

Project Proposal

Lens Controller for Biomedical Cameras

Team 26

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Introduction

Problem

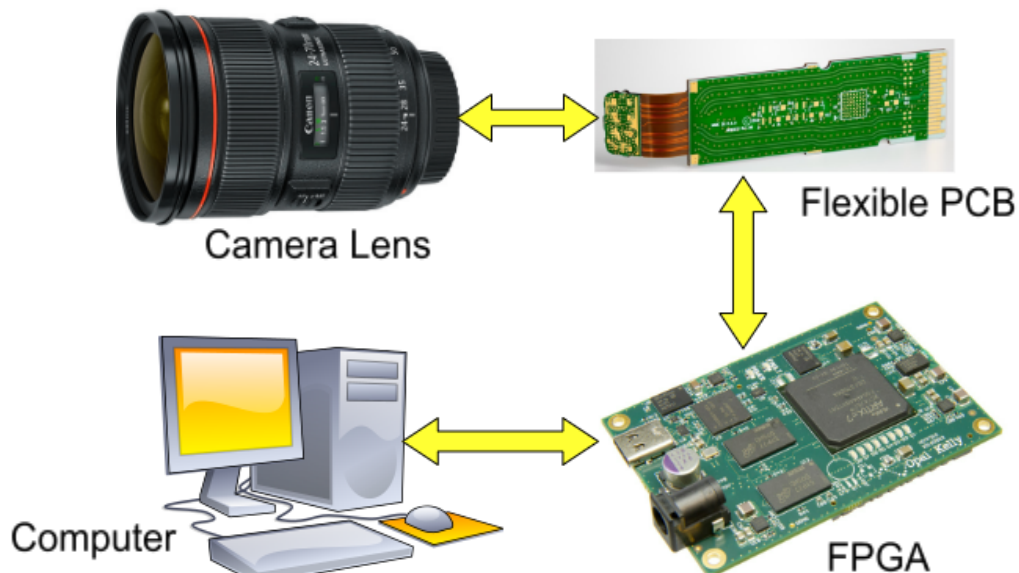
In many operations, the margin for error is very slim. This is especially true for cancer treatment, where operation on tumors is considered one of, if not the only solution to cancer sickness. Operating on tumors requires a high degree of accuracy and so, the use of cameras to aid surgeons in the operating room would significantly reduce the risks associated with any mistakes involved in the removal of tumors. According to a study, incomplete tumor removal occurs in 25% of breast cancer patients, 35% of colon cancer patients and 40% of head and neck cancer patients [1]. From this, it can be seen that the problem is significant and requires a solution to this problem.

Solution

The solution to this problem is to develop a system where the lens of the camera can be adjusted based on a user input (A surgeon or surgery assistant) remotely, which would then help the surgeons in identifying any cancerous tumors and fully removing the tumors.

We are planning to use the FPGA to move the lens of the camera so that users can remotely control the lens from their computer. The flexible PCB board will provide the connection between the FPGA and the lens due to the incompatible port assignments of the two components, which the flexible PCB will be responsible for correctly handling . We will be implementing a finite state machine and using the FPGA to control the overall operation of the camera. Users will be interacting with the movement of the camera using python code from their computer, by inputting their preferences for camera operation

Visual Aid



High-level requirements list :

Correct functionality of Camera Lens

Perhaps the most important requirement of the project is whether the camera functions appropriately according to the user's instruction inputs. Users will be able to zoom in and out of the object manually based on their need. In the context of the operation room, this is critical as it can help identify any straggling bits of the tumor that the surgeon may have missed when viewing the tumor with the human eye.

The correct functionality of the camera lens will also be indicative of the correct mapping of the ports. This is important as it would indicate that the lens is receiving the correct signals from the FPGA and also outputting the correct signals back to the FPGA for user feedback. The user would then be able to adjust the camera's magnification based on the output and would then issue new focus parameters which will then be sent back the same way. The operation of the camera lens will be controlled by the FPGA using Verilog code and the data signals will then be transported by a modified SPI protocol through the flexible printed circuit board. The user will be able to input their instructions into the

computer using a Python program which will then be converted by the FPGA board's API interface for use by the FPGA.

