

Decision Procedures for Artificial Intelligence – INF656L

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SAT Part - Practical work 3

Goal(s)

- ★ Model decision problem into SAT;
- ★ Use PycoSAT solver to find solutions.

1 DIMACS file

Most SAT solvers accept as input a simplified “DIMACS CNF” format, which is a simple text format. Every line beginning “c” is a comment. The first non-comment line must be of the form:

```
p cnf NUMBER OF VARIABLES NUMBER OF CLAUSES
```

Each of the non-comment lines afterwards defines a clause. Each of these lines is a space-separated list of variables; a positive value means that corresponding variable (so 4 means x_4), and a negative value means the negation of that variable (so -5 means $\neg x_5$). Each line must end in a space and the number 0.

For example,

```
c Here is a comment
p cnf 5 3
1 -5 4 0
-1 5 3 4 0
-3 -4 0
```

is the representation of the CNF

$$\{\{x_1, \neg x_5, x_4\}, \{\neg x_1, x_5, x_3, x_4\}, \{\neg x_3, \neg x_4\}\}$$

2 PicoSAT

PicoSAT is a satisfiability (SAT) solver for Boolean variables in Boolean expressions. It is released under the MIT licence.

<http://fmv.jku.at/picosat/>

PicoSAT's usage is:

```
picosat [options] [INPUT-FILE]
```

- INPUT-FILE is a DIMACS file
- The output is a number of lines. Most of these will begin with “c” (comment), and give detailed technical information. The output line beginning with “s” declares whether or not it is satisfiable. The line “s SATISFIABLE” is produced if it is satisfiable (exit status 10), and “s UNSATISFIABLE” is produced if it is not satisfiable (exit status 20).

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- If it is satisfiable, the output line beginning with "v" declares a set of variable settings that satisfy all formulas. For example:

```
v 1 -2 -3 -4 5 0
```

Shows that there is a solution with variable 1 true, variables 2, 3, and 4 false, and variable 5 true.

A Python binding exists, named pycosat,

<https://pypi.org/project/pycosat/>

The input follows the DIMACS format but can be given by a list of list of integers in Python. The output of the Python bindings is simplified.

3 Usefull Python libraries

Sympy library can be used to easily manipulate Boolean formula and convert them into CNF

```
from sympy.logic.boolalg import to_cnf
from sympy.abc import A, B, D
to_cnf(~(A | B) | D)
```

Exercise 1 – Sudoku

Question 1

Write a program to generate a CNF formula to solve a Sudoku. You can consider reading the paper

<https://www.lri.fr/~conchon/mpri/weber.pdf>

for more details on the encoding (and the total number of clauses to deal with).