Human-like artificial creatures

8. Representation

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Motivation

1. How to evaluate if-then rules in a timely fashion?
2. How to describe virtual world?
   - extensibility
   - semantic meaning for virtual beings
3. What must the creature remember?

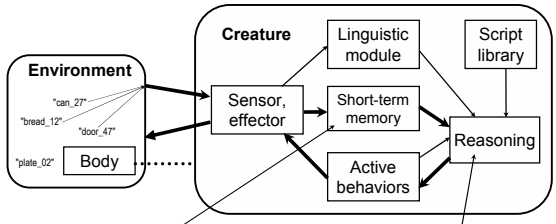
How to represent knowledge!

⇨ Franklin

Outline

1. Logic-based representation
   - RETE
2. Affordances
   - smart objects
   - Gibson
   - IVE
   - computer games
3. Role-passing
4. Deictic representation
   - Pengi
5. Other...

Cognitive paradigm



A condition is...

Memory:

belong(key15, door27) .
water(can27, 15) .
object("key", key15) .
object("door", door27) .
color(key15, "yellow") .

an input

Queries:

belong(+Key, +Door) ?
belong(+Key, -Door) ?
belong(+Key, -Door) &
object("door", -Door) ?

water(+Can, X) & X > 10 ?
object("key", -Key) ?
object("key", -Key) &
color(-Key, "gray")?

all_objects("key", -List) ?

an output

- **if:**
  EXIST x: $d_1(x)$ *?* → yes/no
  ONE x: $d_2(x)$ *?* → ...
  ALL x: $d_3(x)$ *?* → [...]
- what is d_y?
  - an interval of a property value
  - a relation: binary, ternary?
  - a conjunction / a disjunction
- quantifiers?
- first-order predicate calculus?
- not all queries are always allowed...

The ENTs

obtaining a dry bed

a general handle

```
findTheBed( hBed ):-
  query_ObjectsAnywhere( [ "object" = "bed" :
                           "room" = "garden" :
                           "special1" = "dry"],
                         [],
                         sListDryBeds
                       ) ,
  returnTheClosestOne( hBed, sListDryBeds ) ,
```

a memory query

an output: a list of dry beds

EXIST x : d*(x) ? where* d *means "a bed" & "in the garden" & "a dry object"*

an output

The ENTs

is the can empty?

```
if canInHandEmpty then sgFindAndTakeCan fi ,
```

```
canInHandEmpty :-

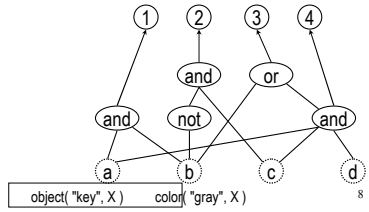
   holdInHand( "can", hCan ),

   NOT state( hCan, "special", "water").
```

EXIST x : d*(x) ? where* d *means "a can" & "in hands" & not "water in it"*

Evaluation - RETE

```
1. if a(x) and b(x)
2. if not(b(x)) and c(x)
3. if [a(x) and c(x) and d(x)] or b(y)
4. if a(x) and c(x) and d(x)
```



