An interactive pattern-based approach for extracting non-taxonomic relations from texts

Marie Chagnoux, Nathalie Hernandez, Nathalie Aussenac

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What do we build ontologies for?

**Information Retrieval**
- semantic automatic indexation of texts
- need for ontologies
  - with a structure (concepts, relations, instances)
  - a large lexical component

**Ontology and Texts**

Diagram showing the flow from texts to ontologies through ontology engineering and population.
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**Ontology and Texts**

- Ontology Engineering
- Ontology Population
- Semantic Annotation
- Ontologies
How to build an ontology?

General Issues
- how to assist the ontologist?
- how to articulate learning strategies and manual technics?
- how to exploit text richness (and how to deal with specific text issues)?
How to build an ontology?

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Progression

1. **State of the art**
   - Semantic relations
   - Relation Extraction
   - Pattern Approaches

2. **Pattern Approach Contribution**
   - Cameleon
   - Evalution
   - Going further evaluation

3. **Framework**
   - General Overview
   - Processing Steps
   - Interactive Interfaces
1. State of the art
   - Semantic relations
   - Relation Extraction
   - Pattern Approaches

2. Pattern Approach Contribution

3. Framework
What is a relation?

- taxonomic relations
- transversal relations

What is "really" a relation?
Relations within Ontologies

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What is "really" a relation?

- FlightPhases
  - TakingOff
  - InFlight
  - Landing

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Pattern-based Approach
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- INITIATE
- REFUSE
- BEGIN
- END
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Pattern-based Approach
Linguistics Issues

- **polysemy**: "plant"
- **metonymy**: "the pilot climbed to height 600 m"
- **anaphora**: "The Airbus A310 is a medium to long-range widebody airliner manufactured by Airbus SAS. It was the second model to be introduced by Airbus after the A300"

Main conceptual issue

- "American General Electric CF6-50 engines powered the A300"
- "The Airbus A318 Elite will be powered by CFM engines"

\[ \text{POWER}(c_i, c_j) \]
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Existing Approaches

- **Manual approaches**
  - expert building

- **Engineering approaches**
  - resources exploitation

- **Fusion approaches**
  - ontology mapping

- **Dictionaries, thesaurus, lexicon**

- **Texts**

- **Databases and semi-structured data**

- **NLP**

- **Hybrid approaches**

- **Statistics & Learning approaches**
  - clustering
  - neuronal network
  - bayesian network
  - Markov
  - genetic algorithms
  - Kohonen maps

- **Distributionnal Analysis Pattern Approaches**
Linguistic Approaches

Distributional Approaches
- terms sharing similar contexts may be related
  - ontology - taxonomy
  - insert in X, organize in X, structure in X, built X, etc.

Pattern-based Approaches
- morphosyntactic reproducible pattern
  - ONTOLOGY
  - TAXONOMY
  - ...is a kind of...
  - ...is richer than...
### Linguistic Approaches

<table>
<thead>
<tr>
<th>Distributional Approaches</th>
<th>Pattern-based Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>terms sharing similar contexts may be related</td>
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|                           | ...is richer than...      | TAXONOMY           |
Pattern based Approaches : Hearst Proposal

[Hearst 1992]

“...identify a set of lexico-syntactic patterns that are easily recognisable, that occur frequently and across text genre boundaries, and that indisputably indicate the lexical relation of interest...”

Illustration

"The bow lute, such as the Bambara ndang, is plucked [...]"

- hyponym relation inherent to construction : “X such as Y".
- identification of potential patterns for a specific kind of semantic relation resulted from the human interpretation of their occurrences
Pattern based relation extraction

Example

“The heads report to the vice president”

- lexical pattern: X report to Y
- lexico-syntactic pattern:
  - PREP-X report to the Y
  - PREP-X VB IN DT Y
  - PREP-X MD VB to DT Y
  - PREP-X MD VB-report to DT Y
  - PREP-X MD report to DT Y
  - PREP-X MD VB to DT Y

- compromise between
  - constrained and marginal structures
  - excessively permissive structures
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  - \( P^{REPORT}_4 \): X MD [report] to the Y
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“*The heads will directly report to the executive vice president*”

- compromise between
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Patterns for ontology enrichment

NLP Preprocessing
- tokenization
- lemmatization
- POS tagging

Processing steps
1. Pattern building
2. Pattern matching process
3. Mapping of the terms related by the pattern to ontology lexicon
   - Identification of the concepts
   - Identification of the structural level

Hypothesis
- several patterns express the same relation
- possible relation types depend on the corpus
- for a given relation type, patterns depend on the corpus
2. State of the art

Pattern Approach Contribution
- Cameleon
- Evalution
- Going further evaluation

3. Framework

Pattern-based Approach
A support for relation extraction

1 – Identify semantically rich phrases
2 – Concept and relation definition
3 – Normalization
4 – Knowledge representation

