Brian Bairstow

16.412 Problem Set #1

Part A:

Cooperative Robotics

In cooperative robotics, the group of robots have the same goals, and thus it is most efficient if they work together to achieve those goals. They can simultaneously work on different aspects of the goals, or can combine their efforts to do tasks that aren't possible individually. If the problem is simple, or if enough is known about the situation, then the individuals can deduce what the other robots will do and thus what they need to do. However, this is often not the case and then coordination is required.

Machine Learning

Machine learning is essentially the recognition and extrapolation of patterns. This can be important to robotics, since the "artificial intelligence" of current robots is typically a set of commands for various circumstances. However, with elegant enough algorithms for machine learning, one can imagine a machine that can eventually teach itself unexpected things. This capacity to learn could develop an "artificial intelligence" which is more meaningful than an array of specifically instructed behaviors.

Neural Networks

Neural networks consist of nodes which pass data via links to other nodes. They are good at learning because the weightings of the links can be altered to adjust the output of the neural network. Thus the network can be trained on data until the outputs match the expected outputs. One use for this is to make parametric approximations of complicated models, so that a neural network can quickly come up with low fidelity results.

Part D:

Task Directed Imaging in Unstructured Environments by Cooperating Robots

Vivek A. Sujan

http://www.ee.iitb.ac.in/~icvgip/PAPERS/115.pdf

This paper covers visual sensing strategies for robots working on a task. The issue is to place sensors in order to see certain targets. Depending on the degree of sensor articulation, there is more or less leeway. With multiple robots sharing information, the problem of optimizing camera placements is more interesting. Sensor fusion can be used to combine the data, and areas which aren't visible from one robot could be viewed with the other robot. A goal is to create a 3D geometric model by using multiple sensors.

The paper goes on to describe an algorithm to optimize camera pose while considering factors such as depth of field, target resolution, and visibility. A simulation was run on the algorithm.

This paper brings up a useful topic for rovers working together in the same area. One consideration in planning of cooperative robots is combining their sensor data in useful ways. For instance, when traversing difficult terrain it can be useful for a stationary rover to observe a moving rover to make sure everything goes well. This paper is not applicable for programmatic planning such as how to assign rovers to different geographic areas, except that it suggests that rovers can work well together.

Using Cooperative Robots for Explosive Ordinance Disposal

James McLurkin

http://nms.lcs.mit.edu/~eugene/education/courses/6.836/eod-paper.pdf

This paper discussed techniques for using a number of cooperative robots for unexploded ordinance removal. Typically this will take place in an unconstrained and unknown environment, which is the case with Mars exploration. Ordinance removal is one of the most applicable areas for autonomous cooperative robots. Due to the large number of mines in a minefield and the desire to find them quickly, multiple robots would be used, and thus cooperation is useful to make them efficient. This paper explored using a "behavior-based approach to form a structured community from the local interactions of simple individuals." These behaviors included clustering and dispersal to produce a swarm with the desired density of robots. Experiments were done with micro-robots to analyze the applicability of the behaviors.

This is applicable to Mars exploration in that it discusses how to cover ground with multiple robots. It is a good examination of cooperative techniques. The strategies used are probably too simple for Mars exploration, and they promote redundancy to ensure that mines are found. In Mars exploration redundancy is inefficient, because though you might find an interesting objective you would have missed, you would be better off covering brand new territory.

This paper relates to a different scope than the imaging paper, in that this is related to how to move the rovers relative to each other in order to find an objective, while the imaging paper was more interesting in placing the rovers relative to each other after the objective is found.

Scene Understanding using Cooperative Robotics

Declan O'Beirne, Michael Schukat

http://corrib.it.nuigalway.ie/ResearchDay2004/infotech/O_BeirneDeclan.pdf

This paper is about object recognition combined with cooperative mapping. The goal is for a team of robots to map a complex environment using the objects within as landmarks. The benefits of cooperation in mapping include concurrency, reliability, and accuracy. Greater accuracy comes from multiple robots viewing the same object, which should provide a more accurate estimate of position and ameliorate sensor errors. Also multiple robots can view an object from different angles to get better 3D data. This 3D data can be used to create 2D images for object recognition.

This topic is similar to the first Imaging paper in that it concerns relative positions of robots in observing and object. This paper is more focused on mapping using visual object recognition. Like the Imaging paper, it suggests advantages for performing exploration with multiple cooperative rovers. However, positioning rovers for Martian surface exploration could be done differently with techniques such as GPS.

Part E:

I think an interesting topic would involve autonomous cooperative robots for unexploded ordinance removal. Utility would be provided by quickly and redundantly searching area. Number of robots and strategy used would be variables. Modeling the environment and the robots themselves might be a lot of work even before strategies could be implemented.

The world could be modeled as a grid, and the robots could move around up, down, left, and right. Exploring a space once could be worth 2 points, while exploring it a second time could be worth 1 additional point. The project could explore different strategies to try to maximize the score achieved in a minimum number of moves. The world should be extremely simple at first, because even that could take a lot of coding, and it is not the interesting part of the project.

This is a project I would be interested in pursuing.