Project Plan v2 - Group 15-22

Ultrasound Imaging System

Project Members

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PROBLEM STATEMENT

In this project, our group is tasked with developing a program system used for ultrasound brain imaging. An NI PXI controller was provided to us, but it was not configured for use with the NI hardware it came with. We must configure the system, then interface with hardware equipment in order to analyze ultrasound signals and produce imagery of the brain by creating labVIEW programs on the PXI controller.

DELIVERABLES

FIRST SEMESTER
1. Diagram the ultrasound brain imaging system and interface with machine hardware.
   - Block out the basic idea of the beamformer and receiver.
   - Learn how plane waves and traditional ultrasound image with multiple focal zones and arbitrary will contribute to the development of the product.
2. Become proficient in labVIEW and implement knowledge from other programming languages we have experience with.
3. Contact NI support for configuration information.
4. Configure NI PXI controller to work with NI 5752 cards
5. Develop basic IO programs to test system while waiting for hardware.
6. Develop PCB Test board to analyze results.

SECOND SEMESTER
1. Assess adjustments that need to be made to the previous semester's design.
2. Program the receiver to collect echo signals and form the ultrasound image offline.
3. Program the receiver to collect echo signals and form the ultrasound image in real time.
4. Programing the beamformer to transmit plane waves.
5. Program the beamformer to generate a traditional ultrasound image with multiple focal zones.
6. Program the beamformer to select arbitrary phases for each array element
7. Develop documentation and a user guide for operating.

SYSTEM REQUIREMENTS

PROJECT REQUIREMENTS

The designed system will be used to create images the user's brain. The images will be produced in our labVIEW program in aid of the NI hardware that is provided (We

haven't received ultrasound hardware from National Instruments yet). The system will be expected to meet the following criteria. Currently, our client is lacking clarity on whether funds will be available to purchase the required ultrasound hardware. In the event that he does not have the funds to provide the custom hardware, the scope of our project may be altered.

Sample preparation
- The beam former ultrasound hardware must be able to transmit plane waves, generate a traditional ultrasound image and select arbitrary phases for each array element.
- The receiver ultrasound hardware must be able to collect echo signals form the ultrasound image offline and in real time.

Evaluation of Ultrasound Hardware and LabVIEW Software Setup
- Must the read documentation that is included in the manual of the ultrasound hardware.
- Must understand the structure of how ultrasound hardware produces signals.
- Must be able to evaluate correctness of all functions and channels of the ultrasound hardware and that they work properly.
- Must make sure the LabVIEW software can interface with ultrasound hardware properly.
- Must produce expected output imagery and run in realtime.
- Create a repository for code and write documentation so that the project can be developed on later.

VALIDATION OF PROPOSED SOLUTION

Strengths and Weaknesses

Strengths:
     Our proposed solution has a lot of documentation provided by NI. Therefore, development will be based on less trial and error. Additionally, out PCB test equipment will allow us to fine tune and adjust system output so that we lessen the chance of damaging the custom hardware when testing.
Weaknesses:
     Our project relies on the funding provided to our client. If this falls through, we may not produce ultrasound imagery. Additionally, the labVIEW setup may not be optimal for realtime output because it is not as efficient as other languages. Our client controls this design element, though.

Trade-offs:
     Implementing the system in labVIEW adds a positive ease of use factor. Because our client is proficient in the software, it will be easy for him to make

adjustments later. Additionally, labVIEW allows us to quickly access NI cards in the PXI system.

Acceptance Test

The labVIEW instrument should produce imagery of the brain provided the receiver and transmitter produce expected I/O. Users should also be able to interface easily with the product and tune it if necessary. In order to test each of these evaluations, we will:

- Produce noted details of information gathered from resource documents.
- Consult professor Bigelow with concerns and questions about the system.
- Use documentation suggested methods for data analysis.
- Test signals for accuracy with PCB test board, oscilloscope, and function generators.
- Test image production algorithms with objects of known shape and density.
- Test UI functionality with several non-developing users.
- Use other faculty to test the system and provide usability feedback.

