Undergraduate Research in Left Ventricle Dynamics

1 getting started

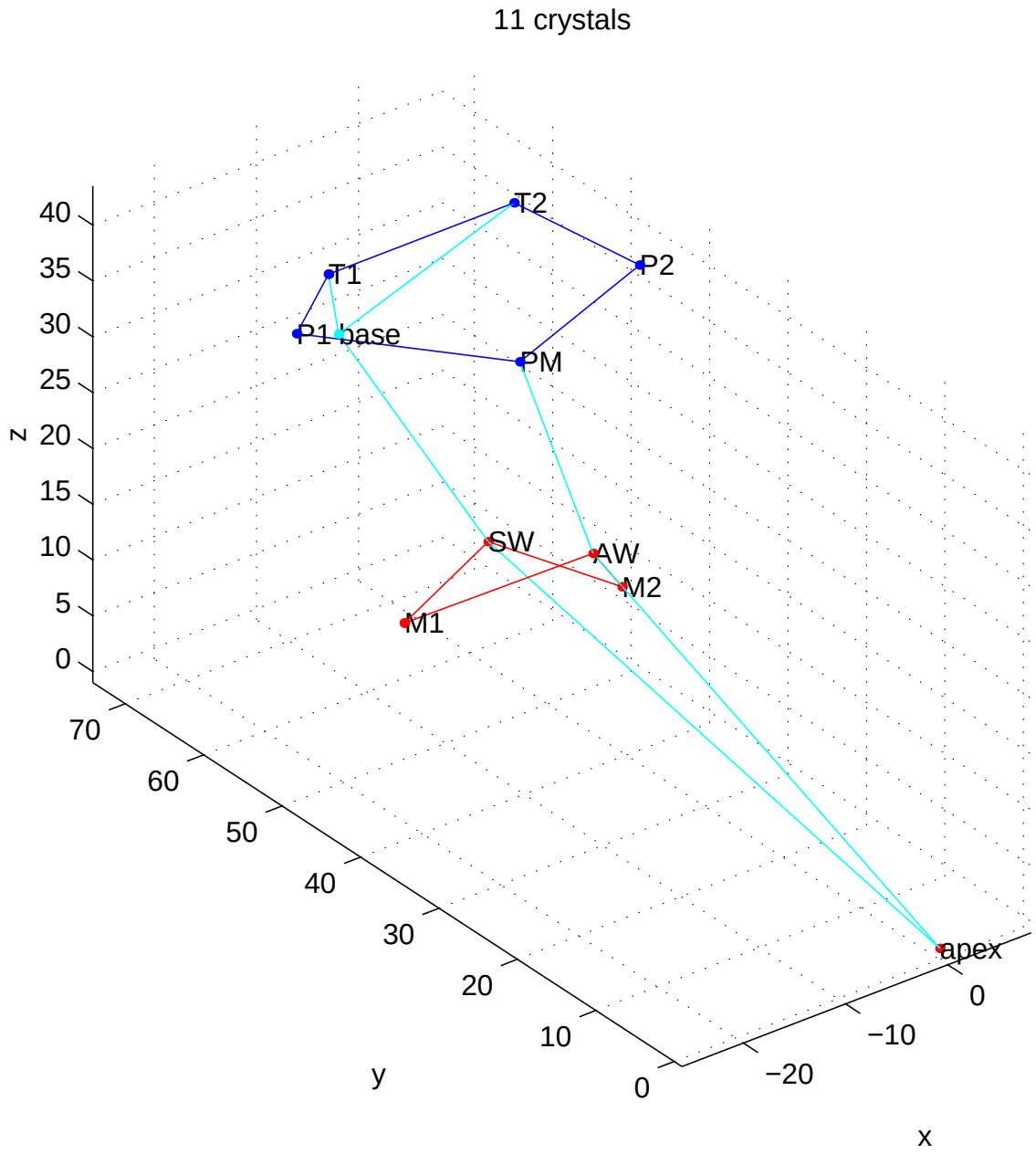
Go to our website: http://vortex.bd.psu.edu/ sas56/UGR

Download following files and put them all in the same directory. If you are in a lab, you can use the temp directory or a floppy drive.

