# Collaborative Multi-Robot Localization Small Undergraduate Research Grant Proposal

**John Sweeney (sweeney@andrew.cmu.edu)**
**Advisor: Tucker Balch (trb@cs.cmu.edu)**

**Abstract**

Multiple robots working together to learn their location in an environment is an important, open area of research. The purpose of this project is to develop a method for multiple robots to cooperatively determine their position and learn the localization reliabilities of fellow robots. These methods will be tested and developed in simulation on the computer for the remainder of the current semester, and then will be tested on real robots. As there is currently only one robot available, this grant will be used to purchase another similar robot. This project is an SCS Senior Thesis project and as such there will be a number of presentations and a paper describing the research at the end of the school year.

## Introduction

One of the most important and challenging problems facing the designer of an autonomous robot is how the robot will determine its location. Recently, several algorithms have been suggested for successfully localizing a robot in a land-marked environment based on sensor readings. This project will focus on the less understood problem of collaborative multi-robot localization, that is, multiple robots working together to determine their position in the environment. Multiple robots working collaboratively allows the observations of one robot to aid others in their own localization, which can very useful in situations such as when not all robots have the same kind of sensor, or when there are relatively few landmarks in the environment.

The problem of autonomous robotic localization is relevant to domains where humans cannot directly control the robot in real-time, or when it is inefficient or impossible for the operator to accurately determine the robot's position.

Examples of such situations include robots exploring Mars, military reconnaissance, or robotic soccer. In each of those domains it is very important for the robot to be able to accurately determine its position, and, if it somehow becomes lost, it should be able to relocate itself without any intervention from a human operator. In the case of multiple robots, it seems that the robots could share their knowledge and help each other in localizing. For example, if one robot possessed a high quality camera, and another was only equipped with an unreliable sensor, it would be very useful if one robot could use information from the other to better localize itself. A method will be developed for the robots to learn the reliability of another robot's information, and to accurately incorporate that information into its own belief of its position.

In this project, we will first implement and develop our algorithm for multi-robot cooperative localization using a simulation package on the computer. Testing the methods in simulation is a useful and efficient way to develop such a system because the simulation world is easily adjustable, and various aspects of the algorithm can be tested very thoroughly. Once this has been completed we will transfer the localization methods developed in simulation to actual Cye robots and test their functionality in the real world. Although the simulation strives to be realistic, there are a number of simplifying assumptions in its representation. The result of this is that even if our localization method is very successful in simulation, it does not necessarily mean that it will be successful in the real world. The main reason is that the simulation environment does not model real world noise very well. It is very important to verify that the methods work with erroneous, noisy data as well as in the theoretical realm. We anticipate that the robot's vision sensors will be the most affected by noise. At the present time, we have only a single Cye robot. This grant will be used to buy another Cye robot so that we will be able to test our multi-robot localization methods in the real world.

## Project Design

This research will be performed as an SCS Senior Thesis Project. The first part of the project will be to implement the localization methods in simulation. This will be accomplished using the TeamBots simulation environment developed by Tucker Balch. The advantage of this system is that the transition of code from simulated to real robots is relatively simple. The

development of the multi-robot localization algorithms and their implementation in the simulated environment is scheduled to be completed by the end of the first semester (Fall 1999). The following semester the system will be moved to real robots and tested.

## Background

I am senior majoring in Computer Science. This past summer I worked with the CMU RoboCup group and developed a localization simulation of their robot on the soccer field. Although the localization technique used in that simulation is different from the localization methods of the proposed project, the work gave me a better understanding of the problems involved with robotic localization. My coursework that is relevant to this project include 15-381 Introduction to Artificial Intelligence and 15-681 Machine Learning.

## Presentation and Evaluation

As this project is a sanctioned SCS Senior Thesis Project, there are various evaluations and reports which will be given throughout the remainder of the school year. These include brief oral presentations at mid-semester, as well as a longer presentation and paper due at the end of the year. This project will be evaluated by my advisor for a grade at the end of the year.

## Budget

The cost of one Cye robot is $700. I am requesting the full grant amount of $500, and the other $200 will be funded by the SCS Minnow Project. The Cye robot was chosen primarily for its excellent movement sensors and its low cost.

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