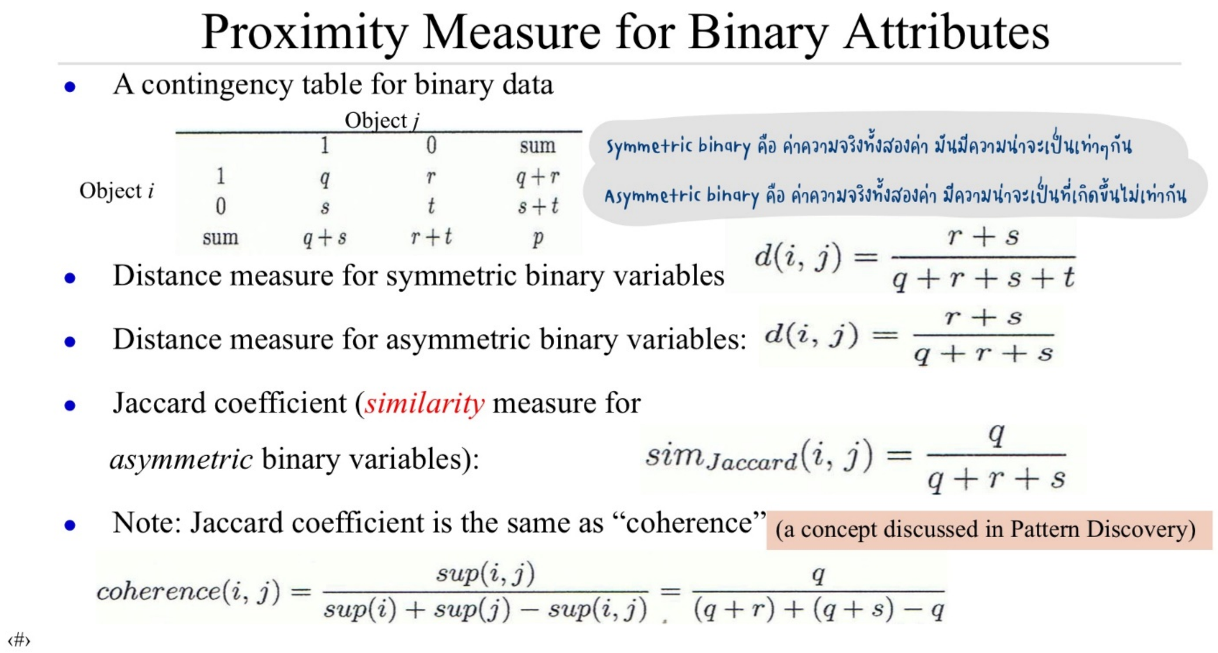
Dissimilarity between Asymmetric Binary Variables



Proximity Measure for Binary Attributes

- A contingency table for binary data

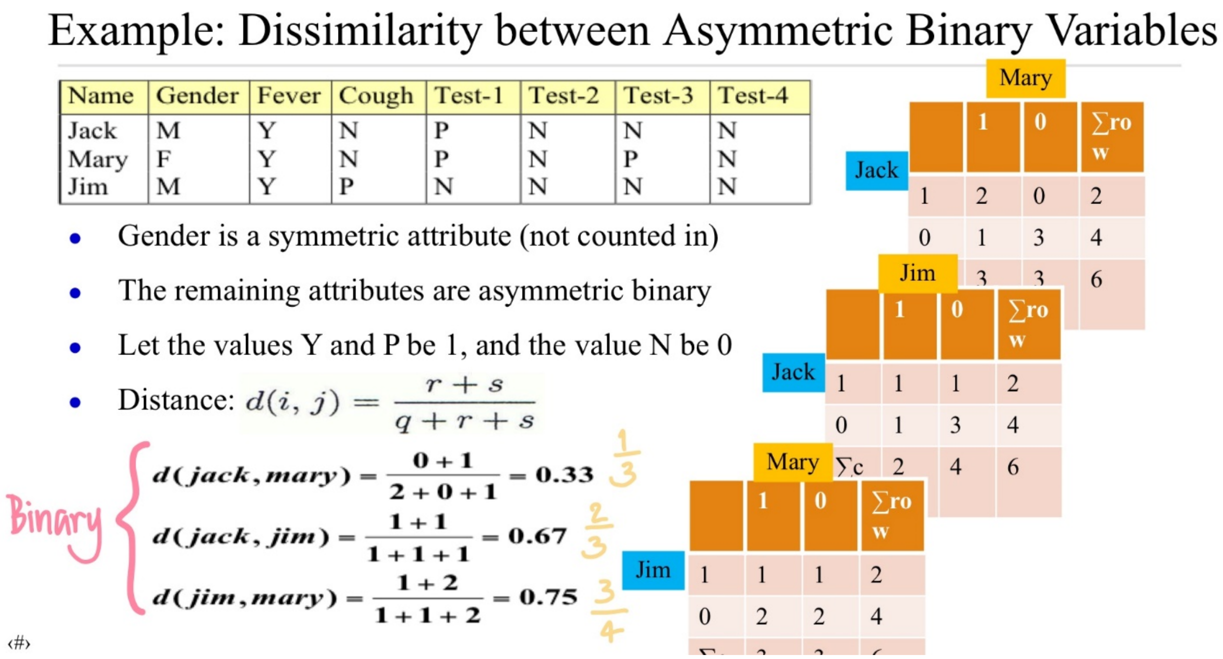
		Object j		
		1	0	sum
Object i	1	q	r	$q+r$
	0	s	t	$s+t$
	sum	$q+s$	$r+t$	p

