Probabilistic Semantic Frames

(IB030)

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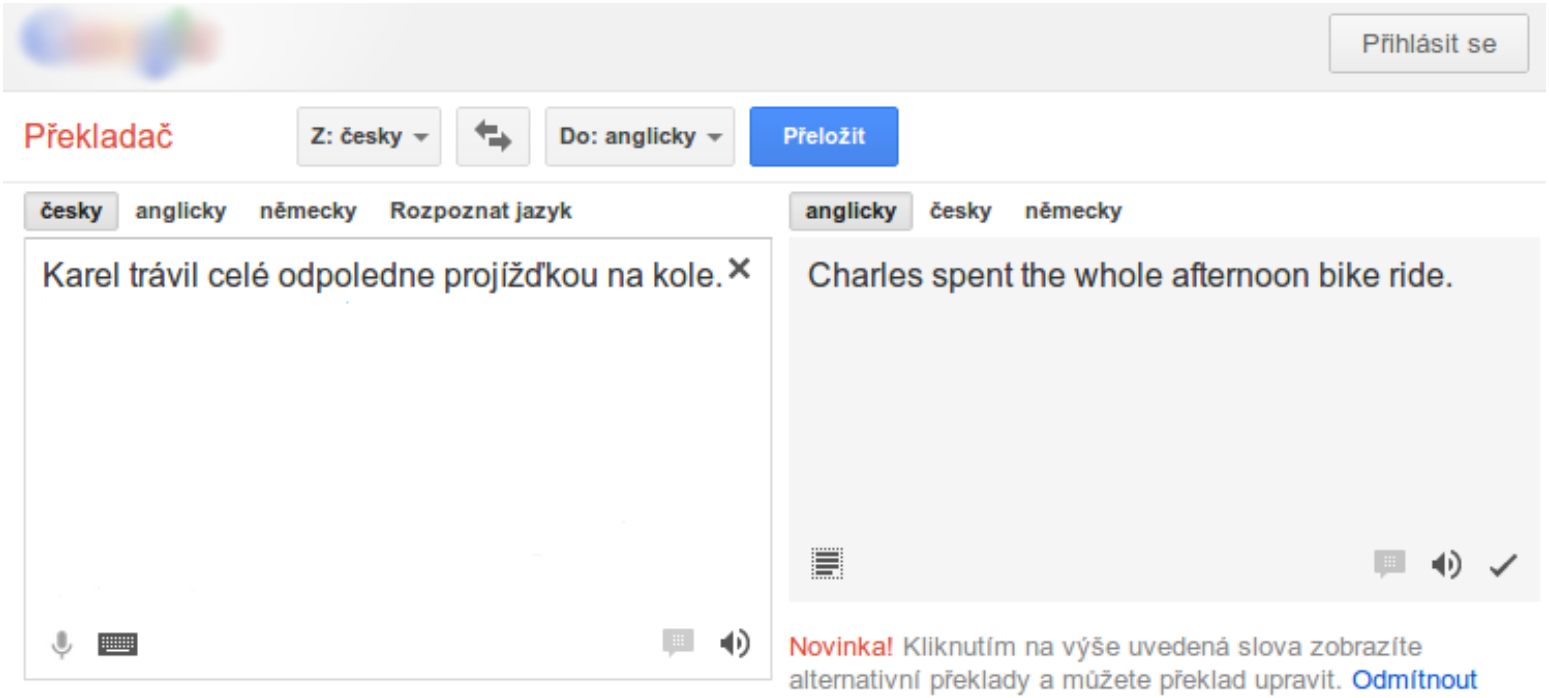
