THE DESIGN AND FABRICATION OF AN INDUSTRIAL ROBOT SCALE MODEL, WITH POSITION CONTROL VIA A WEB INTERFACE

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In this project I designed a scale model replica of an industrial robot, with 6 degrees of freedom and direct driven axes. The robot can be controlled via a web interface either by individually addressing the axes, or through inverse kinematics by specifying a specific effector position.

CUVINTE CHEIE: Arduino, Web control, Kinematics

1. Introduction

In the following paper I will present a functional scale replica of the IRB 6700-175 / 3.05 industrial robot printed in 3D, controlled via a NodeMCU ESP-12E development board with Wi-Fi, programmed via Arduino. The 6 axes of the robot are replicated by means of servomotors directly coupled to the driven element. With the help of an Arduino library, the microprocessor can perform calculations for direct and reverse kinematics.

Thus, the replica model of the robot can be used for educational purposes, as a demo presentation model, or it can be integrated in a miniature structure similar to that of a flexible manufacturing cell, in order to be able to replicate it on a more convenient scale with similar movements.

2. Current status

I. Robot design

Fig. 1. The robot model that the project is based on

IRB 6700 is a series of large industrial robots produced by the Swedish-Swiss company ABB since 2013, as a successor to the 6640 series. Intended predominantly for spot welding, handling, and machine tending applications, with a load-bearing capacity between 150 and 300 kg, and a maximum length between 2.7 and 3.2 m

The 3D model for IRB 6700-175 / 3.05 was taken from the company's website and inserted into Autodesk's Fusion360 design software. Then it was scaled to 15:100 to fit the maximum size of the 3D printer, while keeping the possibility to add motors to drive each axis.

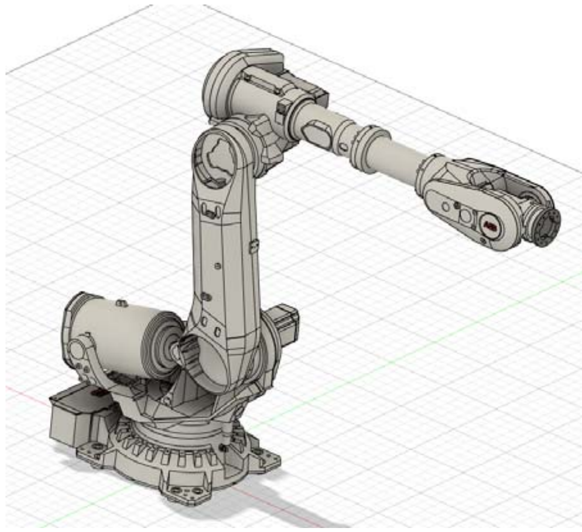

Fig. 2. 3D model of the robot in the CAD workspace

Thus, the first step was to clean the model by removing the edges that were too thin to be 3D printed and strengthening the base to provide the possibility of screw mounting. The next problem was finding the space in the robot's body for the 6 motors, without influencing the kinematics of the robot or its external appearance.

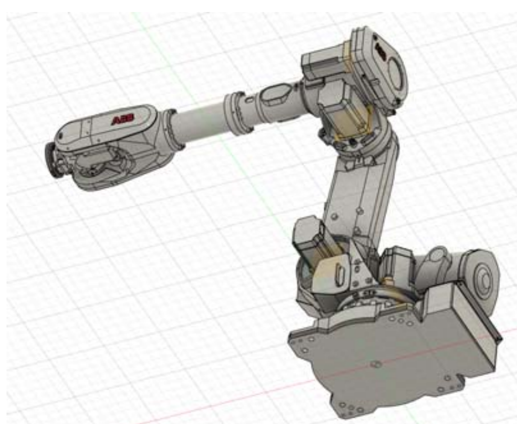

Fig. 2. 3D model of the robot with highlighted motor positions

For axes 1, 2 and 6, the same location of the motors was used as in the real robot. For the others this was not feasible, so they were placed in the most convenient place for operation.

