A Robotic Set-Up With Remote Access For "Pick and Place" Operations Under Uncertainty Conditions

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Abstract. The work describes on-going work at the University of Pisa on the field of tele-laboratories and distance learning. In particular, the group is working at the evolution of existing tele-laboratory experiments in the field of robotics and control into learning units of a self-consistent didactic project. The pick-and-place system described has been designed to provide the set-up for robot arm motion planning with specific objectives and evaluation tools.

1 Introduction

The interest of the System, Control and Robotics research group at the University of Pisa in exploiting Internet and web-based technologies for remote instructional activities dates back to several years ago [1]. The initial motivation has been the need to provide hands-on experience to engineering students in mechanical and electronic courses. The increasing number of students at the University of Pisa, coupled with constraints to laboratory space and budget, has led to the choice of remote, web-based access ("tele-laboratory") as the sole possibility to maintain a widespread didactic link between theoretical notions and experimental practice. Through the years, a number of didactic experiences have been developed, at different levels of difficulty and student skills [1–4]. Similar experiences have been documented by several others laboratories world wide. A recent review as for robotic applications can be found in [5].

Since the last year, our group is part of two related projects, sponsored by the Italian National Res. Council (CNR) and the Italian Ministry of Education and Research (MIUR), having as objective the development of a distributed e-learning environment in the field of robotics and automation systems. The projects team together Italian labs with previous tele-laboratory experiences, and have the aim of steering the evolution of tele-laboratory activities into complete learning units of a common instructional project.

Within this framework, one of the task of our group is to provide a previous available tele-laboratory set-up with tools for evaluation and student skill self-assessment. The set-up consists of a robotic arm and of a graphic language for robot motion planning. This paper briefly describes our on-going work toward this objective. In particular, to provide a goal for the students, the set-up (mechanics, electronics and software) has been enlarged to include a pick-and-place experiment; perturbation to the planned

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motion, as well as sensor feed-back at the planning level, have also been introduced. The students have to devise a high level motion-planning algorithm able to fulfill the pick-and-place task vis-a-vis the introduced uncertainty. Quantitative performance evaluation (for final student skill assessment and for self-assessment as well) is obtained by defining two distinct measures, one for algorithm efficiency and one for algorithm complexity.

2 The Set-Up

The developed set-up consists in a hardware platform, a graphic language for robot motion planning and a remote interface system which are briefly described in the following.

Fig. 1. A picture of the anthropomorphic arm SCORBOT ER-V PLUS.

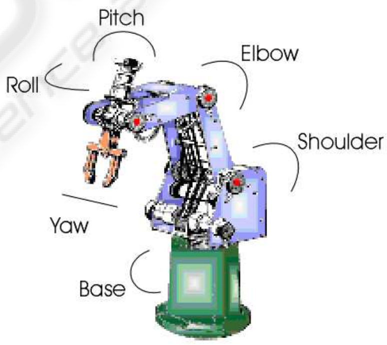

Fig. 2. The anthropomorphic arm SCORBOT ER-V PLUS.

2.1 The hardware platform

As already mentioned a Pick and Place task has been considered as educational test. For this purpose the robotic arm SCORBOT ER-V PLUS (see Fig. 1,2) has been choosen.

The Scorbot has 5 degrees of freedom and a gripper end-effector with two fingers. Furthermore, a joint control system is available and programmable through the ACL command language primitives.

The Scorbot robot is mounted on a $0.7m$ diameter platform sheltered by a plexiglas protection. The platform holds also the object for the Pick and Place task, the initial position retrieval system and the Place circular target mounted at the center of a sensorized plate (see Fig. 3).

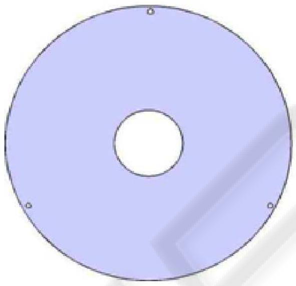

Fig. 3. The placing target has been realized in the center of the sensorized plate.

