Strategies to reduce manufacturing costs in collaborative robotic arms

Leonardo Alonso Jiménez Berrocal[1] and Paula Ramírez Alfaro[2]

[1] Universidad de Costa Rica, leonardo.jimenezberrocal@ucr.ac.cr
[2] Universidad de Costa Rica, paula.ramirez@ucr.ac.cr

Abstract. This study investigates the strategies to reduce the manufacturing costs of a collaborative robotic arm, which is important because there is a large sector of SMEs whose financial solvency does not allow them to invest in these technologies. To do this, first, the main characteristics of robotic arms are exposed, then four of the main methods present in the literature to achieve the aforementioned objective are explained. These consist of a proper choice of alternative materials for the arm structure based on stress and vibration analysis, the use of 3D printing as part of the initial stage of development, the implementation of counterbalancing methods that allow the use of motors and reducers cheaper speedometers and finally, the reuse of materials and components of obsolete equipment.

Keywords: Robotics · robotic arm · cost reduction · SMEs.

1 Introduction

Robotics can be defined as the generation of movements of physical objects controlled by computers. This offers improvements in terms of agility, speed, quality and process efficiency when implemented in the industry. However, one challenge that prevents the use of robotics on a large scale is cost [1]. Within this area, robotic arms stand out, which are versatile and suitable for heavy and repetitive tasks [2]. Given that small and medium-sized enterprises (SMEs) tend to have low capacity to invest in research and development in an increasingly competitive market [3], it is evident that these organizations are the ones that show the greatest difficulty in acquiring this type of technology. and include it within its operations.

Based on the above and taking into account the fundamental role of SMEs in regional socioeconomic contexts [4], the need to explore technologies belonging to the area of robotics that are accessible to organizations that do not have the solvency becomes evident. economy of the big transnationals. Therefore, this study investigates strategies to reduce the manufacturing costs of a collaborative robotic arm, thus enabling companies in the aforementioned market sector to afford its acquisition.

2 Characteristics of a collaborative robotic arm

First of all, it is necessary to highlight that the word robot refers to an artifact that automatically performs complex and commonly repetitive tasks [5]. Within these, robotic arms consist of an articulated body which is capable of performing operations similar to those performed by a human arm. These can accept instructions to accurately locate a point in three-dimensional space and integrate advanced control technology and a memory system that can complete complex motion instructions repeatedly [6]. The most important aspects associated with these robots are presented below.

2.1 Joints and degrees of freedom

The functionalities of the articulated body depend on its degrees of freedom, which can be defined as a specific way in which a machine works. A generic robotic arm of 4-degree-of-freedom is made up of four joints and three links. Each link represents the structure of a human arm, that is, link 0: shoulder, link 1: elbow, and link 2: wrist. In each joint there is a motor connected to it in a way that allows it to rotate parallel or perpendicular to its axis [2].

2.2 Grip system

A gripper is the most used mechanism as an end effector of robotic arms, it is modeled as its fingers, it allows to hold, manipulate and release an object. It is often made up of two or more claws. It has a wide range of applications in various industries, in assembly units and packaging facilities. In pick-and-place robotic arms, grippers and rotary actuators are two of the key elements that replicate the work of the wrist and hand [7].

2.3 Collaborative aspect

A collaborative robot, also known as a cobot, is a robotic arm created to work alongside humans on a production line. Cobots should not only serve as components of production and make the daily activity of employees more comfortable, but also facilitate and optimize data collection at the internal company level. The continuous development of cobots is largely due to the safety aspect, for which they are currently equipped with force sensors, capacitive sensors and a variety of systems that collect information in real time and transmit it to software. If the software detects a fault or a risk, it must be able to immediately interrupt the operation of the device [8].

3 Improvement opportunities

For opportunities for improvement in relation to the decrease in costs associated with a robotic arm, the following strategies were found through literature review.

Based on stress and vibration analysis, the choice of the appropriate materials for the manufacture of a robotic arm has been found, with this it is obtained that the mixture of magnesium and aluminum alloy guarantees high values of safety factor, acceptable deflection and high natural frequencies compared to the other options, this offers a relatively low price and light weight [9].

An alternative method to reduce material costs, according to [10], is the use of 3D printing. During the initial stage of robot development, 3D printing provides design freedom, customization, and sustainability, ultimately leading to direct cost benefits. A robotic arm that is specified by design parameters tied to a specific task is developed quickly and cheaply using a 3D printing process. The wide range of new polymer-based additive manufacturing techniques and materials would provide significant benefits for future robotics design and development.

In relation to operation, most robotic arms use expensive motors and speed reducers to provide enough torque to support the mass and load of the robot. In order to compensate the gravitational torques due to the mass of the robot and the load, counterweight mechanisms (CBM) or passive gravity compensators have been developed, which would allow energy savings and the use of cheaper actuator modules. Experimental results show that CBMs effectively reduce the torque required to support the robot's mass and payload, which allows the use of low-cost motors and speed reducers for high-performance robotic arms [11].

Finally, it is necessary to highlight the importance of reusing materials and components of obsolete or damaged equipment for the manufacture or repair of current technology. Technological advances in the areas of computing and automation provide the opportunity to investigate which technologies can be combined to transform the mode of operation of an obsolete machine into a functional one capable of producing efficiently again. Even damaged equipment may have functional components inside. For example, from a damaged 3D printer it is possible to extract a functional servomotor, which is a usable part for the elaboration of a robotic arm, thus reducing component costs [12].

4 Conclusion and Future Work

There are strategies to reduce the manufacturing costs of robotic arms, which drives the acquisition of this type of 4.0 technology by SMEs, thus demonstrating that not only large transnationals are necessarily capable of investing in this area. As future research lines, it is proposed to carry out a cost comparison between the standard multifunctional robotic arms on the market with potential designs developed for particular processes of a specific industry, which, therefore, would be simpler. All this taking into account the cost reduction strategies that best suit each case.

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