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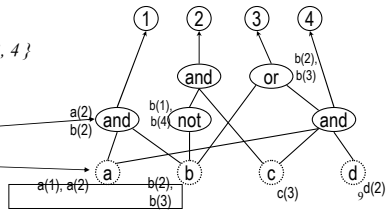
```

x, y from { 1, 2, 3, 4 }

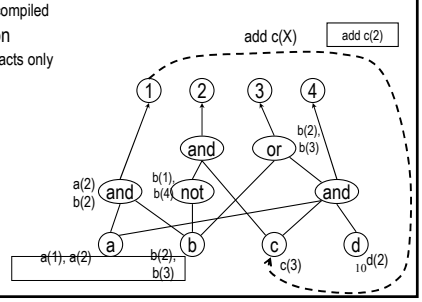
unifications

fetches



Evaluation - RETE

- Fixed set of rules
  - the tree is precompiled
- "Lazy" evaluation
  - evaluate new facts only



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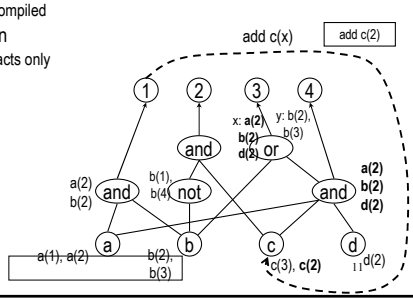
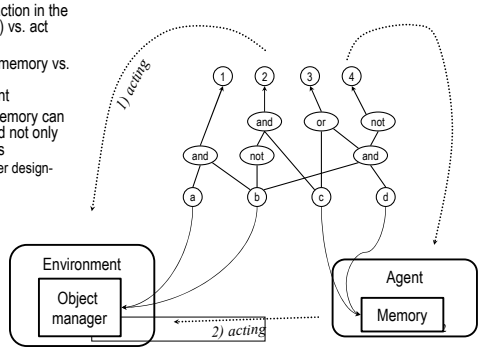


Internal memory vs. external environment

- Store the action in the memory (1) vs. act directly (2)
- Query the memory vs. query the environment
- Working memory can be changed not only by the rules
  - observer design-pattern

[IVE, 2005]



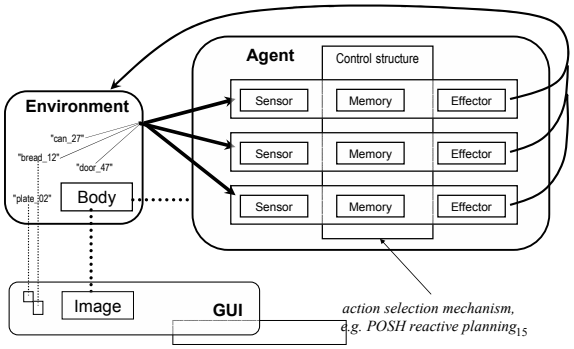
Pros vs. Cons

- Pos:
  - RETE tree & lazy evaluation
  - formalism allows for inference
- Cons:
  - the whole environment must be represented in the same way
  - complicated design
  - remification problem
  - the rules produce "rigid" / "crisp" behaviour (contrary to fuzzy)
  - how to represent space?

Alternatives

- Bryson's approach [Bryson, 2001; Kwong, 2003]
  - but the environment must be still represented somehow
  - it is suitable if one needs "plug-in" approach

Bryson's Behavioural Oriented Agent



Alternatives

- Bryson's approach [Bryson, 2001; Kwong, 2003]
  - but the environment must be still represented somehow
  - it is suitable if one needs "plug-in" approach
- Objects with references
  - it is just another view of logic-based representation
- Affordances
  - formally, it is only a different logic
- 3D environment?
  - high-level representation vs. graphical representation
- Do not use memory at all [Brooks, 1991]
  - but a virtual environment must be still represented somehow
  - creatures needs memory!
  - deictic representation

Brooks

- A robot
- Subsumption architecture
- Perceptual aliasing problem

⇨ Brooks

Outline

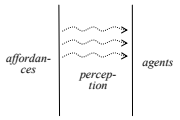
1. Logic-based representation
2. **Affordances**
3. Role-passing
4. Deictic representation
5. Other...

Motivation

- What is the meaning of a symbol?
- How to derive that one can "eat" an "apple" from "the apple?
- Can a "deer" "eat" an "apple" in the same way as a "human"?
- How to manage extensions?
- Could not the creatures perceive action possibilities itself?
  - is it cheating?

Affordances

- How a human perceive its world?
