BIEN 3200: Lab 2

Descriptive Statistics Using Arrays, Looping, File I/O Functions, and Modular Programming

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Abstract:

Introduction:

The use of arrays, looping, and file input/output (I/O) functions to perform descriptive statistics on a given set of data is introduced in this lab exercise. Modular program design is implemented to execute the statistical operations. MatLab is linked to from C code to produce the desired graphics. These capabilities are all important for signal processing as it relates to biomedical engineering because these operations will become necessary during data analysis in research and product development.

Methods:

Equations:

$$MAP = diastolic\ pressure + \frac{systolic\ pressure - diastolic\ pressure}{3} \quad (1)$$

$$PP = systolic\ pressure - diastolic\ pressure \quad (2)$$

$$mean = \frac{1}{N}\sum_{i=0}^{N-1} x_i = \frac{x_0 + x_1 + \cdots + x_{n-1}}{N} \quad (3)$$

$$variance = \frac{1}{N-1}\sum_{i=0}^{N-1} x_i - \bar{x}^{\,2} \quad (4)$$

$$skewness = \frac{\frac{1}{N-1}\sum_{i=0}^{N-1} x_i - \bar{x}^{\,3}}{\sigma^{2\ 3/2}} \quad (5)$$

Data Files:

Physiologic_data.xls (1)

This spreadsheet contains physiologic data from over a dozen normal patients. The systolic pressure and diastolic pressure from the first ten subjects are used in the program for part 1.

SYS_P.txt (2)

This text file contains resting systolic arterial pressures for a normal sample group.

HR.txt (3)

This text file contains resting heart rate values for a normal sample group.

sinus2.txt (4)

This text file contains normal sinus rhythms and the timing for the rhythms for a given sample group.

The program for part 1 of this lab called for a function that calculates the mean arterial pressure (MAP) and pulse pressure (PP) on an input systemic arterial systolic and diastolic pressures for a given subject. The program used equations 1 and 2 to accomplish the task of

calculating the MAP and PP, respectively. These equations are each run in separate functions, which the main function calls, in order to perform the operations on the input values.

The program for part 2 of this lab requires a function that calculates the mean, variance, and skewness on an input dataset. It writes the results to a text file. Then a connection to MatLab is established and a histogram for the dataset is produced.

For part 3 of this lab, a program utilizes a connection to MatLab to produce a plot of a patient's normal sinus rhythm. The dataset from sinus2.txt (data file 4) is necessary for this program. MatLab should plot the data as a function of amplitude (mV) versus time (seconds).

Results:

```
Enter the systemic arterial systolic and diastolic pressures (mmHg)
Systolic: 120
Diastolic: 80

Systolic Pressure:      120 mmHg
Diastolic Pressure:     80 mmHg
MAP in mmHg:            93.3333
PP in mmHg:             40
Press any key to continue . . .
```

Figure 1: Screenshot of the output of MAP and PP functions from the program for part 1

Systolic Pressure	Diastolic Pressure	Mean Arterial Pressure	Pulse Pressure
128	77	94	51
108	74	85.3	34
138	76	96.6	62
165	91	115.6	74
140	64	89.3	76
132	72	92	60
154	74	100.6	80
131	66	87.6	65
109	63	78.3	46
152	97	115.3	55

```
Lab 2, Part 2
Input file name: HR.txt

Output file name: out_hr.txt
Press any key to continue . . .
```