The motors used are 180° digital hobby servos. For the first 4 axes, the model used is TowerPro MG995, and for the pitch and roll axes of the orientation system, it was the TowerPro MG90S. The overall dimensions and the arrangement of the mounting holes were measured, and the slots for them were cut into the CAD model.

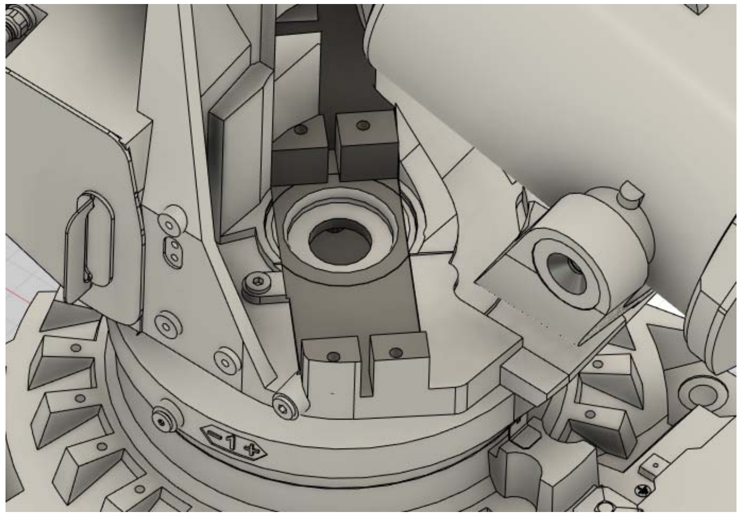

Fig. 3. The space for the Axis 1 motor, cut from the robot's turntable

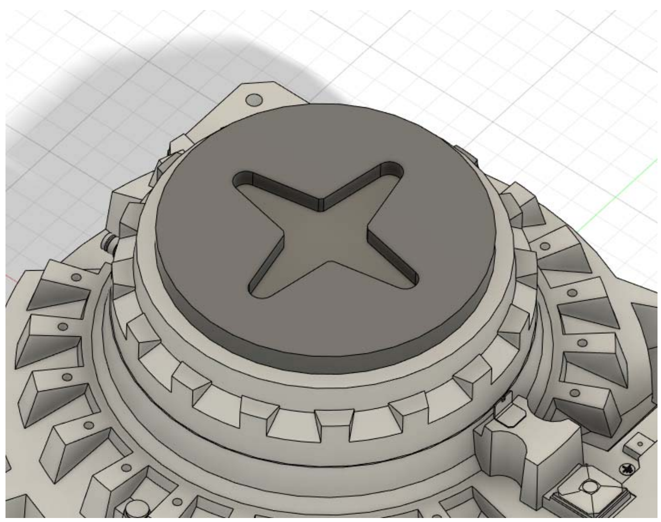

Fig. 4. The slot for the servo flange, cut out of the robot's base

A similar process followed for the other robot couplings, using the different shaft-mounted flange shapes to allow each component to be driven. This was followed by the separation of the box containing the electronic part of the robot to be hollowed out, and the addition of slots for the power plug and switch.

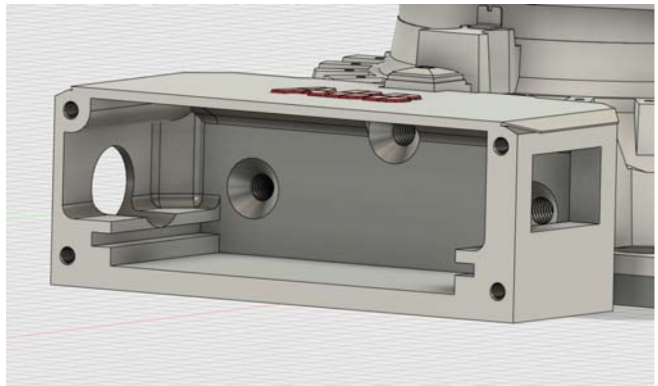

Fig. 5. The box for the robot’s electronics

The static balancing device of the robot has been implemented here as well, to counterbalance the weight of segments 1 and 2 when the robot bends forward. Thus, an elastic band was fastened to the end of the inner cylinder with a screw, passed through the hole at the base of the outer cylinder, tensioned and fastened with another screw. Thus, an effect similar to that of the real model is obtained, on a much smaller scale.

