Abstract

Integrating high level software with low level hardware components is a major challenge for complex real time systems. For digital systems with strict real time constraints or parallel processing and communication Field Programmable Gate Arrays (FPGA) offer significant advantages. However, using FPGAs in embedded systems brings the challenge of combining the different programming models used for FPGAs and regular processors. This thesis explores the integration of direct input/output (I/O) control into ReconROS, a framework that provides the widely used Robot Operating System (ROS) communication mechanisms with direct access to FPGA features. To this end, the thesis introduces methods for incorporating hardware description languages (HDLs) like VHDL into ReconROS and enabling direct mapping of signals to physical FPGA pins.

To develop and demonstrate these capabilities a system for controlling an ultrasonic phased array is designed and implemented. This allows us to evaluate the I/O control mechanisms in two ways: jitter measurements assessed the timing accuracy of signal generation, while schlieren imaging visualized ultrasonic wave patterns to verify the effectiveness of beamforming. The results demonstrate the system's capability to produce synchronized and complex waveforms, confirming its applicability for precision ultrasonic applications.

This work enhances the ReconROS ecosystem, allowing seamless integration of I/O control with existing workflows and extending its utility for robotics and real-time applications.