Figure 2: Screenshot of the console of the program from part 2

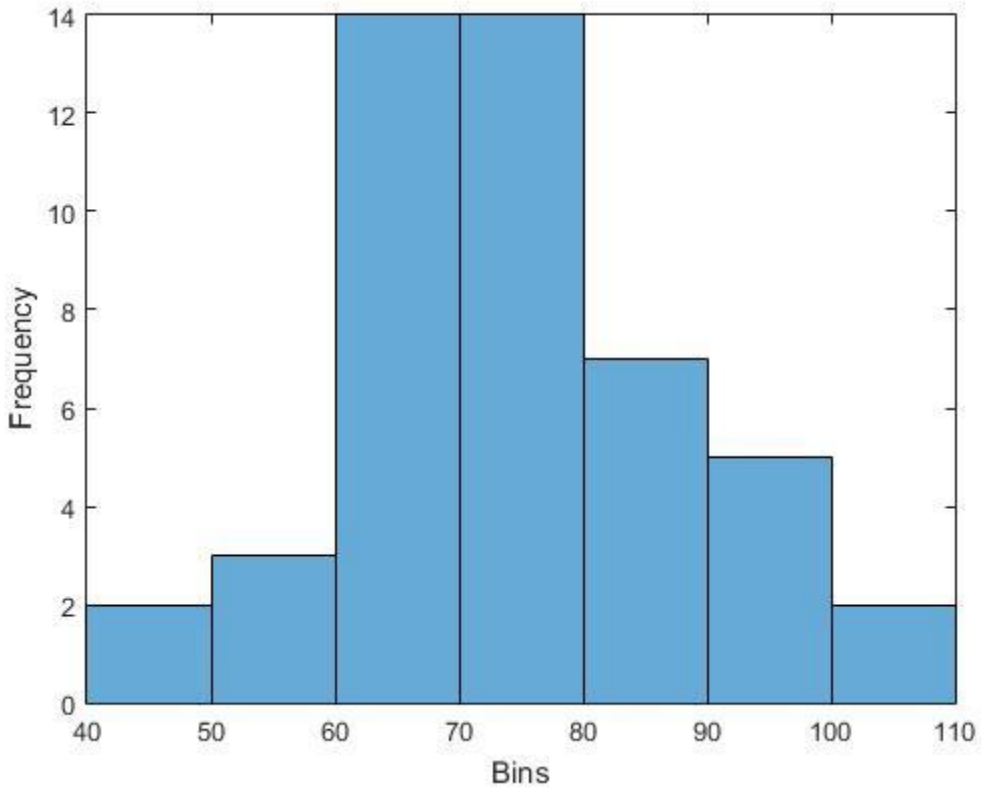

Figure 3: Histogram of heart rate data from HR.txt for part 2

mean:	73.8
variance:	0.00011
skew:	-1.15e+28

Figure 4: Contents of output file for part 2 program with HR.txt as input data set.

