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Kansas State University's Autonomous Robot Borivoj: an entry in the AAAI2002's Robot Host competition

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Abstract

A robust competitor was developed using simple approaches on an Activmedia Pioneer robot using sonars and an infrared sensor. Simple techniques were developed to sense people, serve food, sense an empty food tray, and to locate the food refilling station. Simple voice recognition and text-to-speech tools were used.

Introduction

The AAAI 2002 robot host competition team from Kansas State University was international in character. The three students were exchange students from Czechoslovakia. The three engineering students were not familiar with robots when they started this challenge in January 2002. Their goal in this assignment was to produce an entry to the AAAI 2002 host robot competition. Since the students were limited in experience and were starting from scratch, it was decided to base the solution on very simple designs that could be debugged in a short time and could be tuned to provide an effective solution.

Figure 1: Borivoj in food serving mode

The robot platform used is an Activmedia pioneer robot. The students named the robot Borivoj (an old Czech name). This robot is equipped with front and back sonar. This robot also has a commercial IR sensor added to its normal set of sonar. With only these two sensors the students decided to try to make as good a robot host as possible.

The whole system was divided into 3 separable tasks. The tasks were human interaction; motion and human identification; and tray load sensing and returning to the refilling station. Each task was solved by one team member and then the tasks were integrated together.

The motion of the robot was programmed in C++ using the Aria library. After experiments with sensors and mapping techniques (which will be described later) the students decided not to try to use any sophisticated techniques like mapping that could simplify the orientation in environment. They only used simple obstacle avoidance and simple restrictions on the robots active area using the robot's x-y decoders. These decoders are very inaccurate but proved to be more useful than anything else since a crowd of people often surrounded the robot.

The studets programmed the robot to actively search for people using the IR sensor and to approach any stationary people. This approach worked well when performing tests at low concentrations of people. On the exhibition area, the robot was often surrounded by too many people who completely prevented the robot from moving. For that kind of exhibition, it seems to be a better approach to do less motion and do more interaction.

Detection of an empty tray

One of the requirements of the host competition was to detect an empty food tray and to return to the refilling station to refill the tray. To detect whether food is on the tray the students implemented an interface for a commercial digital scale, which was connected to the parallel port using a standard cable. When the scale reading dropped below a set threshold, the robot

determined that the tray was out of food and returned to the refilling station.

Navigation and positioning

Navigation back to the refilling station was one of the most problematic tasks. As an example, assume that Borivoj is started at the refilling station with position [0,0] and then Borivoj wanders around the serving area. When the serving tray is empty, Borivoj has to move back to the starting point to be refilled. However, the dead reckoning error would be too large to allow an accurate return to the refilling station. A simple example of such inaccuracy is displayed in figure 2. The map on the left depicts the real environment with the track of robot's trip. On the right side there is map drawn by the robot.

The only available positioning system was internal coordinates based on measuring the X and Y distance the robot had moved from the starting point. Basically the distance was measured on two robot's wheels. While wandering, the wheels would slip on the floor and the position information would become inaccurate.

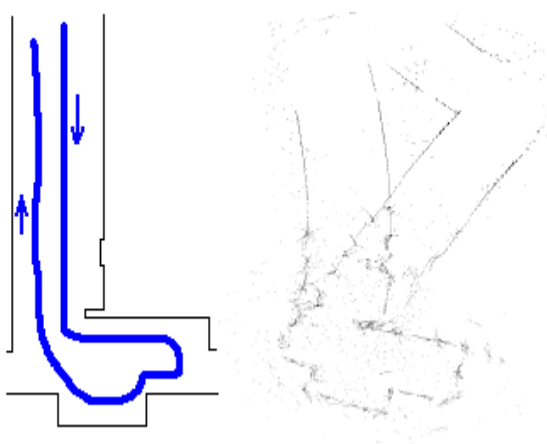

Figure 2 – actual and sonar from 30 foot hallway

Position correction

One aim was to correct the position. Figures 3 and 4 show two possible sonar readings from approximately the same position (0,0) and (15,15). Below each reading there is a histogram that shows the pixel decomposition in the left-right direction. This might be helpful to recognize the shift between two following readings. However the histogram includes redundant information, so it is necessary to approximate it using Gaussian curve.

