Project Proposal

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Autonomous Tiny Robots

1. Introduction

1.1 Objective

Swarm robotics is an emerging field of robotics that has a huge potential for application. By having a collection of robots that can work cooperatively and communicate with one another, they can complete complex tasks given the right instruction, much like colonies of ants are able to complete tasks far beyond the capability of the individual. The primary focus of a swarm is to coordinate the motion of the robots to form certain patterns. However, motion coordination for a swarm is challenging due to limitations like the lack of communication between the robots and hardware constraints.[1] As the number of robots increase in the swarm, the failure rate of the swarm increases as the time of operation continues.[2] Given swarm robotics commonly use a decentralised decision system through local robot communication, these failure events in the swarm can greatly impact the correct operation of many neighboring robots, and possibly even the entire swarm itself.

Our goal of this project is to investigate the reliability and potential application of a more constant stream of commands from a centralized decision system giving basic movement commands to the tiny robots in a different way rather than using the wireless communication (such as wifi). The project will try using a projector to communicate movement path commands to the robots with light patterns. Each robot in the group will have a light sensor that allows it to receive the projectors light commands. We plan try to simulate the situation in a lab environment. The type of robots we will use will be very small and simple in design so that we can duplicate them as much as possible. The main functionality of our robots is computer interaction and coordinated movements to create patterns. This is to showcase that we can use a single remote server to control a group of robots to achieve a targeted task with predictable reliability. We will try to develop simple robots to keep costs low, explore and research the possible applications of swarm robotics using the projector method. Also, by keeping the individual cost of each robot low may help investigate the scalability of the swarm and the project.

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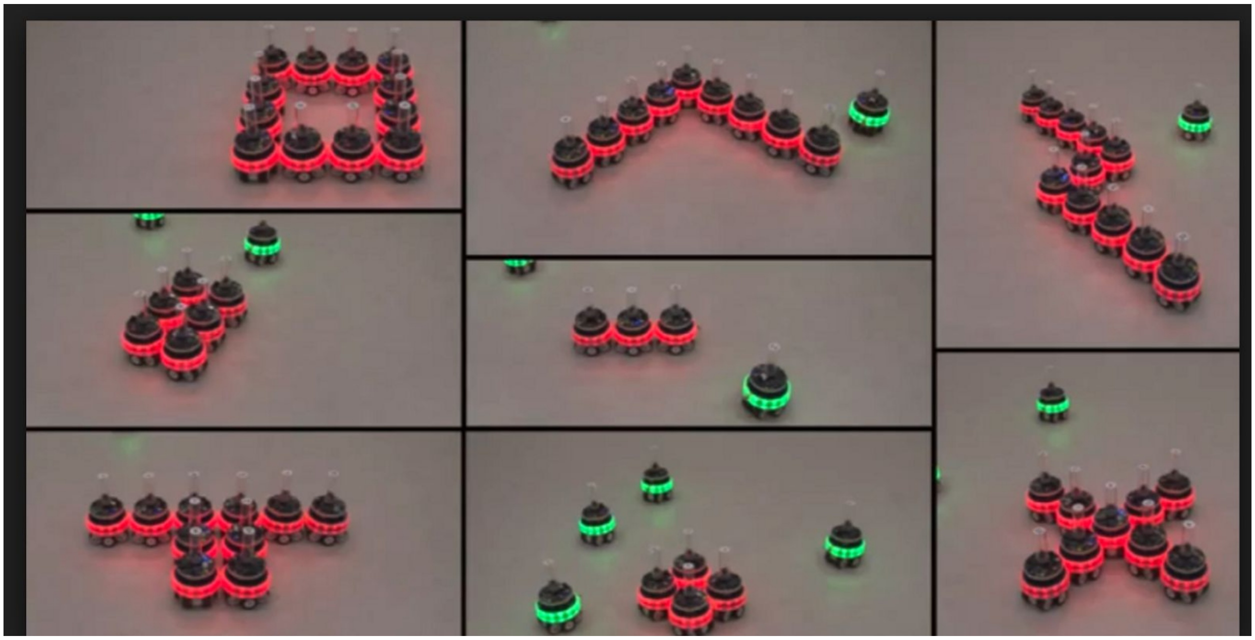
[1] Distributed Algorithims for swarm Robots
http://www.igi-global.com.proxy2.library.illinois.edu/gateway/chapter/full-text-html/142001
[2] A. Martinoli et al. (Eds.): Distributed Autonomous Robotic Systems, STAR 83, pp. 431–444.
springerlink.com



