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INVESTIGATION OF SWARM ROBOT APPLICATIONS AND SWARM ROBOT EXPERIMENT PLATFORMS

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Abstract

Robots are used to make human life easier. In our daily life, the work done with classical machines is done with autonomous robots by reducing human intervention. Thanks to the network infrastructure, remote command operation and communication with each other can be provided. It is also possible to do the work done with only one robot in a shorter time with many robots. In this case, it is necessary for the robots to communicate and coordinate with each other. Various algorithms have been developed on this situation, which is evaluated within the scope of swarm robot studies. Coordinated movement is envisaged in studies with more than one robot of the same type. In some cases, the swarm may also consist of heterogeneous robots. In this case, it is necessary to coordinate according to the abilities of robots with different characteristics. In this study, information will be given on swarm robots, their usage purposes, and structures. Physical robot applications used to test academic studies will be mentioned.

Keywords: Swarm Robots, Robot Applications, Autonomous Robot

INTRODUCTION

Autonomous mobile robots are used in many areas in our daily lives. Intelligent robots are widely used in housework for some reasons such as developing computer-based software technologies and cheaper hardware. A software algorithm is used in robots that sense their surroundings, make decisions, receive remote commands and scan areas. Their efficiency is gradually increasing with artificial intelligence-based algorithms. These robots, which are used to make people's work easier, work autonomously and can do many jobs such as scanning the area and making their own decisions. The next step is for these commercial robots to act as a swarm. It is more efficient to use collaborative robots to clean large areas or scan an area in less time. In some areas where robots are used, using more than one robot shortens the time to complete the task[1]. Increasing the number of robots further can further shorten the time. In this optimization, it should be ensured that the robots work in coordination with each other, so that the robots communicate with each other. Thanks to this communication, the robots will share information with each other and perform the given task together.

Swarm robots are groups of robots in which many robots are coordinated in a distributed and decentralized manner. Multiple simple robots will be able to perform complex tasks more efficiently than a single robot. This can add durability and flexibility to the application[2, 3].

In studies with swarm robots, the improvement of 30-60% as a result of the use of swarm intelligence instead of individual task in studies based on the communication of robots with each other by eliminating the ground station and the detection of a 90% reduction in the additional communication load from the ground station was tested for 20 tasks with 18 robots. This application has been experimentally investigated on simulation[4, 5]. Another study on the importance of swarm intelligence and robotic applications based on swarm intelligence, algorithms used in swarm intelligence and studies using these algorithms are discussed [4]. A simulation study on the task sharing of swarm robots and how to switch between tasks and the methods of task functioning in swarm robots are discussed in Ducatelle's study[6]. Some studies have been carried out to perform algorithmic approaches to task assignment in swarm intelligence with multidisciplinary studies, and these studies have pioneered the concept of artificial intelligence in herd robots. Inspired by natural life, swarm behaviors were examined. Algorithms including the transfer of these swarm behaviors to the computer environment were created by examining in detail.

The behaviors of ants and bees working in harmony with each other to perform their duties were examined and the software was converted into algorithms. For similar tasks, robots are coded with these algorithms to create swarm intelligence [7-9]. With the use of this intelligence and infrastructure in various engineering fields, the importance of swarm robots has increased [10]. Comprehensive studies with swarm robots, heterogeneous robotics studies and current use were published in 2013, and an even greater momentum was gained for the future [2, 11]. After the academic studies were followed by commercial robots, new usage areas of swarm robots were presented to end users. iRobot autonomous cleaning robot, mi robot are a few of them[12, 13]. Before the commercialization of autonomous robots, the target area in this project is to run academic studies in the real world. Within the scope of this project, which aims to combine academic infrastructure and practice, real task-based studies will be carried out by testing the tasks closest to commercial robots. For this purpose, suitable hardware was selected to test the academic algorithms, which is the post-test before the commercial product. Selected robots should support open source ROS (robot operating system)[14-16] and be able to make applications on academic development platforms.

In this study, an exemplary platform for physical performance of academic tests of swarm robot features and heterogeneous collaborative robots will be discussed.

SWARM ROBOTS

Swarm robots are groups of robots in which many robots move in a decentralized manner. Robots in this group act autonomously. It has sensors that detect the environment and decision-making mechanisms on it. Swarm robots can be homogeneous or heterogeneous. There may be similar robots or different robot groups may be part of the swarm[1, 2, 11, 17]. Some hardware is required for robots to communicate with each other locally. Swarm robots are expected to perform certain behaviors. These behaviors are defined below.[18]

Rallying

Before the swarm robots fulfill the given tasks, they are expected to gather in an area and share tasks. During the gathering, the robots in the swarm with communication structure are expected to communicate with each other.[19]

Distribution

It is the dispersal feature that the robots in time settle in the area at the appropriate distance between each other and in the appropriate pattern. With a good distribution, field scanning and search activities are done more efficiently.[20]

Assignment

Robots work on a task basis to do a job. The task in the swarms is clear, but it is not clear how and by which robot this task will be done. Various algorithms have been developed for this process. The robot performs the given operation by sharing tasks among themselves[21].