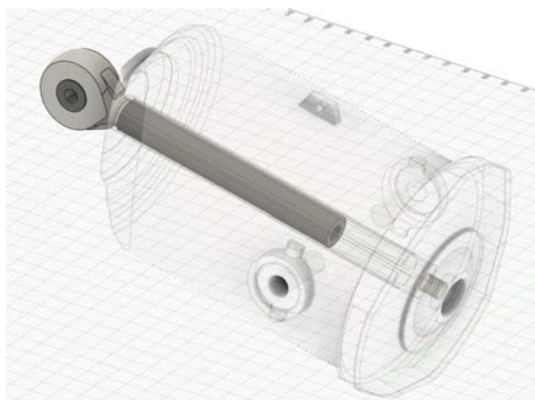

Fig. 7. The robot’s balancing device

The final step was to prepare the routing for the cables, so that they would not limit the movement of the robot. A passageway was made through segment 1, similar to the actual robot, and segment 2 was partly hollowed out and split I half, to allow the passage of cables for motors 5 and 6, as well as the correct assembly of motor flange 4.

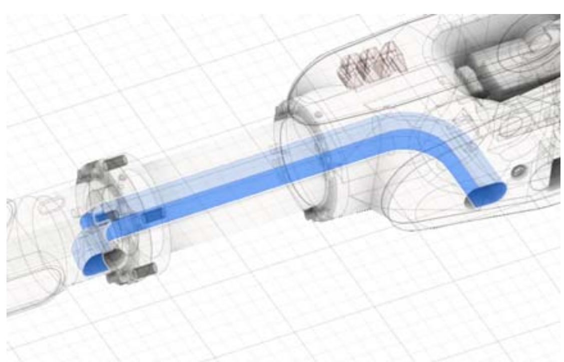

Fig. 6. The wire path through the robot’s second segment

II. Fabrication and implementation of the robot

The robot model was fabricated on a Tiertime Cetus Mk.III 3D printer. The parts are made of white PLA and assembled with various screws and self-locking nuts.

Fig. 7. Actual physical model of the robot

The electronics were designed with an emphasis on simplicity, in order to highlight the web interface control. Thus, the NodeMCU ESP-12E board has 6 PWM digital pins connected to the 6 servo motors. Communication with the computer can be done either via USB serial interface or through Wi-Fi.

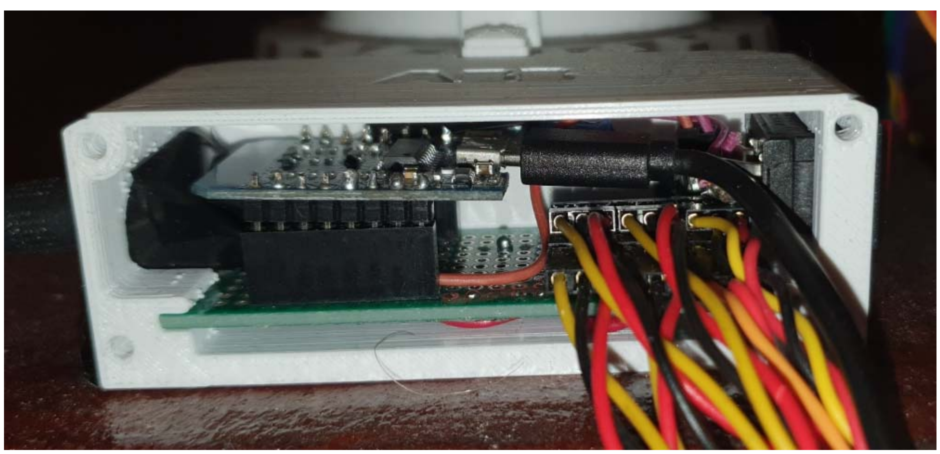

Fig. 8. The robot's electronics

The programming was done through the Arduino IDE, using the Kinematics library, which can solve the direct and inverse kinematics of the robot. However, it has some limitations, as it is not possible to define the maximum angles for each axis, which leads to many positions that are impossible to achieve in this configuration. Also, the NodeMCU board processor is relatively weak, and cannot perform many iterations of the Newton-Raphson method in a short time. This leads to rather rudimentary position control.

