

Nyāya for iPad

Interactive Environment with BoolTool



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What is BoolTool?

Manipulation and evaluation
of formulae in propositional logic

- BoolTool is powerful
- But it is not for beginners.

The screenshot shows the BoolTool web application. The browser address bar displays the URL: `http://www.informatik.uni-bonn.de/~uibk.ac/soft/booltool/source/php/convert_sol.php?PHPSESSID=`. The page has a yellow header with the 'BoolTool' logo and 'Computational Logic' text. Below the header is a navigation bar with 'Convert', 'Info', and 'Sokrates' tabs. The main content area is divided into two panels. The left panel, titled 'Formulas', contains a 'File' input field with a 'Durchsuchen...' button, a 'Workspace' text area containing the formula $\neg(x \rightarrow ((x > y) \wedge y))$, a 'Comment' text area, and 'Start' and 'Delete' buttons. It also has checkboxes for output formats (cnf, pdf, zip) and a 'Bdd' checkbox labeled 'unreduced'. The right panel, titled 'Solution', has tabs for 'Bdd', 'Truthtable', 'Solution', and 'Output'. The 'Solution' tab is active, showing the following results for the formula $\neg(x \rightarrow ((x > y) \wedge y))$:

Formula:	$\neg(x \rightarrow ((x > y) \wedge y))$
CNF:	$\neg x \wedge ((x + y) \wedge \neg y)$
DNF:	$\neg x \wedge \neg y$
Satisfiable:	yes
Tautology:	no
Contradiction:	no

What is BoolTool?

Manipulation and evaluation
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- BoolTool is powerful
 - ▶ It defines an input syntax for formulas

BoolTool

Computational Logic

Convert Info Socrates

Formulas

File ?

Durchsuchen...

Workspace

Textarea: $!(x + ((x > y) \& y))$

Comment ?

Start Delete

Bdd Truthtable Solution Output

$!(x + ((x > y) \& y))$

CNF: $!x \& ((x + !y) \& !y)$

DNF: $!x \& !y$

Satisfiable: yes

Tautology: no

Contradiction: no

What is BoolTool?

Manipulation and evaluation
of formulae in propositional logic

- BoolTool is powerful
 - ▶ It defines an input syntax for formulas
 - ▶ It derives normal forms

The screenshot shows the BoolTool web application. The browser address bar displays the URL: `http://www.informatics.uibk.ac.at/software/booltool/source/php/convert_sol.php?PHPSESSID=...`. The page has a yellow header with the 'BoolTool' logo and 'Computational Logic' text. Below the header is a navigation bar with 'Convert', 'Info', and 'Socrates' tabs. The main interface is divided into several sections:

- Formulas:** A text area containing the formula $\neg(x \rightarrow ((x \rightarrow y) \wedge y))$. Below it are buttons for 'Start' and 'Delete'.
- File:** A section with a 'Durchsuchen...' button and a list of file types: 'cnf', 'dot', 'unreduced'.
- Order of Variables:** A section with two dropdown menus for 'x' (set to 1) and 'y' (set to 2).
- Output:** A section with four tabs: 'Bdd', 'Truthtable', 'Solution', and 'Output'. The 'Solution' tab is selected, showing the following results:
 - CNF:** $\neg(x \wedge ((x \rightarrow y) \wedge y))$
 - DNF:** $\neg(x \wedge (x \rightarrow y) \wedge y)$
 - Satisfiable:** yes
 - Tautology:** no
 - Contradiction:** no

What is BoolTool?

Manipulation and evaluation
of formulae in propositional logic

- BoolTool is powerful
 - ▶ It defines an input syntax for formulas
 - ▶ It derives normal forms
 - ▶ It computes truth tables and binary decision diagrams

What is BoolTool?

Manipulation and evaluation
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- BoolTool is powerful
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 - ▶ It computes truth tables and binary decision diagrams
 - ▶ It calculates satisfiability, tautologies and contradictions

The screenshot shows the BoolTool web application. The browser address bar displays the URL: `http://uibk.ac.at/~sofka/booltool/source/php/convert_sol.php?PHPSESSID=`. The page has a yellow header with the 'BoolTool' logo and 'Computational Logic' text. Below the header is a navigation bar with 'Convert', 'Info', and 'Socrates' tabs. The main content area has four sub-tabs: 'Bdd', 'Truthtable', 'Solution', and 'Output'. The 'Solution' tab is active, showing the following results for the formula $I(x + ((x > y) \& y))$:

Result	Value
CNF:	$I(x \& ((x + 1) \& 1) y)$
Satisfiable:	yes
Tautology:	no
Contradiction:	no

What is BoolTool?

Manipulation and evaluation
of formulae in propositional logic

Convert Info Socrates

Formula(s) ?
 $!(x | ((x > y) \& y))$

File ?
Durchsuchen...

Workspace
Textarea: $!(x + ((x > y) \& y))$

Comment ?