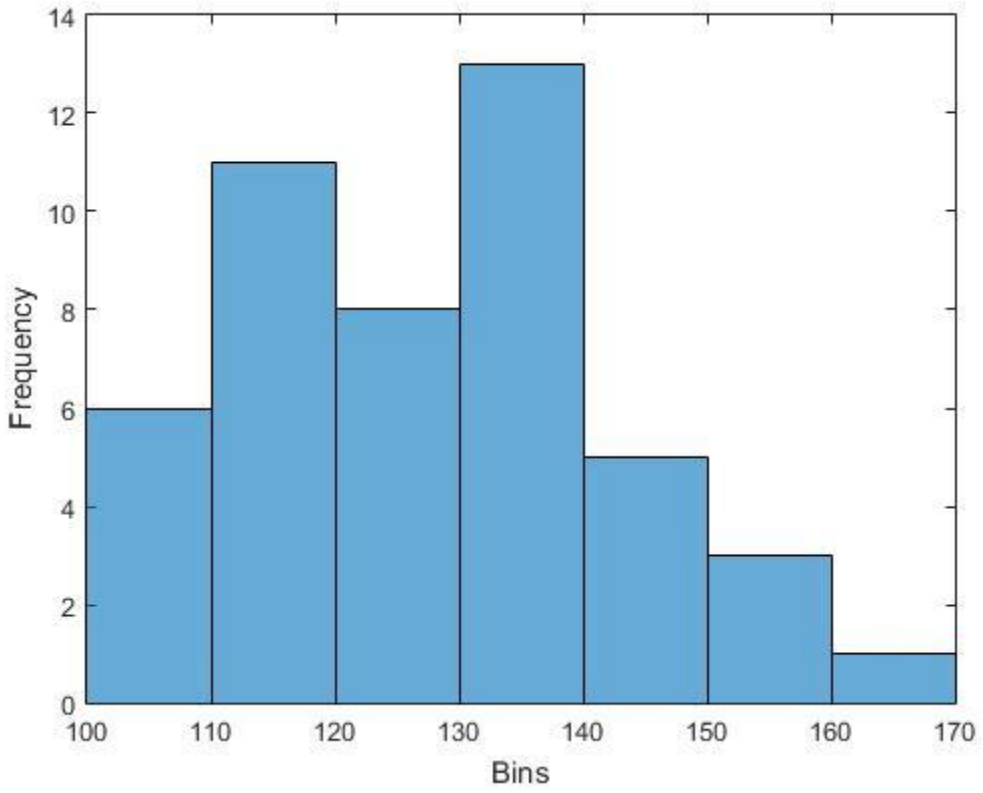

Figure 5: Histogram of data from SYS_P.txt for part 2

mean:	127
variance:	9.11e-05
skew:	-1.39e+28

Figure 6: Contents of output file for part 2 program with SYS_P.txt as input data set.

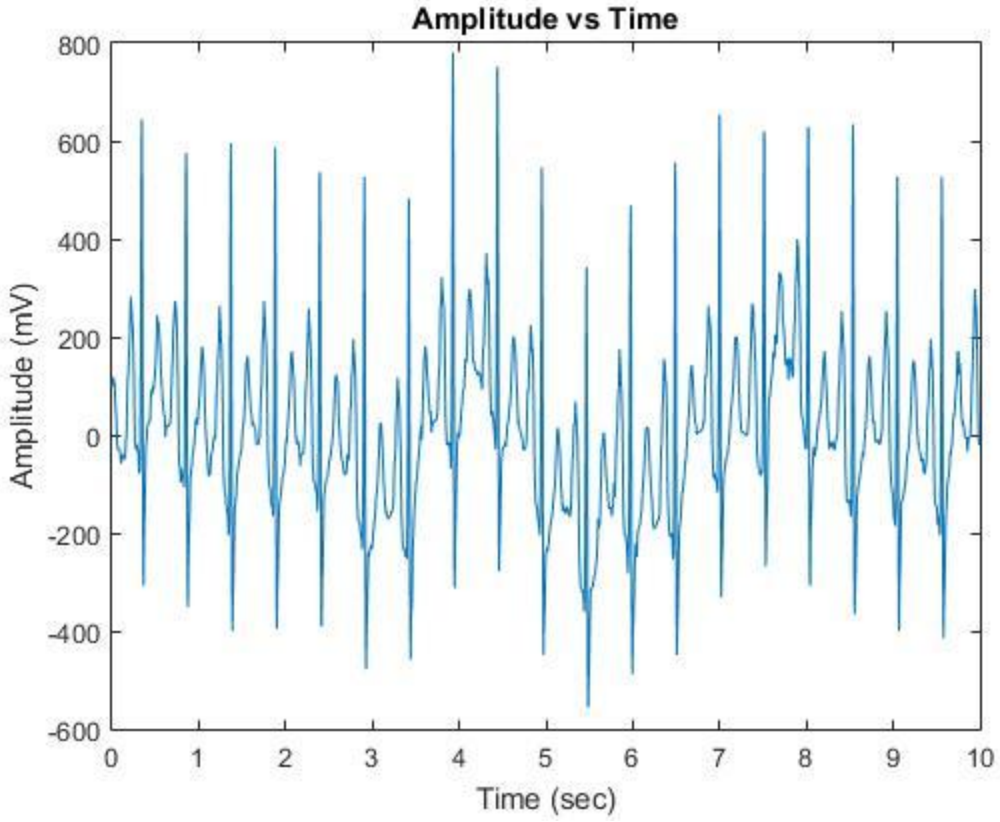

Figure 7: Plot of normal sinus rhythm for part 3

Discussion:

The modularization of code that performs data analysis on a set of data was successful by following best practices as shown in examples from class. The ability of C to interface with MatLab is a very handy tool for signal processing. It will certainly be useful for future projects. Unfortunately the speed of the program is still an issue. Since the libraries have to be loaded into the program in order for it to run, each time the C code establishes a connection with MatLab, the code hits a point of idling. Hopefully this will not be too much of an issue in the future.

Conclusion:

The objective of implementing signal analysis using modular programming, arrays, looping, and file I/O functionality was accomplished. The three programs exhibit the correct usage, as outlined is the lab description.

