

CS 4210 – Assignment #5

**Maximum Points: 100 pts.**



Bronco ID: | | | | | | | | | | Last Name: First Name:

**Note 1:** Your submission header must have the format as shown in the above-enclosed rounded rectangle.

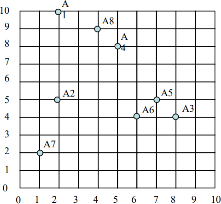
**Note 2:** Homework is to be done individually. You may discuss the homework problems with your fellow students, but you are NOT allowed to copy – either in part or in whole – anyone else’s answers.

**Note 3:** Your deliverable should be a .pdf file submitted through Gradescope until the deadline. Do not forget to assign a page to each of your answers when making a submission. In addition, source code (.py files) should be added to an online repository (e.g., github) to be downloaded and executed later.

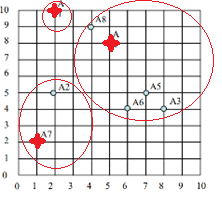
**Note 4:** All submitted materials must be legible. Figures/diagrams must have good quality.

**Note 5:** Please use and check the Canvas discussion for further instructions, questions, answers, and hints. The bold words/sentences provide information for a complete or accurate answer.

1. [25 points] By considering the following 8 2D data points below do:
   1. [20 points] Group the points into 3 clusters by using k-means algorithm with Euclidean distance. Show the intermediate clusters (**by drawing ellipses on this 2D space**) and centroids (**by drawing marks like X on this 2D**) in each iteration until convergence. Also, **fill the solution table** below to show the distances from data points to the current centroids and the new centroids found. Consider the initial centroids as: C1 = A1, C2 = A4, and C3 = A7.



|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1st iteration | | | | | | | | |
| Centroid: (C1, C2, C3) | | | | | | | | |
| Instance | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
| C1 dist. | 0 | 5 |  |  |  |  |  |  |
| C2 dist. |  |  | 5 | 0 |  |  |  |  |
| C3 dist. |  |  |  |  |  |  | 0 |  |
| Cluster Assigned | C1 | C3 | C2 | C2 | C2 | C2 | C3 | C2 |



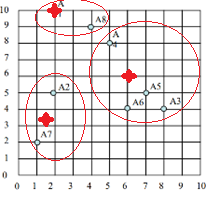
2nd iteration centroid:

C1 = (2, 10)

C2 = (6, 6)

C3 = (1.5, 3.5)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2nd iteration | | | | | | | | |
| Centroid: (C1, C2, C3) | | | | | | | | |
| Instance | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
| C1 dist. | 0 | 5 |  |  |  |  |  |  |
| C2 dist. |  |  |  |  |  | 2 |  |  |
| C3 dist. |  |  |  |  |  |  |  |  |
| Cluster Assigned | C1 | C3 | C2 | C2 | C2 | C2 | C3 | C1 |



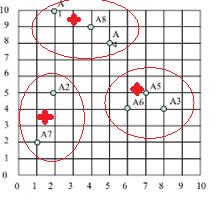
3rd iteration centroid:

C1 = (3, 9.5)

C2 = (6.5, 5.25)

C3 = (1.5, 3.5)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 3rd iteration | | | | | | | | |
| Centroid: (C1, C2, C3) | | | | | | | | |
| Instance | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
| C1 dist. |  |  |  |  |  |  |  |  |
| C2 dist. |  |  |  |  |  |  |  |  |
| C3 dist. |  |  |  |  |  |  |  |  |
| Cluster Assigned | C1 | C3 | C2 | C1 | C2 | C2 | C3 | C1 |



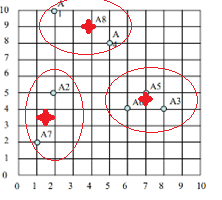
4th iteration centroid:

C1 = (3.665, 9)

C2 = (7, 4.333)

C3 = (1.5, 3.5)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4th iteration | | | | | | | | |
| Centroid: (C1, C2, C3) | | | | | | | | |
| Instance | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
| C1 dist. |  |  |  |  |  |  |  |  |
| C2 dist. |  |  |  |  |  |  |  |  |
| C3 dist. |  |  |  |  |  |  |  |  |
| Cluster Assigned | C1 | C3 | C2 | C1 | C2 | C2 | C3 | C1 |



Centroids do not change! Convergence reached!

* 1. [5 points] Calculate the SSE (Sum of Square Errors) of the final clustering.

SSE = 14.33

1. [15 points] Complete the Python program (clustering.py) that will read the file training\_data.csv to cluster the data. Your goal is to run k-means multiple times and check which k value maximizes the Silhouette coefficient. You also need to plot the values of k and their corresponding Silhouette coefficients so that we can visualize and confirm the best k value found. Next, you will calculate and print the Homogeneity score (the formula of this evaluation metric is provided in the template) of this best k clustering task by using the testing\_data.csv, which is a file that includes ground truth data (classes).
2. [20 points] The dataset below presents the user ratings on a 1-3 scale for 6 different rock bands.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Bon Jovi | Metallica | Scorpions | AC/DC | Kiss | Guns n’ Roses |
| Fred | 1 | 3 | - | 3 | 1 | 3 |
| Lillian | 3 | - | 2 | 2 | 3 | 1 |
| Cathy | 2 | 2 | 2 | 3 | - | 2 |
| John | 3 | 2 | 2 | 2 | ? | ? |

* 1. [10 points] Apply **user-based** collaborative filtering on the dataset to decide about recommending the bands Kiss and Guns n’ Roses to John. You should make a recommendation when the predicted rating is greater than or equal to 2.0. Use cosine similarity, a neutral value (1.5) for missing values, and the top 2 similar neighbors to build your model.