Start Delete

Output
☐ cnf ☐ dot
☐ pdf ☐ png
☐ zip

Bdd
☐ unreduced

Order of Variables
x

Solution

Formula: $!(x + ((x > y) \& y))$

CNF: $!(x \& ((x + !y) \& !y))$

DNF: $!(x \& !y)$

Satisfiable: yes

Tautology: no

Contradiction: no

- But it is not for beginners.

What is BoolTool?

Manipulation and evaluation
of formulae in propositional logic

Formula(s) ?

File ?

Workspace

Comment ?

Start

Delete

Output

cnf dot pdf png zip

Bdd

unreduced

Order of Variables

x

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Manipulation and evaluation
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- ▶ It does not use standard symbols of propositional logic

What is BoolTool?

Manipulation and evaluation
of formulae in propositional logic

Formula(s) ?

File ?

Workspace

Comment ?

Output

cnf dot pdf png zip

Bdd

unreduced

Order of Variables

x

1

Start

Help

BoolTool

Computational Logic

Convert Info Sokrates

Bdd TruthTable Solution Output

Formula: $!(x \vee ((x > y) \wedge y))$

CNF: $!x \wedge ((x + 1y) \wedge !y)$

DNF: $!x \wedge !y$

Satisfiable: yes

- But it is not for beginners.

- ▶ It does not motivate or explain anything.
- ▶ It does not use standard symbols of propositional logic
- ▶ It does not explain equivalence transformations

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 - ▶ It does not explain equivalence transformations
 - ▶ It does not define normal forms.

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Formula:	$\neg(x \vee ((x > y) \wedge y))$
CNF:	$\neg x \wedge ((x + 1y) \wedge 1y)$
DNF:	$\neg x \wedge 1y$
Satisfiable:	yes
Tautology:	no
Contradiction:	no

What is an iPad?

not: useless, an big iphone, the saviour of the newspaper industry
always on, small screen, single window, small ram, small ops

What is Nyāya?

Project Aim

Allow the user to learn

- Formalism of propositional logic
- Separation of syntax and semantics
- Normal forms (NNF, CNF, DNF)
- Standard transformations of Boolean functions
- Coherence of different representations

in a self-explanatory environment.

What is Nyāya?

Platform agnostic concept

- Tutorials for general concepts and definitions
- Exercises to consolidate the learned concepts and definitions
- Playground to build and transform formulas
- Glossary of technical terms
- BoolTool

What is Nyāya?

Platform specific iPad App

A learning tool for propositional logic

Nyāya is an interactive environment to learn simple facts about the formalism of propositional logic and standard transformations of Boolean functions. It is integrated with BoolTool (provided by the Computational Logic Research Group at the Institute of Computer Science on the University of Innsbruck) which allows the manipulation and evaluation of boolean functions. BoolTool supports different representations of boolean functions and a variety of different algorithms.

Overview

The tab bar on the bottom of this page let you switch between the five individual areas of the app

- Nyāya – the first and actual page – presents an overview of the app.
- The Tutorials provides an introduction to propositional logic and exercises for knowledge checks.
- The Playground is a place to create and manipulate formulas freely.
- The Glossary is a simple list of technical terms used in propositional logic and this app.
- BoolTool provides an implementation of BoolTool that does not need an internet connection. It provides a native user interface which works similar to the new and simplified web interface.

Credentials

- Nyāya for iPad was implemented as part of a bachelor course in computer science at the University of Innsbruck and was supervised by Georg Moser.
- [LICS] Logic in Computer Science, Modelling and Reasoning about Systems, Michael Huth und Mark Ryan (Cambridge University Press 2004)
- [LLOG] Lecture Logic by Aart Middeldorp (University of Innsbruck 2011/12).
- Nyaya's introduction to propositional logic follows corresponding sections in [LICS] and the structure of [LLOG].
- "Nyāya" (Sanskrit ni-āyā, literally "recursion" with the meaning "syllogism, inference") is one school of Hindu philosophy — specifically the school of logic. *Obtaining valid knowledge is the only way to obtain release from suffering.* (cited from wikipedia)

Tutorials

Top and Bottom

Semantics

Valuation

Truth Tables

Entailment and Equivalence

Satisfiability and Validity

Normal Forms

Implication Free Form

Negation Normal Form

Conjunctive Normal Form

Disjunctive Normal Form

Binary Decision Diagrams

Boolean Functions

Boolean Expressions

Binary Decisions

ROBDD

Semantics – Truth Tables

open exercise

Chapter 3
Semantics

the truth assignment for the set of variables of a formula and of the formula. When we write down all possible truth values of a formula and we calculate the truth value of the formula we create the truth table of the formula.

truth assignments for one variable and so there are $2 \times 2 = 4$ different

a	b	$a \wedge b$	$a \vee b$	$a \rightarrow b$
T	T	T	T	T
T	F	F	T	F
F	T	F	T	T
F	F	F	F	T

truth assignments for n variables.

