НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
УНИВЕРСИТЕТ

Dependency grammar and dependency parsing

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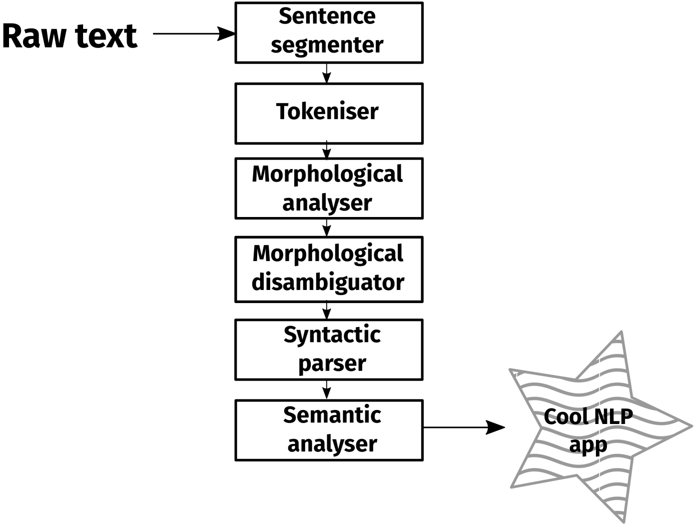
Pipeline



Raw text

Sentence segmenter

Tokeniser

Morphological analyser

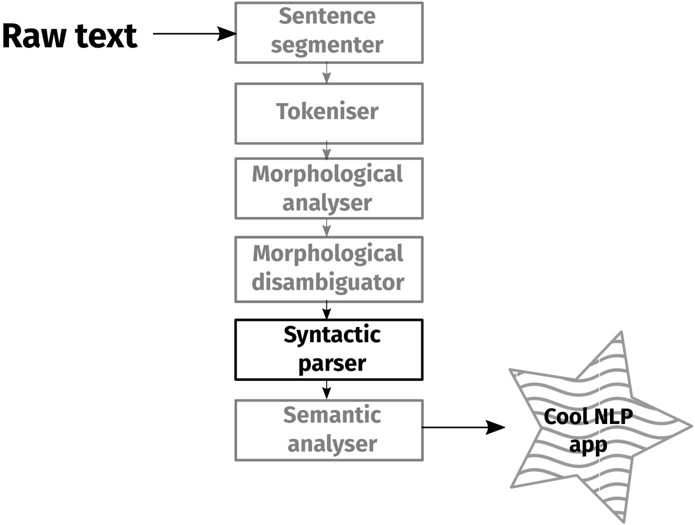
Morphological disambiguator

Syntactic parser

Semantic analyser

Cool NLP app

Pipeline

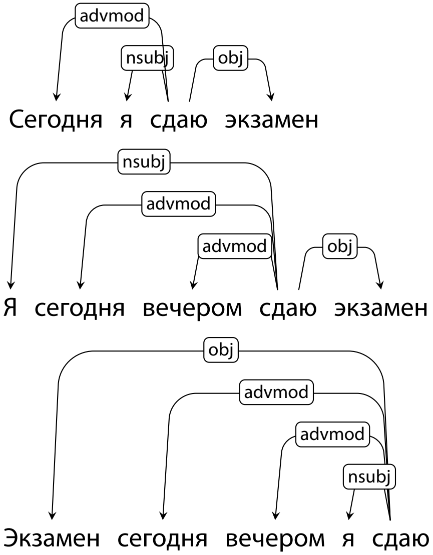

Raw text
Sentence segmenter
Tokeniser
Morphological analyser
Morphological disambiguator
Syntactic parser
Semantic analyser
Cool NLP app

Motivating example

	Bigrams
Сегодня я сдаю экзамен	я сдаю, сдаю экзамен
Я сегодня вечером сдаю экзамен	вечером сдаю, сдаю экзамен
Экзамен сегодня вечером я сдаю	я сдаю, сдаю EOS