The web interface was created using the RemoteMe website, a cloud platform for Internet of Things projects, which integrates easily into the Arduino workspace. On this platform, the control panel and the robot itself are defined, and they can communicate via the Internet. Thus, because the computer does not connect directly to the development board, the two do not have to be in close proximity to function, as long as they both have access to the network.

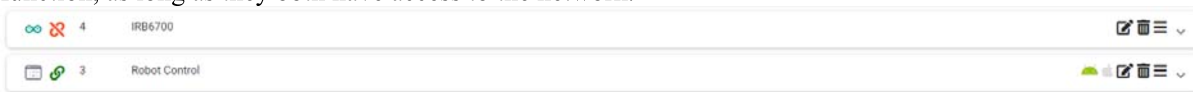

Fig. 9. The robot and the control panel on the RemoteMe platform

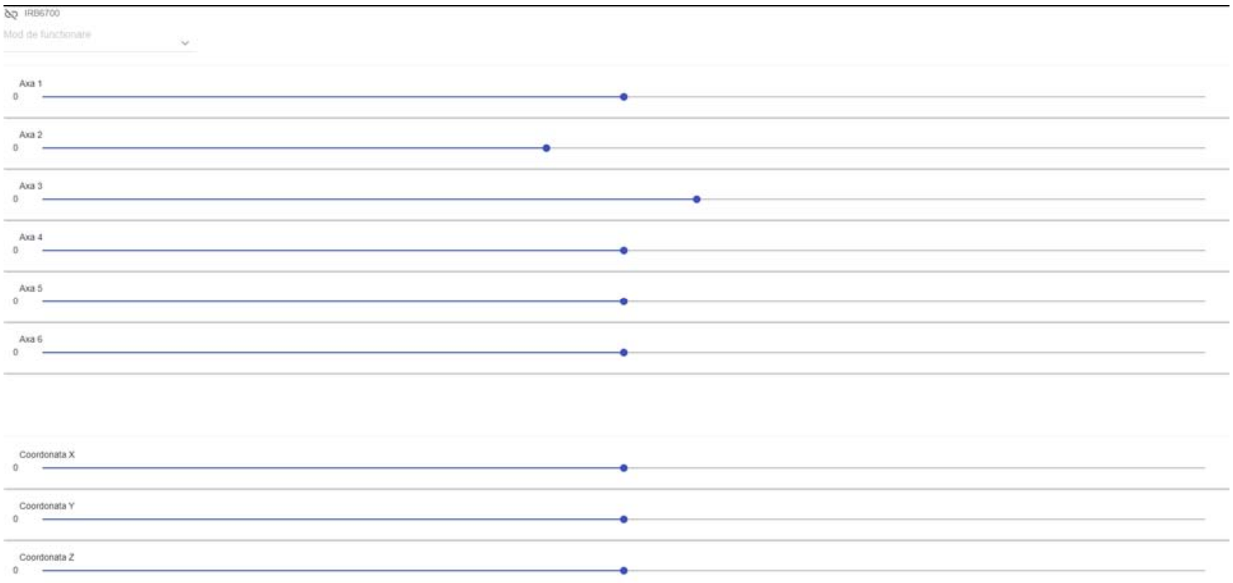

Fig. 10. The command screen interface

Through the control panel it is possible to switch between the 2 operating modes of the robot: Individual axis control and Tool centre point. Using the sliders on screen, the angle of the robot's axes or the coordinates of the effector can be controlled.

3. Conclusion

To sum up, the robot model is functional and can be used for scale simulation of a robotic application. For the future, this could be improved by using a different way of calculating reverse kinematics, such as using the RoboDK platform with a driver for Arduino, which would solve the problems with position control.

4. Bibliography

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