Automated Robot Communication System Using Swarm Intelligence

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Abstract. Swarm intelligence is best example of natural phenomenon giving of team work. Here the focus is on use of swarm intelligence to form the communication between automated robots for better and reliable results. With the main aim of exploring the concept for the progressive development of swarm robotics in an engineering field and solve the complex real time applications by setting a communication among automated robots. Currently, Swarm robotics is one of the most important application areas for swarm intelligence. Swarming behaviors of groups of organisms is called as swarm intelligence. There are many advantages of swarm intelligence like, good performance, high reliability, low cost with less complexity. Swarm robotics is the group of robots which are self-assembled and self-communicating to solve such task, which are difficult to solve individually by a single robot. Swarm robots are designed in such a way that they can self-configure and dynamically change their structure to meet environmental conditions. Section 1 will give the detail introduction of research work carried out. While coming consecutive sections will explain literature review, complete implemented system, result and references used.

Keywords: Swarm robotics · Swarm intelligence · Multi-Robot Communication · Server-Client Application · Obstacle detection

1 Introduction

There are various insects and creatures in the natural world, which follow simple law to accomplish an assignment cogently and expertly. The different cases of collective intelligence seem to arise from very simple individuals that are working together. There are many examples of collective intelligence seems to arise from very simple individuals that are working together [1]. Swarm Intelligence is the trait found throughout the animal kingdom. Swarm intelligence is an effective tool for managing complicated tasks, which comes via coordinating with each other without the leader. Application of swarm intelligence on the robots is called as swarm robotics. Swarm robotics is group of robots communicating together to perform task. This provides lot of diversity and helps in widening the capabilities of individual robot.

This swarm of simple robots coordinates their actions in a decentralized way. Robot swarming provides flexibility and robustness. Swarm Robotics is inspired from the

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swarming nature of organisms. Examples such as Bees, Ants [11], Schooling of fishes, Flock of birds, colony of bats, bacteria colony [9], etc. Behaviors of such beings are mirrored on the robots. Different algorithms are developed for functioning on the same concept, so that robots can replicate the functioning of swarm [2–5]. Swarm robotics provides application in the field of science such as navigation [8] in the confined area, agriculture foraging, searching for tumors in the human body; target searching, search and rescue operations, military applications. Swarm robots fix up other issues, which a single large robot faces [6]. These robots are cost efficient, power efficient [7], durable as such, if small unit of swarm fails, the swarm continue to work, multi-tasking is possible as each robot or the batch of swarm with different tasks. This paper focuses on one of the application of swarm intelligence. Swarm bots are implemented using Arduino microcontroller. Multiple robots communicate using sensors. Stepper motors are used to maneuver the bots. Path of each robot is monitored [10]. Ant colony optimization is used for identifying the shortest path for the robots [11, 12].

2 Literature Review

Where the problems that seems difficult or impossible for single individuals to resolve, can easily be solved by a group of organisms by working together. So, swarm intelligence can be seen as a mechanism in which multiple robots can be used to overcome some of their own cognitive limitations. Such system doesn't work on Master-Slave configuration, where one robot is master and others are slaves and slaves have to follow the instructions given by the master. But here each and every robot acts freely and asks for help when ever required. By this type of approach it becomes easy to solve the problems that are hard to solve individually. There are number of fields where swarm robotics is playing important role like, environment monitoring systems, oil cleaning, under water surveillance and many more.

A large number of researches are taking place continuously in the field of Swarm Intelligence. Zhu and Tang [1] gave a broad overview of swarm intelligence. They defined the term swarm intelligence in three parts namely biological basis, artificial literature and swarm engineering.

Nair, Frye, Coronado and Qin [2] has developed multi-robot system using particle swarm optimization (PSO) technique, which is used to evaluate the social characteristics of the insects. Also different approaches are discussed that are used for formation control and collaborative control of self-governing vehicles.

