1 Test I (classes) 23 XI
2 Test II (—"—) 25 I
3 Exam 8 II, 15 II 2024
15.15 - 16.55

classes grade (average of test grades): **C = (C1 + C2)/2**
(test retakes will take place on 1 II 2024)

final FoKE grade (average of classes and exam grades): **F = (C + E)/2**

Chapter I Introduction

1. Knowledge engineering (KE) - methods and operations concerning knowledge

Data 50, 16, 150
Information „Police car no 50 is driving along street no.16 with driving speed of 150 km/h"
Knowledge, „The police car is probably chasing another car"

Operations:
a) acquisition
b) representation
c) processing
d) validation and updating

→ KBS (knowledge-based system)
KBDSS (—"— decision support system)
ES (expert system)

2. Knowledge acquisition

Sources of knowledge :

a) experts (human experts) : wisemen, scientist, encyclopedias, books, experienced, skillfull operators (ppl who know how to act) - explicit knowledge

b) data - knowledge assumed to be hidden in the data needs to be discovered using data mining methods - implicit knowledge

Kinds of knowledge :

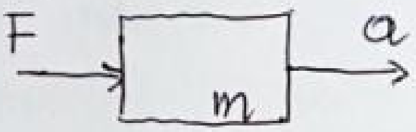
a) declarative (descriptive) - describes „how it is", describes principles, rules

b) procedural (prescriptive) - describes „how to act"

3. Knowledge representation (KR)

KR – format model of knowledge, usually different to what we call classical math. mod. (functional models are classical).

$a = \frac{F}{m}$ 2nd law of dynamics (classical)



4. Knowledge processing

Transformations, leading to conclusions or to another kind of knowledge.

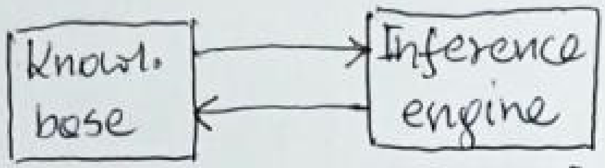
Obtaining conclusions – through reasoning, deduction process.

5. Knowledge validation and updating

Knowledge validation – to determine if knowledge is consistent, or to determine if knowledge is consistent (not contradictory) with real-life observation

Knowledge updating – making knowledge consistent with incoming real-life observations, making knowledge more precise

6. Expert systems (ES)



computer implementation of knowledge processing algorithm

computer implementation of knowledge representation

Other modules (components) of ES:

a) user interface
b) knowledge acquisition
c) explanation module
d) knowledge validation

Individuals involved in ES development

a) user – needs, goals, requirements, data sources, evaluates product

b) experts
c) knowledge engineer
d) designer
e) software engineer

7. ~~Problems~~ ~~To~~ Basic problems for an ES supporting a decision maker.

The "causal relationship" is exploited in ES support.

cause, effect – general names of input and output

action – intentional activity
result – effect of intentional activity

Three basic problems:

a) analysis problem (AP) – „What are possible effects of particular causes?"
Given: cause (hypothetical) **prediction**
Find: effect (potentia).

b) diagnostic problem (DP) – „What are possible causes to the observed effect?"
Given: effect (observed) **explanation**
Find: causes (potentials)

c) decision making problem (DMP) – „What action will guarantee achievement of the desired result?"
design
Given: result (required).
Find: decision (that guarantees ...)

Lecture material

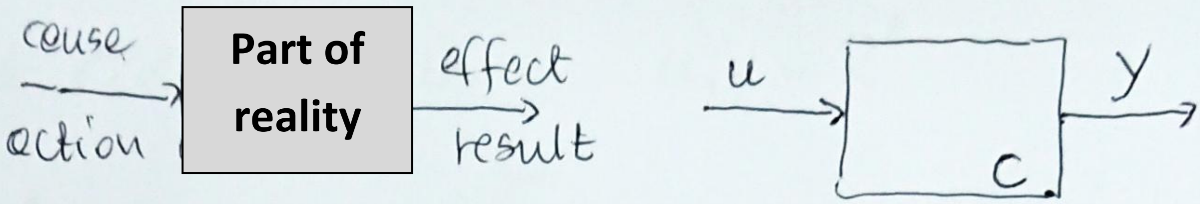
Part I Knowledge from experts - explicit, representing and processing of knowledge

