COMP60711 - DATA ENGINEERING

Coursework Description

Marking Scheme and Model Answers

Coursework Description

1. Data Description

Each student has access to two traffic data files in csv format, **'rawpvr_2018-02-01_28d_1083 TueFri.csv'** and '**rawpvr_2018-02-01_28d_1415 TueFri.csv**'. Each file contains observations collected via Inductive Loops sensors planted on a particular site of Chester Road in the city of Manchester. For example, file **'rawpvr_2018-02-01_28d_1083 TueFri.csv'** contains observations collected from site 1083, while file '**rawpvr_2018-02-01_28d_1415 TueFri.csv**' contains observations collected from site 1415. The observations were collected on all Tuesdays and Fridays of the month of February 2018. Note that each row of the file contains one observation, i.e., the properties associated with one detected vehicle. As a consequence, if you count the total number of records with the following timestamp (06/02/2018), you are able to estimate the total volume of traffic on the 6th of February.

Both data files present the same structure, composed of the following attributes or properties:

- ***Date*** is a timestamp containing day of the month and year and time of the day when a vehicle was detected, with the following format: dd/mm/yyyy HH:MM:SS.
- ***Lane*** is an identifier of a given lane of the road (a road may have multiple lanes and each lane has a unique identifier).
- ***Lane Name*** is the name given to a particular lane of the road. Each lane has a unique name.
- ***Direction*** identifies the direction followed by a road lane (e.g., North, South, etc.). Different lanes may follow the same direction.
- ***Direction Name*** is the name of the direction followed by a lane of the road.
- ***Speed (mph)*** is the speed with which the detected vehicle was moving at the time it was detected.
- ***Headway (s)*** is the time distance between two consecutive vehicles following the same route. More precisely, it is the time distance between the front bumper of one vehicle and the front bumper of the vehicle behind it.
- ***Gap (s)*** is also a time distance between two consecutive vehicles following the same route, but it indicates the time distance between the rear bumper of one vehicle and the front bumper of the vehicle behind it.
- ***Flags*** is a number that identifies the day of the week when a vehicle was detected.
- ***Flag Text*** is the text description of the day of the week when a vehicle was detected.

2. When Developing the Coursework

The coursework is composed of a list of tasks, divided into three sub-lists, as follows:

Sub-list 1: This is the first sub-list and contains a single task, which does not carry any marks, and so, it is NOT MANDATORY. However, you are free to develop it and submit it as a single PDF file.
The main aim of this task is to allow each student to become familiar with the dataset, use case and at least one data preparation tool AND one Programming Language (PL) of his/her choice. We suggest a few tools and a couple of PLs for the student to choose, most of which are available from the Department's machines and can be remotely accessed from the comfort of the student's home, for his/her convenience. Please, refer to Section 5 to see the list of suggested Data Preparation tools and PLs. However, we are aware there are other tools and PLs a student might want to use, and s/he is free to do it. Note that, for this task, we ask each student to develop two versions of the same solution: one solution developed using a PL, and the second solution, developed using a tool. The deadline for the completion of this task is the end of the second week of the course unit. More specifically, **one hour before** the timetabled **lecture-related** Q&A activity of the following week (Week 2 of the course).

Sub-list 2: This is the second sub-list of tasks and contains three tasks. This sub-list of tasks carries 100 marks and the deadline for its submission is the end of the third week of the course unit. More specifically, **one hour before** the timetabled **lecture-related** Q&A activity of the following week (Week 3) of the course unit. A more detailed description of this task has been made available to you in a separate document.

Sub-list 3: This is the third sub-list of tasks and contains three tasks. This sub-list of tasks carries 100 marks and the deadline for its submission is the end of the fourth week of the course unit. More specifically, **one hour before** the timetabled **lecture-related** Q&A activity of the following week (Week 4) of the course unit. A more detailed description of this is provided later in this document.