- **beforedata.m** This file contains the data before the chords are cut.
- **afterdata.m** This file contains the data after the chords are cut.
- **setup.m** This is the mother program file.
- **crystalplot.m** This is a plotting file called from in setup.m or after you run setup.m in the Matlab main window. It makes 3D graphs of the crystals.
- **pressflowplot.m** This is a plotting file called from in setup.m or after you run setup.m in the Matlab main window. It makes graphs of the aortic pressure and ventricular pressure on the same axes and a graph of aortic flow in the same window below the pressure graphs.
- **animpfplots.m** This is a plotting file called from in setup.m or after you run setup.m in the Matlab main window. This produces the same graphs as pressflow.m but steps you through each point on the graph. (animated pressure flow plot = animpfplots).
- **deltaV.m** This is a plotting file called from in setup.m or after you run setup.m in the Matlab main window. This will calculate and plot the change in ventricular volume by integrating the flow plot by the trapezoid method.

2 beforedata.m and afterdata.m

These are two files each contain a matrix called DATA. This matrix represents the data regarding pressures, flow, and 3D crystal location. These are MATLAB files and therefore have the extension ".m". They can be read into a MATLAB program file or the main window by typing the file name without the ".m". Both of these files contain data in the same format but one is the data before the chordae are cut and one after the chordae are cut. After you run setup.m decommenting the allcrystplot command at the bottom, a graph will appear like the one shown below

