Cognitive Science
Knowledge Representation & Organisation

Erasmus Programme
Professor Markos Dendrinos

DIKW scheme

- Data
- Information
- Knowledge (Insight)
- Wisdom

Data

- Simple unprocessed symbols
- Unstructured elements
- The terms of a meaningful sentence, such as named entities (subjects or objects), actions (verbs), properties (adjectives), spatial or temporal referents (adverbs)

Information

- Processed data
- Structured data in a spreadsheet or a database
- Answers to questions (what, who, when, where) according to Ackoff
-Meaningful propositions (independently of their truth value)
- ‘Meaningful’ depends on the receptor (human or machine)

Knowledge

- Information written in a typical language (Propositional or Predicate Calculus)
- A system of propositions with an incorporated reasoning mechanism (given propositions and deduced propositions)
- Database relation scheme (tables related to other tables)
- Knowledge concerns the answer to ‘how' questions and has to do with actions, aiming at the optimization of *efficiency*, according to Ackoff
- Justified information («*episteme* is a justified true belief» / Platonic dialogue *Theaetetus*)
-A meaningful proposition including its truth value
- *Insight* concerns the answer to 'why' questions.

Wisdom

- Long term view
- A view including aesthetic and ethical issues
- Evaluated understanding, according to Ackoff
- DIK(i) concern efficiency, while W concerns effectiveness, according to Ackoff
- Efficiency: how to do things in a right way, according to (supposedly) set right aims
- Effectiveness: how to do the right things by the reassessment of aims

Tacit and explicit knowledge

- Polanyi: Tacit knowledge is what we have learnt, which is more than what we can talk about
- Laudon: Explicit knowledge is the part of the tacit knowledge, which has been recorded

Propositional and Procedural knowledge

- Zeleny: Knowledge is a process, the knowhow – There is no explicit knowledge – The recorded knowledge becomes information
- Zins: Knowledge can be expressed propositionally – It is either tacit in the form of subjective beliefs or recorded objective propositions

Propositional Logic

- The items are propositions
- Unitary and binary operations on propositions
- Unitary operation: negation NOT $\neg p$
- Binary operations: AND $p \wedge q$, OR $p \vee q$, implication $p \rightarrow q$, equivalence $p \leftrightarrow q$
- Truth value assignment
- Truth table
- Proof process

Truth table of binary operations

I(p)	I(q)	I(¬p)	I(p∧q)	I(p∨q)	I(p→q)	I(p↔q)
0	0	1	0	0	1	1
0	1	1	0	1	1	0
1	0	0	0	1	0	0
1	1	0	1	1	1	1

Truth table example

p	q	r	p∨q	~r	(p∨q) ∧ ~r
0	0	0	0	1	0
0	0	1	0	0	0
0	1	0	1	1	1
0	1	1	1	0	0
1	0	0	1	1	1
1	0	1	1	0	0
1	1	0	1	1	1
1	1	1	1	0	0

Logically equivalent propositions

$p \rightarrow q \mid=\mid \neg p \lor q$

$\neg (p \lor q) \mid=\mid \neg p \land \neg q$

$\neg (p \land q) \mid=\mid \neg p \lor \neg q$

$p \land (q \lor r) \mid=\mid (p \land q) \lor (p \land r) \mid=\mid p \land q \lor p \land r$

$p \lor (q \land r) \mid=\mid (p \lor q) \land (p \lor r)$

Exercise - 1

- Prove through a truth table the following equivalence:
- $p \land (q \lor r) \mid\!=\!\mid (p \land q) \lor (p \land r)$

Proof process

- Given propositions (considered as true)
- Deduction rules

  Modus Ponens (if $p \rightarrow q$ and p then q)

  Modus Tollens (if $p \rightarrow q$ and $\neg q$ then $\neg p$)

Resolution Principle

From the true propositions:

p v r

q v ¬ r

we deduce the truth of a new proposition:

p v q

Proof process: An example

p: I am exposed to covid
q: I am vaccinated
r: I get sick with covid
s: I have strong immune system
t: I am hospitalized

Proof process: An example (cont.)

Given propositions

$p \wedge \neg q \rightarrow r$: ‘if I am exposed to covid and not vaccinated then I get sick with covid’ (pr.1)

$r \wedge \neg s \rightarrow t$: ‘if I get sick with covid and do not have strong immune system then I am hospitalized’ (pr.2)

p : ‘I am exposed to covid’ (pr.3)

$\neg q$: ‘I am not vaccinated’ (pr.4)

$\neg s$: ‘I do not have strong immune system’ (pr.5)

To be proved

t : ‘I an hospitalized’ (pr.6)

Proof through MP rule

(pr.1), (pr.3), (pr.4) and M.P. $\Rightarrow$ r (pr.7)

(pr.2), (pr.7), (pr.5) and M.P. $\Rightarrow$ t

Proof through Resolution principle

Step 1. We apply logical transformation to propositions, so that they include only OR - NOT.
Step 2. We include also the proposition to be proved but negated in the set of the given propositions
Step 3. We apply the Resolution principle until the deduction of a contradiction of the form $(p \wedge \neg p)$

Proof through Resolution principle (cont.)

Step 1.

(pr.1) |=| ¬p ∨ q ∨ r (pr.1)

(pr.2) |=| ¬r ∨ s ∨ t (pr.2)

p (pr.3)

¬q (pr.4)

¬s (pr.5)

¬t (pr.6) … we have negated the proposition to be proved

Proof through Resolution principle (cont.)

Step 2.

(pr.1), (pr.4) $\Rightarrow \neg p \lor r$ (pr.7)

(pr.2), (pr.5) $\Rightarrow \neg r \lor t$ (pr.8)

(pr.7), (pr.8) $\Rightarrow \neg p \lor t$ (pr.9)

(pr.9), (pr.6) $\Rightarrow \neg p$ (pr.10)

(pr.3), (pr.10) $\Rightarrow 0$ (contradiction)

Proof through MT example

- If someone drinks hydrocyan then he dies
- We know that someone died. It is not valid to conclude that he drank hydrocyan
- We know that someone did not die (he is alive). It is valid to conclude that he did not drink hydrocyan.

Exercise - 2

p: ‘a force is exerted on an object x’
q: ‘the object x accelerates’
r: ‘the velocity of the object x remains the same’
s: ‘the object x is at rest’
Given propositions:
$p \rightarrow q$, $q \rightarrow \neg r$, $s \rightarrow r$, p
The proposition to be proved:
$\neg s$ (that is ‘the object is not at rest’)

The proof must be presented (a) through deduction rules : Modus Ponens (M.P.), Modus Tollens (M.T.) and (b) through ResolutionPrinciple

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