PLIN009 – Machine translation

Automatic MT quality evaluation
Other MT topics

Vít Baisa

Motivation

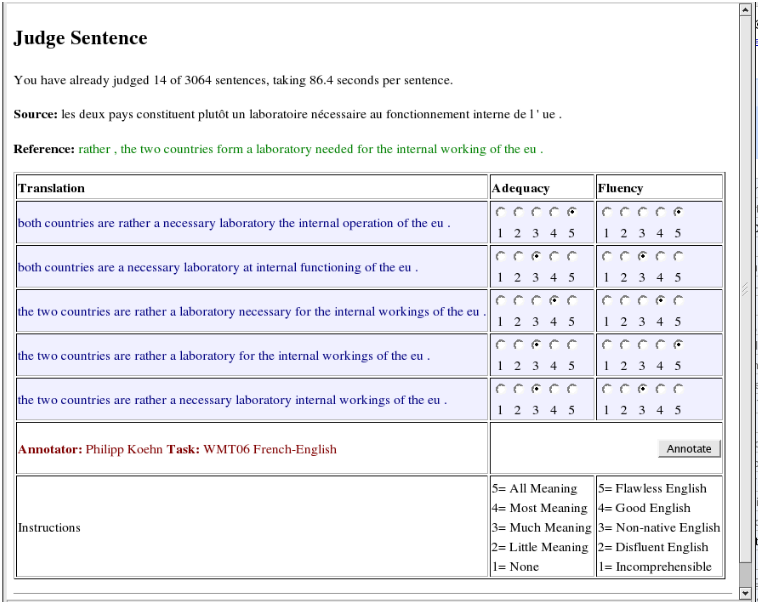
- **fluency** – is the translation fluent, in a natural word order?
- **adequacy** – does the translation preserve meaning or changes/skews it?
- **intelligibility** – do we understand the translation?

Evaluation scale

adequacy	
5	all meaning
4	most meaning
3	much meaning
2	little meaning
1	no meaning

fluency	
5	flawless English
4	good
3	non-native
2	disfluent
1	incomprehensible

Annotation tool



Judge Sentence

You have already judged 14 of 3064 sentences, taking 86.4 seconds per sentence.

Source: les deux pays constituent plutôt un laboratoire nécessaire au fonctionnement interne de l ' ue .

Reference: rather , the two countries form a laboratory needed for the internal working of the eu .

Translation	Adequacy	Fluency
both countries are rather a necessary laboratory the internal operation of the eu .	○ ○ ○ ○ ● 1 2 3 4 5	○ ○ ○ ○ ● 1 2 3 4 5
both countries are a necessary laboratory at internal functioning of the eu .	○ ○ ● ○ ○ 1 2 3 4 5	○ ○ ● ○ ○ 1 2 3 4 5
the two countries are rather a laboratory necessary for the internal workings of the eu .	○ ○ ○ ● ○ 1 2 3 4 5	○ ○ ○ ● ○ 1 2 3 4 5
the two countries are rather a laboratory for the internal workings of the eu .	○ ○ ● ○ ○ 1 2 3 4 5	○ ○ ○ ○ ● 1 2 3 4 5
the two countries are rather a necessary laboratory internal workings of the eu .	○ ○ ● ○ ○ 1 2 3 4 5	○ ○ ● ○ ○ 1 2 3 4 5
Annotator: Philipp Koehn **Task:** WMT06 French-English	Annotate	
Instructions	5= All Meaning 4= Most Meaning 3= Much Meaning 2= Little Meaning 1= None	5= Flawless English 4= Good English 3= Non-native English 2= Disfluent English 1= Incomprehensible

Disadvantages of manual evaluation

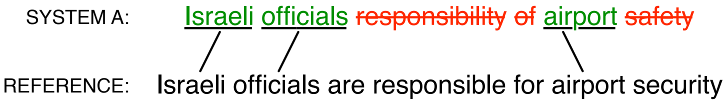
- slow, expensive, subjective
- inter-annotator agreement (IAA) shows people agree more on fluency than on adequacy
- another option how to measure quality: is X better translation than Y?
- → bigger IAA
- time spent on post-editing
- how much cost of translation is reduced

Automatic translation evaluation

- advantages: speed, cost
- disadvantages: do we really measure quality of translation?
- gold standard: manually prepared reference translations
- candidate *c* is compared with *n* reference translations r_i
- the paradox of automatic evaluation: the task corresponds to situation where students are to assess their own exam: how they know where they made a mistake?
- various approaches: n-gram shared between *c* and r_i, edit distance, . . .

