

Short REVIEW 1

CSE 537

AI Lecture Notes

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PART ONE

- CONCEPTUALIZATION DEFINITION (NILSON)
- **Conceptualization** – step one of formalization of knowledge in declarative form

$$C = (U, F, R)$$

- **U** – Universe of discourse; it is a **FINITE set** of objects.
- **F** – Functional Basis Set; Set of functions (defined on **U**). Functions may be partial.
- **R** – Relational Basis Set; Set of relations defined on **U**.
- Remark: sets **U, R, F** are **FINITE**

Problem 1

- **Conceptualize** the following situation using **Nilsson's definition**
- *In a room there are 2 cats, 3 dogs, and 2 kind of FOOD– one for cats and one for dogs.*
- **The following properties must be true.**
 - 1. One cat likes all dogs.*
 - 2. One dog hates all cats.*
 - 3. Everybody (cats and dogs) like all FOOD.*
 - 4. One dog hates cat food.*
 - 5. All cats hate dog food.*

Problem 1- Notation

- We use the following notation

- **U** – Universe of discourse is the set

$$U = \{ o1, o2, o3, o4, o5, o6, o7 \}$$

- **R** – Relational Basis Set; Set of relations

$$R = \{ CAT, DOG, FOOD, CFOOD, DFOOD, LIKE, HATE \}$$

- WE USE **INTENDED Interpretation**, i.e.

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Relation **CAT** is defined intuitively by a property **x is a cat**

- Relation **DOG** is defined intuitively by a property **x is a dog**

- Relation **FOOD** is defined intuitively by a property **x is food**

- Relation **CFOOD** is defined intuitively by a property **x is cat food**

- Relation **DFOOD** is defined intuitively by a property **x is dog food**

- Relation **LIKE** is defined intuitively by a property **x likes y**

- Relation **LIKE** is defined intuitively by a property **x likes y**

- Relation **HATE** is defined intuitively by a property **x hates y**

Problem 1-Relations

Remark that the relations

CAT, DOG, FOOD, CFOOD, DFOOD

are *one argument relations* and

the relations

LIKE, HATE

are *two argument relation* and

all of them are **defined on** the Universe **U**

Solution: Relations Definition

- We define, for example the relation **CAT** \subseteq **U** (one argument relation) as
 - **CAT** = { o1, o2 }
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- We define, for example the relation **DOG** \subseteq **U**
- (one argument relation) as
 - **DOG** = { o3, o4, o5 }
- Observe that the sets **CAT** and **DOG** must be **disjoint**- as we use the **intended interpretation**

Solution: Relations Definition

- Observe that the sets **CAT**, **DOG** and **FOOD** must also be **disjoint**- as we use the **intended interpretation**
- We must define now the relation **FOOD** \subseteq **U**
- (one argument relation) as
- **FOOD = { o6, o7 }**
- We define, for example the one argument relations
- **CFOOD** \subseteq **FOOD** \subseteq **U**, **DFOOD** \subseteq **FOOD** \subseteq **U**, as
- **CFOOD = { o7 }**, **DFOOD = { o6 }**
- Observe that the sets **CFOOD** and **DFOOD** must be **disjoint**- as we use the **intended interpretation**

DEFINITION of the relations LIKE, HATE

- Relations **LIKE, HATE** are defined intuitively by respective properties: *x likes y* and *x hates y*
- Both are 2 argument relation defined on **U**, i.e.
- **LIKE** \subseteq **UxU** and **HATE** \subseteq **UxU**

and must fulfill the following properties:

- 1. One cat likes all dogs.*
- 2. One dog hates all cats.*
- 3. Everybody (cats and dogs) like all FOOD.*
- 4. One dog hates cat food.*
- 5. All cats hate dog food*

Definitions of the relations **LIKE**, **HATE**

- Observe that the relations **LIKE** and **HATE** in order to fulfill the conditions **1.-5.** must be defined differently on different subsets of **U**.
- We define first appropriate parts
- **LIKE1, LIKE2** of the relation **LIKE** that correspond to properties **1., 3.** and define **LIKE** as set union of all of them, i.e. we put
- **LIKE = LIKE1 \vee LIKE2**

Definition of the relation **LIKE**

- **PROPERTIES**
- *1. One cat likes all dogs*
- We define **LIKE1** as follows
- **$LIKE1 \subseteq CAT \times DOG \subseteq U \times U$**
- **$LIKE1 \subseteq \{o1, o2\} \times \{o3, o4, o5\} \subseteq U \times U$**
- We put
- **$LIKE1 = \{(o2, o3), (o2, o4), (o2, o5)\}$**
- Observe that there are many ways of defining **LIKE1** – this is just my choice

Definition of the relation **LIKE**

- **PROPERTIES**

- *3. Everybody (cats and dogs) like all FOOD*

We define **LIKE2** as follows

- **LIKE2** \subseteq (CAT \vee DOG) \times FOOD \subseteq U \times U
- **LIKE1** \subseteq { o1, o2, o3, o4, o5 } \times {o6, o7} \subseteq U \times U
- We put
- **LIKE2** = { o1, o2, o3, o4, o5 } \times {o6, o7}
- **LIKE** = **LIKE1** \vee **LIKE2**

Definition of the relation **HATE**

- We define first appropriate parts
- **HATE1, HATE2, HATE3** of the relation **HATE** that correspond to properties **2., 4., 5.** and define **HATE** as set union of all of them, i.e. we put
- **$HATE = HATE1 \vee HATE2 \vee HATE3$**

