Frames for sortal, relational, and functional concepts

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CTF 2007, Düsseldorf
1. Classification of concepts (Löbner)

2. Frames
   - Definition of frames
   - Classification of frames

3. Attributes and type signatures
   - Attributes and functional concepts
   - Type signatures and minimal upper attributes
Outline

1. Classification of concepts (Löbner)

2. Frames
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   - Attributes and functional concepts
   - Type signatures and minimal upper attributes
1 Classification of concepts (Löbner)

2 Frames
- Definition of frames
- Classification of frames

3 Attributes and type signatures
- Attributes and functional concepts
- Type signatures and minimal upper attributes
Concept classification

person, pope, house, verb, sun, Mary, wood, brother, mother, meaning, distance, spouse, argument, entrance
## Concept Classification: Relationality

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-relational</td>
<td>person, pope, house, verb, sun, Mary, wood</td>
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## Concept Classification: Uniqueness of Reference

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Löbner
## Concept Classification

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Löbner
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Lübner
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- Frames provide the fundamental representation of knowledge in human cognition.
- At their core, frames contain **attribute-value sets**.
Classification of concepts

Example: passport frame

Concept Frames

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Classification of concepts

Frames

Attributes and type signatures

**lolly-frame**

![Diagram of a lolly frame with attributes and type signatures]
Frame definition

Frames are rooted, connected, directed graphs with:

- one central node (here: double-encircled)
- nodes labeled with types
- arcs labeled with attributes
- no node with two equally labeled outgoing arcs
type hierarchy and frame subsumption
Definition

A node is a root of a frame if all other nodes can be reached from it by a path of directed arcs.
**terminology**

**Definition**
A node is a **root** of a frame if all other nodes can be reached from it by a path of directed arcs.

**Definition**
A node is a **source** if it has no incoming arc.
**lolly-frame (sortal concept)**

- **lolly**: sortal concept
- **body**: COLOR, SHAPE
  - **red**: COLOR
  - **round**: SHAPE
- **stick**: BODY, PRODUCER, COLOR, SHAPE
  - **green**: COLOR
  - **long**: SHAPE
- **factory**: PRODUCER
**lolly-frame (sortal concept)**

![Diagram of the lolly-frame concept]

- **Central node**: root = source

**Concept Frames**

- **Frames**: lolly-frame
  - **Attributes and type signatures**
  - COLOR, SHAPE, PRODUCER

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*stick-frame* (functional concept)
stick-frame (functional concept)

central node \neq \ root = \ source
sister-frame (proper relational concept)
sister-frame (proper relational concept)

- person
- female
- MOTHER
- FATHER
- no root & central node = source
classification of acyclic frame graphs

C: central node, R: root, S: source

<table>
<thead>
<tr>
<th>C = R</th>
<th>C = S</th>
<th>∃R</th>
<th>∃S</th>
<th>typical graph</th>
<th>frame class</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td>sortal</td>
</tr>
<tr>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
<td></td>
<td>functional</td>
</tr>
<tr>
<td>−</td>
<td>+</td>
<td>−</td>
<td>+</td>
<td></td>
<td>proper relational</td>
</tr>
<tr>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td></td>
<td>???</td>
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Concept Frames
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4th frame class: not lexicalized?

relational concept: father of a niece
4th frame class: not lexicalized?

brother in law

Concept Frames

Wiebke Petersen
4th frame class: not lexicalized?

brother in law

Concept Frames

Wiebke Petersen
4th frame class: not lexicalized?

brother in law

“male person who is the spouse of someone who has a sibling”

“male person whose spouse has a sibling”
concept classification and frame graphs

relationality

The arguments of relational concepts are modeled in frames as sources that are not identical to the central node.

functionality

The functionality of functional concepts is modeled by an incoming arc at the central node.

conclusion

The concept classification is reflected by the properties of the frame graphs.
concept classification and frame graphs

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attributes in frames

Barsalou, 1992: *Frames, Concepts, and Conceptual Fields*

“I define an attribute as a concept that describes an aspect of at least some category member.”

Guarino, 1992: *Concepts, attributes and arbitrary relations*

“We define attributes as concepts having an associate relational interpretation, allowing them to act as conceptual components as well as concepts on their own.”
interpretation of functional concepts

denotational interpretation
A functional concept denotes a set of entities:

\[ \delta : \mathcal{R} \to 2^\mathcal{U} \]

\[ \delta(\text{mother}) = \{ m \mid m \text{ is the mother of someone} \} \]

relational interpretation
A functional concept has also a relational interpretation:

\[ \varphi : \mathcal{R} \to 2^{\mathcal{U} \times \mathcal{U}} \]

\[ \varphi(\text{mother}) = \{ (p, m) \mid m \text{ is the mother of } p \} \]

consistency postulate (Guarino, 1992)
Any value of an relationally interpreted functional concept is also an instance of the denotation of that concept.

