Learning and Interpreting STS with Structural Kernels

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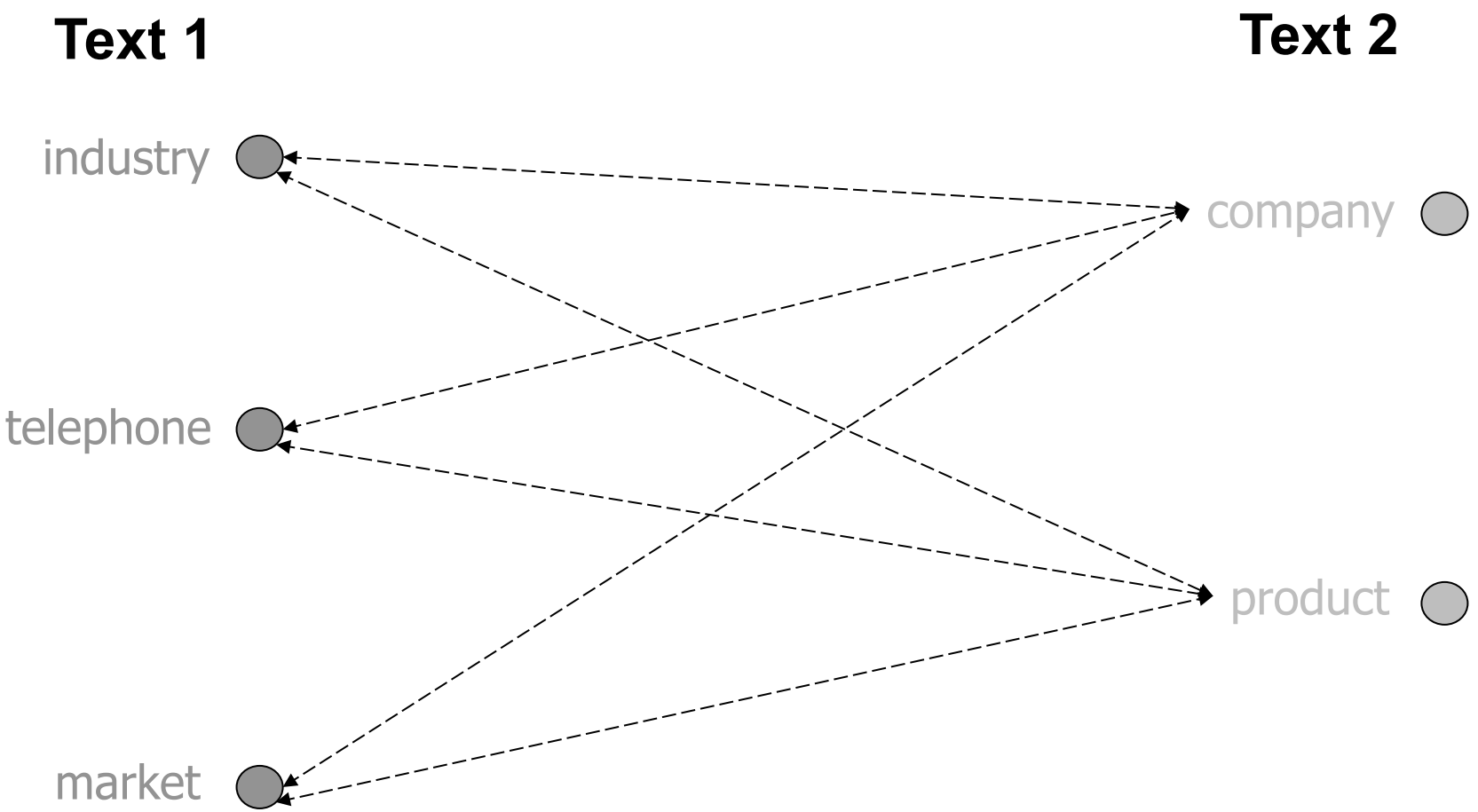
Motivations

- Learning STS automatically from sentence pairs
- Supervised Methods → Training Data
- Which features?
- What generalization?
- Which structures?
- What combination?
- Kernels can give a big help

Role of Kernels

- They can provide lexical similarities
- They can provide structural similarity
- They can also provide combined similarities
- Are they the similarity we want?
- **No!**
- They provide high level representation
- They are a big help to learn automatically sentence similarity that we want

Text Similarity



Lexical Semantic Kernel [CoNLL 2005]

- The text similarity is the K function:

