Competing in the AAAI scavenger hunt with a budget robot built of commodity parts.

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Abstract

Bridgewater State College's entry into the AAAI-06 scavenger hunt was built of commodity parts. It priced in less than half of the price of any of the other competitors in the scavenger hunt. It still managed to find several objects and perform at a reasonable level. Such a robot platform is ideal for use as a budget educational robot.

Introduction.

In the AAAI-06 scavenger hunt, teams competed to find and identify objects in the AAAI conference venue. Bridgewater State College entered a low cost robot which competed successfully with its higher priced competitors. The robot, Bridgewater Wanderer, was composed entirely of commodity parts and toolbox salvage.

In 2004, Bridgwater State College decided to return robotics to its curriculum. In the second year of the program, we obtained an XBC robot controller from the KISS Institute(KISS Institute 2006). We now had a robot controller which had a simple vision interface suitable for students. With vision, our robot could identify objects. The question that presented itself naturally was, how far could we push this controller? Could such a simple device compete effectively in a scavenger hunt against the more sophisticated equipment routinely used in the AAAI scavenger competition.

Robot Hardware Components.

Component overview

The Bridgewater Wanderer was built entirely of off the shelf components and scrap hardware. See figure 1 for a view of the completed robot. We used the XBC controller(LeGrand *et al.* 2005) as the "brains" of the robot. See figure 2 for a close up of the XBC controller itself.

The XBC controller provides the usual sensor and motor I/O ports. It provides color vision through the built in camera. The XBC allows interface with the user through the LCD panel and controls of the built-in game-boy advance. We used a modified Octobot kit from Budget Robotics(Budget Robotics Inc 2006) for the robot's body. The original Octobot servos were replaced with motors from the KISS institute for easy integration with the XBC. Four IR sensors and two touch sensors rounded out the robot's hardware.

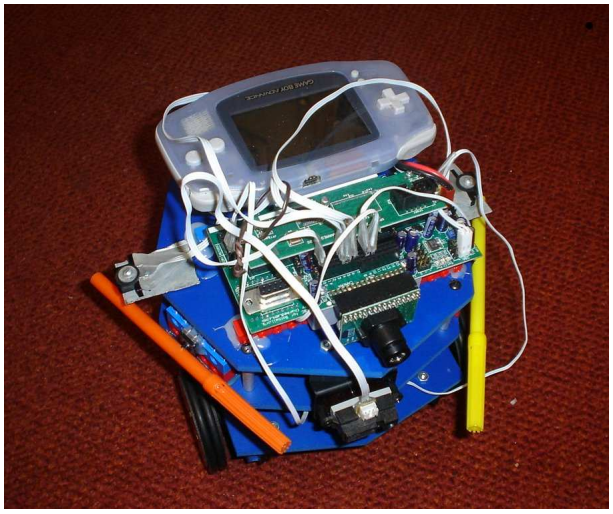

Figure 1: Bridgewater Wanderer

Cost

The entire cost of this robot was significantly less than half of the next cheapest robot. We included in this comparison only those other scavenger hunt entrants whose computation was done on-board the robot. At least one other scavenger hunt robot was quite inexpensive, but achieved its low cost by doing computation on a remote computer. The significant components of the robot and their costs as of summer 2006 are listed below.

- XBC: approximately $440
- Sensors: approximately $70
- Octobot Base: approximately $90
- Total: approximately $600

The next cheapest scavenger hunt entry (which did its computation on-board) was an AIBO. When Aibo's

Figure 2: The XBC controller

were readilty available at retail locations they were close to $1400 more expensive.

Control Software.

Vision

The XBC is programmed in Interactive C (IC), a language commonly used in robotics classes which use handyboard robots. See Kumar and Meeden(Kumar & Meeden 1998) for one such example. The interactive C library for the XBC comes with built-in routines for color vision using the XBC's color camera.

