Project: Health Score

CS 1324.001 **Points: 100**

Fall 2017

Deadline: December 3rd, 2017, 11:59 PM using eLearning ONLY.

1. Project Summary

This project is based on the concept of multisensor data fusion, using basic statistical analysis. Multisensor data fusion is the process of combining observations from a number of different sensors to provide a robust and complete description of an environment or process of interest.

The variables of interest for this project are:

- *Body Temperature* (**BT**): A single value considered to be normal between 97F to 99F.
- *Blood Pressure* (**BP**): Two values are monitored. (**BPS**) Systolic and (**BPD**) Diastolic. Normal BPS is below 120. From 120 to 139 is called *prehypertension*. 140 or higher is *hypertension*. A normal BPD is less than 80. Between 80 and 89 indicates *prehypertension* and 90 or higher is considered *hypertension*. Blood pressure is measured in millimeters of mercury (mm Hg)
- *Heart Rate* (**HR**): A single value. **HR** Is the number of times the heart beats per minute. For adults 18 and older, a normal resting heart rate is between 60 and 100 beats per minute (bpm). *Tachycardia* is generally considered to be a resting heart rate of over 100 beats per minute. *Bradycardia* is a condition where the heart rate is too low, typically less than 60 bpm.

Based on these three variables, at any point in time the health score is calculated as:

$$f(time, temp, press, rate) = 20 * temp + 25 * press + 30 * rate + 25 \qquad \text{Eq. 1}$$

where:

- *temp* is based on the body temperature at time *t*, and is defined as:

$$temp = \begin{cases} 1 & if\ 97F \leq BT \leq 99 \\ 0 & otherwise \end{cases}$$

- *press* is based on the blood pressure at time t, and is defined as:

$$press = \begin{cases} 1 & if\ BPD \leq 80\ and\ BPS \leq 120 \\ 0.5 & if\ 80 < BPD \leq 89\ or\ 120 < BPS \leq 139 \\ 0 & if\ BPD \geq 90\ or\ BPS \geq 140 \end{cases}$$

- *rate* is based on the heart rate ending at time t based on some Δt, usually 15 to 60 seconds, and is defined as:

$$rate = \begin{cases} 1 & if\ 60 \leq HR \leq 100 \\ 0 & otherwise \end{cases}$$

In this project, all the sensor information is obtained through input files.

2. Input Parameters

The user should enter:

- ✓ Data File Location (full path for the containing folder of the data files),
- ✓ Time Interval (t_{start} and t_{end}),

After this information is provided, the user can calculate the health score for any time between $t_{initial}$ and t_{final}.

3. Input Files

The filename includes the variable name and the sensor number as:

<*variable_name*>_<*sensor_id*>.txt

For example "BT_1.txt" is the file that contains the data collected by body temperature sensor 1.
NOTE: all time stamps are integers.

- **BT** files have the following format:

  <time_stamp> <value>

  For example:

  0034 97.5
  0054 97.4
  0074 97.6

- **BP** files have the following format:

  <time_stamp> <BPD> <BPS>

  For example:

  0024 78 118
  0044 79 119
  0064 76 119

- **HR** files have the following format:

  <time_stamp> <value>

  For example:

  0034 96
  0035 94
  0036 98

4. Multisensor Data Fusion

You will be given 5 sensors to monitor BT, BP, and HR respectively (5 data files for each seonsor), to compute the value of any variable, compute the average of the samples over the window at time *t*. If no data is available, use linear interpolation—see Section 13.

5. Functional Requirements

Roles: User

Use Case A: "[Enter File Location]" (**5 Points**)

1. The user selects option a) from the menu
2. The user is asked to enter the file location (full path of containing folder)
3. The program displays the main menu

NOTE: your program should be able to read in all data files from the location. Use string manipulation to append proper file names to the location and open each of the file respectively.

Use Case B: "[Time Interval t_{start} and t_{end}]" (**5 Points**)

1. The user selects option b) from the menu
2. The user is asked to enter the values for t_{start} and t_{end}
3. The program displays the main menu

Use Case C: "[Get Health Score]" (**20 Points**)

1. The user selects option c) from the menu
2. The user is asked to enter the time at which to calculate the Health Score
3. The program displays:
    a. a table with the values for BT, BP and HR at this time,
    b. a report on any of the conditions described above, and
    c. the Health Score value obtained using Eq. 1
4. The program displays the main menu

Use Case D: "[Get Statistical Values]" (**20 Points**)

1. The user selects option d) from the menu
2. The program displays a table with the statistical parameters (over the time interval) for each variable
3. The program displays the main menu

Use Case A-D: "[VALIDATION]" (**10 Points**)

1. Input should be an expected valid data type for the input:
    a. Integer, float, c-string, etc.
2. Range values should be valid
    a. Based on dependent parameters
    b. Within the limits of each others parameters
    c. In proper order
3. If an input option depends on other parameters, the selection of the option should be rejected until the depended options have correct input.
4. If the input data is invalid, the user should be asked to enter the data again
5. File name and location (path) should be valid, as well as the file data (i.e., corrupted files, incorrect format, etc.)