Patil, Upadhye, Kazi and Singh [4] have used Arduino MEGA-2560 to control robot for swarm application. In order to accomplish their objectives they have made use of target tracking algorithm.

Liyan, Sainan, Geng, Yongli and Guanyan [11] has proposed ant colony clustering algorithm based on swarm intelligence which is much efficient than ant colony algorithm. They have also proposed a new methodology of picking and dropping objects.

Lv and Zhu [10] have explained a new dynamic routing algorithm for packet switch communication networks. This algorithm is inspired by ants that explore the area as a network and find the best route to the destination.

Ravinandan, Prasad and Kumar [12] have proposed a novel way of discovering different paths/routes to the known destination and create an intellectual map using

swarm intelligence. The technique is developed so that human interruption. The target of this paper is path exploration in combat and non-combative area for search and rescue operation.

3 Developed System

The system had been developed step by step by setting following goals, initially design a system of robots to follow a random path to reach a destination. In the initial phase all the robots will try to identify the path to the destination. The robot which will identify the destination first will communicate with other robots. These robots after the communication is get setup among all, will calculate shortest path to reach destination. Every robot will create its own database that will contain step values given to the stepper motors. The robots trying to find destination will share its database so that a map can be created using the step values. The database created by each robot will be stored for reference and it will be used for reaching the destination point. The system flowchart has been shown in Fig. 1.

There will be a confined area/field where two or more bots will be travelling randomly in search of an unknown destination (Black-patch). Swarm-robots travel the route randomly to reach the aim. The microcontroller used is ATmega328p. The power supply of 7 V to 12 V is provided to the micro-controller. Interfaced are the two IR sensors, Wi-Fi module (ESP8266) and two stepper motors. The system block diagram has been shown in Fig. 2.

IR (infrared sensor) used serves two purposes. One is for object detection and other is for black spot detection. IR sensor is present in circular manner above the robot for detection of objects around the robot. One IR sensor will be below the robot for black spot detection (destination identification).

Micro-controller generates random step values. These are feed to the stepper motors through the motor driver. According to the step values received by the stepper motors, the robots direct themselves in a random direction. Thingspeak.com is a very popular website used for implementation of IoT (Internet of Things) applications. The random step values generated are transmitted to thing speak server with the help of Wi-Fi module interfaced with micro-controller. Using various AT commands, a wireless connection is established between the ESP and thing speak web server. Thingspeak.-com provides API keys (Write API key and Read API key) using which the data can be stored or accessed. Once the connection is established, using write API key the ESP starts sending the step values to the web server, results has been shown in Fig. 6. After successfully sending data to the server, the connection is cut-off. The send step values have accessed through a program using read API key or download the file in various formats such as.csv,.txt, etc.

The step values retrieved from the server used to generate a GUI map. The map makes understanding of robot location easier as shown in Fig. 4. If any of the robots find the destination, it will reveal its location to other robots and wait at the destination until the remaining robots arrive. The notified robots find the shortest pathway to the destination from their current location [10]. Following the shortest distance, they will reach the destination.

Once the destination is traced and notified to other robots, the shortest path to the destination of each individual robot will be calculated in GUI (software) and then the respective number of steps of the motors will be calculated and given to the robots [14].