Reliability for a long period of operation

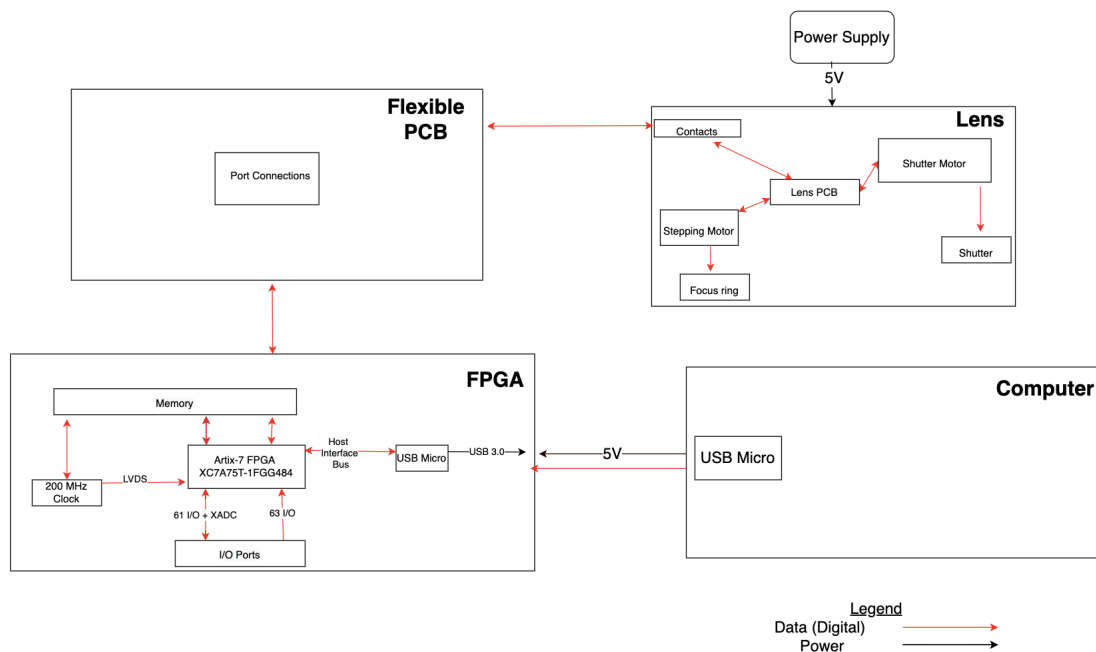
We need to ensure that the program still executes correctly and goes through the correct set of states of the state machine even after running the program for a long period of time. We should not see the case where the program enters into the forbidden state in the middle of the operation.

Correct visual output

Another requirement that we need to ensure is that the users are able to see the result on their computer screen. They need to be able to see the result immediately so that they can input corresponding instructions for the next process. To ensure the low latency of the output, we need to make sure that the FPGA is operating at high enough frequency.

Design

Block Diagram



Subsystem Overview

FPGA

The FPGA board component for our project is the XEM7310 by Opal Kelly. It is an easy to use, high performance, and reliable FPGA that will be used as a hardware accelerator in our design. The primary FPGA is an XC7A75T-1FGG484 FPGA which requires a voltage supply of around 0.95 to 1.05 V to operate. It also has flash and SDRAM components that form the memory store for the board. The board has an important feature in the form of the complete Application Programmer's Interface (API) that is specific for the Python language which is necessary for our project. It has 126 user I/O ports and has a SuperSpeed USB 3.0 interface port. Overall, the FPGA board will be communicating in between the computer subsystem and the Flexible PCB subsystem, based on the HDL code written by us.

The FPGA will interact with the PC through the USB 3.0 port and control the lens using I/O pins through the flexible PCB board. The FPGA board will be receiving a power supply of 5V from the computer through the USB 3.0 port.

Requirement 1:

The FPGA must be able to control the operation of the lens through a state machine.

Requirement 2:

The FPGA must be able to communicate with the computer through the USB port

Requirement 3:

The FPGA must be able to communicate with the 7 digital camera lens ports.

Flexible PCB

The flexible PCB board will be providing interconnection between the FPGA board and the Canon camera lens. On the PCB board, there will be circuit components to help enable the transfer of data from the FPGA board to the lens. We are using the flexible PCB for two reasons: The contacts on the lens are very

thin and also the port assignments between the FPGA and lens are incompatible. A flexible PCB would be better suited as it can handle multiple port assignments and through the specific sub-model of the flexible PCB known as a flat flexible cable, be able to perform the function of wires in transporting data signals. This will allow better connection with the fine contacts on the lens and allow the FPGA and lens to communicate through the reworked port assignments. Furthermore, this data will be transferred using an 8 bit modified SPI protocol which will be responsible for handling the seven data signals involved.

Requirement 1:

The flexible PCB must be able to provide the correct mapping of the ports of the FPGA and the lens.

