and programming architectures, especially with the nowadays recom-
mended Model View ViewModel (MVVM) architecture, which will be introduced later. Currently, there are different ROS applications for Android available for download, Table 1, which all suffer different short comings:

ROS Control [13], the most advanced application, allows for example map view, remote control or laser scan visualization. However, it is based on outdated Android versions and is not supported any longer. ROS Teleop Controller AuTURBO [14] is mainly designed for control and display data supported by the robots from the TurtleBot family [15]. ROS Image Viewer only allows to display images received from a ROS framework.

1.2. ROS-Mobile

We propose a highly customizable ROS application for Android operated devices for remote control and to monitor mobile robotic systems. The application is based on the MVVM architecture which comes with simple testing structures and extensibility. In order to use our application, only a mobile device, e.g. a smartphone or a tablet, with Android Version 5.0 (Lollipop) or higher is required. Additionally, a wireless ethernet connection between the ROS master and the mobile device has to be established. After starting our application, a new configuration can be set up or an already existing one can be loaded. A new configuration requires to set the correct ROS master IP. Required ROS nodes can then be added in the Details section and customized. The remote control and the visualization can then be accessed in the Viz section.

2. Software description

In the following, we describe the basic architecture, called MVVM, which our Android application is based on. This standard architecture allows the development of robust, efficient applications. In addition, we give an overview over the main functionalities of our application and demonstrate how they can be integrated in a common ROS workflow.

2.1. Software Architecture

The basic architecture that our app is based on is MVVM, Figure 2. The underlying principle is the Separation of Concerns [16]. This means that each concern should be addressed by a different section of our program. For example, we require a User Interface
(UI), to enable user interaction, as well as ROS nodes, to subscribe or publish to certain ROS topics. The information produced by the user and the data received or sent via the ROS nodes are thereby the concerns of our program which have to be handled separately. Moreover, Android applications in comparison to desktop applications in general do not have a single entry point instead they are consisting of multiple components, such as Activities or Fragments. These application components are then used by the Android Operating System (OS) for integration into the device workflow. Hence, our application has to be able to handle app hopping behavior correctly. To do so, we use the ViewModel class, which has been designed for managing UI related data, as a connection between our model/data storage system and our UI. The required data is provided by a model/data storage system and is requested by the ViewModel object. This ViewModel object is directly assigned to a UI Controller (e.g. Activity, Fragment), which requests the data from the ViewModel object and let the user interact with them. Thus, the UI controller is decoupled from the data management system and can be destroyed and rebuilt during runtime by the OS to enhance performance. In order to implement such type of architecture, the ROSJava code, which was designed for older Android versions and architectures had to be modified according to the requirements of the MVVM architecture.

2.2. Software Functionalities

Our ROS Android application enables Android devices to easily control ROS operated systems. Therefore, the application establishes a ROS connection via WLAN with the system. This allows to control the robot by publishing ROS messages (e.g. velocity commands), visualize published measurement results (e.g. map data) or analyze the system’s behavior. Moreover, an additional control possibility is given by the included SSH client, which allows
direct access to the operating system. All in all, ROS operated systems can be easily manipulated using the proposed ROS Android application which makes it much easier to work with mobile robots outside laboratory environments.

3. Application Example

The goal of this task was to build a map of an apartment environment using a differential drive robot. Therefore, we connected the application with the ROS master running the differential drive robot over WLAN by inserting the correct IP address in the MASTER configuration tab, Figure 3a. Adding ROS nodes in the details tab, Figure 3b and Figure 3c, enables the control of the differential drive robot via a joystick method sending geometry_msgs/Twist to a cmd_vel topic and the visualization of the generated occupancy grid map by subscribing to the map topic via a gridmap method. In the visualization tab, Figure 3d, the recorded occupancy grid map is displayed as well as the joystick. The joystick can be used via touch for sending control inputs over the cmd_vel topic to the differential drive robot. For a more detailed example, we refer to the explanatory video1.

4. Current Application Domains

ROS-Mobile is an Android application which allows direct control and data visualization for mobile robots using ROS. It can be used to easily conduct or supervise outdoor experiments with mobile robots using mobile devices, such as smartphones or tablets. Thus, it

1https://www.youtube.com/watch?v=T0HrEcO-0x0
enables researchers to simplify field experiments and hence, accelerates the evaluation time for mobile robotic devices. Currently, we use the ROS-Mobile in different research projects, Figure 4, which we shortly summarize in the following.

4.1. Household Robots

An area of increasing importance in the last decade is the field of low-cost robotics. Robots such as lawn mowers, Figure 4a, or vacuum cleaners are used ubiquitously in households and work exclusively in closed environments, e.g. on a lawn or in an apartment. We develop low cost sensors, mapping and path planning algorithms for such robots, which are tested in real garden scenarios using the ROS-Mobile application. Among other things, the joystick node and the SSH connection have been used intensively.

4.2. Aufbau des Deutschen Rettungsrobotik-Zentrums (A-DRZ)

The A-DRZ project investigates the use of robot systems for civil terrestrial danger prevention in inhospitable environments. As part of the A-DRZ, we explore the use of intelligent Autonomous Surface Vehicles (ASV) and quadrocopters for fast detection of hazardous substances and flooding. For testing these robotic exploration approaches in realistic outdoor environments, the ROS-Mobile application is used for remote control and visualization.

4.3. Mobile Intelligent Robotic Agent for Navigation and Assistance (MIRANA)

Intelligent navigation and information services will make the visit in hospitals a better experience. In the MIRANA project, we build the software that enables robots to guide humans autonomously in the healthcare environment. We are starting with the software solution for SLAM in hospital buildings, speaker tracking and speech recognition and synthesis. To that end, we are using the personal transporter robot from Segway Robotics and developing applications on the Segway Robot platform. For visualization during the testing of the different approaches, we use the ROS-Mobile application.
5. Conclusions

We introduced ROS-Mobile, an android application for the robot operating system. We showed that ROS-Mobile allows fast and efficient control and supervision for realistic experiments with mobile robotic systems in outdoor as well as in indoor environments. Thus, it accelerates the development process for new sensors, algorithms or methods. The current version of ROS-Mobile implements different nodes, e.g. for teleoperational control or grid map visualization. Additional nodes and visualization methods can be added easily by following the tutorial on the GitHub repository. Contributions are welcome since ROS-Mobile is constantly being developed.

6. Conflict of Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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Abbreviations

ROS  Robot Operating System
UAV  Unmanned Aerial Vehicle
MPC  Model Predictive Control
SLAM Simultaneous Localization and Mapping
rviz  ROS Visualization
MVVM Model View ViewModel
UI  User Interface
OS  Operating System
ASV  Autonomous Surface Vehicles
A-DRZ Aufbau des Deutschen Rettungsrobotik-Zentrums
MIRANA Mobile Intelligent Robotic Agent for Navigation and Assistance
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