Multiword Expression Identification and Statistical Dependency Parsing

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Our task

He made that fairy tale up
Our task

- syntactic analysis (dependency paradigm)
Our task

- syntactic analysis (dependency paradigm)
- lexical segmentation (multiword expressions)
Our task

- syntactic analysis (dependency paradigm)
- lexical segmentation (multiword expressions)

MWE-aware parsing
This talk

- Background: MWE processing, main approaches to MWE-aware parsing

- A transition-based system for joint lexical and syntactic analysis
  (Constant and Nivre ACL 2016)
Multiword Expressions (MWEs)

Definitional features

- A sequence of multiple lexemes that displays a certain degree of non-compositionality
- i.e. irregularity on one or more linguistic dimensions: morphological, lexical, syntactic, semantic, and pragmatic

Examples

- Nominal compounds: grand-mère, cordon bleu
- Adverbial compounds: à fond, en dépit (de)
- Grammatical compounds: bien que, de la
- Verbal idiomatic expressions: casser les pieds
- Light verb constructions: prendre une décision
MWE challenges for NLP I

Ambiguity

• MWE vs. literal meaning
  \textit{prendre la porte} = \textit{sortir} vs. \textit{emporter la porte}

• MWE vs. accidental co-occurrence
  \textit{J’aime bien que tu viennes chez moi bien que tu me fasses faire des bêtises}

Discontiguity

• \textit{Luc fait souvent face à ce problème}

• \textit{Luc prend cet argument en compte}
MWE challenges for NLP II

Non-compositionality

- Various degrees of compositionality
  
  \textit{cordon bleu} < \textit{eau de vie} < \textit{arme blanche} < \textit{appel d’offre}
  
  \textit{casser les pieds} < \textit{nager dans le bonheur} < \textit{trembler de peur}

- Internal compositional modifications
  
  \textit{prendre une grande} \textit{décision}

Variability

- \textit{Luc a cassé sa pipe}/\textit{Luc et Marie ont cassé leur pipe}

- \textit{Luc prend une décision}/\textit{La décision prise par Luc me semble la bonne}

Embeddings

\textit{Luc (fait un (faux pas))}
MWE Processing

MWE discovery

- **Task**: given a raw corpus, extract an MWE lexicon
- **Approaches**: linguistic patterns, association measures, modeling of MWE linguistic properties, distributional semantics, ...

MWE identification

- **Task**: given an input text and MWE resources, annotate occurrences of MWEs
- **Approaches**: rule-based identification based on lexicons, word sense disambiguation, supervised sequential tagging, ...
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Motivations for MWE-aware parsing

MWE identification can help parsing

- MWEs constitute syntactic constituents
- Their identification can help syntactic attachments
  - rule-based parsing (Werhli et al. 2010, 2014)
  - statistical parsing (Cafferkey et al. 2007)

Parsing can help MWE identification

- help distinguish MWEs and accidental co-occurrences of words
  ex. French grammatical compounds (Nasr et al. 2015)
- help handle discontiguity and variability (Werhli et al. 2010)
Our framework

- **Syntactic parsing** in combination with **MWE identification**

- **Supervised statistical approach:**
  - Training phase: annotated dataset $\rightarrow$ model
  - Annotation phrase: new raw data + model $\rightarrow$ annotated data

- **Use of lexical resources**

- **Example**

```
Jean prend le premier ministre en grippe
```

```
ROOT
suj

Jean
prend
le
premier
ministre
en
grippe
```

```
p_obj

obj

obj

det

mod
```

```
Jean
prend
le
premier
ministre
en
grippe
```
Our framework

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- **Supervised statistical approach:**
  - Training phase: annotated dataset → model (no details in this talk)
  - Annotation phrase: new raw data + model → annotated data
- **Use of lexical resources** (no details in this talk)
- **Example**

Jean prend le premier ministre en grippe
Few words on statistical dependency parsing

- No underlying grammatical formalism
- Parsing algorithms vary from local search (Nivre 2003) to global search (McDonald 2005)
- Discriminative approach
- Use of machine learning techniques: the deep learning revolution (Chen and Manning 2014, Dyer 2015, Weiss et al. 2015, Kiperwasser and Goldberg 2016)
Few words on statistical dependency parsing