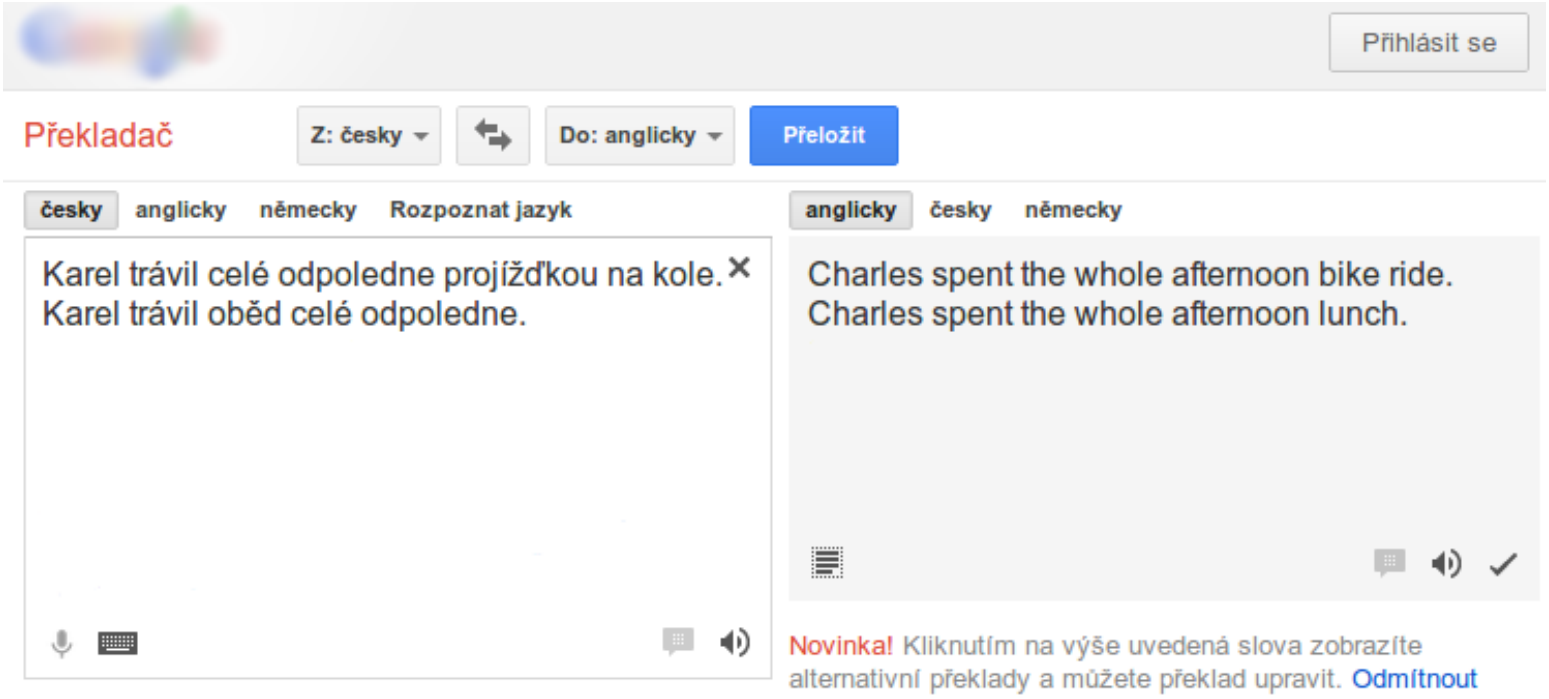
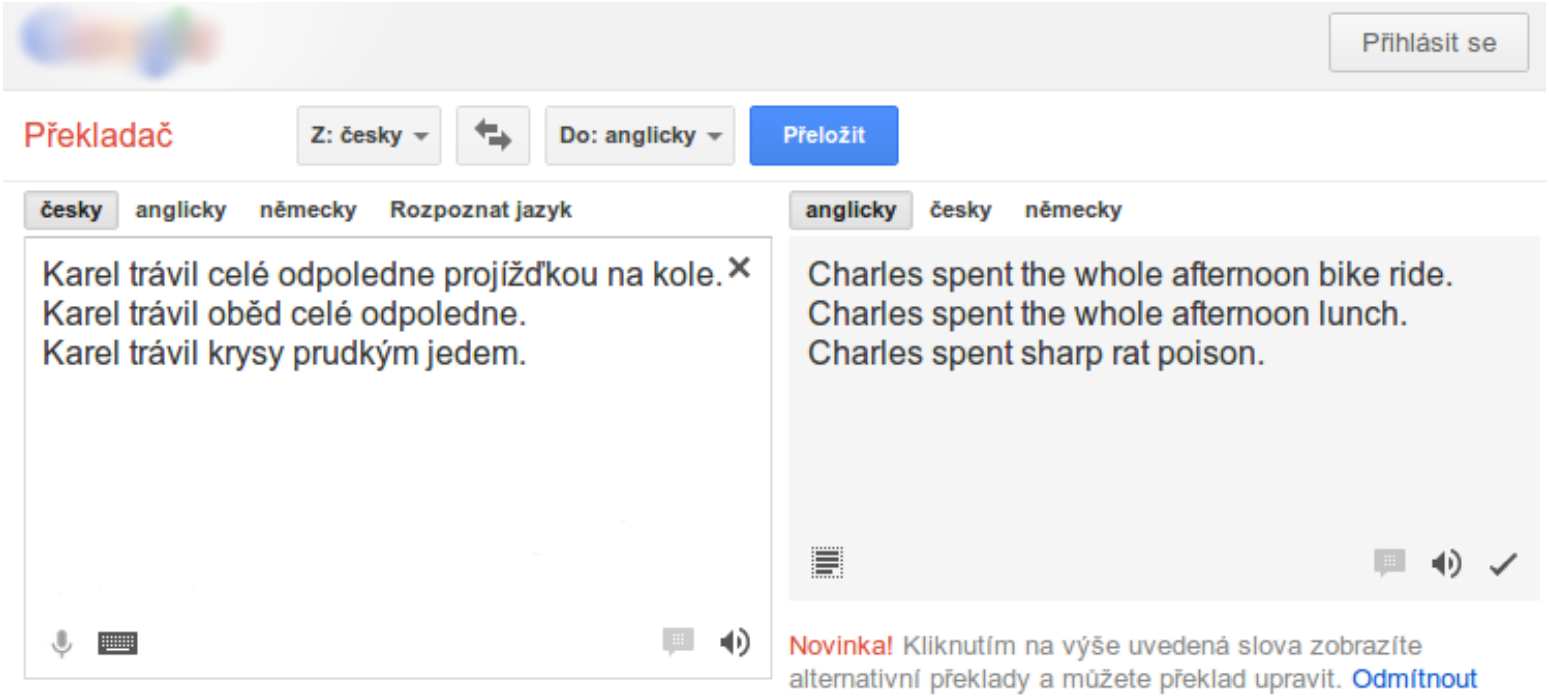
Motivation I