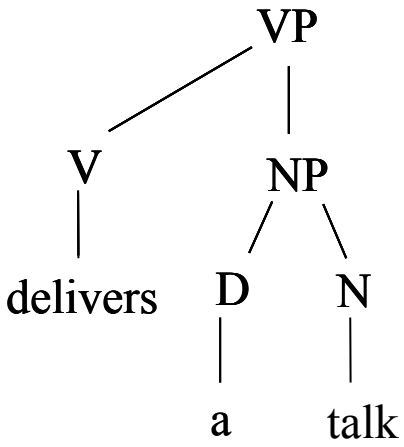
$$K(d_1, d_2) = \sum_{w_1 \in d_1, w_2 \in d_2} s(w_1, w_2)$$

- where *s* is any similarity function between words, e.g. WordNet [Basili et al.,2005] similarity or LSA [Cristianini et al., 2002]
- Good results when training data is small

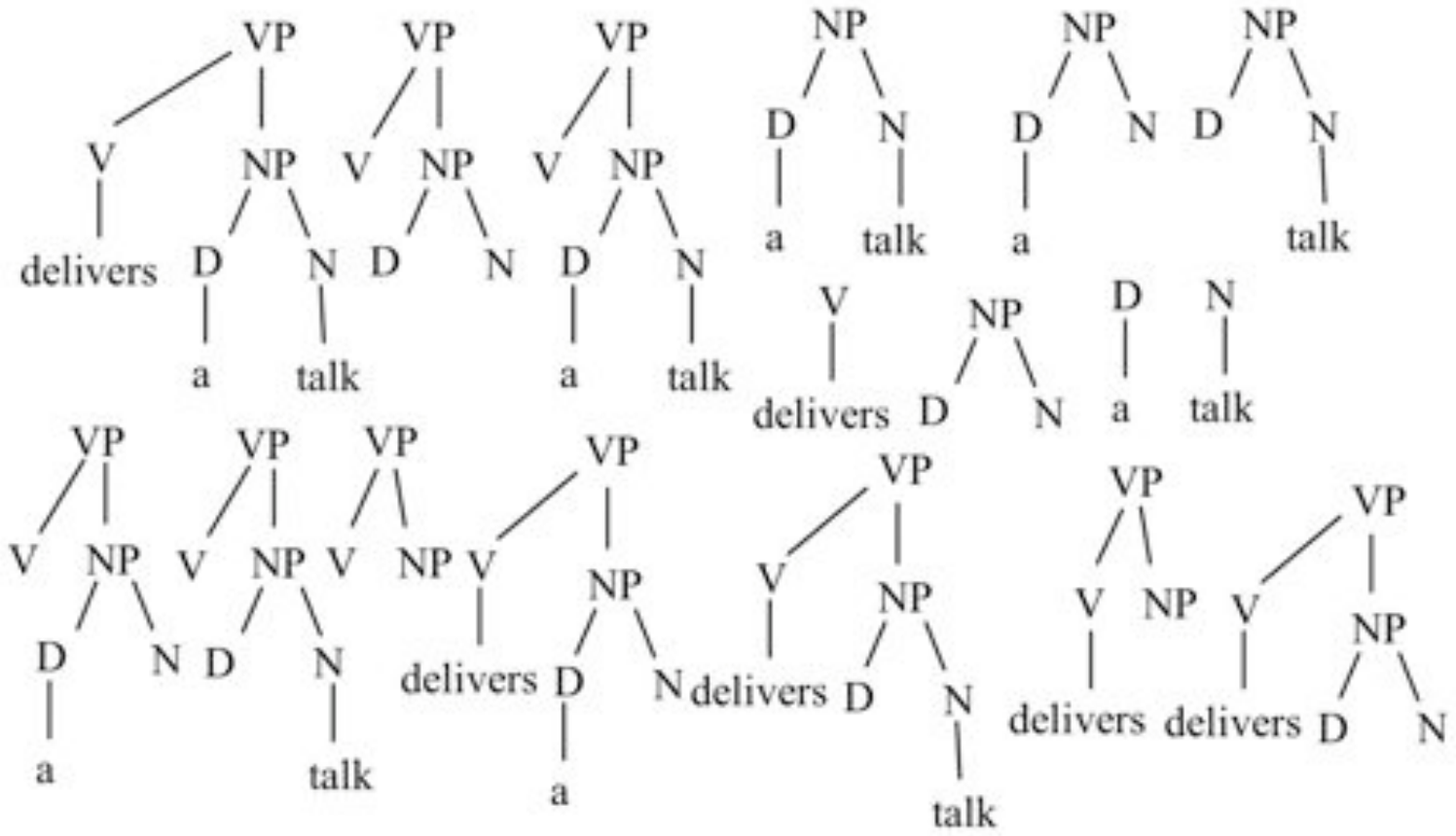
Sequence Similarity: Sequence Kernel

- *I am going to give a talk about structural kernels*
- *I give a talk on kernel methods*
- SK matches many subsequences:
- ***I give a talk kernels***, ***I talk kernels***, ***give kernels*** and all possible skip-grams

