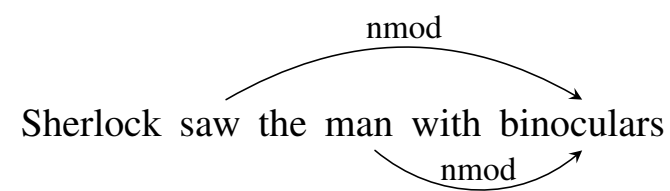
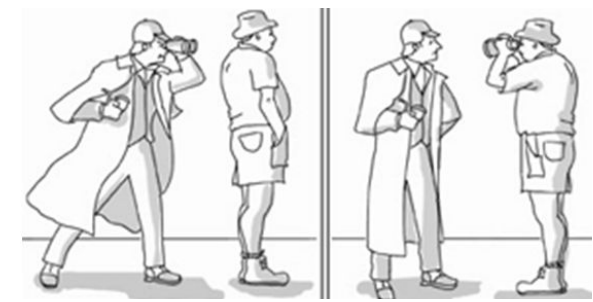


Natural Language Semantics for Dependency Trees

Siva Reddy[†], Oscar Täckström[‡], Tom Kwiatkowski[‡], Dipanjan Das[‡], Slav Petrov[‡], Michael Collins[‡], Mark Steedman[†], Mirella Lapata[†]

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Dependency Trees help Semantics



Cool Facts

- Dependency trees are human-friendly
- Treebanks in 40 languages
- Accurate Parsers
e.g., Google's Parsey McParseface

Not cool enough :(

Dependencies **lack** a theory of semantics

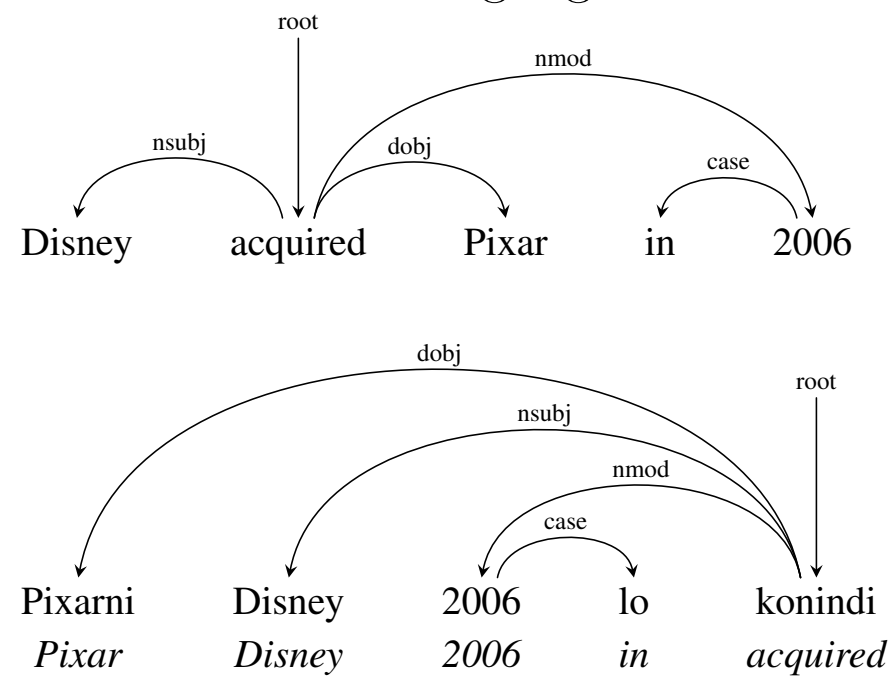
No formal theory to convert to target-application's representation

Diagram showing dependency arcs for 'Pixar is a company located in CA' with arcs like nsubj, cop, det, acl, nmod, case, and arg_{in}.