Motivation II

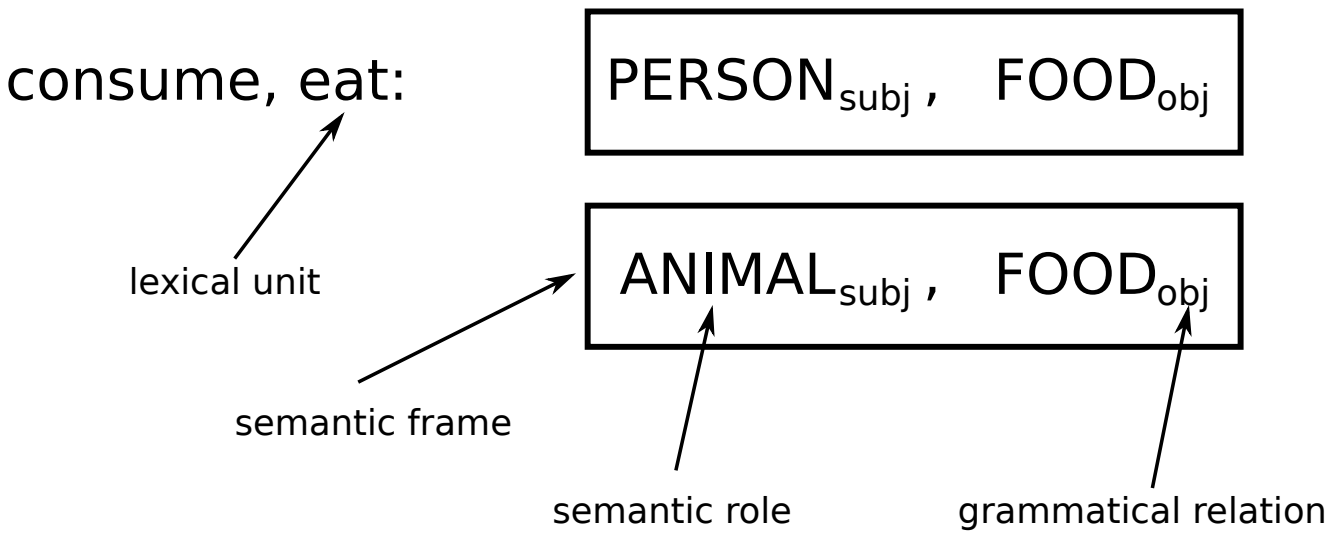


Motivation III



Semantic frames

- terminology adopted from Frame Semantics
- captures selectional preferences of grammatical relations



Criticism of current DBs of SFs

- development of SFs is very time-consuming and expensive
- small coverage
- no statistical information
- subjectively biased

Objectives

- semantic frames should be generated automatically from corpora
- algorithm must be unsupervised
- model should be probabilistic
- model should provide a possibility to estimate its parameters automatically
- set of semantic roles should be shared between different SFs

LDA-Frames

- unsupervised method for discovering semantic frames
- generative model inspired by Latent Dirichlet Allocation
- language independent
- for each lexical unit a probability distribution over frames
- semantic roles represented as probability distributions over words
- need for a syntactically annotated corpus
- labels for roles must be assigned manually (if required)

Web demo

EAT

	SUBJECT		OBJECT	
	222		40	
0.554086 frame 1166	0.794216	person	0.085888	food
	0.010335	people	0.046396	meal
	0.007963	one	0.01947	egg
	0.005797	man	0.01947	breakfast
	0.004342	who	0.01726	lunch
	0.003409	woman	0.016846	dinner
	0.002687	child	0.015189	fish
	0.002519	that	0.013256	meat
	0.002307	all	0.012289	potato
	0.002215	someone	0.012151	cake
	152		40	
0.128011 frame 622	0.027104	bird	0.085888	food
	0.026926	dog	0.046396	meal
	0.023538	animal	0.01947	egg
	0.023181	fish	0.01947	breakfast
	0.016049	cat	0.01726	lunch
	0.014979	child	0.016846	dinner
	0.013374	people	0.015189	fish
	0.01266	prey	0.013256	meat
	0.011947	man	0.012289	potato
	0.011769	horse	0.012151	cake

LDA-frames – training data

Set of frame realizations for each lexical unit

Lexical unit	**subject**	**object**	**frame**
eat	John Mike man	food pizza cake	(Person, Food)
	dog mouse	meat cheese	(Animal, Food)
drink	Jane Mike	coffee tee	(Person, Drink)
teach	teacher professor	student Mike	(Person, Person)
	Peter	dog	(Person, Animal)

Table : Example of grammatical relation realizations.

Multinomial and Dirichlet distributions

Multinomial distribution:

$$P(\vec{m}|\vec{p}) = \frac{(\sum_{i=1}^{k} m_i)!}{m_1!m_2!\ldots m_k!} \prod_{i=1}^{k} p_i^{m_i}, \tag{1}$$

Dirichlet distribution:

$$\mathrm{Dir}(\vec{p}|\vec{\alpha}) = \frac{\Gamma(\alpha_1 + \alpha_2 + \cdots + \alpha_k)}{\Gamma(\alpha_1)\Gamma(\alpha_2)\ldots\Gamma(\alpha_k)} \prod_{i=1}^{k} p_i^{\alpha_i - 1}, \tag{2}$$