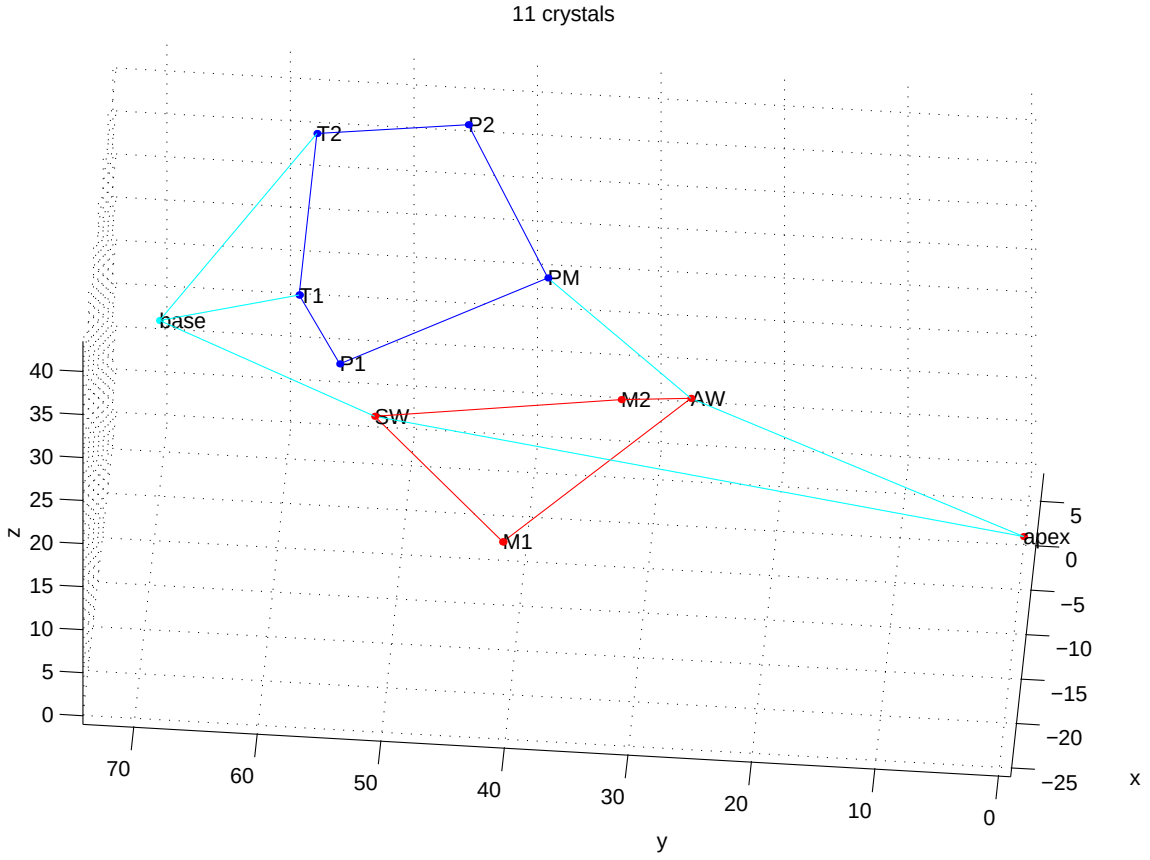


There are 397 times at which data are recorded. There are about 120 time units per cardiac cycles so we only have about 3 cardiac cycles worth of data. At each time frame there are 52 data elements recorded. One is time, One is Aortic Pressure, One is Ventricle Pressure and One is Aortic Flow. This leaves 48 data points left. These are the (X,Y,Z) coordinates of each of 16 implanted crystals. We will not be using the data from five of the crystals but the (X,Y,Z) coordinates are in DATA. These crystals are not depicted in the graph above. After you have this plot you can rotate it from inside the graphics window. You can export this as a .eps file by clicking on export from the graphics window.

Each row of DATA contains one time frame of data. The table below describes what data is contained at what indices.

data index	Description	MATLAB Symbol	crystal number
1	Time (sec)	time	-
2-4	(X,Y,Z) of Papillary 1	M1	1
5-7	(X,Y,Z) of Papillary 2	M2	2
8-10	(X,Y,Z) of Anterior Wall	AW	3
11-13	(X,Y,Z) of Posterior Wall	SW	4
14-16	(X,Y,Z) of S1	NOT USED	5
17-19	(X,Y,Z) of S2	NOT USED	6
20-22	(X,Y,Z) of mitral annulus (trigone 1)	T1	7
23-25	(X,Y,Z) of mitral annulus (trigone 2)	T2	8
26-28	(X,Y,Z) of Anterior Leaflet (AL)	NOT USED	9
29-31	(X,Y,Z) of Posterior Leaflet (PL)	NOT USED	10
32-34	(X,Y,Z) of mitral annulus P1	P1	11
35-37	(X,Y,Z) of mitral annulus P2	P2	12
38-40	(X,Y,Z) of mitral annulus (posterior)	PM	13
41-43	(X,Y,Z) of aortic base	base	14
44-46	(X,Y,Z) of commisure	NOT USED	15
47-49	(X,Y,Z) of apex	Apex	16
50	Aortic Pressure	Ap	-
51	Ventricle Pressure	Vp	-
52	Aortic flow	Af	-

We will not be using crystal numbers 5,6,9,10,and 15.



3 starting MATLAB

Double click on the MATLAB icon. This will open the main frame. From here you can do a lot but we will do almost everything from M-files. From the main window type ls this will give you a list of the files in the current directory. Use "cd .." and "cd directoryname" to get to the directory containing your .m files.

4 setup.m

Open this up from MATLAB by clicking on the "file-open" button from the top bar then choosing setup.m. A new window will open up. This window is where you will open (and edit) other files.

Everything after a % symbol is ignored by MATLAB. They are used for comments or eliminating lines you don't want.

This file reads either beforedata.m or afterdata.m (you choose in the second line of code). It organizes the data into time, aortic pressure, ventricular pressure, and aortic flow. The aortic flow is manipulated to have the correct sign and to be timed in such a way to depict flow right at the valve as opposed to a centimeter above the valve.

This file also generates the (X,Y,Z) data into an **x**-array, **y**-array and **z**-array. For example **x**(3,4) contains the x-coordinate of the fourth crystal at the third time frame (think **x**(timeframe, crystal number)). Therefore, the variable **x** is a matrix with rows equal to the number of time frames and columns equal to the number of crystals.

