Nasser Rezzoug, Philippe Gorce, Philippe Hoppenot, Etienne Colle : "Mobile platform configuration definition during grasping" - AAATE, Lille, 6-9 septembre 2005, p. 429-433.

Mobile platform configuration definition during grasping

Nasser REZZOUG[a], Philippe GORCE[a], Philippe HOPPENOT[b] and Etienne COLLE[b]
[a] *Laboratoire ESP EA 3162, Université du Sud Toulon -Var, France*
[b] *Laboratoire Systèmes Complexes, IUP d'Evry, France*

Abstract. In this paper, we present a learning based method for the definition of the ARPH mobile platform configuration during grasping. Based on the principle of semi autonomy, the proposed scheme uses information provided by the user to help him(her) during the tedious task of manually coordinating the robot motions. From a crude posture provided by the user a reinforcement scheme is used to optimize the kinematic configuration of the MANUS robot to align the gripper with the axis of the object and grasp it. Simulation results illustrate the capability of the proposed method.

Keywords. Mobile platform, Navigation, Grasping, semi-autonomy, Neural network.

Introduction

Since more than three decades, robotic assistive technologies have been developed to increase the autonomy of heavily disabled persons (suffering from myopathia or traumatisms). In this frame, several robotic platforms have been proposed. Three types of systems are now available : fixed workstations (RAID, AFMASTER, [2]), robotic arms embedded of an electric wheelchair (MANUS [4, 6]), and, last, mobile platforms equipped with a robotic arm (MOVAID [3], ARPH [9, 10]). These latter systems are the most complex but they constitute the most adaptive solution to enhance the performances of robotic assistance.

Due to the specificity of the potential users, the utilization of robotic systems induces some particularities. Indeed, the control mode have to be adapted to the physical and cognitive capacities of the user.

The ability to use a robot in various environments (inside and outside home) is one of the most required functionalities [2, 7, 11]. Thus, navigation and manipulation in non structured environments are important issues of assistive technologies. In a cluttered environment, the robot can not work in a full autonomous mode and its movements have to be manually controlled by the user. This induces physical and cognitive loads that may be incompatible with the disabled persons capacities. Semi autonomy may be an interesting way to investigate in order to solve this problem. Its principle is to execute semi-automatically some part of the grasping movement and let the user solve the high level tasks. This has two main advantages : the user is involved in the task execution and since some motions are executed autonomously by the robot, the physical and cognitive loads are lowered.

In this frame, we propose a reinforcement learning based method in order to define in a semi autonomous way the kinematic configuration of the ARPH mobile platform during grasping.

1. ARPH system architecture

The ARPH system is composed of a robotic arm mounted on a wheeled mobile platform The whole is controlled from a remote control station. (Fig. 1).

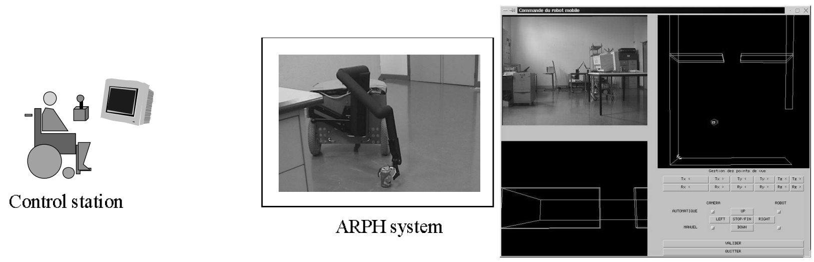

Figure 1. ARPH system and user interface.

The user controls the robot from a fixed workstation composed of a control panel adapted to the user residual capacities and a screen that displays picture send from a camera and other useful information to monitor the robot. (Fig. 1).

1.1. ARPH control

To take advantage of the machine capabilities, the user is an actor in the control loop [10]. A very crucial problem is the degree of cooperation between the user and the semi autonomous robot. In fact, each agent (the user and the robot) can contribute to a particular aspect of the task: the user can elaborate high level strategies while the robot can execute these strategies and interact with the environment. In order to have a relative autonomy while respecting some constraints of cost and complexity, the robot can fulfill autonomously a set of predefined functions adapted to specific criteria of the field of assistance to the disabled [1]. Thus, ARPH proposes a variable semi autonomy centered on the man-machine cooperation.