Answers to Questions:

1. MAP, as defined by equation 1, is not the arithmetic average of the systolic and diastolic pressures. The arithmetic average of the two pressures would be the sum of the pressures divided by 2.
2. A common cause for an increase in pulse pressure is leaky valves, as often occurs in elderly patients. A common cause for a decrease in pulse pressure indicates poor heart function.

C Code:

```
/* SimpleCProgram.c : Defines the entry point for the console application.
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	Program Description:
		This program calculates and displays the mean arterial pressure
		and the pulse pressure for a patient whose systolic and diastolic
		pressures are inputs.

*/

#include "stdafx.h"
#include <stdio.h>

float CalcMeanArterialPressure(float systolic, float diastolic) {
	//Calculate the mean arterial pressure (MAP)
	float MAP = diastolic + (systolic - diastolic) / 3;
	return MAP;
}

float CalcPulsePressure(float systolic, float diastolic) {
	//Calculate the pulse pressure (PP)
	float PP = systolic - diastolic;
	return PP;
}

int main(void) {
	float systolic, diastolic;

	//User Input
	//	blood pressure
	printf("Enter the systemic arterial systolic and diastolic pressures (mmHg)\n");
	printf("Systolic: ");
	scanf_s("%g", &systolic);
	printf("Diastolic: ");
	scanf_s("%g", &diastolic);

	//Calculate mean arterial pressure (MAP)
	float MAP = CalcMeanArterialPressure(systolic, diastolic);

	//Display systolic pressure, diastolic pressure, and MAP
	printf("\nSystolic Pressure:\t %g mmHg", systolic);
	printf("\nDiastolic Pressure:\t %g mmHg", diastolic);
	printf("\nMAP in mmHg:\t\t %g", MAP);

	//Calculate and display pulse pressure (PP)
	float PP = CalcPulsePressure(systolic, diastolic);
	printf("\nPP in mmHg:\t\t %g\n", PP);

