Chapter 7
New Redundant Manipulator Robot with Six Degrees of Freedom Controlled with Visual Feedback

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ABSTRACT

The design and implementation stages of a redundant robotized manipulator with six Degrees Of Freedom (DOF), controlled with visual feedback by means of computational software, is presented. The various disciplines involved in the design and implementation of the manipulator robot are highlighted in their electric as well as mechanical aspects. Then, the kinematics equations that govern the position and orientation of each link of the manipulator robot are determined. The programming of an artificial vision system and of an interface that control the manipulator robot is designed and implemented. Likewise, the type of position control applied to each joint is explained, making a distinction according to the assigned task. Finally, functional mechanical and electric tests to validate the correct operation of each of the systems of the manipulator robot and the whole robotized system are carried out.

INTRODUCTION

Currently, robotics is possibly immersed in all industrial fields because of the countless applications that it can be given (Siqueira & Terra, 2011; Ben-Gharbia et al., 2014). These systems have improved the productivity and quality of manufactured products and their use has extended from the automobile industry (General Motors: Unimate in 1960) (Hunt, 1983) to the aerospace industry (National Aeronautics and Space Administration: Curiosity in 2012) (Kaufman, 2012).

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Regarding Degrees Of Freedom (DOF), robots are classified in two categories:

- Redundant and
- Non-redundant.

The robot developed in this study corresponds to a redundant robot, since it possess a high number of DOFs (equal or superior to 6). Industrial robots, which are commercialized globally, are non-redundant and built with enough DOFs as to carry out specific tasks within their physical limitations. Having different types of manipulator robots focused on only one activity is impractical and expensive. In addition, the extensive range of applications has therefore required flexibilizing the work space of the robots as well as improving their position, accuracy and orientation. These characteristics can be achieved by increasing their degrees of freedom, i.e., providing them with redundancy.

However, all these activities would not be possible without an adequate design of the robot and of its technical control. Fulfilling this requires the knowledge and study of a mathematical model and of a certain class of "intelligence" that can direct the manipulator robot to perform the assigned tasks. Specifically, the control of the manipulator robot is based on an artificial vision system, but the technique used is not the same for all the joints. In the case of the first three rotational joints, this visual feedback system filters images and is capable of determining the position of a laser beam that is placed in the manipulator robot's end-effector. In the case of prismatic joints, position is controlled by limit switches, while for the rest of the joints there is no position feedback, but a functioning routine with sequential movements. Image processing is key for achieving a good control of a manipulator robot. For this purpose, there is a variety of techniques, among which morphological operations and filtering may be underlined.

Using the basic laws of physics that govern the robot's dynamics, it is possible to derive a mathematical model that represents its behavior, and through appropriate programming tools, develop an environmental simulation to subject it to different tests such as, for example, following trajectories (Angulo & Avilés, 1989; Selig, 1992; Iñigo & Vidal, 2004; Torres et al., 2002; Craig, 2006).

On the other hand, there are many kinds and configurations of robots with different Degrees Of Freedom (DOF) (Siciliano & Khatib, 2008; Urrea & Coltters, 2015; Urrea & Kern, 2016).

To make the design and implementation of a Selective Compliant Assembly Robot Arm (SCARA) type manipulator robot with six DOF and an RRRPRP (R: Revolution and P: Prismatic) with visual feedback, and in addition get this robotized system to develop correctly an application in real time, it is necessary to be conversant with several subjects, among them robotics fundamentals, servomotor and microcontroller operation, the use of artificial vision, computer programming, systems control, etc.

RELATED WORK

The applications of the manipulator robots are varied and flexible, even more when the extension of the environment or the location of the elements that the robot should manipulate are uncertain. Occasionally, tasks are undermined by other factors, such as dark environments or bad weather. In contrast to other studies, the visual feedback system used does not comprise obstacle avoidance, nor does integrate a system that helps to counteract the effects of ambient noise. The main difference is that it has been implemented in a redundant robotic design. Most research works with non-redundant robots, which restricts movement and results in a decrease in the volume of work.