Institut de Recherche en Informatique de Toulouse
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TouIST tutorial #1: Discovery of TouIST

1 Prerequisites

You must first master the following knowledge and skills:

- know the notions of: propositional variable, valuation, model, logical consequence, (un)satisfiability;
- correctly use the logical connectors for problem modeling;
- assess a logical consequence, look for a model, draw the right conclusions about their (non)existence.

2 Goal of the tutorial

At the end of this tutorial, you will be able to encode simple problems, use the TouIST SAT solver and interpret its responses.

3 Discovery of TouIST

3.1 Start-up

1. Check if TouIST is already installed: find the file "touist.jar";
2. Otherwise, open a browser and download the version corresponding to your operating system;
3. Unzip the zip and launch "touist.jar" by clicking on it (JAVA must be installed on your machine).

3.2 Graphic interface

In the left frame you will enter the desired formulas or sets, in the right one you will have the visual rendering.

- Type `p and q => p`

- You can also make your entries using the mini-editor in the menu on the far left: click on the box `a => b`, replace `$b` with `p`, delete `$a` and replace it by clicking on `a` $\wedge$ `b`, and replace `$a` by `p` and `$b` by `q`.
- We will see the role of \$ later.

Propositional logic	TouIST language
$\neg p$	`not p`
$p \wedge q$	`p and q`
$p \vee q$	`p or q`
$p \oplus q$	`p xor q`
$p \rightarrow q$	`p => q`
$p \leftrightarrow q$	`p <=> q`

4 Using the prover

4.1 Check if a formula admits a model (that is, is satisfiable)

1. Enter the formula $p \vee q \rightarrow p$
2. Check, at the bottom right, that the selector is on *SAT* then click on *Solve*;
3. The solver shows you a model of the formula: the valuation $v(p) = 0$ and $v(q) = 0$. By clicking on *Next* you access the other models (if there are any). The check marks *True* and *False* allow to display only the propositions to True or False.
4. Back to the edition;
5. Enter the formula $p \wedge \neg p$. Solve. You have a pop-up which informs you that there is no model: the formula is unsatisfiable;
6. Enter $p \vee \neg p$. Solve: there are two models out of two possible, what is normal, the formula beeing valid!

Exercise 1 *Find the models of* $(p \vee q \vee r) \wedge (p \rightarrow \neg q) \wedge (q \rightarrow \neg r) \wedge (r \rightarrow \neg p)$. *Check that in each model, one and only one proposition is true.*

4.2 Validity checking of a formula

Reminder 1 *A valid formula has no counter-model. (In other words, any interpretation is a model.)*

If you enter a formula and want to know if it is valid, you have to check that it has as many models as there are possible, which is not very practical!

We proceed indirectly, by refutation. If it is valid, its negation will be unsatisfiable. So we test its negation, here $\neg(p \vee \neg p)$. Do it. You notice that there is no solution, so the formula $p \vee \neg p$ is valid!

Exercise 2 *Check that* $rain \wedge (rain \rightarrow wetRoad) \wedge (wetRoad \rightarrow danger) \rightarrow danger$ *is valid.*

4.3 Check if a set of formulas admits a model (that is, is satisfiable)

We simply enter the formulas of the set, one above the other (we press the *Enter* key after each formula to return to the line), then we click on *Solve*.

Exercise 3 *Check that the set* $\{coffee \vee tea, \neg tea\}$ *is satisfiable. What unique model does it accept?*

4.4 Check if a formula C is a logical consequence of a set H of formulas

Suppose that $H = \{H_1, ..., H_n\}$ is a set of n hypotheses.

Again, it would be tedious to verify that C is true in all H models. We proceed indirectly using the theorem:

$$H \models C \text{ if and only if } H \cup \{\neg C\} \text{ is unsatisfiable}$$

In other words, to check if $H \models C$, we will test if the formulas H_1, H_2, ..., H_n, $\neg C$ taken *all together* are satisfiable. If not, we can conclude that $H \models C$. If it is not the case, we will have at least a counter-model ($\sim$ a counter-example) which will tell us in which situation we have the true hypotheses and the false conclusion.

Exercise 4 *Test the following consequences and give a counter-model when they are not correct (we assume that:* f *reads "I have fever",* m *reads "I have measles",* s *reads "I am sick"):*

- $\{f \rightarrow s, f\} \models s$
- $\{f \rightarrow s, m \rightarrow s, \neg f \wedge \neg m\} \models \neg s$
- $\{f \rightarrow s, m \rightarrow s, \neg s\} \models \neg f \wedge \neg m$

Exercise 5 *We assume that we have the following set of rules and facts* H*:*

1. *If the patient has measles, he has a fever.*
2. *If the patient has hepatitis but does not have measles, he has a yellow complexion.*
3. *If the patient has a fever or yellow complexion, he has hepatitis or measles.*

4. *The patient is not yellow.*

5. *The patient has a fever.*

1) Formalize each of the five hypotheses above by choosing the propositional variables corresponding to the different propositions appearing in the hypotheses.

2) Check that in all the H models, the variable m (corresponding to the patient has measles*) is set to True.*

3) Check that $H \models m$.

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