BLOCK DIAGRAM

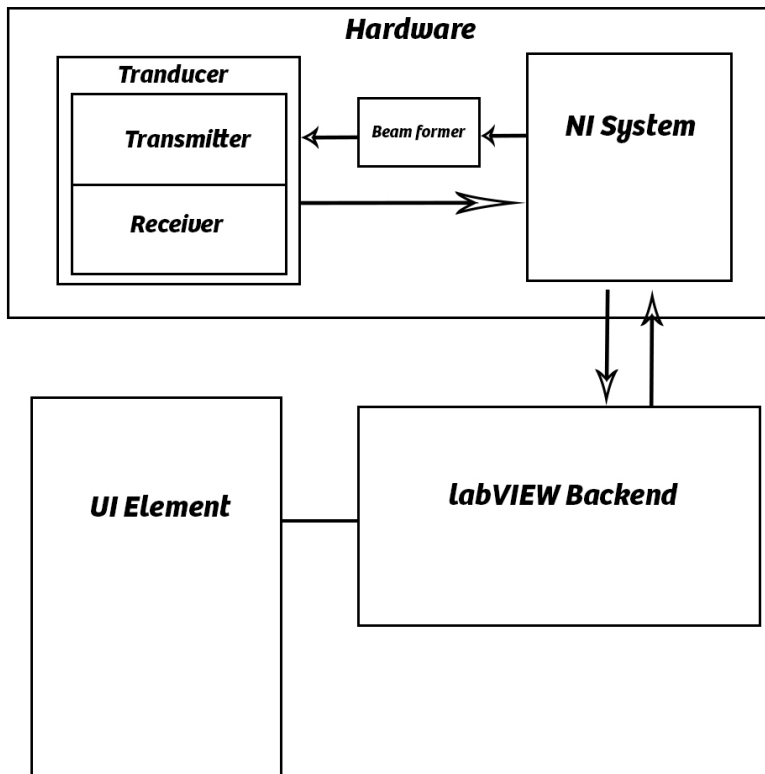Below is the block diagram of connected components in our system:

Figure 1

SYSTEM DESCRIPTION

CONTENT

For the beam former, all programming process work will be prepared, designed, debugged and tested in LABVIEW. We will make sure that the beam former can transmit plane waves correctly. We will also make sure that the beam former can generate a traditional ultrasound image with multiple focal zones and can select arbitrary phases for each array element.

For the receiver, all programming process work will be prepared, designed, debugged and tested in LABVIEW as well. We will make sure that it can collect echo signals form the ultrasound image offline and in real time.

The software will have a graphical user interface, which will show imagery as well as controls for tuning and running the system.

TECHNICAL APPROACH

In order to make the system functional we must

1. Interface with the hardware.
2. Configure it for transmitting and receiving waves in the correct context.
3. Use signal processing to analyze the wave data.
4. Develop a way to create images from the wave data

Data will be streamed in real time at target of 30fps. This will mean making an efficient program that quickly analyzes data and outputs results. If there is an error with the hardware or data, the system will notify the user

Our product needs to display accurate results because it is intended to be used as a precise medical device. However, this project is a lab experiment, so it will not be brought to market. Therefore, the goal is get a prototype working, not develop a commercialize-able product. Therefore, non-functional requirements are relatively lenient.

PROCESS DETAILS

At the beginning of our project, there was a lot of time spent configuring things to work properly later on. When we received the NI hardware, although it was supposed to work properly when we got it, nothing worked. Therefore most of the time was spent trying to configure the system to work and learning the software. We also did not have access to the custom hardware and did not know if there would be funding for it.

During the second semester, more time will be spent on development. Because we

no longer have funds for the custom hardware from TI, we will be creating our own. Time will be spent using multiSim to create PCBs. We will also spend more time developing labVIEW programs. Because we now have experience with both and a system that works properly, it will be much easier to develop.

