RoboArm: Demonstrating Control Algorithms & FPGA Acceleration Using Embedded Processors

1. Abstract

Application-specific robotic systems often must operate with low latency and under considerable compute constraints in austere environments. To this end, strategic use of fixed point computation, in conjunction with FPGA-enabled acceleration can offer considerable performance increases with acceptable space/power tradeoffs. For the RoboArm project, a simple RRT\* path-planning algorithm was implemented in C++ to run on the provided BeagleBone MCU. This was used in conjunction with a Forward Kinematics algorithm and simple obstacle detection protocol to control a robotic arm with six degrees of freedom. The functions used to control the robotic arm were profiled using gprof to identify the most computationally intensive tasks. The most expensive function was then processed using the DAISY HLS toolchain and converted into synthesizable fixed-point Verilog using the ap\_fixed type format to run on a Basys3 FPGA. Using this set-up a speedup of X% was observed in the accelerated function. Fixed-point computation remains an important strategy in embedded robotics, and this project offers valuable insight into the application of this approach to improve robotic performance in constrained environments.

1. Introduction

An introduction: well-formed motivation, background information (10 pts).

1. Method

Method: Method used is clearly explained, with your contributions, if you used ideas from our class readings or other materials, make sure to detail in the report. Your report should still be self-contained by including the used equations and formulations necessary for understanding the approach, any algorithms. The method should be well justified, and consider complete system usability in the real-world (20 pts).

* 1. RRT\*
  2. Forward Kinematics
  3. Obstacle Detection
  4. DAISY

1. Results

Results: Experimental setup should be clearly explained. Was any data used, evaluation protocol and metric definition details, are the experiments well justified, analyze the system comprehensively (with quantitative and qualitative results) (30 pts).

1. Limitations & Future Work

Limitations and future work: Discuss what didn’t work, e.g., if different from expectations, what wanted to implement but didn’t have time (e.g., to further tune), conclusion (5 pts).