Recall and precision on words

The simplest method of automatic evaluation.



SYSTEM A: Israeli officials ~~responsibility~~ ~~of~~ airport ~~safety~~

REFERENCE: Israeli officials are responsible for airport security

- precision

$$\frac{\textit{correct}}{\textit{output-length}} = \frac{3}{6} = 50\%$$

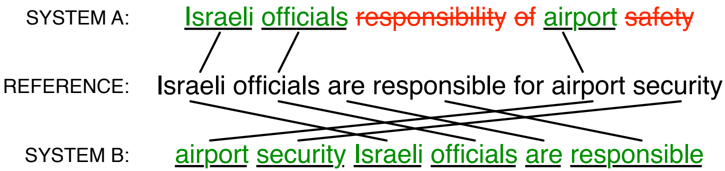
- recall

$$\frac{\textit{correct}}{\textit{reference-length}} = \frac{3}{7} = 43\%$$

- f-score

$$\frac{\textit{precision} \times \textit{recall}}{(\textit{precision} + \textit{recall})/2} = \frac{.5 \times .43}{(.5 + .43)/2} = 46\%$$

Recall and precision – shortcomings



SYSTEM A: Israeli officials ~~responsibility~~ ~~of~~ airport ~~safety~~

REFERENCE: Israeli officials are responsible for airport security

SYSTEM B: airport security Israeli officials are responsible

metrics	system A	system B
precision	50%	100%
recall	43%	100%
f-score	46%	100%

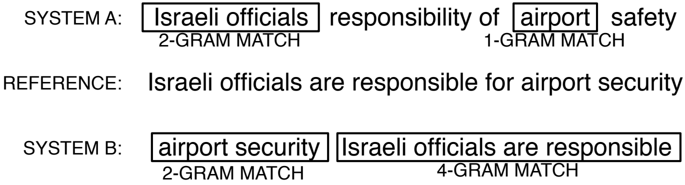
It does not capture wrong word order.

BLEU

- the most famous (standard), the most used, the oldest (2001)
- IBM, author Papineni
- n-gram match between reference and candidate translations
- precision is calculated for 1-, 2- ,3- and 4-grams
- $+$ **brevity penalty**

$$\mathrm{BLEU} = \min\left(1, \frac{\textit{output-length}}{\textit{reference-length}}\right) \ \big(\prod_{i=1}^{4} \textit{precision}_i\big)^{\frac{1}{4}}$$

BLEU – an example



SYSTEM A: Israeli officials responsibility of airport safety

2-GRAM MATCH

1-GRAM MATCH

REFERENCE: Israeli officials are responsible for airport security

SYSTEM B: airport security Israeli officials are responsible

2-GRAM MATCH

4-GRAM MATCH

metrics	**system A**	**system B**
precision (1gram)	3/6	6/6
precision (2gram)	1/5	4/5
precision (3gram)	0/4	2/4
precision (4gram)	0/3	1/3
brevity penalty	6/7	6/7
BLEU	0 %	52 %

Other metrics

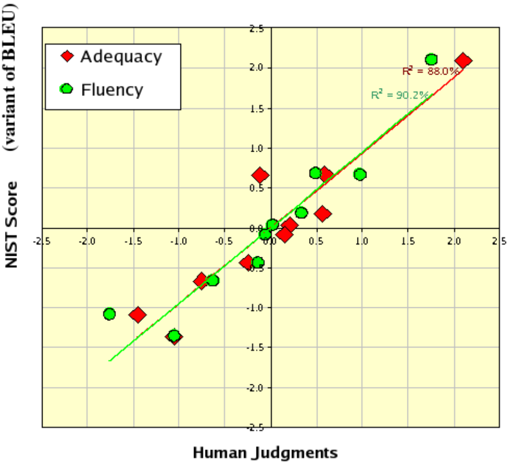
- NIST
  - NIST: National Institute of Standards and Technology
  - weighted matches of n-grams (information value)
  - very similar results as for BLEU (a variant)
- NEVA
  - Ngram EVAluation
  - BLEU score adapted for short sentences
  - it takes into account synonyms (stylistic richness)
- WAFT
  - Word Accuracy for Translation
  - edit distance between c and r
  - $\text{WAFT} = 1 - \frac{d+s+i}{max(l_r,l_c)}$

