Chapter 19
Self Control and Server–Supervisory Control for Multiple Mobile Robots and its Applicability to Intelligent DNC System

F. Nagata
Tokyo University of Science, Japan

A. Otsuka
Tokyo University of Science, Japan

T. Yamashiro
Tokyo University of Science, Japan

K. Watanabe
Okayama University, Japan

N. Kitahara
Tokyo University of Science, Japan

Maki K. Habib
The American University in Cairo, Egypt

ABSTRACT

Multiple mobile robots with six PSD (Position Sensitive Detector) sensors are designed for experimentally evaluating the performance of two control systems. They are self-control mode and server-supervisory control mode. The control systems are considered to realize swarm behaviors such as Ligia exotica. This is done by using only information of PSD sensors. Experimental results show basic but important behaviors for multiple mobile robots. They are following, avoidance, and schooling behaviors. The collective behaviors such as following, avoidance, and schooling emerge from the local interactions among the robots and/or between the robots and the environment. The objective of the study is to design an actual system for multiple mobile robots, to systematically simulate the behaviors of various creatures who form groups such as a school of fish or a swarm of insect. Further, the applicability of the server-supervisory control scheme to an intelligent DNC (Direct Numerical Control) system is briefly considered for future development. DNC system is an important peripheral apparatus, which can directly control NC machine tools. However, conventional DNC systems can neither deal with various information transmitted from different kinds of sensors through wireless communication nor output suitable G-codes by analyzing the sensors information in real time. The intelligent DNC system proposed at the end of the chapter aims to realize such a novel and flexible function with low cost.

DOI: 10.4018/978-1-4666-4607-0.ch019

INTRODUCTION

Swarm robotics originally initiated from biological and nature studies and the advances made in the field of swarm intelligence. Recently, many research studies on swarm robotics have been conducted, in which the aim focuses on the realization of complex task ability and complex behaviors from simple rules and simple design by establishing enabling interaction, coordination and cooperation functionalities between large numbers of physically simple robots. The research in the area of swarm robotics includes the design of robots, their physical body, simulation, scalability, and their collective behaviors that emerge through real time interaction. Cost and miniaturization are key parameters in the development of swarm robotics. Future and emergence progress in the field and the development of concrete and potential applications like in micromachinery, human body, rescue, mining, agriculture forging task, etc. are under consideration by many research groups. It is important to notice that the characteristics of self-organization describe changes in the structure of a multiple mobile robot team as a function of its experience and interaction with its environment. Hence, self-organization capability is highly demanded for swarm of robots. Researchers in the field are inspired by the behavior of animals and insect societies such as colonies of ants, wasps, termites, flocks of birds, schools of fish, to develop different structures, organization, configuration, and interaction capabilities among members of a multi robotic system.

As for the studies focusing on multiple mobile robots, Fok and Kabura introduced a flexible multiple mobile robots system (Fok & Kabuka, 1992). The mobile robots were capable of performing their own path planning and collision avoidance by means of ultrasonic sensors, standard patterns, and rotary optical encoders. The designed algorithms for the mobile robot and local controller were presented. Simeon et al. presented an efficient geometry-based approach for multiple mobile robot motion coordination, in which a new model was derived from a bounding-box representation of the obstacles in the elementary 2-D diagrams (Simeon et al., 2002). In addition, Clark et al. proposed a new approach to multi-robot motion planning which was based on the concept of planning within dynamic robot networks (Clark et al., 2003). The system enabled multiple mobile robots with limited ranges of sensing and communication to manoeuvre safely in dynamic and unstructured environments.

In this chapter, multiple mobile robots each with six PSD (Position Sensitive Detector) sensors are designed for experimentally evaluating the performance of two control systems (Yamashiro & Nagata, 2010; Yamashiro et al., 2011). They are self-control mode and server-supervisory control mode. The PSD sensor is a kind of photo sensors. For example, the control system behavior aims to realize swarm behavior of Ligia exotica as shown in Figure 1. This is done by using only information of PSD sensors. Many organisms, who develop group formation behavior, live in many parts of earth. Ligia exotica is one of such organisms that swarm at the seashore. Inspired by such behaviors, experimental results of the presented work under this chapter show the development of basic but important behaviors that enable multiple mobile robots to accomplish complex tasks using simple individual behaviors influenced by changes within its environment. Some of the developed collective behaviors are: the avoidance behavior and the schooling behavior. These behaviors emerge from the local interactions among the robots and/or between the robots and its environment. The objective of the presented research is to design and implement a group of robots. Each robot in such structure represents a basic element of multiple mobile robots to systematically develop, test and verify behaviors of various creatures that form groups such as a school of fish or a swarm of insect, and to know their important characteristics.