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Behavioral control of swarm robots with implicit communication: A New approach

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Abstract: *The Practical Swarm Optimization (PSO) algorithms are required behavioral control to perform successful navigation. The role of communication with behavioral control is an important issue in swarm robotics. This paper presents how the leader and follower robots can change their mode of behavioral control by switching between centralization and decentralization processing methods with a new approach using implicit communication. The target of the robots is to reach the goal point, which is placed with IR beacon. The robots can avoid obstacles with the help of IR sensors (1 meter range) and communicates with RF Transceivers (2.4GHz).If there is no obstacle in between leader and follower, then follower continues to follow the leader as per centralization behavior mode. In this process if obstacle arrives between the leader and follower, it can avoid with IR sensor's information. When both of them are away from original path, then they are decentralized and plan to reach the goal individually. The customized prototype Robots are developed with Arduino Uno ATMEGA328P which is used as the control unit for both leader and follower with a transceiver pair of NRF24L01 (2.4 GHz) to achieve inter – swarm communication. The proposed algorithm is implemented in our laboratory and this design is pragmatic in industrial and medical fields.*
IndexTerms: *centralization, decentralization, obstacle avoidance, swarm robotics*

I. Introduction

Man being a social animal need to communicate with each other to live in society for his smoothness of living, by using language and gestures. Similarly in case of robots there is a vast research going on the way about a group of robots does the work by communicating each other there by emerging a field called swarm robotics with behavioral control.

The swarm robotics navigation and behavior control are majorly inspired by biological axis of ants, bees and even humans [1]. This has its advantages in flexibility, robustness, scalability over a single robot path planning. This field has got its importance in present robotic research that is in way of synchronizing of multiple robots to perform particular task.[2]Jung and Zelinsky (2000) have designed a heterogeneous cooperative multi robot system that was inspired by communication method of biological systems.

The robot path planning is one the most rattling issue in research which can be classified basing on the environment it is defined as known and unknown environment .which is done with the technique of SLAM (simultaneous localization and mapping) where the robots completely reckon on sensor information for exploring of unknown environment. The research axes was classified by swarm size, communication range, communication bandwidth, swarm reconfigurability by [3] Dudek et al. (1993).

The obstacle avoidance is one of main constraint in robot navigation. The single robot obstacle avoidances are proposed by Lumelsky et al [6] & [7].The new versions of obstacle avoidance by tangent bug algorithms [8]. The intensity based algorithm for improvement of the bug algorithms by Taylor et al [9]. In similar lines the obstacle avoidance in swarm robotics also creates more hurdles in path planning of robots.The other side of axes of the research influenced with obstacles disturbances, which creates the communication gap in between robots .In this scenario the robots changes from centralization to decentralization methods.

The centralization in robotics mean that robotic system or community where any one of them will be responsible for the work done by whole swarm which is cited to be leader robot, while other robots (follower) take its command from leader and acts accordingly. Similarly the decentralization inrobotic community is dwelled with fully autonomous robots which act independently for decision making. The authors [11] R.hamed et al is proposed algorithm regarding the obstacle avoidance of the robots in decentralization environment. In the swarm robotics navigation the centralization and decentralization methods are having their own advantages and disadvantages [1]. This paper presents the new approach of the behavioral control of multi robot which can swap between centralized and decentralized processing methods. The Microcontroller robots are best in implementation of algorithm with less power consumption [10]. It is economical and reconfigurable.

This paper is machinated as follows, section II deals with the proposed algorithm of the behavioral control between robots. The section III presents about design setup of embedded robots. Section IV is regarding the experimental results for proposed algorithm. Section V concludes the importance of algorithm.

II. Proposed Algorithm For Swarm Robotics

Key idea:-

The behavioral control based swarm robotic algorithm proposed here is to have communication between swarm robots. This algorithm is mainly developed with two aspects. The first key idea is development of communication between two robots using RF transceivers for behavioral control of robots. In this method the robots maintained to operate with centralization process. The leader always leads in this method, the follower robots follows the leader to reach targeted goal. The second level of algorithm is switching of robots from centralization to decentralization when situation demands. The both robots are navigated to goal independently with intensity based concept [4][9]. The both the robots are equipped with the IR seeker, there are navigated towards goal which is developed with IR beacon.

