Cyclope: Visual Motion Control of Multi-Robots.

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Abstract. We propose a way to control several robots at a glance by using images provided by a single camera. Position and orientation of the group is given by a main robot (a master) which has a very simple system on its top.

1 Introduction

We propose a system to visually control several robots at a glance. A digital camera is mounted on the top of a master robot. We use computer vision techniques to retrieve position and orientation of other (slave) robots inside the field of view of the camera. The slave robots have a sphere painted with two colors on its top allowing its detection by the vision system (Figure 1). Only the master robot has encoders (angle sensors) that can be used, in combination with vision marks posted in the environment, for determining its position and orientation related to the environment origin. All robots have local sensing capabilities and a processing unit that can run, locally, some small behaviors so they can eventually perform some tasks autonomously, as obstacle avoidance. The robots communicate to each other and to a main computer via an infra-red port. All robots can be remotly controled, at a glance, through a communication protocol also developed in this work.

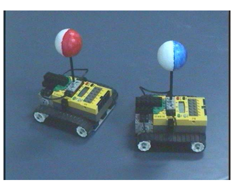

Figure 1: Two colors (red/blue and white) ball.

2 The proposed system

Our system basically has three low-level modules and a high-level control module. The first module (image acquisition) is responsible for taking pictures from the camera posted on the master robot and passing them to the computer. Its output must be an array of chars (bytes) encoding the image. The second module, vision, receives as input an image and returns position and orientation of each robot inside the field of view. We basically segmentate the original image and try to localize the ball inside the "visibility cone", in a horizontal line. We first locate the ball by using band-pass filtering (for both colors) and searching its center in a binarized image. We next calculate the ball radius (in pixels) and from this the the robot position. After, we determine position of the edge separating the two colors. Orientation angle can then be calculated, regarding some precision. This algorithm can currently run at 10 fps, not the drawback here, since this is the rate of the the communication protocol. The third low-level module (robot control) is responsible for taking high-level commands and sending them to all robots, that is, it provides communication between the computer and the robots. We are currently trying to improve global performance (currently 10fps).

3 Experiments and results

The error in determination of the ball radius was up to 10%. That means a maximum linear error up to 15 cm in the robot position. The error for determining orientation varied from 3 degrees on good positioning (as right robot of Figure 1) to 15 degrees on bad positioning (as left robot of Figure 1). Table 2 summarizes some calculated and measured by hand data.

Image	Xc	Yc	Rc	zh	xh	zc	xc
a31	264	152	18	57	-15	53	-14
a32	171	151	19	57	0	56	0
a33	63	151	17	57	15	59	16

Figure 2: Data taken by hand and calculated by the system.

3.1 Conclusions and future work

The proposed technique allows to define position and orientation of the robots using only one single camera and a ball with two colors posted on the top of the robot. This is a very good scheme that could be implemented by using very simple hardware interfaces. We are currently developing a very robust robotic platform. We will change the LEGO robots by this one in short term. This new master robot will have embedded processing (PC-104) and a stereo head vision system (6 DOF). We will implement attentional behaviors already tested by us in previous work [1] for landmark detection [2]. As the current positioning is known regarding a certain precision, the robot can search for some determined features in determined places of its field of view, trying to identify those, and from them its global position.

References

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