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Three positions for MWE identification

- **Before parsing**: retokenization ($\text{carte verte} \rightarrow \text{carte}_\text{verte}$)
  - predicted (Cafferkey 2007, Constant et al. ACL 2012)

- **During parsing**: joint approach
  - Multilayer parsers (Constant et al. NAACL 2016, Constant and Nivre 2016)

- **After parsing**: Performing MWE identification on parsed text
  (Fazly et al. 2009)

→ Performances depend on the MWE types (Eryigit et al. 2011, Vincze et al. 2013)
Combining positions

- **before+during:**
  - \( n \)-best MWE tagger: lattice (Constant et al. ACM TSLP 2013) or beam (Urieli 2013) given to parser
  - dual decomposition: agreement on MWE segmentation for MWE taggers and joint parsers (Le Roux et al. COLING 2014)
  - reparser (Constant et al. SPMRL ST 2013)

- **during+after:**
  - \( n \)-best joint parser + MWE-based reranker (Constant et al. ACL 2012)
Joint approach using standard dependency parsers

Principle

- Each MWE is annotated as a subtree of the syntactic tree in the reference treebank
- Use of off-the-shelf parsers that are learned from the reference treebank

How to represent MWEs?

- deep subtree (Vincze et al. 2013, Candito and Constant ACL 2014)
Flat MWE representation

- MWE is annotated with a flat subtree within the syntactic tree
- The left-most (or right-most) MWE item is the head and other items are the modifiers
- Use of specific arc labels for MWE arcs
A dual MWE representation I
(Candito and Constant ACL 2014)

Irregular MWEs

- They display irregular syntactic structure (e.g., *en vain* = Prep Adj)
- Use of flat MWE representation

Regular MWEs

- Internal syntactic structure is kept: use of classical syntactic dependency structure
- Arc label = syntactic label + MWE status
A dual MWE representation II
(Candito and Constant ACL 2014)
Multilayer lexical and syntactic parsing

Drawback of standard parsers

- No lexical embedding in dual representation
- $|\text{Label tagset}| \leq |\text{MWE info}| \times |\text{syntactic functions}|$
- Same mechanisms to predict lexical segmentation and syntactic structure

Principle

- Representations with two layers (or dimensions): lexical layer and syntactic layer
- Mild extension of dependency parsing algorithms
A Transition-based System for Joint Lexical and Syntactic Analysis
Contributions

A new factorized representation of lexical and syntactic analysis

- Dependency analysis
- Inclusion of Multiword Expression analysis

A new transition-based system

- Input: a sequence of tokens
- Output: above representation
- Special mechanisms to handle Multiword Expressions

Work originally presented at ACL 2016
The prime minister made a few good decisions.
Lexical and Syntactic representation

prime-minister

the prime minister

made-decisions

made a few good decisions
Lexical and Syntactic representation

Form: made decisions
Lemma: make decision
POS: V

prime-minister

the prime minister

made decisions

made a few good decisions
The prime minister made a few good decisions.
MWE embedding

took-rain-check

rain-check

she took a rain check

subj det mod obj
Background: a standard transition-based parser

Input/Output

• **Input**: a sequence of tokens
• **Output**: a set of syntactic arcs

Internal mechanism

• predict a **sequence of actions** (namely *transitions*)
• A transition goes from one parsing state (namely *configuration*) to another one
• **Configuration**: a stack, a buffer and a set of arcs
Background: a standard transition-based parser (Cont’d)

Configurations

• **Initial configuration**: buffer filled with input tokens, empty stack and set of arcs

• **Terminal configuration**: buffer is empty, stack has one item left

Transitions

• **Shift**: push the next token of the buffer on top of stack

• **Left-arc\(k\)**: creates a left arc labeled \(k\) between the two top tokens of the stack; only head item is kept in stack. The created arc is added to the set of arcs

• **Right-Arc\(k\)**: same as Left-arc, but creates a right arc
Example
John likes linguistics

Transition
-

Buffer
[John likes linguistics ]

Stack
[
]

Arcs
-


Example

John likes linguistics

Transition
Shift

Buffer
[likes linguistics ]

Stack  Arcs
[John]  –
Example
John likes linguistics

Transition
Shift

Buffer
[linguistics]

Stack
[John likes]