TEST PLAN

In order to test this project, we will complete test procedures in accordance to the Experiment Design section outlined above. These test procedures will be implemented once the associated component is completed. We also follow this method to test our code/PCB design
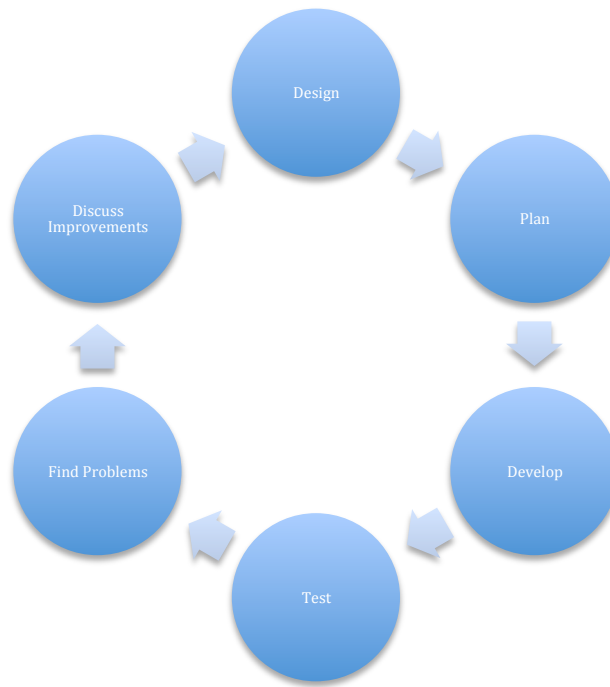

Figure 2

Hardware testing will be done using a volt meter/Oscilloscope. Once we feel that the PCB test board is made to specification, we will use that to test the output from the NI system. We can then make sure that the NI system is outputting the correct values and test any amplification hardware that we produce for transmitting/receiving. The test board will be then used to compare inputs with labVIEW input readings. The flow of testing will look as follows:

Figure 3

WORK BREAKDOWN STRUCTURE

All members in our group are required to study LabVIEW individually. All members must carefully read through the documentation of the ultrasound hardware to understand the structure of the machine and know how to use the labVIEW interface functions. At the end of this first semester, our plan is that make sure the beam former and receiver of the certain channel work correctly. Our group has decided on the following roles:

Aaron Tainter: Programming Leader
Jingyu Xie: Schedule Timeline/ Electronics leader
Haoyu Wang: Presentation/Documents leader

One of our members dropped the 491 class, so he will no longer be working on the project. Therefore, we will adjust roles in order to compensate for his absence.

RESOURCE REQUIREMENTS

Resource	How will we get it?	Estimated cost
Custom ultrasound hardware	Provided by client	N/A
Computer with LabVIEW installed	Provided by client	N/A

Figure 4

TIMELINE

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Ultrasound Research	■								
Machine Hardware Research	■								
Practice LabVIEW Programs	■	■							
Troubleshoot With NI	■	■	■						
Configure NI System			■	■					
Finish PCB			■	■					
Test Signals			■	■	■				
Send/Receive Programs				■	■	■			
Hardware Design					■	■	■	■	
UI Development								■	■

Figure 5

RISKS TO THE PROJECT TIMELINE

Currently, the hardware vendor is behind on schedule. Additionally, the funding for the hardware may be revoked if it cannot be delivered in time. This would mean that we could only code half of the project and be unable to test. This is huge problem that is currently being addressed by professor Bigelow. If this equipment is not acquired by next semester, professor Bigelow will work with us to readdress the scope of the project.

PHYSICAL DANGERS

The main risk is that the hardware gets damaged. Obviously, lab equipment like this is very expensive, so we need to be careful.

MARKET/LITERATURE SURVEY

The goal of this project is to build a functional prototype from concept that works in lab. Currently, this is a research project that is not intended to be commercialized. We are using the NI system because it is what Professor Bigelow provided. LabVIEW is used to connect to the NI hardware. While inefficient to program, it is easier to set up than embedded C code.

Currently, there is no specialized ultrasound system used for the brain. Ours is distinct because we use more IO channels that the typical system for a higher resolution. The original design also used state of the art signal generation and amplification hardware, but since TI could not get it to work properly, we creating our own hardware with technology that actually exists.

CONCLUSION

By the end of this project, our goal is to create the software system that interfaces with custom signal generation hardware provided by National Instruments. Ultrasound Pulse signals will be transmitted and received by the system and controlled by our software. Received data is analyzed and converted into imagery that can be viewed by the user. The system will include UI elements that allow the user to manipulate system settings.