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Virtual Environment for Robotic Assistance

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Abstract.

This article presents a virtual laboratory tool for robotics practices, which for the case is oriented in assistive robot applications. The virtual environment shows the behavior of the robot based on the planning of trajectories from a point where a group of tools are located to a point determined by the hand of a user, simulating the action of delivery of tools. Based on this type of environment, it can be implemented algorithms of trajectory planning, gripping and variations of the robotic agent kinematics. The interface is evaluated through the task of collecting and delivering 3 different tools to a user, obtaining a precision of 97% in the performance of the assistance work.

Keywords: Robotic assistance, planning of trajectory, kinematics, virtual environment.

INTRODUCTION

From the conception of robots as systems capable of performing heavy tasks in relation to the work developed by the man, its application in various fields has generalized this way of seeing them, its application in various fields has generalized this way of seeing them, performing many more tasks of precision than of force, which allows the accompaniment to the man in the performance of a work, where, for that case, they are known as welfare robots.

In the field of robotics assistance, applications that can be addressed on different fronts has increased. From where, in the state of the art there can be found robots that assist the action of getting up to elderly people or with any incapacity that presents this problem [1] [2], additionally robotic assistants have been developed in feeding tasks [3] and in assistance to rehabilitation therapies [4] [5]. However, one of the main fields of application of this type of robot is nowadays in medicine, as assistants in surgery rooms, where advances are evidenced in strength applied by the robot for bone cutting [6], cardiovascular operations [7], laparoscopies [8], lung cancer [9] and thus could continue the list.

Making relevant all those applications that allow to follow this type of development based on robotics assistance. In support of these developments there are the virtual laboratories, which have a wide field in applications of teaching in engineering [10] and that have been applied to the robotic part in diverse scenarios [11] [12]. Within the tasks that can be developed with robots, in this type of virtual environments, is the planning of trajectories of a robotic agent [13] or several [14]. With obvious advantages in the cost reduction of the evaluation of the planning algorithm by not requiring an expensive industrial robot, reducing the space required for learning practices and even giving security to the programmer as not being at risk of contact with the robot.

These planning tasks are applicable to robot assistance as presented in [15], where a virtual environment based on robotics assistance would allow the evaluation of different test scenarios in the development of algorithms for robotic manipulation. Based on this, this article presents the development of a virtual environment for a robot assistance in a surgery room, supporting as an instrumentation facilitator.

The article is then divided into three sections, the methods and materials used, the results obtained and the conclusions reached..

MATERIALS AND METHODS

The virtual environment, associated to a surgery room, was developed under the VRML tool of MATLAB®, using an assistive robotic manipulator. The environment consists of the manipulator, a group of tools and a hand ready to receive the instruments. A gripping point was set on the required tool and the manipulator moves to that point to take the tool and transfer it directly to the surgeon’s hand.

The virtual environment consists of a surgical table of metallic appearance on which the manipulator and tools are located, the virtual hand simulates the end point to which the selected tool must be carried, this selection is made by entering the name of the tool in the program. The manipulator was assembled piece by piece using SolidWorks software, starting with a fixed base that was added fitted to the table and ending with the gripper, this includes small metal spheres at each joint, which simulate the robot's motors, to allow the rotational movements of each link. Each additional piece of the manipulator was added fitted to the previous pieces, so that any change of rotation in any of the motors of the joints generates a movement in the following links until reaching the gripper, as would a real manipulator.

After assembling the robot and adding color details, a rectangular box was added on the metal table to put the tools on it, and thus allow the manipulator a greater range of motion than when it has to go to a point located at the height of its base. On the box were placed 3 tools, a scissors, a screwdriver and a scalpel, each one of different color to recognize them with greater visual facility. Fig. 1 shows the developed virtual environment.

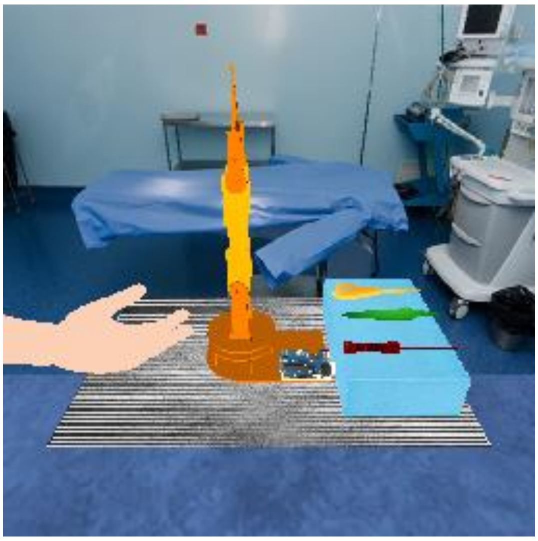

Figure 1: Virtual Environment

Once the virtual environment is finished, it is necessary to implement an algorithm to generate the movement of the robot, i.e. the trajectory, for which it is necessary to calculate the inverse kinematics of the manipulator. A function is used which receives as input the gripping point X, Y, Z according to the desired tool, from which, when applying the inverse kinematics, the angles in radians of each joint are obtained as output. These angles are sent to the virtual environment, which allows to validate the displacement of the robot.