1.2. Movement modes and strategies

The ARPH system can be controlled according to three modes : a) full automation, the robot is fully controlled by the system, b) manual, the user remotely controls the robot, c) shared, the robot control is shared between the user and the machine. For example, the user can specify a direction that the robot will track while automatically avoiding obstacles. To date, these different modes have been implemented on ARPH.

Apart from the navigation of the mobile platform the grasp function is also very important. In the next section, we discuss a method to define the mobile platform kinematic configuration to perform grasping tasks.

2. Semi autonomous grasping

Several movements are needed to grasp an object : an approach phase during which the end-effector is brought in the vicinity of the object followed by a grasping phase that implies precise adjustments in order to orient properly the end-effector. This latter phase can necessitate fine motions that are tedious if executed in manual control. To reduce the difficulty of this task, we propose to automate partially the grasping phase working in the vicinity of the arm configuration chosen by the user at the end of the approach phase. More precisely, we define the angular configuration of the robot joints in order to place the end-effector in an adequate configuration.

2.1. Method

To define the mobile platform configuration 9 degrees of freedom have to be controlled (6 for the MANUS and 3 for the mobile base). This task is made difficult due to the existence of an infinite number of solutions to put the platform and the MANUS arm in a given configuration.

In order to identify the object to be grasped, it is necessary to obtain information from a camera. It seems important to define the needed amount of information to achieve the task considering the trade off between efficacy and complexity.

We consider that during the grasping phase two points defined on the end effector of the MANUS arm are associated with two points on the surface of the object. The goal is to bring the MANUS arm in such a configuration that the two pairs of points overlap. In this way, we treat the constraints relative to the position as well as the orientation of the end effector. Furthermore, we limit the amount of the needed information to the position of four points in 3D.

From the platform configuration defined by the user, a specific module is devoted to the definition of the suitable configuration. The method used is based on reinforcement learning [5], a trial and error strategy that allows to find a solution even if the forward kinematics model of the platform is of low precision.

The inputs of the model are the location of the two points of interest both on the MANUS gripper and on the object and also the arm joint limits. The output is the mobile platform configuration that optimizes a particular cost function composed of two parts:

1. A first term that insures that the axes defined by the two points on the surface of the object and on the MANUS gripper are collinear.

2. A second term to minimize the distance between each couple of points.

The first part evaluates the orientation of the gripper relative to the object, its expression is given in Eq. (1).

$$R_1 = \left|\mathbf{n}_{\mathbf{Gripper}} \cdot \mathbf{n}_{\mathbf{Object}}\right| \qquad (1)$$

$\mathbf{n}_{\mathbf{Gripper}}$ is the unit vector aligned with the axe defined by the two points on the MANUS gripper and $\mathbf{n}_{\mathbf{Object}}$ is the unit vector defined by the two points on the object. The maximum value of R_1 is reached when the two vectors are collinear, then $R_1 = 1$. On the other hand, when the two vectors are orthogonal $R_1 = 0$.

The second part of the cost function evaluates the distance between the couples of points. It is defined as following:

$$R_2 = 1 - \tanh(d) \qquad (2)$$

where

$$d = \min\left(\left\|\mathbf{X}_1^{\mathbf{Object}} - \mathbf{X}_1^{\mathbf{Gripper}}\right\| + \left\|\mathbf{X}_2^{\mathbf{Object}} - \mathbf{X}_2^{\mathbf{Gripper}}\right\|, \left\|\mathbf{X}_2^{\mathbf{Object}} - \mathbf{X}_1^{\mathbf{Gripper}}\right\| + \left\|\mathbf{X}_1^{\mathbf{Object}} - \mathbf{X}_2^{\mathbf{Gripper}}\right\|\right) \qquad (3)$$

$\mathbf{X}_\mathbf{i}^{\mathbf{Object}}$ and $\mathbf{X}_\mathbf{i}^{\mathbf{Gripper}}$ (i = 1, 2) represent the 3D position in a common reference frame of the points attached to the object and to the gripper.

d represents the minimum of the summed distances between the couple of points on the gripper and the object. The function tanh insures that R_2 lies in the interval [0, 1]. R_2 is minimum if d is high and maximum ($R_2 = 1$) if $d = 0$. Combining the two criteria, the cost function R (Eq. 4) is obtained.

$$R = \frac{R_1 + R_2}{2} \qquad (4)$$

The platform configuration is optimized through maximization of R by using a neural network based implementation of reinforcement learning [8].