There are three color channels available to programs using the IC libraries with the XBC. The scavenger hunt items were announced before the contest and most were brightly colored. Most were yellow, red, blue or some combination of these colors. This allowed us to identify most items using static definitions of each color. The entire project was focused on using existing commodity parts to do something interesting. Using the existing color identification to do object recognition fit nicely into this theme.

Object identification was done using color blobs and distance information provided by one of the IR sensors. Once the robot had approached a potential target object, the object identification system looked for color blobs of the right color(s), which were the correct size. The notion of the correct blob size depended on which object the robot was looking for. This approach allowed the robot to tell the difference between the Winnie the Pooh doll (yellow with a red shirt and about 20" tall) from the large yellow ball (about 36" tall) sitting just behind the red bucket (about 12" tall).

One drawback of using the unmodified components in vision was that the camera is attached to the XBC in a fixed position. When the XBC is placed on a robot base, this results in a camera that is positioned at a fixed height. The floor of the competition area was dotted with yellow flowers of just the right color to distract the robot from the yellow scavenger hunt items. The robot itself was only about 7" tall and would have been better served by pointing its camera at a slight upward angle given its simple color blob vision.

Navigation.

No scavenger hunt robot can hunt very well without being able to navigate in its environment. The Bridgewater Wanderer originally used a simplified potential fields(Arkin 1998) technique for navigation. Using this technique, the robot had an irritating habit of taking a very long time to find an object behind an obstacle.

Abandoning a more principled approach, and relying on the fact that these competitions often took place in large relatively open spaces, we settled on a more primitive navigation technique. The robot would first turn in place looking for the objects it had been asked to find. If it found a candidate, the robot would approach to to a distance of approximately 10" and then try to identify the object. If there was no candidate after a 360 degree turn, the robot headed off in a random direction for about 4-6 feet and tried again. This navigation was very primitive compared to the contest leaders, but it exploited the "wide open space" advantage of the competition and worked reasonably well.

Lessons learned at AAAI.

We set out to answer the question, can such an inexpensive robot compete reasonably well against much better equipped robots in a AAAI scavenger hunt. The robot performed reasonably well. It identified several items correctly both in the preliminary round and in the actual competition round. The robot was able to move to objects and identify them as the object it had been asked to look for. If the object was moved (slowly) while the robot was heading toward it, the robot could track the object and continue to move toward it.

However, the robot did make one false positive identification (identifying the Winnie the Pooh doll, which it was not looking for, as the red bucket which it was) and was continually stymied by unexpected sources of the colors it used for identification including blue jeans on spectators and the yellow flowers on the floor.

The Bridgewater Wanderer represents the efforts of a (very) small team for a very short time. If we had had the XBC controller for another 2-3 months, we could have really pushed its limits. Such a test would show exactly how well this low-cost platform could really do against the more expensive robots.

Conclusions and future directions.

The Bridgewater Wanderer was an experiment in budget robotics. In answer to the question can an inexpensive robot built of commodity parts compete in this sort of competition. The answer has to be a qualified yes. The robot took advantage of the built in color recognition that the XBC controller and its IC libraries provide. Though it uses a very primitive navigation technique, by leveraging the advantages on its environment (lots of open space to see quite a distance) the robot was still able to find and identify several scavenger hunt items.

We would like to see exactly how far this robot platform could be pushed. We never tried dynamically swapping the color definitions based on the objects that we were asked to find. It is an ideal platform for teaching the basics of navigation, color vision, and object recognition to robotics students. The students can easily work with the robot without having to deal with the lower level details of soldering or learning a complex robot. Classes currently using handyboard can use most of their existing sensors with this new platform. The XBC user interface is a bit easier for students than the user interface of the older handyboard. The user interface is certainly not as impressive as those used many other robots at the competition. However, since the XBC uses a gameboy advance for its user interface, there is a builtin audience that finds it a very natural interface. We think, given its performance in the scavenger hunt that students would find this inexpensive robot controller to be an ideal platform for developing hands on experience with robotics

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