	system("PAUSE"); //pauses command window for user to view results
	return 0;
}
```

```
/* lab2part2.cpp : Defines the entry point for the console application.
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	13 September 2016
	Lab 2

	Program Description:
		This program takes in a column of float data values and performs
		statistic calculations (mean, variance, skew) on it.
*/

#include "stdafx.h"
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include "engine.h"
#include "mex.h"
#include <string.h>

/*
	data : float array that holds data set
	n : int representing size of array

	Calculates the mean of the input set of data
*/
float fmean(float data[], int n) {
	float mean = 0;
	for (int i = 0; i < n; i++)
		mean = mean + data[i];
	mean = mean / n;
	return mean;
}

/*
	data : float array that holds data set
	n : int representing size of array

	Calculates the variance of the input data set
*/
float fvariance(float data[], int n) {
	float variance = 0;
	float mean = fmean(data, n);
	for (int i = 0; i < n; i++)
		variance = variance + pow(data[i] - mean, 2);
	variance = 1 / (variance - 1);
	return variance;
}

/*
	data : float array that holds data set
	n : int representing size of array

	Calculates the skew of the input data set
*/
float fskewn(float data[], int n) {
	float skew = 0;
	float mean = fmean(data, n);
	float variance = fvariance(data, n);
```

```
	for (int i = 0; i < n; i++)
		skew = skew + pow(data[n] - mean, 3);
	skew = skew / ((n - 1)*pow(variance, 3 / 2));
	return skew;
}

int main() {
	printf("Lab 2, Part 2");
	float xdata[100];
	static float mean, var, skewN;
	static int n;
	FILE *inputfile, *outputfile;
	char inputName[10];
	char outputName[10];

	//prompt user for name
	printf("\nInput file name: ");
	scanf("%s", &inputName);

	// read in data
	inputfile = fopen(inputName, "r");