for a formula with many variables, because for each additional variable,

and for "big" formulas, they are very complex, the properties for "small"

	a	b	c	$\neg b$	$\neg b \wedge c$	$a \vee (\neg b \wedge c)$	$(a \vee (\neg b \wedge c)) \rightarrow a$
v	T	T	T	F	F	T	T
v	T	T	F	F	F	T	T
v	T	F	T	T	T	T	T
v	T	F	F	T	F	T	T
v	F	T	T	F	F	F	T
v	F	T	F	F	F	F	T
v	F	F	T	T	T	T	F
v	F	F	F	T	F	F	T

defined top and bottom as

formulas of $a \vee \neg a$ and $a \wedge \neg a$. Since

they do not contain any variables, their valuation should not depend on any truth assignment, as easily shown by calculating a truth table.

is equal to $v(b \wedge a)$ for all truth assignments. Further $v(a \wedge b)$ is equal to $v(b \rightarrow a)$ for all truth assignments.

a	b	$b \rightarrow a$	$a \rightarrow b$
T	T	T	T

Exercises

Semantics – Truth Tables

open exercise

Truth Tables

In the last tutorial we wrote a program that calculated the truth values for each assignment of truth values to the variables.

There are two truth assignments for two variables.

In general there are 2^n assignments for n variables. Thus the calculation of the truth value for a formula with n variables is a very expensive calculation.

Although truth tables are useful to demonstrate the truth value of formulas.

Top and bottom

a	$\neg a$	$a \wedge \neg a$	$a \vee \neg a$
T	F	F	T
F	T	F	T

Symmetry

As you can check for yourself, the truth value of $a \vee (b \wedge a)$ is the same as the truth value of $a \vee (a \wedge b)$. But $a \vee (a \rightarrow b)$ is not the same as $a \vee (b \rightarrow a)$.

Evaluate formula and tap on buttons to change truth values.

r	q	$q \rightarrow r$	
T	T	T	
T	F	T	
F	T	F	
F	F	F	



Chapter 3 Semantics

a	b	$a \wedge b$	$a \vee b$	$a \rightarrow b$
T	T	T	T	T
T	F	F	T	F
F	T	F	T	T
F	F	F	F	T

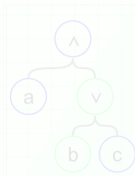
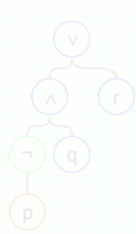
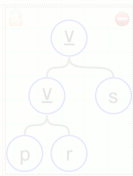
$a \wedge c$	$(a \vee (\neg b \wedge c)) \rightarrow a$
	T
	T
	T
	T
	T
	T
	F
	T

by truth assignment,

a	b	$b \rightarrow a$	$a \rightarrow b$
T	T	T	T

Playground

Formulas



Glossary

Entry

when the evaluation order does not matter for the result.

s	
	associative
	associative
	associative
c	right associative
c	associative

Atom

Biconditional \leftrightarrow \leftrightarrow

a	b	$a \leftrightarrow b$
F	F	T
F	T	F
T	F	F
T	T	T

A relation between two propositions that is true only when both propositions are simultaneously true or false.

BoolTool does not support Biconditional, but $\neg(P \wedge Q)$ is equivalent. Nyāya accepts $P \text{ BIC } Q$, $P \leftrightarrow Q$, and $P \leftrightarrow Q$ as input.

to propositions that is true only when both propositions are true.

$P \text{ AND } Q$, Nyāya accepts $P \text{ AND } Q$, $P \wedge Q$, $P.Q$, and $P \& Q$ as input.

a	b	$a \wedge b$
0	0	0
0	1	0
1	0	0
1	1	1

are formulas as sub formulas of a new formula.

to propositions that is true when one or both propositions are true.

$P \text{ OR } Q$, Nyāya accepts $P \text{ OR } Q$, $P \vee Q$, $P+Q$, and $P|Q$ as input.

a	b	$a \vee b$
0	0	0
0	1	1
1	0	1
1	1	1

BoolTool

BoolTool

Evaluate

pVrVs

Unsatisfiable

Satisfiable

Unsatisfiable

NNF

CNF

DNF

p	r	s	Φ
F	F	F	F
F	F	T	T
F	T	F	T
F	T	T	F
T	F	F	T
T	F	T	F
T	T	F	F
T	T	T	T



pVrVs

Satisfiable

NNF

CNF

DNF

- Barwise, Etchemendy und Barker Plummer, **Tarski's World**
- Middeldorp, **Logic**, Lecture
- Huth and Ryan, **Logic in Computer Science**
- Apple iOS Developer Documentation

p	r	s	φ
F	F	T	T
F	F	T	T
F	T	F	T
F	T	T	F
T	F	F	T
T	F	T	F
T	T	F	F
T	T	T	T

