Development and Integration of New Software for a Cardiac Flow Phantom

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Description of Clinical Need

- Over 600,000 people each year are affected by heart disease in the United States alone.
- Earlier diagnosis of heart-related issues could significantly reduce the death rate caused by heart problems.
- Cardiac Magnetic Resonance Imaging (MRI) is a technique that is being used more and more to look at the beating and flow patterns of the heart to detect abnormalities that may be missed or require more invasive procedures.
- However, because of the high velocities seen and many motion artifacts created by the beating heart, MRI data can be difficult to read.

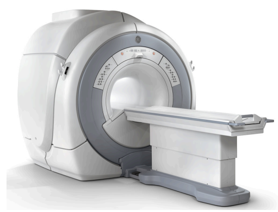

Figure 1. Sample GE Cardiac MRI Machine

Our Approach: The Phantom

- Cardiac flow phantoms are research tools that allow flow patterns to be studied of various blood flow paths through the heart, such as carotid or femoral blood flow.
- The phantom uses a stepper motor to pump a blood-mimicking fluid (glycerin) through a cylindrical unit that sits in the MRI according to signals sent to it via various waveforms.
- A cardiac flow phantom can allow a baseline to be established for a particular flow type, which will give physicians something to compare human data to, and allow for better detection of abnormalities in heart function.
- Allegheny General Hospital provided a Cardiac Flow Phantom that ran on outdated software, and also had structural issues.
- Our goal was to create new updated software with a better user interface using LabVIEW that controls the phantom, and design and manufacture a new casing for the phantom.

Our Approach: Novelty

- Although the design of the software is new, the concept of the software for the Cardiac Flow Phantom is based off of the old software program, therefore it is not patentable.
- The support structure design is novel and can be patented, but is very specific to the particular cardiac flow phantom that we have available to us.

Description of Previous Design

The previous phantom design and software interface is shown below in Figure 2. Part (a) shows the user interface of the old design, which displays the graph of the chosen waveform. Part (b) is the portion of the phantom that goes into the MRI. The wooden casing holds the cylinder together during the cycles. Part (c) is the unit that holds the stepper motor, which drives the pump.

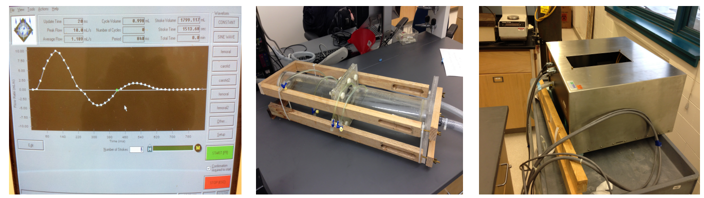

Figure 2. (a) User interface of old software (b) Phantom that goes into the MRI (c) Unit that house stepper motor

Our Improvement: Software

The first part of our design is a new software program to control the phantom. The current program is outdated and we wanted to expand the parameters being tested while making a user-friendly interface (Figure 3a and b). With the use of LabVIEW, the user is able to pick the type of waveform they want to use, as well as input the number of cycles it will run through to produce their desired results. This LabVIEW software also interfaces with the Motion Planner program, which communicates with the stepper motor that drives the phantom. These new features within the LabVIEW program improve the function of the device and improve the rate of communication.

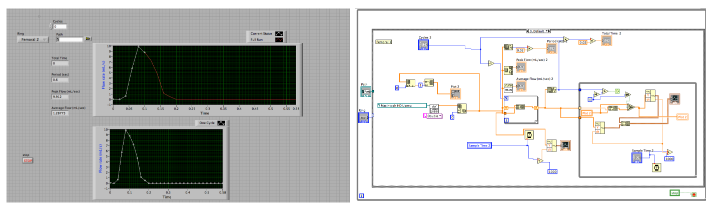

Figure 3. (a) Graphical User Interface of New Software (b) LabVIEW Block Diagram of New Software

Our Improvement: Hardware

The second part of our design is to make a new casing to fit the phantom and keep it tightened to the proper tension to prevent leakage during runs. The current casing is make out of wood, which is currently rotting. The new casing (Figure 4) is made out of acrylic and nylon plastic, chosen because of its minimal weight, durability, and strength. Also, we added in a flange on the cylindrical end to support the phantom and maintain the stability of the device as a whole.

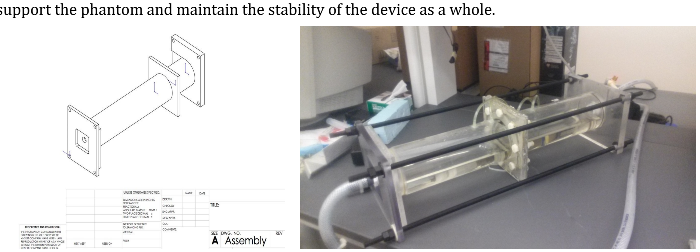

Figure 4. (a) SolidWorks Design of Casing (b) Finished Product of Casing

In Depth: Design of New Software

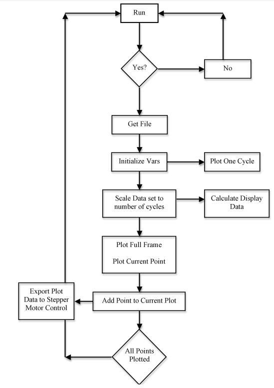

Figure 5. Flowchart of LabVIEW Interface

Estimation of Production Costs

Table 1. Estimation of Production Costs for Cardiac Phantom

Unit	Quantity	Volume Discounted Price
Phantom Support Frame	1	$99
Plexiglass Phantom Unit	1	$50
LabVIEW Student Addition	1	$20
Parker Brushless Servo Motor	1	$2500
Parker Gemini Servo Drive	1	$1600
Control Unit (PC)	1	$300
Piston Pump	1	$50
Piping	4	$40
Cabling	(50 feet)	$10
Glycerin	(20L)	$20
Total		**$4389**

Conclusion and Future Work

- Implemented a new support structure and casing for the cardiac phantom.
- Designed a new graphical interface using LabVIEW.
- Future work would have to be done to communicate with the phantom through the motor inputs rather than the serial port.

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