



# O prijaznih računalnikih, ki nas razumejo in se od nas učijo

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Univerza v Göteborgu, Švedska

<https://clasp.gu.se>

4. januar 2019

Pišemo računalniške programe, ki se vedejo, kot da bi razumeli človeški/naravni jezik, ali proizvajajo človeški jezik.

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Gradimo umetne agente/robote, ki z nami komunicirajo v naravnem jeziku.

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Zakaj?

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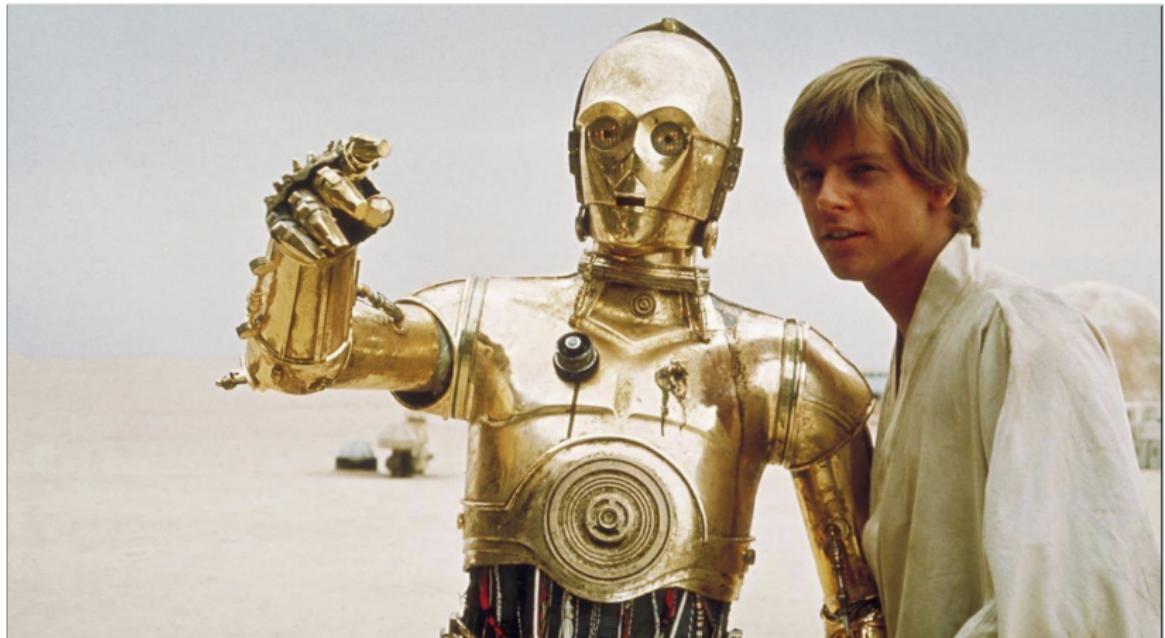
Zakaj?

CoLi, LT, NLP in AI?

# Jezikovne tehnologije prihodnosti



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[www.starwars.com/databank/c-3po](http://www.starwars.com/databank/c-3po)

"tekoče se sporazumeva v več kot v sedem milijonov oblik komunikacije"

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and studies in probability

# Jezikovne tehnologije sedanjosti



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- ▶ Iskanje dokumentov
- ▶ Strojno prevajanje
- ▶ Klasificiranje dokumentov
- ▶ Strojno povzemanje dokumentov
- ▶ Odgovarjanje na vprašanja
- ▶ Sistemi za dialog
- ▶ ...

# Odgovarjanje na vprašanja: Google, I



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Google which countries does the danube flow through

All Maps News Shopping Videos More Settings Tools

About 462 000 results (0,69 seconds)

The longest river in the European Union, the Danube River is the second-longest river in Europe after Russia's Volga. It begins in the Black Forest region of **Germany** and runs through **10 countries (Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova and Ukraine)** on its way to the Black Sea.

**About the Danube River - Viking River Cruises**  
[www.vikingrivercruises.com/cruise-destinations/europe/rivers/danube/about.html](http://www.vikingrivercruises.com/cruise-destinations/europe/rivers/danube/about.html)

[About this result](#) • [Feedback](#)

People also ask

Where is the Danube River located? ▾

Where does the Danube begin and end? ▾

Which way does the Danube river flow? ▾

Where is the Danube River born? ▾

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# Odgovarjanje na vprašanja: Google, II



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Which way does the Danube river flow?

DANUBE RIVER FACTS. The longest river within today's European Union – and second-longest on the continent – the Danube River originates in Germany's Black Forest, and flows in a southeasterly direction through central and eastern Europe to the **Black Sea**.

[Danube River Facts | Tauck](#)

[www.tauck.com/river-cruises/danube-river-facts.aspx](http://www.tauck.com/river-cruises/danube-river-facts.aspx)

Search for: [Which way does the Danube river flow?](#)

Where is the Danube River born?

Danube River, German Donau, Slovak Dunaj, Hungarian Duna, Serbo-Croatian and Bulgarian Dunav, Romanian Dunărea, Ukrainian Dunay , river, the second longest in Europe after the Volga. It rises in the Black Forest mountains of western **Germany** and flows for some 1,770 miles (2,850 km) to its mouth on the Black Sea.