The Syntactic Tree Kernel (STK)
[Collins and Duffy, 2002]

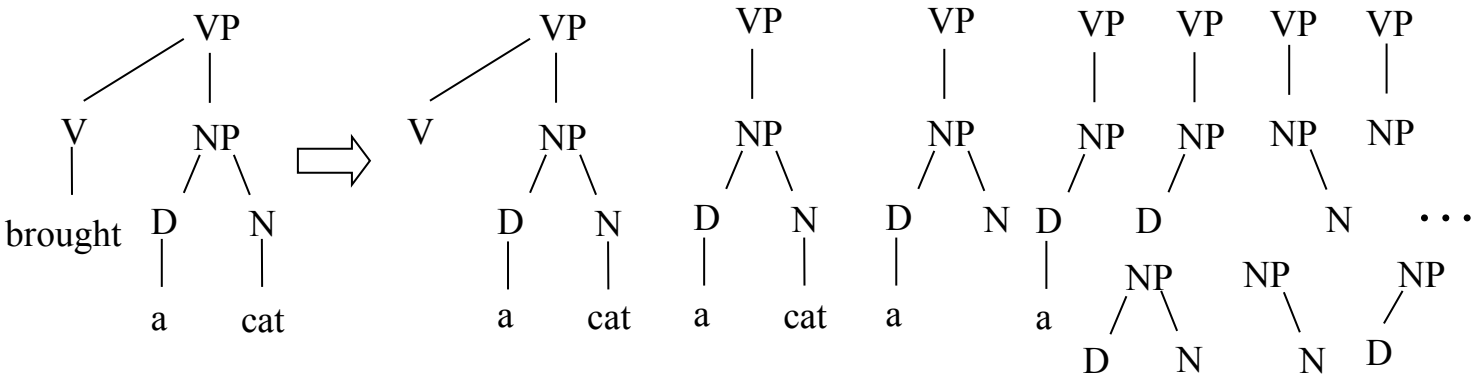


The overall fragment set

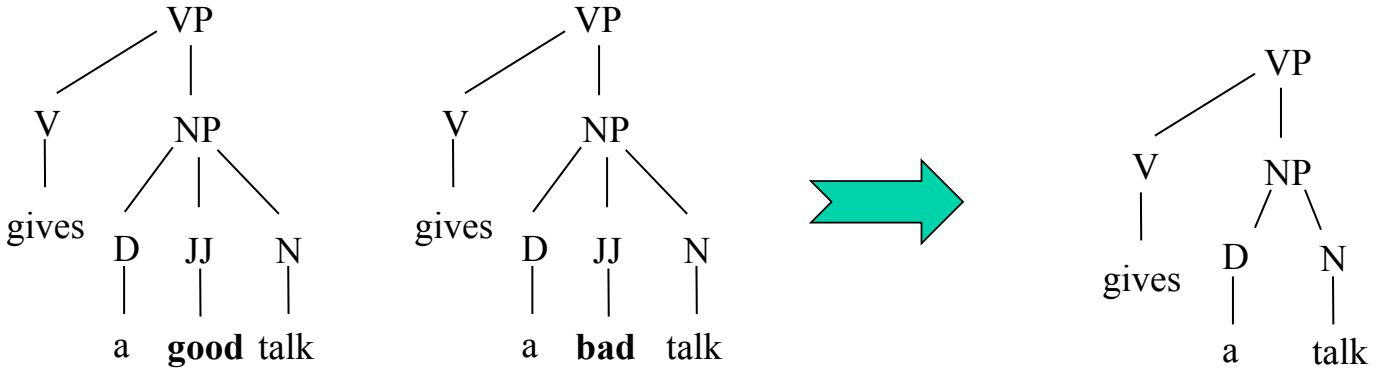


Partial Trees, [Moschitti, ECML 2006]

