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Q1:

(1) Answer:

0	<i>Location</i>	<i>Time</i>	<i>Item</i>	<i>SUM(Quantity)</i>
1	Sydney	2005	PS2	1400
2	Sydney	2006	PS2	1500
3	Sydney	2006	Wii	500
4	Melbourne	2005	Xbox 360	1700
5	Sydney	2005	ALL	1400
6	Sydney	2006	ALL	2000
7	Sydney	ALL	PS2	2900
8	Sydney	ALL	Wii	500
9	Sydney	ALL	ALL	3400
10	Melbourne	2005	ALL	1700
11	Melbourne	ALL	Xbox 360	1700
12	Melbourne	ALL	ALL	1700
13	ALL	2005	PS2	1400
14	ALL	2005	Xbox 360	1700
15	ALL	2005	ALL	3100
16	ALL	2006	PS2	1500
17	ALL	2006	Wii	500
18	ALL	2006	ALL	2000
19	ALL	ALL	PS2	2900
20	ALL	ALL	Xbox 360	1700
21	ALL	ALL	Wii	500
22	ALL	ALL	ALL	5100

(2) Answer:

```
SELECT Location, Time, Item, SUM(Quantity)
FROM SALES
GROUP BY Location, Time, Item
UNION
SELECT Location, Time, "ALL", SUM(Quantity)
FROM SALES
GROUP BY Location, Time
UNION
SELECT Location, "ALL", Item, SUM(Quantity)
FROM SALES
GROUP BY Location, Item
UNION
SELECT "ALL", Time, Item, SUM(Quantity)
FROM SALES
GROUP BY Time, Item
UNION
```

```

SELECT "ALL", "ALL", Item, SUM(Quantity)
FROM SALES
GROUP BY Item
UNION
SELECT "ALL", Time, "ALL", SUM(Quantity)
FROM SALES
GROUP BY Time
UNION
SELECT Location, "ALL", "ALL", SUM(Quantity)
FROM SALES
GROUP BY Location
UNION
SELECT "ALL", "ALL", "ALL", SUM(Quantity)
FROM SALES

```

(3) Answer:

<i>Location</i>	<i>Time</i>	<i>Item</i>	<i>SUM(Quantity)</i>
Sydney	2006	ALL	2000
Sydney	ALL	PS2	2900
Sydney	ALL	ALL	3400
ALL	2005	ALL	3100
ALL	2006	ALL	2000
ALL	ALL	PS2	2900
ALL	ALL	ALL	5100

(4) Answer:

Step1:

<i>Location</i>	<i>Time</i>	<i>Item</i>	<i>SUM(Quantity)</i>
1	1	1	1400
1	2	1	1500
1	2	3	500
2	1	2	1700
1	1	0	1400
1	2	0	2000
1	0	1	2900
1	0	3	500
1	0	0	3400
2	1	0	1700
2	0	2	1700
2	0	0	1700
0	1	1	1400
0	1	2	1700
0	1	0	3100

0	2	1	1500
0	2	3	500
0	2	0	2000
0	0	1	2900
0	0	2	1700
0	0	3	500
0	0	0	5100

Step2:

Offset	Quantity
17	1400
21	1500
23	500
30	1700
16	1400
20	2000
13	2900
15	500
12	3400
28	1700
26	1700
24	1700
5	1400
6	1700
4	3100
9	1500
11	500
8	2000
1	2900
2	1700
3	500
0	5100

Reorder:

Offset	Quantity
0	5100
1	2900
2	1700
3	500
4	3100
5	1400
6	1700
8	2000
9	1500
11	500
12	3400
13	2900

15	500
16	1400
17	1400
20	2000
21	1500
23	500
24	1700
26	1700
28	1700
30	1700

MD ARRAY:

<i>MD ARRAY</i>
5100
2900
1700
500
3100
1400
1700
2000
1500
500
3400
2900
500
1400
1400
2000
1500
500
1700
1700
1700
1700

Function:

f(location, time, item) = (3 * location + time) * 4 + item

Q2:

(1) According to the naïve bayes classifier:

$$P(y|x) = \operatorname{argmax}_{x \in \{C_j\}} \prod_{i=1}^n P(k_i|C_0) \cdot P(C_0)$$

Since the feature of the value is binary which is 0 and 1, if the value is 0:

$$f(x = 0) = \operatorname{argmax}_{x \in \{C_j\}} \prod_{i=1}^n P(k_i|C_0) \cdot P(C_0)$$

and if the value is 1:

$$f(x = 1) = \operatorname{argmax}_{x \in \{C_j\}} \prod_{i=1}^n P(k_i|C_1) \cdot P(C_1)$$

if $f(x=0)-f(x=1)>0$, then $f(x)$ is classified to 1, otherwise classified to 0

we can change it to d dimension:

$$f(y = 1) = P(y = 1) \prod_{i=1}^n P(x_i = 1|y = 1)^{x_i} \cdot P(x_i = 0|y = 1)^{1-x_i}$$

$$f(y = 0) = P(y = 0) \prod_{i=1}^n P(x_i = 1|y = 0)^{x_i} \cdot P(x_i = 0|y = 0)^{1-x_i}$$