[Danube River | river, Europe | Encyclopedia Britannica](#)

[www.britannica.com/EBchecked/topic/151250/Danube-River](http://www.britannica.com/EBchecked/topic/151250/Danube-River)

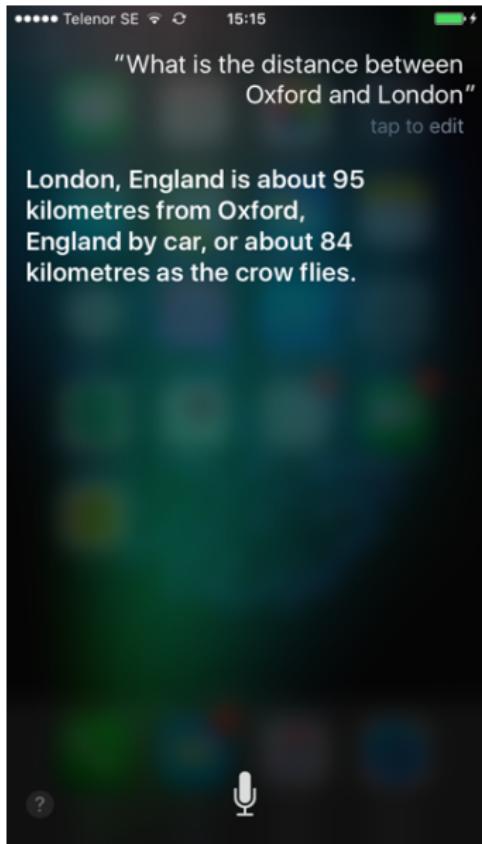
Search for: [Where is the Danube River born?](#)

[Feedback](#)

# Odgovarjanje na vprašanja: Siri, I



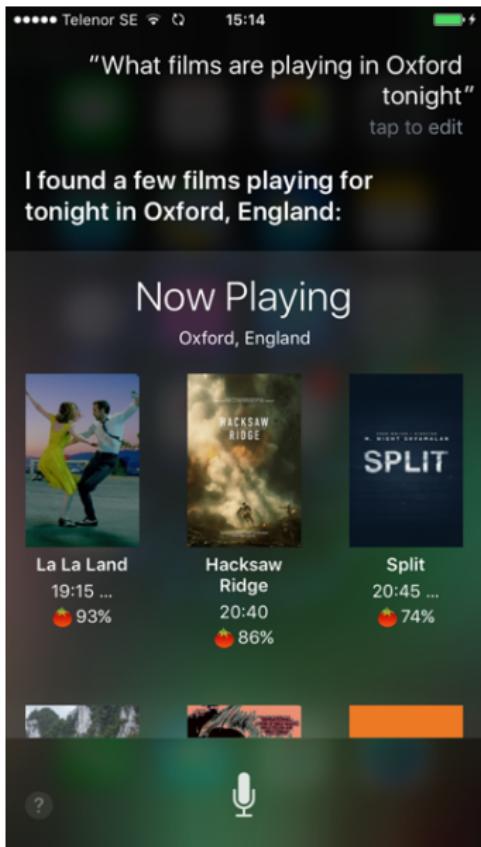
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# Odgovarjanje na vprašanja: Siri, II



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# Sistemi za dialog: Družabniki/Companions

<https://www.youtube.com/watch?v=BmDMNguQUmM>  
(Smith et al., 2011)

# Kako to naredimo?



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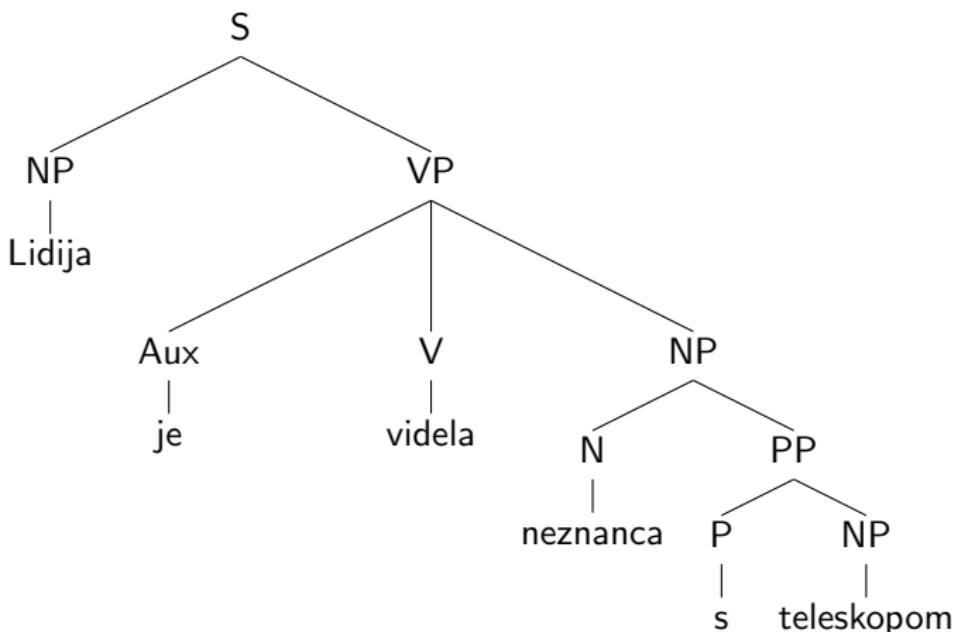
- ▶ Lingvistika, psihologija in kognitivna znanost: kakšne so jezikovne strukture, kako ljudje povežejo jezik, percepциjo, dejanja in dialog?
- ▶ Formalni sistemi: kako predstaviti jezik v računalniku?
- ▶ Aplikacije: kako rešiti določen problem z računalniškim algoritmom?