**Kiss**

Fred = (1, 3, 1.5, 3, 3)

Lillian = (3, 1.5, 2, 2, 1)

Cathy = (2, 2, 2, 3, 2)

*John = (3, 2, 2, 2, 1.5)*

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cos(Fred, John) = 0.848415

cos(Lillian, John) = 0.990865

cos(Cathy, John) = 0.953996

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Choose Lillian and Cathy

Kiss is recommended

**Guns n’ Roses**

Fred = (1, 3, 1.5, 3, 1)

Lillian = (3, 1.5, 2, 2, 3)

Cathy = (2, 2, 2, 3, 1.5)

*John = (3, 2, 2, 2, 1.5)*

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cos(Fred, John) = 0.857350

cos(Lillian, John) = 0.955972

cos(Cathy, John) = 0.956989

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Choose Lillian and Cathy

Guns n’ Roses is not recommended

* 1. [10 points] Now, apply **item-based** collaborative filtering to make the same decision. Use the same parameters defined before to build your model.

Guns n’ Roses = (3, 1, 2)

Kiss = (1, 3, 1.5)

AC/DC = (3, 2, 3)

Scorpions = (1.5, 2, 2)

Metallica = (3, 1.5, 2)

Bon Jovi = (1, 3, 2)

**Kiss**

cos(Kiss, Guns n’ Roses) = 0.687243

cos(Kiss, AC/DC) = 0.822346

cos(Kiss, Scorpions) = 0.937043

cos(Kiss, Metallica) = 0.768221

cos(Kiss, Bon Jovi) = 0.992685

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Choose Bon Jovi and Scorpions

Kiss is recommended

**Guns n’ Roses**

cos(Guns n’ Roses, Kiss) = 0.687243

cos(Guns n’ Roses, AC/DC) = 0.968665

cos(Guns n’ Roses, Scorpions) = 0.876523

cos(Guns n’ Roses, Metallica) = 0.99236

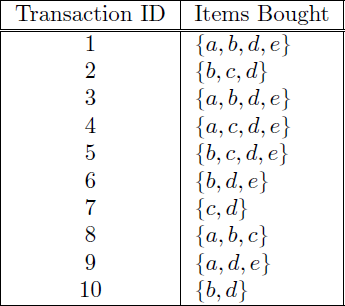
cos(Guns n’ Roses, Bon Jovi) = 0.714286

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Choose AC/DC and Metallica

Guns n’ Roses is not recommended

1. [25 points] Consider the following transaction dataset.



Suppose that minimum support is set to 30% (*minsup*) and minimum confidence is set to 60%.

* 1. [5 points] Rank all frequent itemsets according to their support (list their support values).

1. {d} 9/10
2. {b} 7/10
3. {e} 6/10
4. {b, d} 6/10
5. {d, e} 6/10
6. {a} 5/10
7. {c} 5/10
8. {a, d} 4/10
9. {a, e} 4/10
10. {b, e} 4/10
11. {c, d} 4/10
12. {a, d, e} 4/10
13. {b, d, e} 4/10
14. {a, b} 3/10
15. {b, c} 3/10
    1. [5 points] For all frequent 3-itemsets, rank all association rules - according to their confidence values - which satisfy the requirements on minimum support and minimum confidence (list their confidence values).
    2. [5 points] Show how the 3-itemsets candidates can be generated by the 𝐹𝑘−1 X 𝐹𝑘−1 method and if these candidates will be pruned or not.

K-1 frequent sets (in lexical order):

{a, b}

{a, d}

{a, e}

{b, c}

{b, d}

{b, e}

{c, d}

{d, e}

Merge({a, b}, {a, d}) = {a, b, d}

Merge({a, b}, {a, e}) = {a, b, e}

Merge({a, d}, {a, e}) = {a, d, e}

Merge({b, c}, {b, d}) = {b, c, d}

Merge({b, c}, {b, e}) = {b, c, e}

Merge({b, d}. {b, e}) = {b, d, e}

Prune {b, c, e} because {c, e} is infrequent

We are left with:

{a, b, d}

{a, b, e}

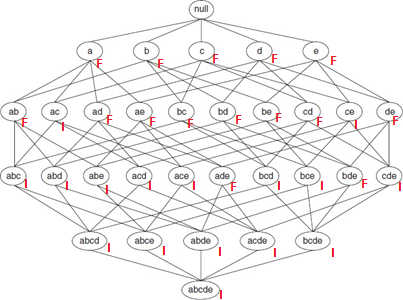
{a, d, e}

{b, c, d}

{b, d, e}

* 1. [10 points] Consider the lattice structure given below. Label each node with the following letter(s):

*F* if it is frequent and *I* if it is infrequent.



1. [15 points] Complete the Python program (association\_rule\_mining.py) that will read the file retail\_dataset.csv to find strong rules related to supermarket products. You will need to install a python library this time. Just use your terminal to type: pip install mlxtend. Your goal is to output the rules that satisfy *minsup* = 0.2 and *minconf* = 0.6, as well as the priors and probability gains of the rule consequents when conditioned to the antecedents. The formulas for this math are given in the template.

GitHub link: <https://github.com/meap02/Assignment-5_CS4210-Machine-Learning-and-its-Applications>

**Important Note:** Answers to all questions should be written clearly, concisely, and unmistakably delineated. You may resubmit multiple times until the deadline (the last submission will be considered).

**NO LATE ASSIGNMENTS WILL BE ACCEPTED. ALWAYS SUBMIT WHATEVER YOU HAVE COMPLETED FOR PARTIAL CREDIT BEFORE THE DEADLINE!**