Building a Rule-Based Expert System with the CoKE constructivist methodology

Marco Bettoni
Basel University of Applied Sciences (FHBB)

Georges Fuhrer
Ministry of Finance Baselland (FKD BL)

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Agenda

- Part 1 - ATA Case Study: How business rules automation is being used in a Tax Return Assessment (TRA) automation project.
- Part 2 - Constructivist Knowledge View
  Foundations of the constructivist theory of knowledge
- Part 3 - Constructivist Knowledge Engineering (CoKE): How CoKE has been applied to model and implement the knowledge of assessment experts for building the ATA system

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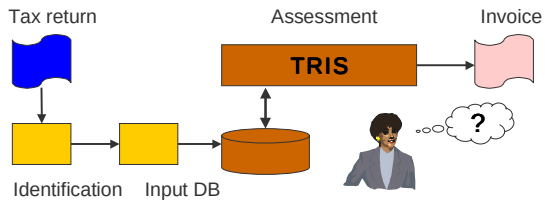
Tax Return Assessment: manual



Assessment = does the case comply with regulations ?

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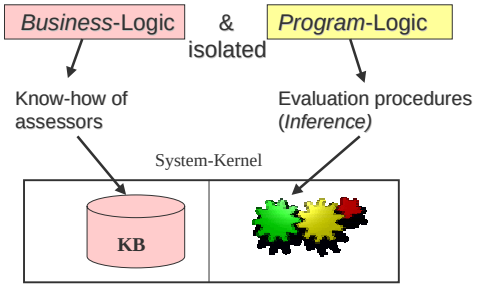
Business Rules Automation



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Allegro Tax Assistant (ATA)

- *Task*: Automated tax return assessment
- *Technology*: Rule-based, object-oriented
- *Tool*: Aion 8 by Computer Associates
- *Delivered*: Productive prototype & system
- *Rules*: 500 expert => 950 system
- *Scope*: employed and unemployed (retired) individuals (with or without real estate)

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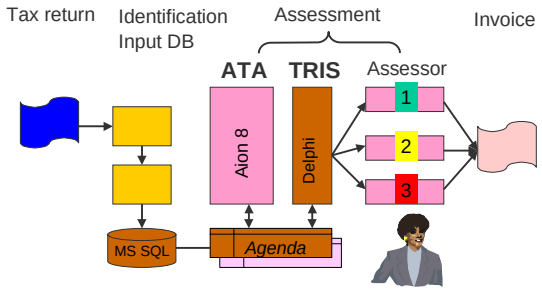
TRA Workflow with ATA



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ATA Architecture: Integration

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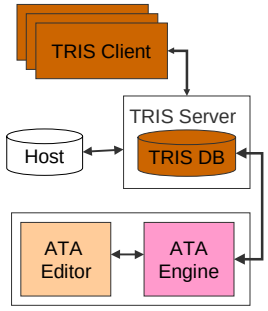

Tax Return Information System (TRIS)
- Identification
- Data Entry
- Assessment
- Special taxes

ATA Expert System
- Automated Assessment of Routine Cases
- Engine Maintenance Without Programming

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Parts

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- Part 1 - ATA Case Study: How business rules automation is being used in a Tax Return Assessment (TRA) automation project (8 slides).
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Knowledge modeling for IT

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- *Find objects*
- *Choose concepts or predicates*
- *Validate objects & concepts*
- *What is modeled ?*
- *What is an object ?*
- *What is a concept ?*
- *What is a model ?*
- *What does a model represent?*
- *What do we do in modeling ?*
- *How do we do it ?*

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Knowledge modeling as ‚mapping'

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Modeling tasks	Knowledge as mapping
Find objects	Are ready-made
Choose concepts or predicates	Are evident / Informally / Invent
Validate objects & concepts	Compare them with reality
What is modeled ?	Reality
What is an object ?	A thing
What is a concept ?	A list of attributes
What is a model ?	A surrogate that matches reality
What does a model represent?	Reality
What do we do in modeling ?	We map reality onto concepts
How do we do it ?	We analyse reality and extract knowledge (mining)

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Common daily words

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look at ..... see

listen ..... hear

➨ *what* we see depends on *how* we look!