	if (inputfile == NULL) { //file not found
		printf("Input file not found!\n");
		system("PAUSE");
		return 1; //end program
	}
	for (n = 0; fscanf(inputfile, "%g", &xdata[n]) != EOF; n++); /*EOF: End Of File*/
	fclose(inputfile);

	//calculate mean data
	mean = fmean(xdata, n);

	//calculate variance
	var = fvariance(xdata, n);

	//calculate skew of n
	skewN = fskewn(xdata, n);

	//prompt user for output file name
	printf("\nOutput file name: ");
	scanf("%s", &outputName);

	//write to the file
	outputfile = fopen(outputName, "w");
	fprintf(outputfile, "mean:\t\t%3.3g\n", mean);
	fprintf(outputfile, "variance:\t%0.3g\n", var);
	fprintf(outputfile, "skew:\t\t%0.3g\n", skewN);

	system("PAUSE");

	//use MATLAB to create histogram
	Engine *ep;
	if ((ep = engOpen(NULL)) == NULL) return 1;
	mxArray* matx1 = mxCreateNumericMatrix(n, 1, mxSINGLE_CLASS, mxREAL);
	memcpy((void *)mxGetPr(matx1), (void *)xdata, sizeof(float) * 100);
	engPutVariable(ep, "xdata", matx1);
	engEvalString(ep, "fig = figure; histogram(xdata)"
		"xlabel('Bins'); ylabel('Frequency');"
```

```
		"print(fig,'histogram','-dpng')");

	system("PAUSE");

	engClose(ep);

	//system("PAUSE");
	return 0;
}

/* lab2part3.cpp : Defines the entry point for the console application.
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	Program Description:
		This program reads clinical sinus rhythm (normal) ECG data from
		a text file (sinus2.txt) and uses a connection with MATLAB to plot
		the data on a graph
*/

#include "stdafx.h"
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include "engine.h"
#include "mex.h"

int main(void) {
	printf("Lab 2, Part 3");
	int length;
	static float xdata[2500], ydata[2500];
	FILE *fp;

	//read from file
	fp = fopen("sinus2.txt", "r");
	if (fp == NULL) { //file not found
		printf("Input file not found!\n");
		system("PAUSE");