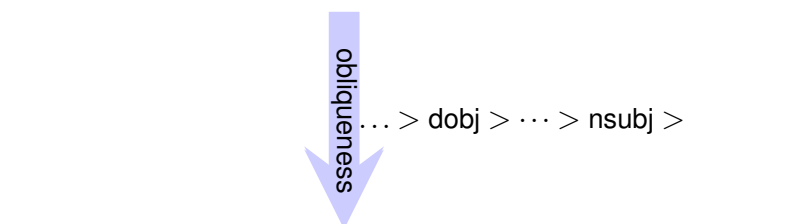
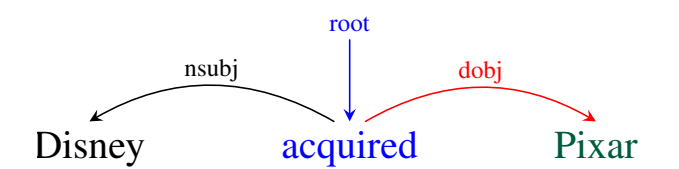
$\exists z. \text{company}(\text{Pixar}) \wedge \text{located}(z_e) \wedge \text{arg}_2(z_e, \text{Pixar}) \wedge \text{arg}_{in}(z_e, \text{CA})$

Universal Dependencies

Homogeneous syntactic representation across languages



DepLambda: Dependencies to Logical Forms



(dobj acquired Pixar)
 $\lambda f g z. \exists y. f(z) \wedge g(y) \wedge \text{arg}_2(z_e, y_a)$

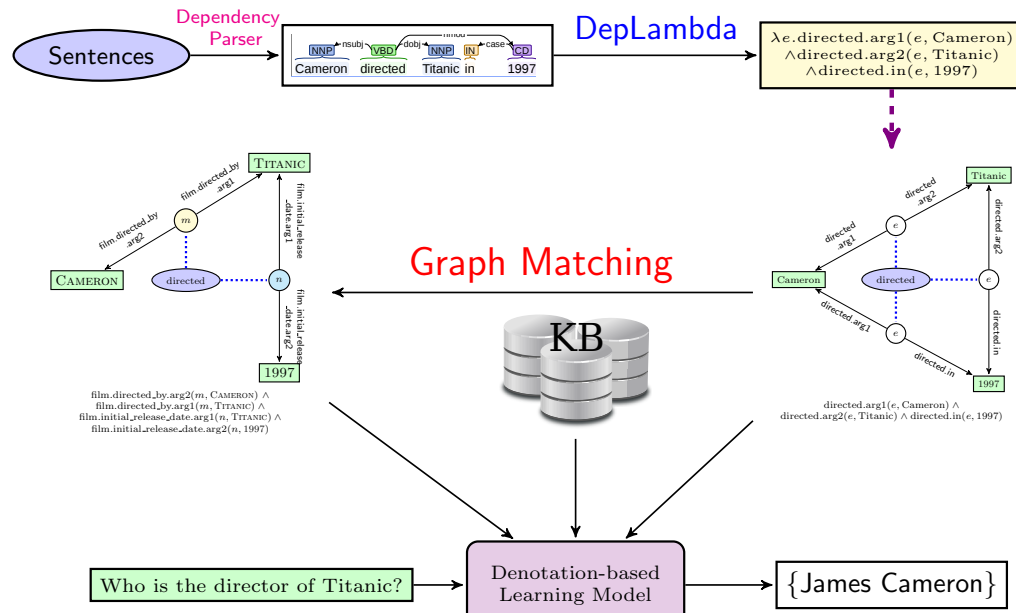
$\lambda g z. \exists y. \text{acquired}(z_e) \wedge g(y) \wedge \text{arg}_2(z_e, y_a)$

(nsubj dobj acquired Pixar) Disney
 $\lambda f g z. \exists x. f(z) \wedge g(x) \wedge \text{arg}_1(z_e, x_a)$

$\lambda g z. \exists x y. \text{acquired}(z_e) \wedge \text{Pixar}(y_a) \wedge g(x) \wedge \text{arg}_1(z_e, x_a) \wedge \text{arg}_2(z_e, y_a)$

$\lambda z. \exists x y. \text{acquired}(z_e) \wedge \text{Pixar}(y_a) \wedge \text{Disney}(x_a) \wedge \text{arg}_1(z_e, x_a) \wedge \text{arg}_2(z_e, y_a)$

Application: Freebase Question Answering



Multilingual QA Results

Test Data: WebQuestions – 2034 real Google Queries

| | English | German | Spanish |
|--------------|-------------|-------------|-------------|
| Bag of Words | 47.4 | 43.5 | 45.1 |
| DepTree | 47.8 | 43.7 | 45.7 |
| DepLambda | 49.0 | 44.3 | 46.2 |

The Future is bright..

Richer composition functions
e.g. Neural Networks, Tensors

Tree to Target Representation directly