6. Output Examples

The program should display:

1. A menu that allows the user to perform the following operations:

    a. input the data files location
    b. set the time interval t_{start} and t_{end}
    c. process and display the Health Score output
    d. process and display the data statistical parameters for each variable used to calculate the current Health Score
    e. exit the program

2. If option c) is chosen, the program should ask the user for a time point to calculate the Health Score. After entering a valid time (i.e. should be within the given time interval), the program should display:
    a. a table with the values for BT, BP, and HR,

b. a report on the detection of any conditions (i.e., normal / prehypertension / hypertension) described above, and
c. the HealthScore value obtained using Eq. 1.

For example:

```
Body Temperature    | Blood Pressure       | Heart Rate
--------------------+----------------------+------------------
97.5F               | 80 - 120 mm Hg       | 58 bmp
Normal              | Normal               | Bradycardia
--------------------+----------------------+------------------
At time 55, the Health Score was 70/100.
-------------------------------------------------------------
```

3. If option d) is chosen, a table with the statistical parameters (over the time interval) for each variable should be displayed. For example:

```
-----------------------------------------------------
     Statistical Values between time 40 and 80
---------+-----------+---------------------+------------
Variable | Body Temp | Blood Pressure      | Heart Rate
---------+-----------+---------------------+------------
     Min | 97.00F    |  76.0 - 118.0 mm Hg |  62.0 bpm
     Max | 98.00F    |  79.0 - 119.0 mm Hg |  68.0 bpm
 Average | 97.50F    |  77.0 - 118.0 mm Hg |  65.3 bpm
  StdDev |  0.50F    |   1.5 -   0.5 mm Hg |   3.0 bpm
---------+-----------+---------------------+------------
```

7. Environment

The computer program should comply with a set of code style rules (i.e., commenting and formatting) developed by the team. These rules should follow the guidelines discussed in class. For example, there should be a header for the whole program that gives all of the team member's names, class name, date, and description. Some form of section, line, and portion comments should be included. Some form of code alignment and indenting format should be included. Please ask if you have any questions.

8. Test Cases (10 Points)

For each Use Case in Section 5, define a set of values as input data to test the correctness of your program.

9. Other Requirements (non-functional and system) (15 points)

Provide a report that includes the following:

- a section documenting the Requirements (as this document IS your Requirements, you are free to copy this document in it entirety with modification—I should not see this comment in your document ☺)
- a section on any Assumptions made clearly explained (i.e., team decisions made outside scope of the given requirements, such as "Time values are always considered a single precision floating point type…")
- a section documenting a set of Flow Charts for each Use Case

- a section documenting the set of Test Cases
- a section documenting the Design of your program, processes, and functions (pseudo-code can be used to describe each design element and how they work together)
- a section documenting experimental results with example input and output data
- a section on the team's conclusions, comments, and future work (what would you do if you had more time?)

10. MATLAB Graphical Representation of Data (15 points)

In **MATLAB©**, write a script file which can read all sensor data in from all 15 files and generate plots for all data entries (from all sensors) of BT, BP, and HR (an example of BT plot is shown below in Figure 1). Also, compute the average value from 5 sensors for BT, BP and HR and generate a plot for each type of sensors (an example is shown below in Figure 2).

