The University of Hong Kong

MEDE 4500 Biomedical instrumentation and systems

Lab 1 report

Cheung Evelyn Hok Yee	(UID: 3035123071)
Chong Pui Ka	(UID: 3035175634)
Lee Wing Yan	(UID: 3035178088)
Lv Ruyi	(UID: 3035142560)

Experiment 1 - Blood pressure measurement

1. You should notice the difference in SP value between when the sound actually began, was detected by the stethoscope transducer, and the time when the observer first heard the sound and pressed the marker button. (Example: 141 mmHg – 135 mmHg = 6 mmHg). Same difference should have happened in the DP values, i.e. at the marker insertion point when the director signaled the DP point during recording, and where the sound data detected by transducer disappeared. Tabulate the recorded values as follow. And explain what factors could account for this difference?

Task	**Systolic mmHg** (CH1 value)		**Diastolic mmHg** (CH1 value)	
	At Marker Insertion	**When first sound detected**	**At Marker Insertion**	**When last sound disappeared**
Left arm, sitting up	124.02	123.90	65.98	65.22
Right arm, sitting up	111.50	108.72	49.23	46.44
Right arm, lying down	99.18	96.33	45.46	40.69
Right arm, after exercise	117.57	116.31	46.76	41.51

Table 1.1

There is a difference between the blood pressure at marker insertion and the sound because there can be a time delay between the moment when the first sound is heard and the the moment when the director call out. Also, there can be a time delay between the moment when the director call out and the moment when the recorder insert the event marker.

2. Complete Table 1.2 with the average from sound data from tables 1.1 and then calculate the mean Arterial Pressure (MAP) and pulse pressure (PP). Also fill in the heart beat rate (in beat per min (bpm)) based on the 4 data segments.

Task	**SP (mm/Hg)**	**DP (mm/Hg)**	**Heart rate (bpm)**	**MAP (mm/Hg)**	**PP (mm/Hg)**
Left arm, sitting up	123.96	65.60	54.68	85.05	58.36
Right arm, sitting up	110.11	47.835	61.59	68.593	62.275
Right arm, lying down	97.755	43.075	60.60	61.302	54.68
Right arm, after exercise	116.94	44.135	83.07	68.403	72.805

Table 1.2

3. Blood conduction speed can be estimated by measuring the time duration between the peak of the R wave of an ECG cycle and the peak of the corresponding pressure wave in the pulse recording. Based on your measured data and the measurement done in Step 44, estimate the conduction speed values in the four tasks.
Distance between Subject's sternum and right shoulder: 20cm
Distance between Subject's right shoulder and antecubital fossa: 27cm
Total distance travelled: 0.47m

	Duration between the two peaks (s)	Blood conduction speed (m/s)
Left arm, sitting up	0.92	0.51
Right arm, sitting up	1.024	0.46
Right arm, lying down	1.0422	0.451
Right arm, after exercise	0.7278	0.646

4. Based on the answers for Questions 2 and 3, justify the relationships among heart rate, blood pressure, conduction speed by considering the two cases: "after exercise" and "sitting up".
By considering the case "after exercise", the heart rate is 83.07bpm, the MAP is 68.403mm/Hg and the conduction speed is 0.646m/s.

By considering the case "sitting up", the heart rate is 61.59bpm, the MAP is 68.593mm/Hg and the conduction speed is 0.46m/s.
Therefore, the higher the heart rate, the higher the conduction speed. However, the MAP of both cases are similar so there is not any significant relationships between the heart rate and blood pressure.

