

Preface

This text started as a collection of notes of the lectures on Space Robotics given by the author to the students of the International Master on Space Exploration and Development Systems (SEEDS). The aim of the course was the study of the automatic machines aimed to operate both autonomously and as a support to astronauts in space exploration and exploitation missions, with particular attention to the devices designed for planetary environment, including small planets, comets and asteroids.

This material was then completed and made more systematic so that it can hopefully be useful not only to the students of that course but also to those who have an interest in the wide and much interdisciplinary field of space robotics, and in particular in its mechanical aspects.

The focus is drawn mainly on the mechanics of space robots: the author is well aware that, even in this specific field, it is far from being complete and that robots, like all mechatronic systems, are so integrated that no single aspect can be dealt separately. Many important aspects are either dealt with only marginally or altogether left out. The very important topics of the control and the behavior of robots, for instance, are only marginally touched, even if their influence on the mechanical aspect to which this book is dedicated is not at all marginal.

The structure of the book is so organized:

- Chapter 1: a very short introductory overview of human and robotic space exploration, stressing the need for man-machine cooperation in exploration. The various types of robotic missions in LEO, deep space and on planets and their basic requirements are shortly summarized.
- Chapter 2 deals in a synthetic way with the main characteristics of the environments space robots are facing and will face in the future. Since space environment is a specialized subject, dealt with in many books, this subject is only briefly summarized.
- The configurations of robot arms and the basic kinematic and dynamic relationships needed for their design are described in Chap. 3.
- Chapter 4 is devoted to the study of mobility on planetary surfaces, using different kind of supporting devices, like wheels, legs and aerodynamic or aerostatic devices.

- The basic characteristics of wheeled robots and vehicles are summarized in Chap. 5. The behavior of wheeled devices is studied in its various aspects, like longitudinal, lateral and suspension dynamics. The consequences of operating wheeled machines in the various environments are analyzed in some detail. The chapter is concluded by a description of the only vehicle that successfully carried humans on the surface of the Moon, the *Apollo* Lunar Roving Vehicle.
- Vehicles and robots that use legs, tracks or other devices to move on a solid surface are described in Chap. 6. Since a great number of different architectures were proposed and sometimes even used in the past, not all the possible configurations are illustrated: the choice was based on the actual existing applications and on the perspectives of future use.
- Chapter 7 is devoted to a short overview of the transducers used for actuation and sensing in space robots.
- A short overview of the energy sources and storage devices that can be used for space robots is reported in Chap. 8.

The book includes two appendices summarizing the theoretical formulations allowing to write mathematical models of space robots including a variety of mechanical components, such as arms, legs, etc. The author found it necessary to include them, since the participants to the course in Space Exploration and Development Systems have a much varied background and what may seem obvious to some students, could be difficult for other ones. In a similar way, some of the readers of this book may not be familiar with the concepts of analytical mechanics or dynamics of deformable bodies used in the text, mainly in Chaps. 3 and 5.

The author is grateful to colleagues and students of the Mechanics Department and the Mechatronics Laboratory of the Politecnico di Torino for their suggestions, criticism and general exchange of ideas. Students, in particular postgraduate students, cooperated to this book with their thesis work and their questions, but mainly with their very presence that compelled me to clarify my own ideas and to work out all details. To all of them goes my gratitude.

Last, but far from least, this book could not have been written without the support, encouragement and patience by my wife Franca—advisor, critic, editor, companion and best friend since 44 years.

A Note on the Illustrations I have made every effort to seek permission from the original copyright holders of the figures, and I apologize if there are cases where I have not been able to achieve my objective. This applies in particular to figures taken from the web, like Figs. 4.10, 4.35, 4.36, 4.40, 5.2, 6.1, 6.15, 6.17, 6.21, 6.23b, 6.24, 6.25a, 6.28, 6.31a, b, c, 7.18, 7.19 and 7.21.

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