Other metrics II

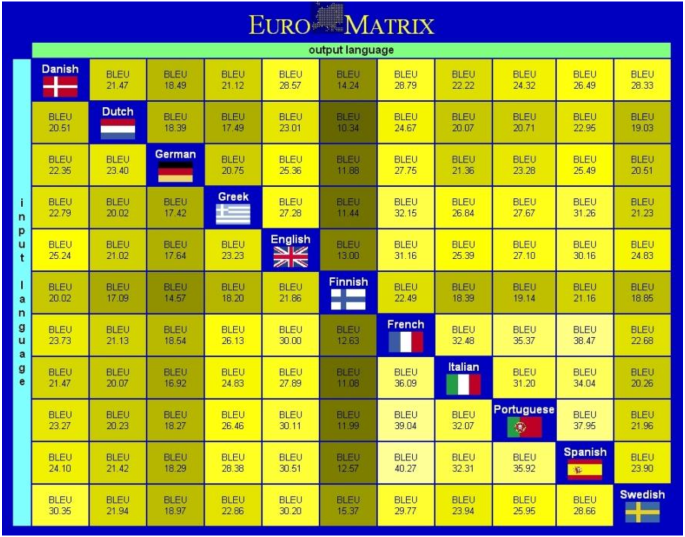
- TER
  - Translation Edit Rate
  - the least edit steps (deletion, insertion, swap, replacement)
  - $\text{TER} = \frac{\text{number of edits}}{\text{avg. number of ref. words}}$
  - $r =$ dnes jsem si při fotbalu zlomil kotník
  - $c =$ při fotbalu jsem si dnes zlomil kotník
  - $\text{TER} = 4/7$
- HTER
  - Human TER
  - r manually prepared and then TER is applied
- METEOR
  - takes into account synonyms (WordNet) and
  - morphological variants of words

Evaluation of evaluation metrics

Correlation of automatic evaluation with manual evaluation.



Translation evaluation example– EuroMatrix



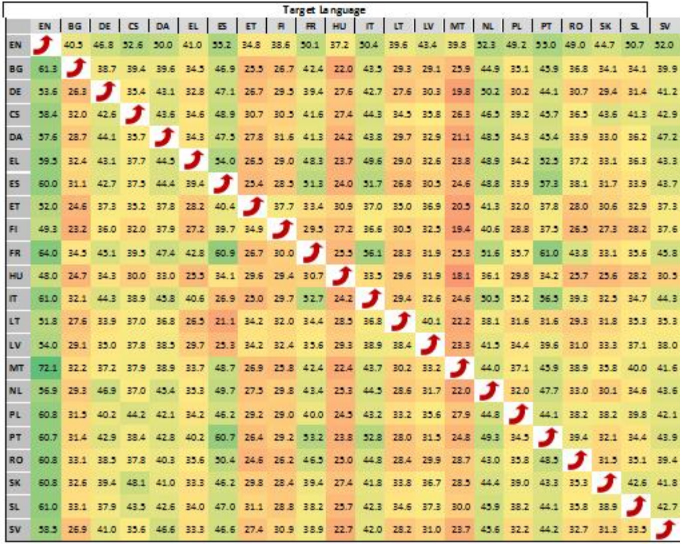
EURO MATRIX

output language

input language

Danish	BLEU 21.47	BLEU 18.49	BLEU 21.12	BLEU 28.57	BLEU 14.24	BLEU 28.79	BLEU 22.22	BLEU 24.32	BLEU 26.49	BLEU 28.33
BLEU 20.51	Dutch	BLEU 18.39	BLEU 17.49	BLEU 23.01	BLEU 10.34	BLEU 24.67	BLEU 20.07	BLEU 20.71	BLEU 22.95	BLEU 19.03
BLEU 22.35	BLEU 23.40	German	BLEU 20.75	BLEU 25.36	BLEU 11.88	BLEU 27.75	BLEU 21.36	BLEU 23.28	BLEU 25.49	BLEU 20.51
BLEU 22.79	BLEU 20.02	BLEU 17.42	Greek	BLEU 27.28	BLEU 11.44	BLEU 32.15	BLEU 26.84	BLEU 27.67	BLEU 31.26	BLEU 21.23
BLEU 25.24	BLEU 21.02	BLEU 17.64	BLEU 23.23	English	BLEU 13.00	BLEU 31.16	BLEU 25.39	BLEU 27.10	BLEU 30.16	BLEU 24.83
BLEU 20.02	BLEU 17.09	BLEU 14.57	BLEU 18.20	BLEU 21.86	Finnish	BLEU 22.49	BLEU 18.39	BLEU 19.14	BLEU 21.16	BLEU 18.85
BLEU 23.73	BLEU 21.13	BLEU 18.54	BLEU 26.13	BLEU 30.00	BLEU 12.63	French	BLEU 32.48	BLEU 35.37	BLEU 38.47	BLEU 22.68
BLEU 21.47	BLEU 20.07	BLEU 16.92	BLEU 24.83	BLEU 27.89	BLEU 11.08	BLEU 36.09	Italian	BLEU 31.20	BLEU 34.04	BLEU 20.26
BLEU 23.27	BLEU 20.23	BLEU 18.27	BLEU 26.46	BLEU 30.11	BLEU 11.99	BLEU 39.04	BLEU 32.07	Portuguese	BLEU 37.95	BLEU 21.96
BLEU 24.10	BLEU 21.42	BLEU 18.29	BLEU 28.38	BLEU 30.51	BLEU 12.57	BLEU 40.27	BLEU 32.31	BLEU 35.92	Spanish	BLEU 23.90
BLEU 30.35	BLEU 21.94	BLEU 18.97	BLEU 22.86	BLEU 30.20	BLEU 15.37	BLEU 29.77	BLEU 23.94	BLEU 25.95	BLEU 28.66	Swedish

