

Pedagogical Enhancements to the DeSymbol Logic Translator

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Abstract

DeSymbol is a program that translates first-order predicate logic expressions into English. It is intended to be a practice tool for students who are learning logic for the first time or who are trying to refresh their memories if they need to use symbolic logic for an upper-level course. Students start with an English sentence and translate it by hand into symbolic logic notation; then they can check their work by using DeSymbol to translate their notation back into English. If the English sentence produced by DeSymbol differs significantly from the original English sentence, this helps the student to see what error was made in the logic expression.

The latest version of DeSymbol adds support for prepositions, so that the student can now test expressions such as $\text{on}(a, b)$ and $\forall x \forall y (\text{on}(x, y) \rightarrow \text{under}(y, x))$. It also now supports a wider variety of idiomatic translations, including improved translations of common student mistakes. For example, the student who begins with the English sentence *All cats are mammals* and writes the expression $\forall x(\text{cat}(x) \wedge \text{mammal}(x))$ will see DeSymbol re-translate the expression as *Everything is a cat and a mammal*, which helps the student to see why the expression is incorrect.

1 Introduction

Symbolic logic is important in many areas of computer science, but students sometimes struggle when learning to use the language of symbolic logic to represent their ideas. The DeSymbol logic translator is intended as an aid to students who are learning to translate English sentences into symbolic logic notation.

In a typical homework assignment, a student may be asked to provide the symbolic logic notation for sentences like these:

All bats are little.
Some birds swim.
No poodles are amphibians.

Correct answers look like this:

$$\begin{aligned} &\forall x (\text{bat}(x) \rightarrow \text{little}(x)) \\ &\exists x (\text{bird}(x) \wedge \text{swims}(x)) \\ &\neg \exists x (\text{poodle}(x) \wedge \text{amphibian}(x)) \end{aligned}$$

Some students are able to learn how to do these translations easily. Others, however, struggle. They may confuse \rightarrow (*implication*) and \wedge (*and*):

$$\begin{aligned} &\forall x (\text{bat}(x) \wedge \text{little}(x)) \\ &\exists x (\text{bird}(x) \rightarrow \text{swims}(x)) \end{aligned}$$

or be unsure about where a negation symbol goes:

$$\exists x (\text{poodle}(x) \wedge \neg \text{amphibian}(x))$$

Often, translating the logic sentences back into English is enough to let students know that they have made a mistake:

Everything is a little bat.
There exists an x such that if x is a bird, then x swims.
Some poodles are not amphibians.

A teacher can give this feedback during exercises in class, and students can give feedback to each other if they are working in a study group. DeSymbol is meant to give this same kind of feedback, but since DeSymbol is a computer program, it is available at all hours of the day or night, and it has infinite patience, if a student needs to practice for several hours or days.

2 DeSymbol overview

DeSymbol is a web-based program which, given a symbolic logic expression, translates that expression into English. The user enters an expression like this

$$\forall x (\text{bat}(x) \rightarrow \text{little}(x))$$

into a text box and asks for a translation; DeSymbol provides an English equivalent like this

All bats are little.

The user can then check whether that was what he or she really intended to say. When

entering the logic expression, regular ASCII characters can be typed into the text box from the keyboard, while special symbols such as \forall and \rightarrow are entered using buttons on the form.

The translation is done using definite clause grammars in Prolog, with the vocabulary stored as a collection of Prolog facts. (See [1], [2], [3], and [6] for more information on Prolog grammars.) The web interface is written in JavaScript and communicates with the server using Ajax. A default vocabulary is provided, but users can add their own vocabulary words as desired. [4], [5]

These are some sample DeSymbol translations:

Logic expressions	Translation
$\forall x (\text{poodle}(x) \rightarrow \text{dog}(x))$	All poodles are dogs.
$\forall x (\text{dog}(x) \rightarrow \neg \text{green}(x))$	No dogs are green.
$\neg \exists x (\text{little}(x) \wedge \text{frog}(x) \wedge \text{barks}(x))$	No little frogs bark.
$\exists x (\text{insect}(x) \wedge \text{purple}(x))$	Some insects are purple
$\forall x (\text{lizard}(x) \rightarrow \text{small}(x) \wedge \text{reptile}(x))$	All lizards are small reptiles
$\forall x (\text{bat}(x) \rightarrow \text{brown}(x) \vee \text{black}(x))$	All bats are brown or black
$\text{loves}(\text{arthur}, \text{guinevere})$	Arthur loves Guinevere.
$\text{likes}(\text{bob}, \text{snow}) \wedge \neg \text{likes}(\text{bob}, \text{ice})$	Bob likes snow and Bob does not like ice.

3 Improvements in the new version

The newest version of DeSymbol includes improvements both to the user interface and to the actual translations.

3.1 User interface

The new DeSymbol user interface includes tabs that provide the user with general instructions, example translations, some sample exercises, and a history of previous expressions entered by the user in the current session. Editing expressions and adding new vocabulary words has also been made easier.

3.2 Translation

The translation ability of DeSymbol has been improved. Prepositions have been added to DeSymbol's vocabulary, so that the user can enter expressions like these:

on(a, b)
near(sam, frodo)
 $\forall x \forall y \forall z (\text{above}(x, y) \wedge \text{above}(y, z) \rightarrow \text{above}(x, z))$

Uncountable nouns like *water* have also been added:

likes(kermit, water)

More kinds of sentences now have idiomatic translations. For example, the expression

$\forall x (\text{cat}(x) \wedge \text{furry}(x))$

instead of being translated symbol-for-symbol as

For all x, x is a cat and x is furry

now gets the simpler translation

Everything is a furry cat.

The new system will be used in the Fall 2013 *Foundations of Computer Science* class at Rowan, in which we teach the students introductory symbolic logic, and feedback from the students will be used to evaluate the new features. DeSymbol is free software covered by the GNU Public License, and it is available on the web at <http://elvis.rowan.edu/desymbol/> for anyone to use.

4 Acknowledgements

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