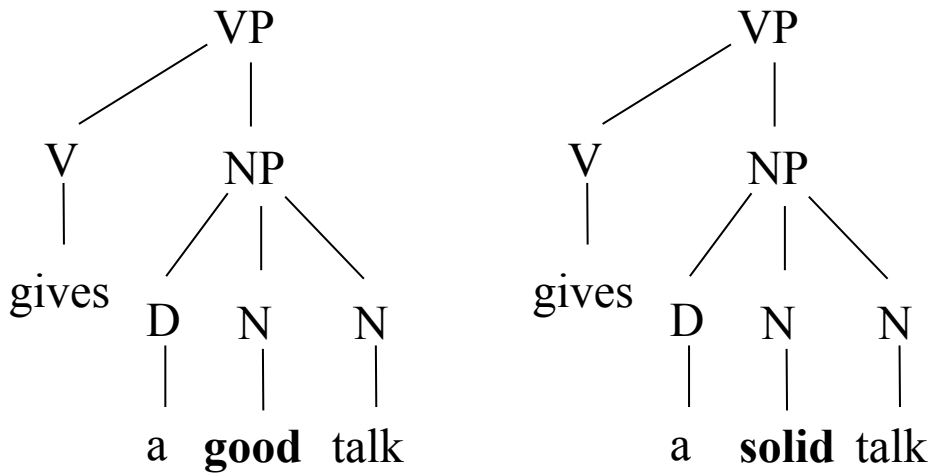
- STK + String Kernel with weighted gaps on Nodes' children



More and larger matches



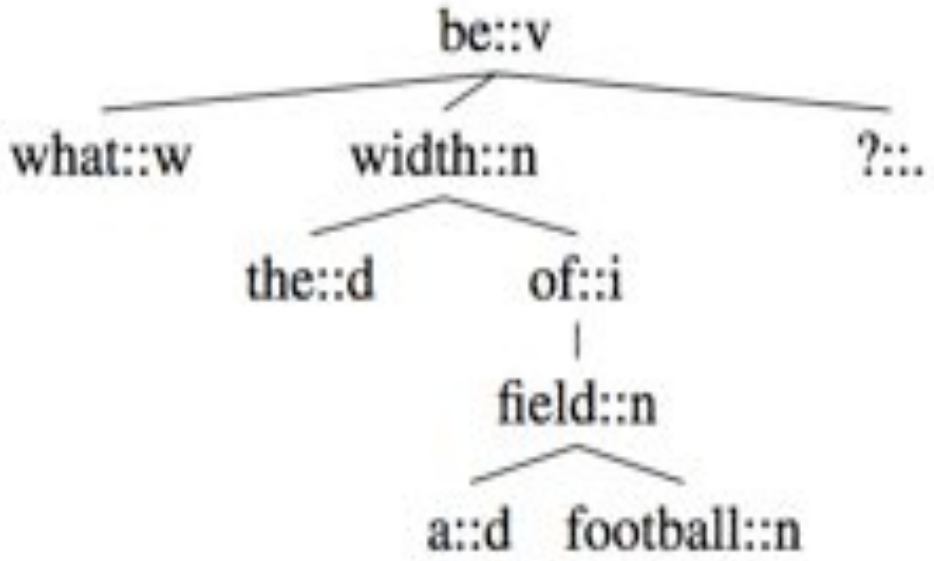
Syntactic/Semantic Tree Kernels
[Bloehdorn & Moschitti, ECIR 2007 & CIKM 2007]



- Similarity between the fragment leaves
  - Tree kernels + Lexical Similarity Kernel

Similarity on Dependency Trees

- What is the width of a football field?