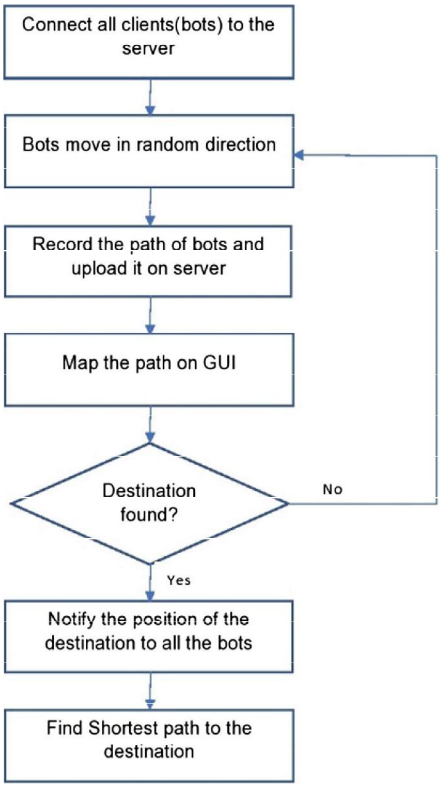

Fig. 1. Proposed system flow-chart

There will be a confined area where two robots will be travelling freely in search of a black spot. Black Spot is nothing but the destination of all the robots and all will try to find it. To detect the black spot and to communicate with other robots, IR sensors have been used. The robot that finds the black spot will notify to other robots that he have successfully identified the black spot. Initially, there is no master robot or Slave robot as shown in Fig. 3(a), (b) and (c). All the robots will travel randomly in the area and the robot that first find the black spot will act as master and order the others to find the shortest path to destination and follow it and reach the destination. As shown in the Fig. 3, there are three robots i.e. bot1, bot2 and bot3.

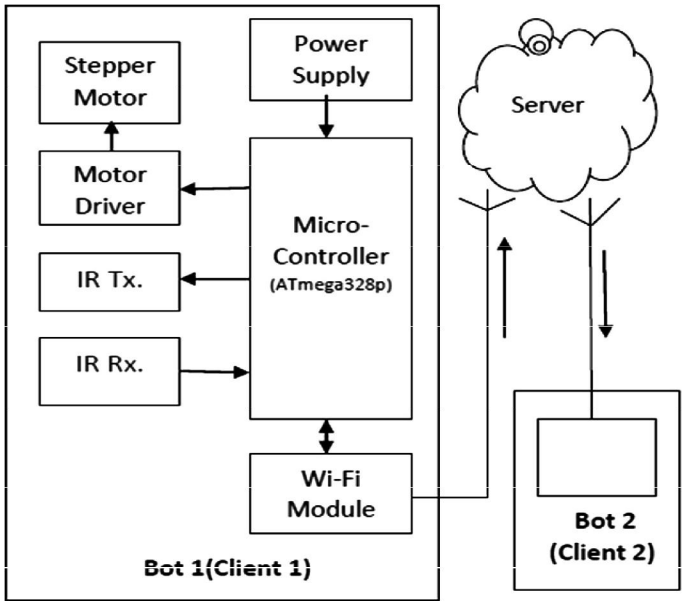

Fig. 2. System block diagram

All robots are allowed to departure from a same starting point. These three robots move in random fashion in order to find the black spot (destination). Random step values are given to stepper motor so that the robots can follow a random path. Bot2 is successful in finding the black spot and hence it will convey the message to bot1and bot3 that he has found the black spot. WiFi module is used for transmission and reception of the information between two robots. The step values of each bot will be transmitted to server using Wi-Fi module [13]. Accessing these step values a map will be created as shown in Fig. 4. Once the destination is determined the other two robots i.e. bot1 and bot3 referring the map, will find the shortest route to the destination using any shortest path algorithm which will save the time of robot to reach destination as well make the system more time efficient [15]. Following the shortest path the robots will reach the destination.

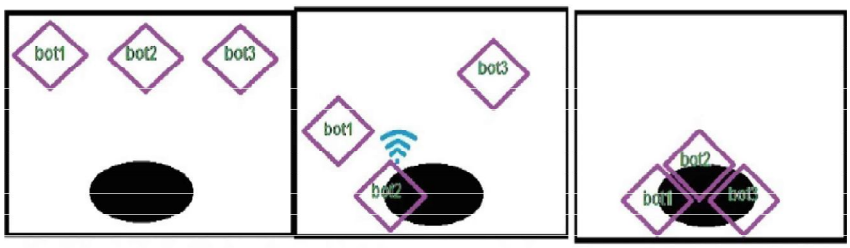

Fig. 3. Robots finding destination (black spot) with same starting point and reaching to destination by following shortest path

