Ontology, semantic map, cognitive scheme

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Upper ontology
- Ontology of third level concepts
  - Semantic-cognitive schemes
- Ontology of second level concepts
  - Classes of linguistic markers (indicators + clues)
- Ontology of first level concepts
  - Classes of instances

Cognitive and semantic foundations
Summary of the Presentation

- Three levels of ontologies
  - First level: Domain Ontology and LDO (Logic of Determination of Objects)
  - Second level: The semantic maps is used for a construction of domain ontologies from automatically annotated texts
  - Third level: Upper Ontology for the description of the meaning of concepts

- Aspectual values (State, Event and Process): towards an Ontology of Time and Space
1/ First level Domain Ontologies

First level Ontologies and Logic of Determination of Objects (LDO)

Extension and intension of a concept ‘f’ in a Simple Taxonomic Ontology

- Extension (Ext(f))
- Intension (Int(f))
- Instances: {x}, {y}
- Elements: x1, x2, y1, y2, y3
\[ x_1 = \delta(g_1)(\tau(f)) \]
\[ x_2 = \delta(g_2)(\delta(g_1)(\tau(f))) \]
\[ \vdots \]
\[ x_n = \delta(g_n) (... (\delta(g_2)(\delta(g_1)(\tau(f))) ...)) \]

A problem of Inheritance

<table>
<thead>
<tr>
<th>‘Good’ Deduction:</th>
<th>‘Bad’ Deduction:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) All men have two feet</td>
<td>(4) A man has two feet</td>
</tr>
<tr>
<td>(2) Aristotle is a man</td>
<td>(5) John is a man</td>
</tr>
<tr>
<td>(3) \therefore Aristotle has two feet</td>
<td>(6) John has only one foot</td>
</tr>
<tr>
<td>(7) \ast John has two feet</td>
<td></td>
</tr>
</tbody>
</table>

If we accept as general knowledge:

(8) the property “to have two feet”

“incompatible” with:

(9) the property “to have only one foot”

then the following contradiction arises:

(9) John has only one foot and John has two feet.
John to be a man
has two feet
∈
⊆
∈
has only one foot
Int(be-a-man)
contradiction
Int (John)
τ
(f)
Expansion (f)
z
Ext τ (f)
Typical object
does not belong to Expansion(f)
δ(g1) (τ(f))
δ(g2) (τ(f))
Typical fully specified instances
Ext (f)
2/ How to build a Domain Ontology?

Second Level Ontologies and Semantic maps
Building Domain Ontologies from texts

Semantic relations between concepts: examples

- This concept f is a part of the concept g;
- A relation is a localization;
- A relation of causality;
- A concept f is defined by an integration of more elementary concepts g₁, ..., gₙ;
- A concept is related to a process, or to a state
- This concept designates an activity;
- ....
Notion of connexion between individuals

• Who has met whom?
• Where?
• When?

« Qui est avec qui ? »
Who has met with who?
When? Why?
Semantic Map (intension) of a notion

Notion 1

Notion 1.1.

Class of linguistic markers of the notion 1

Class of linguistic markers of the notion 1.1.

CE rules for the notion 1

Class of linguistic markers of the notion 1.2.

CE rules for the notion 1.2.

Notion 1.2.

Notion 2

Class of linguistic markers of the notion 2

CE rules for the notion 2

Contextual Exploration Rule: IND I1 et I2 at left & I3 and I4 at right
THEN annotate according to a viewpoint
An example of annotation: Topic announcement

Research space: a sentence

Clues

Hypothesis I1 = my

Indication of hypothesis IND = is expressed as follows:

Hypotheses

Conclusive remarks

Goals

Results

Class of linguistic markers of goals

Class of linguistic markers of conclusive remarks

Class of linguistic markers of results

CE rules for « hypotheses »

CE rules for « goals »

CE rules for « results »

Class of linguistic markers of the notion 1.1.
Engine for texts Annotation by Contextual Exploration

Viewpoints for text Mining

Linguistic resources according to a viewpoint for text mining

Viewpoint « meeting »
Viewpoint « quotations »
Viewpoint « causality »
Viewpoint « definition »
Viewpoint « temporal information »

