Introduction to Formal Semantics

Tutorial Lecture 4: Typed Lambda Calculus

Nicolaie Dominik Dascalu, Dr. Volha Petukhova
Spoken Language System Group
Saarland University

UNIVERSITÄT DES SAARLANDES

18.05.22

Tutorial Overview

- **Matrixes**

  Exercise 1
- **Types & Lambda Abstraction**

  Exercises 2
- **Trees & Lambda reduction**

  Exercise 3

Reading:

- Coppock, E., and Champollion, L. (2021). Invitation to formal semantics. Manuscript, Boston University and New York University (Ch.5)

Discussion

Discussion

- Did you have any difficulties understanding **the main concepts**?
- Were the **exercises** difficult?
- Is there something you would like to review from **tutorial 3**?

Exercises

Exercise 1

$f_{\text{LOVE}} = \{\langle \text{bonnie, clyde} \rangle, \langle \text{clyde,bonnie} \rangle, \langle \text{susan, megan} \rangle\}$

$$f_{LOVE} = \begin{bmatrix} < bonnie, bonnie > & \mapsto & 0 \\ < bonnie, clyde > & \mapsto & 1 \\ < bonnie, megan > & \mapsto & 0 \\ < bonnie, susan > & \mapsto & 0 \\ < clyde, clyde > & \mapsto & 0 \\ < clyde, bonnie > & \mapsto & 1 \\ < clyde, megan > & \mapsto & 0 \\ < clyde, susan > & \mapsto & 0 \\ < megan, megan > & \mapsto & 0 \\ < megan, bonnie > & \mapsto & 0 \\ < megan, clyde > & \mapsto & 0 \\ < megan, susan > & \mapsto & 0 \\ < susan, susan > & \mapsto & 0 \\ < susan, bonnie > & \mapsto & 0 \\ < susan, clyde > & \mapsto & 0 \\ < susan, megan > & \mapsto & 1 \end{bmatrix}$$

Characteristic Function

$$f_{LOVE\leftarrow} = \begin{bmatrix} bonnie \mapsto & \begin{bmatrix} bonnie & \mapsto & 0 \\ clyde & \mapsto & 1 \\ megan & \mapsto & 0 \\ susan & \mapsto & 0 \end{bmatrix} \\ clyde \mapsto & \begin{bmatrix} bonnie & \mapsto & 1 \\ clyde & \mapsto & 0 \\ megan & \mapsto & 0 \\ susan & \mapsto & 0 \end{bmatrix} \\ megan \mapsto & \begin{bmatrix} bonnie & \mapsto & 0 \\ clyde & \mapsto & 0 \\ megan & \mapsto & 0 \\ susan & \mapsto & 1 \end{bmatrix} \\ susan \mapsto & \begin{bmatrix} bonnie & \mapsto & 0 \\ clyde & \mapsto & 0 \\ megan & \mapsto & 0 \\ susan & \mapsto & 0 \end{bmatrix} \end{bmatrix}$$

Curried Function

Exercise 2

(1) Mary loves herself : $\langle e,\langle e,t\rangle\rangle \longmapsto \lambda x.[loves(x,x)]$

(2) All philosophers are evil : $\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle \longmapsto \lambda P.\lambda E.\forall x.[P(x)\rightarrow E(x)]$

(3) John likes cats : $\langle e,\langle e,t\rangle\rangle \longmapsto \lambda x.\lambda y.[likes(y,x)]$

(4) Cloe gave Mark the keys : $\langle e,\langle e,\langle e,t\rangle\rangle\rangle \longmapsto \lambda x.\lambda y.\lambda z.[gave(z,y,x)]$

(5) Yoda floats : $\langle e,t\rangle \longmapsto \lambda x.[floats(x)]$

(6) Anakin is Luke's father : $\langle e,\langle e,t\rangle\rangle \longmapsto \lambda x.\lambda y.[fatherOf(y,x)]$

(7) Some bagels are gluten free : $\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle \longmapsto \lambda B.\lambda G.\exists x.[B(x)\wedge G(x)]$

P,Q,O,M, are arbitrary.
these are not:
old(x), man(x)

(8) Eddie lives in Seattle : $\langle e,\langle e,t\rangle\rangle \longmapsto \lambda x.\lambda y.[livesIn(y,x)]$

(9) Old man : $\langle\langle e,t\rangle,\langle e,t\rangle\rangle \longmapsto \lambda O.\lambda M.\lambda x.[O(x)\wedge M(x)]$

(10) Someone's thirsty : $\langle\langle e,t\rangle,t\rangle \longmapsto \lambda P.\exists x.[P(x)]$

Exercise 3

1

S : t
sleeps(t)
λx.(sleeps(x))(t)

NP : e
t

VP : ⟨e,t⟩
λx.(sleeps(x))

Tom

sleeps

2

remember that we can adopt different notation styles:

Loves(x)(y)
Loves(x,y)

λx.λy.[likes(y,x)]
λy.λx.[likes(x,y)]

λyλx[likes(x,y)]
λyλx[Likes(x,y)]
λyλx(Likes(x,y))
[λyλx(Likes(x,y))]

S : t
likes(s,n)
λx.(likes(y,n))(s)

NP : e
Sabrina

VP : ⟨e,t⟩
λy.(likes(y,n))
λx.λy.(likes(y,x))(n)

V : ⟨e,⟨e,t⟩⟩
λx.λy.(likes(y,x))
likes

NP : e
n
Nicholas

Exercise 3

3

- S : t
  $\exists x.(bird(x) \wedge fly(x))$
  $\lambda F.\exists x.(bird(x) \wedge F(x))(\lambda y.(fly(y)))$
  - NP : ⟨⟨e,t⟩,t⟩
    $\lambda F.\exists x.(bird(x) \wedge F(x))$
    $\lambda B.\lambda F.\exists x.(B(x) \wedge F(x))(\lambda z.(bird(z)))$
    - Det : ⟨⟨e,t⟩,⟨⟨e,t⟩,t⟩⟩
      $\lambda B.\lambda F.\exists x.(B(x) \wedge F(x))$
      - Some
    - N : ⟨e,t⟩
      $\lambda z.(bird(z))$
      - birds
  - VP : ⟨e,t⟩
    $\lambda y.(fly(y))$
    - V : ⟨e,t⟩
      $\lambda y.(fly(y))$
      - fly

Thank you all for the kind attention!

If you need further help

or have additional

questions,

please contact us.