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Multiple Perceptions

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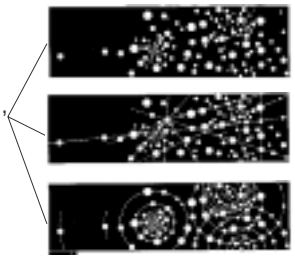
We must become aware ... of the possibility to have multiple perceptions, all equally valid.

(de Bono, 1998, p. 75)



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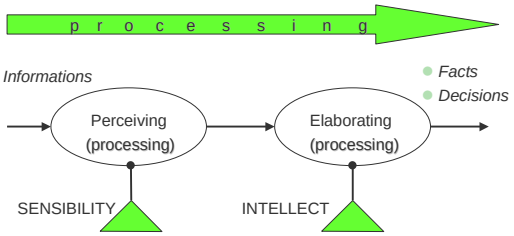
Perception neglected: cognition as ‚information processing'



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Perception neglected: Why?

- Perplexity caused by the uncertainty of perception
  - optical illusions: obstacle or curiosity
- Main strength of the brain: *'efficiency principle'*
  - to see anything in terms of past experiences
  - preference for available patterns

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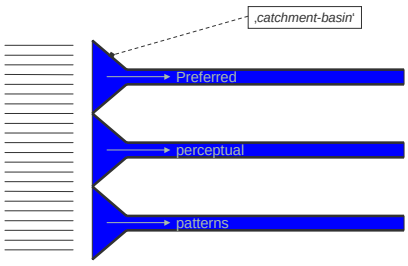
Preferred paths or patterns



(adapted from: de Bono, 1998, p. 14)

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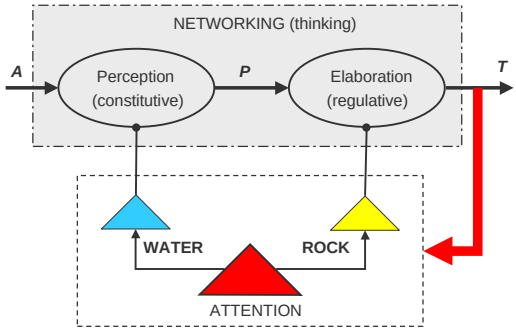
Perception revaluated: Rock Logic & Water Logic



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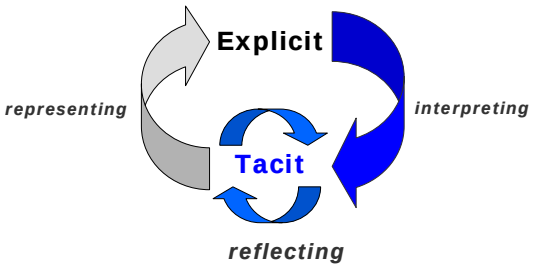
Anatomy of Knowledge: States & Transformations



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What do we do in modeling?

Modelling tasks	Knowledge as mapping	**Knowledge as constructing**
Find objects	Are ready-made	**We determine them tacitly**
Choose concepts or predicates	Are evident / Informally / Invent	**We choose according to schemata and principles**
Validate objects & concepts	Compare them with reality	**We compare them with other objects & concepts**
What is modeled ?	Reality	**Sensation and experience**
What is an object ?	A thing	**The unity of our synthesis**
What is a concept ?	A list of attributes	**A pattern of activity**
What is a model ?	A surrogate that matches reality	**A construction that fits (is viable in) reality**
What does a model represent?	Reality	**Specific experiences**
What do we do in modeling ?	We map reality onto concepts	**We construct generalizations of experiences**
How do we do it ?	We analyse reality and extract knowledge (mining)	**We synthesize knowlege that is viable**

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Knowledge Engineering: Process

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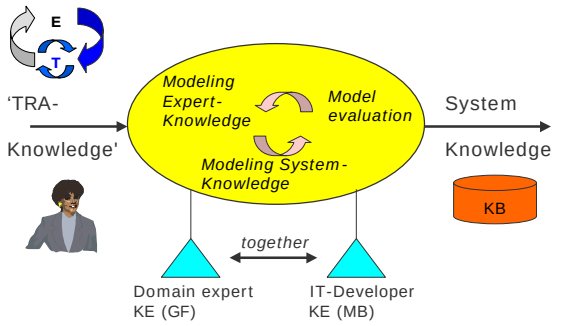