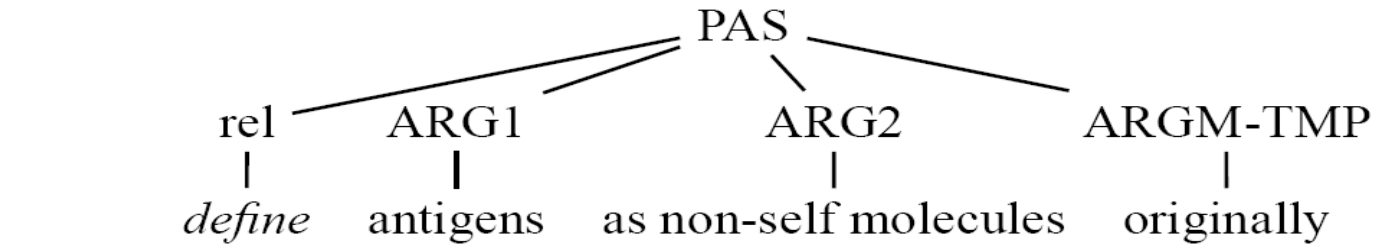


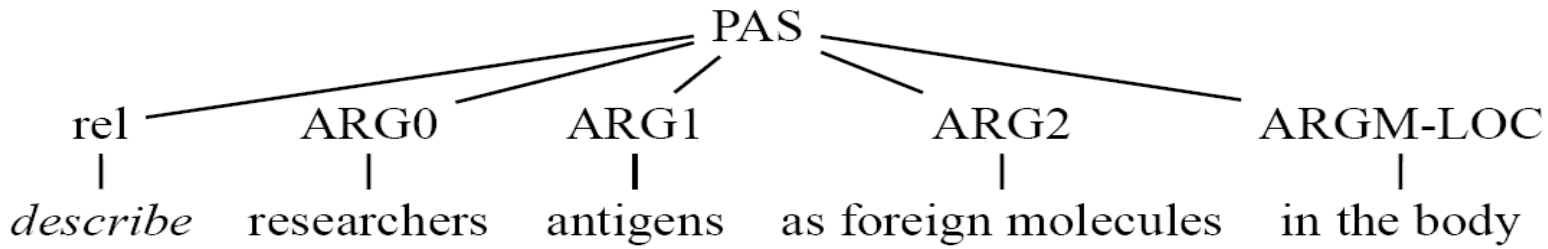
- Lexical similarity applied to any node of any substructure

- Word+generalized POS-tag

Predicate Argument Structure Similarity

- [**ARG1** Antigens] were [**AM–TMP** originally] [**rel** defined] [**ARG2** as non-self molecules].
- [**ARG0** Researchers] [**rel** describe] [**ARG1** antigens][**ARG2** as foreign molecules] [**ARGM–LOC** in the body]

