1. (i) Give a general technique for translating a finite discrete CSP to an equivalent propositional satisfiability (SAT) problem where in a finite discrete CSP each variable has a finite domain and each constraint is a finite set of tuples.

(ii) Use the translation to map the CSP below to a SAT problem.

\[(C_1(x_1, x_2, x_3), C_2(x_1, x_3), x_1 \in \{1, 2, 3\}, x_2 \in \{1, 2, 3\}, x_3 \in \{1, 2, 3\})\]

where \(C_1 = \{(1, 2, 3), (2, 2, 3), (3, 2, 3)\}\) and \(C_2 = \{(1, 2), (1, 3), (2, 1), (2, 3), (3, 1), (3, 2)\}\).

2. Consider the global cardinality constraint \(gcc_{l,u}(X)\) where \(X\) is a vector \((x_1, \ldots, x_n)\) of variables and \(l, u\) are functions from the union of domains \(D_1, \ldots, D_n\) of variables \(x_1, \ldots, x_n\) to non-negative integers. A tuple \(t = (a_1, \ldots, a_n) \in D_1 \times \cdots \times D_n\) belongs to \(gcc_{l,u}(X)\) iff \(l(a_i) \leq \#(a_i, t) \leq u(a_i)\) where \(\#(a_i, t)\) denotes the number of times the value \(a_i\) appears in the tuple \(t\).

(i) Express the alldiff\((X)\) constraint using \(gcc_{l,u}(X)\).

(ii) Consider the constraint \(gcc_{l,u}(x_1, \ldots, x_8)\) where for all \(i = 1, \ldots, 8\), \(D_i = \{1, 2, 3\}\) and for all \(a \in \{1, 2, 3\}\), \(l(a) = 0, u(a) = 2\). Is this constraint hyper-arc consistent?

3. Compare WalkSAT and Novelty algorithms.

(i) Give a setting for the parameter \(p\) such that Novelty is deterministic but WalkSAT is not.

(ii) Explain why Novelty is said to be greedier than WalkSAT.

4. Write an integer program such that variables \(x_1, x_2\) can have only values 0 or 1 and variable \(x_3\) has the value of the Boolean function \(xor(x_1, x_2)\) in all feasible solutions.