Preface

Endowing mobile agents with the ability to autonomously navigate an environment is a fundamental research problem in robotics. In particular, systems that consist of multiple autonomous robots moving in coordinated fashion have received tremendous attention recently. Compared with single-robot setups, multirobot systems provide more efficient and robust task completion, and enable behaviors having a higher degree of complexity and sophistication. These properties make them attractive in numerous applications across diverse domains that include manufacturing, transportation, farming, environmental monitoring, or search and rescue missions. Technological advances in computation, sensing, actuation, and communications are continuously enabling new real-world implementations of multirobot control systems. Relevant current challenges in this field concern the development of increasingly reliable, flexible, and scalable systems while taking into account critical aspects such as efficiency of performance and cost per agent.

Autonomous robots rely on sensors to obtain the primary information they need to make decisions. Vision sensors provide abundant information while being widely available, convenient to use, and relatively inexpensive, which has made them a usual choice in many robotic tasks. When dealing with systems that comprise multiple robots, the simplicity and cost advantages associated with the use of cameras become particularly relevant. Still, mobile robot control using vision presents challenges inherent to the very nature of this sensing modality, and faces specific problems when multirobot scenarios are considered.

This book addresses a number of these research issues, presenting solutions that advance the state of the art in the field of vision-based control of multiple robots. We first introduce novel methods for control and navigation of mobile robots using 1D multiple-view models computed from angular visual information obtained with omnidirectional cameras. The relevance of the approaches presented lies in that they overcome field-of-view and robustness limitations, while at the same time providing advantages in terms of accuracy, simplicity, and applicability on real platforms. In addition, we address coordinated motion tasks for multiple robots, exploring different system architectures. In particular, we propose a partially distributed image-based control setup where multiple aerial cameras are used to drive a

team of ground robots to a desired formation, with interesting characteristics regarding simplicity, scalability, and flexibility. Furthermore, we also describe decentralized formation stabilization methods whose significance comes from the fact that they exhibit strong stability properties while relying only on information expressed in the robots' local reference frames and, thereby, being amenable to vision-based implementations. Some of the aspects investigated in the context of these decentralized multirobot control strategies are global convergence guarantees, the presence of time-delays in the communications, or their application to target enclosing tasks.

In this research monograph, we describe in detail the proposed control approaches and formally study their properties. In addition, the performance of the different methodologies is evaluated both in simulation environments and through experiments with real robotic platforms and vision sensors.

This book is primarily aimed at researchers, engineers, and postgraduate students in the areas of robotics, automatic control, and computer vision. The ideas presented can also have links with broader research problems in applied mathematics, industrial control, and artificial intelligence, and be of interest to specialist audiences in those fields. A background in mathematics and engineering at graduate student level is necessary in order to fully understand this book.

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