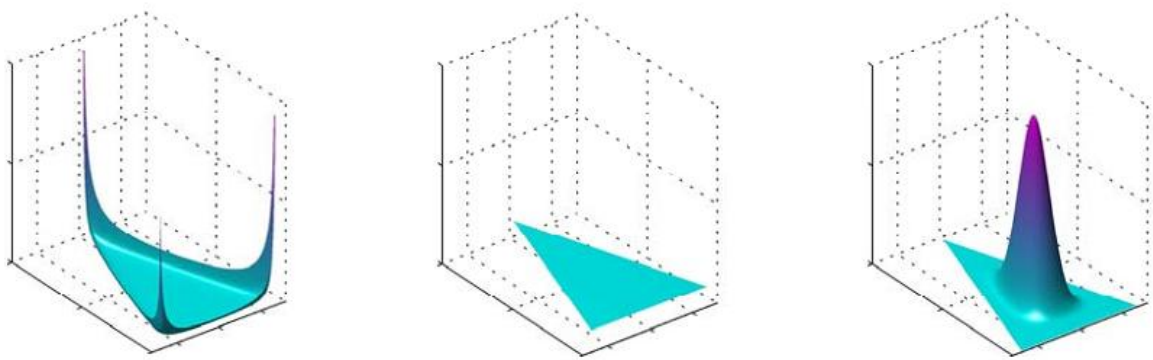
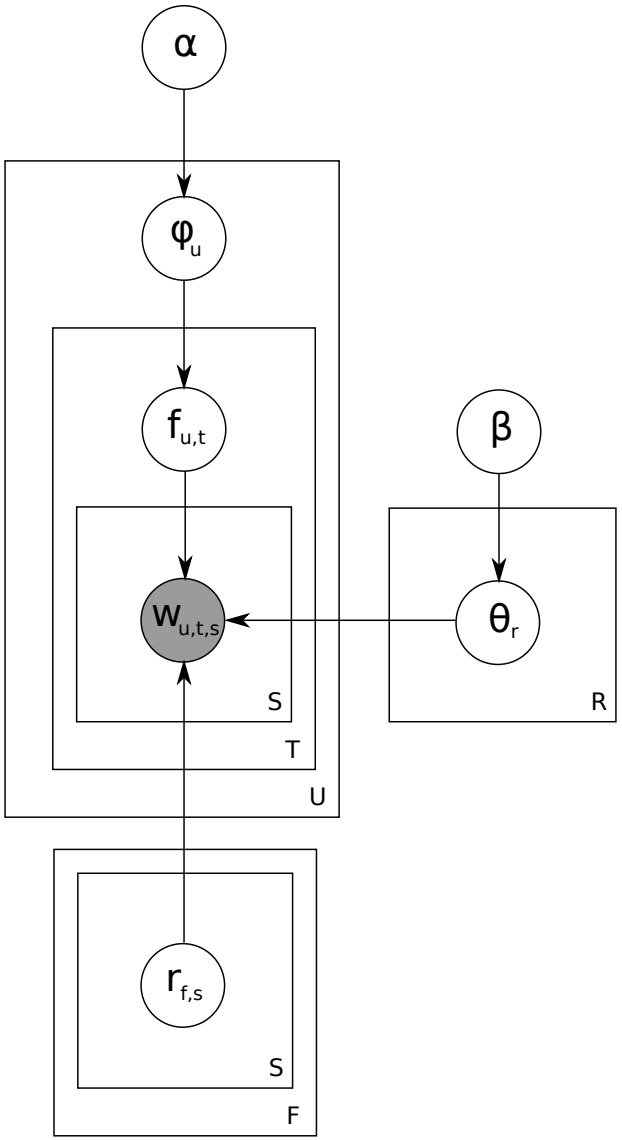
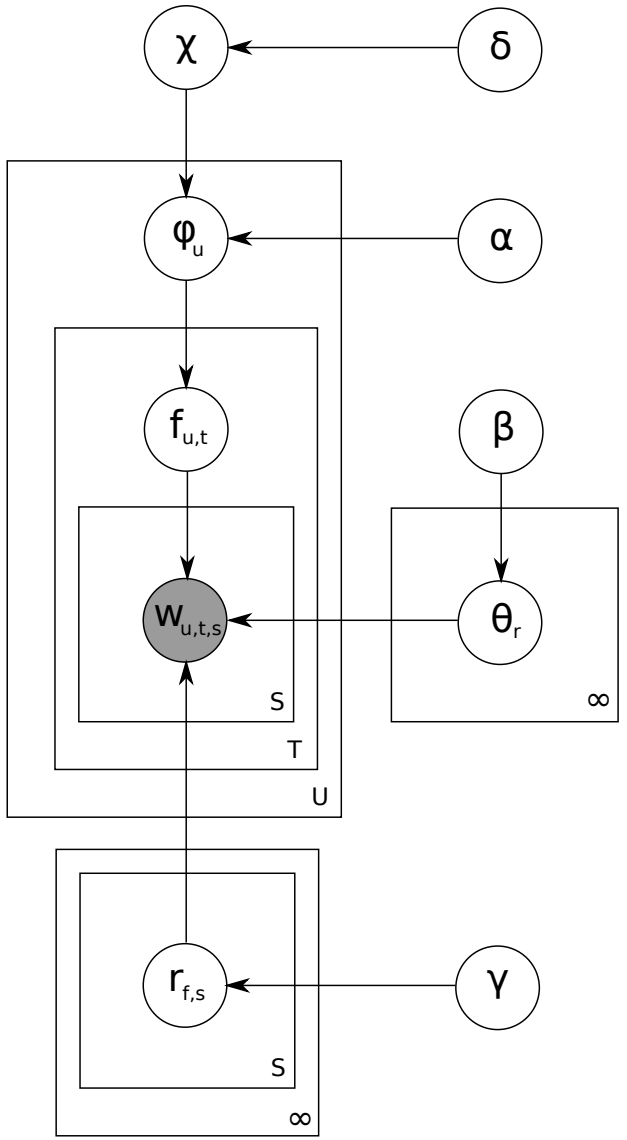