- Gibson [1979]
  - "...the **affordances** of the environment are what it **offers** the animal, what it **provides** or **furnishes**" [Gibson, 1979]
  - relative to a particular actor
  - independent of an actor's ability to perceive it
  - relationships
  - binary
  - positive and negative



- A philosophical question: is it really cheating?
  - What is the appropriate level of abstraction for describing perception?
  - In some situations, we perceive them [Warren, 1984], but sometimes, we don't [Shepard & Metzler, 1971]

Smart objects

- **Smart objects** are objects in a virtual world with the capability to describe and perform its possible actions and interaction with an actor [Kallmann, Thalmann, 1998]
  - low-level actor-object interaction
  - they encapsulate information for a graphical viewer
- They can be loaded as plug-ins
- They can be hierarchically nested
  - a door, a handle
- The Sims?

"Problems" of smart objects

- Actor-subject-object interaction
  - open a can with an opener
- Actor-actor interaction
  - dancing in a couple
- An object affords different actions to different actors
- How can an actor choose among more objects?
  - eat an apple or a goulash from a can that must be opened by an opener?
- How to describe high-level behaviour?

IVE solution

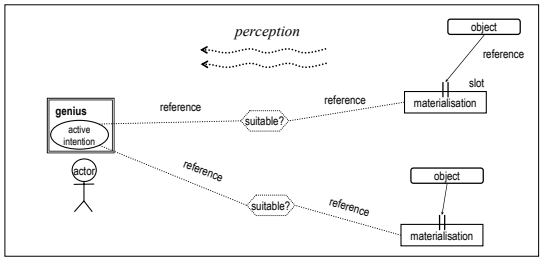
- **Smart activities** ("processes") are abstract entities in a virtual world with the capability to describe and perform its course. They navigate actors.
  - 1..n actors – 1..n object interaction
  - hierarchically nested
- **Suitabilities** are entities placed in a world that mediate perception of activities to actors. Since not all activities are aimed for a particular actor, the actor must first "perceive" the activities that afford him/her participation. This perception is conveyed by suitabilities.
  - a child will not perceive a process of drinking a beer.

IVE – action selection

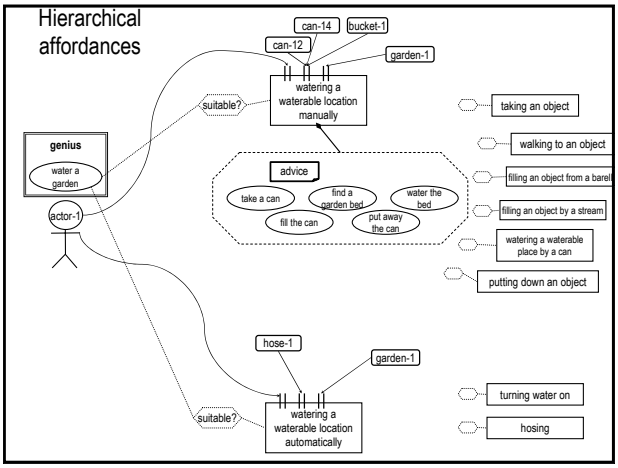
- BDI approach
- Intentions and "plans" are represented within the environment rather then within the creatures minds

1. An actor has a goal. It asks the environment for schemes of the activities that accomplish the goal.
2. The actor chooses a schema and instantiates it (in a heuristic fashion) it with objects or other actors.
