

Logic Tutorial 2

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Overview

- ▶ 16:00 What's it all good for?
- ▶ 16:10 Recap
- ▶ 16:20 **Q&A**
- ▶ 16:50 Quiz
- ▶ 17:00 **Q&A**
- ▶ 18:00 Feierabend

What's it all good for? – Studies

Bachelor

- ▶ Reasoning techniques
- ▶ Logic for AI (elective)
- ▶ Prolog (elective)

Master

- ▶ Foundations of Agents
- ▶ Master projects

Logic master Amsterdam, Munich

What's it all good for? – Studies

Programming paradigms

- ▶ **Imperative:** C, Java, Python, Javascript
- ▶ **Functional:** Elm, Scala, Haskell, Racket
- ▶ **Relational:** Prolog

What's it all good for? – Studies

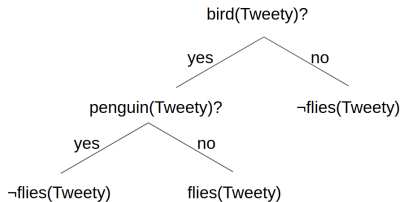
bird(x) \rightarrow flies(x)
penguin(x) \rightarrow \neg flies(x)
penguin(x) \rightarrow bird(x)



flies(Tweety)?

penguin(Tweety) penguin(x) \rightarrow \negflies(x)	\neg flies(Tweety)
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penguin(Tweety) penguin(x) \rightarrow bird(x) bird(x) \rightarrow flies(x)	flies(Tweety)
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What's it all good for? – Industry

- ▶ Expert systems, decision support systems
 - ▶ Law: *Neota Logic*, *Bryter*, *LegalOS*, *KnowledgeTools*
- ▶ ...

What's it all good for? – Research

Symbolic AI [Explainable AI] (*vs neural AI*)

- ▶ Probabilistic logic programming
- ▶ Neural logic programming
- ▶ Relational machine learning
 - ▶ Inductive logic programming
- ▶ Neuro-symbolic learning
- ▶ Answer set programming
- ▶ ...

What's it all good for? – Summer schools

~~Law and logic~~

Logic, language and information

~~Logic and formal epistemology~~

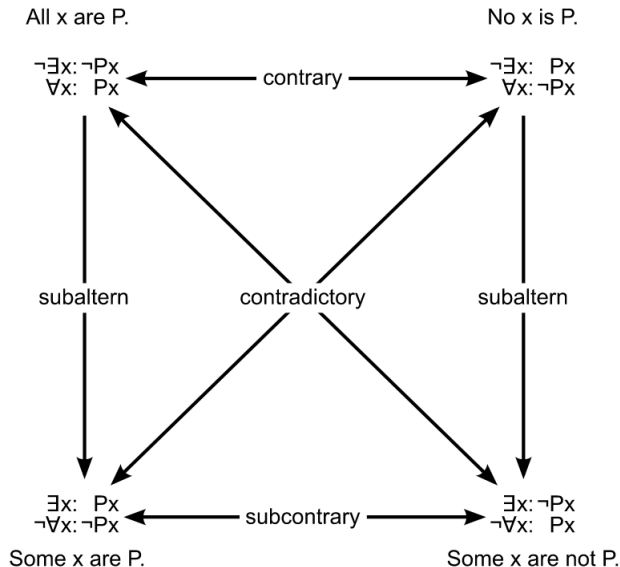
~~Contemporary logic, rationality and information~~