		return 1; //end program
	}
	for (length = 0; fscanf(fp, "%g %g", &xdata[length], &ydata[length]) != EOF;
length++); /*EOF: End Of File*/
	fclose(fp);

	//interface with Matlab for plotting
	Engine *ep;
	ep = engOpen(NULL);

	mxArray* matx1 = mxCreateNumericMatrix(length, 1, mxSINGLE_CLASS, mxREAL);
	mxArray* maty1 = mxCreateNumericMatrix(length, 1, mxSINGLE_CLASS, mxREAL);

	/* Copies values of x1 and y1 into the allocated space: copies 10 *(# of bytes for
a float) bytes
	from x1 to matx1 or from y1 to maty1 */
	memcpy((void *)mxGetPr(matx1), (void *)xdata, sizeof(float) * length);
```
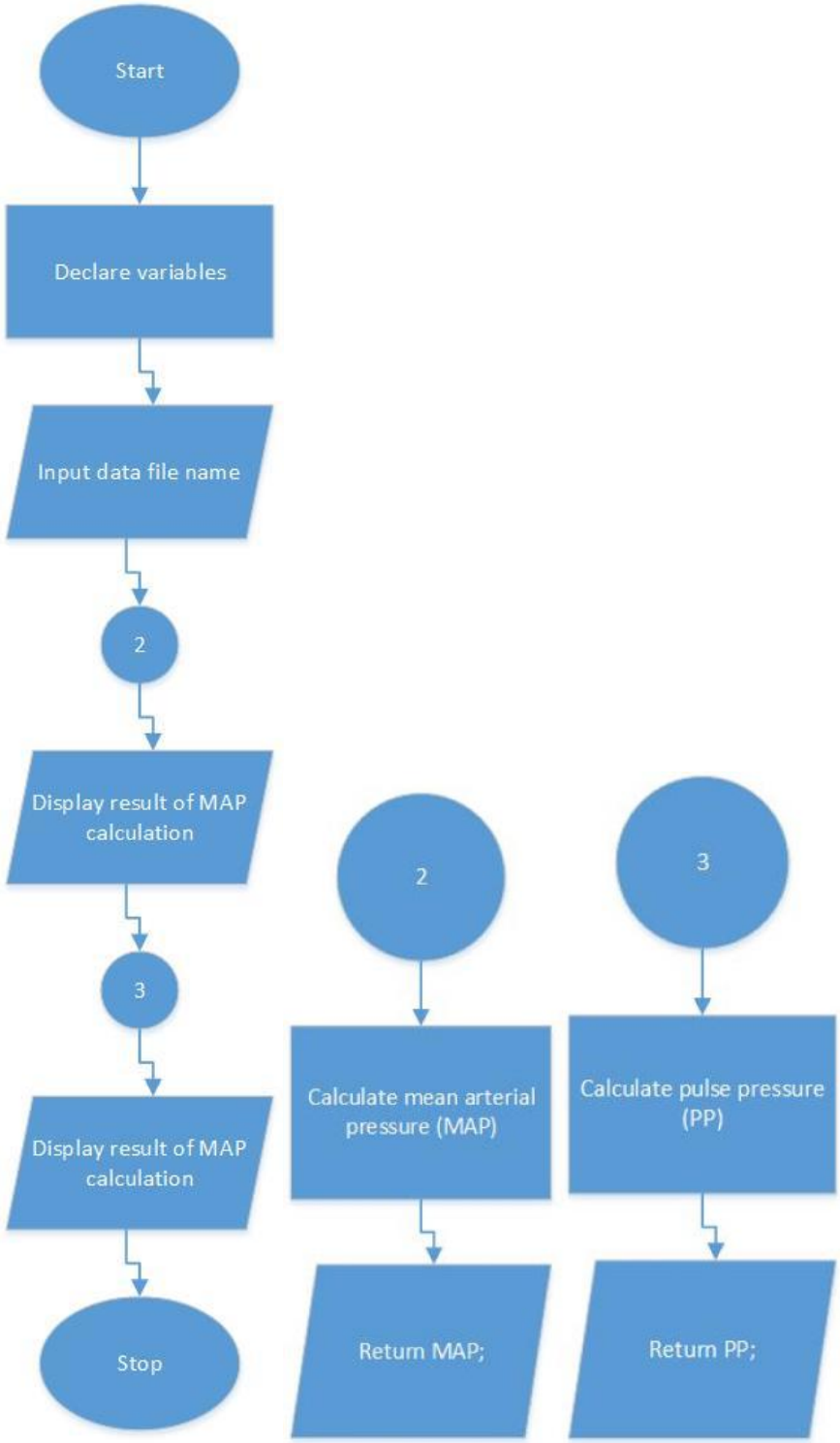
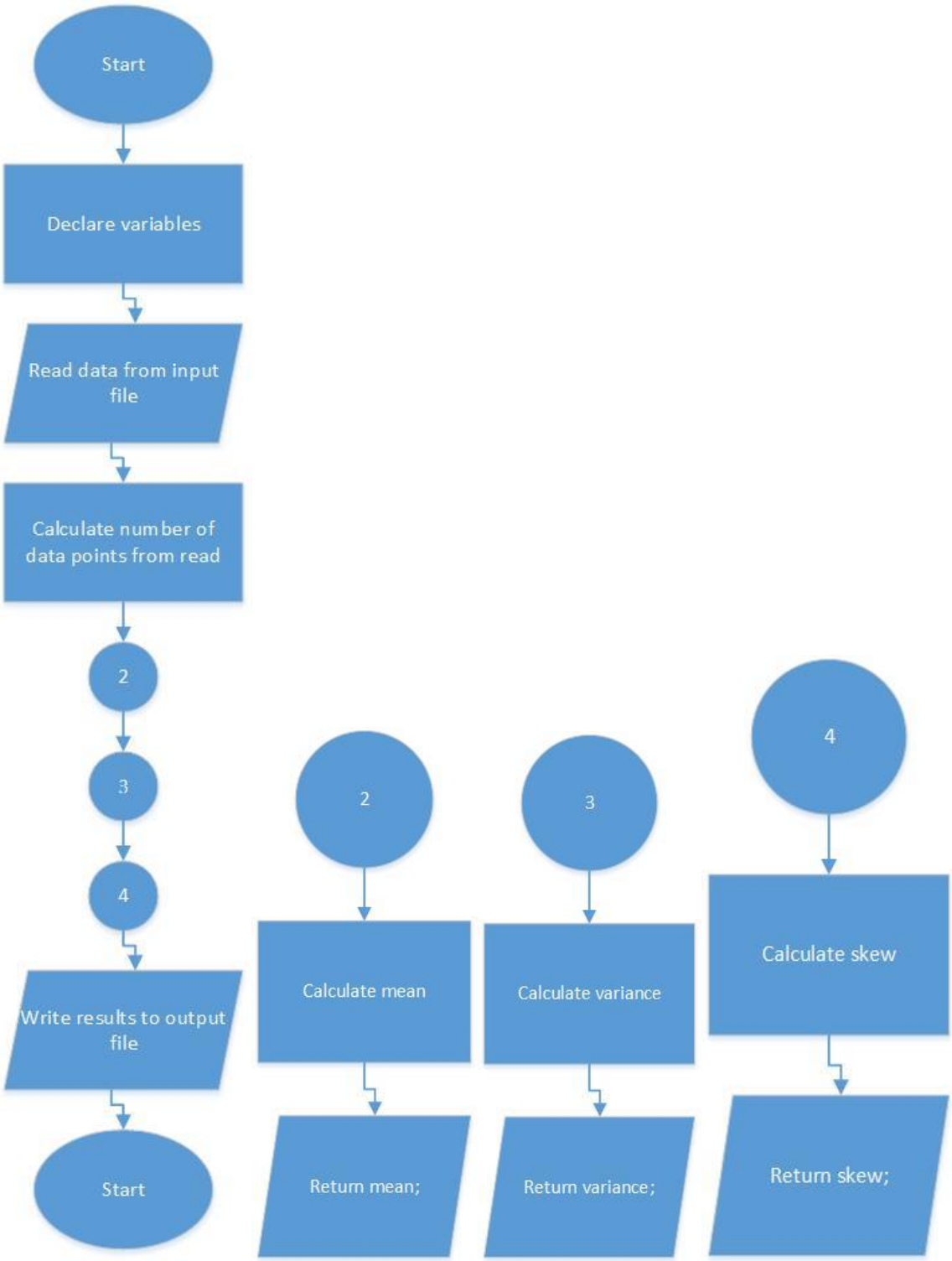
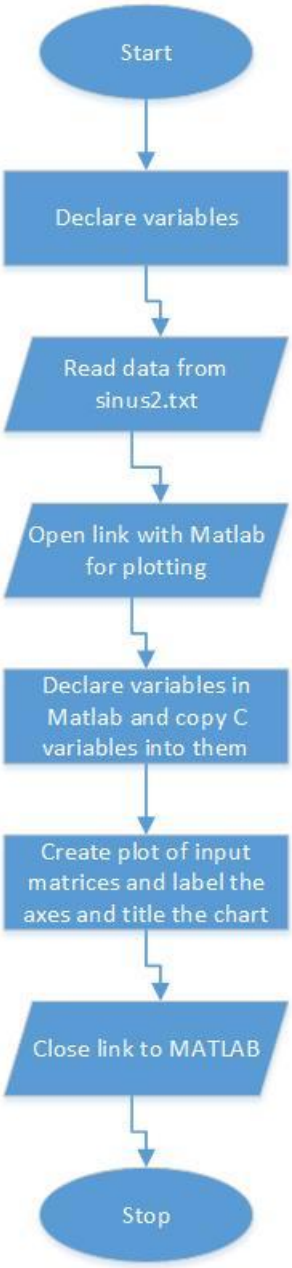

```
        memcpy((void *)mxGetPr(maty1), (void *)ydata, sizeof(float) * length);

        engPutVariable(ep, "X", matx1);
        engPutVariable(ep, "Y", maty1);

        engEvalString(ep, "figure; plot(X,Y);"
               "title ('Amplitude vs Time');"
               "xlabel ('Time (sec)');"
               "ylabel ('Amplitude (mV)');");

        system("pause");
        engClose(ep);
        return 0;
}
```

Flow Charts:


Start
Declare variables
Input data file name
2
Display result of MAP calculation
3
Display result of MAP calculation
Stop
2
Calculate mean arterial pressure (MAP)
Return MAP;
3
Calculate pulse pressure (PP)
Return PP;


Start
Declare variables
Read data from input file
Calculate number of data points from read
2
3
4
Write results to output file
Start
2
Calculate mean
Return mean;
3
Calculate variance
Return variance;
4
Calculate skew
Return skew;


Start
Declare variables
Read data from sinus2.txt
Open link with Matlab for plotting
Declare variables in Matlab and copy C variables into them
Create plot of input matrices and label the axes and title the chart
Close link to MATLAB
Stop