Chapter 2
Ontology-Based Coalition Creation by Autonomous Agents in Smart Space: An Approach and Case Study

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ABSTRACT

The chapter presents an approach to agent indirect interaction in smart space based on the publication/subscription mechanism. It is proposed to describe every agent with an ontology and support the ontology matching between ontologies of different agents in smart space to enrich the semantic interoperability between them. When the agents reach the semantic interoperability, they are aimed to create a coalition to perform a task. The task is described by ontology and the agents determine what they can propose to implement it. Group of agents that can perform the task together is called coalition. The considered case study describes the mobile robot interaction for the case of joint obstacle overcoming by the 6WD robot with lifting chassis, quadrocopter that scans an obstacle, and knowledge base service that contains algorithms for obstacle overcoming.

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INTRODUCTION

Last years, there are a lot of research and development in the topic of mobile robotics and coalition creation by mobile robots (Li et al., 2019; Kirichek, Paramonov, Vladyko, & Borisov 2016; Du, He, Chen, Xiao, Gao, & Wang, 2017). They are actively used for different tasks such as scouting, technological accidents and catastrophes consequences liquidation, counterterrorism operations and patrolling (Teja, Harsha, Siravuru, Shan, Krishna, 2015; Reddy, Kalyan, Murthy, 2015). Often robots are used for manipulating an object when a human cannot achieve it in some reasons. At the moment in the world there are a lot of mobile robots developed that can implement simple tasks. However, these robots alone usually cannot implement complex tasks that requires joint actions from several robots. In this case, automation of coalition creation is an actual and promising task. When a task is determined the robots should interact with each other, understand each other, and create a coalition for joint task solving.

The paper presents an approach to ontology-based mobile robot interaction for coalition creation. The approach is based on such concepts as cyber-physical-social systems (Zeng et al., 2017), mobile robotics, ontology modeling (Carvalho, Almeida, Fonseca, Guizzardi, 2017), semantic interoperability models (Ganzha et al., 2017), and context management (Snidaro, García, Llinas, 2015). The core concept is the cyber-physical-social system where the physical devices are interacted in smart space with each other and with human for implementing joint actions in physical space. Cyber-physical-social systems tightly integrate physical, information (cyber), and social spaces based on interactions between them in real time. This kind of systems relies on communication, computation and control infrastructures for the three spaces with various resources:

- Acting resources (mobile robots, sensors, actuators) that implements actions in physical space;
- Information resources (robot control blocks, user mobile devices, services, computation resources, etc.) that operate in information space;
- Social resources (human) that form tasks in social space.

For interaction in the cyber-physical-social system the smart space technology is used, which allows to provide information sharing between different services of the system. This technology (Cook & Das, 2007; Balandin & Waris, 2009) aims to the seamless integration of different devices by developing ubiquitous computing environments, where different services can share information with each other, make different computations and interact for joint tasks solving (Korzun, Balandin, Kashevnik, Smirnov, & Gurtov, 2017). In the considered approach, the main goal of smart space technology is to provide ontology-based information sharing for the cyber-physical-social system.

In scope of the presented in the paper an approach the context-based model for mobile robots interaction, the ontological model of mobile robot, and the method for robot ontology matching have been developed as well as a case study for task performing by the group of mobile robots for obstacle overcoming. The presented case study has been implemented both: using LEGO Mindstorms EV3 robotic kit as well as models of robots developed using the ROS system and Gazebo modelling environment. The ontologies in the considered scenarios formally represents knowledge as a set of concepts within a domain, using a shared vocabulary to denote the types, properties, and interrelationships of those concepts. The context is defined as any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and application themselves (Dey, Salber, & Abowd, 2001).