Symmetric binary คือ ค่าความจริงทั้งสองค่า มันมีความน่าจะเป็นเท่าๆกัน

Asymmetric binary คือ ค่าความจริงทั้งสองค่า มีความน่าจะเป็นที่เกิดขึ้นไม่เท่ากัน

- Distance measure for symmetric binary variables $d(i, j) = \frac{r+s}{q+r+s+t}$
- Distance measure for asymmetric binary variables: $d(i, j) = \frac{r+s}{q+r+s}$
- Jaccard coefficient (*similarity* measure for *asymmetric* binary variables): $sim_{Jaccard}(i, j) = \frac{q}{q+r+s}$
- Note: Jaccard coefficient is the same as "coherence" (a concept discussed in Pattern Discovery)

$$coherence(i, j) = \frac{sup(i, j)}{sup(i) + sup(j) - sup(i, j)} = \frac{q}{(q+r) + (q+s) - q}$$



Example: Dissimilarity between Asymmetric Binary Variables

Name	Gender	Fever	Cough	Test-1	Test-2	Test-3	Test-4
Jack	M	Y	N	P	N	N	N
Mary	F	Y	N	P	N	P	N
Jim	M	Y	P	N	N	N	N

- Gender is a symmetric attribute (not counted in)
- The remaining attributes are asymmetric binary
- Let the values Y and P be 1, and the value N be 0
- Distance: $d(i, j) = \frac{r+s}{q+r+s}$

Binary
$$d(jack, mary) = \frac{0+1}{2+0+1} = 0.33 \quad \frac{1}{3}$$
$$d(jack, jim) = \frac{1+1}{1+1+1} = 0.67 \quad \frac{2}{3}$$
$$d(jim, mary) = \frac{1+2}{1+1+2} = 0.75 \quad \frac{3}{4}$$

Mary

Jack	1	0	∑row
1	2	0	2
0	1	3	4
	3	3	6

Jim

Jack	1	0	∑row
1	1	1	2
0	1	3	4
∑c	2	4	6

Mary

Jim	1	0	∑row
1	1	1	2
0	2	2	4
∑c	3	3	6

Name	Gender	Fever	Cough	Test-1	Test-2	Test-3	Test-4
Jack	M 1	Y 1	N 0	P 1	N 0	N 0	N 0
Mary	F 0	Y 1	N 0	P 1	N 0	P 1	N 0
Jim	M	Y	P 1	N	N	N	N

สูตร

		Object *j*		
		1	0	sum
Object *i*	1	q	r	$q+r$
	0	s	t	$s+t$
	sum	$q+s$	$r+t$	p

Mary

Jack	1	0	sum
1	2	1	3
0	1	3	4
sum	3	4	7

ถ้าเป็น symmetric binary จะใช้สูตรนี้ $$d(i, j) = \frac{r+s}{q+r+s+t} = \frac{1+1}{2+1+1+3} = \frac{2}{7}$$

ถ้าเป็น Asymmetric binary จะใช้สูตรนี้ $$d(i, j) = \frac{r+s}{q+r+s}$$

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Mary	F 0	Y 1	N 0	P 1	N 0	P 1	N 0
Jim	M 1	Y 1	P 1	N 0	N 0	N 0	N 0

สูตร

		Object *j*		
		1	0	sum
Object *i*	1	q	r	$q+r$
	0	s	t	$s+t$
	sum	$q+s$	$r+t$	p

Jim

Jack	1	0	sum
1	2	1	3
0	1	3	4
sum	3	4	7

ถ้าเป็น symmetric binary จะใช้สูตรนี้ $$d(i, j) = \frac{r+s}{q+r+s+t} = \frac{1+1}{2+1+1+3} = \frac{2}{7}$$

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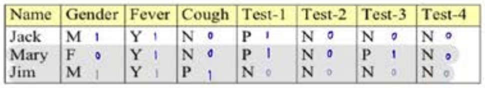
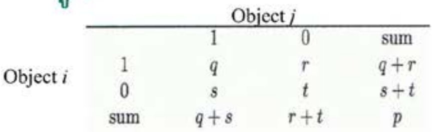


Name	Gender	Fever	Cough	Test-1	Test-2	Test-3	Test-4
Jack	M 1	Y 1	N 0	P 1	N 0	N 0	N 0
Mary	F 0	Y 1	N 0	P 1	N 0	P 1	N 0
Jim	M 1	Y 1	P 1	N 0	N 0	N 0	N 0