If \((p, m) \in \varphi(\text{mother})\), then \(m \in \delta(\text{mother})\).
### denotational interpretation

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attributes in frames

thesis:
Attributes in frames are relationally interpreted functional concepts!

consequence (1):
Frames decompose concepts into relationally interpreted functional concepts!

consequence (2):
The distinction between the attribute set and the type set is artificial: \( \text{ATTR} \subseteq \text{TYPE} \).
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Barsalou, 1992: *Frames, Concepts, and Conceptual Fields*

“I define an attribute as a **concept** that describes an aspect of at least some category member.”

“Values are subordinate concepts of an attribute.”
**Definition**

A **minimal upper attribute** of a type is a minimal element of the set of upper attributes of the type. Where an upper attribute of a type is an attribute which is a supertype of the type.
red apple

Classification of concepts
Frames
Attributes and type signatures

Concept Frames
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Classification of concepts

Frames

Attributes and type signatures

ATTR \subseteq TYPE

object
  TASTE: taste
  TEMPERATURE: temperature
  COLOR: color
  SHAPE: shape

apple
  SHAPE: round

pepper

TASTE: taste
temperature
color
SHAPE: shape
sour sweet hot cold red green blue round long

red apple

Concept Frames

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Classification of concepts

Frames

Attributes and type signatures

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red apple

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Classfication of concepts

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red apple

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Classification of concepts

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taste
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sour sweet hot cold red green blue round long

red apple

apple
COLOR red
SHAPE round
taste
What is a red lolly?
What is a red lolly?
What is a red lolly?
What is a red lolly?
What is a red lolly?
polysemy

hot pepper?
polysemy

taste

sour sweet hot cold
temperature

hot pepper?
polysemy

- Taste
- Temperature
  - Sour
  - Sweet
  - Hot
  - Cold

hot pepper?
polysemy

taste  temperature

sour  sweet  hot  cold

hot pepper?
logical reformulation of a frame

\[ \lambda x \exists y_1 \exists y_2 \exists y_3 \exists y_4 \exists y_5 \]
\[ \text{lolly}(x) \land \text{body}(y_1) \land \text{stick}(y_2) \land \text{red}(y_3) \land \]
\[ \text{long}(y_4) \land \text{factory}(y_5) \]
\[ \land \text{BODY}(x) = y_1 \land \text{STICK}(x) = y_2 \]
\[ \land \text{COLOR}(y_1) = y_3 \land \text{SHAPE}(y_2) = y_4 \]
\[ \land \text{PRODUCER}(y_1) = y_5 \land \text{PRODUCER}(y_2) = y_5 \]
\[ \land \text{PRODUCER}(y_1) = \text{PRODUCER}(y_2) \]

\[ \iff \]

\[ \lambda x \text{lolly}(x) \land \text{body(BODY}(x)) \land \text{stick(STICK}(x)) \land \]
\[ \text{red(COLOR(BODY}(x))))) \land \]
\[ \text{long(SHAPE(STICK}(x))) \land \]
\[ \text{factory(PRODUCER(COLOR(BODY}(x))))) \land \]
\[ \land \text{PRODUCER(BODY}(x)) = \text{PRODUCER(STICK}(x)) \]
The concept classification is reflected by the graph-theoretical properties of the associated frame graphs.

Attributes in frames are relationally interpreted functional concepts and therefore, frames decompose concepts by means of functional concepts.

Type signatures provide a powerful tool for reducing redundancies in frame-based systems.
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summary

- The concept classification is reflected by the graph-theoretical properties of the associated frame graphs.
- Attributes in frames are relationally interpreted functional concepts and therefore, frames decompose concepts by means of functional concepts.
- Type signatures provide a powerful tool for reducing redundancies in frame-based systems.


### origin of the pictures

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<tbody>
<tr>
<td>Hot pepper (1)</td>
<td><a href="http://www.sxc.hu/pic/m/a/an/anissa/39574_hot_pepper.jpg">http://www.sxc.hu/pic/m/a/an/anissa/39574_hot_pepper.jpg</a> (17/08/2007)</td>
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