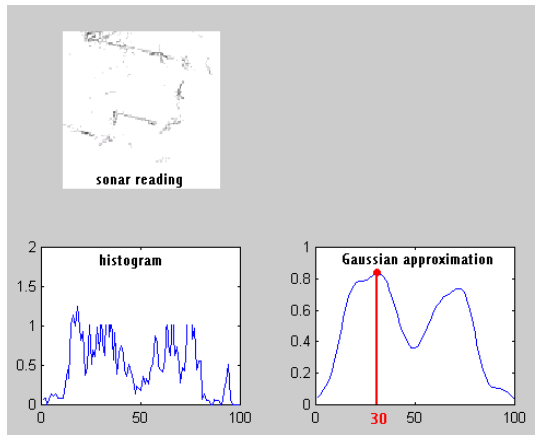

Figure 3 - Sonar reading at position [0,0] and X-position detected by peak-searching method

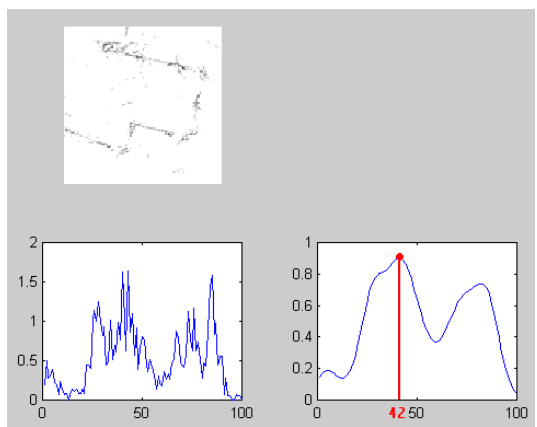

Figure 4 - Sonar reading at position [15,15] and X-position detected by peak-searching method

To detect the shift between the two readings, the peak-searching method was used. Basically this was not reliable enough. The real shift in the X-direction was 0.15 m, whereas the computed shift was 0.12 m.

Shift detection using cross-correlation

Using cross-correlation, we were able to detect the shift with much higher precision, which is good enough for position correction. To correct rotation, we basically used the same approach in polar coordinates.

In the real environment, however, the rough sonar readings often caused a situation where many of the surrounding object were not visible at one time, but they were present in the next reading. Noise also caused problems. To be able to use the described method, we would have to develop a segmentation algorithm to remove redundant information from the sonar readings.

Figure 5 - segmentation of sonar readings

The approach used

Since the task was very complex and not all features of an exact map would be used in the project, we decided to navigate the robot using a source of heat. The robot found a wall and followed it until it hit the heat-source, which was significantly warmer than all other objects. We used simple algorithms to avoid the robot getting stuck moving around the same object (e.g. a person) and to switch from the Follow-wall mode to Find-wall mode when the robot lost the wall.

Interaction facilities

Borivoj used a text-to-voice utility for interaction. Similarly, Via Voice was used for simple voice recognition. A microphone designed for voice identification was employed. However, the background noise made it hard to identify most audio responses. The keyboard was the main input source. Initially, the main output was audio. After the first kiosk trial, all output was also shown as text.

A Eliza-style conservation utility was devised. The database of ideas was limited to a small set of concepts. The results was a simple conversational dialogue that asked about weather, feelings and friends.

The competition

Borivoj worked well during the competition. During the information kiosk portion, the robot easily found and approached individuals and small groups. Often the robot was surrounded by spectators and was unable to move freely. During the first trial, the spoken output proved inadequate for communicating the information. Before the second trial, a text display of the information was added to the visual interface. The combination of audio and video was very effective during the second trial.

During the dessert trial in the AI festival, Borivoj was also successful. The empty tray sensor worked well. The crowd made detours necessary in the route back to the refilling station. The crowd also made sensing the light associated with the refilling station hard. The robot found an edge of the open space and followed it until it reached the refilling station.

Again the number of people, especially children,, surrounding the robot made motion impossible at times.

Conclusion

Borivoj won second place in the Robot Host competition. The project was successful. The use of simple sensors and simple algorithms was effective.