Arcs
[ ]
Example

John likes linguistics

Transition
Left-Arc(subj)

Buffer
[linguistics ]

Stack
[likes]  

Arcs
subj(likes, John)
Example

John likes linguistics

Transition
Shift

Buffer
[
]

Stack
[likes linguistics]

Arcs
subj(likes, John)
Example
John likes linguistics

Transition
Right-Arc(obj)

Buffer
[ ]

Stack
[likes]

Arcs
subj(likes, John)
obj(likes, linguistics)
Our new transition-based system

Handling two linguistic dimensions

- Two stacks: a syntactic stack and a lexical stack
- One buffer to synchronize the two dimensions
- Processed items: a set of syntactic arcs and a set of lexical trees

Handling MWEs

- Mild extension of arc-standard parser
- Specific transitions to deal with MWE identification
Transition system

**Configuration**

(Buffer, SynStack, SynArcs, LexStack, LexTrees)

**Initial**

\([w_1, \ldots, w_n], [], \{\}, [], \{\})\)

**Input:** \(w_1, \ldots, w_n\)

**Terminal**

\([], [x], \text{SynArcs}, [], \text{LexTrees} \)

**Output:** SynArcs, LexTrees
Transition system

Shift
Moves next token from Buffer to both stacks

Right-Arc($k$), Left-Arc($k$)
Adds syntactic arc between top items on syntactic stack

Merge$_F(t)$
Creates lexical tree from top items on both stacks – fixed MWE

Merge$_N(t)$
Creates lexical tree from top items on lexical stack – non-fixed MWE

Complete
Adds lexical tree from lexical stack
Example parse

Transition
–

Buffer
[he made a few decisions]

SynStack
[ ]

SynArcs
–

LexStack
[ ]

LexTrees
–
Example parse

Transition
Shift

Buffer
[made a few decisions]

SynStack
[he]

SynArcs
–

LexStack
[he]

LexTrees
–
Example parse

Transition
Complete

Buffer
[made a few decisions]

SynStack       SynArcs
[he]            –

LexStack       LexTrees
[ ]             he
Example parse

**Transition**
Shift

**Buffer**
[a few decisions]

**SynStack**
[he made]

**SynArcs**
–

**LexStack**
[made]

**LexTrees**
he
Example parse

Transition
Left-Arc(subj)

Buffer
[a few decisions]

SynStack
[made]

SynArcs
subj(made, he)

LexStack
LexTrees
[made]
he
Example parse

Transition
Shift

Buffer
[few decisions]

SynStack
[made a]

SynArcs
subj(made, he)

LexStack
[made a]

LexTrees
he
Example parse

Transition
Shift

Buffer
[decisions]

SynStack
[made a few]

SynArcs
subj(made, he)

LexStack
[made a few]

LexTrees
he
Example parse

Transition
Merge$_F$(A)

Buffer
[decisions]

SynStack
[made A(a, few)]

SynArcs
subj(made, he)

LexStack
[made A(a, few)]

LexTrees
he
Example parse

Transition
Complete

Buffer
[decisions]

SynStack
[made A(a, few)]

SynArcs
subj(made, he)

LexStack
[made]

LexTrees
he, A(a, few)
Example parse

Transition
Shift

Buffer
[

SynStack
[made A(a, few) decisions]

SynArcs
subj(made, he)

LexStack
[made decisions]

LexTrees
he, A(a, few)
Example parse

**Transition**
Left-Arc(mod)

**Buffer**
[ ]

**SynStack**
[made decisions]

**SynArcs**
subj(made, he)
mod(decisions, A(a, few))

**LexStack**
[made decisions]

**LexTrees**
he, A(a, few)
Example parse

Transition
Merge_{N}(V)

Buffer
[ ]

SynStack
[made decisions]

LexStack
[V(made, decisions)]

SynArCs
subj(made, he)
mod(decisions, A(a, few))

LexTrees
he, A(a, few)
Example parse

Transition
Complete

Buffer
[
]

SynStack
[made decisions]

LexStack
[
]

SynArcs
subj(made, he)
mod(decisions, A(a, few))

LexTrees
he, A(a, few), V(made, decisions)
Example parse

Transition
Right-Arc(obj)

Buffer
[ ]

