DESIGN OF A MOBILE MANIPULATOR FOR PICK AND PLACE ACTIVITIES.

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***Abstract:** This work develops the design of a mobile manipulator robot that aims to be able to pick up, transport and place an object. The robot moves by itself thanks to a line follower. A manipulator arm with three degrees of freedom is used to pick up the object. The project is developed with the purpose of reduce operating costs in companies' warehouses and to reduce the time it takes to move their products.*

***Keywords:** mobile manipulator, line follower, robot.*

1 INTRODUCTION

Nowadays, companies compete for being the first to deliver their products to customers, as a result they search for ways to speed up the shipping processes in their warehouses and reduce their operating costs. In traditional warehousing processes, company's workers search for the item, retrieve the product, and then delivery it to the packing area. This is where the problem lies because has been shown that workers lose around 55% of their time in displacements (Tompkins 2010) causing a significant business cost. In addition, workers tend to get distracted and make mistakes during these activities.

The implementation of a mobile manipulator in the activities mentioned above can be very useful to reduce downtime because it can perform activities uninterruptedly for many hours. Also, it can reduce the error rate and bring objects to their destination faster, contributing to an increase on productivity and reducing operating costs.

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2 THEORETICAL AND CONCEPTUAL FRAMEWORK

To improve their product warehousing processes, modern commercial enterprises invest enormous amounts of time and effort in automation and robotics research (Huang 2019). A popular example is Amazon's use of autonomous robots to pick customer orders in the company's huge warehouses. Amazon has managed to reduce the travel time of workers and the amount of labor used (Wurman 2008).

Likewise, there is research showing that the use of autonomous mobile robots can increase productivity and flexibility in industries which can translate into higher profits for them (Fragapane 2020). However, according to (Huang 2019) creating robots capable of handling different products at a reasonable cost and in a short time is still a challenge, as current systems are designed to work in specific environments and to handle specific objects (usually boxes).

That is why this paper proposes the integration of a manipulator robot with a mobile robot. The manipulator arm can provide the robot with the ability to pick up different types of objects based on its end-effector. On the other hand, integrating a mobile platform to the manipulator robot adds the ability to transport itself to the place where it is indicated.

It should be noted that implemented correctly, robots can take care of repetitive tasks in less time than it takes a human operator (Tian 2015), obtaining an additional benefit if they are repetitive actions, tedious or dangerous for a human being.

3 METHOD

First, the physical characteristics of the robotic arm were determined: a 3 degree-of-freedom (DOF) manipulator that uses a gripper to grab the object. The 3 DOF and the gripper are driven by servo motors.

As for the mobile platform, 2 standard wheels driven by 2 geared motors and a spherical wheel (used to facilitate the displacement) were used. A computer-aided design (CAD) of the mobile manipulator can be seen in Figure 1.

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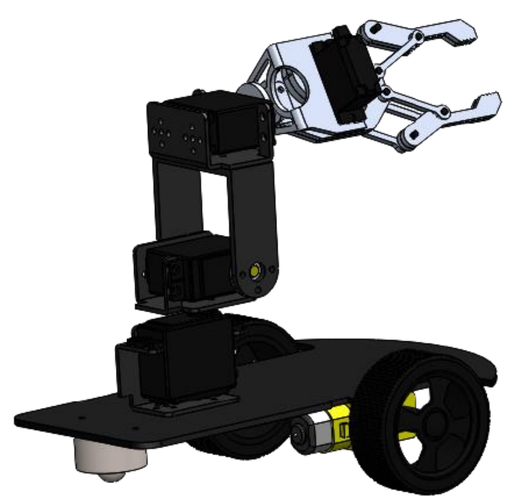

Figure 1: Mobile manipulator CAD model.

Now, for the robot's displacement, the black line following method has been used. A set of 6 reflective sensors (Sensor QTR-8RC) detects the position of the line, and then a controller commands the motors to differentially reduce or increase their speed so that the platform rotates as it moves forward and keeps the line within the measurement range of the sensors. A schematic of the control system used can be seen in Figure 2.

The controller is also responsible for driving the servomotors of the robotic arm and can be told when to stop the platform.

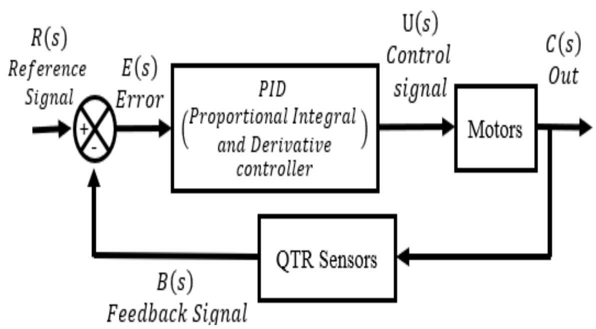

Figure 2: Robot control diagram.

4 RESULTS

Figure 3 shows one of the tests performed on the line follower, as can be seen, the blue line represents the set point which in this case is 2500, the red line represents the QTR-Sensor lecture. If the value measured by the sensors is less than 2500 it means that the black line is deflecting to the right of the robot. On the contrary, if it is more than 2500 it means that it is deflecting to the left. The PID would try to keep the robot as close as possible to the value 2500 as this means that the line is being followed correctly.