- Generalise over linear order
- Generalise long-distance

Motivating example



Bigrams

я сдаю, сдаю экзамен

Я сдаю, сдаю экзамен

я сдаю, сдаю экзамен

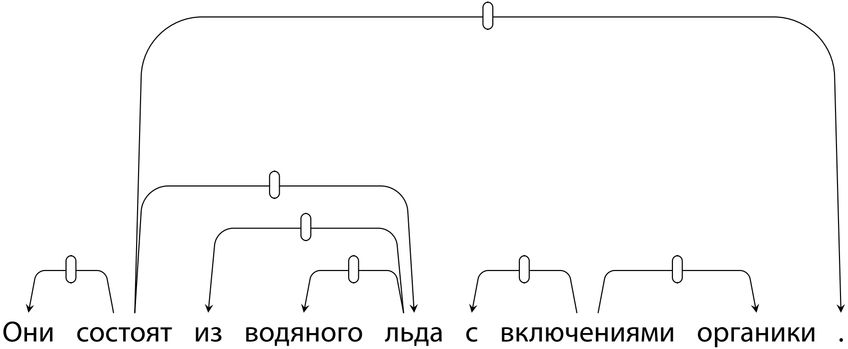
Dependency syntax

- Word based
- No non-terminals
- Words are linked by one-way binary relations
- Relations may be typed or untyped

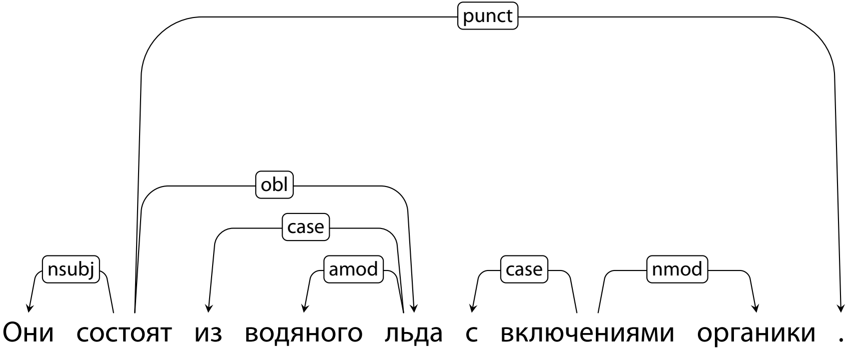
Dependency structure

Они состоят из водяного льда с включениями органики .

Dependency structure



Dependency structure



Terminology

Superior	**Inferior**
Head	Dependent
Governor	Modifier
Regent	Subordinate
Mother	Daughter
Parent	Child

...

Notational variants

x

Notational variants

x

Notational variants

x

Phrase structure

Comparison

Dependency structures explicitly represent:

- head–dependent relations (directed arcs)
- functional categories (arc labels)

Phrase structures explicitly represent:

- phrases (non-terminal nodes)
- structural categories (non-terminal labels)

Heads and dependents

- Criteria for a syntactic relation between a head H and a dependent D in a construction C (Zwicky, 1985)[1]
  1. *H* determines the syntactic category of *C*; *H* can replace *C*
  2. *H* determines the semantic category of *C*; *D* specifies *H*
  3. *H* is obligatory, *D* may be optional
  4. *H* selects *D* and determines optionality of *D*
  5. The form of *D* depends on *H* (agreement or government)
  6. Linear position of *D* is specified with reference to *H*
- An issue:
  - Syntactic (and morphological) versus semantic criteria

[1] Zwicky, A. (1985) "Heads"*Journal of Linguistics*, 21:1–29

Some fuzzy cases

- Complex verb groups (auxiliary–main verb)
- Subordinate clauses (complementiser–verb)
- Coordination (coordinator–conjuncts)
- Adpositional phrases (adposition–nominal)
- Punctuation