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Modelling Expert-Knowledge

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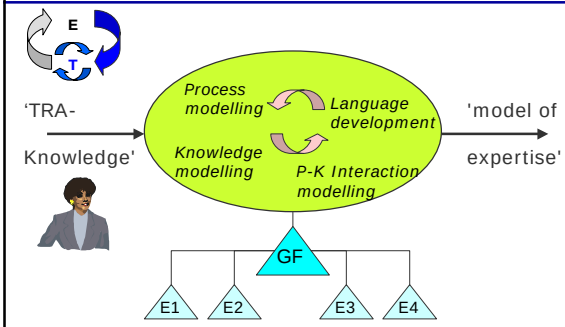

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'Model of expertise': Position 25

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Doc

- System-, Data- & Process-Model
- Knowledge-Model of domain expert
- Problem solving strategy
- Analysis of constraints (TRIS, Host)
- Modify, test strategy
- Develop dependency formula
- Test strategy, develop expert rules
- Pos. 25(97) S *a_025 = Pos. 25 (97) C

Doc

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Expert-Knowledge modeling

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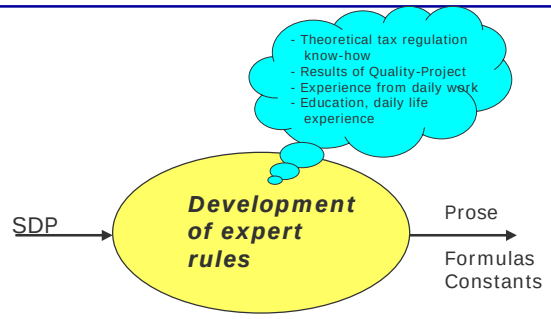

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System-, Data- & Process-Model

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- Increase of *AHV-/IV*-pensions
- System-Model:
  Gris-DB ↔ TRIS ↔ Host
- Data-Model:
  - current declaration in DB
  - assessed declaration of prior tax year
  - Gris-Tables
- Process-Model: Assessment activity

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Model of Expertise: Prose, Formulas, Parameters

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25	*25,01*	*A self-hiring value must be equal to the GRIS value (State tax)*
	25,02	*A self-hiring value must be the same in both years (State tax)*
	25,03	*A self-hiring value must be the same as in the prior tax period (State tax)*
	25,04	*A land-register value of the building (Pos. 101) must be the same as in the prior tax year*

25	**25,01**	**Pos. 25 (97) = s_025a**
	25,02	**Pos. 25 (97) = Pos. 25 (98)**
	25,03	**Pos. 25 (97) = Pos. 25 (96)**
	25,04	**Pos. 101 (97) = Pos. 101 (95)**

s_025a	Sum 025a = all "self_hiring_value_sst" in Tab gris_emw
s_025b	Sum 025b = all "self_hiring_value_bst"in Tab gris_emw

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Test problem solving strategy

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- Applying the rules produced assessment errors in more than 30% of the cases
- Error analysis pointed to host data errors
- Host DB for real estate data was inconsistent with manually assessed tax returns
  - Why this difference ?

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Analysis of constraints

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- Missing data of real estate DB (Gris)
- Gris-Data < > assessed real estate data
- Court decision ‚collective property' was still not implemented in the system
- County of ‚Laufental' assigned to the canton of Baselland: errors in data transfer and in handling of modified or new properties

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Model of Expertise: Rules Decision Tree (1)

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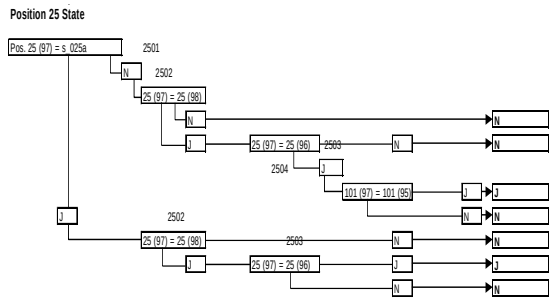

