truthable: \LaTeX Package for automatically generated Truth Tables

Dominic Flück <K-Trout>

0.1.0 2023/09/16

Abstract

truthable is a \LaTeX package for creating automatically generating truth tables given a table header. It supports a number of logical operations which can be combined as needed. It’s built upon the package \texttt{luacode} and therefore has to be used with the Lua\LaTeX compiler.

Contents

1 Introduction 1

2 Dependencies 2

3 Usage 2
  3.1 \texttt{\textbackslash truthtable} ......................................................... 2
  3.2 \texttt{\textbackslash truthtableasc} .......................................................... 2
  3.3 Comma separated variables ........................................................................... 2
  3.4 Comma separated display variables ............................................................... 2
  3.5 Comma separated statements ......................................................................... 3
    3.5.1 NOT / Negation ......................................................................................... 3
    3.5.2 AND / Conjunction ................................................................................... 3
    3.5.3 OR / Disjunction ....................................................................................... 3
    3.5.4 XOR / Exclusive disjunction ....................................................................... 3
    3.5.5 NAND / Negated conjunction ..................................................................... 3
    3.5.6 \texttt{\rightarrow} / Implication ................................................................. 3
    3.5.7 \texttt{\leftrightarrow} / Equality ................................................................. 4
  3.6 Comma separated display statements ............................................................ 4
  3.7 Display true value .......................................................................................... 4
  3.8 Display false value ......................................................................................... 4

4 Example of use 4

5 Development 5
  5.1 Repository .................................................................................................... 5
  5.2 Changes .......................................................................................................... 5
  5.3 Known issues and bugs ................................................................................... 5

6 Implementation 6

1 Introduction

Tables in \LaTeX have the reputation of being a bit tedious. When creating a table with many cells, such as a truth table, they are not only tedious to build, but also not very readable.
To help this situation when creating a truth table for a document, this package provides a macro, which allows simply for the variables and the columns of a truth table to be defined. The package then takes care of the rest.

2 Dependencies

\texttt{truthtable} uses the package \texttt{luacode} to run, as the heavy lifting of the processing is done in Lua. The package checks if \texttt{luacode} is already loaded, and if not, does so. \LaTeX{} is required to compile the resulting documents.

3 Usage

The \texttt{truthtable} package provides two commands: \texttt{\textbackslash truthtable} and \texttt{\textbackslash truthtableasc}. Both commands take the same arguments, but generate the table in different order.

They position in the normal table boilerplate. This leads to the redundant practice of defining the column count twice, once for the table environment as the column layout and once in the command by defining the variables and statements.\footnote{See Listing 1 for example}

This is intentional to allow for more flexibility in customising the column layout as well as pre- and appending of further rows to the table.

3.1 \texttt{\textbackslash truthtable}

\begin{verbatim}
\texttt{\textbackslash truthtable} \{comma separated variables\} \{comma separated display variables\}
\{comma separated statements\} \{comma separated display statements\}
\{display true value\} \{display false value\}
\end{verbatim}

This command generates the table in descending value of the variables, from all variables being \texttt{true} to being \texttt{false}.

3.2 \texttt{\textbackslash truthtableasc}

\begin{verbatim}
\texttt{\textbackslash truthtableasc} \{comma separated variables\} \{comma separated display variables\}
\{comma separated statements\} \{comma separated display statements\}
\{display true value\} \{display false value\}
\end{verbatim}

This command generates the table in ascending value of the variables, from all variables being \texttt{false} to being \texttt{true}.

3.3 Comma separated variables

The basic variables, for which every combination of \texttt{true} and \texttt{false} a row of table will be generated. The variables should be relatively simple, as they are not used for the formatting the table but simply to calculate the answers. The variables should be separated using commas. Don’t use variables, which contain another variable, i.e., don’t do this: \{n,An\}.

3.4 Comma separated display variables

These are the display values corresponding to the \textit{Comma separated variables}. Fancy variable formatting can be applied. At least normal text and “math” mode seem to work.\footnote{More testing needs to be done} The same number of display variables as variables is required. The comma cannot be used as a display character, as it is used as delimiter.
3.5 Comma separated statements

The statements using the *Comma separated variables* which are used to evaluate the statements for any given combination of variables. Parentheses can be used in the normal fashion to indicate the order of combined statements. The notation for the different operations is as follows:

### 3.5.1 NOT / Negation

To negate a variable or statement, the exclamation point ! is used.

