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A Strategy to Push Box from One Place to Destination with the Swarm of Robots

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ABSTRACT: The paper proposes a strategy for transporting a large object to a goal using large number of mobile robots. Robots will communicate with each other and push the object towards goal. The paper aims at combining biological phenomenon of ant colony carrying food from one place to another and robotics to develop a system which can work more efficiently and user friendly for industrial/construction applications. This paper deals with a Swarm of robots which work together on designed algorithm to search for randomly spread blocks and push those blocks to some predefined locations. Source will be different and destination is fixed. The system will be completely autonomous and will inter communicate to complete the task in accordance with the designed algorithm. The robots will traverse in different directions in search of blocks. If a block is detected by any one of them, the robot will send its positions to other robots, also it will send message to the robots that it is busy and they can search for another blocks. After that it will start pushing block towards goal. In this way, object will be transported towards goal.

KEYWORDS*:* Source, Object, Field, Destination, Cooperative, etc

I. INTRODUCTION

Swarm robotics is based on swarm intelligence concept. Basically swarm means a mass of people, animals or things in motion. Swarm intelligence is based on the social behavior of insects colonies and other animal societies. There are multiple agents interacting with each other and performing a particular task. In swarm robotics, individual robot act as an agent, intercommunicate with each other and performs a particular task. Swarm robotics systems make use of algorithms like particle swarm optimization, ant colony algorithm, bee algorithm, etc. Proposed system makes use of ant colony algorithm which is based on behavior of ant colony in nature. Ants find optimum path to reach towards food destination from nest source. The system uses swarm robotics concept for carrying building blocks from source to destination. Jianing Chen, Melvin Gauci, Wei Li, Andreas Kolling, Roderich Grob proposed the paper which gives generalship that deports a big object towards goal with the use of multiple moving robots where goal is obstructed by an object.[1] Lorenzo Sabattini, Matteo Cocetti, Alessio Levratti, and Cesare Fantuzzi, proposed an approach which cooperatively finds different paths. It included independent robots and dependent robots which coordinates with each other.[2] Jonathan Fink, M. Ani Hsieh, and Vijay Kumar, proposed a paper which presents a system where multiple robots are sent in an environment where they surrounds an objective and push it towards destination.[3] Jianing Chen, Melvin Gauci and Roderich GroB, proposed a paper which presents a system where group of robots push an object towards a goal where the view of the goal is occluded by the object.[4] K. Kashiwazaki, N. Yonezawa, M. Endo, K. Kosuge, Y. Sugahara, Y. Hirata, T. Kanbayahi, K. Suzuki, K. Murakami, and K. Nakamura have presented a paper which gives a new way to transportation of car using more number of moving robots.[5] The existing system for carrying blocks from one place to another needs manual control over robots, and it is centralized. The proposed system is autonomous and decentralized, that means each robot has control on its own and they keep sharing information and work according to it. Important drawback of existing systems are:

- Inefficient use of human resources
- Centralized system
- less flexible
- no cooperation.

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II. COMPONENTS USED IN PROPOSED SYSTEM

The proposed system offers an effective solution for transporting blocks from one place to another. Components used in proposed systems are as follows:

1. AVR ATmega16 microcontroller Advanced Virtual RISC(AVR ATmega16) is a 40 pin microcontroller with 10kBytes of program memory. It is widely used due to its simplicity, low cost and it is open source. Microcontroller is a heart of proposed system and is responsible for processing input sensors and take respective actions.
2. Line Sensor TCRT5000: The TCRT5000 is a reflective sensor which includes an infrared emitter and phototransistor in a leaded package which holds visible light. The proposed system uses it for mapping arena.
3. SHARP sensor: It is digital output sensor and is wide angle distance measuring sensor. It is nothing but an IR sensor and the proposed system uses it as an obstacle detection sensor for detection of the block.
4. Motor Driver IC L293D: L293D is a dual H-bridge motor driver IC. Motor drivers act as current amplifier since they take low current control signal & provide a higher current signal. This high current signal is used to drive motors. L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously both in forward and reverse direction.
5. RF module: The Nordic nRF24L01+ is a high integrated ultra low (ULP) 2Mbps RF transceiver. It uses Gaussian frequency shift keying modulation technique to transmit and receive data wirelessly at frequency 2.4GHz. The proposed system uses it to communicate between robots.
6. LCD 16*2: LCD is used for display purpose to make the proposed system user friendly.
7. SERVO Motor & DC motor: For performing mechanical actions in order to complete task as per algorithm.