The Robots coordination with behavioral control is new approach in the swarm robotics. The control unit for each robot is developed in modes one is for centralization and other is decentralization.

CENTRALIZATION AND DECENTRALIZATION APPROACH:

The leader follower approach is one of basic concept of centralization. In this paper the leader robot is decision maker and it plans to traverse in the indoor environment in centralization approach. The leader robot checks the follower robot behavior at every 0.5 secs of time period. The leader realizes either the follower robot is followingit or not,by mode of implicit communication.

Initially the task is assigned to the leader robot by external user.The leader robot starts communicating the follower robot using RF transceivers (NRF24L01) for implicit mode communication. The SPI protocol is used to interface the RF transceivers with control unit board. The robots are also avoiding the obstacle in real time for both static and dynamic scenarios.

The static type obstacle avoidance is developed on similar lines of ‘M’algorithm. If the obstacle is dynamic it waits for 2 sec’s time period and checks the scenario. After completion of obstacle avoidance the leader checks the status of the follower. If the follower is also performed the obstacle avoidance in the guide lines of the leader robot then it acknowledge its status to the leader robot.

In this process if the status of the follower is away from the original path of the leader, then both will switch into decentralization control mode.In the decentralization mode each robot plans to navigate successfully towards goal. They are predesigned with the obstacle avoidance module to overcome the obstacle in indoor environment. The both leader and follower robotsused IR seeker to traverse towards the goal point.

Algorithm steps of behavioral control of swarm robots

Step 1: Initialization of the robots with the task by the external user, then the leader robot communicates with follower robot.

Step 2: The leader plans to traverse towards the goal with the intensity based method and every time checks the behavior of follower. When the leader is in forward motion until it encounters an obstacle and follower does the same by following leader that is in centralized mode.

Step 3: When the leader is confronted with obstacle it can avoid it withIR sensors and overcome with obstacle avoidance mechanism. The same information is transmitted to follower through RF transceiver ensuring that even follower avoids the obstacle.

Step 4: In centralized mode there is a chance of loss of communication between robots in that case the both robots switches to decentralized mode and individually reaches the goal with the help of intensity from IR beacon.

Remark 1: In centralization mode if there is an obstacle in path of follower it communicates this information to leader and avoids the obstacle by sensor values. The leader waits until the follower clears obstacle.

Design setup of Embedded Robot:

The Embedded Robots both leader and follower are designed and developed with sensors like five pairs of IR sensor, IR seeker and RF Transceiver module. All the modules are implemented on the device Arduino Uno ATMEGA328P as shown in Figure 4. The control unit module is heart of the embedded robot. The RF Transceiver module interfaced with devices NRF24L01 (RF transceivers), this interfacing developed with SPI (Serial Peripheral Interface) protocol as shown in Figure 1. The RF transceivers play key role in the algorithm for implicit communication.

The IR sensors are used for obstacle avoidance. The IR seeker is preferred for intensity based approach to reach the goal. The Goal is developed with IR Beacon which always transmits the IR signals for every 15° angle. This robot is powered with 12 volts/7 amps and regulated to the 5 volts level with level translator for driving the sensors. The 5v DC motors are used to traverse the robot motion.