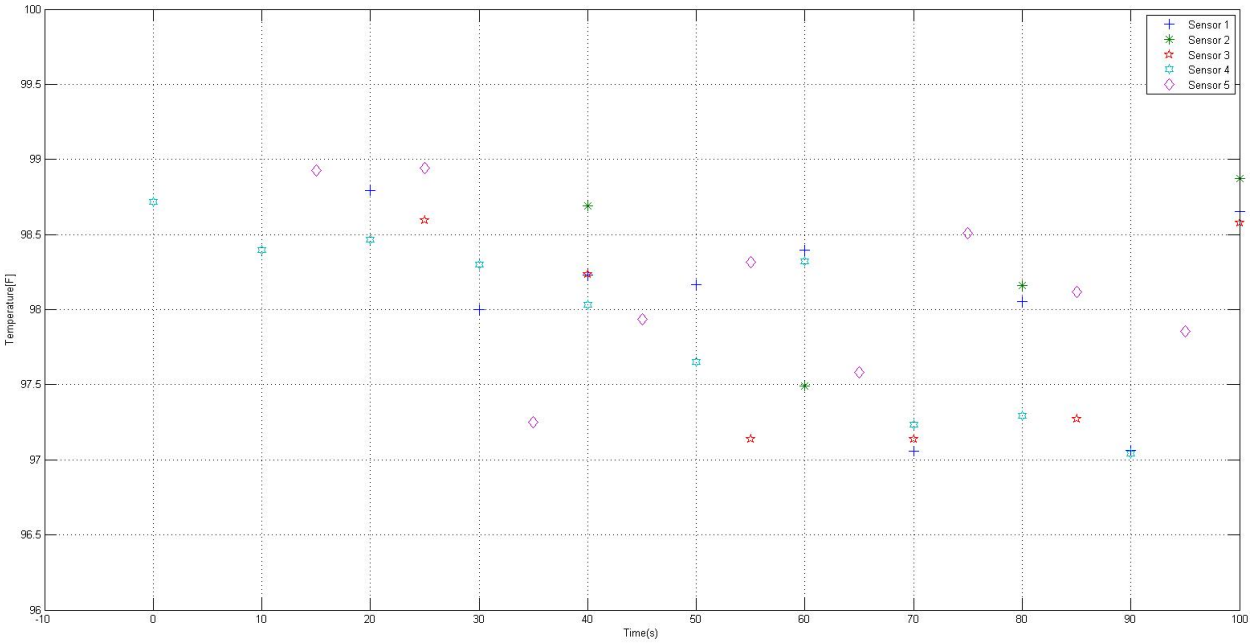

Figure 1: Body Temperature with 5 sensors

- Figure 1 shows an example of input data for Body Temperature, using 5 sensors, from t_{start} = 0s and t_{end} = 100s.
- Figure 2 shows an example of average Body Temperature, using 5 sensors and linear interpolation.

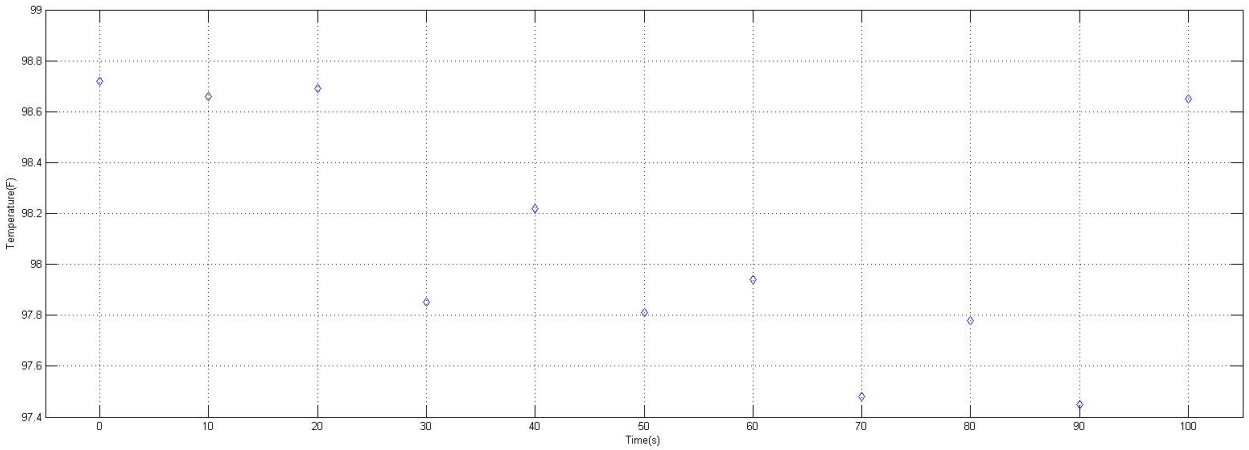

Figure 2: Average Temperature

11. Deliverables (Mandatory):

The team shall submit one zip file that shall include:

- the Report document (PDF)
- the C source file(s) (.c file)
- an executable
- MATLAB script file(s) (.m file)

12. Topics Covered

- File Processing, Flow Control, Operators and Expressions, Pointers, Arrays and Functions.

13. Resources

- Linear Interpolation: http://en.wikipedia.org/wiki/Linear_interpolation
- Multisensor Data Fusion: http://www.hindawi.com/journals/tswj/2013/704504/