Project Proposal: Gesture Controlled Manipulator Using FPGA

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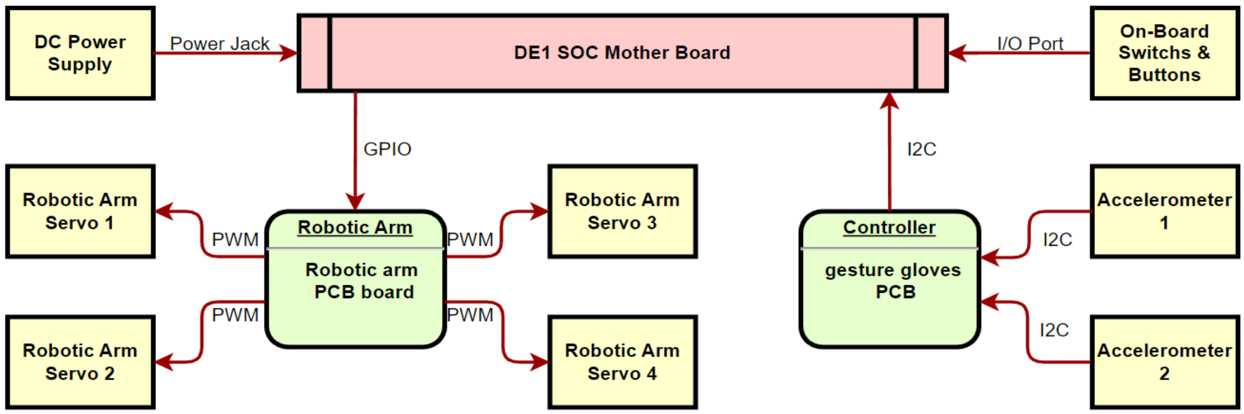
Introduction

Manipulators are used in various applications such as manufacturing, healthcare, and transportation. The precise control of manipulators is essential for their safe and efficient operation. Field-Programmable Gate Arrays (FPGAs) are increasingly being used for controlling manipulators due to their high-speed processing capabilities, low power consumption, and programmability. In this proposal, we propose to develop a manipulator control system using FPGA.

System Overview

In our upcoming project, we aim to develop a highly innovative gesture-controlled manipulator system. To achieve this, we will be utilizing two accelerometers, integrated into a specially designed glove, to collect real-time gesture data from the wearer. This data will then be analyzed by the powerful DE1-SOC platform, which will imitate the movement of the wearer's hand on a 3-axis robotic arm. Through the use of this control glove, users will have complete control over the robotic arm's movements, enabling them to grasp, transport, place, and adjust the posture of objects in its field of view with ease. On the firmware side, we will use factory PCB and cables to build the electrical links for two accelerometers, four servo motors, a DE1-SOC board. Furthermore, we will be leveraging 3D printing technology to design and fabricate the mechanical support structure of the entire system, ensuring maximum durability and stability. On the software side, we will be using advanced programming languages such as System Verilog and C to develop robust firmware drivers and core algorithms, enabling seamless communication between the various hardware components and ensuring optimal system performance.



Method

- Hardware Design
  - Our hardware implementation will utilize a DE1-SOC board to handle computing, storage, and physical interfaces. The board's onboard GPIO interfaces will enable the connection of sensors and the robotic arm. Onboard switches and buttons will allow for control over the manipulator, including the ability to switch between automatic and manual operation modes, initialize the origin, debug, and start and stop actions. Real-time attitude information from the accelerometer will be received by the FPGA board via the I2C communication protocol, which will then perform calculations to correct the current motion behavior of the robotic arm.
- Software Design
  - We will use SystemVerilog and C language to develop the firmware drivers and core algorithm of the system. The firmware drivers will be responsible for the data transfer between the sensors, actuators, and FPGA board, while the core algorithm will control the manipulator's position, velocity, and acceleration accurately. We will develop trajectory planning and path following algorithms to enable the manipulator to move along a specified path with precision. We will also develop a user interface to enable users to interact with the system easily and intuitively.
- Mechanical Design
  - We will design the manipulator structure using 3D modeling software (Solidworks) and 3D printing technology, which will allow us to build lightweight and sturdy structures. Preliminary CAD design is showed in fig. 1.

Milestone

Time	Task
Feb. 27 - Mar. 12	Design the hardware PCBs and build the

	manipulator by 3D-painting
Mar. 13 - Apr. 2	Develop the software for the control system, including the algorithms for position, velocity, and acceleration control, trajectory planning, and path following.
Apr. 3 - Apr. 16	Integrate the hardware and software and test the system's performance using a simulated manipulator
Apr. 17 - May. 7	Implement the system on the real manipulator and evaluate its performance

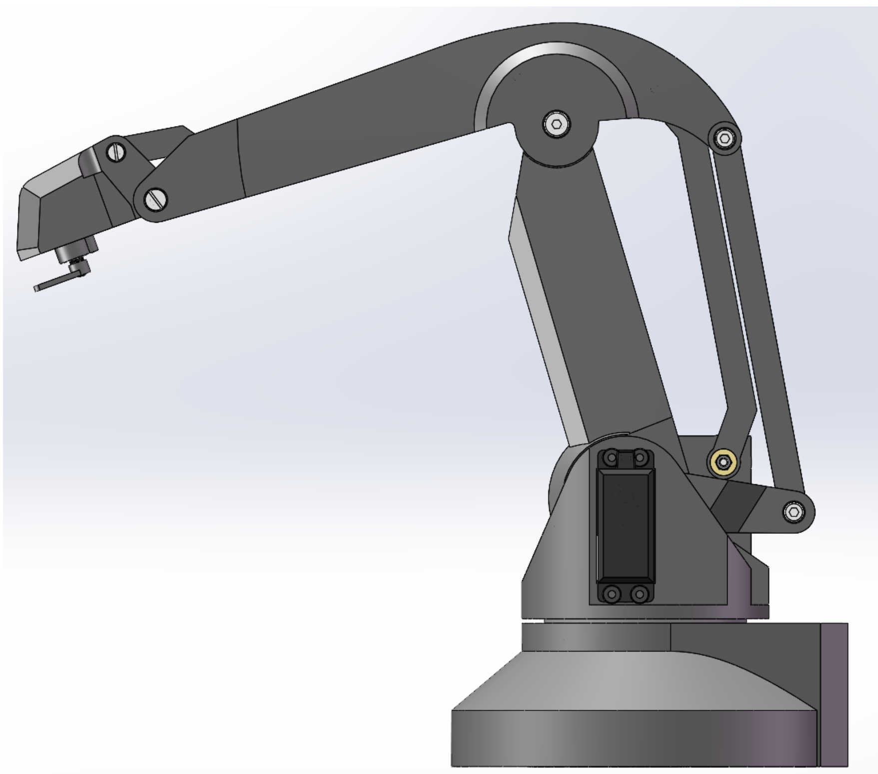


Fig 1. Preliminary CAD design