5. Give three sources of error in the indirect method of determining systemic arterial blood pressure.

(1) Defective measuring and processing equipment
(2) Observational bias
(3) Calibration error

6. Using ONLY the pressure curves of any one of the four data segments, develop a differential algorithm to estimate the SP and DP. This approach emulates the oscillometric method for automated blood pressure measurement without the use of stethoscope. How do you compare the values obtained by this method with the ones estimated by the auscultatory method? (Hint: You should use MATLAB to process the data. And please explain clearly how your algorithm works)

By passing the data obtained in the "Left arm sitting" session to the baseline-finding function, we got the pattern of cuff pressure oscillations in the recorded time. We assumed that MAP occurs when cuff pressure oscillation reaches its maximum. SP occurs when differentiated envelope reaches its maximum and DP occurs when differentiated envelop reaches its minimum. The detailed code and explanations (comments) are attached below.

Matlab Code:

```
Rawdata = xlsread('BP.xlsx', 1, 'B2:B17064'); %Load the data in the excel file
disp('Reading Data');
Rawdata(13000:end) =[];
subplot(3,1,1); %Plot the rawdata for comparison
plot(Rawdata);
title ('Rawdata');
xlabel('time');
ylabel('BP (HHmg)');
disp('Data read and Rawdata plotted');
baseline = sgolayfilt(Rawdata,4,2301);  %extract baseline and filter the rawdata
filtered = Rawdata - baseline;
hold on
plot(baseline);
subplot(3,1,2);       %Plot the filtered signal and its envelope
plot(filtered);
[up low] = envelope (filtered,1000,'peak');
hold on;
plot(up);
subplot(3,1,3);       %Plot the differentiated envelope
diffe = diff(up);
plot(diffe);
[maxv, maxi] = max(diffe); %find the maximum and minimum of the envelope and memorize index
hold on
plot(maxi,maxv, 'o');
diffe(1:maxi) = 500;
[minv, mini] = min(diffe);
hold on
plot(mini,minv,'o');
max = 0;      %Find out where the maximal oscillation occurs
prior = 0;    %and use the index to find out the corresponding pressure
index = 1;
for i = 1:length(Rawdata)
    temp = filtered(i);
    if(temp>max && abs(prior-temp)<0.5)
        max = temp;
        index = i;
    end
    prior = temp;
end
X = ['Calculated MAP is (mmHg): ', num2str(Rawdata(index))];  %Print out the values with the assumed
ratios
disp (X);
A = ['Estimated SP: ', num2str(Rawdata(maxi))];
B = ['Estimated DP: ', num2str(Rawdata(mini))];
disp (A);
disp (B);
```

Experiment 2 – Electro-Oculography (EOG) Application

1. Describe any difficulties that you encountered in calibrating the EOG signal to control the position of the dot on the screen.

   The whole process was fairly smooth for our group. There was not much problem with the calibration of EOG axes. However, it took us several tries to find the optimal value for sensitivity. Originally, we set the sensitivity too low, hence the dot on the screen did not move much even when the subject swipe through A to E, both vertically and horizontally.

2. Describe any problems you had with training the subject to toggle the color of the dot by blinking. How long did it take to train the subject?

   At first, we checked the peak frequency of the subject when she intended to change the colour of the spot. It was around 3Hz. As a result, we set the peak frequency detection limits to be 2.8 to 3.2 Hz. However, as we proceeded the experiment, we found her intended eye-blinking frequency fluctuate too much, the frequency went off both the upper and lower limits. In the end, we found that a wider frequency range, 2 to 4 Hz, worked the best for our subject. It took us around 5-6 times of calibrating the peak frequency detection range.

3. While blinking may be useful to control the click feature of the mouse, it could be a potential source of noise for controlling the position of the dot. Therefore, it should be filtered out of the signal. Using MATLAB, import the data from the "blinking" data file that you created. Then create a filter that could be used to remove blinking from the EOG signal.

   From blinking data, horizontal EOG (DC) signal, vertical EOG (DC) signal and vertical EOG (AC) signal are retrieved. The vertical EOG (DC) signal is processed to design the filter. Fourier Transform of the vertical EOG (DC) signal is performed to obtain the cut-off frequencies, 1Hz and 5.4Hz, for the bandstop filter. The following graph shows the original vertical EOG (DC) signal and the filtered vertical EOG (DC) signal.