Part II —— " —— - explicit } integration
Knowledge from data - implicit
knowledge validation and updating

Part III Knowledge from data - implicit
knowledge acquisition

Chapter II AP, DP and DMP with relational knowledge representation (RKR)

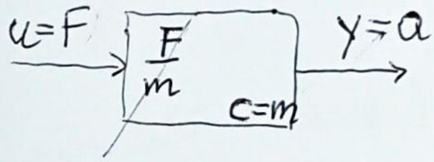
1. Introduction



$u \in U$ - cause, action, input $\quad c \in C$ - parameter
$\searrow$ input domain

$y \in Y$ - effect, result, output
$\searrow$ output domain

$a = \frac{F}{m} \longrightarrow$



$$y = \frac{u}{c}$$

If parameter „c" is only known to be inside $[c_1, c_2]$, $c \in [c_1, c_2]$

$$c_1 \leq c \leq c_2,$$

then
$$\frac{u}{c_2} \leq y \leq \frac{u}{c_1}$$

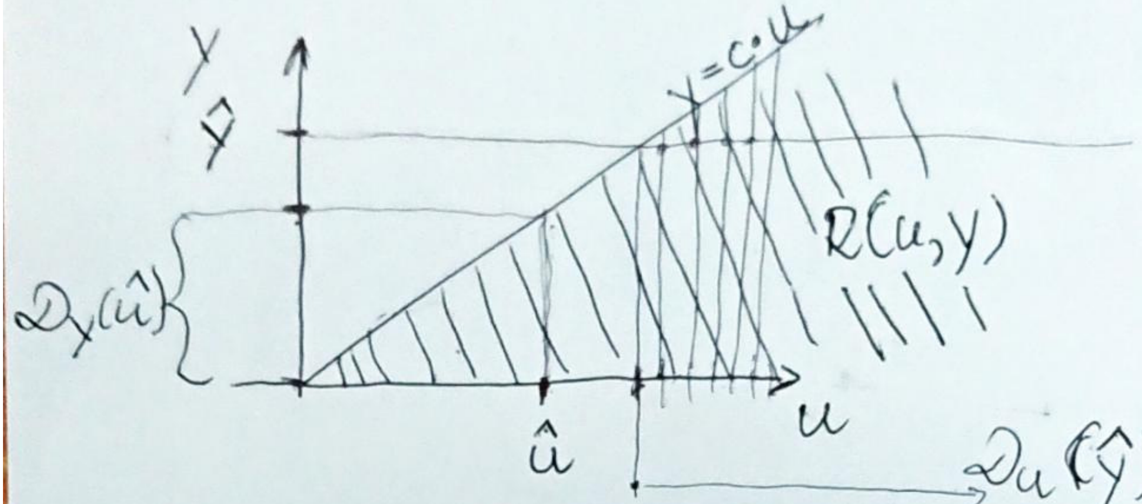
$\mathcal{D}_y(u)$ - set of possible outputs (effects) „y" resulting from input „u".

$\mathcal{D}_y(u) = [\frac{u}{c_2}, \frac{u}{c_1}]$ $\Big\}$ $\mathcal{D}_y(u) = \{\hat{y}\}$ singleton

2. Relational knowledge representation

$u \longrightarrow \mathcal{D}_y(u)$

Ex. 1. $0 \leqslant y \leqslant c \cdot u \qquad u, y \in R^*$



$\mathcal{D}_u(\hat{y})$ - set of possible inputs (reasons) for observed $\hat{y}$

$u \longrightarrow \boxed{R(u,y)} \longrightarrow y$

Because we get sets $\mathcal{D}_y(\hat{u})$, $\mathcal{D}_u(\hat{y})$ and not particular values, then it is reasonable to consider generalized <u>input property</u> and <u>output property</u>.

