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Swarm Robots Communication-base Mobile Ad-Hoc Network (MANET)

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***Abstract*—This paper describes the swarm robots communication and control base Mobile ad-hoc network (MANET). MANET is a source of codes which migrate the network, collects and exchanges information of network nodes. In this work, the communication networks, which do not rely on fixed, preinstalled communication devices like base stations or predefine communication cells. Communications standards are considered in this work use the ad-hoc network such as Wireless LAN, X-Bee/Zig-Bee and Internet platform. All standards are integrated on swarm robots for real experiments. For finding the target, Particle swarm optimization (PSO) algorithm is proposed to control the real swarm robots communication in unknown experiment. As a results swarm robots-base MANET use PSO algorithm produce past response to find the target and swarm robots can move in the group without collision.**

Keywords—component; swarm robots; MANET; communication system

I. Introduction

Robot cooperation is a challenging domain for researchers in swarm application. It is the ability of solving a task by a group of robots. Robots cooperate as a team in order to achieve a common goal. Multi-robot cooperation increases efficiency of single robot and allows the achievement of complex tasks, which cannot be accomplished by a single robot [1,2]. Robots act through a cooperative behavior. They are aware of their teammates, they share goals and their actions are useful for the whole group [3].

Accomplishing a cooperative task needs some form of communication. This process allows robots to communicate through their environment based on environmental change or robot behavior. Robots are equipped with sensors to observe the changes. The sensor can exchange messages to transfer various information about the environmental situation such as, robot positions, current status, future actions and target position. Several works explored communication effect on performance of multi-robot systems in different cooperative tasks. They concluded that communication between robots can multiply their capabilities and can improve their efficiency. It can provide benefit for many tasks [3,4].

Using wireless communication among multi-robot systems has become an important area of cooperative systems research [5]. Wireless communication, such as X-Bee/Zigbee, WiFi, or Bluetooth, provides convenient way to enable robot swarm cooperation. Mobile Ad Hoc Network (MANET) is pervasive for the communication of a group of mobile robot or robot swarm [4,5]. To facilitate the cooperation between swarm robots which fulfill a complicated task or monitor an area, MANET cooperation based on mobile agent (MA) can be used. This paper is organized as follows. Section 2 discusses related works in robot swarm MANET cooperation. Section 3 presents swarm robots based on mobile agent. Section 4 describes swarm robots experimental and results. Finally, section 5 concludes this paper.

II. Related Works

A Mobile Ad-hoc Network (MANETs) is a network of mobile devices that can communicate with each other without the use of a predefined infrastructure [4]. Generally, MANETs consist of wireless sensor device that are enhanced by mobile platforms. In most applications, these mobile platforms are mobile robot systems [5]. It has long been recognized that there are several tasks that can be performed more efficiently and robustly using multiple robots. Moving from one robot to a group of robots increases the resources available to accomplish a task, but adds its own complexity. Locating one or more targets within an unknown environment is a task well-suited to a group of mobile robots. One major challenge within multi-robot research is to design effective algorithms that allow a swarm robots work in the group to find target locations. Some literature describe a techniques proposed for efficient multi-robot application in order to facilitate the development of cooperative control systems [5-8]

One of method that can be applied for robots to search the target is particle swarm optimization (PSO). PSO uses multi-agent search to find global optima in a multi-dimensional solution space [9]. This method is based on mathematical operations in primitive computational and not complex in terms of speed processing and memory utilization. The algorithm is very simple; it can be implemented in just a few lines of code [10]. This method explores the ability of animals looking for food sources. Each individual in PSO will be considered as a particle [10,11] in the case of a swarm of robot, robot that represents the particles and the target position represents the available food sources. PSO based multi-robot target search approach is presented in [6,10,12]. However, in that paper the implementation PSO in multi-agent only in simulation platform not in real swarm robots. This paper presents PSO algorithm to control the real swarm robot communication for finding the target as mobile agent-base MANET in real experiment".