Od zgoraj navzdol

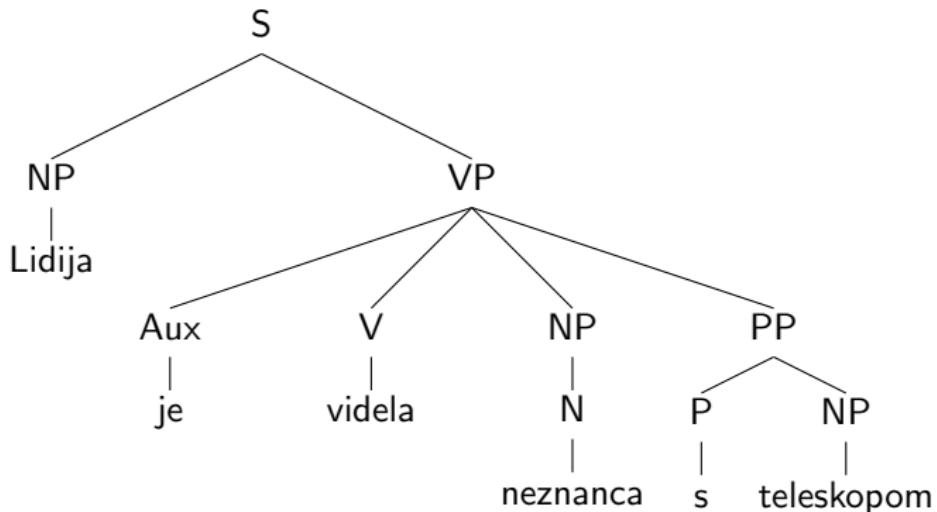
- ▶ Analizirajmo jezik
- ▶ Pretvorimo besede, stavke, itd. s formalnimi pravili v formalne strukture, npr. drevesa ali logične izraze
- ▶ Procesirajmo formalne strukture z računalniškimi algoritmi
- ▶ Pretvorimo rezultat nazaj v naravni jezik

# Jezik ni le zaporedje besed

Lidija je videla neznanca s teleskopom.



# Jezik je nedoločen: po strukturi



# Jezik je nedoločen: po pomenu



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- ▶ koordinator projektov ima razgovor z vsakim novim zaposlenim

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- ▶  $\exists x[\text{koordinator\_projektov}(x) \wedge \forall y[\text{nov\_zaposleni}(y) \rightarrow \text{ima\_razgovor}(x, y)]]$

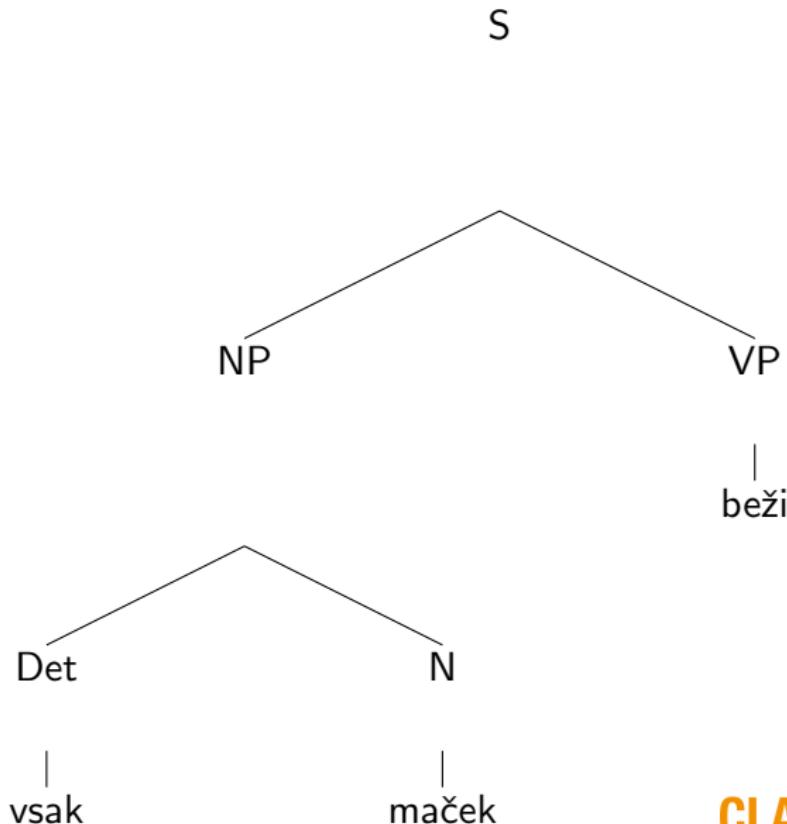
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# Jezik je kot lego kocke

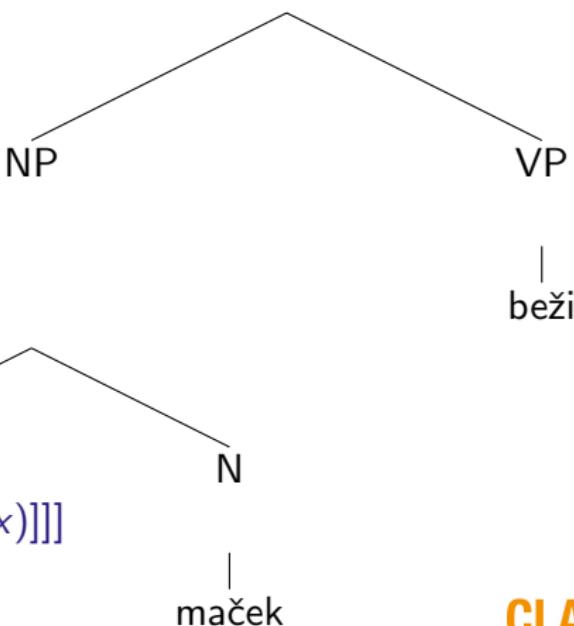


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# Jezik je kot lego kocke

S



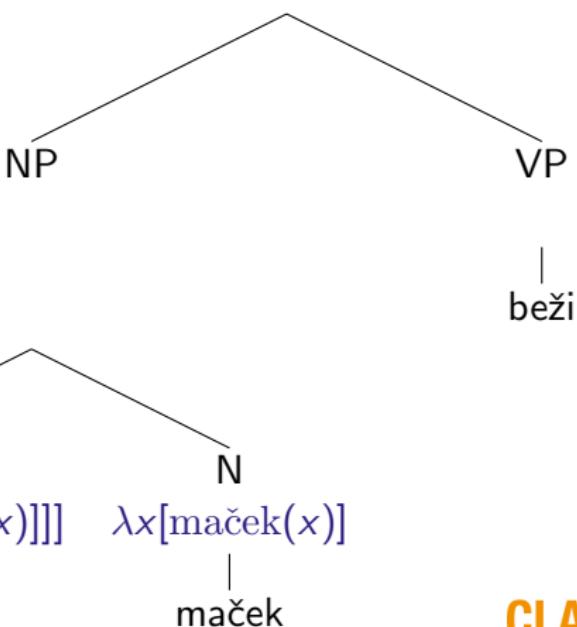
$\lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]]$

