Multimedia Contents

Moving

Part E

Part E Moving in the Environment

Ed. by Raja Chatila

Until the mid 1960s, robots were only able to move in a predetermined workspace, the one they could reach from their firmly fixed base. Part E is about their conquest of the whole space. Mobile Robotics started as a research domain in its own right in the late 1960s with the Shakey project at SRI. 2015 marks the 50th anniversary of this seminal project that had a lasting legacy such as A^*. The seminal paper by N.J. Nilsson *A Mobile Automaton: An Application of Artificial Intelligence Techniques* at the International Joint Conference on Artificial Intelligence (IJCAI) 1969, already addressed perception, mapping, motion planning, and the notion of control architecture. Those issues would indeed be at the core of mobile robotics research for the following decades. The 1980s boomed with mobile robot projects, and as soon as it was necessary to cope with the reality of the real physical world, problems appeared that fostered novel research directions, actually moving away from the original concept in which the robot was just an application of artificial intelligence (AI) techniques. This part addresses all the issues that, put together, are necessary to build and control a mobile robot, except for the mechanical design itself.

Navigation is the capacity of moving from one location to another arbitrarily distant one. To move efficiently, a robot needs to use appropriate representations of its environment in order to plan and control its motions according to the presence of obstacles and terrain difficulties, and also to use environment features as landmarks for its localization. This is the topic of Chapter 45 which addresses the different representations used for indoors or outdoors environments, including topological maps and semantic attributes.

However, building environment maps is usually achieved incrementally, as the robot discovers its environment while navigating in it. Hence partial perceptions built from different positions, need to be fused together – taking into account sensing errors and uncertainties (see Chapter 5, Part A) to construct a consistent global map. This requires the robot to know these positions, and, because of motion inaccuracies, the transforms between them are uncertain. This requires to reference the positions to environment features which are only defined in the environment map itself. As a result, localization needs the map and mapping needs localization. Hence, localization and mapping are two interwound problems that must be solved simultaneously. The solution to this problem is the topic of Chapter 46.

Once environment maps are available, or during their construction, the robot has to plan its path as optimally as possible to reach its targets while avoiding obstacles. Chapter 7 in Part A overviews the techniques for solving this central problem, which requires geometrical reasoning in the configuration space (CS) whose construction is complex. To avoid an explicit construction of the CS, probabilistic techniques proved the most efficient way to compute paths – at the price of optimality. However, the kinematic constraints of the robot's locomotion system such as non-holonomy have to be taken into account. We see in Chapter 47 in this part how control problems cannot be separated from geometry. This chapter addresses motion planning from the viewpoint of mobile robotics and introduces the tools from control theory and differential geometry that enable to tackle kinematics constraints. In addition, it provides an overview of local sensor-based methods that are used when the robot encounters unknown or mobile obstacles while moving.

The rest of this part essentially focusses on various means of locomotion used to move in the environment: legged locomotion (Chapter 48), robots with wheels (Chapter 49), with tracks (Chapter 50), and underwater and aerial robots (Chapters 51 and 52 respectively) which face the specific problems of three-dimensional (3-D) motion with environment perturbations. In these two last cases the close links between Robotics and Control are of course central.

Finally, after explaining how one single robot moves in different environments, Part E concludes with Chapter 53 on the interaction and coordination of multiple mobile robot systems.