Dependency graphs

A dependency graph, G

- a set of V nodes,
- a set of A arcs,
- a linear precedence order $<$ on V

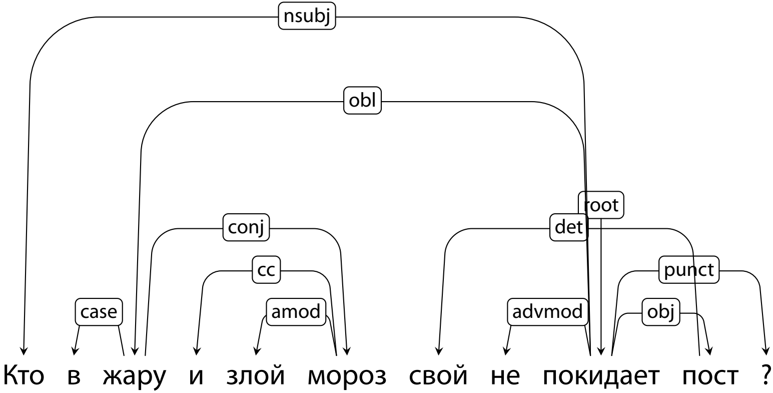
Labelled graphs:

- Nodes in V are labelled with word forms (and annotation)
- Arcs in A are labelled with dependency types

...

Conditions

Projectivity



Parsing methods

Transition-based

General idea

Components

Data structures:

- Stack:
  - Starts as containing only the ROOT
- Buffer
  - Starts as containing the full sentence
- Arcs
  - Starts as empty

Operations:

- SHIFT: Take the word on top of the buffer and put it on the stack
- LEFT-ARC: Make the word at the top of the stack the head of the word below it
  - Then remove the word at the top
- RIGHT-ARC: Make the word second from top the head of the word above it
  - Then remove the second from top word

Example

ROOT Мы пошли домой

Stack	**Buffer**
ROOT	Мы пошли домой

Example

SHIFT

ROOT Мы пошли домой

Stack	**Buffer**
ROOT Мы	пошли домой

Example

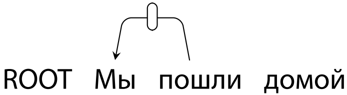
SHIFT

ROOT Мы пошли домой

Stack	**Buffer**
ROOT Мы пошли	домой

Example

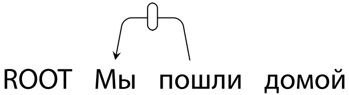
LEFT-ARC



Stack	**Buffer**
ROOT пошли	домой

Example

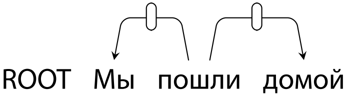
SHIFT



Stack	**Buffer**
ROOT пошли домой	

Example

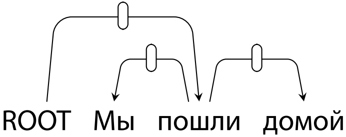
RIGHT-ARC



Stack	**Buffer**
ROOT пошли	

Example

RIGHT-ARC



Stack	**Buffer**
ROOT	

Configurations

A **configuration** is a snapshot of the state of the parser at a given time.

- A stack: Representing the word(s) currently being processed
- A buffer: Representing the remaining words
- A set of arcs representing a (partial) tree

We can conceive parsing as transitioning from one configuration to another via an operation.

Oracle

How do we get the sequence of operations?

Deterministic algorithm:

- LEFT-ARC: Configuration has arc from the top of stack to the word below
- RIGHT-ARC: Configuration has arc from the of the stack to the first word in the input buffer
    - In addition: The dependent must have no dependents of its own
- SHIFT: All other cases

Oracle

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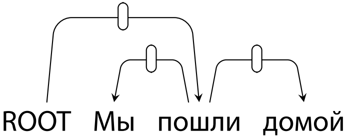
Deterministic algorithm:

- LEFT-ARC: Configuration has arc from the top of stack to the word below
- RIGHT-ARC: Configuration has arc from the of the stack to the **first word in the input buffer**
  - In addition: The **dependent** must have no dependents of its own
- SHIFT: All other cases