- \( \neg A \): !A
- \( \neg (\neg A) \): !(!A)

### 3.5.2 AND / Conjunction

For the conjunction of two variables or statements the and symbol & is used. The & must not be escaped for the comma separated statements!

- \( A \land B \): A & B
- \( A \land (A \land B) \): A & (A & B)

### 3.5.3 OR / Disjunction

For the Disjunction of two variables or statements the vertical line character | is used.

- \( A \lor B \): A | B
- \( A \lor (A \lor B) \): A | (A | B)

### 3.5.4 XOR / Exclusive disjunction

The exclusive disjunction (XOR) is written in parentheses preceded by the hat operator. Note that the delimiter used is the semicolon ; and not the comma , ! This is because the statements are separated using the comma.

- \( A \oplus B \): \(\hat{(A; B)}\)
- \( A \oplus (A \lor B) \): \(\hat{(A; (A | B))}\)

### 3.5.5 NAND / Negated conjunction

The NAND operation is written in parentheses preceded by the NOT and the AND operator (!&). Note that the delimiter used is the semicolon ; and not the comma , ! This is because the statements are separated using the comma.

- \( A\downarrow B \): !(A; B)
- \( A\downarrow (A \lor B) \): !(A; (A | B))

### 3.5.6 → / Implication

The implication can also be expressed. Note that the delimiter used is the semicolon ; and not the comma , ! This is because the statements are separated using the comma.

- \( A \rightarrow B \): >>(A; B)
- \( A \rightarrow (A \lor B) \): >>((A; (A | B))
- \( A \land (A \rightarrow B) \): A & >>((A; B)

3
### 3.5.7 ↔ / Equality

The equality can also be expressed. Since version 0.0.2 this command can also be expressed as $<> (A; B)$. The previous definition\(^3\) of $__(A; B)$ also works. **Note that the delimiter used is the semicolon; and not the comma, !** This is because the statements are separated using the comma. The $$must not be escaped for the comma separated statements!*

- $A \leftrightarrow B$: $__(A; B) = <>(A; B)$
- $A \leftrightarrow (A \lor B)$: $__(A; (A \lor B)) = <>(A; (A \lor B))$
- $A \land (A \leftrightarrow B)$: $A \land __ (A; B) = A \land <> (A; B)$

### 3.6 Comma separated display statements

Display statements are defined the same way as the *comma separated display variables*. The comma cannot be used as a display character, as it is used as delimiter.

### 3.7 Display true value

The displaying string which will be used in the table body for *true*. Normal text and “math” mode can be used.

### 3.8 Display false value

The displaying string which will be used in the table body for *false*. Normal text and “math” mode can be used.

### 4 Example of use

The code snippet seen in Listing 1 is the entirety of code required to produce the truth table seen in Table 1.\(^4\) The code for the ascending truth table as seen in Table 2 is identical, except for the command used being `\truthtableasc` instead of `\truthtable`.

The command generates the code seen in Listing 2.

---

\(^3\)The equality operation was defined this way in v0.0.1

\(^4\)The captioning setup was omitted in the listing.
\begin{tabular}{c|c|c|c|c|c|c|c|c|c}
  $A$ & $B$ & $\neg A$ & $A \land B$ & $A \lor B$ & $A \lor B$ & $A \mid B$ & $A \rightarrow B$ & $A \leftrightarrow B$ \\
  \hline
  $T$ & $T$ & $F$ & $T$ & $T$ & $F$ & $F$ & $T$ & $T$ \\
  $T$ & $F$ & $F$ & $T$ & $T$ & $T$ & $F$ & $T$ & $F$ \\
  $F$ & $T$ & $T$ & $F$ & $T$ & $T$ & $F$ & $T$ & $F$ \\
  $F$ & $F$ & $T$ & $F$ & $F$ & $F$ & $F$ & $T$ & $T$ \\
\end{tabular}