$u \in \mathcal{D}_u$

D_u, D_y - sets of some values of u and of y

$y \in \mathcal{D}_y$

$u \in \mathcal{D}_u \longrightarrow \boxed{R(u,y)} \longrightarrow y \in \mathcal{D}_y$

model of RKR based description

$R(u,y) = \{(u,y) \in U \times Y : \; u \, \mathcal{S} \, y\}$ $\mathcal{S}$ - particular property

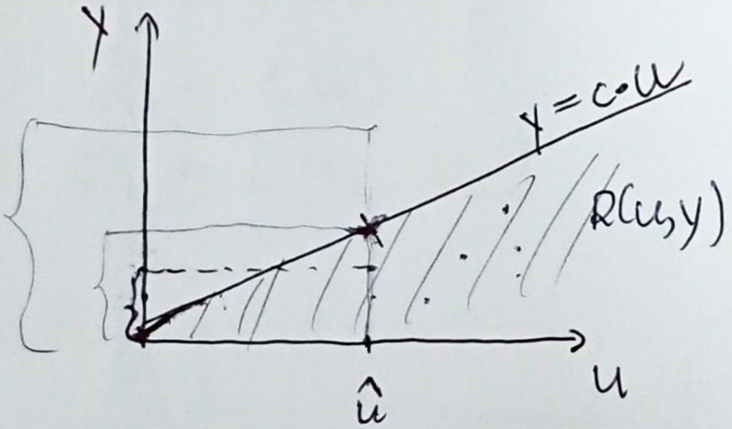
$$(u \in \mathcal{D}_u) \wedge (u,y) \in R \Rightarrow (y \in \mathcal{D}_y) \qquad (1)$$

3. AP with RKR

Given: $\mathcal{D}_u$, R.

Find: The ~~set~~ <u>smallest</u> set $\mathcal{D}_y$ satisfying (1).

Ex. 2 $\quad 0 \leq y \leq c \cdot u \Rightarrow R(u,y) = \{(u,y) \in \mathbb{R}^2 : 0 \leq y \leq c \cdot u\}$



