Department of Electrical and Electronic Engineering

C Programming: Coursework Assignment (2023)

SUBMISSION DATE

May 2nd, 2023: 13:00
DASS students have extensions to submission date as have been previously agreed.

OBJECTIVE

To apply your C programming knowledge and skills gained from the unit lectures and laboratory classes to interpret and analyse a real-world electrical engineering dataset.

The purpose of this assignment is to develop a program to perform a statistical analysis on an engineering dataset and to calculate measures such as mean, standard deviation, minimum, and maximum values for two floating-point variables. The program will read the data associated with these 2 variables from a file, perform the necessary calculations, and output the results to the console. Your data analysis program is intended for use by production engineers who will look to incorporate it into a larger automated battery test platform aimed at optimising future battery pack designs.

INTRODUCTION

THE DATASET

The global science and engineering safety company, Underwriters Laboratories, has published a dataset [1] from their investigations into repeated battery cycling and the effects it has on cell current carrying capacity and total energy capacity. The battery under investigation in this dataset is of a lithium nickel cobalt aluminium chemistry and housed in a cylindrical cell 18650 formfactor (Figure 1) with a 3400 mAh current capacity.

LITHIUM BATTERY CELL UNDER INVESTIGATION

- Nominal Capacity = 3400 mAh
- Graphite / NCA
- 18650 Cell

This type of cell is identical to those found in a Tesla Model S battery pack.

Figure 1: 18650 Lithium-Ion NCA Battery Cell

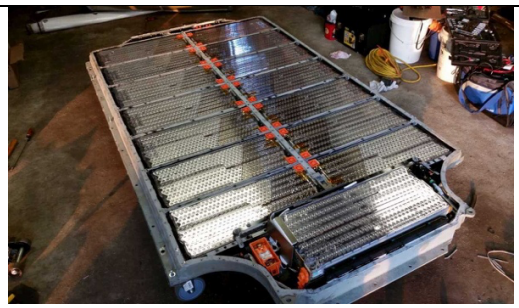

Figure 2: 18650 cells being used in a Tesla Model S 100 kWh battery pack [2]

The measurements contained within this dataset involved cycling a 18650-battery cell from 0-100% discharge at a constant current of 0.5 cell capacity = (3.4 Ah * 0.5 = 1.6 A), and at a constant temperature of 23°C while recording the following parameters:

- Min and max current (A)
- Min and max voltage (V_{DC})
- Charge and discharge capacity (Ah)
- Charge and discharge energy (Wh)

Tests like these are useful for assessing the expected lifetime of batteries when subjected to different environments, as well as for assessing their safety profiles.

The larger dataset [1] contains 20 other tests measuring at different levels of current, temperature, and rates of discharge, however in the assignment folder you will find a reduced version of the original dataset (**dataset.txt**) showing only the results from the following columns:

Column 1: Test number	Column 2: Battery Charge Capacity (units: Ah)	Column 3: Battery Energy Capacity (units: Wh)

The reduced dataset is formatted in CSV format (comma separated variable) and contains a total of **319 results**.

TASKS

Requirements

Your task is to write a C program that will perform a statistical analysis of the **first 100** results from the dataset and then output your findings onto the terminal in a pre-specified format (see below).

The dataset is stored in a file named "Dataset.txt" and is structured as follows:

```
ID,Charge,Energy
1,3.24,56.8
2,6.72,54.2
3,1.99,50.3
...
```

Figure 3 – Dataset format (3 column CSV)

Where:
- ID is an integer which lists the test number (1,2,3,4…)
- Charge is a floating-point value holding each measurement of charge (Ah)
- Energy is a floating-point value holding each measurement of energy (Wh)

Your program should perform the following tasks:

1. Read the CSV data from the .txt file and store the test ID, charge, and energy values in an appropriate data structure (e.g., into arrays). Your file-read functions should return a status code indicating the file was read successfully and handle any errors if the file was not read correctly.

2. Calculate the mean, sample standard deviation, minimum, and maximum values for the 100 charge and energy readings.

3. Output your results to the console in a formatted table (see below).

Output format

The output from your program should be printed onto the terminal as a 3-column table which exactly follows the layout shown below in Figure 4.

```
| 1234|  Charge |  Energy |
|-----|---------|---------|
| Mean|    3.24 |   56.80 |
| Sdev|    1.91 |    2.84 |
| Min |    0.00 |   50.30 |
| Max |   10.18 |   62.60 |
```

Figure 4 – Output format (3 column table with last 4 digits of student ID in cell 0,0)

Note - Each calculation should be printed to 2 decimal places.

Note - The last 4 digits of your student ID should be printed in column 0, row 0 (as shown here as 1234).

Note - Colours are not required.

Submission details

Your program should be implemented in a single file named **main.c**.

You may assume that the input file "Dataset.txt" is located in the same directory as the program executable.

Your program should include a comment block at the top of your main file (maximum half of 1-page A4) detailing your design choices/program functionality, and any learning reflections you have about completing the exercise.

MARK SCHEME

Criteria	Marks available	Notes
Correctness	40	The program reads the files correctly. The program calculates the statistical measures correctly. The program outputs are correctly formatted onto the terminal.
Design	20	The program uses functions appropriately Error handling is used appropriately Variables and data structures are used appropriately
Documentation	15	Program flow is well commented Comments are logical and easy to understand Functions are well commented Program has a readme guide at the top of the file which describes your design choices and reflections
Style	15	Program flow is logical and easy to understand The code is well formatted and indented Variable names are logical and easy to follow
Bonus	10	The program uses some advanced C design techniques such as pointers or dynamic memory allocation etc in an intelligent/sensible manner.
Total	**100**	

REFERENCES

1 Juarez-Robles, D., Jeevarajan, J.A., Mukherjee, P.P.: "Degradation-Safety Analytics in Lithium-Ion Cells: Part I. Aging under Charge/Discharge Cycling"*Journal of The Electrochemical Society*, 2020, **167**, (16), p. 160510.

2 Tim Dillard: "Rare Look Inside A Tesla Model S Battery Pack," https://insideevs.com/news/323682/rare-look-inside-a-tesla-model-s-battery-pack/, accessed May 2022

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Issue 1.1
20/03/2023