SynStack
[made]

SynArcs
subj(made, he)
mod(decisions, A(a, few))
obj(made, decisions)

LexStack
[ ]

LexTrees
he, A(a, few), V(made, decisions)
Implementation and Evaluation

Implementation

- **Greedy parser** trained with averaged **perceptron**
- **Hard constraints**: Complete transitions are made implicit, i.e. only activated when arc transitions are selected by classifier

Evaluation

- **Two datasets**: English Web Treebank (+ Streusle) and French Treebank
- **Comparisons** with
  1. **standard parser with extended labels** including the MWE status
  2. **partial systems** where some transitions are deactivated
  3. **pipeline systems**: fixed MWE identification + parsing
Datasets for experiments I

French Treebank  
(Abeille et al. 2004)

- dependency version of SPMRL Shared Task 2013  
  (Seddah et al. 2013)
- MWE annotation modified: regular vs. irregular MWEs  
  (Candito and Constant 2014)
- MWEs limited to compounds (very few verbal expressions)

Streusle Corpus  
(Schneider et al. 2014)

- Comprehensive annotation of MWEs
- Reviews subpart of the English Web Treebank  
  (Bies et al., 2012)
### Datasets for experiments II

| Corpus | Streusle | | FTB | |
|--------|----------|-----------------|-----------------|
|        | Train    | Test            | Train           | Dev  | Test |
| # sent. | 3,312    | 500             | 14,759          | 1,235| 2,541|
| # tokens | 48,408    | 7,171           | 443,113         | 38,820| 75,216|
| # MWEs  | 2,996     | 401             | 23,556          | 2,119| 4,043|
| # fixed | -         | -               | 10,987          | 925  | 1,992|

**Warning:** datasets not entirely satisfying

- **FTB**: limited to compounds
- **Streusle**: small datasets

→ Results only provide a partial view
Main experimental findings

Comparison with standard parser with extended labels

- Joint system significantly outperforms it for MWE analysis
- Hard constraints are helpful for syntactic analysis

Comparison with partial systems

- Lexical layer helps syntactic layer prediction
- Syntactic layer does not help lexical layer prediction

Comparison with pipeline system

- Preidentifying fixed MWE is helpful
- Prediction of fixed MWEs seem to confuse non-fixed MWE prediction in joint system
## Results on French Treebank

<table>
<thead>
<tr>
<th>System</th>
<th>DEV</th>
<th>TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UAS</td>
<td>LAS</td>
</tr>
<tr>
<td>Extended Labels</td>
<td>86.28</td>
<td>83.67</td>
</tr>
<tr>
<td>Ours (explicit)</td>
<td>86.36</td>
<td>83.77</td>
</tr>
<tr>
<td>Ours (implicit)</td>
<td><strong>86.61</strong></td>
<td><strong>84.10</strong></td>
</tr>
<tr>
<td>Syntactic only</td>
<td>86.39</td>
<td>83.77</td>
</tr>
<tr>
<td>Lexical only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fixed only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pipeline</td>
<td>85.49</td>
<td>83.50</td>
</tr>
</tbody>
</table>
## Results on Streusle

<table>
<thead>
<tr>
<th>System</th>
<th>TRAIN Cross-validation</th>
<th>TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UAS</td>
<td>LAS</td>
</tr>
<tr>
<td>Extended labels</td>
<td>86.16</td>
<td>81.76</td>
</tr>
<tr>
<td>Ours (explicit)</td>
<td>86.25</td>
<td>82.09</td>
</tr>
<tr>
<td>Ours (implicit)</td>
<td>86.81</td>
<td>82.68</td>
</tr>
<tr>
<td>Syntactic only</td>
<td>86.35</td>
<td>82.23</td>
</tr>
<tr>
<td>Lexical only</td>
<td>-</td>
<td>-</td>
</tr>
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</table>
General conclusions

Contributions

• A new representation of lexical and syntactic analysis
• A new transition-based system predicting such representation including special transitions for handling MWEs

Future work

• Implementing more advanced features: beam-search, dynamic oracles, deep learning, distributional semantics
• Evaluating on more relevant datasets (to be built)
• Analysis of produced sequences of transitions (actions)
→ ANR PARSEME-FR Project
Thanks!

Questions/Comments?