In (1) it is shown the equation used to calculate each intermediate step of the path, where $[X_f Y_f Z_f]^T$ are the coordinates of the end point, $[X_i Y_i Z_i]^T$ are the coordinates of the starting point, $[x_k y_k z_k]^T$ are the coordinates of the current position of the end effector, $[x_{k+1} y_{k+1} z_{k+1}]^T$ are the coordinates of the next position of the end effector and n is the number of intermediate positions that the manipulator will take to move from the initial position to the final position. The calculation of (1) is repeated iteratively until the error between the current position and the end reaches the desired minimum value.

$$\begin{bmatrix} x_{k+1} \\ y_{k+1} \\ z_{k+1} \end{bmatrix} = \begin{bmatrix} x_k \\ y_k \\ z_k \end{bmatrix} + \frac{1}{n}\left(\begin{bmatrix} X_f \\ Y_f \\ Z_f \end{bmatrix} - \begin{bmatrix} X_i \\ Y_i \\ Z_i \end{bmatrix}\right) \quad (1)$$

In order to differentiate one tool from another, the user selects in the simulation code the type of tool to be grasped and, according to what he chooses, a position offset is added to the grip coordinate found to reach the correct tool, i.e., if the scissors are chosen and these are to the left of the manipulator, a position offset is added to the left to bring the manipulator up to the scissors, but if the desired tool is, for example, the screwdriver, the offset is added to the right. In the case of a scalpel, the final position depends only on the calculated grip and an offset in the direction opposite to the center of the manipulator.

After adjusting the grip coordinates for the desired object, trajectories were defined in a straight line between the initial point of the robot and the surgeon’s hand, and the inverse kinematics were used to obtain the angles of rotation of each joint at each point of the trajectory and to enter them into the motors of the virtual robotic arm. In addition, the selected tool was moved along with the gripper to simulate the grip and transfer it to the surgeon’s hand.

RESULTS

In order to set the operation of the interface with respect to the trajectory, consecutive gripping tests of each tool are performed, decreasing the minimum error between the point of variation of the kinematics and of the tool. The execution time is counted from the input of the desired tool to its delivery and the accuracy of grip achieved. Table 1 shows the results obtained.

Table 1: Grip-delivery validations

Test	**1**	**2**	**3**	**4**	**5**
Error (mm)	0.5	0.25	0.1	0.075	0.05
Precision (%)	26	48	68	82	96
Time (s)	33	54	62	84	106

It is possible to observe that the correct error value for an optimum grip is in 0.05, which although it requires a longer time, the precision achieved makes this threshold the best option, lower values fail to improve performance. Figure 2 illustrates some scenes of the tool gripping operation and subsequent delivery to the end user, in the steps of locating, gripping, transporting and delivering.

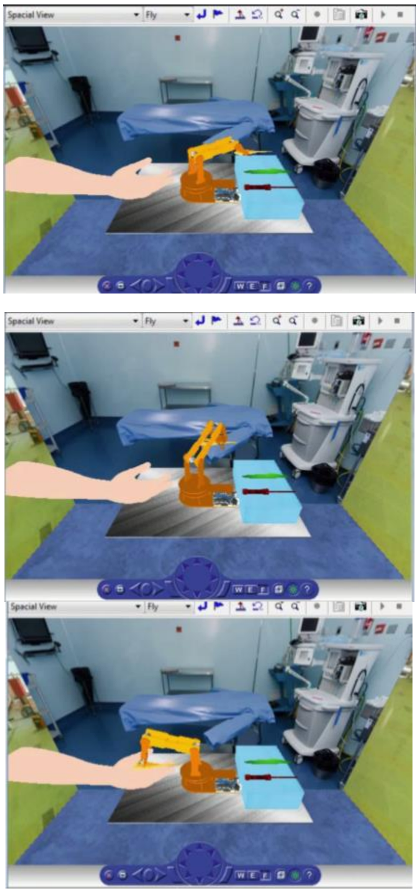

Figure. 2: *Simulation tests.*

The virtual environment presented shows the entire programming process of the algorithm of planning and gripping of the tool. Using the VRML own command it is possible to change the view of the scene.

CONCLUSIONS

The design of virtual environments such as the one presented, shows its versatility when developing robotic control algorithms. In this type of environment, as it is illustrated, it is easy to change parameters of control and execution of tasks, reducing their implementation time and associated costs.

The virtual environment presented required the integration of various concepts such as the design of the robotic architecture, the calculation of its kinematics, its implementation in CAD and application, the benefits provided in teaching and research focus the various models for their adjustment and tuning as a step prior to a real implementation. In turn, for this implementation, it is required to set mechanisms for gripping the tool, which for the case was assumed stationary, around the center of gravity.