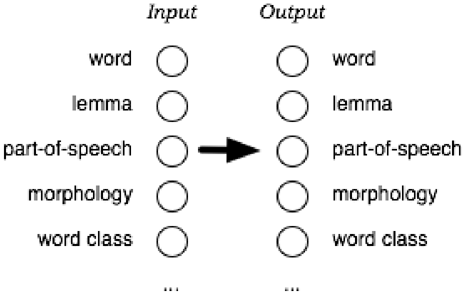
Translation quality by language pairs



	Target Language																				
	EN	BG	DE	CS	DA	EL	ES	ET	FI	FR	HU	IT	LT	LV	MT	NL	PL	PT	RO	SK	SL	SV
EN	⤴	40.5	46.8	52.6	50.0	41.0	55.2	34.8	38.6	50.1	37.2	50.4	39.6	43.4	39.8	52.3	49.2	55.0	49.0	44.7	50.7	52.0
BG	61.3	⤴	38.7	39.4	39.6	34.5	46.9	25.5	26.7	42.4	22.0	43.5	29.3	29.1	25.9	44.9	35.1	45.9	36.8	34.1	34.1	39.9
DE	53.6	26.3	⤴	35.4	43.1	32.8	47.1	26.7	29.5	39.4	27.6	42.7	27.6	30.3	19.8	50.2	30.2	44.1	30.7	29.4	31.4	41.2
CS	58.4	32.0	42.6	⤴	43.6	34.6	48.9	30.7	30.5	41.6	27.4	44.3	34.5	35.8	26.3	46.5	39.2	45.7	36.5	43.6	41.3	42.9
DA	57.6	28.7	44.1	35.7	⤴	34.3	47.5	27.8	31.6	41.3	24.2	43.8	29.7	32.9	21.1	48.5	34.3	45.4	33.9	33.0	36.2	47.2
EL	59.5	32.4	43.1	37.7	44.5	⤴	54.0	26.5	29.0	48.3	23.7	49.6	29.0	32.6	23.8	48.9	34.2	52.5	37.2	33.1	36.3	43.3
ES	60.0	31.1	42.7	37.5	44.4	39.4	⤴	25.4	28.5	51.3	24.0	51.7	26.8	30.5	24.6	48.8	33.9	57.3	38.1	31.7	33.9	43.7
ET	52.0	24.6	37.3	35.2	37.8	28.2	40.4	⤴	37.7	33.4	30.9	37.0	35.0	36.9	20.5	41.3	32.0	37.8	28.0	30.6	32.9	37.3
FI	49.3	23.2	36.0	32.0	37.9	27.2	39.7	34.9	⤴	29.5	27.2	36.6	30.5	32.5	19.4	40.6	28.8	37.5	26.5	27.3	28.2	37.6
FR	64.0	34.5	45.1	39.5	47.4	42.8	60.9	26.7	30.0	⤴	25.5	56.1	28.3	31.9	25.3	51.6	35.7	61.0	43.8	33.1	35.6	45.8
HU	48.0	24.7	34.3	30.0	33.0	25.5	34.1	29.6	29.4	30.7	⤴	33.5	29.6	31.9	18.1	36.1	29.8	34.2	25.7	25.6	28.2	30.5
IT	61.0	32.1	44.3	38.9	45.8	40.6	26.9	25.0	29.7	52.7	24.2	⤴	29.4	32.6	24.6	50.5	35.2	56.5	39.3	32.5	34.7	44.3
LT	51.8	27.6	33.9	37.0	36.8	26.5	21.1	34.2	32.0	34.4	28.5	36.8	⤴	40.1	22.2	38.1	31.6	31.6	29.3	31.8	35.3	35.3
LV	54.0	29.1	35.0	37.8	38.5	29.7	25.3	34.2	32.4	35.6	29.3	38.9	38.4	⤴	23.3	41.5	34.4	39.6	31.0	33.3	37.1	38.0
MT	72.1	32.2	37.2	37.9	38.9	33.7	48.7	26.9	25.8	42.4	22.4	43.7	30.2	33.2	⤴	44.0	37.1	45.9	38.9	35.8	40.0	41.6
NL	56.9	29.3	46.9	37.0	45.4	35.3	49.7	27.5	29.8	43.4	25.3	44.5	28.6	31.7	22.0	⤴	32.0	47.7	33.0	30.1	34.6	43.6
PL	60.8	31.5	40.2	44.2	42.1	34.2	46.2	29.2	29.0	40.0	24.5	43.2	33.2	35.6	27.9	44.8	⤴	44.1	38.2	38.2	39.8	42.1
PT	60.7	31.4	42.9	38.4	42.8	40.2	60.7	26.4	29.2	53.2	23.8	52.8	28.0	31.5	24.8	49.3	34.5	⤴	39.4	32.1	34.4	43.9
RO	60.8	33.1	38.5	37.8	40.3	35.6	50.4	24.6	26.2	46.5	25.0	44.8	28.4	29.9	28.7	43.0	35.8	48.5	⤴	31.5	35.1	39.4
SK	60.8	32.6	39.4	48.1	41.0	33.3	46.2	29.8	28.4	39.4	27.4	41.8	33.8	36.7	28.5	44.4	39.0	43.3	35.3	⤴	42.6	41.8
SL	61.0	33.1	37.9	43.5	42.6	34.0	47.0	31.1	28.8	38.2	25.7	42.3	34.6	37.3	30.0	45.9	38.2	44.1	35.8	38.9	⤴	42.7
SV	58.5	26.9	41.0	35.6	46.6	33.3	46.6	27.4	30.9	38.9	22.7	42.0	28.2	31.0	23.7	45.6	32.2	44.2	32.7	31.3	33.5	⤴

