REMOTELY CONTROLLED
MULTI-ROBOT FORMATION

COLLISION-FREE NAVIGATION FOR SYNCHRONIZED TRANSPORTATION AND SURVEILLANCE

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This project aims to build a swarm of four robots that will move in unison and maintain a globally rigid formation. This formation will be maintained by satisfying the distance and angle constraints of each robot from its neighbors at every position. The robots will be able to sense distance from each other and from other objects, and thereby avoid obstacles for collision-free navigation.

The group of robots will have one leader, one co-leader and two other robots that will be only followers. The user will be able to completely control the leader’s position and partially control the co-leader’s position from a remote interface. The other robots in the formation will rearrange themselves when they detect a change in their respective leader’s position.

The swarm of robots can then be used to accomplish tasks that require physical coordination-- such as, moving large objects from one place to another.

Following this, the swarm of robots will have additional features to sense their environment and make decisions. The user may specify a location for the swarm to deliver items to, and the robots will use Global Positioning System (GPS) navigation system to reach their destination via the most efficient route.
Motivation

Why form groups?

Because birds of a feather flock together! Yes, it is basic animal survival instinct to swarm together, especially if they feel threatened or they have to perform a big task. For example, the figure on right shows ants carrying a big piece of food.

How do animals optimize group work?

They follow one leader and the leader moves freely. The leader is the focal point for members of the group, which means that n members of the group have to keep track of just one other member, instead of n-1 members.

Why do we want group formations for robots?

Groups of coordinated robots are ideal for search and rescue mission as they can quickly transport valuable resources and also can provide first-person view over video link.
Remotely Controlled Multi-Robot Formation

Research methods

Theory

Simulations

Hardware

Theory for Synchronized Movement of Robots

We shall use algorithms based on Persistence theory, which is an interesting application of rigidity theory to control theory of robots. These algorithms would represent robot movements as self-efficacious formations of connected nodes.

Simulation

Aysha has written a user-interactive two-dimensional multi-robot simulation program, that represents the problem that we are trying to solve. A group of four robots -- with one leader (red), one co-leader (blue) and two followers (black) -- stay in their globally rigid formation in 2D, by maintaining distance constraints between robots. Each robot can follow up to two other robots.

Whenever the user drags the leader to a new position, every other agent in the formation rearranges itself to find the new position where it can satisfy the distance constraints with its leaders. The co-leader follows the leader and stays at the same y-position as the leader.

We will follow similar methods and specifications to build our multi-robot formation, except with an angle constraint added between robots.
Hardware

We will investigate the different wheeled robot platforms that will most effectively represent a globally rigid multi-agent formation, while allowing sufficient mobility. The factors we will consider are size, controls, flexibility, portability and cost. The platform must be able to support the motors, actuators, sensors and controllers required for our project. We will look further into the following:

- **Arduino** is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators.

- **Raspberry Pi** is a credit-card sized single-board computer, which can allow greater portability to our robots. Raspberry Pi-powered robots are useful for wi-fi and camera features, while being a flexible and cost-effective substitute for larger machines.

- **iRobot Create** is an affordable mobile robot platform, based on the Roomba platform. It is pre-assembled and can be programmed to read data from installed sensors and cameras, and issue commands to its motors to interact with its environment. There have been many applications of iRobot Create in autonomous robotics research.
Timeline

**Fall 2013**

| Week 1 and 2 | • Debug Telo's motor movements -- control distance for each move.  
|             | • Add left and right movement.  
|             | • Readings  
| Week 3 and 4 | • Get familiar with sensors and find ways to implement them in Telo.  
|             |   o Play with Arduinos.  
|             | • Be done with ROS tutorials.  
| Week 4 and 5 | • Learn more about robot platforms that could be useful in our research.  
|             |   o Ordering parts and playing with them.  
| Week 5 and 6 | • Develop hardware and software for a robot that moves in two directions.  
| Week 7 and 8 | • Add sensors to the robot to avoid obstacles.  

Conclusion

Our team of four robots will be capable of moving and performing group tasks with the help of efficient algorithms. This project is not just a proof-of-principle of group formations in robots, but we can also use multiple robots to coordinate with each other to transport materials.