vsak

maček

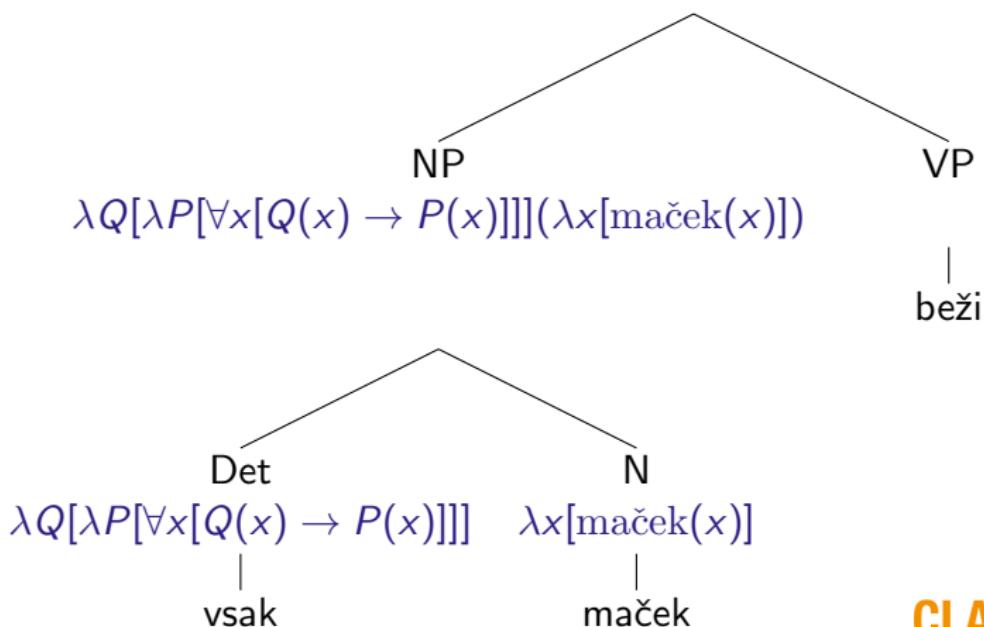
# Jezik je kot lego kocke

S

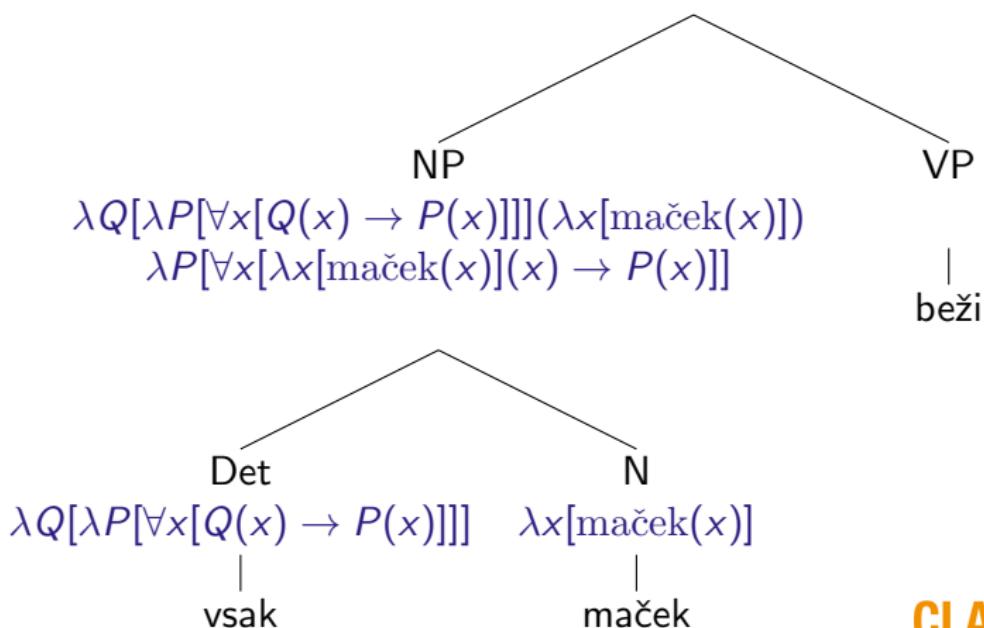


# Jezik je kot lego kocke

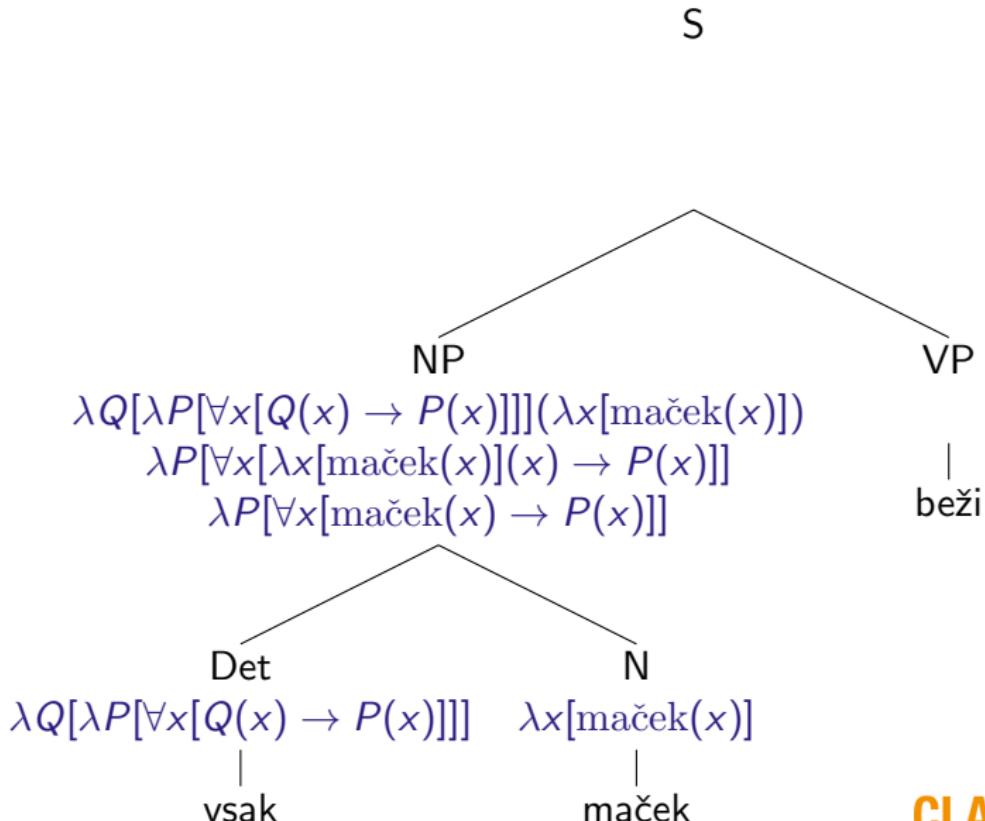
S



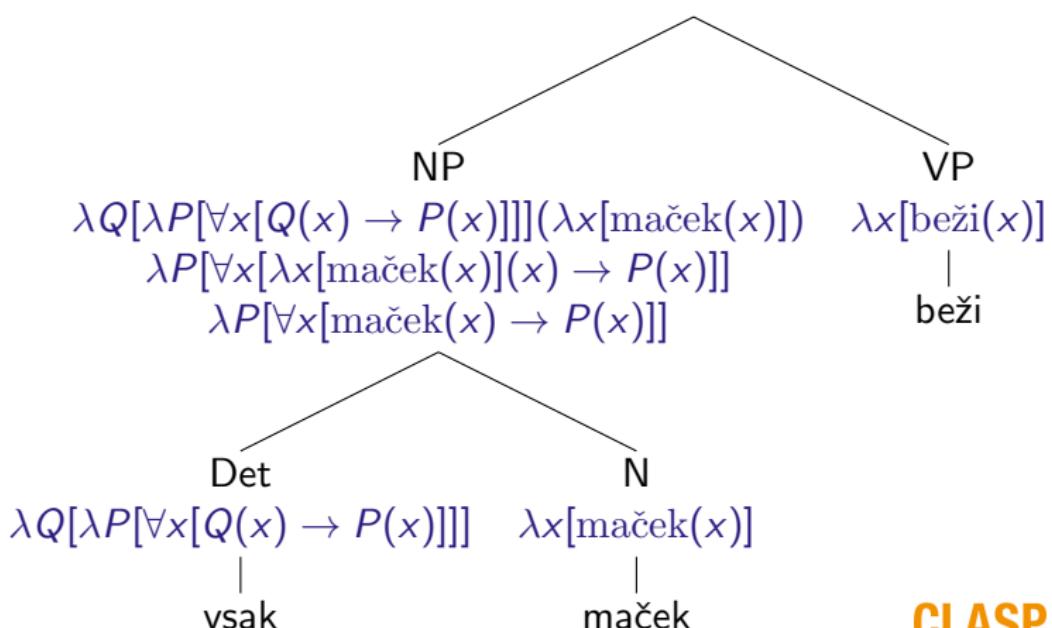
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# Jezik je kot lego kocke



# Jezik je kot lego kocke



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S

$$\lambda P[\forall x[\text{maček}(x)] \rightarrow P(x)]](\lambda x[\text{beži}(x)])$$

NP

VP

$$\begin{array}{ccc} \lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]](\lambda x[\text{maček}(x)]) & & \lambda x[\text{beži}(x)] \\ \lambda P[\forall x[\lambda x[\text{maček}(x)](x) \rightarrow P(x)]] & & | \\ \lambda P[\forall x[\text{maček}(x) \rightarrow P(x)]] & & \text{beži} \end{array}$$

Det

N

$$\begin{array}{cc} \lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]] & \lambda x[\text{maček}(x)] \end{array}$$

vsak

maček

# Jezik je kot lego kocke



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S

$$\lambda P[\forall x[\text{maček}(x)] \rightarrow P(x)](\lambda x[\text{beži}(x)])$$
$$\forall x[\text{maček}(x) \rightarrow \lambda x[\text{beži}(x)](x)]$$

NP

VP

$$\lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]](\lambda x[\text{maček}(x)]) \quad \lambda x[\text{beži}(x)]$$
$$\lambda P[\forall x[\lambda x[\text{maček}(x)](x) \rightarrow P(x)]]$$
$$\lambda P[\forall x[\text{maček}(x) \rightarrow P(x)]]$$

beži

Det

N

$$\lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]] \quad \lambda x[\text{maček}(x)]$$