When developing the coursework, each student should do the following:

1. Use file '**rawpvr_2018-02-01_28d_1083 TueFri.csv**' for all tasks, unless they are explicitly told in the task to use both files, **'rawpvr_2018-02-01_28d_1083 TueFri.csv'** and '**rawpvr_2018-02-01_28d_1415 TueFri.csv**'.
2. Ideally, aim to choose one Graphical User Interface (GUI) based tool and one Programming Language (PL) to perform all tasks. So, once the tool and PL are chosen, the same tool and PL should be used to perform each of the tasks. The recommended PLs are the following: Python and R; and the recommended GUI-based tools are the following: Knime, OpenRefine, Talend and Microsoft Excel. All of these are available from the machines in the M.Sc. lab (with the exception of Knime), but all can be easily installed on your personal computer.
3. Use the tool/PL you are most familiar with, to avoid steep learning curves.
4. Each week, each student should submit one pdf file containing the solution to the task(s) of the previous week.

3. Each Week's Tasks

Week 1 Task Sub-list 1

Deadline: End of the second week of the course (end of Week 2).
This is a "warm up" task, therefore, there is no lab, discussion or drop in sessions associated with it, and it should be developed during Week 1 and the part of Week 2, before Week 2's lecture-related timetabled activity (the morning Q&A session). Since it does not incur marks, it is not a mandatory task, but, if you decided to submit it, then you will receive some rubric-based feedback. It is, however an important task, because it allows each student to familiarise him/herself with the data, languages/tools enabling the student to choose his/her preferred languages/tools.

Task 1: (no marks)

Week 2 Tasks Sub-list 2
Three tasks to be developed during the course of Week 2, carrying 100 marks.
Deadline: **one hour before** the timetabled **lecture-related** Q&A activity of the following week (Week 3) of the course unit.

Task 2 (30 marks)
Task 3 (35 marks)
Task 4 (35 marks)

Week 3 Tasks Sub-list 3
Three tasks to be developed during the course of Week 3, carrying 100 marks.
Deadline: **one hour before** the timetabled **lecture-related** Q&A activity of the following week (Week 4) of the course unit.

Task 5 (30 marks)
Task 6 (35 marks)
Task 7 (35 marks)

4. Tasks Description

Week3	
Task5	This task is divided into two sub-tasks, described as follows: ***Task 5.1:*** Using a ***Column Completeness*** approach, apply the formula below to **(i)** make a data quality assessment of the level of completeness of the 'Gap (s)' column *considering only Tuesdays between 7:00 and 19:00*, and to **(ii)** make an assessment of the level of completeness of the 'Headway (s)' column *considering only Tuesdays between 7:00 and 19:00*. **Column_Completeness = (number_of_non-empty_cells x 100) / number_of_cells** ***Task 5.2:*** Fill the missing values of columns 'Gap (s)' and 'Headway (s)' for all records associated with the NB_MID lane (North direction), considering any Tuesday between 7:00 and 19:00 for which values for one or both of these columns are missing. To fill the missing values, you should use the *median* calculated for the particular hour of the day when the missing value occurs, as replacement value. For example, if missing values are found on Tuesday 06/02/2018 - 10:00 and Tuesday 20/02/2018 - 15:00, then you should calculate the median of gap (or headway)