use log and then:

$$f(y) = \log(P(y)) + \sum_{i=0}^d P(x_i = 1|y)^{x_i} \cdot P(x_i = 0|y)^{1-x_i}$$

since $k_i \in \{0,1\}$, $k_1 = 1 - k_0$, so can change the function to be:

$$f(y) = \log \frac{P(y = 0)}{P(y = 1)} + \sum_{i=0}^d \log \frac{P(x_i = 0|y = 0)}{P(x_i = 0|y = 1)}$$

$$+ x_i \sum_{i=0}^d \log \frac{P(x_i = 0|y = 0)P(x_i = 1|y = 0)}{P(x_i = 0|y = 1)P(x_i = 1|y = 1)}$$

we can let:

$$x_0 = \log \frac{P(y = 0)}{P(y = 1)} + \sum_{i=0}^d \log \frac{P(x_i = 0|y = 0)}{P(x_i = 0|y = 1)}$$

$$w_i = \log \frac{P(x_i = 0|y = 0)P(x_i = 1|y = 0)}{P(x_i = 0|y = 1)P(x_i = 1|y = 1)}$$

so
$$f(y) = x_0 + \sum_{i=0}^d w_i x_i$$

So it satisfied the linear classifier, and the x range from $[1, x_d]$ which is d+1 dimension of linear classifier.

- (2) w_{NB} is easier to get than w_{LG} that is because NB model can learned data by conditional independence data from training data set, like $P(y)$, $P(x|y)$

and so on, it is not that difficult to be calculated, while LR classifier do not have such preprocess data calculation, it needs to search whole linear space of possible models. So NB models hold the necessary parameters on the same time which help it to easy calculate the solution.

Q3:

(1) Answer:

According to the questions, we can conclude that it is a binomial distribution, so the log likely function should be like this:

According to the log likely function:

$$l(y|\theta) = \log P(y|\theta)$$

$$\log P(p_o | p_m) = \log \left(\binom{n}{p_o n} p_m^{p_o n} \cdot (1 - p_m)^{(1-p_o)n} \right)$$

so

$$\begin{aligned} (1) l_1 &= \log P(u_1 | q) = \log (u_1 \cdot q^{\frac{0.1}{0.1+0.4} u_1} \cdot (1 - q)^{\frac{4}{5} u_1}) \\ &= \log (u_1 \cdot q^{\frac{1}{5} u_1} \cdot (1 - q)^{\frac{4}{5} u_1}) \end{aligned}$$

$$(2) l_2 = \log P(u_2 | q) = \log (u_2 \cdot q^{\frac{2}{7} u_2} \cdot (1 - q)^{\frac{5}{7} u_2})$$

$$(3) l_3 = \log P(u_3 | q) = \log (u_3 \cdot q^{\frac{7}{8} u_3} \cdot (1 - q)^{\frac{1}{8} u_3})$$

$$(1) \rightarrow \log u_1 + \frac{1}{5} u_1 \log q + \frac{4}{5} u_1 \log(1 - q)$$

$$(2) \rightarrow \log u_2 + \frac{2}{7} u_2 \log q + \frac{5}{7} u_2 \log(1 - q)$$

$$(3) \rightarrow \log u_3 + \frac{7}{8} u_3 \log q + \frac{1}{8} u_3 \log(1 - q)$$

so

$$l = \sum l^i = l_1 + l_2 + l_3$$

$$\begin{aligned} &= (\log u_1 + \log u_2 + \log u_3) + \left(\frac{1}{5} u_1 + \frac{2}{7} u_2 + \frac{7}{8} u_3 \right) \log q \\ &+ \left(\frac{4}{5} u_1 + \frac{5}{7} u_2 + \frac{1}{8} u_3 \right) \log(1 - q) \end{aligned}$$

$$l' = \frac{\frac{1}{5} u_1 + \frac{2}{7} u_2 + \frac{7}{8} u_3}{q} - \frac{\frac{4}{5} u_1 + \frac{5}{7} u_2 + \frac{1}{8} u_3}{1 - q}$$

In the log likely function, q is the only parameter.

(2) Answer:

$$l' = \frac{\frac{1}{5}u_1 + \frac{2}{7}u_2 + \frac{7}{8}u_3}{q} - \frac{\frac{4}{5}u_1 + \frac{5}{7}u_2 + \frac{1}{8}u_3}{1 - q}$$

If $u_1 = 0.3, u_2 = 0.2, u_3 = 0.5$

$$l' = \frac{\frac{1}{5}u_1 + \frac{2}{7}u_2 + \frac{7}{8}u_3}{q} - \frac{\frac{4}{5}u_1 + \frac{5}{7}u_2 + \frac{1}{8}u_3}{1 - q} = 0$$

so $q \approx 0.554$

so $q_1 \approx 0.554, q_2 \approx 0.446$

The expected of each component is:

$$u_1 = 0.1 * q_1 + 0.4 * q_2 = 0.23$$

$$u_2 = 0.2 * q_1 + 0.5 * q_2 = 0.33$$

$$u_3 = 0.7 * q_1 + 0.1 * q_2 = 0.43$$