The sensorized plate is anchored with springs and dampers positioned at the vertices of an equilateral triangle; such anchoring system guides and constraints possible movements of the sensorized plate (see Fig. 4). A contact switch is positioned at the

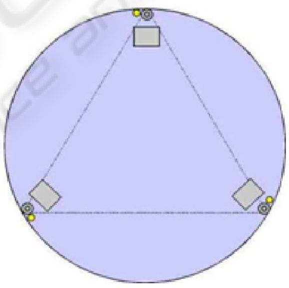

Fig. 4. The figure shows the equilateral triangular disposition of contact switch.

base of each spring-damper column. With this system, an incorrect placing leads the object in contact with the sensorized plate. It is possible to detect in which zone of the plate the object is positioned on the basis of the geometrical information from switch sensors (see Fig. 5). It is then possible to plan the subsequent movement to correct the placing error. The considered system is quite precise with respect to the Pick and Place task of non micro object. In order to make the task more challenging for the end-user, a random noise on the arrival desired position has been introduced.

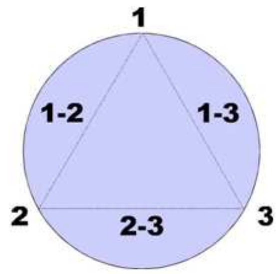

Fig. 5. The switch configuration enable the object localization on the sensorized plate in case of failed placing task.

The pick and place task can be planned and executed several times thanks to a retrieval system. Indeed, at the end of each experiment, the object placed in the target position is brought back to the initial position for a new pick task by a cable and a low power motor system mounted below the platform. Furthermore, such retrieval system allows the set-up to be used also after failures such that erroneous placing position or object loss from the gripper during robot arm movements. The sensorized plate and the gripper are shown in figures 6.

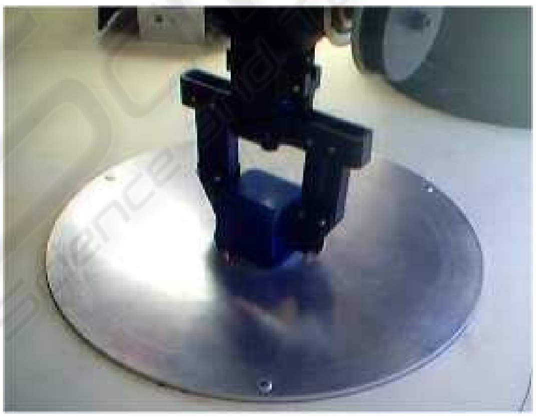

Fig. 6. The sensorized platform with the gripper

It is important to underline that, besides the Pick and Place task, the end-user can plan and execute arm movements in the whole feasible workspace.

2.2 A graphic language for a high level programming of the Robot

The GeT language, initially developed at Centro Piaggio [6, 7], has been updated with a set of flow commands and with primitives for sensor reading. The end-user first programs his own algorithm for the pick and place execution, the program is then tested by simulation. If, during simulation, no failure is caused by language syntax or by violation of physical constraints related to the manipulator workspace, the program is executed on the experimental tool.

2.3 A remote interface system

A remote interface system has been developed for several purpose. One of the most important thing is control of access at the set-up and the user identification: the former to monitor possible bad attacks and safeguard the experiment, the latter for a documentation of users evaluation from the teacher. The remote interface manages also the visual feedback based on a camera viedo streaming fundamental for a remote user. Finally, the remote interface manages also experimental results transmission and manipulation, as described in next section.

3 Learning process through experiments

The learning of motion planning for robotic arms through the particular Pick and Place task has two main purposes: from one side it allows a stimulating and challenging end-user learning; from the other side it permits a quantitative evaluation of the skill reached by the user as described in the following.

Two different criteria are used to evaluate the motion planning designed by the end-user: the first criterion is the motion planning algorithm complexity, computed on the basis of the number of GeT language instructions of the developed program; the second criterion is the algorithm efficiency measure, computed on the basis of the mean number of robot arm operations for the placing task. Obviously, it is awarded to the algorithm that leads to a correct placing with the lowest number of operations. The end-user can use those measures for auto-evaluation through the comparison with evaluation obtained by other users. The set of the evaluations allows the determination of a minimum threshold for the student final mark of the global learning process.

4 Conclusion

Currently the experimental set-up described in this paper is available in the DSEA firewall system and accessible only from the department intranet. Software tools for the user evaluation, the experiment documentation and the educational support material are under development. Furthermore, a protection procedure from undesired attacks is under study. Once those support and protection tools will be tested, the set-up will be available also from outside the DSEA for all Wide Area Networks users.

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