REAL TIME UNILATERAL TELEOPERATION SYSTEM FOR ARM MOVEMENT PERFORMANCE

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Abstract: This paper presents a solution in manipulating robotic arms. The solution follows the line drawn up by the human-robot interaction based on gestures. The movements of a human arm are captured, and a robotic arm reproduces the human movements in real time. The position of the joints of the arm are obtained by means of the motion capture suit GypsyGyro-18. These movements are treated by a controller and sent to the PA-10 robotic arm developed by Mitsubishi, which will execute them trying to diminish the difference of position between both arms. It has been necessary to implement a proportional controller that determines the reaction of the error.

1 INTRODUCTION

The flexibility and the maneuverability in systems that must develop certain tasks of a process are two topics that nowadays have great importance. In some cases, the tasks that have to be developed are so complex that they cannot be developed by a unique system. In those cases a strong implication of the user with the system can be necessary. Robots and humans share the work space but they also share objectives.

The use of gestures to approach the human-robot interaction provides the operator with a powerful and intuitive interface that allows controlling the robot in the development of tasks or the control of its operations (Hasanuzzaman et al., 2004). To do so, it is necessary to develop a system that is efficient in the gesture recognition and that works in real time. Two approaches are commonly used in this kind of systems:

- To use vision technology to capture the gestures that the operator makes, as those described in (Waldherr et al., 2000; Deniz et al., 2004).
- By the use of some motion capture device that the operator should wear and that will be connected to a computer. Examples of this system are those described in (Miller et al., 2004; Dhal and Palmer, 2010).

Due to vision technologies do not offer total reliability and precision for real time applications of robotic control, in this paper we only focus on applications related to the latter approach.

Cybernetic exoskeletons considerably increase the skills of the users who handle them. They allow the users to carry out tasks that could not do by means of their own physical capacities (Rosen et al., 2001; Perry et al., 2007).

In the present paper an application is developed using a gesture-based interaction approach through a motion capture device.

This paper is structured as follows. First, an introduction where humans and robots interact is described. Next we describe the system we developed and the results obtained. Then we explain the conclusions and future works. Finally, a list of bibliographical references that have been used for the development of this paper is exposed.

2 SYSTEM DESCRIPTION

In order to be able to solve the interaction problem between a human arm and a robotic one the first of all is to have a device that allows capturing the movements made by the operator. In this case, a motion capture suit developed by Animazoo, the GypsyGyro-18. The GypsyGyro system has 19 MEMS (Micro-Electro-Mechanical System)

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gyroscopes, 18 of them placed in the Lycra suit.

We use the PA-10 made by Mitsubishi, a robotic arm with seven degrees of freedom that counts with seven rotational joints set as follows: two for the shoulder, two for elbow and three for the wrist (Bompos et al., 2007).

The PA-10 can be controlled through speed or position. Speed control uses a vector that contains the speed at which each joints must turn. in contrast, for the control through position a vector is needed that handles the degrees to which each joints of the robot must be positioned (Kennedy and Desai, 2005). In this project we wanted the robotic arm to imitate the movements made by the arm of operator, and as the movement of an arm usually does not have a constant speed, for the resolution of the system it is necessary to control the PA-10 by speed. This allows to be modifying the speed of each one of the joints in small time intervals, reason why the wished effect of acceleration and deceleration is achieved.

Finally we must talk about the controller, which works as an intermediate layer between the suit and the robot: it collects positions of the suit, transforms them and sends them to the robot so that it performs the movements. This happens in a cycle of time that cannot exceed 200 ms., reason why the robot could not have sufficient time to realise the movement. Every time this happened an error in the position would be obtained that would be accumulated, and so, a variation between the positions of the arm and the robot would take place. In order to solve this disadvantage we use a P controller (Proportional Controller).

In the developed system, as seen in Figure 1, an adjustment is done between the position in which the robot should be and in the one it really is.

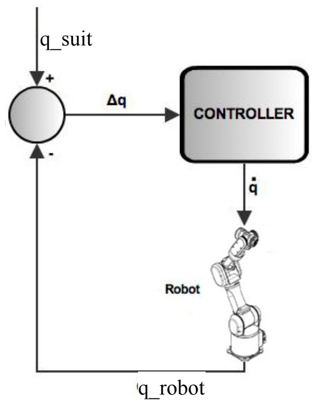

Figure 1: Block diagram of the system using a P controller.

As mentioned elsewhere, the robot counts only with seven joints, reason why only some of the movements that are able to make an arm could be represented by the robot. Consequently it is necessary to obtain a relation between the movements of the arm that offer major functionality and the joints of the robot. Looking at the joints of the robot and the coordinate system of the human arm, shown in 6, the relation is as follows: the W1 joint is related to the turn on z-axis of the wrist; the E2 joint is related to the turn on x-axis of the wrist; the E1 joint is related to the turn on y-axis of the elbow; the S2 joint is related to the turn on z-axis of the elbow.

To simulate by the robot a turn on the y-axis of the elbow, it is necessary to change its starting point, since from no other way its joints would allow to turn on the y-axis. So, initially the S3 joint is turned 90º and the E2 joint -90º. This way a position is obtained that keeps many similarities with the position from the arm.

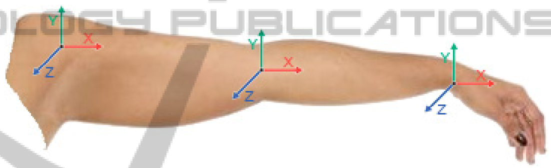

Figure 2: Coordinate system of the human arm.

Although the robot has more joints, these do not reproduce movements that can be made by an arm. It can be said so, that the robot is limited to the movements that the arm can perform and, as well, the arm is limited to the movements that the robot can execute.