   - Suitabilities mediate perception of respective activities. They advise which activity is the best choice for the actor in the given context (e.g., for a miner, to drink a beer would be a better choice than to drink a tea, as opposed to a Buddhist monk).
3. The actor runs the activity instantly, or asks a the activity for sub-goals (and visits the step 1 for each subgoal).

Affordances in IVE - I



Hierarchical affordances



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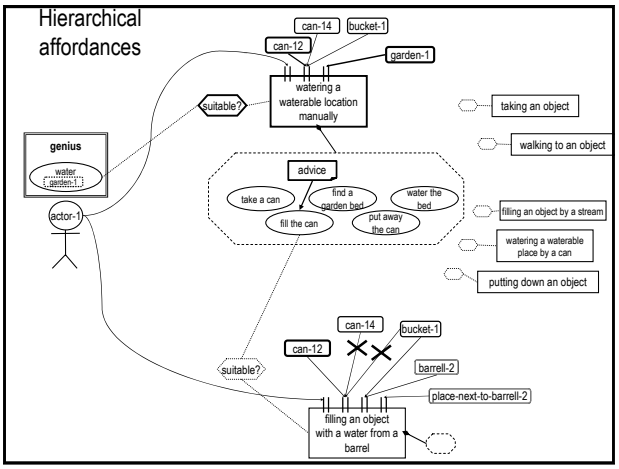
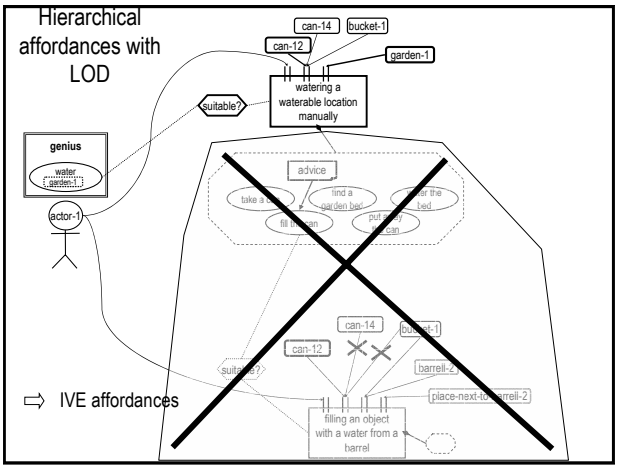


Hierarchical affordances with LOD



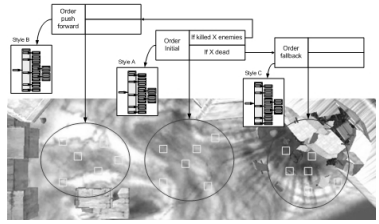
⇨ IVE affordances

Problems

- Planning
  - however, smart objects/suitabilities can pass-on planning operators [Ciger, 2005]
- Learning
  - do we need procedural learning in this kind of applications at all?
  - off-line vs. on-line learning
- Active perception vs. passive perception
  - "laws" – collisions
- Remification problem
  - references?
- Memory?

Affordances in space representation

- way-points
- surrounding information
- navigation mesh
- other cues



[Isla, 2005] (c)

⇨ Jakub Gemrot

Outline

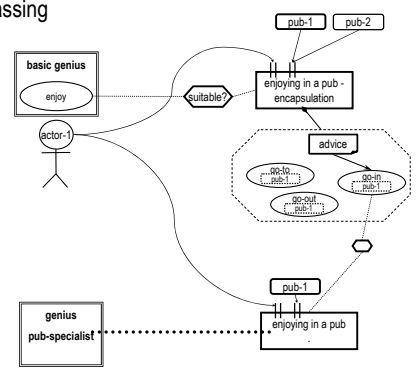
1. Logic-based representation
2. Affordances
3. **Role-passing**
4. Deictic representation
5. Other...

Role-passing

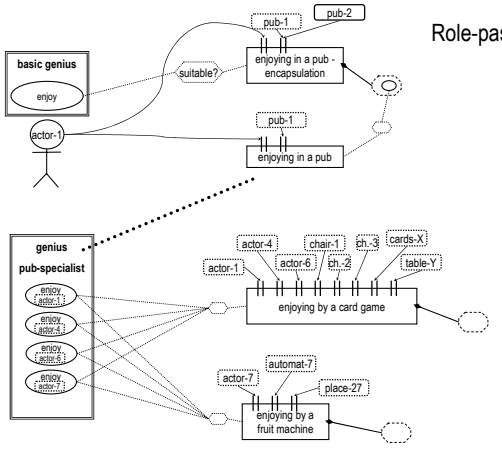
- "Where" to represent artificial mind?
- If you do not know how to simulate a virtual human, delegate the problem to somehow else...
- Centralised vs. emergent approach
  - do not simulate cognitive processes in games!
- Role-passing in IVE:
  - a basic genius can delegate its actor to a genius specialist
  - a pub scenario

[IVE, 2005]

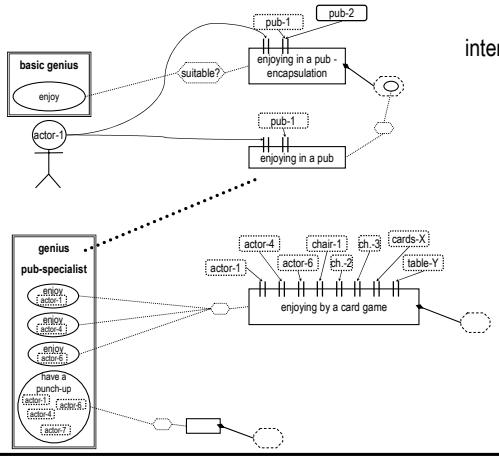
Role-passing



Role-passing



Joint intentions



Outline

1. Logic-based representation
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4. **Deictic representation**
5. Other...

Deictic representation

- Originally used in linguistic, introduced to AI by [Agre, Chapman, 1987]
- Pointer-like variables which refer to a particular object to which the agent is currently attending [Bryson, 2001]
  - name the object according to its role in ongoing activity rather then with "pregiven symbols"
  - "apple" vs. "eat-able", "throw-able" vs.
    "the-object-I-intend-to-eat-up"
  - on(a, b), on-table(b) vs.
    the-object-on-top-of(the-object-I-am-fixated-on)
- IVE
  - a phantom

Pengi I

[Agre & Chapman, 1987]