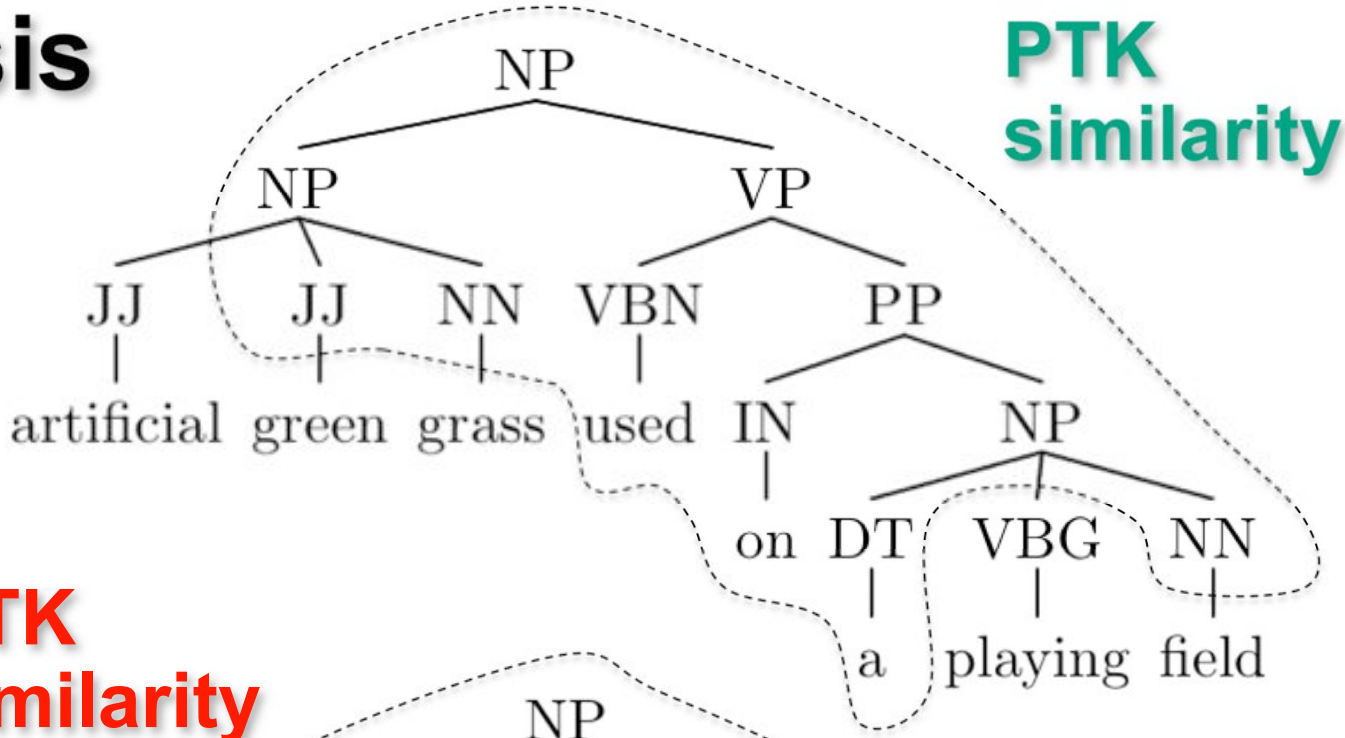




Error Analysis

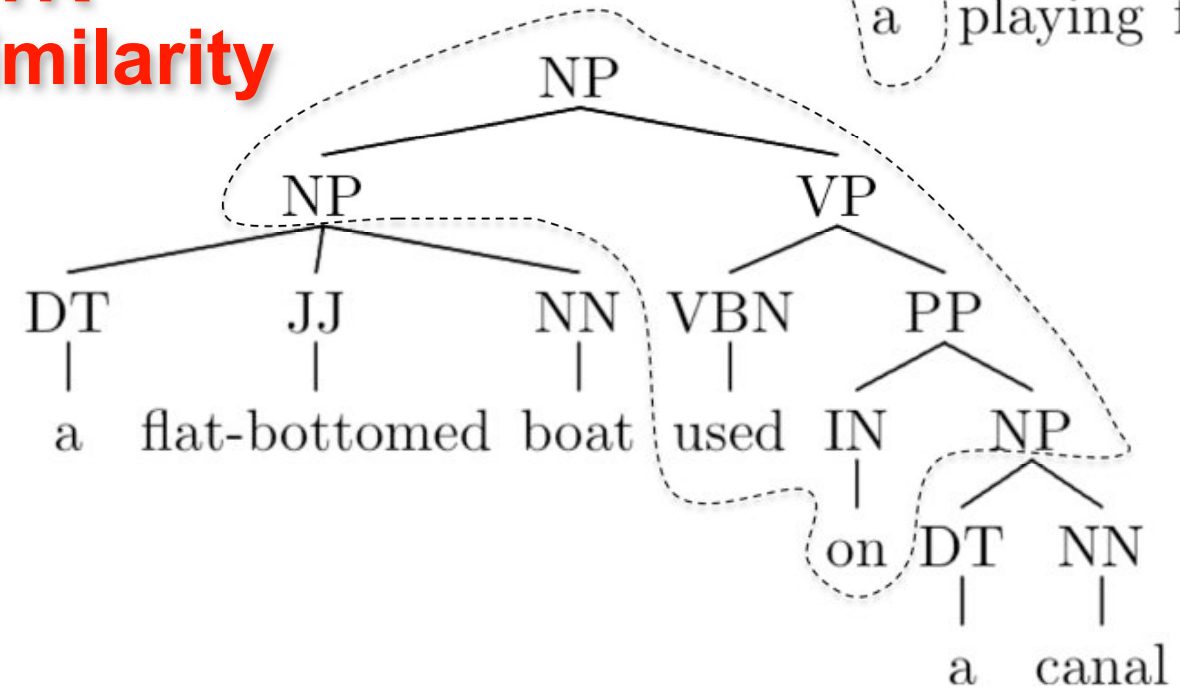
Test Example

- PTK ok
- STK not ok



STK similarity

Training Example

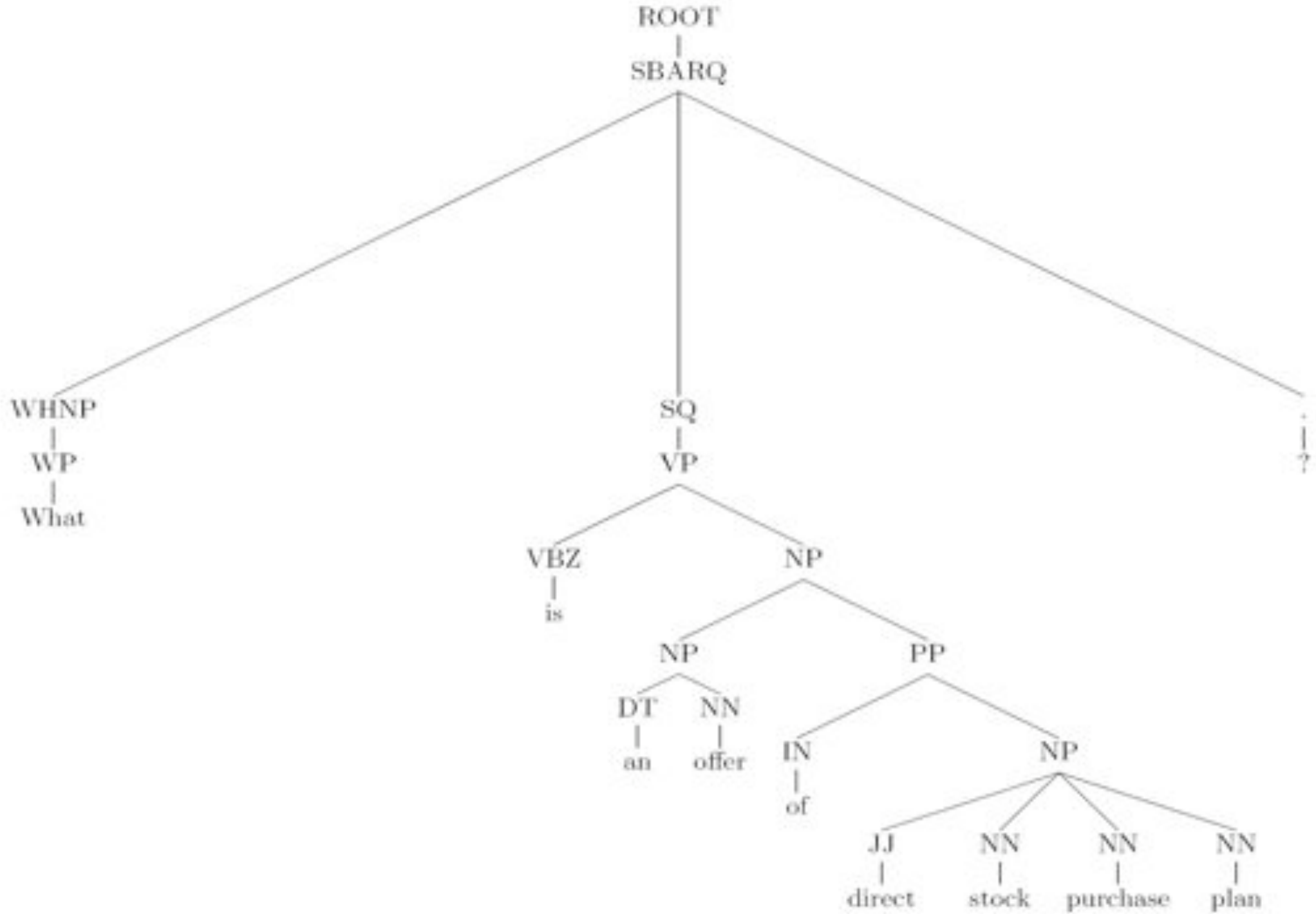


Objection: SVMs and Kernels are a black box

- SVMs provide models
  - Weight for each feature
  - We can watch the best features
- Not much meaningful, e.g., lexical features or string in isolation
- Do kernels make it worse?
- We can reverse engineering structural kernels!

Question Classification

- **Definition**: What does HTML stand for?
- **Description**: What's the final line in the Edgar Allan Poe poem "The Raven"?
- **Entity**: What foods can cause allergic reaction in people?
- **Human**: Who won the Nobel Peace Prize in 1992?
- **Location**: Where is the Statue of Liberty?
- **Manner**: How did Bob Marley die?
- **Numeric**: When was Martin Luther King Jr. born?
- **Organization**: What company makes Bentley cars?


ROOT
SBARQ
WHNP
WP