Texts

Linguistic Resources for segmentation

Segmented Texts

1

2

3

4

Annotated Texts

Linguistic Theory
Discourse markers theory
Ontology of « viewpoints » Semantic maps (Level 2)
Instances classes of markers of relations
Domain Ontologies (Level 1)
Object classes (instances)

Terminology extractor
EXCOM
Annotated Texts

To populate ontologies
3/ Third Level Ontologies: Upper and General Ontologies

Cognitive Semantics Schemes

Scheme = a formal representation of a meaning
(relations, verbal predicates, topological prepositions ...)
Cognitive and Applicative Grammar (CAG) (Desclés, 1990, …)

**Semantico-cognitive representations Generated by Schemes**

- Lexical Analysis
- Lexical Synthesis

**Logico-grammatical Representations By means of applicative expressions**

- Categorial Analysis
- Categorial Synthesis

**Morpho-syntaxic Configurations in Natural Language**

**Semantic Interpretation**

**Extended Categorial Grammars**

Scheme of TO ENTER in « The flight A05 enters the area ZU3 »

- SIT 1\([x,y]\)
- MOV'T
- SIT 2\([x,y]\)

\[ \text{enters' (z, y)} \]

\[ \text{Integrating cognitive units into a lexical predicate} \]

\[ \text{y := the flight A05} \]
\[ \text{z := the area ZU3} \]
The Meaning of TO ENTER

- \([ \text{enters'} = \text{def} \ X \ \text{MOVT REP EXT INT} \ ]\)

- The meaning of the lexical predicate is given as a functional (applicative) combination of the primitives:

  \[
  \text{MOVT, REP, ext and int}
  \]

  with an applicative program expressed by the Combinator ‘X’ of Combinatory Logic
Scheme of **TO ENTER** in
« The Agent X007 enters the area ZU3 »

\[
\begin{align*}
\text{SIT 1}[x,y] & \quad \text{MOVTE} \quad \text{SIT 2}[x,y] \\
< x \text{ REP (ext (Loc(z))) } > & \quad \text{=} \quad < x \text{ REP (int (Loc(z))) } > \\
\end{align*}
\]

\[
\text{[ enters } z' \text{ =def Z CONTR MOVTE REP ext int Loc ]}
\]

\[
\text{x := The agent X007 (an Agent)} \\
\text{z := the area ZU3 (a Localizer)}
\]

Scheme of **TO GET** in
« The agent X007 gets the flight Y05 into the area ZU3 »

\[
\begin{align*}
\text{SIT 1}[x,y] & \quad \text{MOVTE} \quad \text{SIT 2}[x,y] \\
< y \text{ REP (ext (Loc(z))) } > & \quad \text{=} \quad < y \text{ REP (int (Loc(z))) } > \\
\end{align*}
\]

\[
\text{[ enters } 3' \text{ =def U CONTR MOVTE REP ext int Loc ]}
\]

\[
\text{x := an Agent} \\
\text{y := a Patient} \\
\text{z := a Localizer}
\]
« A sells B to C »
figurative scheme

Field of A

\[ B \text{ in } \text{int}(\text{Loc}(A)) \]
\[ D := \text{money} \]

Field of B

\[ B \text{ is } \text{int}(\text{Loc}) \]
\[ D := \text{money} \]

Agents: A, C

< B REP (ext (Loc(C))) >
< B REP (int (Loc(A))) >
< C OWNS D >
< A OWNS D >
NON < A OWNS D >
NON < C OWNS D >

CHANG

< B REP (int (Loc(C))) >
< B REP (ext (Loc(A))) >
< A OWNS D >
< C OWNS D >

Scheme of TO SELL in
« A sells B to C »

\[ \exists D := \text{qnt (money)} \]

SIT 1 [A,B,C]

< B REP (ext (Loc(C))) >
< B REP (int (Loc(A))) >
< C OWNS D >
NON < A OWNS D >

SIT 2 [A,B,C]

< B REP (int (Loc(C))) >
< B REP (ext (Loc(A))) >
< A OWNS D >
NON < C OWNS D >

CHANG

CONTR

A, C

\[ \text{sells'} := \text{def } U \text{ CONTR CHANG OWNS REP ext int Loc (}\exists D \text{)} \]