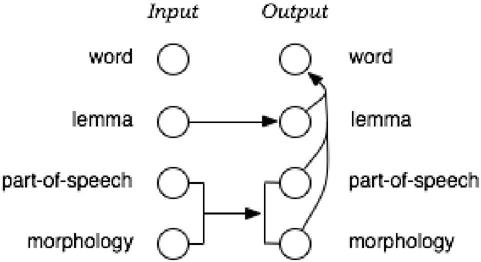
Factored translation models

- common SMT models do not use linguistic knowledge
- usage of lemmas, PoS, stems helps to overcome data sparsity
- translation of vectors instead of words (tokens)



Factored translation models II

- in standard SMT: *dům* and *domy* are independent tokens
- in FTM they share lemma, PoS and part of morph. information
- lemma and morphologic information are translated separately
- in target language, appropriate wordform is then generated



Implemented in Moses.

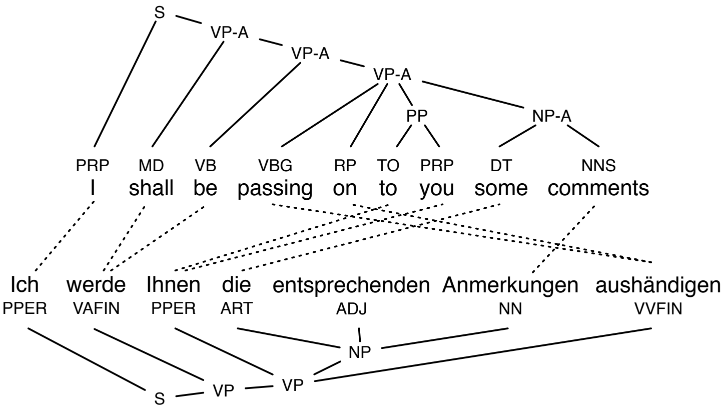
Tree-based translation models

- SMT translates word sequences
- many situations can be better explained with syntax: moving verb around a sentence, grammar agreement at long distance, …
- → translation models based on syntactic trees
- current topic, for some language pairs it gives the best results

