

# Knowledge based systems

## Lab 2

### 1. Formal definitions

$U = \{\text{Smith, Jones, Parker, Hanson, Moore, Fields, Starr}\}$

$A = \{\text{Age, Sex, LEMS}\}$

$V_{\text{Age}} = \{16-30, 31-45, 46-60\}$

$V_{\text{Sex}} = \{\text{Male, Female}\}$

$V_{\text{LEMS}} = \{0, 1-25, 26-49, 50\}$

### 2. Discernability 1

a)  $\text{IND}\{\text{Age}\} = \{\{\text{Smith, Jones, Fields}\}, \{\text{Parker, Hanson}\}, \{\text{Moore, Starr}\}\}$

b) *upper* for *Walk = Yes* by Age =  $\{\{\text{Smith, Fields, Jones}\}, \{\text{Hanson, Parker}\}\}$  *lower* for *Walk = Yes* by Age =  $\{\}$

Accuracy of approximation =  $\frac{0}{5} = 0$

c) Rough membership functions for *Walk = Yes* by  $\text{IND}\{\text{Age}\}$ :  $\{\text{Smith, Jones, Fields}\} = \frac{2}{3} \{\text{Parker, Hanson}\} = \frac{1}{2}$

Good model? No.

### 3. Discernability 2

a) For  $B = \{\text{Age, Sex}\}$ ,  $\text{POS}_B(\{d\}) = \{\{\text{Moore, Starr}\}, \{\text{Fields}\}\}$

b) For  $A = \{\text{Age, Sex, LEMS}\}$ ,  $\text{POS}_A(\{d\}) = \{\{\text{Smith}\}, \{\text{Fields}\}, \{\text{Jones}\}, \{\text{Moore, Starr}\}\}$

### 4. Discernability 3

a) Equivalence classes without  $d = \{\{\text{Smith}\}, \{\text{Jones}\}, \{\text{Fields}\}, \{\text{Parker, Hanson}\}, \{\text{Moore, Starr}\}\}$

b)

	Smith		Jones		Parker		Hanson		Moore		Fields	Starr
Smith	$\Theta$											
Jones	LEMS		$\Theta$									
Parker	Age, LEMS		Age, LEMS		$\Theta$							
Hanson	Age, LEMS		Age, LEMS		$\Theta$		$\Theta$					
Moore	Age, LEMS	Sex, LEMS	Age, LEMS	Sex, LEMS	Age, LEMS	Sex, LEMS	Age, LEMS	Sex, LEMS	$\Theta$			
Fields	Sex		Sex, LEMS		Sex, LEMS		Sex, LEMS		Age, LEMS		$\Theta$	
Starr	Age, LEMS	Sex, LEMS	Age, LEMS	Sex, LEMS	Age, LEMS	Sex, LEMS	Age, LEMS	Sex, LEMS	$\Theta$		Age, LEMS	$\Theta$

c) Boolean discernability function

$$\begin{aligned}
 &= (\text{LEMS})(\text{Age} \vee \text{LEMS})(\text{Age} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Sex})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{LEMS}) \\
 &(\text{Age} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Sex} \vee \text{LEMS}) \\
 &(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{LEMS}) \\
 &(\text{Age} \vee \text{LEMS}) \\
 &= (\text{LEMS})(\text{Sex})
 \end{aligned}$$

{Smith} is discernable from {Parker, Hanson}, but the latter two are never discernable.

## 5. Rule-based classification

a)

- {Smith} = Yes
- {Jones} = No
- {Fields} = Yes
- {Parker, Hanson} = {Yes, No}
- {Moore, Starr} = No

The table is inconsistent due to {Parker, Moore}.

b)

	Smith		Jones		Parker	Hanson		Moore	Fields	Starr
Smith	$\Theta$									
Jones	LEMS		$\Theta$							
Parker	Age, LEMS		$\Theta$		$\Theta$					
Hanson	$\Theta$		Age, LEMS		$\Theta$	$\Theta$				
Moore	Age, LEMS	Sex,	Age, LEMS	Sex,	$\Theta$	Age, LEMS	Sex,	$\Theta$		
Fields	$\Theta$		$\Theta$		Sex, LEMS	$\Theta$		Age, LEMS	$\Theta$	
Starr	Age, LEMS	Sex,	$\Theta$		$\Theta$	Age, LEMS	Sex,	$\Theta$	Age, LEMS	$\Theta$

c)

Boolean disjunctive function

$$\begin{aligned}
 &= (\text{LEMS})(\text{Age} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS}) \\
 &(\text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{Sex} \vee \text{LEMS})(\text{Age} \vee \text{LEMS})(\text{Age} \vee \text{LEMS}) \\
 &= (\text{LEMS})
 \end{aligned}$$

The prime implicant is LEMS.

d) Decision rules based on LEMS:

- IF LEMS = 50 THEN Yes
- IF LEMS = 26-49 THEN {Yes, No}
- IF LEMS = 1-25 THEN No
- IF LEMS = 0 THEN No

e) Accuracy for Walk = No:

- IF LEMS = 50 THEN Yes  $\Rightarrow \frac{0}{2}$
- IF LEMS = 26-49 THEN {Yes, No}  $\Rightarrow \frac{1}{2}$
- IF LEMS = 1-25 THEN No  $\Rightarrow \frac{2}{2}$
- IF LEMS = 0 THEN No  $\Rightarrow \frac{1}{1}$

Coverage for Walk = No:

- IF LEMS = 50 THEN Yes  $\Rightarrow \frac{0}{4}$
- IF LEMS = 26-49 THEN {Yes, No}  $\Rightarrow \frac{1}{4}$
- IF LEMS = 1-25 THEN No  $\Rightarrow \frac{2}{4}$
- IF LEMS = 0 THEN No  $\Rightarrow \frac{1}{4}$

Strength for Walk = No:

- IF LEMS = 50 THEN Yes  $\Rightarrow \frac{2}{7}$
- IF LEMS = 26-49 THEN {Yes, No}  $\Rightarrow \frac{2}{7}$
- IF LEMS = 1-25 THEN No  $\Rightarrow \frac{2}{7}$
- IF LEMS = 0 THEN No  $\Rightarrow \frac{1}{7}$

Support for Walk = No:

- IF LEMS = 50 THEN Yes  $\Rightarrow \frac{0}{7}$
- IF LEMS = 26-49 THEN {Yes, No}  $\Rightarrow \frac{1}{7}$
- IF LEMS = 1-25 THEN No  $\Rightarrow \frac{2}{7}$
- IF LEMS = 0 THEN No  $\Rightarrow \frac{1}{7}$

6.

	Classifier says "Lung" (1)	Classifier says "Colon" (0)
Real origin "Lung" (1)	34	3
Real origin "Colon" (0)	10	22

a) True positive = 34

b) True negative = 22

c) False negative = 3

d) False positive = 10

e) Sensitivity =  $\frac{34}{34+3} = \frac{34}{37} \approx 0.92$

f) Specificity =  $\frac{22}{22+10} = \frac{22}{32} \approx 0.69$

g)

ROC curve shows separation of positives from negatives.

x-axis shows false positive rate

y-axis shows true positive rate

h)

This classifier is reasonably strong and could probably be used.

i)

Threshold values:

- 0.8 is good
- 0.9 very good
- Close to diagonal is bad

- If very low, flip how we categorize outcomes