What
SQ
VP
VBZ
is
NP
NP
DT
an
NN
offer
PP
IN
of
NP
JJ
direct
NN
stock
NN
purchase
NN
plan
.
?

Interpretation (Abbreviation Class)

(NN(abbreviation))
(NP(DT)(NN(abbreviation)))
(NP(DT(the))(NN(abbreviation)))
(IN(for))
(VB(stand))
(VBZ(does))
(PP(IN))
(VP(VB(stand))(PP))
(NP(NP(DT)(NN(abbreviation)))(PP))
(SQ(VBZ)(NP)(VP(VB(stand))(PP)))
(SBARQ(WHNP)(SQ(VBZ)(NP)(VP(VB(stand))(PP)))(.))
(SQ(VBZ(does))(NP)(VP(VB(stand))(PP)))
(VP(VBZ)(NP(NP(DT)(NN(abbreviation)))(PP)))

Interpretation (Numeric Class)

(WRB(How))
(WHADVP(WRB(When)))
(WRB(When))
(JJ(many))
(NN(year))
(WHADJP(WRB)(JJ))
(NP(NN(year)))
(WHADJP(WRB(How))(JJ))
(NN(date))
(SBARQ(WHADVP(WRB(When)))(SQ)(.(?)))
(SBARQ(WHADVP(WRB(When)))(SQ)(.))
(NN(day))

Interpretation (Description Class)

(WRB(Why))

(WHADVP(WRB(Why)))

(WHADVP(WRB(How)))

(WHADVP(WRB))

(VB(mean))

(VBZ(causes))

(VB(do))

(SBARQ(WHADVP(WRB(How)))(SQ))

(WRB(How))

(SBARQ(WHADVP(WRB(How)))(SQ)(.))

(SBARQ(WHADVP(WRB(How)))(SQ)(.(?)))