Expected behaviors of robots

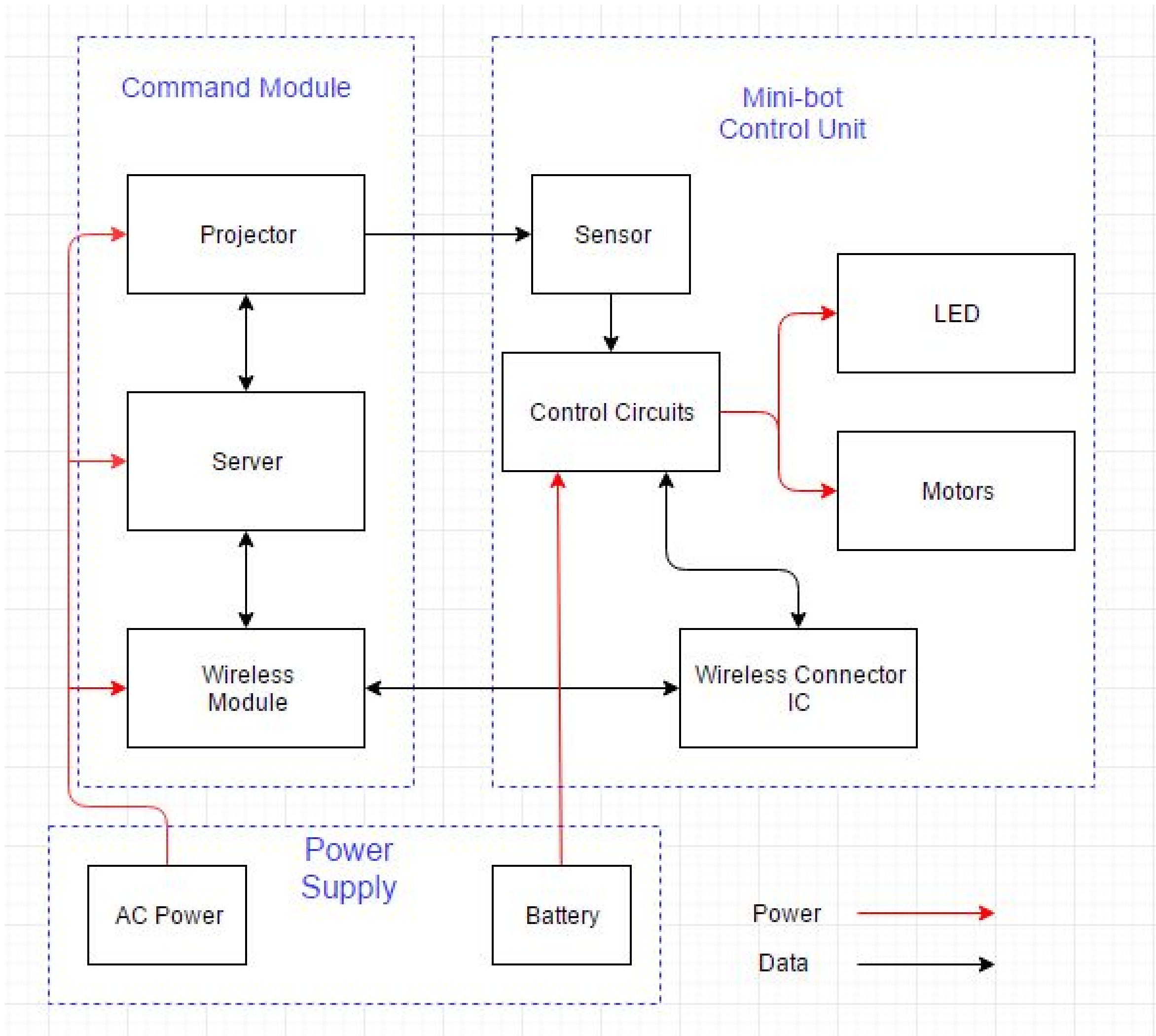
1.2 Background:

There are a lot applications for robot swarms. We try to explore the possibility of control multiple robots using one remote server. I believe that this type of technology can be applied to many types of robots. Some artists use swarm robotics techniques for interactive arts. For example, Intel used a group of drones during the super bowl halftime show. This is just for pure entertainment, and there are some more practical uses as well. We can use distributed robots to perform sensing tasks at different environments. Swarms of robots can be sent to places that are not easy for humans to reach. More controversially, swarms can be used in military to form an autonomous army.

1.3 High-level requirements list:

- Finish the assembly of each individual robot and each of them works as expected.
- Parse graph data from backend server to the light projector and the display is correct. The backend algorithms works as expected.
- The robots will be able to interact with computers. They will listen to the commands from computers and will be able to send feedbacks.