- Text selection defines a corpus
- NLP helps during step 1
- Human interpretation is required for steps 2 and 3
- Caméléon : supports steps 1 and 2
Pattern definition in Camélén

Pattern-based Approach
Pattern definition in Caméléon

BEGIN
Context X
Context Y
END

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Pattern-based Approach
Pattern definition in Caméléon

Pattern definition in Caméléon

BEGIN
Context
END
Evaluation

Method

- Define 71 reusable patterns for French (adapted from linguistic studies)
  - Relation types: hyperonymy, meronymy, definition, ...
- Select 8 corpora in 8 different domains of 3 genres
  - Technical writings, Scientific papers, Handbooks
- Evaluation measures
  - Recall: only available for definition patterns
  - Precision: correct phrases / matched phrases
  - No measure of the relevance for the ontology

Results

- Dependency of a pattern efficiency and meaning on the textual genre
- Requires manual evaluation
- Precise but not very productive (silence)
- Adapted to well written, pedagogical texts
- Requires to capitalize patterns and experiments with pattern performances
Conclusions from the evaluation

- **Claims about pattern reuse**: There is no generic (universal) pattern. But any pattern should be reusable after adaptation.

- **Claims about pattern manual definition**: Manual pattern definition is time consuming. Pattern definition requires linguistic competency. Reuse of already defined patterns reduces this cost. Patterns adaptation to each corpus improves efficiency.

- **Claims about pattern evaluation**: Capitalize previous uses of patterns together with the corpus and evaluation scores. Pattern efficiency may vary a lot according to the corpus.
Our goals from the first evaluation

Answers to evaluation

- Claims about pattern reuse
  - validation of "generic" patterns through uses
  - construction of annotated pattern base depending on domain
- Claims about pattern manual definition
  - learning to improve time pattern acquisition
  - NLP assistance to user at each step (building and validating)
  - capitalization of patterns

Toward more assistance

=> how to improve the existant tool with learning and NLP technics?
3. Pattern-based Approach

State of the art

Pattern Approach Contribution

Framework
- General Overview
- Processing Steps
- Interactive Interfaces
Processing Steps

State of the art
Pattern Approach Contribution
Framework

General Overview
Processing Steps
Interactive Interfaces

Pattern-based Approach

INPUT

Corpus
Ontology

NLP chain

Pattern Base
Pattern Matching $\text{Rel}(t_i, t_j)$
tagged text

Ontology enrichment
- Identified Relation
- Unknown Relation

Pattern Base enrichment
- Concept Identification $\text{REL}_C(C_i, C_j)$
- Ontology Integration $\delta\text{REL}(C_i, C_j)$
- Relation Proposal $\text{REL}$
- Pattern Proposal $\text{P}_{\text{REL}}$
- Watson

User validation

OUTPUT

Enriched Ontology
Enriched Pattern Base

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State of the art
Pattern Approach Contribution
Framework

General Overview
Processing Steps
Interactive Interfaces

Input

Required Resources
- Lightweight Ontology
- Pattern Base
- Corpus

Pattern-based Approach
Inputs

A lightweight Ontology defined with
- a structure: tuple $S := \{C, R, \leq, \partial R\}$
- a lexicon: a tuple $L : \{L^C, L^R, F, G\}$

For our approach: at least a hierarchy of concepts defined with
- a lexicon $L^0 := \{L^C, F\}$
- a structure $S^0 := \{C, \leq\}$.

A corpus
- extracted by experts from existing document collections
- tagged with a morpho-syntactic analysis (tokenisation, lemmatization and POS)

A pattern base
- storing existing patterns (mostly adapted from Caméléon)
- organised according to the relation captured by the patterns (relation type, label ...)
For each pair of distinct ontology concepts \((c_i, c_j)\), we look for each sentence \(s\) containing \(t_i, t_j\) (labels of \(c_i\) and \(c_j\) defined in the lexicon of the ontology).

If a base pattern \(P^\text{REL}_i\) can be matched on the sentence \(s\), we store the relation \(REL, REL^C(c_i, c_j)\) and \(s\).

Else, we search for a relation that could be defined in an existing ontology. If such a relation is found, we store \(REL_{\text{new}}, REL^C_{\text{new}}(c_i, c_j)\) and \(s\).
### Relation proposal

1. Detection of co-occurring concepts \((c_i, c_j)\) in sentences but no relations extracted after pattern matching.
2. Search for a relation between the concepts in an existing ontology.
3. Proposition of the relation \(REL_{new}\) between \((c_i, c_j)\).

### Example between the concepts “Person” and “Company”

- “Airbus Names New Chief Managers for A380, A320 Programs”
- “Aircraft maker Airbus has named Mario Heinen senior vice president and chief manager of the A380 aircraft program”
- “Laurence Barron, the vice senior president of Airbus”

\[ \Rightarrow \text{Watson proposes the “Work_for” relation.} \]
Proposition of a set of patterns

- Analysis of each sentence containing a concept pair $REL_{new}(c_i, c_j)$
- Proposition of patterns according to each element known by the system (grammatical category, semantic category or lemma).