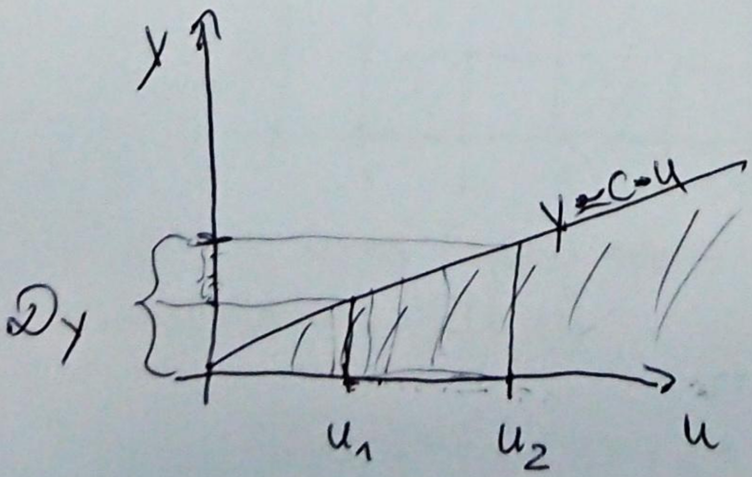
$D_u = \{\hat{u}\}$

Solution

$\mathcal{D}_y = \mathcal{D}_y(\hat{u})$

$\mathcal{D}_y(\hat{u}) = [0, c \cdot \hat{u}]$

Ex. 3 $\quad R$ - as in Ex. 2

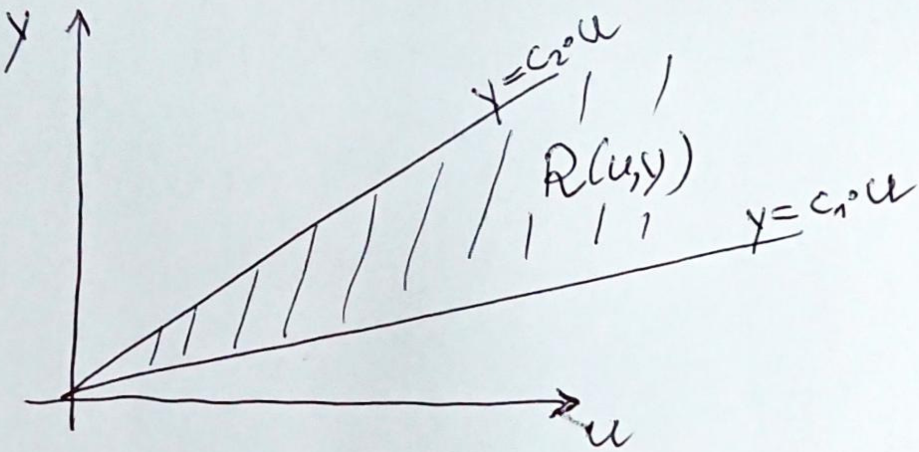


$\mathcal{D}_u = [u_1, u_2]$

Formula useful for determining solutions:

$$\mathcal{D}_y = \bigcup_{u \in \mathcal{D}_u} \mathcal{D}_y(u) \quad \text{(in discrete case)}$$

Ex. 4. $R: 0 \leq c_1 \cdot u \leq y \leq c_2 \cdot u$



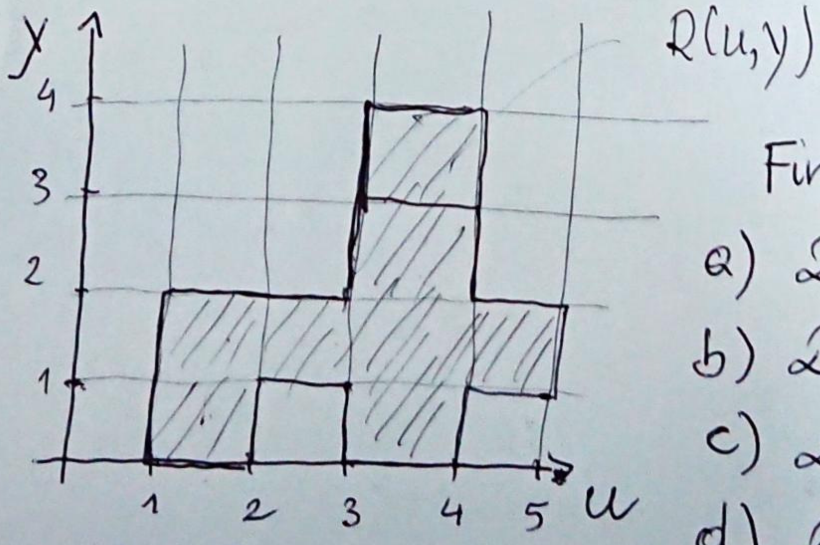
Find $\mathcal{D}_y$ for:

a) $\mathcal{D}_u = \{\hat{u}\}$

b) $\mathcal{D}_u = [u_1, u_2]$

$D_y = ?$

Ex. 5.



Boundary lines (square edges) are included in $R(u,y)$

Find $\mathcal{D}_y$ for

a) $\mathcal{D}_u = \{1.5\}$

b) $\mathcal{D}_u = \{3\}$

c) $\mathcal{D}_u = [1, 3]$

d) $\mathcal{D}_u = [2, 3]$

e) $\mathcal{D}_u = [4.5\ 5]$

Ex. 6. $R(u,y) = \{(1,1), (1,2), (2,1), (2,3), (3,2), (4,1), (4,3)\}$

$U = \{1,2,3,4\}$

$Y = \{1,2,3\}$

Find $\mathcal{D}_y$ for: a) $\mathcal{D}_u = \{1\}$

b) $\mathcal{D}_u = \{1,2\}$

c) $\mathcal{D}_u = \{3,4\}$