Lens

This camera lens is a widely used and reputable product that is one of the main cameras that photographers use. To start, this camera has a lens that has a high-performance zoom that is compatible with EF-S lenses. In addition, one of its main features is its image stabilization mechanism. This Image Stabilizer provides the equivalent effect of that of a shutter speed but four stops faster. Certain conditions such as still objects as well as following moving objects. There is also an aspheric lens that allows for excellent imaging performance as claimed by their manual. Among this performance metric is the ability to shoot very clean closeups at all focal lengths, and lastly there is a round aperture hole that results in the background blur being particularly smooth. The camera lens will have the focus mode switch set to manual so that the user can change the focus according to their own specifications.

The lens will interact with the power supply subsystem as it will be powered through a 5V supply and will also interact with the flexible PCB to receive instructions on how to adjust the appropriate camera features.

Requirement 1:

The camera lens receives and executes the commands as directed by the user.

PC

The PC component will be implemented through the use of a personal computer or laptop. It should provide HDL code, written in Verilog, to the FPGA board. The USB port of the PC will be responsible for sending the HDL program to the FPGA board as well as providing its power. The USB port will be outputting 5V DC voltage and will be connected to the USB port on the FPGA board using a USB cable. Furthermore, it will also provide the Python code utilized by the user to adjust camera features.

The PC component will mainly be communicating with the FPGA subsystem to effectively operate the camera lens.

Requirement 1:

The machine has to be able to run for a long enough time for all of the instructions to be carried out.

Requirement 2:

The machine has to be able to compile and use Python to activate the entire project.

Tolerance Analysis

As our project involves a lot of programming, we need to ensure the reliability of the operation even after running the program for an extended period of time. An operation would be multiple hours in length, if not more and so we must make sure there are no unexpected crashes or errors. By doing this, we minimize the chance of ineffective tumor removal as discussed in the Introduction. In particular, the Finite State Machine, which is mainly responsible for the implementation of the various instructions put into the camera, has to continuously run for as long as the operations take, and we need to ensure that nothing breaks down in the middle of its functions.

This will be done by simulating the Finite State Machine to make sure that it steps through all the states effectively. Furthermore, the ability to simulate will also allow us to see the entire operating cycle of the Finite State Machine which will allow us to more effectively diagnose and solve any potential errors or faulty states.

Ethics and Safety:

As with any mechanical contraption, there is always a risk of the machine malfunctioning and worst case scenario, exploding. The PCB will need to be structured properly, as any mismatching connection can cause a short circuit. The camera breaking down during its intended operation will also pose a risk to the patient, and we most definitely want to avoid this. However, for the scope of our project, this will not be a main concern.

Regarding the camera lens, there are a few precautions that the manufacturer themselves have warned about in the manual. To quote the Canon manual “Whether it is attached to the camera or not, do not leave the lens under the sun without the lens cap attached . This is to prevent the lens from concentrating the sun’s rays, which could cause a fire. If the lens is taken from a cold environment into a warm one, condensation may develop on the lens surface and internal parts. To prevent condensation in this case, first put the lens into an airtight plastic bag before taking it from a cold to warm environment. Then take out the lens after it has warmed gradually. Do the same when taking the lens from a warm environment into a cold one. Do not leave the lens in excessive heat such as in a car in direct sunlight. High temperatures can cause the lens to malfunction.” [3]

Another potential risk that they have stated in their disclaimers is the fact that there is no guarantee that the interference will not occur in any particular installation. It is of course tested and compliant with part 15 of the FCC regulations for a class B digital device, designed to provide reasonable protection against harmful interference in a residential installation. As such, the camera can generate, use, and radiate radio frequency energy, and if not adhered to the proper usage regulations, may cause harmful interference to radio communications or television reception. Should this happen, there are instructions for the user to attempt and correct the complication.

As for ethics, there are a few potential concerns that we will address throughout the project. IEEE Section I-1 [4] and ACM 1.6 [5] states that we must always protect the privacy of others. Because we are working with a camera, there is always the issue of privacy when recording and collecting data. There will need to be consent and confidentiality measures taken to ensure proper usage of the camera. IEEE Section II [4] as well as ACM 1.2 [5] states that we must not injure or bring harm to others, and this was already addressed in part a of this section. No matter which part of the entire contraption, none of it should have the possibility of harming anyone in the vicinity.

Last but not least, we must always uphold the code of conduct among every engineering organization, among our colleagues and in regards to everything that we do. Aside from the specific points of each code mentioned above, we must always look to follow and practice the code in its entirety at all times.

References

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