The idea of intelligent machines helping humans is a constant source of inspiration for researchers all over the world. A lot of work has been done on industrial, mobile, and humanoid robots in a wide spectrum of topics such as programming, planning, grasping, navigation, or perception. This last topic is one of the most studied, not only in the robotics and control communities, but also in many other fields, because it represents a key element in almost any domain of application. Range and vision sensors have been deeply studied because a good perception and interpretation of the environment can give robots the necessary information to be fully autonomous.

In this context, the extension to teams of machines working in cooperation turns out very attractive because it offers a wealth of new possibilities. The idea is very similar to the way humans act in many contexts of their lives. Let us imagine, for example, a brigade of firefighters entering in a big building on fire. In order to efficiently achieve all the different tasks, save possible survivors, put out the fire, etc., they will surely distribute the different tasks to be accomplished. Some firefighters will go to prepare the elements of the lorry to work and some others will go inside the building, dividing themselves into the different floors and areas to explore. In summary, for efficient execution of their mission, the members of the team will act as a distributed system. The same idea applies to a system that is composed of multiple autonomous robots. The versatility and robustness of such systems have motivated, in the last decades, an intensive research for the development of multi-robot solutions to carry out tasks that are inherently distributed in space, time, or functionality.

A consistent perception of the state will be crucial for the good development of any multi-robot application. Depending on what each robot sees and their current situation, they will communicate with each other whenever they can to share what they have found and keep updated their mates. However, in a realistic scenario, distributed solutions to this problem are not trivial. This book introduces novel solutions to the different problems that come up when a team of robots need to execute a task in cooperation, with monocular cameras as their primary input sensors.
What does the book cover? We focus the book on the high-level problem of cooperative perception by a multi-robot system. We decompose the main problem into four key ideas and we develop solutions for each one of them along the different chapters of the book. We present a deep study of distributed consensus algorithms and how they can be used by a team of robots equipped with monocular cameras, solving the most important issues that appear because of the use of these sensors. First, we address the problem of finding global correspondences between the observations of the different robots. In this way, the robots know which observations must be combined in the computation of the consensus. After that we treat the problem of robustness and distributed outlier detection, giving a solution to discard erroneous measurements. To counteract the increase in the size of the messages caused by the previous steps, we use the properties of Chebyshev polynomials, reducing the number of iterations required to achieve the consensus. Finally, we show how these algorithms can be applied to cooperatively build a topological map of the environment using planes as features. All the ideas are written in the context of distributed development and implementation. We identify the main issues associated to the different problems, and we present in each chapter different distributed strategies for solving them.

The organization allows us to discuss topics that are classical in these scenarios and to study several ideas that are crucial in multi-robot systems. Thus, the purpose of this book is to give the reader insight into some problems related to perception in multi-robot systems. In addition, we try to motivate and give tools to the reader for studying new solutions to the problem of multi-robot systems and perception, particularly with vision systems. In order to improve the readability, the book includes numerous explanations and demonstrations and provides enough references to complement all the topics treated along the different chapters.

Who is this book for? This book can be of high interest to postgraduate students and researchers in the domains of multi-robot systems, distributed control, computer vision, and cooperative perception. Nevertheless, specialists in mathematics, engineering, computer science, or artificial intelligence can also find in the book new ideas to advance in related research fields. In order to fully understand the concepts developed in the book, the reader should have the basic understanding of a graduate student in engineering, mathematics, and physics.

Acknowledgments We would like to thank Profs. Rosario Aragüés, Sonia Martínez, and Juan I. Montijano for their contributions to Chaps. 3, 4, and 5, respectively.

We are grateful to Ministerio de Economía y Competitividad (Spain) for economically supporting our research, as well as to our employing universities, Centro Universitario de la Defensa, and Universidad de Zaragoza for all the support given.

December 2014
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Distributed Consensus with Visual Perception in Multi-Robot Systems
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2015, XII, 159 p. 46 illus. in color., Hardcover
ISBN: 978-3-319-15698-9