2. Desgn



The graph above covers all the elements we use for this project. The whole design works like this: The server will read any patterns we want to display and the software program will calculate and assign a position for each robot we have. The light projector will project the pattern onto the surface and the Wifi module will stream the position data to the robot. The robots will provide feedbacks to the computers, which will be its latest position. When one robot get to the assigned position, the photodiode attached on the robot will raise the signal and this will be sent back to the server. The robot will stop move and we are done until all the robots get to the targeted spot.

2.1 Command Module

2.1.1 Server - The Server used for this project will be any computer that can run the code we write. The program running on the server will precalculate the position of robots and then use Wifi Module to propagate the signal. The program will then use the projector to show the desired pattern the tiny robot group should assemble into.

2.1.2 Projector - Our system will use a projected-based tracking system. We will use DLP LightCrafter by Texas Instruments. A sequence of grey-coded patterns will be projected onto the surface.

2.1.3 Wifi Module - A Wifi device that can communicate with the minibots to provide the computer with the feedback produced from each robot.

2.2 Power Supply

2.2.1 Battery - We will use a 100 mAh LiPo battery for each individual robot. This power supply will be enough our robots since each robot doesn’t have too many components.

2.3 Minibot Control Unit

2.3.1 Sensor We will use touch sensors for touch sensing and photodiodes for light tacking. These allow the minibots to receive instructions from the projector and aid in location detection by detecting contact with other objects.

2.3.2 Circuit - The central circuit that will make simple, local decisions on what the robot should do given the input from the sensors and will output signals to the rest of the robot's systems. This will be implemented on a PCB board.

2.3.3 Wireless connector - This system will receive feedback data from the robot's main circuit and communicate it to the central computer using a NRF24L01+ chip.

2.3.4 LED - RGB will be the best choice because we want to switch between colors. These will serve as physical indicators for each robot's status, and will also help with debugging.

2.3.5 Motors - The motor is small in order to fit on the small minibot structure and low cost so that it will aid in the scalability of the project. The motor will receive power from the minibot's central circuit to drive the wheel of the robot. A potential motor for this task is DCM015 from Novatech international's website.

2.4.5 Other parts - We will need an enclosure, a Wheel and a motor holder. We will use CAD tools to build 3D models and 3D print them.

2.3 Block requirements:

Module:	Block:	Requirements:
Command Module	Wireless Module	Wi-Fi device signal should maintain connection within 2 meter range of the robot.
		The feedback data should be received for each robot within a certain reliability.
	Server	The command module must be able to manage the operation of at least 10 robots while active.

	Projector	The projector must be able to illuminate an area of 1 m^2 to 1.5 m^2
Minibot	Control Circuit	Total robot size should be near 20 cm wide and 25cm tall.
		Shouldn't weigh more than 20lbs
	Motor	The robot must be able to provide the motor with at least its minimum required voltage, a minimum of 0.5V and 25mA.
	Sensor	The light sensor must be able to detect light from the projector in a dark room.
	Wireless Connector IC	Must be able to communicate with the wireless module at least 2 meters away
	LED	Must be able to light up in red, blue and green.
Power	Battery	100mAh, needs to last more than 15 mins to support the robots moving to desired destination
	AC Power	Must have surge protection functionality.

2.4 Risk Analysis:

The Mini-bot unit presents the largest problem to successfully completing the project. The bot design is simple and small, but it does not allow a whole lot of functionality in terms of debugging. In addition, since there will be a number of these tiny bots, there will always be a possibility when a bug is found that it may also be in other robots, which will greatly increase the time spent testing each bot and fixing them. Using LED's and building the robots with the same design will mitigate some of this risk, but not completely. Another risk associated with the robots is the wireless connection to the controlling server. Again, to keep the bots small, a smaller IC will be used to allow communication to the controller, which limits the ability to debug any problems that may appear

3. Ethics and Safety

One of the safety issue that comes to my mind is the safety of our power supply- lithium-ion battery. Recently Samsung smartphones were banned on US domestic flights because it carries lithium battery which has a possibility of exploding when pressure changes, i.e. when plane taking off. It was also reported that several incidents occurred on these types of batteries. Also when these types of batteries ignite, the gases emitted are very toxic. So during our development and testing, we need to take care of all kinds of environmental issues that might be critical to the safety of our power supply: temperature, pressure and so on.

According to IEEE Code of Ethics #7, " To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;". In order to meet the requirement brought out here, we decided to encourage members who dared to come up with criticism and different ideas. This is the proper way to do it because it can let everyone in our team contribute to the project. We also brought out the idea that everyone should be treated equally in the process of group work regardless of race, religion and nationality. As a really diverse team we believe this will help us achieve a positive atmosphere.