Autonomous Multi-Agent Docking using Color Segmentation

Jeffrey Hyams
University of South Florida
4202 East Fowler Avenue, ENB 118
Tampa, FL 33620-5399
813-974-1347
hyams@csee.usf.edu
http://www.csee.usf.edu/∼hyams/docking

This poster will look at the work in progress of an autonomous multi-agent scheme for ego-centric docking, meaning that the agent docking has no communication or help from the agent to which it is docking. Docking has become a major issue in marsupial robots, and has applications in space exploration, urban search and rescue, and reconnaissance. This work attempts to make use of color segmentation of a fiducial and affordances in reactive behaviors to autonomously dock a mobile robot agent, specifically a marsupial type of heterogeneous team. To this end, a real-time solution was also needed, and thus limited the algorithm to the lowest order complexity that could be managed while still being robust.

(a)

(b)

Figure 1: In (a), Bujold is shown next to the docking bay, with the gate and fiducial in view. In (b), the USF Perceptual Robotics Labs's Marsupial team, Silverbullet and Bujold.

In any real-world docking situation, there are different lighting conditions, and most current vision applications do not work well in in these conditions. This work uses a specific color segmentation which is better in unstructured lighting(Hyams, Powell, & Murphy 1999). Future work will use other techniques such as adaptation and imprinting to adapt to different lighting conditions. Having two heterogeneous mobile robot agents coordinate is difficult, and the current work implies no communication between them. Future work will also include mother-centric docking, as well as a cooperative docking.

For the color segmentation task, a two-color fiducial of dimensions seven inches long by four and a half inches high was used. The left half is painted magenta, while the right half is painted cyan. The image is transformed into the Spherical Coordinate color space, which has been shown to be very good at distinguishing the color from the type and intensity of the lighting conditions.(Hyams, Powell, & Murphy 1999) The magenta and cyan are segmented on the color triangle, then then a connected components algorithm is run on these images to remove noise and to provide a more exact segmentation. This gives statistics for the segmentation of the fiducial, the most important of which is the size of each color region in the image.

With the size and position in the image derived from the color segmentation, a daughter robot then uses a reactive behavior to dock to the mother. There are two main ideas in this docking algorithm, perspective and looming. These provide the information necessary to get to the dock from anywhere behind the mother robot within about two meters from the dock.

Current work in progress includes implementing an adaptive method which will change the segmentation parameters over time (Murphy & Arkin 1990) and imprinting the colors by taking a quick check when Bujold first leaves Silverbullet. This will hopefully eliminate many of the problems with unknown or unstructured lighting conditions. It has been demonstrated that the current autonomous docking system works 17% faster than 22 human operators who teleoperated the robot, and has a 96% success rate while teleoperation had 95%. Further, the segmentation algorithm runs with a low order of complexity, with a worst case of $O(m \times n^2)$ and an average case of $O(m \times n)$. Also, the color segmentation works well in unstructured lighting conditions(Hyams, Powell, & Murphy 1999) and can be run on an off-the-shelf platform. This work could be used for numerous situations where multi-agents are in use, such as space exploration, urban search and rescue, or surveillance.

References

Hyams, J.; Powell, M.; and Murphy, R. 1999. Cooperative navigation of micro-rovers using color segmentation. In *IEEE International Symposium on Computational Intelligence in Robotics and Automation*, 195–201.

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