Probability and logic

Mathematical philosophy for female students

- ▶ More extensive list by UvA

Square of opposition



Semantic Tableau

\neg	$\begin{array}{c} \neg\varphi \circ \\ \\ \varphi \circ \end{array}$	$\begin{array}{c} \circ \neg\varphi \\ \\ \varphi \circ \end{array}$
\wedge	$\begin{array}{c} \varphi \wedge \psi \circ \\ \\ \varphi, \psi \circ \end{array}$	$\begin{array}{c} \circ \varphi \wedge \psi \\ / \quad \backslash \\ \circ \varphi \quad \circ \psi \end{array}$
\vee	$\begin{array}{c} \varphi \vee \psi \circ \\ / \quad \backslash \\ \varphi \circ \quad \psi \circ \end{array}$	$\begin{array}{c} \circ \varphi \vee \psi \\ \\ \circ \varphi, \psi \end{array}$
\rightarrow	$\begin{array}{c} \varphi \rightarrow \psi \circ \\ / \quad \backslash \\ \circ \varphi \quad \psi \circ \end{array}$	$\begin{array}{c} \circ \varphi \rightarrow \psi \\ \\ \varphi \circ \psi \end{array}$
\leftrightarrow	$\begin{array}{c} \varphi \leftrightarrow \psi \circ \\ / \quad \backslash \\ \varphi, \psi \circ \quad \circ \varphi, \psi \end{array}$	$\begin{array}{c} \circ \varphi \leftrightarrow \psi \\ / \quad \backslash \\ \varphi \circ \psi \quad \psi \circ \varphi \end{array}$
\exists	$\begin{array}{c} \exists x\varphi(x) \circ \\ \\ \varphi(a) \circ \\ \text{For a new } a \end{array}$	$\begin{array}{c} \circ \exists x\varphi(x) \\ \\ \circ \varphi(a_1), \dots, \varphi(a_n) \\ \text{For all existing } a_1, \dots, a_n \end{array}$
\forall	$\begin{array}{c} \forall x\varphi(x) \circ \\ \\ \varphi(a_1), \dots, \varphi(a_n) \circ \\ \text{For all existing } a_1, \dots, a_n \end{array}$	$\begin{array}{c} \circ \forall x\varphi(x) \\ \\ \circ \varphi(a) \\ \text{For a new } a \end{array}$

Natural deduction

Diagram illustrating the relationship between modus ponens and deduction:

- modus ponens:** A horizontal line with $\varphi, \varphi \rightarrow \psi$ above it and ψ below it.
- deduction:** A vertical line with φ at the top, followed by three dots, and ψ at the bottom. A horizontal line is below ψ , with $\varphi \rightarrow \psi$ below that line.

$$\frac{\varphi \wedge \psi}{\varphi}$$

$$\frac{\varphi \wedge \psi}{\psi}$$

$$\frac{\varphi, \psi}{\varphi \wedge \psi}$$

Diagram illustrating the relationship between E- and I-derivations:

- E-derivation (Left):** A horizontal line above $\neg\varphi, \varphi$ and a vertical line below \perp .
- I-derivation (Right):** A horizontal line above φ and a vertical line below \perp .
- A vertical line connects the two horizontal lines.
- The word "refutation" is written to the right of the I-derivation.

E_{Δ}

$$\mathbf{I}_{\Delta}$$

$$\mathbf{E}_{\neg}$$

$\varphi \vee \psi,$	φ \vdots χ	$,$	ψ \vdots χ
χ			

$$\mathbf{E}_{\vee}$$

$$\mathbf{I}_{\neg}$$

φ
$\varphi \vee \psi$
ψ
$\varphi \vee \psi$

$$\mathbf{I}_{\vee}$$

Natural deduction

$$\frac{\forall x \varphi}{(\varphi)_t^x}$$

$$\frac{\begin{array}{c|c} u & (\varphi)_u^x \\ \hline \vdots & \\ \hline \end{array}}{\forall x \varphi}$$

provided that no variable in t occurs bounded in φ

for u a special symbol not used anywhere else in the proof

E_{\forall}

I_{\forall}

$$\frac{\exists x \varphi, \begin{array}{c|c} u & (\varphi)_u^x \\ \hline \vdots & \\ \hline \psi \end{array}}{\psi}$$

$$\frac{(\varphi)_t^x}{\exists x \varphi}$$

for u a special symbol not used anywhere in the proof

provided that no variable in t occurs bounded in φ

E_{\exists}

I_{\exists}

$$\frac{t_1 = t_2, \varphi}{\varphi[t_1/t_2]}$$

$$\frac{t_1 = t_2, \varphi}{\varphi[t_2/t_1]}$$

$$\frac{}{t = t}$$

where $\varphi[t_1/t_2]$ is the result of replacing, in φ , some occurrences of t_2 by t_1 , provided that

- t_2 contains only variables that occur freely in φ , and
- t_1 contains only variables that do not get bounded after replacement.

for any term t .

$E_{=}$

$I_{=}$

Q & A

excalidraw

Quiz

- ▶ Tahook

Feedback

Anonymous feedback form:

- ▶ linktr.ee/davidpomerenke