	considering all Tuesdays at 10:00 and all Tuesdays at 15:00 to obtain two values, *median_at_10:00_allTuesdays* and *median_at_15:00_allTuesdays*. These are to be used as replacement values. To calculate these values, you can do the following: • sort the values (gap or headway) inside each time interval, e.g. from 10:00 to 11:00; and • get the value in the middle. If there are two values in the middle, then take the average of both. **Output**: Task 5.1: Two numerical values, one for each of the two columns. Task 5.2: X numerical values (X depends on the number of missing values and associated day times) representing medians of the Gap and Headway columns for all Tuesdays between 7:00 and 19:00. A screenshot of the updated dataset should be included as well. Provide a step-by-step description of the development of the task, emphasising the features of each of the tools/languages that you used. In other words, **make sure you include (1)** screenshots of intermediate steps you had to carry out while using the technology you chose to use to develop the task (especially where no coding was necessary), **(2)** the final recipe/result, **(3)** an explanation of each step, and **(4)** an interpretation of the results. For this task, you should develop one solution, using the technology (tool or PL) of your choice. **Marking scheme:** Task 5.1: 1 mark for correct column completeness assessments (0.5 mark for each assessment). Task 5.2: 9 marks for correct median results and screenshot (6 marks for results and 3 marks for the screenshot). 20 marks for a clear, correct and complete step-by-step description, which should include not only the complete code you wrote to prepare the data from its original form to the point the analysis was made, but also an explanation of each step in text and your interpretation of the obtained results/analysis.
Task6	Estimate the typical Friday journey time for the road fragment between site 1083 and site 1415, between 17:00 and 18:00, using only the North direction lanes. To make this estimation, you first need to find the average speed at 17:00 on Fridays for the relevant lanes and divide this by the distance between the two sites, which is 4.86km. Multiply the result by 60 to get the result in minutes. To calculate the average speed between 17:00 and 18:00 of the all north lanes, consider not only the three average speeds associated with the three North lanes found on site 1083, but also the two average speeds of the two North lanes found on site 1415 (**use file rawpvr_2018-02-01_28d_1415_TueFri.csv for that**), since these can be quite different. For example, if the values you found are {15837, 14777, 18000, 13222, 14995}, then take the average of these values. **Output**: A value in minutes for the JT. Provide a step-by-step description of the development of the task, emphasising the features the tool/language you used. In other words, **make sure you include (1)** screenshots of intermediate steps you had to carry out while using the technology you chose to use to develop the task (especially where no coding was necessary), **(2)** the final recipe/result, **(3)** an explanation of each step, and **(4)** an interpretation of the results. **Marking scheme:** 5 marks for correct result. 30 marks for a clear, correct and complete step-by-step description, which should include not only the complete code you wrote to prepare the data from its original

	form to the point the analysis was made, but also an explanation of each step in text and your interpretation of the obtained results/analysis.
Task7	This task is divided into two sub-tasks, described as follows: ***Task 7.1:*** Extend **Task 5.1 of Task 5**, by **(i)** suggesting a ***Row Completeness*** formula to measure row completeness (rather than column completeness) – you can search for a row completeness formula in the Data Quality literature; **(ii)** making an assessment of the level of row completeness *considering rows associate with Tuesdays between 7:00 and 19:00,* and **(iii)** discussing what completeness is and whether you believe this formula represents a better way to measure the completeness of the traffic data file at hand, comparing it with the Column Completeness formula given to you in the description of Task 5.1, and the column completeness assessment you made for Task 5.1. ***Task 7.2:*** Develop the same solution for **Task 6** described above using a second technology of your choice (a tool or PL), which should be different to the technology you used to develop **Task 6** for the first time. You can copy and paste here and/or make simple adaptations to the comments and step-by-step description of the solution you provided for Task 6. Considering **Task 6**, described above, and the two technologies you have used to develop **Task 6**, compare the two technologies, discussing advantages and disadvantages of each for **Task 6** specifically, taking into account not only any extra work (manual or not) you had to do for absence of facilities, or limitations of existing facilities associated with the given technology, but also the time it took for you to perform a particular action. **Marking scheme:** 17 marks for Task 7.1 - assessment of completeness (2 marks for the row completeness formula, 1 marks for the row completeness formula application, and 8 marks for the discussion). 18 marks for Task 7.2 – for the second solution and a clear and complete assessment of the two technologies you used to develop the task, which should include **similarities, differences, advantages and limitations, relating each of these to the task** you have performed using the technology, but also a comparison between the two where they are contrasted.