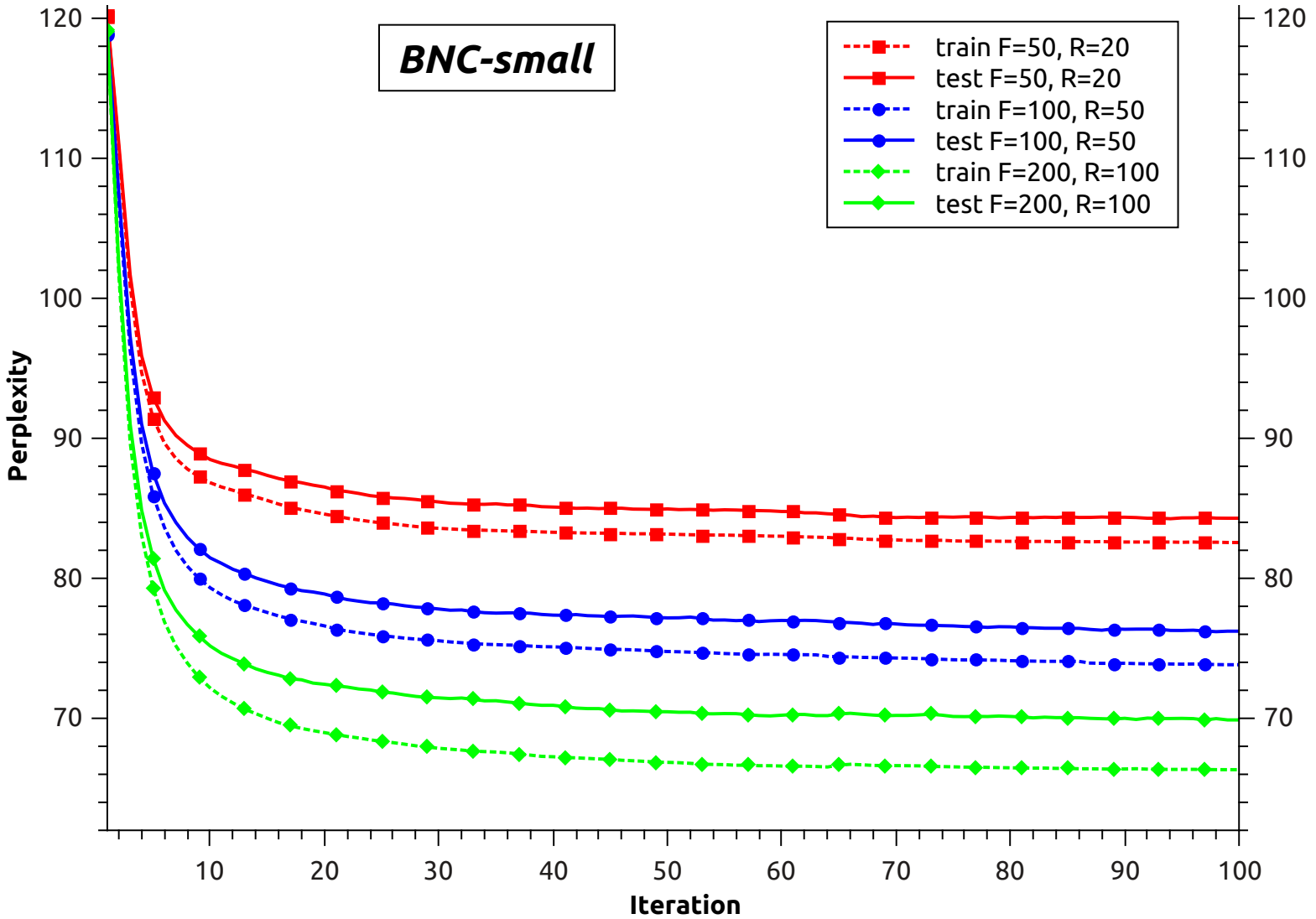
Figure 2.5 Plots of the Dirichlet distribution over three variables, where the two horizontal axes are coordinates in the plane of the simplex and the vertical axis corresponds to the value of the density. Here $\{\alpha_k\} = 0.1$ on the left plot, $\{\alpha_k\} = 1$ in the centre plot, and $\{\alpha_k\} = 10$ in the right plot.