2.2. Simulation results

In this section, simulation results are presented. The grasp of a cube placed at different locations is considered. The contact points location and the position of the object are known and considered as input data. The arm starts from a random position within its workspace. 30 simulations are performed for each of 64 object positions equally distributed in a 0.6 m x 0.6 m x 1m workspace (Fig. 2.). The obtained mean d (Eq. 3) is 9.6 ± 4.1 mm. For one situation, the platform configuration is shown in Fig. 2.

3. Conclusion

Semi autonomy is a concept that may contribute to a better efficacy and acceptance of robots designed to aid disabled persons. In this article, we proposed an application in the frame of grasping. This first step intended to validate by simulation the proposed method. The next steps would be to implement these functionalities on the ARPH platform. The adopted formalism allows to define the configuration but not the motion, this particular point needs further development. Finally, some work has to be done in order to define the suitable grasping points on the object taking into account task and camera constraints.

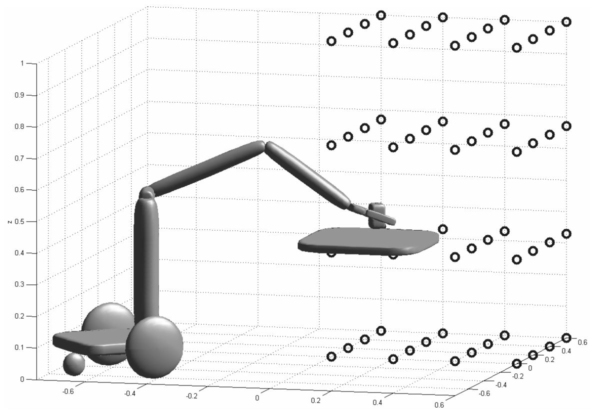

Figure 2. Example of ARPH platform configuration defined by the model and 64 object positions.

References

[1] O. Ait Aider, P. Hoppenot and E. Colle, A model to image straight line matching method for vision-based indoor mobile robot self-location, *Proc. IEEE Int.Conf. IROS* (2002).

[2] M. Busnel, R. Gelin and B. Lesigne, Evaluation of a robotized MASTER/RAID Workstation at home: Protocol and first result, *Proc. ICORR*, **9** (2001), 299-305.

[3] P. Dario, E. Guglielmelli, C. Laschi and G. Teti, MOVAID: a personal robot in everyday life of disabled and elderly people, *Technology and Disability Journal* **10** (1999), 77-93.

[4] H.G. Evers, E. Beugels and G. Peters, MANUS towards a new decade, *Proc. ICORR* **9** (2001), 155-161.

[5] V. Gullapalli, A stochastic reinforcement learning algorithm for learning real valued functions, *Neural Networks* **3** (1990), 671-692.

[6] H. Kwee and C. A. Stanger, The Manus robot arm, *Rehabilitation Robotics Newsletter* **5(2)** (1993).

[7] S. D. Prior, An electric wheelchair mounted robotic arm - a survey of potential users, *Journal of Medical Engineering & technology*, **14(4)** (1990), 143-154.

[8] N. Rezzoug and P. Gorce, A biocybernetic method to learn hand grasping posture, *Kybernetes* **32(4)** (2003), 478-490.

[9] Y. Rybarczyk, E. Colle and P. Hoppenot, Contribution of neuroscience to the teleoperation of rehabilitation robot, *Proc. IEEE Int. Conf. SMC* (2002).

[10] Y. Rybarczyk, S. Galerne, P. Hoppenot, E. Colle and D. Mestre, The development of robot human-like behaviour for an efficient human-machine co-operation, Proc. *AAATE* (2001), 274-279.

[11] C. A. Stanger, C. Anglin, W. S. Harwin and D. P. Romilly, Devices for assisting manipulation : a summary of user task priorities, *Transactions of Rehabilitation engineering* **4(2)** (1994), 256-65.