Chapter 41

Indoor Surveillance Application using Wireless Robots and Sensor Networks:
Coordination and Path Planning

Anis Koubaa
Al-Imam Mohamed bin Saud University, Saudi Arabia & Polytechnic Institute of Porto (ISEP/IPP), Portugal

Sahar Trigui
National School of Engineering, Tunisia

Imen Chaari
National School of Engineering, Tunisia

ABSTRACT

Mobile robots and Wireless Sensor Networks (WSNs) are enabling technologies of ubiquitous and pervasive applications. Surveillance is one typical example of such applications for which the literature proposes several solutions using mobile robots and/or WSNs. However, robotics and WSNs have mostly been considered as separate research fields, and little work has investigated the marriage of these two technologies. In this chapter, the authors propose an indoor surveillance application, SURV-TRACK, which controls a team of multiple cooperative robots supported by a WSN infrastructure. They propose a system model for SURV-TRACK to demonstrate how robots and WSNs can complement each other to efficiently accomplish the surveillance task in a distributed manner. Furthermore, the authors investigate two typical underlying problems: (1) Multi-Robot Task Allocation (MRTA) for target tracking and capturing and (2) robot path planning. The novelty of the solutions lies in incorporating a WSN in the problems' models. The authors believe that this work advances the literature by demonstrating a concrete ubiquitous application that couples robotic and WSNs and proposes new solutions for path planning and MRTA problems.

INTRODUCTION

Robotics and Wireless Sensor Networks (WSNs) are two key technologies that integrate physical processes and phenomena with computation, and contribute to solving real-world problems in several areas such as industrial manufacturing, precision agriculture, smart homes and buildings, health care systems, intelligent transportation systems, military applications, and unknown environment exploration, etc. This technological development has naturally given birth to the paradigm of Cyber-Physical Systems where computation is no longer decoupled from its surrounding environment.

Although robotics and WSNs are typically designed to be deployed in similar contexts, little work has focused on the marriage of these two technologies to solve particular problems. In fact, robotic solutions basically rely on autonomous robots or a collaborative group of ad-hoc (i.e. decentralized) robots to accomplish certain tasks. In these typical robot applications, the intelligence, i.e. processing and data analysis, is embedded in the robot. Thus, the cooperative work between mobile robots in the field requires distributed and ah-hoc communications between the different mobile robots, which might increase the solution's complexity because of their high mobility. The cooperation becomes even more difficult if the real-time guarantee is a major requirement of the robotic distributed application.

Another alternative for mobile robotic applications consists in taking advantage from the Wireless Sensor Network paradigm as a complementary infrastructure allowing for acquiring additional knowledge about the environment. The idea is to feed the robots with additional cyber-physical information that can be carried out by the WSN, which provides substantial support to the robotic system to accomplish its missions. As a consequence, the performance will naturally improve. As an illustrative example, a WSN can afford localization services for robots to support its navigation in an indoor environment, in a similar fashion to what a GPS system can provide

in an outdoor environment. Furthermore, a WSN deployed in the environment would effectively be able to inform the robotic system about crucial events and their locations so that they can act accordingly. In a nutshell, the pervasive and ubiquitous nature of the WSN deployment is of paramount importance to improve the quality of robotic system solutions.

In this chapter, we illustrate our vision by proposing a multi-robot indoor surveillance system, called SURV-TRACK, which takes advantage of WSN-based services to support the operation of a team of collaborative robots. SURV-TRACK is designed to track and capture intruders within a defined area. This application could be instantiated for the surveillance and real-time monitoring of large areas such as shopping centers, manufacturing plants, banks, and critical areas.

Surveillance, using a multi-robot team with the support of a WSN, encompasses several underlying challenges such as inter-robot and robot-WSN collaborations, path planning, target detection and tracking, navigation, mapping, etc. The key challenge is to devise solutions that take into account the efficient interaction between robots and the WSN infrastructure.

In this chapter, we first propose a model for the multi-robot indoor surveillance application supported by a wireless sensor network. Then, we tackle two different underlying issues in the SURV-TRACK application and propose solutions with respect to the following features: (1) multi robot task allocation for target capturing and (2) path planning.

BACKGROUND

In this section, we present a brief overview of WSNs and mobile cooperative robots. The objective is to introduce these concepts and provide an adequate background on these technologies, without being comprehensive, because of the high density of research work in these two areas.

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