Development of the trajectory planner and control system of a spherical robot manipulator embedded in a FPGA board

CISTER – Research Centre in Real-Time & Embedded Computing Systems

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Motivation

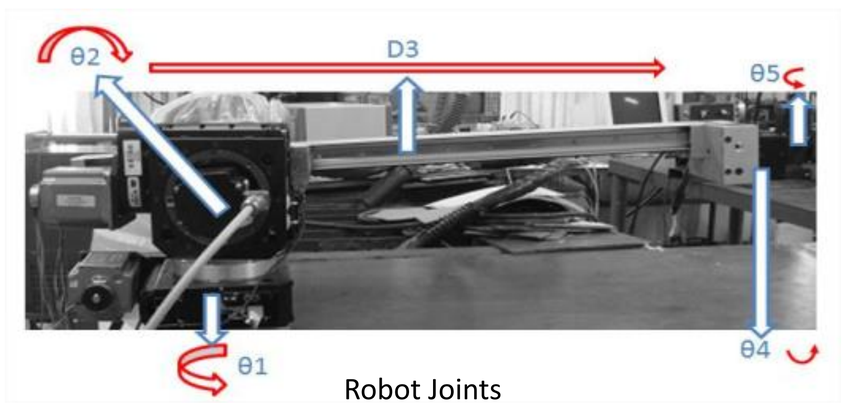
Hydroelectric plants are an important source of energy in many countries around the world. However, its maintenance is somewhat complex and quite time consuming, since the blades can not be removed. Thus, the use of robots to repair turbine damage is a way to make the repair process more efficient.

There are some robots developed for this purpose, using the traditional architecture, based on microcontrollers. In this project, the goal is to develop a controller for a robot welder based on an FPGA platform.

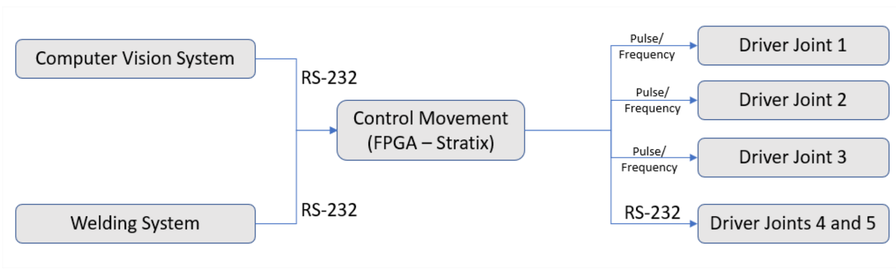
Thus, we seek to obtain the advantage of parallel processing of the FPGA in the implementation of the inverse kinematics in the manipulator and to optimize its movement.

Objectives

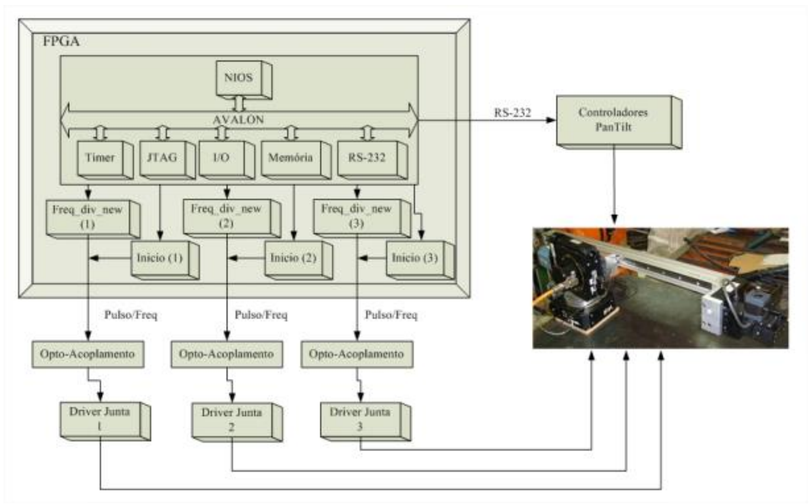
- Develop an open-loop control system to control the manipulator for welding;
- Use a reconfigurable platform to build the control and develop an embedded microcontroller with the desired specifications;
- Solve the kinematics of the robot in real-time, providing a smooth movement of the robot arm;
- Guarantee the communication between the different modules of the robot;
- Solve the calibration problems of the robot;



Robot Joints



System Architecture



Detailed Embedded Architecture

Architecture

The general architecture of the project is composed by:

- A NIOS Microprocessor, designed specifically to read the inputs and perform the kinematics;
- Clock and PLL signals;
- Sensors;
- Motors Control;

Validation

In order to validate the proposed project and its calculations, we used several measurements:

- There was used a simulation tool to test all the possible positions in the workspace of the manipulator. Then, the results where compared with a Matlab simulation of our proposed kinematics. The error was smaller than 0.1%;
- The trajectory path planning of the robot was also tested in simulations and compared with real movement;
- The comparison between the Real Time (RTA) implementation and the List Algorithm (LA) gives advantage for the LA, with better path following.

Robot Prototype

Concluding Remarks

- The main objectives of the project where achieved with the implementation of the controller;
- The tests shows that the proposed parallel architecture was good enough to guarantee the kinematics calculation and path planning of the manipulator;

References

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