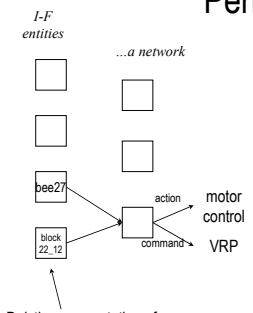
⇨ Pengi

- Autonomous player for Pengo
  - 2D maze of ice-blocks
  - bees chase and try to kill the penguin Pengi
  - penguin and bees can kick blocks, making them slide
- The situation around the penguin is described by **index-functional** (deictic) entities
  - the-block-I'm-kicking, the-bee-on-the-other-side-of-the-block-next-to-me,…
- Properties of the situation in which Pengi finds itself are **aspects**
  - the-block-I'm-going-to-kick-at-the-bee-is-behind-mee

Pengi II

- The central system of the autonomous player does not manipulate with formal symbols (block22_12, bee15). Instead, it manipulate with index-functional entities.
- Index-functional entities are "filled" by a visual-routine-processor
- There is no memory in the central system

Pengi III



- Some visual routines run constantly
  - the-bee-chasing-me
- Others run only under certain circumstances
  - the-block-that-the-block-I've-just-kicked-will-collide-with
  - They are run on demand – that means control mechanism can direct VRP
    - it is a hierarchical approach!
- Logical circuits network
  - emulated

Pengi - recapitulation

- Reactive
- No explicit memory in the central system, but limited "perceptual memory"
- To some extent, it resembles:
  - if-then rules, where antecedents are conjunctions/disjunctions of i-f-entities
  - i-f-entities are similar to neurons of creatures' perception lobe
  - BOD sensing primitives could fill i-f nodes in the network

Outline

1. Logic-based representation
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5. **Other...**

Level of abstraction

- Which level of abstraction is appropriate for the simulation?
  - symbolic, subsymbolic...?
  - sensation vs. perception?
- Combinations
  - High-level decision vs. steering...

Semantic knowledge

- Ontologies, frames...
  - How many legs does the chair have?
  - Is the carrot vegetable?

Conclusion

- Representation = the way how we describe the world, the language, the terminology
- There is no "unified, general-purpose" representation
  - neither first-order predicate logic, nor affordaces
- What do we model?
  - ethology: biological plausibility
  - computational neuroscience: physiological plausibility
  - games: plausibility concerning the story (immersion)

End.

References

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