Boundary Detection in SRL

(ADJP(RB-B)(VBN-P))
(NP(VBN-P)(NNS-B))
(S(NP-B)(VP))
(VP(VBD-P(said))(SBAR))
(VP(VB-P)(NP-B))
(NP(VBG-P)(NNS-B))
(VP(VBD-P)(NP-B))
(VP(VBG-P)(NP-B))
(VP(VBZ-P)(NP-B))
(VP(VBN-P)(NP-B))
(VP(VBP-P)(NP-B))
(NP(NP-B)(VP))
(NP(VBG-P)(NN-B))
(S(S(VP(VBG-P)))(NP-B))

Table 3: Best fragments for SRL BC.

Verb Class Classification

VerbNet class 13.5.1
(VP(VB(target))(NP))
(VP(VBG(target))(NP))
(VP(VBD(target))(NP))
(VP(TO)(VP(VB(target))(NP)))
(S(NP-SBJ)(VP(VBP(target))(NP)))
VerbNet class 60
(VBN(target))
(VP(VBD(target))(S))
(VP(VBZ(target))(S))
(VBP(target))
(VP(VBD(target))(NP-1)(S(NP-SBJ)(VP)))

Conclusions

- Learning STS with
  - Similarity functions (Kernel Methods)
  - Structural syntactic/semantic similarity
- Interpret the results to refine the representation

Future (on going work)

- Modeling more than one sentence with deeper structures: shallow semantics and *discourse*
- The objective is more compact and accurate models applicable to whole paragraphs.
- Use of reverse kernel engineering to study linguistic phenomena:
  - [Pighin&Moschitti, CoNLL2009, EMNLP2009, CoNLL2010]
  - To mine the most relevant fragments according to SVMs gradient
  - To use the linear space

Thank you

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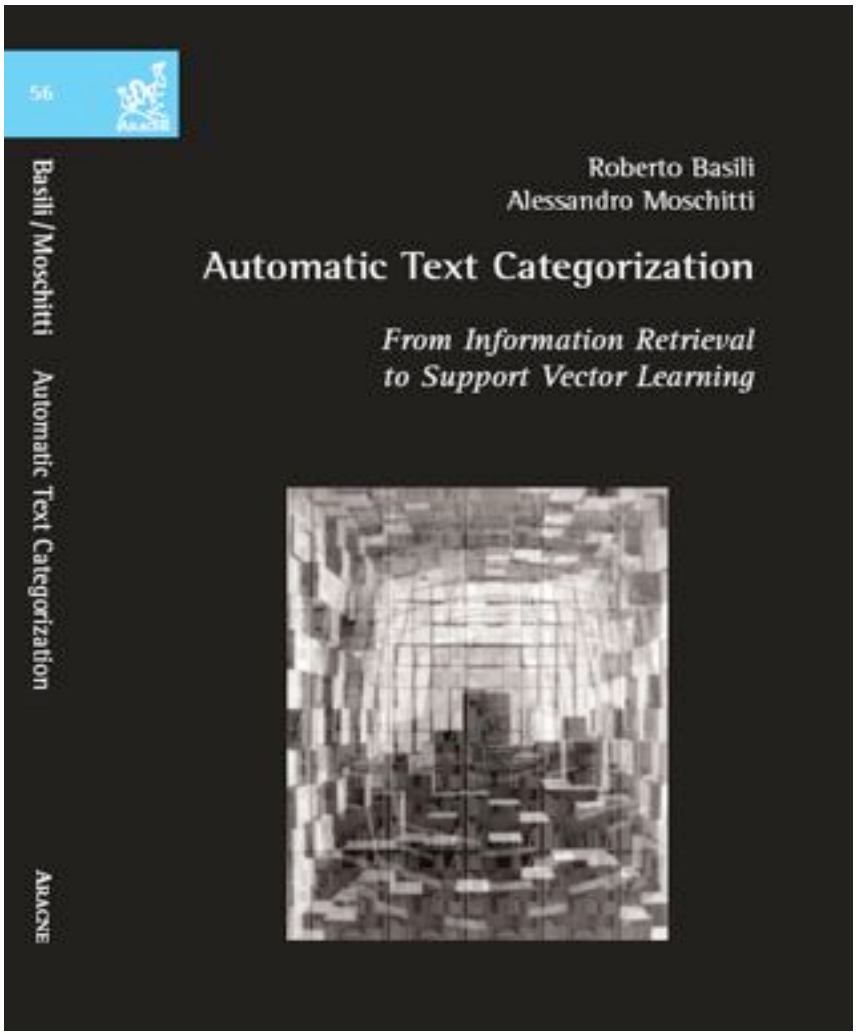

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