Chapter 108
Conflict Resolution in Robotics: An Overview

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ABSTRACT

A long-term goal in Robotics is developing autonomous systems able to assist and support human beings, especially in hazardous and/or repetitive tasks. So, these robotic systems will share their workspace with other robots, people or both of them, possibly having different goals and needs. This fact may result in a conflict that should be solved for properly achieving the intended goals. However, there is no a universal way to do it since different scenarios and behaviours lead to different kinds of conflicts. In addition, execution time is a critical issue in the Robotics field and has to be taken into account when a conflict resolution technique is developed. In this chapter we will discuss the state-of-the-art algorithms applied to several robotic tasks from assembly and disassembly in industrial settings to multi-robot cooperation through collision avoidance in unstructured, crowded environments. So, a deep analysis will highlight approach's applications and utilities, as well as their limitations.

INTRODUCTION

Technological advances are currently being directed to assist human population in performing daily tasks in real scenarios. So, the robot systems should be able to properly reach a variety of tasks in different kinds of environments. In this context, conflict resolution is a key issue since the way to resolve conflicts between the multiple tasks to be performed simultaneously and/or several robots cooperating to achieve a common goal, will determine the success/failure of the robot system.

From a biological point of view, people handle conflicts in five different styles (Kilmann & Thomas, 1977):

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- **Avoiding:** This is an unassertive and uncooperative style. When avoiding, the issue is simply not addressed. So, it can be appropriate when the victory is impossible, when the controversy is trivial, or when someone else is in a better position to solve the problem. However, avoiding is not a good long term strategy in general.
- **Competitive:** This is the "win-lose" approach. That is, this is assertive, uncooperative and a power-oriented mode. This style can be useful when there is an emergency and a decision needs to be made fast, when the decision is unpopular, or when defending against someone trying to exploit the situation selfishly.
- **Accommodating:** This mode takes place when there is high-degree cooperation, even at the individual's own expense. Actually, there is an element of self-sacrifice in this style. So, this unassertive and cooperative (not competitive) approach is effective when the other party is the expert or has a better solution.
- **Collaborative:** This style is both assertive and cooperative. Therefore, when collaborating, an individual attempts to work with the other person to find a solution that fully satisfies the concerns of both. So, the individual breaks free of the "win-lose" paradigm and seeks the "win-win" approach. This style is useful when it is necessary to bring together a variety of viewpoints to get the best solution, when there have been previous conflicts in the group, or when the situation is too important for a simple trade-off.
- **Compromising:** This mode is intermediate in both assertiveness and cooperativeness, and addresses an issue more directly than avoiding. Thus, when compromising, the goal is to find a mutually acceptable solution partially satisfying both parties. This style is useful when the cost of the conflict is higher than the cost of losing ground, when equal strength opponents are at a standstill, or when there is a deadline looming.

Ideally, a system should adopt the proper approach that meets the situation at hand at any time. However, this is not straightforward since it depends on different factors such as the environment, the goal to be achieved and the kind of partners the system has (i.e. other robots and/or people). In addition, the conflict resolution technique must be fast and must result in a reliable negotiation of the shared resources and energy management. So, this chapter reviews those techniques for conflict resolution used in three different fields of Robotics: multi-robot cooperation, human-robot collaboration and multi-tasking assignation.

CONFLICT RESOLUTION IN MULTI-ROBOT COOPERATION

Advances in swarm robotics make it possible to use (large) teams of robots in many applications such as air-traffic control, factory automation, agriculture, logistics, etc. However, despite the popularity of cooperative robotics in the last decades, the problem of conflict resolution is still a challenge, especially when the number of the integrating robots is variable.

In this context, two different issues have been addressed: path planning, where several robots share a workspace and have to avoid collision with obstacles as well as with fellow robots; and, object manipulation.

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