III. DESIGN AND EXPERIMENTS

Coordination and control of MANETs, especially collaborative target localization is an emerging research area. The MANETs monitor an environment. Sensor data is transmitted to a central system for processing through multi-hop communication. Then the navigation commands are delivered. If data needs to be transmitted over a long distance, one has to either use a high power transmission, or several numbers of hops. While the former scheme results in premature exhaustion of the nodes, the latter results in accumulation of delays. Centralized control is prone to network congestion as well.

A possible way to overcome these limitations is to use efficient localization architecture. The desired control and operations in a MANET is illustrated in Fig. 1. Its shows a sketch of an environment, covered by the ad-hoc local network build by robots. This architecture employs data-centric message downloading, processing and uploading. Major requirements of such strategies are: self-organized operation, self-learning properties, reduced network utilization and faster response. In this work PSO is proposed for communication swarm robots as mobile agent in the real environment.

A. Mobile Agent Architecture

In this work, mobile agent with MANET is a MANET whose nodes are mobile robots, they are a source of codes which migrate the network, collects and exchanges information of network nodes. For controlling of mobile agent the main purpose of network communication. The proposed communication architecture and control of mobile agent is shown in Fig 1. They contain four devices: static nodes, mobile nodes, data base system includes a single board computer as a server and clients. All nodes consist of all the sensor nodes. Communications standards between mobile nodes are considered for the ad-hoc network in this research are ZigBee. Communication between the data base system and the client nodes are conducted by using Internet platform. The mobile sensor node is perhaps the low cost of mobile robot [11].

The mobile robot platform have lithium polymer batteries, low-cost infra-red sensors, TGS 2600 gas sensor, simple actuator, and low-cost microcontroller AT Mega 16. Our design uses expandable processing board and sensor board with multi-sensing capabilities, which provides a flexible basis for changing experimental needs. Mobile sensor node uses X-Bee-Pro OEM/ZigBee (IEEE 802.15.4). This is radio frequency transceiver and receiver serves on full duplex communication at frequency 2.4 GHz.

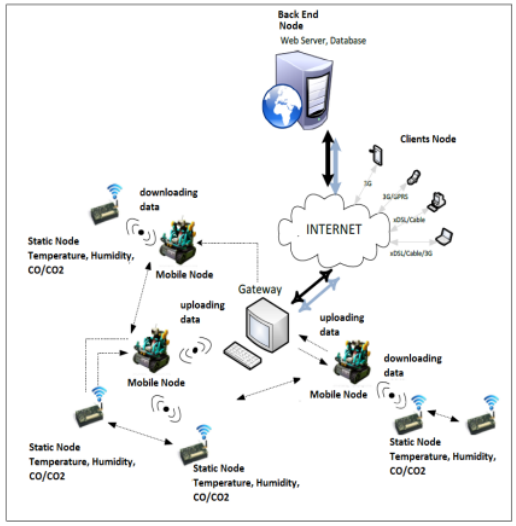


Fig. 1 Mobile agent communication and control in MANET

B. Particle Swarm Optimization Design

PSO based searching algorithms are presented in this work. The algorithm navigates the swarm robots of a mobile agent-base MANET to search for a target. When the first mobile agent reaches a point in sufficiently close vicinity of the target, the tasks is deemed accomplished. The process of PSO algorithm is initialized with a group of random particles (solutions), N. The i_{th} particle is represented by its position as a point in an S-dimensional space, where S is the number of variables. Throughout the process, each particle i monitors three values: its current position (x_i), the best position it reached in previous cycles (p_i), its flying velocity (v_i). These three values are represented as follows,

Current position $x_i = (x_{i1}, x_{i2}, ... , x_{is})$
Best previous position $p_i = (p_{i1}, p_{i2},...., p_{is})$ (1)
Flying velocity $v_i = (v_{i1}, v_{i2},...., v_{is})$