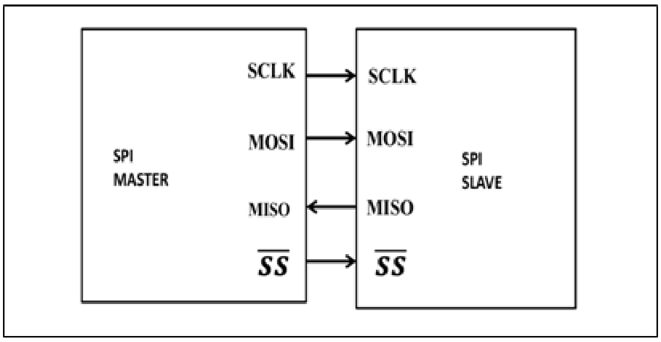

Figure 1: Serial Peripheral Interface Protocol

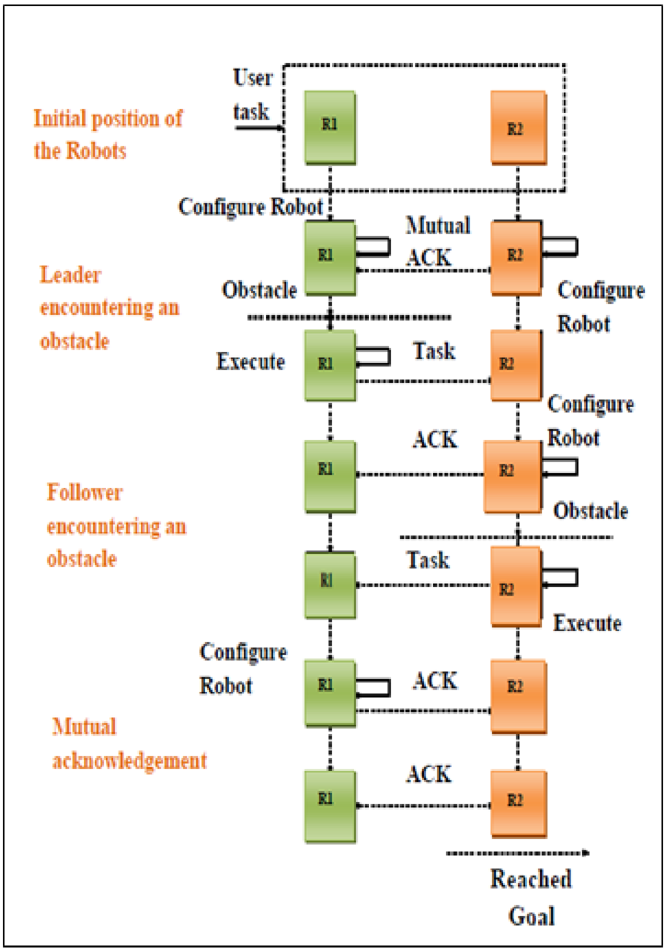

Figure 2: Sequence of the Leader and follower robots centralization flow.

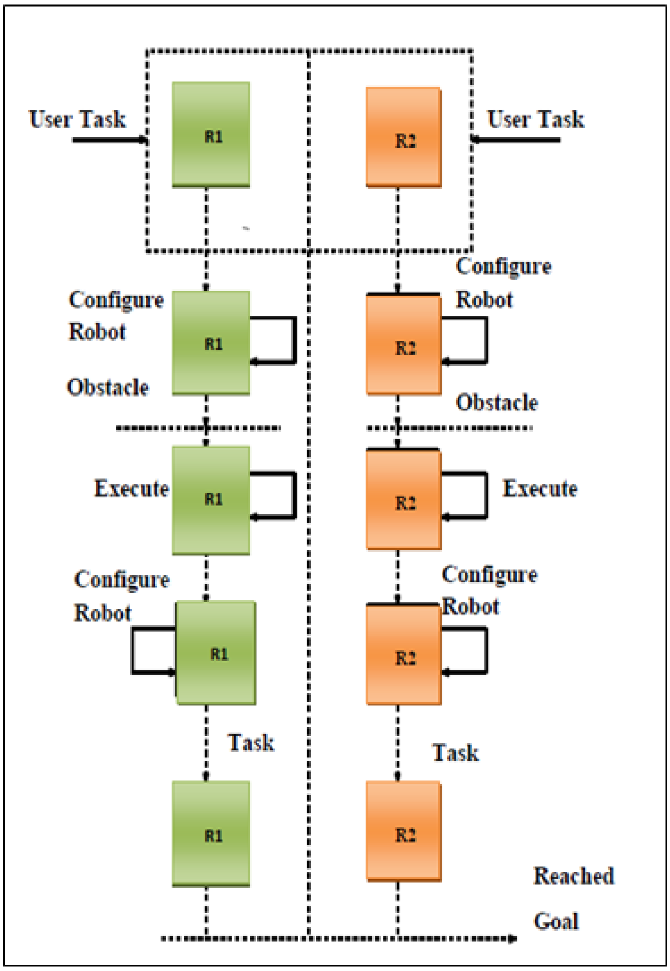

Figure 3: Sequence of the Leader and follower robots decentralization flow.