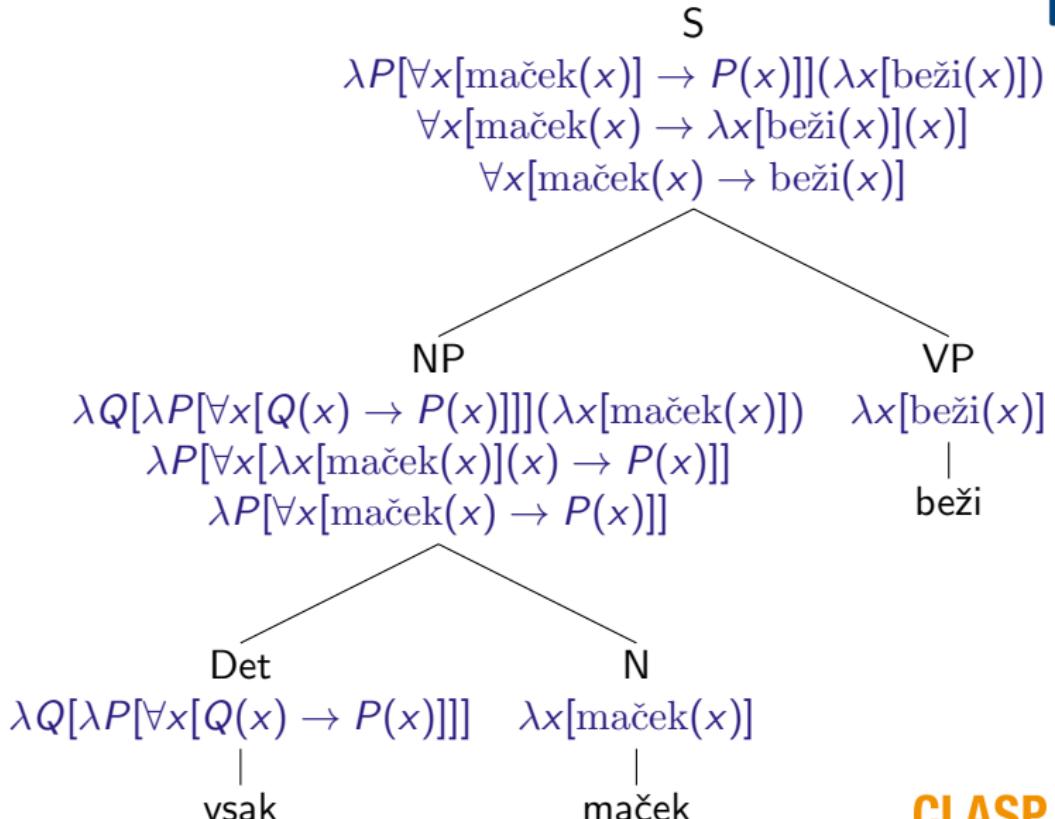
vsak

maček

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# Jezik je kot lego kocke



# Od zgoraj navzdol: prednosti in slabosti



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- + Zelo natančna analiza jezikovnih struktur in pomena
- Zamudno
- Ljudje ne uporabljamo celih knjižno-slovničnih stavkov

Od spodaj navzgor

- ▶ Zberimo veliko količino jezikovnih podatkov
- ▶ Zberemo skupino ljudi, da jih označijo s kategorijami, ki nas zanimajo
- ▶ Uporabimo algoritme strojnega učenja, da sistem samodejno naučimo struktur in pravil

# Strojno učenje - bo nekdo igral golf?

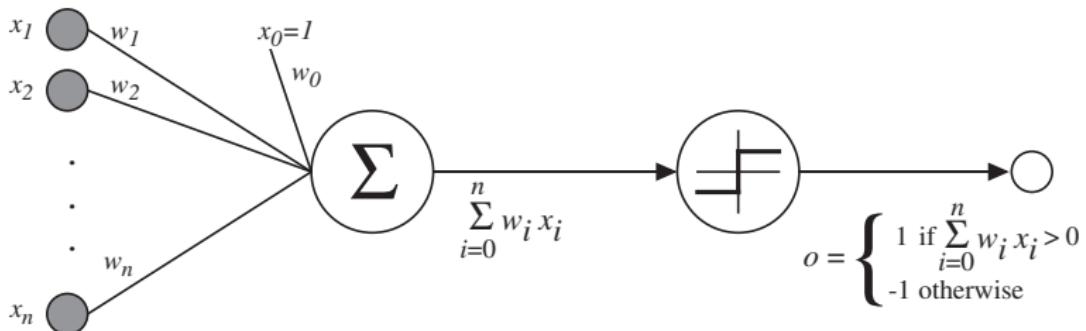
Vreme	Temperatura	Vlažnost	Vetrovno	Golf
sončno	85	85	NE DRŽI	ne
sončno	80	90	DRŽI	ne
oblačno	83	86	NE DRŽI	da
deževno	70	96	NE DRŽI	da
deževno	68	80	NE DRŽI	da
deževno	65	70	DRŽI	ne
oblačno	64	65	DRŽI	da
sončno	72	95	NE DRŽI	ne
sončno	69	70	NE DRŽI	da
deževno	75	80	NE DRŽI	da
...				

(Witten, Frank, and Hall, 2011)

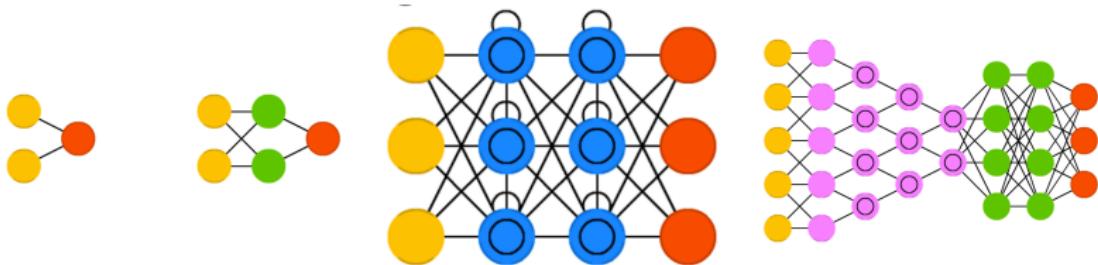
# Perceptron



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Slika iz (Mitchell, 1997).

