Shepherd: A Mobile Interface for Robot Control from a User's Viewpoint

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Introduction

we propose an intuitive remote control technique for robots using a mobile device such as a PDA or a mobile phone. A camera-mounted mobile device recognizes the state of the robot and the user's gesture, and makes the robot move as the user has requested. This technique is less expensive than the other methods, because almost no modifications to the robot and its surrounding environment are needed.

Figure 1

System Overview

Figure 2

Shepherd's system overview is shown in Figure 2. For developing a prototype version of Shepherd, we decided to use mobile PC (Vaio type U by Sony) as it has more computational power compared to PDAs or mobile phones.

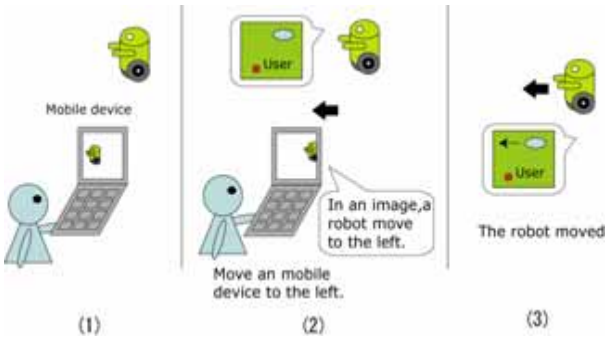

Figure 3

As shown in Figure 3, we assume that the gesture complies with the following rules: 1) When the user holds the mobile PC still, the robot should be at the center of image. 2) When the user moves his mobile PC, this should be done at faster rate than speed of the robot.

Shepherd estimates user's gestures based on the marker's position in a series of images captured by the camera. The following four cases were examined: a) The user is swinging his mobile PC while the robot is moving. b) The user is swinging his mobile PC while the robot is standing still. c) The user holds his PC steadily and the robot is moving. d) The user holds his PC steadily and the robot is not moving. Shepherd calculates the velocity of the marker's motion. Assuming the velocity relation in these cases: a b > c > d, Shepherd can determine the gesture. Informal experiments in these cases proved that a trajectory of the user's gesture could be estimated with sufficient accuracy (recognition rate is 81% at 2 meters away from a robot).

Evaluation

Six university students participated in this study. An experimental setting as shown in Figure 4 was used. The robot is placed at the center of a circle (0.5 meters in radius) directed in one out of 8 possible directions. We selected a random number between 1 and 8 and asked the participants to move the robot in the direction of the number until it is out of the circle.

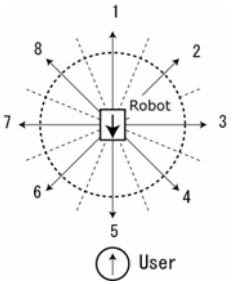

Figure 4

In this study, commercially available radio-control cars have been used. The robot has two wheels which are separately controlled. For easier recognition of the robot, different visual markers were attached to each individual robot. Shepherd identifies robots' positions and orientations by recognizing the marker.

Figure 5

The results showed that the average time of operation with Shepherd was 3.80 seconds. Using traditional remote controller, the task took an average of 7.35 seconds to be completed. According to our observation, there was a little difference in the moving time with both controllers. However, using traditional remote controllers, each participant took considerably more operation time when the robot was placed facing the participant himself as shown in Table 1 and 2. We also found that participants made the more considerations before moving the robot and they often mishandled the situation, when using the traditional controller.

Table 1

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6
1	(4 → 7) 10.99	(4 → 7) 8.82	(7 → 4) 7.97	(4 → 3) 4.95	(7 → 1) 7.64	(4 → 1) 7.34
2	(2 → 3) 4.81	(7 → 3) 10.57	(8 → 2) 4.47	(7 → 1) 8.09	(2 → 5) 4.81	(7 → 4) 8.66
3	(2 → 7) 14.54	(2 → 8) 8.03	(5 → 4) 6.87	(6 → 4) 6.53	(6 → 4) 4.21	(5 → 7) 18.47
4	(2 → 6) 3.27	(2 → 5) 6.83	(5 → 8) 7.66	(5 → 6) 13.11	(4 → 7) 4.15	(8 → 6) 6.28
5	(8 → 6) 4.96	(6 → 4) 6.81	(3 → 1) 4.21	(6 → 1) 4.93	(7 → 5) 6.00	(2 → 4) 4.37
Average	7.71	8.21	6.24	7.52	5.36	9.02

Table 2

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6
1	(4 → 8) 4.5	(1 → 6) 3.15	(5 → 1) 3.89	(6 → 3) 3.43	(5 → 1) 2.33	(6 → 5) 4.38
2	(3 → 2) 4.41	(5 → 7) 4.58	(8 → 7) 4.11	(7 → 5) 3.84	(4 → 3) 3.5	(7 → 8) 3.69
3	(4 → 7) 3.74	(4 → 6) 4.64	(3 → 6) 3.61	(3 → 6) 2.96	(3 → 8) 2.94	(8 → 2) 3.75
4	(8 → 5) 5.25	(7 → 5) 4.05	(5 → 2) 5.62	(5 → 7) 3.74	(6 → 4) 3.54	(3 → 6) 3.93
5	(4 → 1) 3.47	(7 → 3) 3.11	(6 → 1) 3.63	(7 → 1) 3.15	(2 → 4) 3.53	(5 → 4) 3.65
Average	4.27	3.91	4.17	3.42	3.17	3.88