A := Agent
B := Patient
C := Receiver
\[ \lambda z \cdot \lambda y \cdot \lambda x \cdot O_1 \cdot \lambda O_2 \cdot \lambda F \]
\[
\left\{ \begin{array}{l}
\langle x \ \text{CONT} \ (\exists \ D := \text{qnt (money)} \ \text{such that} \rightangle \\
(\langle y \ \text{REP ext (Loc(z))} \rangle \ \text{AND} \ y \ \text{REP int (Loc(x))} \ \text{AND} \ z \ \text{OWNS D} \rangle)_{O_1} \\
\text{MOVT} F \\
(\langle y \ \text{REP int (Loc(z))} \rangle) \ \text{AND} y \ \text{REP ext (Loc(x))} \ \text{AND} \ x \ \text{OWNS D} \rangle_{O_2} \right\}
\]

with temporal conditions:

- \( O_1 \) and \( O_2 \) are open intervals of instants
- \( F \) is a close interval of instants (a transition)
- \( O_1 < F < O_2 \) and \( d(O_1) = g(F) \); \( d(F) = g(O_2) \)

\[ d(O_1) = g(F) \quad d(F) = g(O_2) \]

---

The book **is on** the table

\[ \text{(is (on (the-table))) (the-book)} \]
\[ \langle \text{the-book} \ \text{Rep} \ \text{ON} \ (\text{the-table}) \rangle \]
\[ \langle \text{the-book} \ \text{Rep} \ (\text{Boundary (Loc (the-table))}) \rangle \]
\[
\left\{ \begin{array}{l}
\text{ON} = \text{Boundary} \circ \text{Loc} \\
\text{IS} = \text{Rep} \circ \text{ON} \end{array} \right\}
\]
Static, Cinematic, Dynamic Primitives

• **Field of PERCEPTION** :
  - **STATIC** :
    - topologic location
    - static relations ($\in$, $\subseteq$, $\varepsilon$, localization …)
  - **CINEMATIC** :
    - motion, change

• **Field of ACTION** :
  - **DYNAMIC** :
    - control, doing, teleonomy

DYNAMICAL SYMBOLIC SCHEME
by embedding of static situations inside a cinematic situation

( Dynamical situation : **CONTROL**

( Cinematic situation : **MOVement**

  (static SITUATION : Locating 1)
  (static SITUATION : Locating 2 ) ) )
Semantico-cognitive dynamic scheme

Dynamic SITUation

Cinematic SITUation

Static SITUation 1

< Y Rep Z1 >

MOVT

Static SITUation 2

< Y Rep Z2 >

CONTROLS

X

Schemes Embedding

STATICS
CINEMATICS
DYNAMICS
CAUSALITY
Cognitive and Applicative Grammar (CAG) (Desclés, 1990)

Semantico-cognitive representations Generated by Schemes

Lexical Analysis  ➔  Lexical Synthesis

Logico-grammatical Representations By means of applicative expressions

Categorial Analysis  ➔  Categorial Synthesis

Morpho-syntactical Configurations of a Natural Language

Semantic Interpretation

Extended Categorial Grammars

4/ Notions and Properties of Aspects
Aspectual Values of a Predicative Relation R

![Diagram showing aspectual values of a predicative relation R]

- **STATE (R)**
- **EVENT (R)**
- **PROCESS (R)**

changes

- Open interval
- Closed interval
- Left closed interval
State (R) is True
\[ \exists I \text{ such that } \forall t : (t \in I) \implies \text{Eval}(\text{State}(R), t) = \text{« True »} \]

Process (R) is True
\[ \exists J \text{ such that } \forall t'' : (t'' \in J) \wedge (t'' < t = d(J)) \implies \text{Eval}(\text{Process}(R), t'') = \text{« True »} \]

Event (R) is True
\[ \exists F \text{ such that } (t = d(F)) \implies \text{Eval}(\text{Event}(R), t) = \text{« True »} \]

(a')

PROCESS
The hunter is shooting the deer

(b')

STATE (« he is happy »)
RESULTING-STATE
The hunter has schot the deer

(c')

PROCESS
The hunter was shooting the deer (when) ...