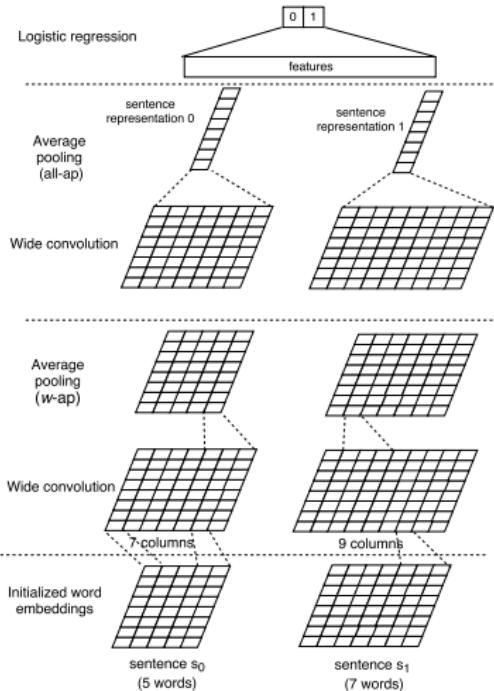


Fjodor van Veen, [www.asimovinstitute.org/neural-network-zoo/](http://www.asimovinstitute.org/neural-network-zoo/)

# Globoko učenje: podoben pomen stavkov, II



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Slika iz (Yin et al., 2015)

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# O (distribucijskem) pomenu besed

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  - (1) Napolnil je **wampimuk**, ga podal med ostale in vsak je malo pil.
  - (2) Majhen kosmat **wampimuk** je skrivaj spal za drevesom.

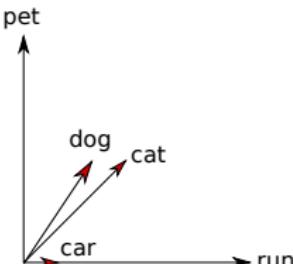
- ▶ Kolikokrat se beseda pojavi v kontekstu?

	povodec	sprehod	teče	lastnik	ljubljenček	laja
pes	3	5	2	5	3	2
mačka	0	3	3	2	3	0
...						
avto	0	0	1	3	0	0

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pes	3	5	2	5	3	2
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...						
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- ▶ Vektorji v večdimenzionalnem prostoru: razdalja med njimi, npr. kosinus ( $\cos 0 = 1$ )



# O (perceptualnem) pomenu besed

Dejanski roboti v prostoru morajo (i) znati povezati pomen besed s tem, kar vidijo v svoji okolici in (ii) obvladati komunikacijo s (človeškimi) pogovornimi partnerji.

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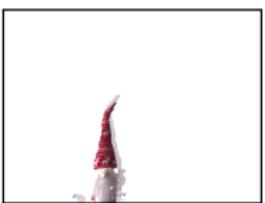
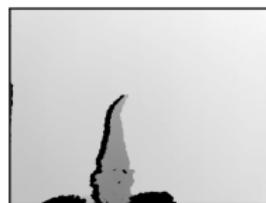
- ▶ Stol je na levi strani mize.
- ▶ Pojdi počasi naprej do naslednjega križišča in zavij levo.
- ▶ A: Na levi strani vidim **dve skodelici**, eno s smešnim pokrovom.  
B: Ok, tudi jaz vidim tisto s smešnim pokrovom.

# Prepoznavanje predmetov



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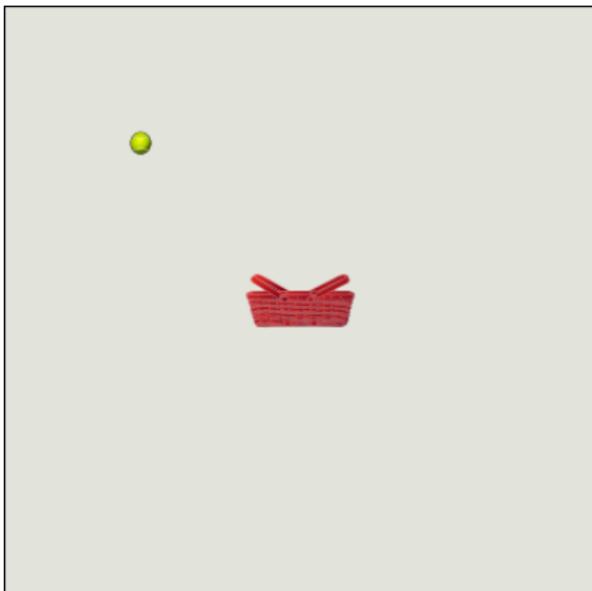
“To je škrat.”



(de Graaf, 2016; Dobnik and de Graaf, 2017)

## #1: Prostorska geometrija

Žoga je nad košaro.