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Model of Expertise: Rules Decision Tree (2)

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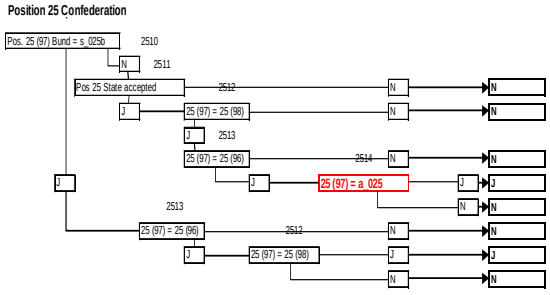

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Development of a functional relation

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- Up to a land-register value of Fr. 204‘800 (self-hiring value Fr. 12‘300) the surcharge for confederation taxes amounts at 71%
- For a land-register value between Fr. 204‘900 and Fr. 340‘800 (self-hiring value between Fr. 12‘400 and Fr. 19‘900) the surcharge for confederation taxes decreases linerly from 71% to 55%
- For land-register value higher than Fr. 340‘800 the surcharge for confederation taxes amounts at 55%

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Function
Pos. 25(97) S *a_025 = Pos. 25 (97) C

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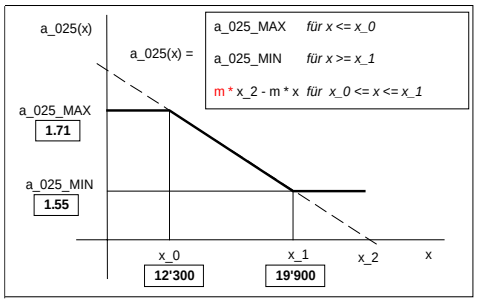

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Modelling System-Knowledge

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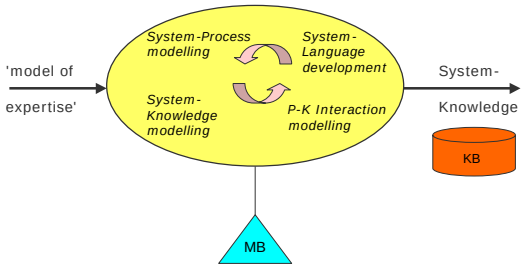

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ATA Knowledge Model: Hierarchy of Facts and Rules

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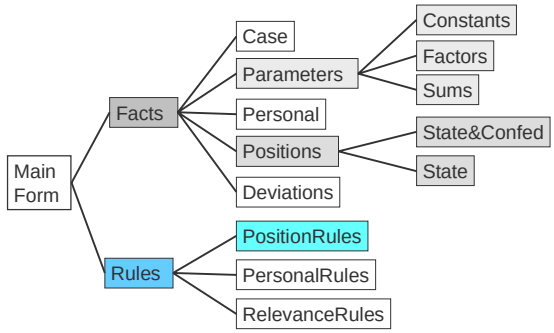

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ATA Knowledge Model: Rule-Classes & Rule-Objects

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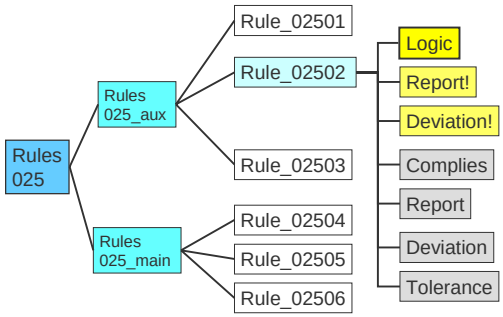

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Constructive Knowledge Engineering - CoKE (1)

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- Constructivist Theory of Knowledge
- Anatomy of Knowledge
- Domain Expert KE & IT-Developer KE
- Domain Expert must be free in modelling
- IT-Developer: Methods & Technology (constraints)
- evolutionary-explorative planning
- Connect modelling & development

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Constructive Knowledge Engineering - CoKE (2)

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- Prototyping
- Development-Prototype
- Integrated Prototype
- Prototype in productive use
- Focus on Routine-Knowledge
- Analysis follows Modelling
- Experiments as Sources of Knowledge

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