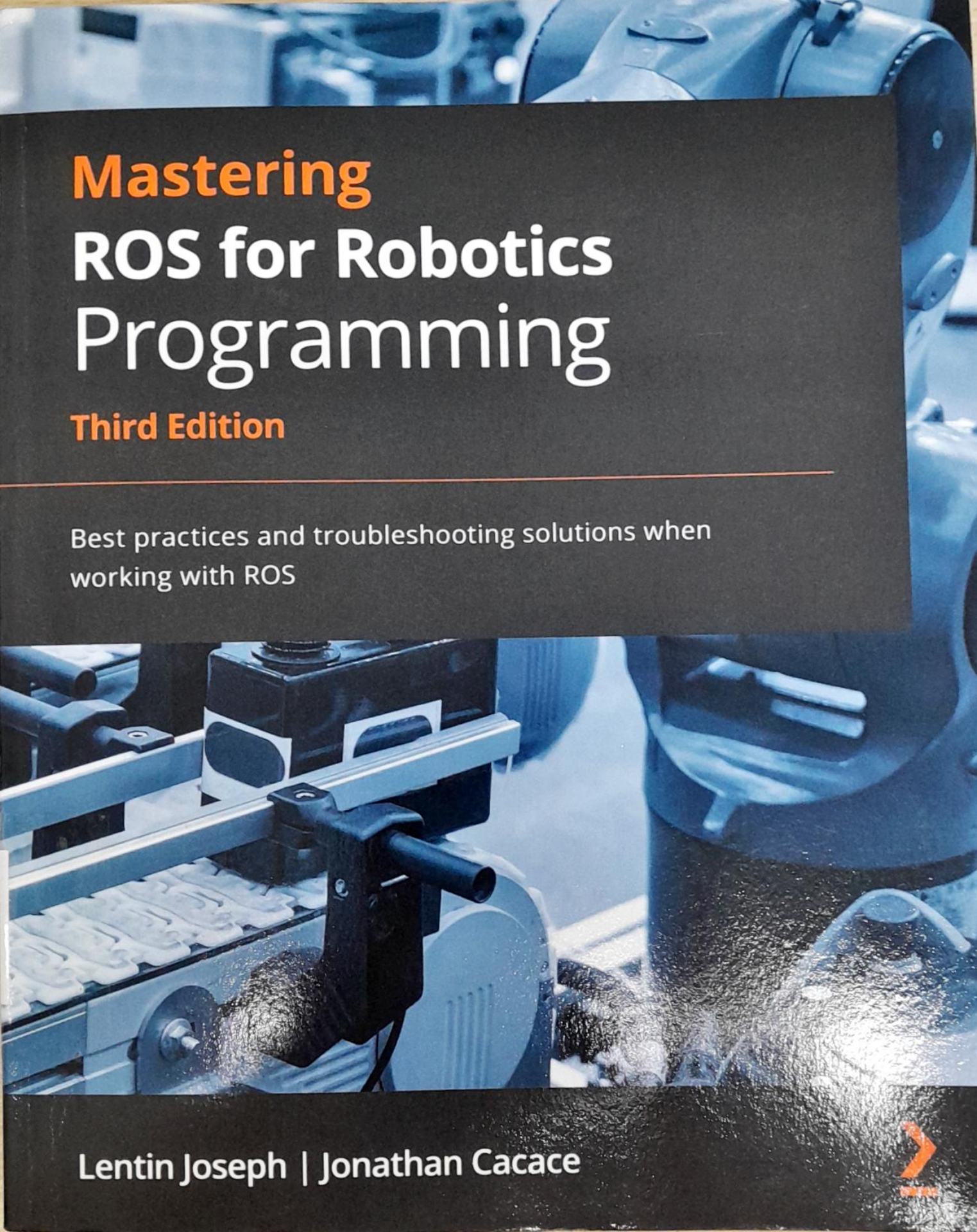

Mastering ROS for Robotics Programming

Third Edition

Best practices and troubleshooting solutions when working with ROS

Lentin Joseph | Jonathan Cacace

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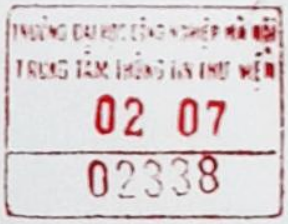

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I would like to dedicate this book to my parents (Jancy Joseph and CG Joseph) and my wife (Aleena Johny).

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I would like to dedicate this book to my family.

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Nick Rotella earned his B.Sc. degree in mechanical engineering from the Cooper Union, followed by his M.Sc. and Ph.D. degrees in computer science from the University of Southern California. As a roboticist, Nick considers himself to be a well-rounded scientist, developer, and engineer. While his Ph.D. thesis focused heavily on model-based motion planning and controls for humanoid robots, he has also worked on autonomous applications in the marine, drone, automotive, mining, and logistics spaces. His experience in controls is based on a deep theoretical understanding of dynamics, estimation, and trajectory generation; Nick has written software at all levels of autonomous system stacks for high-performance controls.