Table 1: Sample truth table

\begin{tabular}{c|c|c|c|c|c|c|c|c|c}
  $A$ & $B$ & $\neg A$ & $A \land B$ & $A \lor B$ & $A \lor B$ & $A \mid B$ & $A \rightarrow B$ & $A \leftrightarrow B$ \\
  \hline
  $F$ & $F$ & $T$ & $F$ & $F$ & $F$ & $F$ & $T$ & $T$ \\
  $F$ & $T$ & $T$ & $F$ & $T$ & $T$ & $F$ & $T$ & $F$ \\
  $T$ & $F$ & $F$ & $T$ & $T$ & $F$ & $F$ & $T$ & $T$ \\
  $T$ & $T$ & $T$ & $F$ & $T$ & $F$ & $T$ & $T$ & $T$ \\
\end{tabular}

Table 2: Sample truth table in ascending order

\section{5 Development}

\subsection{5.1 Repository}

This package is on \textit{CTAN} (ctan.org/pkg/truthtable). The repository of the package is github.com/K-Trout/truthtable. For bug reports and feature requests create an issue on GitHub: github.com/K-Trout/truthtable/issues.

\subsection{5.2 Changes}

**v0.1.0 (2023/09/16)**

\begin{itemize}
  \item Added the \texttt{\textbackslash truthtableasc} command to generate the table in ascending order. Thanks to \textit{slnkahveci} on GitHub for the feature request.
  \item Fixed alignment issues in the first column of the table. Thanks to \textit{cpierquet} on GitHub for the bug report.
\end{itemize}

**v0.0.2 (2021/10/08)**

\begin{itemize}
  \item Added support for \textit{XOR} and \textit{NAND}.
  \item Added definition for equivalence operation to be written as $\leftrightarrow (A; B)$. $\_\_\_ (A; B)$ is still supported
  \item Added some error messages when the number of arguments and display arguments don’t correspond.
\end{itemize}

**v0.0.1 (2021/10/01)**

\begin{itemize}
  \item Initial release
\end{itemize}

\subsection{5.3 Known issues and bugs}

\textbf{Stability} The Lua code of the macro is not very error resistant. The package only checks if the same amount of working and display variables, as well as working and display statements are provided. If a mismatch is detected, an error message is output and the package code halts. Further improvements may be undertaken in the future.

\textbf{Display formatting} Whilst normal text and “math” mode work for both headers and truth values, other text formatting such as \texttt{\textbf{\textbackslash textbf}} does not. It is not yet clear if this will be addressed in future versions.

\textbf{Operations} For the moment seven operations are defined. Further operations may be added in future versions.
6 Implementation

Listing 3: Source code of the truth table package

```latex
\% truthtable .sty
\% Copyright 2021 D. Flück
\%
\% This work may be distributed and/or modified under the
\% conditions of the LaTeX Project Public License, either version 1.3
\% of this license or (at your option) any later version.
\% The latest version of this license is in
\% http://www.latex-project.org/lppl.txt
\% and version 1.3 or later is part of all distributions of LaTeX
\% version 2005/12/01 or later.
\%
\% This work has the LPPL maintenance status "author-maintained.
\%
\% The Current Maintainer of this work is D. Flück.
\%
\% This work consists of the file truthtable .sty.
\% [NeedsTeXFormat{LaTeX 2e}[1994/06/01]
\ProvidesPackage{truthtable}[2023/09/16 0.1.0 Package for generating truth tables automatically using Lu\TeX]
\ProcessOptions[relax]
\IfPackageLoaded{luacode}{
\PackageWarningNoLine{truthtable}{Package luacode was already loaded}}{
\RequirePackage{luacode}}
\begin{luacode*}
function Impl(a,b)
return (not a or b);
end

function Equiv(a,b)
return ((a and b) or ((not a) and (not b)));
end

function Xor(a,b)
return ((a or b) and (not (a and b)));
end

function Nand(a,b)
return (not (a and b));
end

function ComputeRows(header)
return 2^header
end

function Split(s, delimiter)
local result = {};
for match in (s..delimiter):gmatch("(.\-)+")..delimiter do
  table.insert(result, match);
end
return result;
end

function EvaluateFormula(formula)
local parsedFormula = "function res() return ( ".. string.gsub(string.gsub(string.gsub(string.gsub(string.gsub(string.gsub(string.gsub(string.gsub(formula, "\", "\"),\"\>",\"Impl\"),\"\<\",\"Equiv\"),\"\^\",\"Xor\"),\"!\",\"not\")\,"\&\",\"and\")\,"\|\",\"or\")\,"\-\",\"-\") .. ") end"
chunk = load(parsedFormula);
end
```