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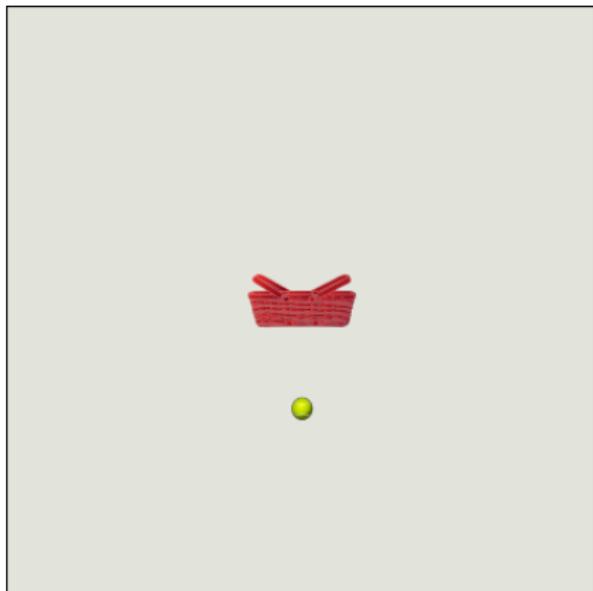
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Žoga je nad košaro.

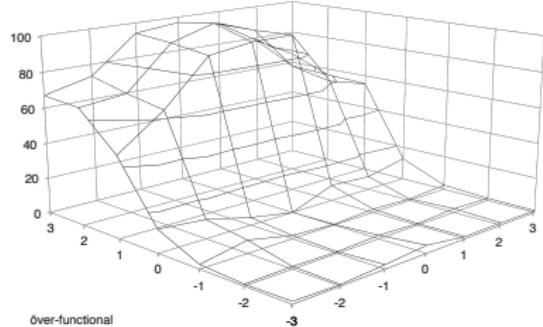


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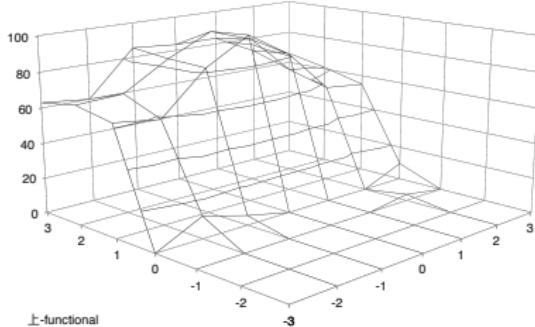
Žoga je nad košaro.



över in ue



över-functional



上-functional

(Åstbom, 2017; Dobnik and Åstbom, 2017)

Opise tvoril sistem iz (Karpathy and Fei-Fei, 2015)



a woman riding a horse on a  
dirt road



an airplane is parked on the  
tarmac at an airport



a group of people standing on  
top of a beach

“...brez intuitivne fizike, psihologije, sestavljenosti in vzročnosti.”  
(Lake et al., 2016)

Ali je B za A?



Ali je B za A?

C

B

A

## #2: Kako deluje svet?

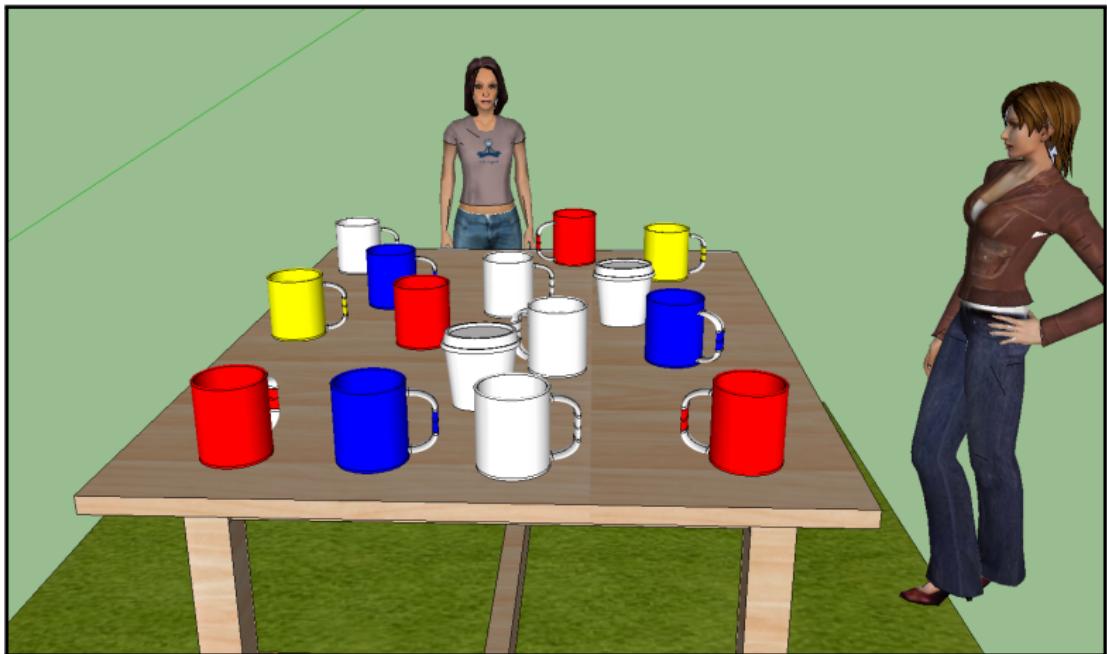
“Lara je za mizo” “Lara je pri mizi”



(Coventry and Garrod, 2004; Dobnik and Kelleher, 2013; Dobnik and Kelleher, 2014; Dobnik, Ghanimifard, and Kelleher, 2018)

### #3: Interakcija med sogovorniki

## Kje je rumena skodelica?



(Dobnik, Kelleher, and Koniaris, 2014; Dobnik, Howes, and Kelleher, 2015) 

## Awkward Prepositions



a person  
on the dog



boats under  
the sky



a black bicycle at  
a green potted plant

(Mitchell et al., 2012)

# KILLE: interaktivno učenje robota



<https://www.youtube.com/watch?v=AsEgaka6tH0>  
(de Graaf, 2016; Dobnik and de Graaf, 2017)



# Najlepša hvala!

# Vprašanja?

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