LDA-Frames models

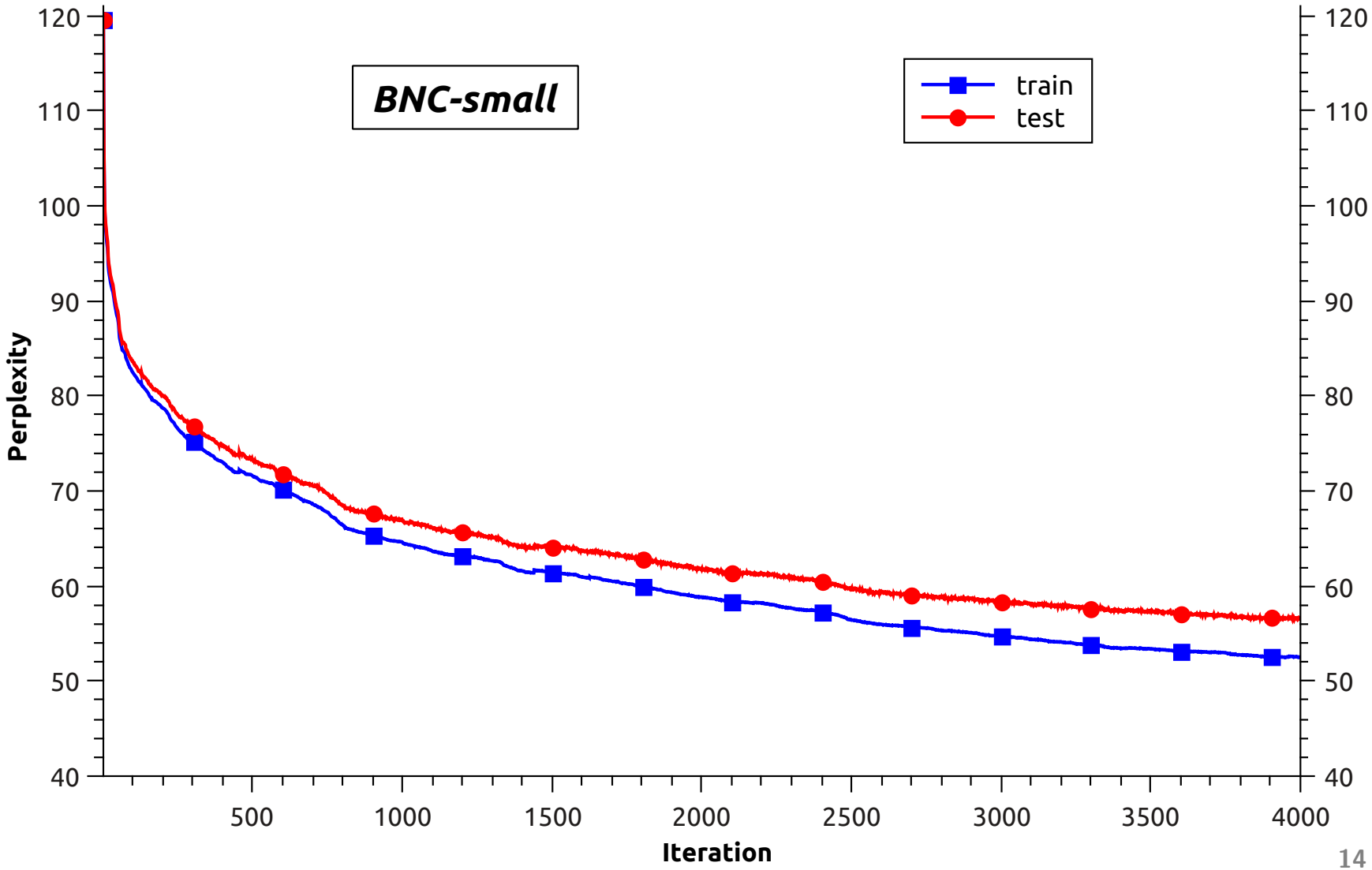




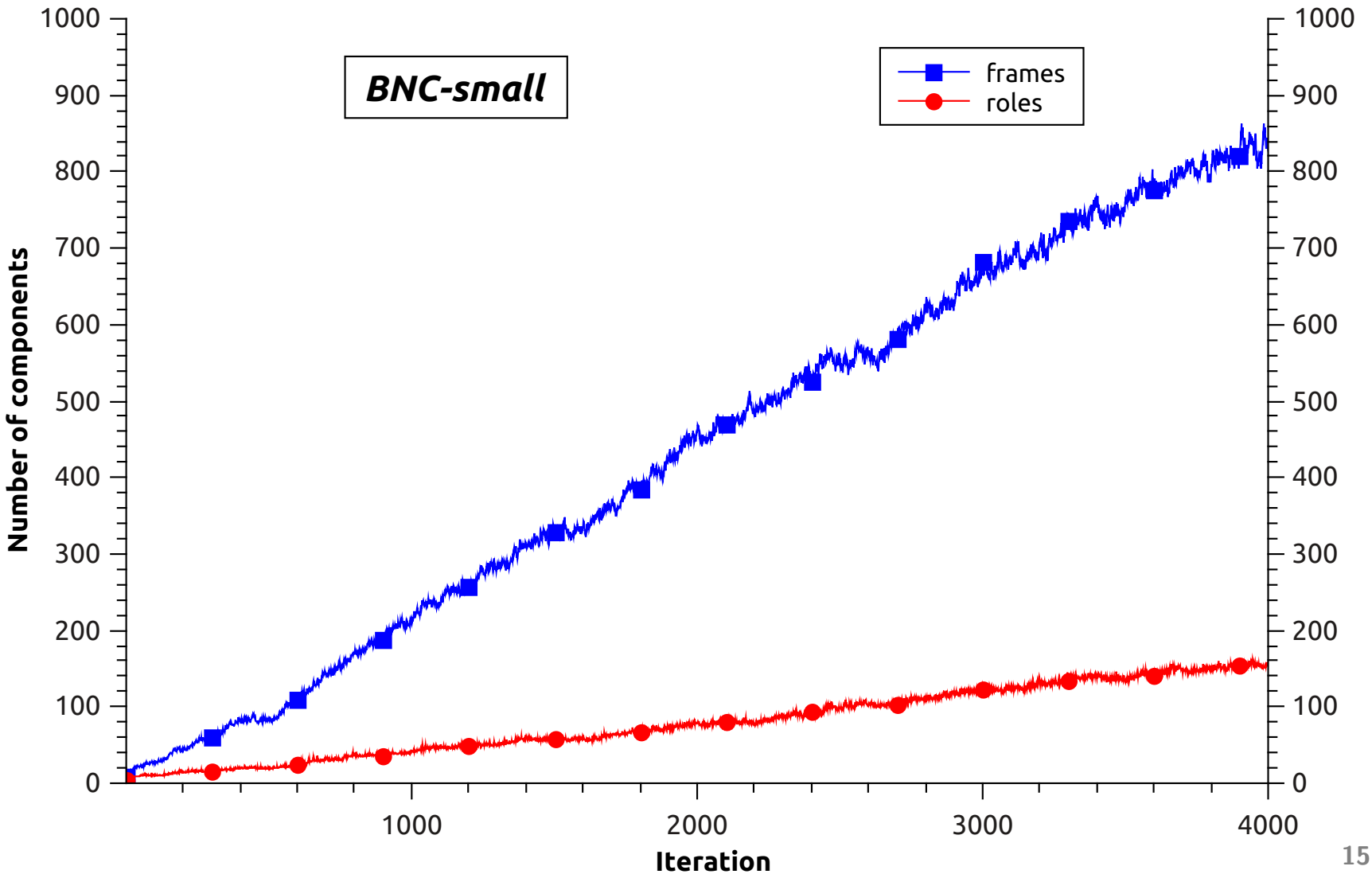
LDA-Frames perplexity



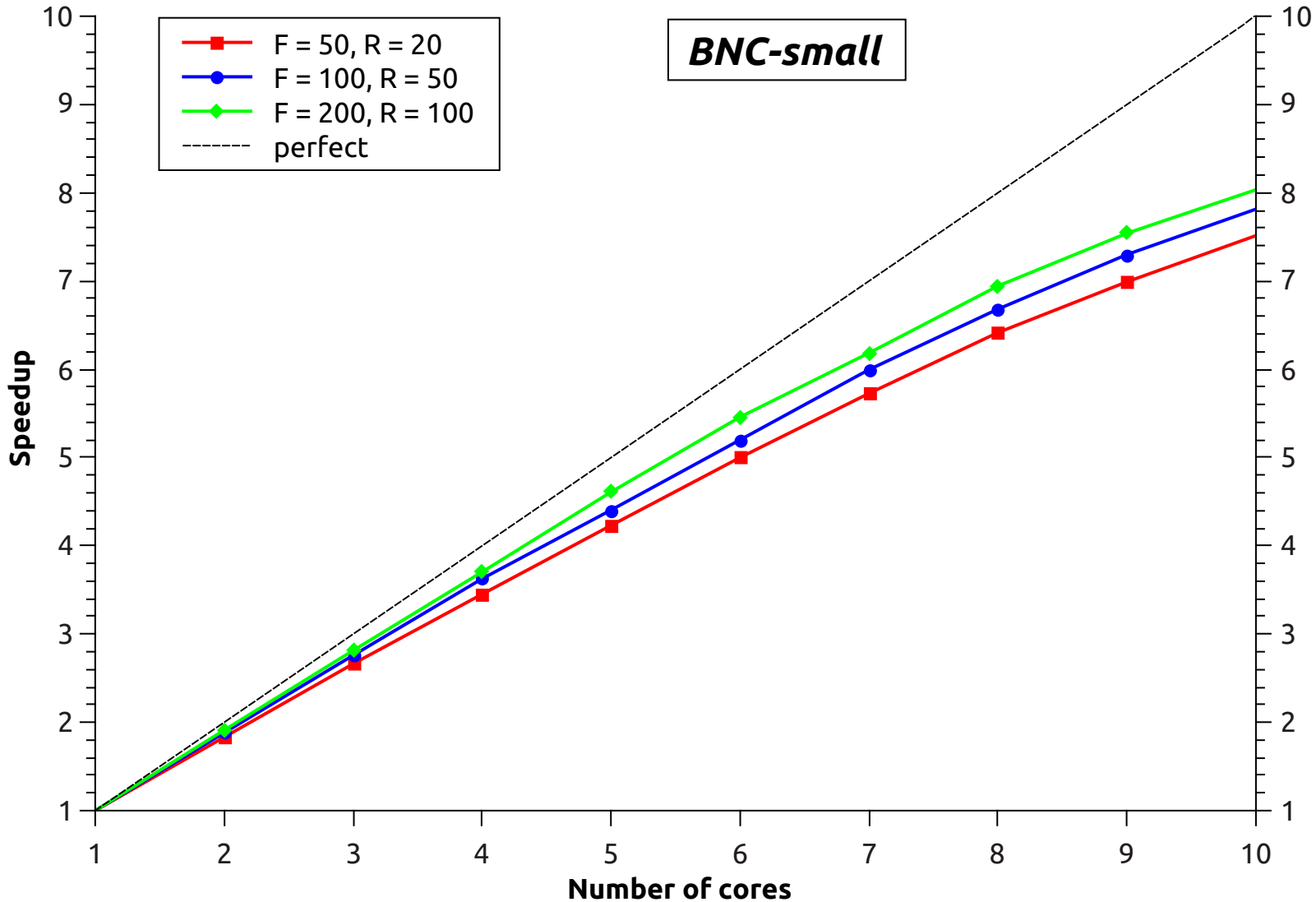
Non-Parametric LDA-Frames perplexity



Non-Parametric LDA-Frames parameters



Scalability of Parallel LDA-Frames



Reconstruction abilities I

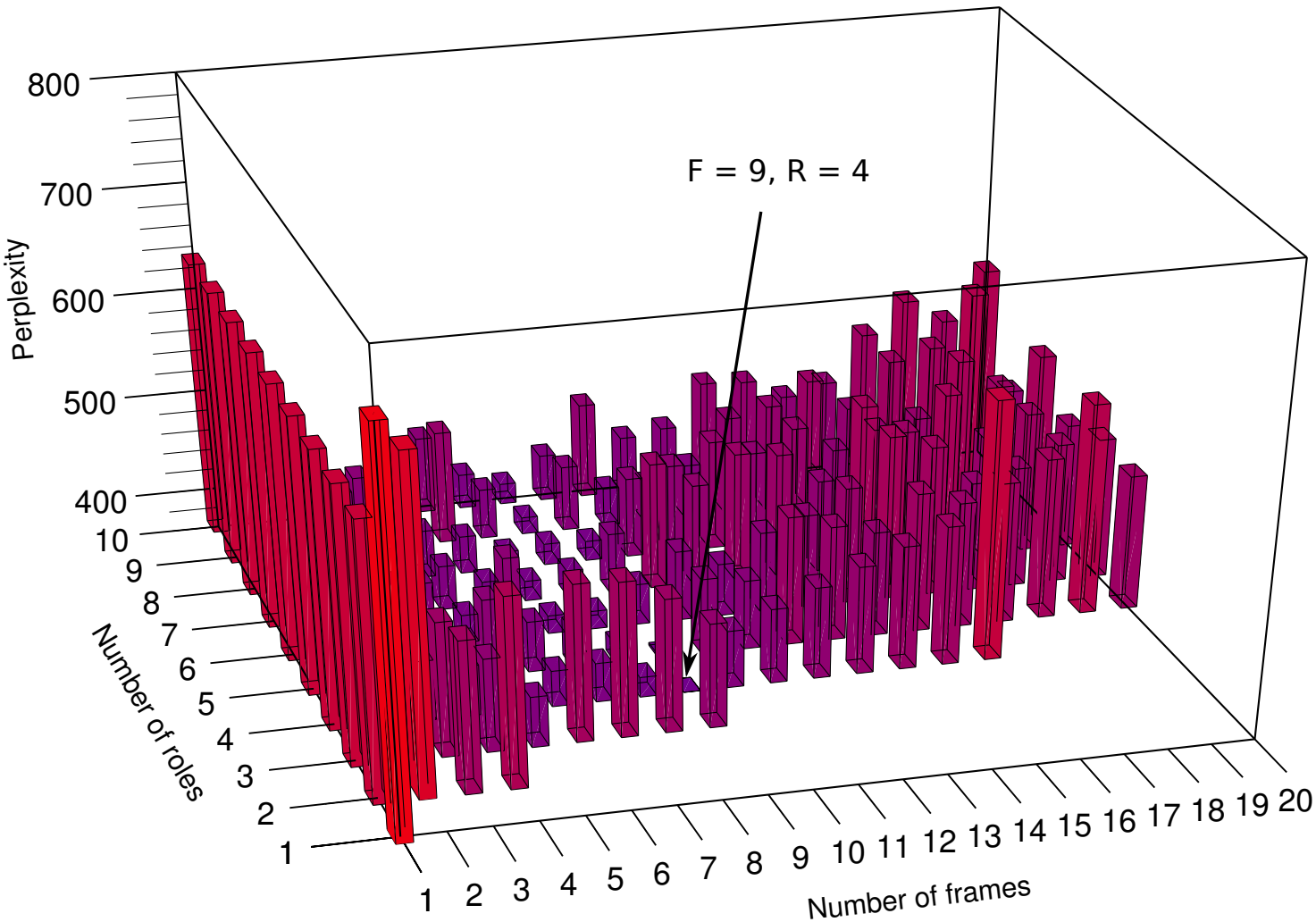
semantic roles	**realizations**
Animal	dog, cat, mouse, fish, chicken, jenny, rabbit
Food	cake, fish, lunch, chicken, dinner, meat, bread, rabbit
Institution	school, state, university, police, company
Person	people, man, woman, john, jenny

Table : Semantic roles and their lexical realizations.

Reconstruction abilities II

Lexical unit	**Semantic frames**
eat	(Person, Food), (Animal, Food)
cook	(Person, Food)
chew	(Animal, Food), (Person, Food)
bite	(Animal, Food), (Animal, -)
paint	(Person, Person), (Person, -)
teach	(Person, Person), (Institution, Person), (Person, Animal)
love	(Person, Person)
hire	(Institution, Person)
pay	(Institution, Person)
produce	(Institution, Food)
buy	(Institution, Food), (Person, Food), (Person, Animal)
feed	(Person, Animal), (Person, Person)
train	(Person, Animal)

Reconstruction abilities III



Conclusions

- LDA-Frames – unsupervised model for generating probabilistic semantic frames
- Non-parametric LDA-Frames
- Useful for linguists
- Many practical applications: statistical thesaurus, word sense disambiguation, machine translation, genetics, etc.

home page: http://nlp.fi.muni.cz/projekty/lda-frames/
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Thank you for your attention.