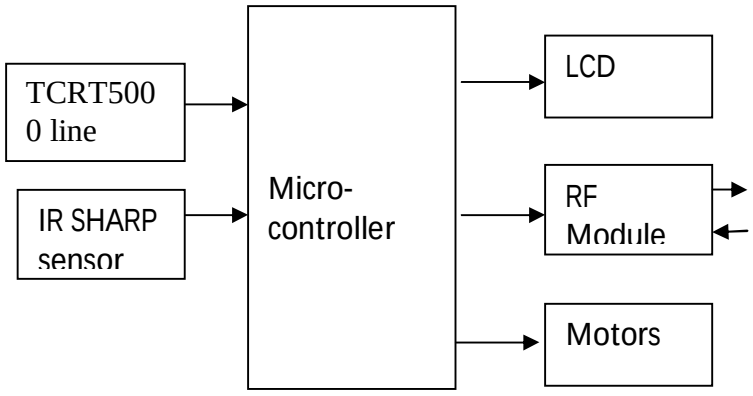

Fig.1Block Diagram of Robot

III. SYSTEM ARCHITECTURE

Fig. 5 shows overview of system architecture. System architecture is described in section II which is consist of :

1.Robotic Interface
2. Mapping area
3. Object Detection & placement

Robots are designed to maneuver in mapping area to scan each and every corner of the field. Scanning is done via marked grid. The grid is followed by the robots according to designed algorithm that is already fed into its library. While maneuvering, robots interact with each other to avoid collision.

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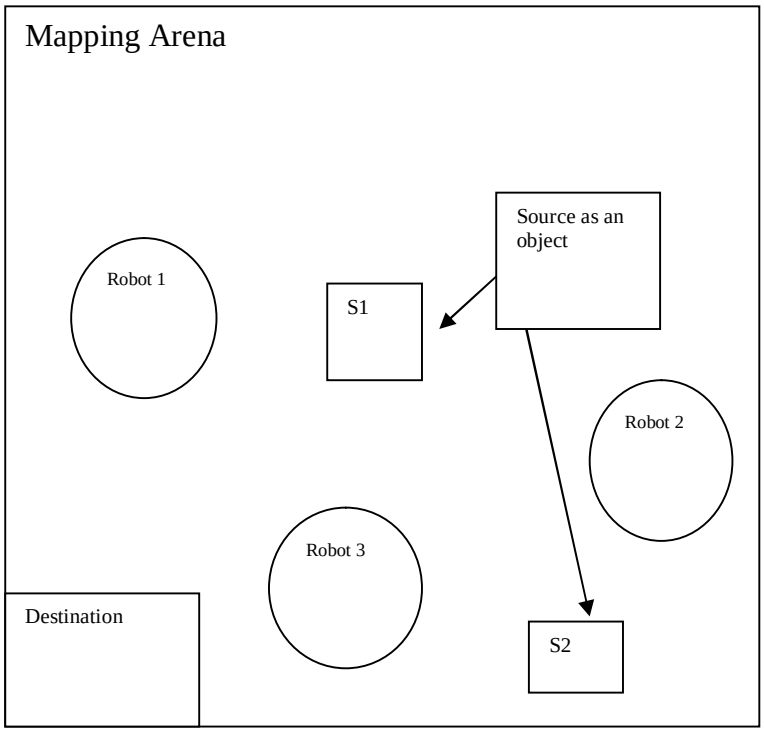

Fig. 2 Overview of System Architecture

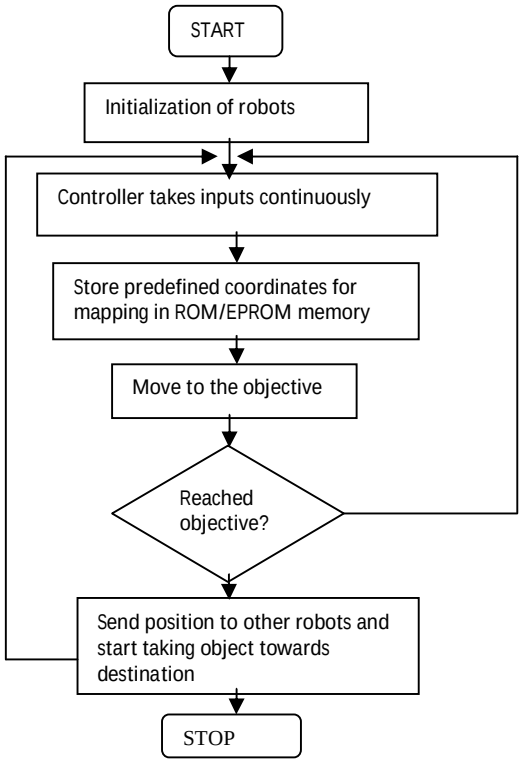

Fig.3 Flow Chart of Overview of Algorithm

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Because of multiple robots where they communicate with each other via RF network. Task that is to be completed is initiated as an objective is reached. This is performed collectively as per the designed algorithm. Fig. 4 shows overview of algorithm that is to be followed.

