

## Chapter 51

# Ontology–Based Interaction of Mobile Robots for Coalition Creation

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### ABSTRACT

*Popularity of research in the area of robotics over the last years opens new tasks to develop in the area of intelligent behavior of robots for coalition creation and joint tasks solving by them. The article presents an approach to ontology-based mobile robots interaction for coalition creation. The approach is based on cyber-physical-social system concept where the physical devices interact in smart space with each other and with humans for implementing joint actions in physical space. In scope of the approach the context-based model for mobile robot interaction, the ontological model of a mobile robot, and the method for robot ontology matching have been developed. The ontology 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 presented approach has been approved by the point exploring and obstacles overcoming case study. Mobile robots have been constructed based on the Lego Mindstorms EV3 educational kit.*

### INTRODUCTION

Nowadays, research and development in the area of mobile robots becomes more and more popular, e.g., see (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

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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 robots 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 humans 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 (humans) 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 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. The ontology 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).

The case study of a point exploring and obstacles overcoming scenario has been implemented. Based on this scenario the coalition of robots and a human expert is formed for task solving. Sometimes while performing a task the manipulating robot tends to face obstacles on its path. In this case the robot can try to overcome it and in case of fail ask human expert to take control and help with obstacle overcoming. For understand the obstacle parameters it is reasonable to create a coalition with quadcopter robot which can reach the obstacle before, implements measurements, and provide the information to the manipulating robot. Each robot consists of several blocks with pairs of wheels and is equipped with ultrasonic sensors. Robots are able to detect obstacles, and overcome them (the height of the obstacle

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