3 RESULTS

An incremental development process has been used for the implementation of the system. First, a system was developed that controlled the robot by position, instead of by speed. With that approach, the robot movements were no soft movements, the human moves its arm and after the movement of the human the robots realizes it movement. This system did not reflect the speed changes that took place in the movement of the arm of the operator, since it always maintained a constant speed, but it is useful to make an initial study of how the robot behaved the movements captured by the suit.

Once prove was taken that the robot correctly interpreted the movements made by the arm of the operator, the system in real time was developed, still controlled by position. This system was quickly rejected because in each 150 milliseconds cycle the robot stopped its movement to do a new reading, taking place a shaking in its movement.

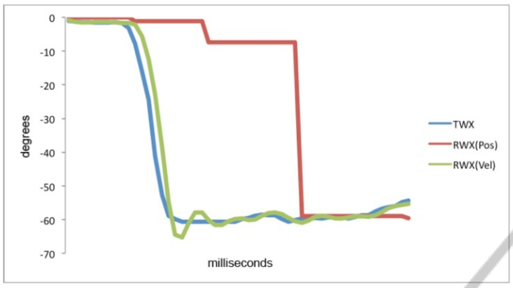

Figure 3: Comparative graph for the turn on x-axis of the wrist.

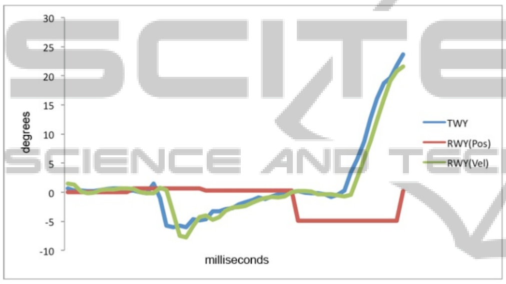

Figure 4: Comparative graph for the turn on y-axis of the wrist.

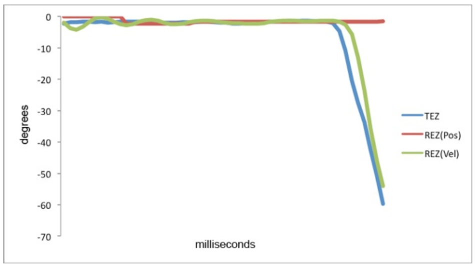

Figure 5: Comparative graph for the turn on z-axis of the elbow.

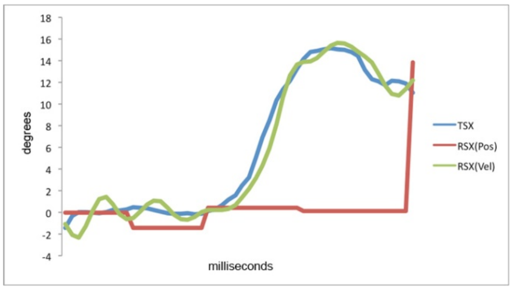

Figure 6: Comparative graph for the turn on x-axis of the shoulder.

Finally the speed control mode of the robot in real time was used. This mode allows assigning to each joint a speed of turn, which will stay constant while it is not modified. This allows readings of the suit without stopping the movement of the robot, reason why the shaking will be completely eliminated.

The final result remarkably improves the reproduction of the movement of the arm of the operator, as we can observe in the graphs of Figures 3, 4, 5 and6. Each graph offers a comparative between the position of a joint of the suit (TW…), the robot using the position control mode (RW…Pos) and of the robot using the real time speed control mode (RW…Vel). It can be seen that the position control mode only takes readings when is not in motion, thus does not capture sufficient movements from the suit to offer a visual result and an optimal reaction time. As seen, in this control mode the robot reproduces with sufficient exactitude the movement of the arm of the operator, although with a slight oscillation produced by the proportional controller. The shoulder joint, being the one supporting the whole structure from the robotic arm, is the most affected (Fig. 6). That is why wrist joints, which are free of weight, show a lower oscillation (Fig. 3 and 4).

In Figure 7 we can see a short sequence that serves as example to observe the behavior of the robot to the movements of the arm of the operator.

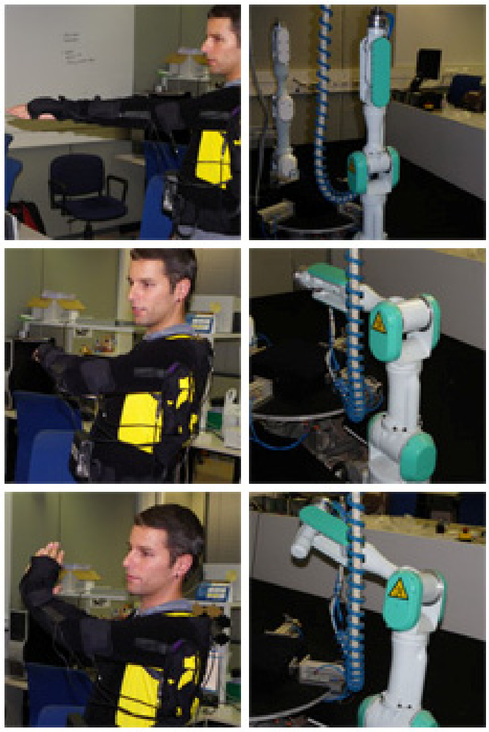

Figure 7: Interaction sequence with the robotic arm.

4 CONCLUSIONS

This paper describes a interaction system based on gestures by means of a device of motion capture.

Departing from this system, a possible future works exist. Integrate a PID controller (Proportional Integral Derivative). In the developed system a P controller is used, therefore, this is some way to solve the permanent error and make the system contain some component that include and configures the integral and derivational actions. On the other hand decoupling all the joints and using the seven degrees of freedom can be studied.

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