Definition of the relation **HATE**

- **PROPERTIES**
- *2. One dog hates all cats.*
- We define **HATE1** as follows
- **$\text{HATE1} \subseteq \text{DOG} \times \text{CAT} \subseteq U \times U$**
- **$\text{HATE1} \subseteq \{o3, o4, o5\} \times \{o1, o2\} \subseteq U \times U$**
- We put, for example
- **$\text{HATE1} = \{(o5, o1), (o5, o2)\}$**
- Observe that there are many ways of defining **HATE1**
– this is just my choice

Definition of the relation HATE

- **PROPERTIES**
- *4. One dog hates cat food.*
- We define **HATE2** as follows
- **$HATE2 \subseteq DOG \times CFOOD \subseteq U \times U$**
- **$HATE2 \subseteq \{o3, o4, o5\} \times \{o7\} \subseteq U \times U$**
- We put, for example
- **$HATE2 = \{(o3, o7)\}$**
- Observe that there are many ways of defining **HATE2**
– this is just my choice

Definition of the relation **HATE**

- **PROPERTIES**
- *5. All cats hate dog food*
- We define **HATE3** as follows
- **$HATE3 \subseteq CAT \times DFOOD \subseteq U \times U$**
- **$HATE3 \subseteq \{o1, o2\} \times \{o6\} \subseteq U \times U$**
- We put **$HATE3 = \{(o1, o7), (o2, o7)\}$**
and
- **$HATE = HATE1 \vee HATE2 \vee HATE3$**
- Observe that there is only one way of defining **HATE3**

PART 2: PREDICATE LOGIC CONCEPTUALIZATION

- Translations from Natural Language
- Translate: **“No house is red”**
- 1. Domain: $X \neq \phi$
- 2. Predicates: $A(x)$ – x is a House $B(x)$ – x is red
- 3. Functions: (none)
- 4. Connectives: \neg - **“not”**
- 5. Quantifiers: $\exists_{A(x)}$ – **“some houses”** (restricted)
- 6. RESTRICTED FORMULA: $\neg \exists_{A(x)} B(x)$
- 7. LOGIC FORMULA: $\neg \exists x (A(x) \wedge B(x))$

PREDICATE LOGIC CONCEPTUALIZATION

- Translations from Natural Language
- **BE CAREFUL!**
- **YOU MUST ALWAYS DO DIRECT TRANSLATION**
- Never translate some logically EQUIVALENT FORM like in this case (via de Morgan Laws)
- “All houses are not red”

PREDICATE LOGIC CONCEPTUALIZATION

- Translations from Natural Language
- Translate: **“All houses are not red”**
- 1. Domain: $X \neq \phi$
- 2. Predicates: $A(x)$ – x is a house $B(x)$ – x is red
- 3. Functions: (none)
- 4. Connectives: \neg – **“not”**
- 5. Quantifiers: $\forall_{A(x)}$ – **“All houses” (restricted)**
- 6. RESTRICTED FORMULA: $\forall_{A(x)} \neg B(x)$
- 7. LOGIC FORMULA: $\forall_x (A(x) \Rightarrow \neg B(x))$

Part 3: Rule Based Systems

Exercise

- Exercise 1
- Here are three simple **expert rules**
- **R1:** If your savings are small, then don't invest in stocks
- **R2:** If you have no children and large income, then invest in stocks
- **R3:** If you have children and small income, then invest in savings

Part 3: Exercise 1

- **Conceptualize** rules **R1, R2, R3** in **Predicate Form** using predicates
attribute(x, value of attribute)
attribute(object, value of attribute)

WRITE a format of a **database TABLE** needed for your conceptualization

REMARK: In order to express the rules **Predicate Form**, we must first define appropriate **ATTRIBUTES** and their **values**

Part 3: Exercise 1

- **We have the following ATTRIBUTES:**

- **Savings**

Values: **small, large**

- **Income**

Values: **small, large**

- **InvestStocks**

Values: **yes, no**

- **InvestSavings**

- Values: **yes, no**

- **Children**

Values: **yes, no**

Exercise 1: Predicate Form Conceptualization

Data Table Example

Records	Savings	Income	InvesrStocks	InvestSavings	Children
O ₁	small	small	yes	yes	yes
O ₂	large	small	no	no	no
O ₃	small	large	yes	yes	no

Exercise 1: Rules in Predicate Form

- **RULES:**
- **R1:** $\text{Savings}(x, \text{small}) \rightarrow \text{InvestStock}(x, \text{no})$
- **R2:** $\text{Children}(x, \text{no}) \wedge \text{Income}(x, \text{large}) \rightarrow \text{InvestStocks}(x, \text{yes})$
- **R3:** $\text{Children}(x, \text{yes}) \wedge \text{Income}(x, \text{small}) \rightarrow \text{InvestSavings}(x, \text{yes})$
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PART3: Exercise 2

- Exercise 2
- The initial database has the following **FACTS**
- **F1:** Savings(John, small)
- **F2:** Children(John, no)
- **F3:** Income(John, large)
- Are these **FACTS** true in **Exercise 1** Data Table for some record $o = \text{John}$?
- Design a **Data Table 2** in which the above **FACTS** are true
- Can you deduce **InvestStocks(John, yes)** on the base of the **Data Table 2**