Project 1 Apriori Algorithm Implementation Report

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Abstract. This project includes the implementation of Apriori algorithm. Apriori algorithms is widely used in database systems to infer useful rules out of transactions. In this project, we illustrate on the implementation details and also demonstrate our experiment results. **Our team made two different original implementations for the Apriori algorithm, as can be seen on our team's Github page: https://github.com/xuanyudo/Pca_Apriori-Algorithm.**

1 Model Description

1.1 Apriori Algorithm

The Apriori algorithm mines the association rules out of a frequent set given a set of transactions. The algorithm contains two steps: (1) generate a set of frequent items which exceeds the required support threshold, and (2) generate rules based on the frequent item sets which satisfies the confidence threshold. Direct computation of the frequent item sets and rules is infeasible given the exponential nature of the possible combinations, and further improvements including pruning technique to reduce the number of candidates, vertical based mining algorithms to reduce the number of transactions, and efficient data structures (hash tables) to reduce the number of comparisons is introduced in the field.

2 Model Implementation

2.1 Implementation of Apriori Algorithm

Generate frequent data set total_number_of_patient: 100
number_of_gene: 100 + 1 disease
support: 30%, 40%, 50%, 60%, 70%
constraint: $|set\_sequence|/total\_number\_of\_patient > support$

```
Class:
Node{
cols: collum_index array
```

```
sample: gene_sequence array
rows: all patient with same sequence index array
}
```

Algorithm Breadth First Search

(1) initialize queue with all nodes with length of 1

(2) count the number of distinct gene behavior (up or down) for each of the patient

(3) if the number of specific gene behavior satisfy the constraint, we push it into the queue and store the node into our length_1 list.

(4) now we can start our next level iteration, keep popping out the first element from the queue and iterating through the candidates and check for constraint satisfaction. Then we repeat step 3 if satisfied which push it to the queue and store node to level_n list where n is lengths of frequent itemsets.

outcome: A array of array with length $n \times max\_length\_frequent\_data\_set$.

Result: we can use this array to obtain the number of each length frequent itemset.

Generate Rule total_number_of_patient: 100
number_of_gene: 100 + 1 disease
support: 50%
confidence: 70%
constraint: $|partial\_set\_sequence|/|total\_set\_sequence$

```
Class:
Rule{
head: head element
body: body element
node: node of rule
}
```

Algorithm Breadth First Search

(1) initialize queue with default rule of all frequent nodes which all genes are located in body array.

(2) keep popping out the first element from the queue and iterating through the body and push body element into head, and check for constraint satisfaction of this rule. if rule behavior satisfy the constraint, we push it into the queue and store the rule into array.

(3) repeat step 2 until queue empty

outcome A array of rule

Result we can use array to search for all rule that satisfy the template requirement O(n)

3 Experiment Result

3.1 Result on Apriori Algorithm

Based on our implementation of Apriori algorithm as described in the previous section, the number of frequent item set with respect to different itemset length and different support threshold is summarized in Table 1. We can see the number of frequent item set decreases as support threshold increases. When support threshold is small such as 0.2 or 0.3, as length of itemset increases, the number first increases and then decreases, which is the tradeoff between the number of combinations and the appearance of the itemset in the transactions. With support level being 30%, the number of all lengths frequent itemset is 12,879. With support level being 40%, the number of all lengths frequent itemset is 1,077. With support level being 50%, the number of all lengths frequent itemset is 174. With support level being 60%, the number of all lengths frequent itemset is 36. With support level being 70%, the number of all lengths frequent itemset is 7. The total number of item set with respect to different support level is also summarized in Table 2. Please see our github page at https://github.com/xuanyudo/Pca˙Apriori-Algorithm for the set generated.

Table 1: The number of frequent item set with respect to different itemset length and different support threshold, we can see the number of frequent item set decreases as support threshold increases.

Support Set Length	0.2	0.3	0.4	0.5	0.6	0.7
1	202	196	167	109	34	7
2	15,014	5,340	753	63	2	0
3	125,664	5,287	149	2	0	0
4	119,945	1,518	7	0	0	0
5	56,408	438	1	0	0	0
6	28,894	88	0	0	0	0
7	15,710	11	0	0	0	0
8	8,049	1	0	0	0	0
9	3,557	0	0	0	0	0
10	1,210	0	0	0	0	0
11	289	0	0	0	0	0
12	43	0	0	0	0	0
13	3	0	0	0	0	0
14	0	0	0	0	0	0

The result of part 2 rule generation is attached below:

Table 2: The total number of frequent item set with respect to different support threshold