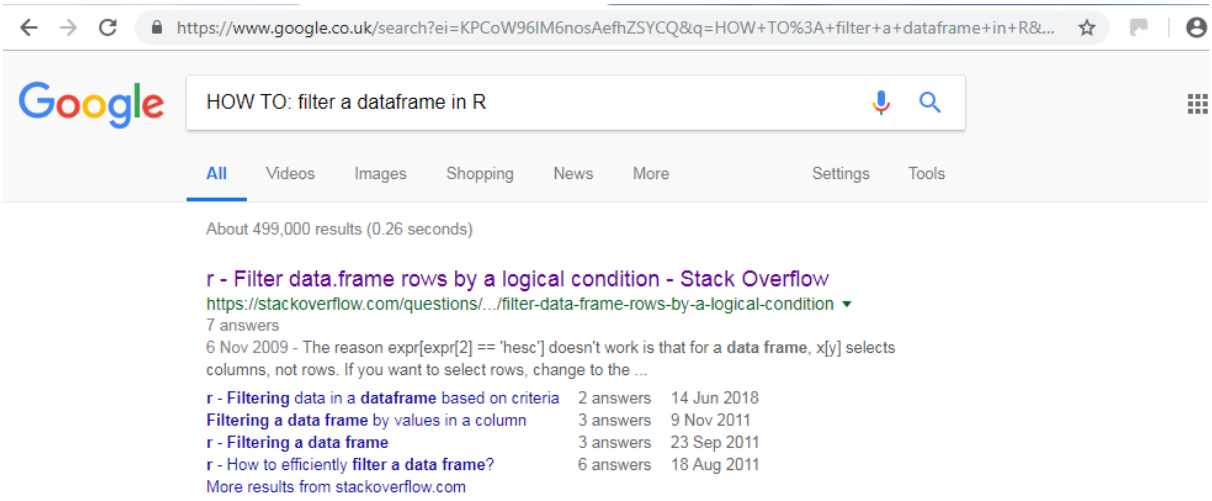
Note: When using a GUI-based tool, **make sure you include (1)** screenshots of intermediate steps you had to carry out while using the tool to complete a task (especially where no coding was necessary), **(2)** the final recipe/result, **(3)** an explanation of each step and **(4)** an interpretation of the results.

5. Further Advice

The following list contains the PLs and Data Manipulation/Preparation tools that we suggest you use in the development of your coursework: *R, Python, Knime, Excel, OpenRefine and Talend Data Preparation*.

All of these are of easy access and free installation. You can have remote access to them (with the exception of Knime) by connecting to the machines in the Department, or you can just download and install them in your machine (all of them). Note that if you have a Windows machine, Excel will already be in your machine.

If you are not familiar with any of the programming languages and/or tools, then you can search for commands in the Web, as shown below:



If using Python, for example, you will be interested in using commands from packages such as *pandas*, *numpy*, *datetime*, *os* and *calendar*, to handle *Date* related data types. If using R, will be interested in using commands from packages such as *lubridate*, *plyr* and *dplyr*.

General tutorials for each of these can be found from the following links:

- **R**
  An Introduction to R (https://cran.r-project.org/doc/manuals/R-intro.pdf)

- **Knime (https://www.knime.com/downloads/download-knime)**
  Documentation: (https://docs.knime.com/)
  Tutorials: (https://www.youtube.com/watch?v=HEp9Cbql2hs, https://www.youtube.com/watch?v=5WAyOiIfHPg)

- **Talend Data preparation** (you get the free trial software from: (https://www.talend.com/products/data-preparation/?utm_medium=bloglink&utm_source=bloglink&utm_campaign=datapreppage&utm_content=dataprep))
  Introduction to Talend Data Preparation (video) (https://www.youtube.com/watch?v=HmjrnRvJqKU ; https://www.youtube.com/watch?v=lE7P2qG3dB0 ; https://www.youtube.com/watch?v=AAPf3cWoOYk)
  Data Prep 101: Getting Started with Talend Data Preparation (https://www.talend.com/blog/2016/02/10/data-prep-101-getting-started-with-talend-data-preparation/)
  Etc.

- **Excel**
  Excel Tutorials:
  (https://digital.com/excel-tutorials/),
  (https://edu.gcfglobal.org/en/excel2016/),
  (https://trumpexcel.com/learn-excel/)
  Etc.

- **OpenRefine** (https://openrefine.org/download.html)
  (https://www.youtube.com/watch?v=WCRexQXYFrI),
  (https://www.youtube.com/watch?v=wGVtycv3SS0),
  (https://www.youtube.com/watch?v=wfS1qTKFQoI)