You can run this file by typing setup in the main window or clicking on the top button containing a page with a down arrow next to it. This will run the program in the main window. Try it, go to the main window and you will see a printed message that came from setup.m.

5 crystalplot.m

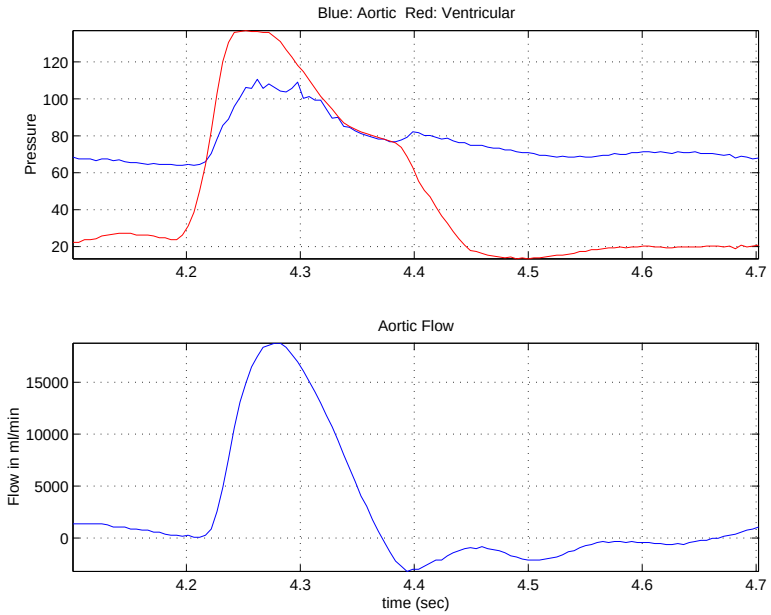
In the "M-file" window, click "file-open" and choose crystalplot.m. This will now be opened in the same window and you can tab between files at the bottom of the window.

This generates a 3D plot of the crystals with labels and some lines to ease viewing. You get to pick the time frame at the very beginning of this file. In the first line of code. This program will not work unless setup.m has already been run. You can call it from setup.m or after setup.m has been run you can type crystalplot in the main window and the graph will appear in a graphics window. You can rotate the graph from inside the graphics window.

You can run this program after running setup.m by typing crystalplot in the main window. Or you can go to the bottom of setup.m uncomment the line containing crystalplot and run setup.m again. This will run setup.m and then call crystalplot.m. Try it.

6 pressflowplots.m

Much like crystalplot this generates pressure and flow plots over the desired number of time frames chosen in setup.m. Comment out crystalplot and uncomment pressflowplot in setup.m and run setup.m. You should get the graph pictured below.



7 animpfplots

This stands for animated pressure flow plots. Open it in the "M-file" window. Comment out pressflowplot and uncomment animpfplots in setup.m. Now run setup.m. A graphics window will appear and you can trace the graphs by touching the space bar. At each point in the graph, the index will be shown in the graph. This will be very useful in determining the indices of important points in the cardiac cycle. For example, ejection begins as soon as ventricular pressure rises above aortic pressure.

Question: At what index (from before data) does ejection begin for the first cardiac cycle.

If you want to escape this process click on the main window and hit the control key and x key at the same time. This aborts the program. This is a helpful trick if you ever get caught in an endless loop or a calculation that is taking too much time.

8 deltaVplot.m

Open this up and have a look. The indices I have there are taken from the first cycle in the before data I found them by viewing the animated pressure flow plots. See if you come up with the same indices. You will need to be able to do this for all three cycles and with both sets of data so be comfortable with this procedure.

Read through this program and make sure you understand it. If you need help with the trapezoid method, let me know.

Comment out animpfplots and uncomment deltaVplot in setup.m and run it. You should get a graph displaying a 25 ml loss in ventricular volume during ejection.

9 Assignment

Read through all of the programs, make sure you understand what is being done. Try altering various elements and displaying different graphs. Andrew, try making and running your own Tex document including figures generated in MATLAB.