In each time interval (cycle), the position (p_g) of the best particle (g) is calculated as the best fitness of all particles. Accordingly, each particle updates its velocity v_i to catch up with the best particle g, as follows,

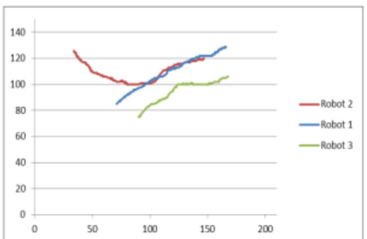
$$v_i^{k+1} = w_i * v_i^k + c_1 * rand * (p_i^k - x_i^k) + c_2 * (p_g^k - x_i^k) \quad (2)$$

$$x(k+1) = x(k) + v(k+1) \quad (3)$$

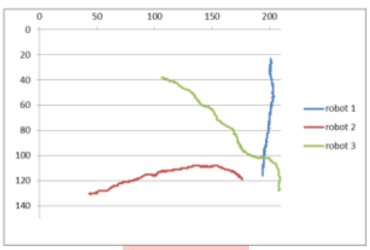
As such, using the new velocity v_i, the particles updated position becomes, where c_1 and c_2 are two positive constants named learning factors. rand() and Rand() are two random functions in the range [0, 1], v_{max} is an upper limit on the maximum change of particle velocity, and w is an inertia weight employed as an improvement proposed by Shi and Eberhart [9] to control the impact of the previous history of velocities on the current velocity. From equation (2) and (3), it can be stated that the speed of the swarm robots will continue to decrease in all iteration and eventually reach the condition where the robot stops moving

C. Swarm Robots Communication Results

In this experiment, three identical robots move in the group towards a predetermined to find target position. The objective in this work is not to navigate a particle to go close to the target, but to navigate a group of particles to converge around the target. The swarm robots that carry the MANET nodes is to converge around the target location. In this work, this task is similar to convergence of a group of swarm robots to achieve around the gas source. As the PSO search progresses, the particles move closer to the target as shown in Fig. 2 (a) and (b) respectively.



(a) Experiment 1



(b) Experiment 2

Figs. 2. Mobile agent trajectory

The communication between robots uses X-Bee/ZigBee hardware. Its wireless communication standard IEEE 802.15.4 with low power consumption and optimized for timing critical applications. It has a data rate of 250 kbps and allows ranges from 10 to 100m. The communication results between robot and server as shown in Table 1.

Table 1 shows the results of sending and receiving sample data from swarm robots to local server. At a distance of 1-30 m without obstacle data successfully send. Except at a distance at 20, 25 and 30 m respectively with thick wall about 25 cm is failed to send, it is caused by obstruction when tested in the form of a thick wall. But when it tests in thin wall about 5 cm the swarm robot can transmit the data and successfully receive in server.

TABLE 1. COMMUNICATION DATA

No	Data Transmit (robot)	Distance (m)	Data Receive (server)	Result
1	50	1	50	success
2	50	5	50	success
3	50	10	50	success
4	50	15	50	success
5	50	20	50	success
6	50	25	50	success
7	300	30	300	success
6	50	20 with thin wall	50	success
8	100	25 with thin wall	100	success
9	50	20 with thick wall	-	fail
10	50	25 with thick wall	-	fail
11	300	30 with thick wall	-	fail

IV. CONCLUSION

Mobile ad hoc networks are well suited for the communication and cooperation of robot swarms. The Communications standards considered in this work for the ad-hoc network are Wireless LAN, X-Bee/ZigBee and Internet platform. All are integrated on three small identical robots for experiments in real world environments. To make swarm robots as mobile sensor node communication for finding the target, Particle Swarm Optimization (PSO) algorithm is used. As a results swarm robots-base MANET use PSO algorithm produce past response to find the target and swarm robots can move in the group without collision. Robot swarm has emerged as a solution for complicated applications in unknown environments. In the future the network is studied analytically, in experiments with large mobile agent to verify the results.

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