A Multi Agent Approach to Vision Based Robot Scavenging

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Abstract

This paper proposes a design for our entry into the 2006 AAAI Scavenger Hunt Competition and Robot Exhibition. We will be entering a scalable two agent system consisting of off-the-shelf laptop robots, capable of monocular vision. Each robot will demonstrate the ability to localize itself, recognize a set of objects, and communicate with peer robots to share location and coordinate exploration.

Overview

Our goal is to produce two fully autonomous robots which will compete as a team in the scavenger hunt and exhibition categories of the 2006 AAAI Robot Competition and Exhibition. In the scavenger hunt, the robots will attempt to look for the target items by bisecting the search space. To facilitate efficient search space coverage, the robots will update each other on their respective positions and findings via ad-hoc wireless connection. In the exhibition, we plan to display some of the advanced features of these robots in more detail.

Each robot will operate independently and will contain at least four major subsystems. In order to cooperate and not overlap their searches, each robot will possess a framework for localization and mapping. A path planning component, incorporating avoidance of dynamic obstacles, such as people, will also be necessary to find a viable route through the mapped space. Finally, object recognition algorithms will be necessary for detecting and approaching target objects once the robots are in range. A peer-to-peer networking protocol will be used for communication. These areas, along with a brief description of the platform we will be using, will be discussed in more detail below.

Platform

Each robot will be based on an Evolution Robotics ER1 kit. The computing platform will be a 2GHz laptop with Windows XP. In addition to the kit-provided USB web cam and short-range infrared sensors, we will investigate other modalities, such as light projection (e.g. a laser pointer) for long-range measurement.

Figure 1: An Evolution ER1 robot with our current configuration. The USB camera and short range infrared sensors are both included with the ER1.

Mapping and Localization

Since our sensing modality is strictly limited, and since floor plans of the competition and exhibition hallways have been made available, we will be using a Hidden Markov Model and recognition based localization algorithm, as described by Kosecka et al [1]. This approach first discretizes a given map, and then characterizes each map segment by building a database of views acquired from within the segment. Each view representation consists of a set of scale-invariant (SIFT) features [2]. Acquiring this knowledge will require an initial data gathering stage, before the robot is competition ready. After the internal representation of the environment has been constructed, scale invariant features will be used to match an input image to the closest stored view. Once the most likely match is found, SIFT features are further used to infer a robot's exact position relative to the location from which the stored view was captured. This final computation uses fundamental methods from epipolar geometry [3].

If we decide to augment our system with a form of long range visual distance sensor, we may implement a particle filtering approach such as Monte Carlo Localization [4] to compare localization results.

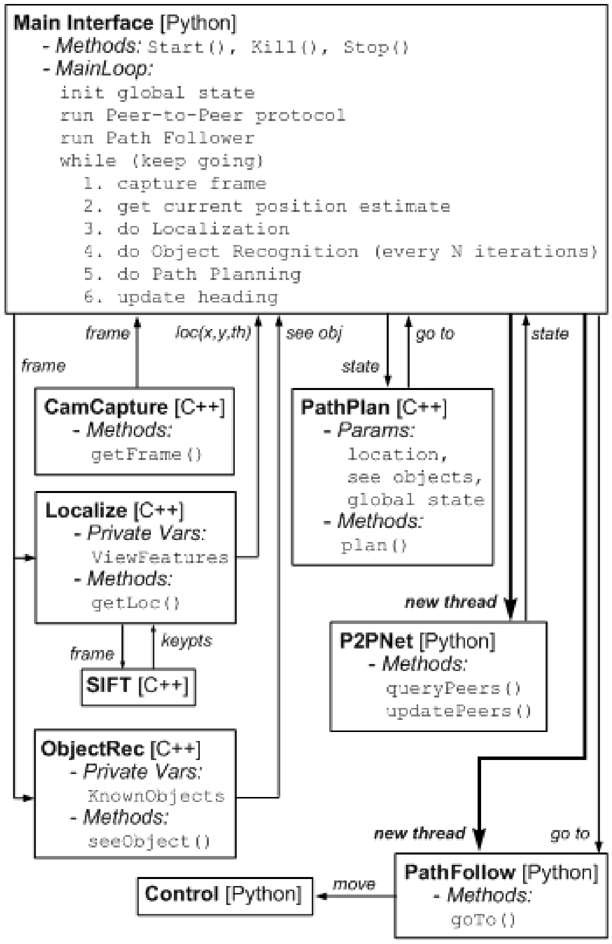

Figure 2: The chart above shows an overview of our system's software architecture and data flow.

Navigation and Path Planning

Our robot will use the maps which have been constructed and partial information about the environment obtained from a camera (or range sensor) to plan paths. For this purpose, we will use the Constrained D* (CD*) algorithm developed by Stentz [5,6].

CD* is a variation on Constrained A* which allows for real-time path planning in unknown, partially known, and dynamically changing environments. The main advantage of CD* over CA* for our purposes is that CD* does not have to re-plan from scratch when new information about the environment is obtained from the sensors.

Object Recognition

In order to recognize objects we encounter in the world, we will utilize a biologically inspired algorithm similar (perhaps identical) to that of [7]. We will build a scale invariant object recognition method which will be trained on a number of images of objects similar to the target objects. It may additionally be trained to detect humans, so they could be asked for directions. This method will not run at web cam frame rate, but will instead be invoked periodically to determine potentially promising locations (such as the locations of the objects, people, or the other robot) which a robot would navigate toward.

Networking

The robots will communicate with an application layer peer-to-peer protocol, over an ad-hoc 802.11 wireless network. The protocol will enable auto discovery of peers that are within range and will be scalable to larger groups of robots running the same protocol. Each peer node will broadcast its location and be able to request information about a specific area of the search space from connected peers.

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