(d')

EVENT
The hunter shot the deer
When accomplished, it generates a transition between two states.

\[ \text{d(F)} = \text{g(O)} \]
Semantic Map of Aspects

State
- Descriptive State
- New state
- Resulting State
- End State

Process
- Non-interrupted Process
- Progressive Process

Event
- Non-completed Event
- Completed Event

Sequence of discrete occurrences (Events, Processes, States)

STATE

Descriptive State
- Permanent State
- Contingent State

Event
- Consequent State
- Resulting State
- New State

Underlying process
- Implies State of activity

STATE

Descriptive State
- Permanent State
- Contingent State

Event
- Consequent State
- Resulting State
- New State

Underlying process
- Implies State of activity
5/ Towards an Ontology of Time

Notion: Time

located inside a reference framework: \textit{Ref}

is-in-interval: \textit{Int}

topological: \textit{Int}

with boundaries: \textit{Int}

closed: \textit{Int}

with-an-open-boundary: \textit{Int}

with-a-closed-boundary: \textit{Int}

is-an-instant: \textit{T}

is-a-boundary: \textit{T}

begin: \textit{T}

end: \textit{T}

Types: instant: \textit{T}

Interval: \textit{Int}
Properties of the relators: $\in$, $\varepsilon$, $\subseteq$, $\delta$

- $X \in Y \iff \forall u, \forall v : [X(u) \Rightarrow (Y(v) \Rightarrow u \in v)]$
  $\in : F(F(FYH)H)(FXH)H$

- $X \varepsilon Y \iff \forall u : [X(u) \Rightarrow (Y(u) ]$
  $\varepsilon : F(FXH)F(FXH) H$

- $X \subseteq Y \iff \forall u, \forall v : [X(u) \Rightarrow (Y(v) \Rightarrow u \subseteq v)]$
  $\subseteq : F(FYH)F(FXH)H$

- $X \delta Y \iff \forall u : [ Y(u) \Rightarrow \exists v : [ X(v) ; u = \delta(Y)(v) ]$
  $\delta : F(FXH)F(FYH)H$

Predication / determination

$\forall t : [\text{is-begin } t]$
  $\Rightarrow \text{is a boundary } t$
  $\Rightarrow \text{is-an-instant } t$
  $\Rightarrow \text{is-in-an-interval } t$

$\forall t : [\text{is-begin } t]$
  $\Rightarrow \text{is a boundary } t$
  $\Rightarrow \text{is-an-instant } t$
  $\Rightarrow \text{is-in-an-}$
  $\text{(closed)}$
  $\text{(boundary)}$
  $\text{(topological)}$
  $\text{(interval))]}$
6/ Temporal Reference Systems

Enunciative Reference system

External Reference System

Enunciative process

T0

J0

tg

tm

td

Enunciative external event
Retrospective organization from the memory

Organization from the chronology of realized events

Realized

No realized

PAST

FUTURE

Enunciative Process

T0

Rupture relation « # » between two Reference Systems
No-concomitance « ≠ » between two instants
NARS = « Non-Actual Reference System » ;
ENRS = « Enunciative Reference System » ;
EXRS = « External Reference System »

\[ \text{EVENT 1} \prec \text{EVENT 2} \prec \text{EVENT 3} \]

\[ \text{EVENT} \prec \text{T0} \]

\[ \text{TIME} \]

NARS = « Non-Actual Reference System »
ENRS = « Enunciative Reference System »
EXRS = « External Reference System »

Reported Events

Realized Events
When two events $Ev_1$ and $Ev_2$ overlap, the linguistic expression of the overlap entails a decomposition of the first event into an initial process and a final event.

**Overlap of Two Events**

**Overlap of Two States**

**Overlap of Two Process**
7/ Theory of Abstract Places with Inner) Interior and (outer) Exterior Boundaries
Different phases (stages) of an EVENT

An Activity State => an underlying Process

Complete event

State Activity: *The plane is in flight*

PROCESS: *The plane is flying*

RESULTING STATE:
The plane has flown
Cognitive and semantic foundations

Annotated texts

TEXTS

Linguistic resources

EXCOM Engine for automatic semantic annotations

Upper ontology

Ontology of third level concepts
Semantic-cognitive schemes

Ontology of second level concepts
Classes of linguistic markers (indicators + clues)

Ontology of first level concepts
Classes of instances

USER

Thank you for your attention!
References


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General Ontologies

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• Sowa
• SUO (IEEE working group)
• BFO (Barry Smith)
• Cyc
• CAGO (Desclés & alii)