สูตร



		Object j		
		1	0	sum
Object i	1	q	r	$q+r$
	0	s	t	$s+t$
	sum	$q+s$	$r+t$	p

Marry

Jim

	1	0	Sum
1	1	2	3
0	2	2	4
Sum	3	4	7

ถ้าเป็น symmetric binary จะใช้สูตรนี้

$$d(i,\, j) = \frac{r+s}{q+r+s+t} = \frac{1+1}{2+1+1+3} = \frac{2}{7}$$

ถ้าเป็น Asymmetric binary จะใช้สูตรนี้

$$d(i,\, j) = \frac{r+s}{q+r+s}$$

Proximity Measure for Categorical Attributes

- Categorical data, also called nominal attributes
  - Example: Color (red, yellow, blue, green), profession, etc.
- Method 1: Simple matching
  - m: # of matches, p: total # of variables

$$d(i,j) = \frac{\overbrace{p-m}^{\text{จำนวนตัวที่ไม่เหมือน}}}{\underbrace{p}_{\text{จำนวนทั้งหมด}}}$$

- Method 2: Use a large number of binary attributes
  - Creating a new binary attribute for each of the M nominal states

ตัวอย่าง method2

	สี	อาชีพ
1	r	นักศึกษา
2	r	อาจารย์
3	g	นักศึกษา

r,g,b

ว่างงาน, นักศึกษา, อาจารย์, Grab

	สี r.	สี g.	สี b	ว่างงาน,	นักศึกษา,	อาจารย์,	Grab
1	1	0	0	0	1	0	0
2	1	0	0	0	0	1	0
3	0	1	0	0	1	0	0

ระยะห่างระหว่าง 1 กับ 3 ห่างกันเท่าไหร่ (Binary)
ตอบ 2/7

Ordinal Variables

- An ordinal variable can be discrete or continuous
- Order is important, e.g., rank (e.g., freshman, sophomore, junior, senior)

  1 2 3 4
- Can be treated like interval-scaled
  - Replace *an ordinal variable value* by its rank: $r_{if} \in \{1, \ldots, M_f\}$
  - Map the range of each variable onto [0, 1] by replacing *i*-th object in the *f*-th variable by $z_{if} = \dfrac{r_{if} - 1}{M_f - 1}$ ลำดับที่? $= \dfrac{1-1}{4-1} = \dfrac{0}{3} = 0$

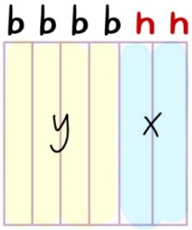
    หาระยะห่างระหว่างจุด
    - Example: freshman: 0; sophomore: 1/3; junior: 2/3; senior 1 $\dfrac{2-1}{4-1} = \dfrac{1}{3}$
      - Then distance: d(freshman, senior) = 1, d(junior, senior) = 1/3
  - Compute the dissimilarity using methods for interval-scaled variables

Attributes of Mixed Type

- A dataset may contain all attribute types
  - Nominal, symmetric binary, asymmetric binary, ตัวเลข numeric, and ordinal
- One may use a weighted formula to combine their effects:

Y(4/6) + X(2/6)

$$d(i,j) = \frac{\sum_{f=1}^{p} w_{ij}^{(f)} d_{ij}^{(f)}}{\sum_{f=1}^{p} w_{ij}^{(f)}}$$

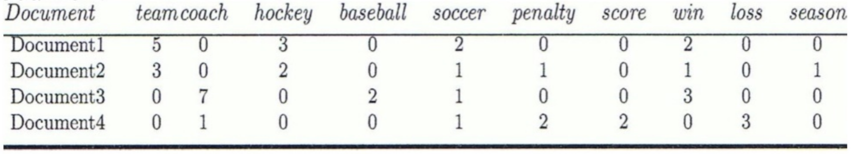


  - If *f* is numeric: Use the normalized distance
  - If *f* is binary or nominal: dij(f) = 0 if xif = xjf; or dij(f) = 1 otherwise
  - If *f* is ordinal
    - Compute ranks zif (where $z_{if} = \frac{r_{if}-1}{M_f-1}$)
    - Treat zif as interval-scaled

ตัววัดความเหมือนอีกหนึ่งตัว

Cosine Similarity of Two Vectors

- A **document** can be represented by a bag of terms or a long vector, with each attribute recording the *frequency* of a particular term (such as word, keyword, or phrase) in the document



Document	*team*	*coach*	*hockey*	*baseball*	*soccer*	*penalty*	*score*	*win*	*loss*	*season*
Document1	5	0	3	0	2	0	0	2	0	0
Document2	3	0	2	0	1	1	0	1	0	1
Document3	0	7	0	2	1	0	0	3	0	0
Document4	0	1	0	0	1	2	2	0	3	0

- Other vector objects: Gene features in micro-arrays
- Applications: Information retrieval, biologic taxonomy, gene feature mapping, etc.
- Cosine measure: If *d1* and *d2* are two vectors (e.g., term-frequency vectors), then

$$cos(d_1, d_2) = \frac{d_1 \bullet d_2}{\| d_1 \| \times \| d_2 \|}$$

where • indicates vector dot product, ||*d*||: the length of vector *d*