Support Level	0.2	0.3	0.4	0.5	0.6	0.7
Total No. of Frequent Set	374,988	12,879	1,077	174	36	7

```
Template1:

(result11, cnt) = asso_rule.template1("RULE", "ANY", ['G59_UP'])
(result12, cnt) = asso_rule.template1("RULE", "NONE", ['G59_UP'])
(result13, cnt) = asso_rule.template1("RULE", 1, ['G59_UP', 'G10_Down'])
(result14, cnt) = asso_rule.template1("HEAD", "ANY", ['G59_UP'])
(result15, cnt) = asso_rule.template1("HEAD", "NONE", ['G59_UP'])
(result16, cnt) = asso_rule.template1("HEAD", 1, ['G59_UP', 'G10_Down'])
(result17, cnt) = asso_rule.template1("BODY", "ANY", ['G59_UP'])
(result18, cnt) = asso_rule.template1("BODY", "NONE", ['G59_UP'])
(result19, cnt) = asso_rule.template1("BODY", 1, ['G59_UP', 'G10_Down'])

Template2:
(result21, cnt) = asso_rule.template2("RULE", 3)
(result22, cnt) = asso_rule.template2("HEAD", 2)
(result23, cnt) = asso_rule.template2("BODY", 1)

Template3:
(result31, cnt) = asso_rule.template3("1or1", "HEAD", "ANY", ['G10_Down'], "BODY", 1, ['G59_
(result32, cnt) = asso_rule.template3("1and1", "HEAD", "ANY", ['G10_Down'], "BODY", 1, ['G5
(result33, cnt) = asso_rule.template3("1or2", "HEAD", "ANY", ['G10_Down'], "BODY", 2)
(result34, cnt) = asso_rule.template3("1and2", "HEAD", "ANY", ['G10_Down'], "BODY", 2)
(result35, cnt) = asso_rule.template3("2or2", "HEAD", 1, "BODY", 2)
(result36, cnt) = asso_rule.template3("2and2", "HEAD", 1, "BODY", 2)


result11:
count: 26
{'G59_Up'}   {'G32_Down'}
{'G59_Up'}   {'G1_Up'}
{'G59_Up'}   {'G72_Up', 'G96_Down'}
{'G82_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up', 'G59_Up'}   {'G82_Down'}
{'G72_Up'}   {'G59_Up', 'G96_Down'}
{'G96_Down'}   {'G59_Up'}
{'G59_Up'}   {'G96_Down'}
{'G59_Up'}   {'G72_Up'}
```

```
{'G72_Up'}   {'G59_Up'}
{'G59_Up'}   {'G13_Down'}
{'G13_Down'}   {'G59_Up'}
{'G82_Down'}   {'G59_Up'}
{'G59_Up'}   {'G82_Down'}
{'G82_Down', 'G59_Up'}   {'G72_Up'}
{'G72_Up'}   {'G82_Down', 'G59_Up'}
{'G88_Down'}   {'G59_Up'}
{'G59_Up'}   {'G88_Down'}
{'G59_Up'}   {'G82_Down', 'G72_Up'}
{'G59_Up'}   {'G10_Down'}
{'G59_Up'}   {'G6_Up'}
{'G59_Up'}   {'G38_Down'}
{'G59_Up'}   {'G28_Down'}
{'G72_Up', 'G59_Up'}   {'G96_Down'}
{'G96_Down'}   {'G72_Up', 'G59_Up'}
{'G59_Up'}   {'G87_Up'}
result12:
count: 0
result13:
count: 26
{'G59_Up'}   {'G32_Down'}
{'G59_Up'}   {'G1_Up'}
{'G59_Up'}   {'G72_Up', 'G96_Down'}
{'G82_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up', 'G59_Up'}   {'G82_Down'}
{'G72_Up'}   {'G59_Up', 'G96_Down'}
{'G96_Down'}   {'G59_Up'}
{'G59_Up'}   {'G96_Down'}
{'G59_Up'}   {'G72_Up'}
{'G72_Up'}   {'G59_Up'}
{'G59_Up'}   {'G13_Down'}
{'G13_Down'}   {'G59_Up'}
{'G82_Down'}   {'G59_Up'}
{'G59_Up'}   {'G82_Down'}
{'G82_Down', 'G59_Up'}   {'G72_Up'}
{'G72_Up'}   {'G82_Down', 'G59_Up'}
{'G88_Down'}   {'G59_Up'}
{'G59_Up'}   {'G88_Down'}
{'G59_Up'}   {'G82_Down', 'G72_Up'}
{'G59_Up'}   {'G10_Down'}
{'G59_Up'}   {'G6_Up'}
{'G59_Up'}   {'G38_Down'}
{'G59_Up'}   {'G28_Down'}
{'G72_Up', 'G59_Up'}   {'G96_Down'}
```