IV. IMPLEMENTATION

Implementation of the proposed system was considered as the difficult one. In order to minimize difficulty, workout with simple concepts is started. It started with constructing robots that can follow line i.e. laid in the mapping area. Following parameters are considered for mapping:

1. Robot Construction for manoeuvring:

Mapping arena is of 5ft by 4ft.Each block of grid is of 30 cm by 30cm. Robot is constructed within dimension of 25cm by 20 cm. Fig.4 shows construction of robot having wheels at back side. Fig. 6 shows the grid of white and black colors for line following.

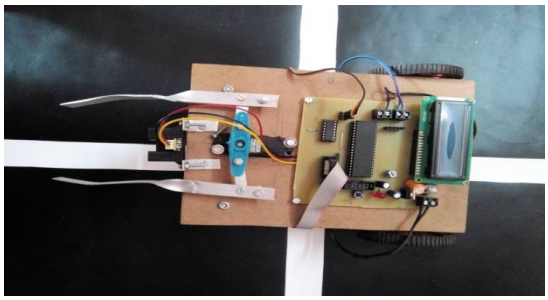

Fig. 4 Construction of Robot

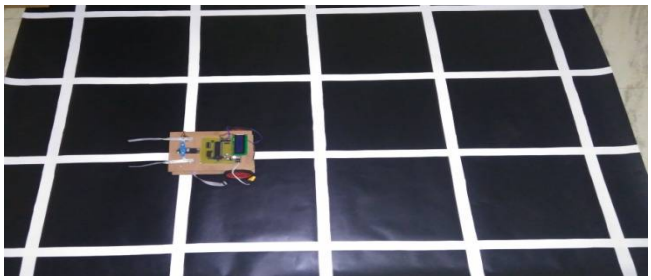

Fig.5 Grid for line following

2. Sensor Interfacing:

TCRT5000 is a five sensor array. It was connected to PORTA of ATmega16 as PORTA is for ADC inputs. ADC has 10 bit resolution. Following are the reading taken:

TABLE 1: ADC reading taken on LCD for TCRT5000 on different surfaces

Surface	ADC readings
Black surface	>500
White surface	<500

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TABLE 2: ADC readings taken on LCD at different conditions

Parameters	ADC readings				
PORTA pins w.r.t. sensor pins	S1-PA0	S2-PA1	S3-PA2	S4-PA3	S5-PA4
On cross points	<500	<250	<150	<100	<500
On line	>700	<400	<350	>700	>700

According to table 1 and table 2, It has been observed that when the robot is on black surface it shows maximum reading and when it is on white surface it shows minimum reading. So considering all these parameters white line can be followed.

3. Final approach towards algorithm:

Counting cross points is a significant task while going for algorithm. first cross point is detected when it meets ADC readings as stated in table 2. Variable is initiated with zero value while writing code and when cross point gets detected, variable increases by one and so on. The predefined algorithm is stored in the library. An array holds all the conditions that need to satisfy for the algorithm.

for example,

a[21]={0,0,0,1,1,0,0,2,2,0,0,1,1,0,0,2,2,0,0,3,0};

0 for moving robot in straight ,1 for taking right turn, 2 for taking left turn, 3 to stop robot. Softwares used are AVRStudio4 for compiling the code and prog is for downloading the code into microcontroller.

Servo motor runs on 5V power supply and PWM input. Variations in the motion is obtained by varying PWM input. It lifts specified object and place it into the destination. At the same time robots do not collide with other because use of SHARP sensor has helped to maintain safe distance between two robots. Robots communicated with each other via wireless module with UART protocol

V. RESULTS

1. Design of robot is optimum and work proper according to desired algorithm.

TABLE 3: Parameter Results

Parameter		
Accuracy	Line Following	98%
Resolution	SHARP sensor	0.01cm

Servo motor's motion for opening and closing for arm is constant for all test conditions as per program. Table 3 shows parameter results which shows that robot works according to algorithm.

2. Wireless communication between robots is achieved practically to all conditions.

3. Execution of algorithm is perfect as per designed parameters and with 100% result and accuracy

VI. ADVANTAGES & APPLICATIONS

System provides intercommunication between robots. System is decentralized and autonomous. Scalability is in case of number of robots. It reduces complexity. It has applications in military, telecommunication networks, medical, entertainment, transportation.

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VIII. CONCLUSION

Swarm of robots which work together on designed algorithm to search for randomly distributed blocks and push those blocks to some predefined locations. Proposed System has analysed through each and every aspect regarding swarm concepts. It has been found that the main conceptual working of swarm is totally dependent on the algorithm that is to be used and the hardware implementation of the system. It reduces human efforts and time, as well as the system is made decentralized and autonomous. Drawbacks of an existing system have been tried to overcome through swarm system.

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