"Work_for"

"Airbus Names New Chief Managers for A380, A320 Programs"
"Aircraft maker Airbus has named Mario Heinen senior vice president and chief manager of the A380 aircraft program"

Proposed patterns:

1. X name Y
2. X name (NP) ? (NP) ? Y
3. X (VB=choose) Y
4. X (MD) ? (VB=choose) Y
5. X name NE_Person Y (with NE_Person semantic class of Named Person)
Relation validation:

1. For each relation detected ($REL$ and $REL_{new}$), the system displays
   - the relation labels
   - the pair of concepts related
   - the sentences where they occur.

2. The user can either decide to
   - add the relation between $c_i$ and $c_j$
   - add the relation between an ancestor of $c_i$ and an ancestor of $c_j$
   - add the relation between a concept linked to $c_i$ in the ontology and a concept linked to $c_i$
   - reject the relation for the pair
The ontologist’s validation (2)

Pattern validation

1. For each new relation $REL_{\text{new}}$, the system displays the relation and all the pairs of concepts $REL_{\text{new}}^c(c_i, c_j)$.
2. The user is asked to validate the relevance of the relation.
3. If he validates the relation, the system proposes the set of patterns generated for the relation and the sentences.
4. The user validates the relevance of the patterns. The patterns validated by the user are added to the base.

When?

AFTER the processing in order to let the ontologist validate with an overview on the propositions.
Required Ressources

- Enriched Ontology
- EnrichedPattern Base
The need for a interactive interface

![Interactive Interface Diagram]

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The need for an interactive interface

Camel Léon

Labels discovery

Number of labels: 320
Number of pairs: 73

<table>
<thead>
<tr>
<th>Nb</th>
<th>Term 1</th>
<th>Term 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Aircraft</td>
<td>Company</td>
</tr>
<tr>
<td>1</td>
<td>Pilot</td>
<td>Seat</td>
</tr>
<tr>
<td>5</td>
<td>Airbus</td>
<td>A320</td>
</tr>
</tbody>
</table>
The need for an interactive interface

Camel Léon

Pattern Matching

**Sumary**

- **Number of pairs:** 73
- **Number of successful matching:** 35

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<tr>
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<th>Term 2</th>
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<td>BUY</td>
<td>Aircraft</td>
<td>Company</td>
</tr>
<tr>
<td>COMMUNICATE</td>
<td>Pilot</td>
<td>Controller</td>
</tr>
<tr>
<td>OWN</td>
<td>Airbus</td>
<td>A320</td>
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**Ontology Building**

**Relation Discovery**

- **Number of orphan pairs:** 38
The need for a interactive interface

Camel Léon

Pattern Matching

Summary New Relations Relation Discovery

Relation Term 1 Term 2
BUY Aircraft Company
COMMUNICATE Pilot Controller
OWN Airbus A320

Ontology Building

Number of orphan pairs : 38

Relation Discovery
The need for an interactive interface

- **Relation Integration**
  - **Relation**: REPORT
  - **Terms**
    - Head
    - Vice_President
    - Co-Pilote
  - **Context**
    - Local_Government
    - Executive_Head
    - Pilote
  - **Pattern**
    - Heas will report to
    - the vice-president
    - and the pilot

- **Context**: VB ? TO, VB Adj, VMOD VB

- **More option...**

- **Term 1**
- **Term 2**

- **Pattern-based Approach**
The WebContent project: a case study

Project for building a computing environment to explore and use the Web Semantic technologies for applications

- **Inputs**
  - a lightweight Ontology dedicated to aeronotics
  - a corpus of news releases
  - a pattern base composed of patterns adapted from Camélion

- **Examples of extracted relations**

<table>
<thead>
<tr>
<th>Relation</th>
<th>ci</th>
<th>cj</th>
<th>Examples of textual segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comm.</td>
<td>Pilote</td>
<td>Controller</td>
<td>“the controller instructed the pilot”</td>
</tr>
<tr>
<td>Build</td>
<td>Aircraft</td>
<td>Plant</td>
<td>“Airbus is expected to begin to build plant”</td>
</tr>
<tr>
<td>Build</td>
<td>Factory</td>
<td>Plane</td>
<td>“the plant will have the capacity to assemble four aircrafts per month”</td>
</tr>
<tr>
<td>Own</td>
<td>Airway</td>
<td>Plane</td>
<td>“the Airbus A320 belonging to Armenian Airlines”</td>
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Conclusion

- "Work in process"
- Evaluation by users and tasks
- Main concerns
  - being modest
    - concerned by quality more than quantity
    - not building the whole ontology, but enriching an existing hierarchy of concepts
  - being ambitious
    - covering all the steps of Ontology Enrichment (Pattern Identification, Representation of relations)
- Future works
  - Interface Implementation
  - User validation (comparison Caméléon I - Caméléon II)
  - Improvement of the pattern set proposal process