Potentializing the presented application can be done by remote loading of the control codes of the robot, so that not only would a virtual interface be obtained but a remote laboratory, which is set as future work.

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REFERENCES

[1] J. Yang, J. Li, D. Bai, B. Sun and S. Wang, "Assistive standing of omni-direetional mobile rehabilitation training robot based on support vector regression algorithm," 2016 IEEE International Conference on Information and Automation (ICIA), Ningbo, 2016, pp. 1050-1055. doi: 10.1109/ICInfA.2016.7831974.

[2] R. Kamnik and T. Bajd, "Robot assistive device for augmenting standing-up capabilities in impaired people," Proceedings 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2003) (Cat. No.03CH37453), 2003, pp. 3606-3611 vol.3. doi: 10.1109/IROS.2003.1249715.

[3] M. Guo, P. Shi and H. Yu, "Development a feeding assistive robot for eating assist," 2017 2nd Asia-Pacific Conference on Intelligent Robot Systems (ACIRS), Wuhan, China, 2017, pp. 299-304. doi: 10.1109/ACIRS.2017.7986112.

[4] M. Nabeel Anwar, V. Sanguineti, P. G. Morasso and K. Ito, "Motor imagery in robot-assistive rehabilitation: A study with healthy subjects," 2009 IEEE International Conference on Rehabilitation Robotics, Kyoto International Conference Center, 2009, pp. 337-342.

[5] H. F. Jelinek et al., "Influence of stroke location on heart rate variability in robot-assistive neurorehabilitation," 2nd Middle East Conference on Biomedical Engineering, Doha, 2014, pp. 253-256. doi: 10.1109/MECBME.2014.6783252

[6] S. W. Hsu and P. L. Yen, "Determine the robot assistive forces based on human intent estimation in bone cutting applications," 2013 13th International Conference on Control, Automation and Systems (ICCAS 2013), Gwangju, 2013, pp. 956-959. doi: 10.1109/ICCAS.2013.6704053

[7] P. Štádler, L. Dvořáček, P. Vitásek, P. Matouš, Robot assisted Aortic and Non-aortic Vascular Operations, European Journal of Vascular and Endovascular Surgery, Volume 52, Issue 1, July 2016, Pages 22-28, ISSN 1078-5884, https://doi.org/10.1016/j.ejvs.2016.02.016.

[8] Mohamad S. Mahmoud, Robotic-Assisted Laparoscopic Trachelectomy: A Standard Technique, Journal of Minimally Invasive Gynecology, Available online 27 February 2017, ISSN 1553-4650, https://doi.org/10.1016/j.jmig.2017.02.018.

[9] Giulia Veronesi, Pierluigi Novellis, Emanuele Voulaz, Marco Alloisio, Robot-assisted surgery for lung cancer: State of the art and perspectives, Lung Cancer, Volume 101, 2016, Pages 28-34, ISSN 0169-5002, http://dx.doi.org/10.1016/j.lungcan.2016.09.004.

[10] Vladimir M Cvjetkovic, Uros Stankovic; "Arduino Based Physics and Engineering Remote Laboratory". International Journal of Online Engineering (iJOE), Vol 13, No 01 (2017).

[11] Lorella Gabriele, Davide Marocco, Francesca Bertacchini, Pietro Pantano, Eleonora Bilotta; "An Educational Robotics Lab to Investigate Cognitive Strategies and to Foster Learning in an Arts and Humanities Course Degree". International Journal of Online Engineering (iJOE), Vol 13, No 04 (2017)

[12] Qu Jing Lei, Li Shao bo, Chen Jing , "Online Monitoring of Manufacturing Process Based on autoCEP Kun". International Journal of Online Engineering (iJOE), Vol 13, No 06 (2017).

[13] Jikai Liu, Albert C. To, Deposition path planning-integrated structural topology optimization for 3D additive manufacturing subject to self-support constraint, Computer-Aided Design, Volume 91, 2017, Pages 27-45, ISSN 0010-4485, http://dx.doi.org/10.1016/j.cad.2017.05.003.

[14] F. Basile, F. Caccavale, P. Chiacchio, J. Coppola, C. Curatella, Task-oriented motion planning for multi-arm robotic systems, Robotics and Computer-Integrated Manufacturing, Volume 28, Issue 5, 2012, Pages 569-582, ISSN 0736-5845, http://dx.doi.org/10.1016/j.rcim.2012.02.007.

[15] [15]P. Bevilacqua, M. Frego, E. Bertolazzi, D. Fontanelli, L. Palopoli and F. Biral, "Path planning maximising human comfort for assistive robots," 2016 IEEE Conference on Control Applications (CCA), Buenos Aires, 2016, pp. 1421-1427. doi: 10.1109/CCA.2016.7588006