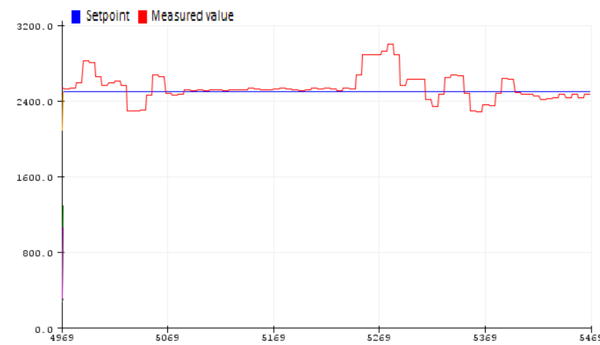

Figure 3 Measured values of the QTR-Sensor

For the manipulator arm an automated sequence was performed, figures 4 to 7 show the value in degrees that the servomotor moves to pick up the object, as a result rotation was not necessary in servomotors 1 and 3 but it was necessary for servos 2 and 4.

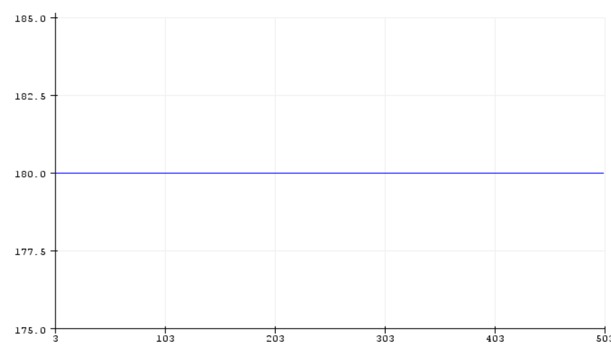

Figure 4: Servomotor #1 Motion.

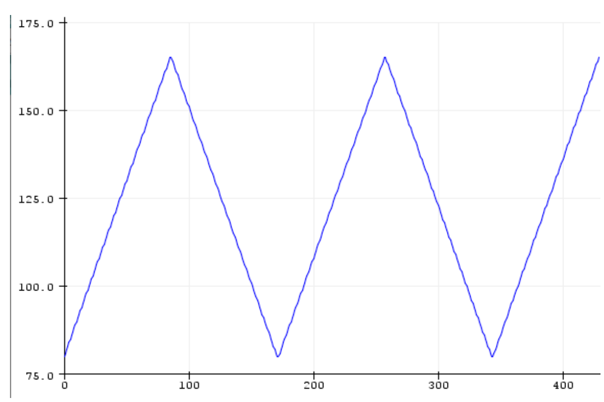

Figure 5: Servomotor #2 Motion.

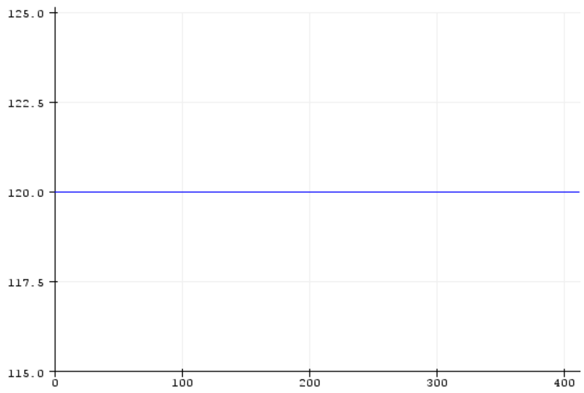

Figure 6 Servomotor #3 Motion.

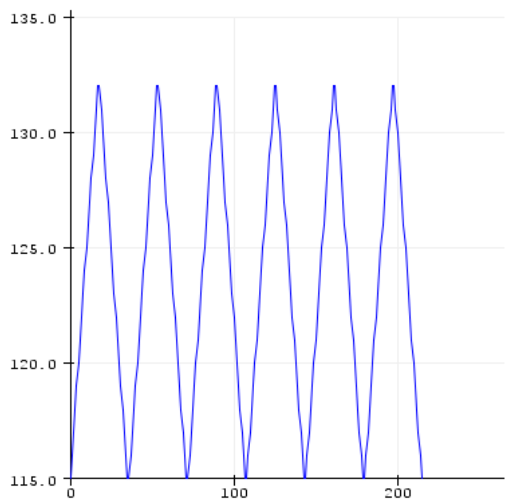

Figure 7 Servomotor #4 Motion.

Finally, a picture of the constructed robot is shown in Figure 8.

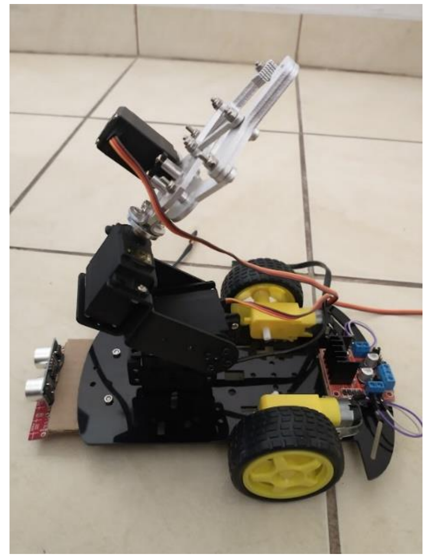
Figure 8: Mobile manipulator chassis construction.

5 Conclusions

As opportunities for improvement, it was found that we should be work on to reduce energy consumption, since all the actuators that are present in the robot in addition to the PID controller cause a very high energy consumption. Also, we found that it is necessary to perform a gain adjustment based on optimal control techniques such as LQR (linear-quadratic regulator).

In addition, it was concluded that this type of robots should be built based on specific needs because they determine the qualities of the robot.

6 References

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