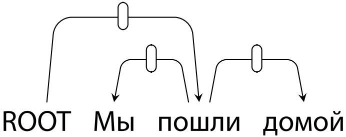
Parsing with an oracle



Stack	**Buffer**
ROOT	Мы пошли домой

- Is there an arc from the first word in the buffer to the top of the stack?
    - (Мы, ROOT)
- Is there an arc from the top of the stack to the first word in the buffer?
    - (ROOT, Мы)
- → then SHIFT

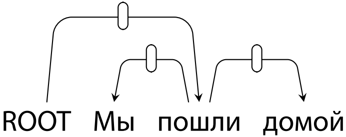
Parsing with an oracle



Stack	Buffer
ROOT Мы	пошли домой

- Is there an arc from the first word in the buffer to the top of the stack?
  - (пошли, Мы) — YES, LEFT-ARC
- Is there an arc from the top of the stack to the first word in the buffer?
  - (Мы, пошли)

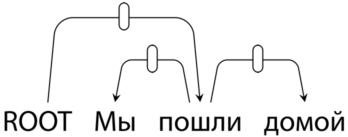
Parsing with an oracle



Stack	Buffer
ROOT	пошли домой

- Is there an arc from the first word in the buffer to the top of the stack?
    - (пошли, ROOT)
- Is there an arc from the top of the stack to the first word in the buffer?
    - (ROOT, пошли) – YES, but *пошли* still has dependents
- → then SHIFT

Parsing with an oracle



Stack	Buffer
ROOT пошли	домой

- Is there an arc from the first word in the buffer to the top of the stack?
  - (домой, пошли)
- Is there an arc from the top of the stack to the first word in the buffer?
  - (пошли, домой) – YES, and *домой* has no dependents
  - → RIGHT-ARC

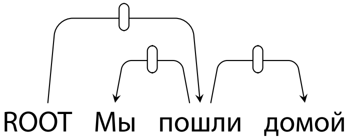
Training data

The “only” training data required is a treebank.

- Collection of sentences annotated for dependency structure
- Universal dependencies: 67 languages, 100s of treebanks

Data trains a classifier to predict a transition from a configuration.

Features



Stack	Buffer
ROOT пошли	домой

Features indexed by address (in stack or buffer) and attribute name.

Traditional:

- (Stack[0], Form) = пошли
- (Buffer[0], Form) = домой
- (Stack[0], UPOS) = VERB
- (Stack[1], Form) = ROOT

Can return NULL.

Indicator:

- Combinations of such features, e.g.
  - (Stack[0], Form) = пошли & (Buffer[0], UPOS) = ADP

Features begone!

Extensions

Graph-based

Basic model

Compared to transition based

Scoring

Maximum spanning tree

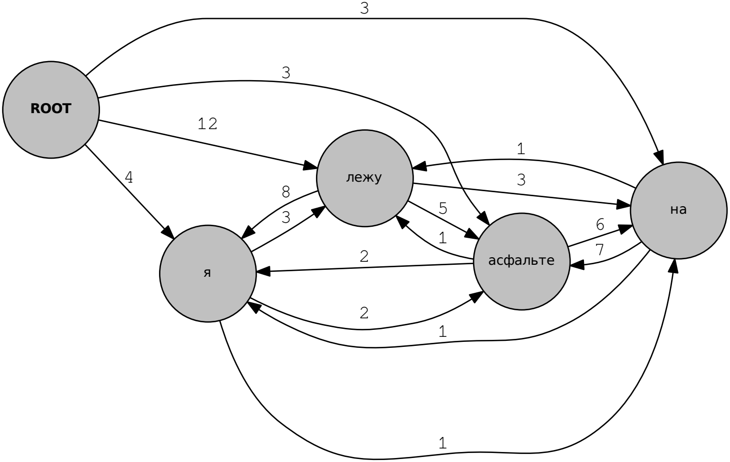
- Higher score
- Contains all nodes
- Each node has at most one incoming edge
- Originates from a single, predefined root