chunk();
local result = res();
return result;
end

toBits (num)
local t = "" -- will contain the bits
while num>0 do
    local rest = math.fmod(num,2)
    if (rest == 1) then
        t = "1" .. t
    else
        t = "0" .. t
    end
    num=(num-rest)/2
end
return t;
end
printTruthValue (expr, dTrue , dFalse )
local returnVal = 
if (expr) then
    returnVal = dTrue ;
else
    returnVal = dFalse ;
end
return returnVal;
end
parse (commaSepVariables , commaSepDisplayVariables , commaSepResultRows ,
commaSepResultDisplayRows , displayTrue , displayFalse , order)
print ("\\n\struthtable v0.1.0\\n")
local vrbls = Split (commaSepVariables , "");
local numberOfColumns = #(vrbls);
local rows = ComputeRows (numberOfColumns);
local dVrbls = Split (commaSepDisplayVariables , "");
local resRows = Split (commaSepResultRows , "");
local dResRows = Split (commaSepResultDisplayRows , "");
local dHeader = string.gsub(commaSepDisplayVariables , "", " & ") .. " & " .. string.gsub(commaSepResultDisplayRows , "", " & ") .. [[ \ hline ]];
if (#(dVrbls ) ~= #( vrbls )) then
    print("Error : The number of variables does not match the number of display variables.");
    return
end
if (#(dResRows ) ~= #( resRows )) then
    print("Error : The number of statements does not match the number of display statements.");
    return
end
tex.print (dHeader);
local startVal;
local endVal;
local stepVal;
if order == "asc" then
    startVal = 0;
    endVal = rows - 1;
    stepVal = 1;
else
        startVal = rows - 1;
        endVal = 0;
        stepVal = -1;
    end
    
    for i = startVal, endVal, stepVal
    do
        local bitString = toBits(i);
        while #bitString < numberOfColumns do
            bitString = "0" .. bitString
        end
        
        local wVrbls = commaSepVariables;
        local wCommaSepRows = commaSepResultRows
        for ii = 1, numberOfColumns
        do
            wVrbls = string.gsub(wVrbls, vrbls[ii], (string.sub(bitString, ii, ii) == "1") and "+" or "-")
            wCommaSepRows = string.gsub(wCommaSepRows, vrbls[ii], (string.sub(bitString, ii, ii) == "1") and "+" or "-"
        end
        
        local aWVrbls = Split(string.gsub(string.gsub(wVrbls, "+", " true"), "-", " false"), ";");
        local aWCommaSepRows = Split(string.gsub(string.gsub(wCommaSepRows, "+", " true"), "-", " false"), ";");
        
        local row = ""
        for c = 1, #(aWVrbls)
        do
            row = row .. printTruthValue(EvaluateFormula(aWVrbls[c]), displayTrue, displayFalse) .. " & "
        end
        for c = 1, #(aWCommaSepRows)
        do
            row = row .. printTruthValue(EvaluateFormula(aWCommaSepRows[c]), displayTrue, displayFalse) .. " & "
        end
        row = string.sub(row, 1, #row - 2) .. \[
    \end{luacode*}
\newcommand{\truthtable}[6]{
    \luadirect{parse("#1", \luaescapestring[#2], \luaescapestring[#3], \luaescapestring[#4], \luaescapestring[#5], \luaescapestring[#6], \luaescapestring{desc})}
} \newcommand{\truthtableasc}[6]{
    \luadirect{parse("#1", \luaescapestring[#2], \luaescapestring[#3], \luaescapestring[#4], \luaescapestring[#5], \luaescapestring[#6], \luaescapestring{asc})}
} \endinput