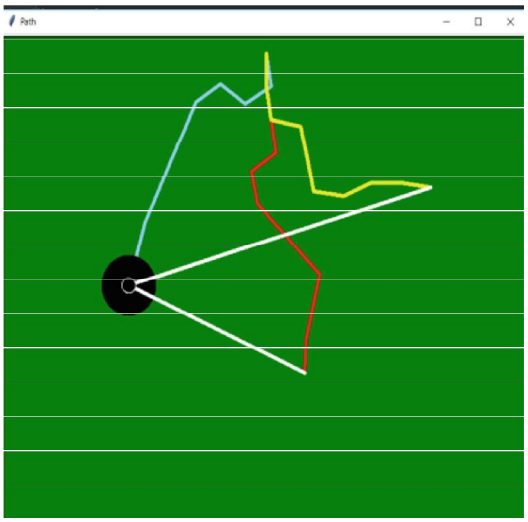

Fig. 4. Map created using fetched values from server

4 Result and Conclusion

Complete system has been implemented successfully. Results received have been shown in following Fig. 5. The designed robot is shown in Fig. 6. Interfacing of IR sensor is done to serve two purposes, destination identification and obstacle detection. Stepper motor is directing the robot in required direction. The data (i.e. step values given

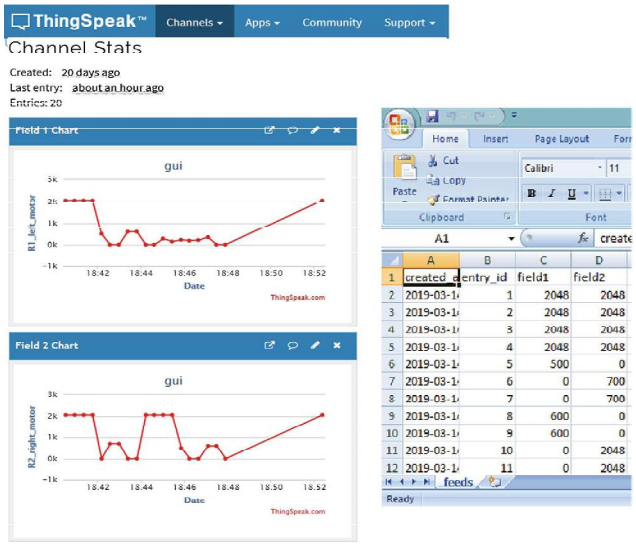

Fig. 5. Communication set up among robots

to stepper motor) is successfully sent to the server website (www.thingspeak.com) using Wi-Fi module. Client can access data from server and create a map based on step values. Robots are tracing the destination successfully. The communication has been set up successfully among robots. Experimental results received has been tested on various scale and given the satisfactory output. Bots are following the accurate path and reaching to destination with shortest path.

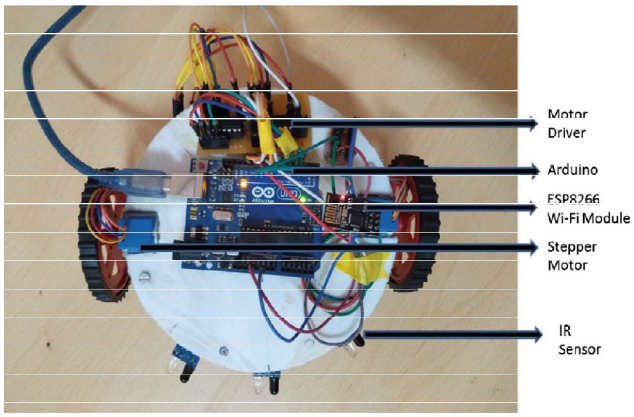

Fig. 6. Complete hardware system implemented

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