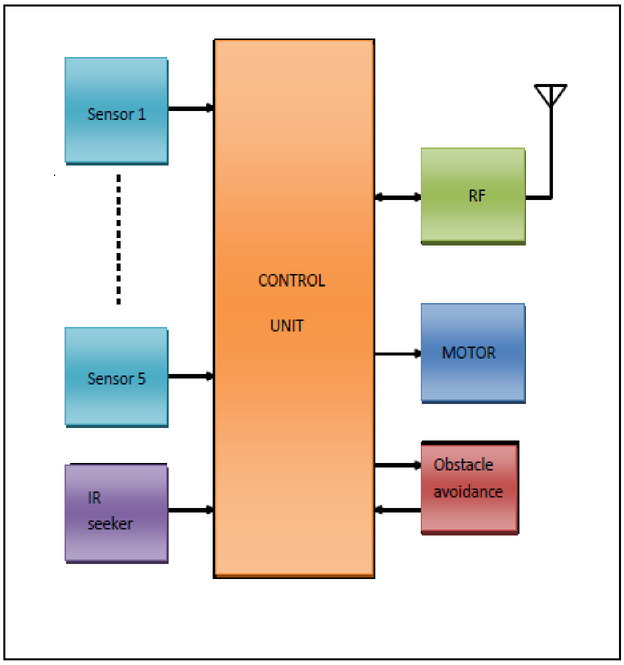

Figure 4: Block diagram of the Embedded Robot.

III. Results

Experiment 1: Centralization Approach

Figure 5: snapshot of Robots while encountering an obstacle

Figure 6: Robots while avoiding obstacle and acknowledging mutually

Figure 7: Robots aligning themselves after clearing obstacle

Figure 8: robots reaching goal point

Experiment 2: Decentralization Approach

Figure 9: loss of communication and the follower robot acting autonomously

Figure 10: A snapshot taken while follower failed to acknowledge leader there by switching to decentralization and reaching goal independently

Experiment 3: NRF communication results :

Figure 11: NRF device connected to Arduino

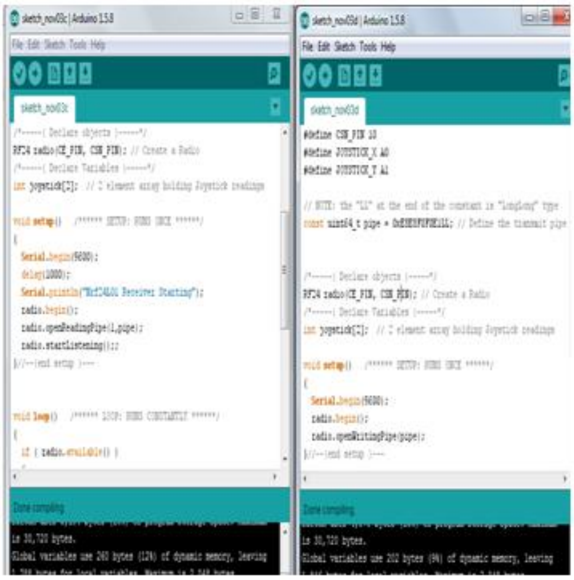

Figure 12: screen shot of Transmitter and receiver code console

Figure 13: serial monitor displaying transmitter and receiver information

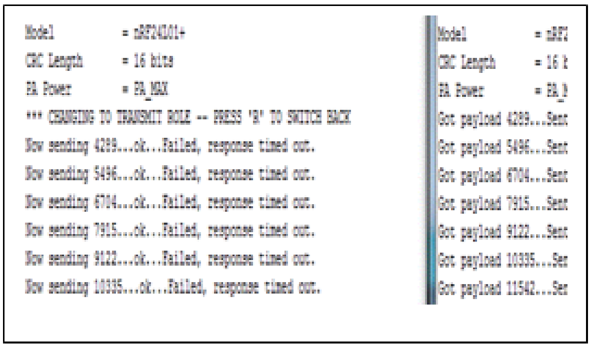

Figure 14: serial monitor displaying the information of communication loss

IV. Conclusion

Theme of this paper is about the behavioral control of multi homogenous robots and way they communicate each other for their synchronization in doing a particular task. Despites of the lot of research in this field there is still lots of improvement should be done for its full-fledged implementation in real world.

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