Collective Action

Swarm robots can move together simultaneously. Groups of robots formed in a suitable distribution can move harmoniously without disturbing the distribution distance.

Collective Mapping

Using multiple robots to scan large areas reduces the time. In swarm robots, large areas can be scanned with robots and appropriate maps can be drawn.

Source Search

Herds are encountered by many living things in natural life. In a certain search activity, the herd members can reach the source in a faster time by searching for the source. It can then direct other robots to this resource.

Transport

There is a workforce that a robot can do. One robot may not be enough for larger workforces. In this case, cooperation can be made and a single job can be done with two or more robots. It is possible to transport a heavy object with more than one robot.

SWARM ROBOT EXPERIMENT PLATFORM

Some commercial robots have been developed to test academic studies with swarm robots on a real robot. The basic features of these robots are the ability to communicate with each other, move and receive data from the environment. They are offered for sale at different prices depending on the hardware features they use. In swarm robots, the robots must be numerically higher in order to behave like a swarm.

Robots used in swarming applications with dimensions of 2-5 cm are Colias, Jasmine and Kilobot. All these robots have distance and light sensors. The movement uses Colias and Jasmine DC motors due to its small structure. This offers a faster mobility. It has a speed of about 35cm/s. Kilobot, on the other hand, provides movement with vibration. However, its speed is around 1 cm/s. This is slower than robots using dc motors. E-puck, SwarmBot, Kobot and R-one swarm robots between 5 and 13 cm in size can be given as examples.[4, 18, 22, 23]

In robots of this size, movement is provided by a DC motor. With the increase in size, additional equipment is also offered in robots. In addition to the sensors found in small robots, the camera is also found in these robots. Again, the processor structure used in proportion to the dimensions also differs. With advanced processors, it is possible to run more comprehensive artificial intelligence software. TurtleBots, which have emerged in recent years and are controlled by the widely used raspberry pi[24], are also used in swarm applications[24-26]. Linux-based robots support ROS. In this way, tests can be performed in both simulation and physical environments. Other robots with ROS support offer validation and testing in academic studies[14-16]. Figure 1 shows the Turtlebot Burger Pi. Figure 2 shows the Turtlebot Waffe with its robotic arm.

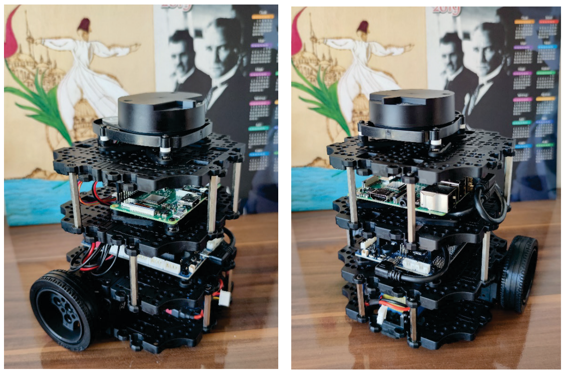

Fig. 1. *Turtlebot Burger Pi*

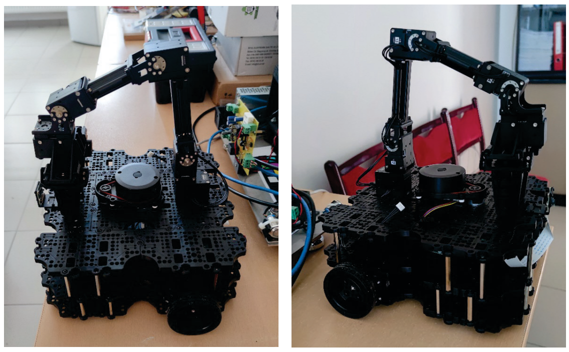

Fig. 2. *Turtlebot Waffe and Arm*

CONCLUSION

In this study, information about swarm robots is given. Rallying, distribution, assignment, collective action, collective mapping, source search and transportation behaviors expected from swarm robots are explained. Unlike autonomous robots, they are robots that act and accomplish tasks by communicating with each other thanks to the communication they establish among themselves. Academic studies with this robot and the experimental platforms used in these studies were also examined. Robots classified according to their size and abilities are mentioned. For herd robot applications, the turtle bot platform, which is currently based on ROS and has a Raspberry pi, is mentioned. In the study, swarm robot definition features and commercial swarm robots that can be tested are discussed.

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