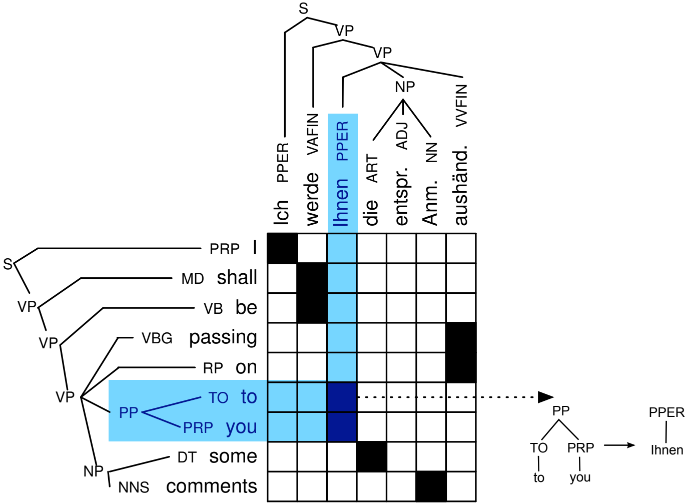
TBTM II – synchronous phrase grammar

- EN rule NP → DET JJ NN
- DE rule NP → DET NN JJ
- synchronous rule NP → $\text{DET}_1\ \text{NN}_2\ \text{JJ}_3 \mid \text{DET}_1\ \text{JJ}_3\ \text{NN}_2$
- final rule N → dům | house
- mixed rule N → la maison JJ_1 | the JJ_1 house

Parallel tree-bank



Syntactic rules extraction



Hybrid systems of machine translation

- combination of rule-based and statistical systems
- rule-based translation with post-editing by SMT (e.g. smoothing with a LM)
- data preparaion for SMT based on rules, changing output of SMT based on rules

Computer-aided Translation

- CAT – computer-assisted (aided) translation
- out of score of pure MT
- tools belonging to CAT realm:
    - spell checkers (typos): *hunspell*
    - grammar checkers: *Lingea Grammaticon*
    - terminology management: *Trados TermBase*
    - electronic translation dictionaries: *Metatrans*
    - corpus managers: *Manatee/Bonito*
    - translation memories: *MemoQ, Trados*

Translation memory

- database of segments: titles, phrases, sentences, terms, paragraphs
- which have already been translated (manually) → **translation units**
- advantages:
  - everything is translated only once
  - cost reducing (repeated translation of manuals)
- disadvantages:
  - majority of the best (biggest) systems are commercial
  - translation units are hard to get
  - inappropriate translation is repeated again and again
- CAT systems suggest translations based on exact match
- or on exact context match, fuzzy match
- CAT systems can automatically translated the repeated texts

Questions I

- Enumerate at least 3 rule-based MT systems.
- What does abbreviation FAHQMT mean?
- What does IBM-2 model adds to IBM-1?
- Explain *noisy channel* principle with its formula.
- State at least 3 metrics for MT quality evaluation.
- State types of translation according to R. Jakobson.
- What does Sapir-Whorf hypothesis claim?
- Describe Georgetown experiment (facts).
- State at least 3 examples of morphologically rich languages (different language families).
- What is the advantage of systems with interlingua against transfer systems? Draw a scheme of translations between 5 languages for these two types of systems.
- Give an example of a problematic string for tokenization (English, Czech).

Questions II

- What is tagset, treebank, PoS tagging, WSD, FrameNet, gisting, sense granularity?
- What advantages does space-based meaning representation have?
- Which classes of WSD methods do we distinguish?
- Draw Vauquois' triangle with SMT IBM-1 in it.
- Explain garden path phenomenon and come up with an example for Czech (or English) not used in slides.
- Draw dependency structure for sentence *Máma vidí malou Emu.*
- Draw the scheme of SMT.
- Give at least 3 sources of parallel data.
- Explain Zipf's law.
- Explain (using an example) Bayes' rule (state its formula).
- What is the purpose of decoding algorithms?

Questions III

- Write down the formula or describe with words *Markov's assumption*.
- $\geq$ 3 examples of frequent word trigrams and quadrigrams for Czech (English).
- We aim at low of high perplexity for language models?
- Describe IBM models (1–5) briefly.
- Draw word alignment matrix for sentences *I am very hungry.* and *Jsem velmi hladový*.