Dense graph

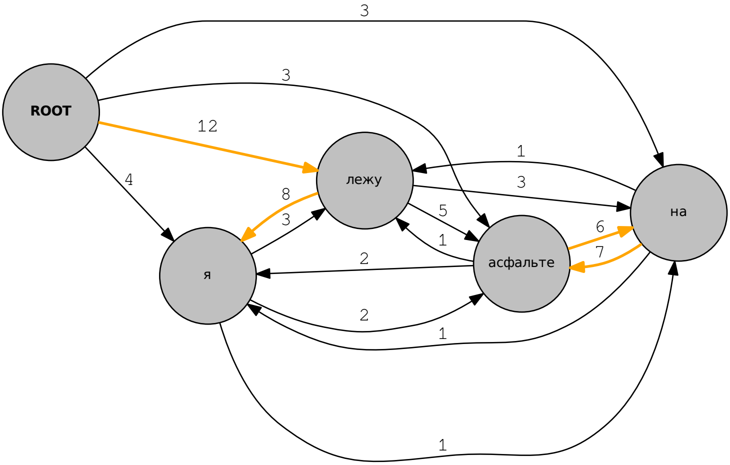
- Links between all nodes
- Except the root

Chu-Liu-Edmonds

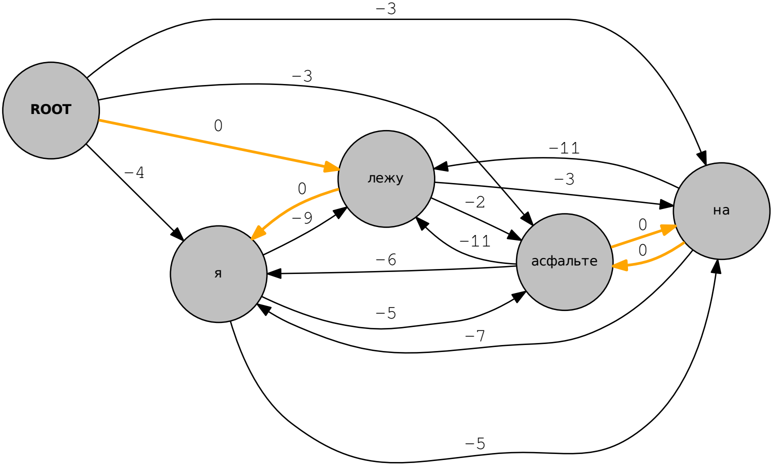
Example



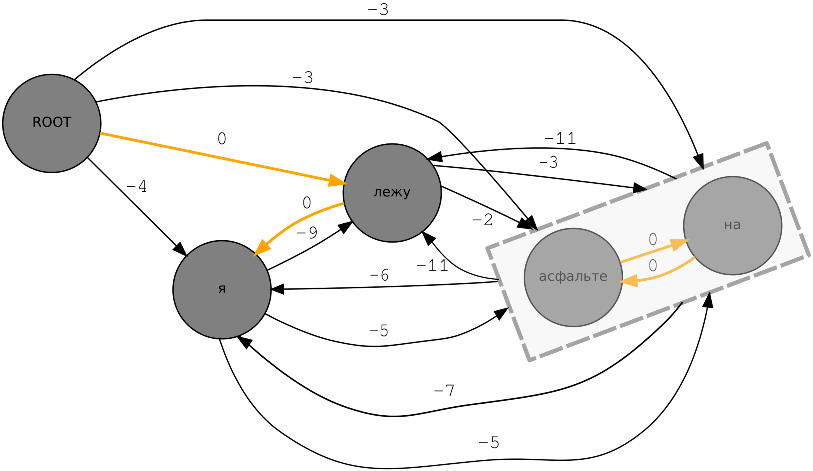
Example



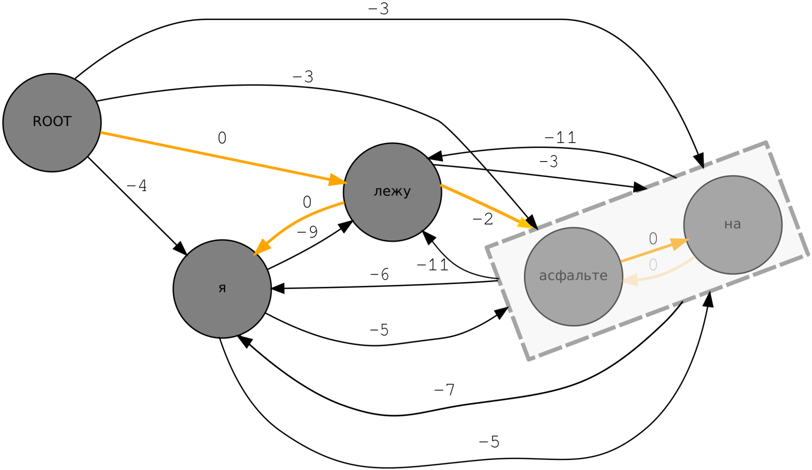
Example



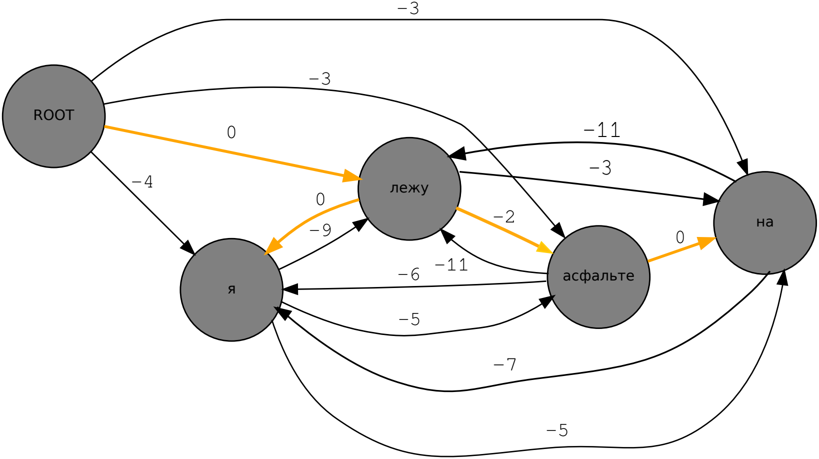
Example



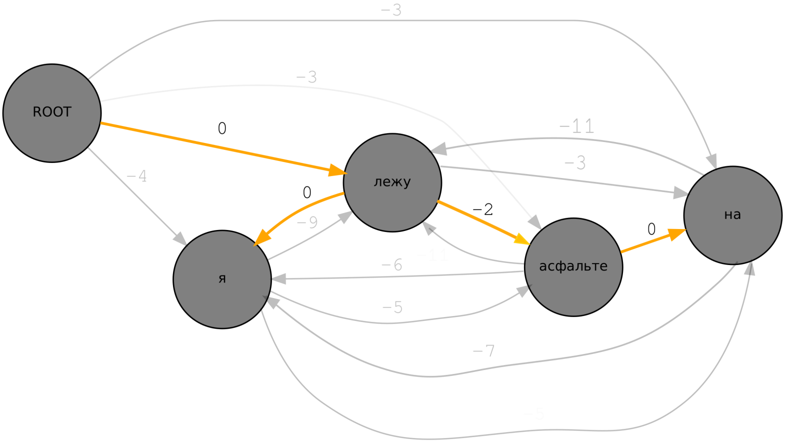
Example



Example



Example



Parsers

- UDPipe
- SyntaxNet
- BiST
  - Both MST and transition variants
- MaltParser
- MSTParser
- Stanford Parser

Evaluation

Simple evaluation:

- Unlabelled attachment score, **UAS**: correct heads/total heads
- Labelled attachment score, **LAS**: (correct heads+labels)/total heads

Shared tasks

CoNLL 2018

Practical

Ace the exam!