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TechnoYantra specializes in providing custom robotic solutions to clients in the automobile, health, industrial, and agricultural sectors in the US, Germany, the Netherlands, Saudi Arabia, Singapore, and more.

When Prateek is not building robots, you can find him playing football or watching sports.

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Preface

The **Robot Operating System** (**ROS**) is a globally used robotics middleware that helps developers to program robotic applications and is currently adopted by robotics companies, research centers, and universities to program advanced robots. *Mastering ROS for Robotics Programming, Third Edition* presents advanced concepts of the ROS framework and is particularly suitable for users who are already familiar with the basic concepts of ROS. However, a brief introduction to the basic ROS concepts is provided in the first chapter in order to help new developers start with the examples in the book.

You will be guided through the creation, the modeling and design, of new robots, as well as simulating and interfacing them with the ROS framework. You will use advanced simulation software to use ROS tools that allow robot navigation, manipulation, and sensor elaboration. Finally, you will learn how to handle important concepts such as ROS low-level controllers, nodelets, and plugins.

You can work with almost all of the examples of the book using only a standard computer without any special hardware requirements. However, additional hardware components will be used in some chapters of the book to discuss how to use ROS with external sensors, actuators, and I/O boards.

The book is organized as follows: after an introduction to the basic concepts of ROS, how to model and simulate a robot is discussed. Gazebo, CoppeliaSim, and the Webots software simulator will be used to control and interact with the modeled robot. These simulators will be used to connect to robots with the MoveIt! and navigation ROS packages. ROS plugins, controllers, and nodelets are then discussed. Finally, the book discusses how to connect MATLAB and Simulink with ROS.

Who this book is for

This book is meant to be used by passionate robotics developers or researchers who want to fully exploit the features of ROS. The book is also good for users who are already familiar with typical robotics applications or who want to start learning how to develop in the world of ROS in an advanced manner, learning how to model, build, and control their robots. Basic knowledge of GNU/Linux and C++ programming is strongly recommended if you want to easily comprehend the contents of the book.

What this book covers

Chapter 1, Introduction to ROS, gives you an understanding of the core underlying concepts of ROS.

Chapter 2, Getting Started with ROS Programming, explains how to work with ROS packages.

Chapter 3, Working with ROS for 3D Modeling, discusses the design of two robots; one is a seven **Degrees of Freedom** (**DOF**) manipulator, and the other is a differential drive robot.

Chapter 4, Simulating Robots Using ROS and Gazebo, discusses the simulation of a seven-DOF arm, differential wheeled robots, and ROS controllers that help control robot joints in Gazebo.

Chapter 5, Simulating Robots Using ROS, CoppeliaSim and Webots, introduces the CoppeliaSim and Webots simulators, showing how to simulate and control different types of robots.

Chapter 6, Using the ROS MoveIt! and Navigation Stack On, covers out-of-the-box functionalities such as robot manipulation and autonomous navigation using ROS MoveIt! and the navigation stack.

Chapter 7, Exploring the Advanced Capabilities of ROS-MoveIt!, discusses the capabilities of MoveIt!, such as collision avoidance, perception using 3D sensors, grasping, picking, and placing. After that, we will see how to interface robotic manipulator hardware with MoveIt!.

Chapter 8, ROS for Aerial Robots, discusses how to simulate and control aerial robots with ROS, considering the particular case of quadcopters.

Chapter 9, Interfacing I/O Boards, Sensors, and Actuators to ROS, discusses interfacing some hardware components, such as sensors and actuators, with ROS. We will look at the interfacing of sensors using I/O boards, such as Arduino or Raspberry Pi, with ROS.

Chapter 10, Programming Vision Sensors Using ROS, OpenCV, and PCL, discusses how to interface various vision sensors with ROS and program them using libraries such as **Open Source Computer Vision** (**OpenCV**) and **Point Cloud Library** (**PCL**).

Chapter 11, Building and Interfacing Differential Drive Mobile Robot Hardware in ROS, helps you to build autonomous mobile robot hardware with differential drive configuration and interface it with ROS. This chapter aims to give you an understanding of building a custom mobile robot and interfacing it with ROS.

Chapter 12, Working with pluginlib, Nodelets, and Gazebo Plugins, shows some of the advanced concepts in ROS, such as ROS `pluginlib`, `nodelets`, and `Gazebo` plugins. We will discuss the functionalities and application of each concept and will practice one example to demonstrate their workings.

Chapter 13, Writing ROS Controllers and Visualization Plugins, shows how to write and run a basic ROS controller. We will also see how to create a plugin for RViz.

Chapter 14, Using ROS in MATLAB and Simulink, discusses how to connect MATLAB and Simulink with ROS.

Chapter 15, ROS for Industrial Robots, helps you understand and install ROS-Industrial packages in ROS. We will see how to develop a MoveIt! IKFast plugin for an industrial robot.

Chapter 16, Troubleshooting and Best Practices in ROS, discusses how to set up a ROS development environment in Eclipse IDE, best practices in ROS, and troubleshooting tips in ROS.