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{'G96_Down'}   {'G72_Up', 'G59_Up'}
{'G59_Up'}   {'G87_Up'}
result14:
count: 9
{'G72_Up'}   {'G59_Up'}
{'G13_Down'}   {'G59_Up'}
{'G82_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up'}   {'G59_Up', 'G96_Down'}
{'G96_Down'}   {'G72_Up', 'G59_Up'}
{'G82_Down'}   {'G59_Up'}
{'G72_Up'}   {'G82_Down', 'G59_Up'}
{'G88_Down'}   {'G59_Up'}
{'G96_Down'}   {'G59_Up'}
result15:
count: 0
result16:
count: 17
{'G72_Up'}   {'G59_Up'}
{'G1_Up'}   {'G10_Down'}
{'G13_Down'}   {'G59_Up'}
{'G70_Down'}   {'G10_Down'}
{'G82_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up'}   {'G59_Up', 'G96_Down'}
{'G28_Down'}   {'G10_Down'}
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{'G88_Down'}   {'G10_Down'}
{'G88_Down'}   {'G59_Up'}
{'G96_Down'}   {'G59_Up'}
{'G94_Up'}   {'G10_Down'}
{'G38_Down'}   {'G10_Down'}
{'G59_Up'}   {'G10_Down'}
result17:
count: 17
{'G59_Up'}   {'G72_Up'}
{'G59_Up'}   {'G32_Down'}
{'G59_Up'}   {'G1_Up'}
{'G59_Up'}   {'G13_Down'}
{'G59_Up'}   {'G72_Up', 'G96_Down'}
{'G72_Up', 'G59_Up'}   {'G82_Down'}
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{'G59_Up'}   {'G38_Down'}
{'G59_Up'}   {'G28_Down'}
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{'G59_Up'}   {'G96_Down'}
{'G59_Up'}   {'G82_Down', 'G72_Up'}
{'G59_Up'}   {'G10_Down'}
result18:
count: 0
result19:
count: 24
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{'G59_Up'}   {'G72_Up', 'G96_Down'}
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{'G72_Up', 'G59_Up'}   {'G96_Down'}
{'G59_Up'}   {'G87_Up'}
result21:
count: 9
{'G59_Up'}   {'G72_Up', 'G96_Down'}
{'G82_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up', 'G59_Up'}   {'G82_Down'}
{'G72_Up'}   {'G59_Up', 'G96_Down'}
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{'G82_Down', 'G59_Up'}   {'G72_Up'}
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{'G72_Up'}   {'G82_Down', 'G59_Up'}
{'G59_Up'}   {'G82_Down', 'G72_Up'}
result22:
count: 6
{'G59_Up'}   {'G72_Up', 'G96_Down'}
{'G82_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up'}   {'G59_Up', 'G96_Down'}
{'G96_Down'}   {'G72_Up', 'G59_Up'}
{'G72_Up'}   {'G82_Down', 'G59_Up'}
{'G59_Up'}   {'G82_Down', 'G72_Up'}
result23:
count: 114
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{'G38_Down'}   {'G10_Down'}
```

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```

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result31:
count: 24
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```

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result32:
count: 1
{'G59_Up'}   {'G10_Down'}
result33:
count: 11
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{'G59_Up'}   {'G10_Down'}
result34:
count: 0
result35:
count: 111
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```

```
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```

```
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{'G70_Down'}   {'G10_Down'}
{'G10_Down'}   {'G70_Down'}
{'G88_Down'}   {'G28_Down'}
{'G88_Down'}   {'G87_Up'}
{'G87_Up'}   {'G88_Down'}
{'G72_Up'}   {'G1_Up'}
{'G1_Up'}   {'G72_Up'}
{'G10_Down'}   {'G28_Down'}
{'G28_Down'}   {'G10_Down'}
{'G28_Down'}   {'G6_Up'}
{'G6_Up'}   {'G28_Down'}
{'G38_Down'}   {'G2_Down'}
{'G1_Up'}   {'G38_Down'}
{'G59_Up'}   {'G38_Down'}
{'G88_Down'}   {'G41_Down'}
{'G41_Down'}   {'G88_Down'}
{'G96_Down'}   {'G82_Down'}
{'G82_Down'}   {'G96_Down'}
{'G32_Down'}   {'G6_Up'}
{'G6_Up'}   {'G32_Down'}
{'G88_Down'}   {'G24_Down'}
```

```
{'G24_Down'}   {'G88_Down'}
{'G2_Down'}   {'G28_Down'}
{'G28_Down'}   {'G2_Down'}
{'G67_Up'}   {'G1_Up'}
{'G72_Up', 'G59_Up'}   {'G96_Down'}
{'G59_Up'}   {'G87_Up'}
{'G1_Up'}   {'G67_Up'}
{'G59_Up'}   {'G28_Down'}
{'G82_Down'}   {'G13_Down'}
{'G13_Down'}   {'G82_Down'}
{'G82_Down'}   {'G97_Down'}
{'G97_Down'}   {'G82_Down'}
{'G38_Down'}   {'G1_Up'}
result36:
count: 3
{'G72_Up', 'G59_Up'}   {'G96_Down'}
{'G82_Down', 'G59_Up'}   {'G72_Up'}
{'G72_Up', 'G59_Up'}   {'G82_Down'}
```