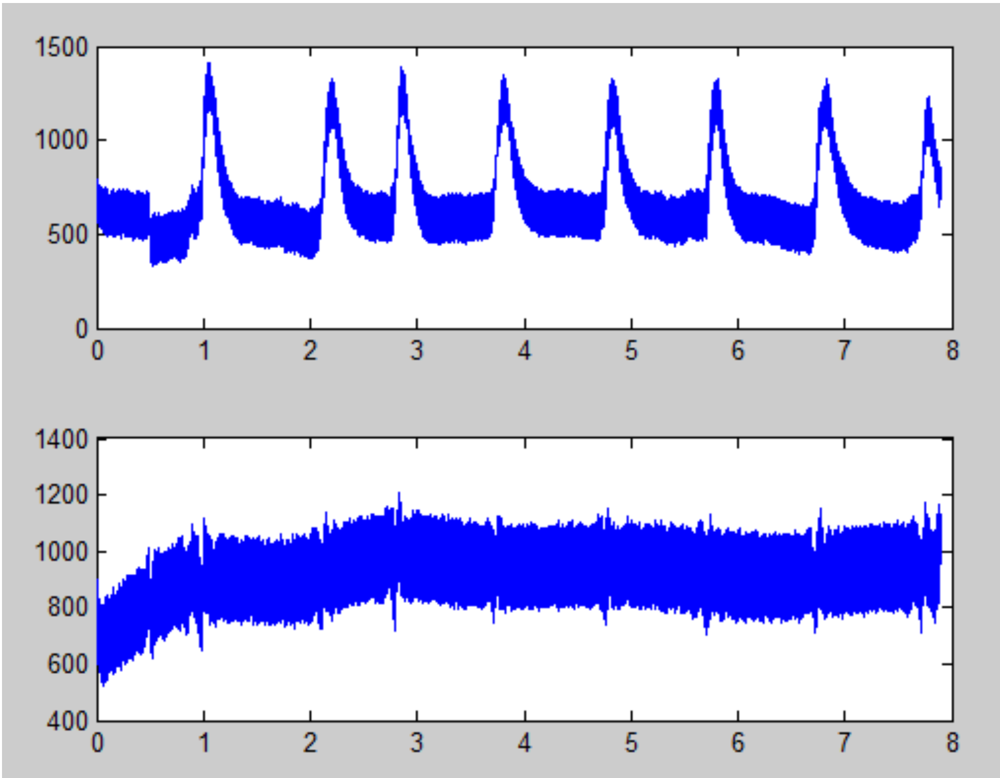
Matlab code:

```
data = importdata('blinking.data');
fs = 480;
x=0:1/fs:3789/480;
horizontal = data(:,1);
verticalDC = data(:,2);
verticalAC = data(:,3);
figure(1)
subplot(3,1,1)
ylabel('Horizontal EOG (DC)')
plot(x,horizontal)
subplot(3,1,2)
ylabel('Vertical EOG (DC)')
plot(x,verticalDC)
subplot(3,1,3)
ylabel('Vertical EOG (AC)')
plot(x,verticalAC)
```

```
Y = fft(verticalDC);
L = 3790;
P2 = abs(Y/L);
P1 = P2(1:L/2+1);
P1(2:end-1) = 2*P1(2:end-1);
f = fs*(0:(L/2))/L;
figure(2)
plot(f,P1)
```

```
[b a] = butter(4,[1/480 0.03],'stop');
filtered = filtfilt(b,a,verticalDC);
figure(3)
subplot(2,1,1)
ylabel('Vertical EOG (DC)')
plot(x,verticalDC)
subplot(2,1,2)
plot(x,filtered)
```

Outputs:



1500
1000
500
0
0 1 2 3 4 5 6 7 8
1400
1200
1000
800
600
400
0 1 2 3 4 5 6 7 8