

National University of Singapore  
School of Computing  
CS3243: Introduction to Artificial Intelligence  
Tutorial 4

**Readings:** AIMA Chapter 6

1. Consider the AC-3(*csp*) algorithm (reproduced below), can the last line “add ( $X_k, X_i$ ) to queue” be replaced with “if  $X_k \neq X_j$  then add ( $X_k, X_i$ ) to queue”? Justify your answer.

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function AC-3(csp) returns the CSP, possibly with reduced domains
inputs: csp, a binary CSP with variables  $\{X_1, X_2, \dots, X_n\}$ 
local variables: queue, a queue of arcs, initially all the arcs in csp

while queue is not empty do
  ( $X_i, X_j$ )  $\leftarrow$  REMOVE-FIRST(queue)
  if REMOVE-INCONSISTENT-VALUES( $X_i, X_j$ ) then
    for each  $X_k$  in NEIGHBORS[ $X_i$ ] do
      add ( $X_k, X_i$ ) to queue

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function REMOVE-INCONSISTENT-VALUES( $X_i, X_j$ ) returns true iff succeeds
  removed  $\leftarrow$  false
  for each  $x$  in DOMAIN[ $X_i$ ] do
    if no value  $y$  in DOMAIN[ $X_j$ ] allows ( $x, y$ ) to satisfy the constraint  $X_i \leftrightarrow X_j$ 
      then delete  $x$  from DOMAIN[ $X_i$ ]; removed  $\leftarrow$  true
  return removed

```

2. Consider the following constraint satisfaction problem:

Variables:

$$A, B, C$$

Domains:

$$D_A = D_B = D_C = \{0, 1, 2, 3, 4\}$$

Constraints:

$$\begin{aligned} A &= B + 1 \\ B &= 2C \end{aligned}$$

Construct a constraint graph for this problem. Show a trace of the AC-3 algorithm on this problem. Assume that initially, the arcs in queue are in the order  $\{(A, B), (B, A), (B, C), (C, B)\}$ .

3. Consider the 4-queens problem on a  $4 \times 4$  chess board. Suppose the leftmost column is column 1, and the topmost row is row 1. Let  $Q_i$  denote the row number of the queen in column  $i$ ,  $i = 1, 2, 3, 4$ . Assume that variables are assigned in the order  $Q_1, Q_2, Q_3, Q_4$ , and the domain values of  $Q_i$  are tried in the order 1, 2, 3, 4. Show a trace of the backtracking algorithm with forward checking to solve the 4-queens problem.

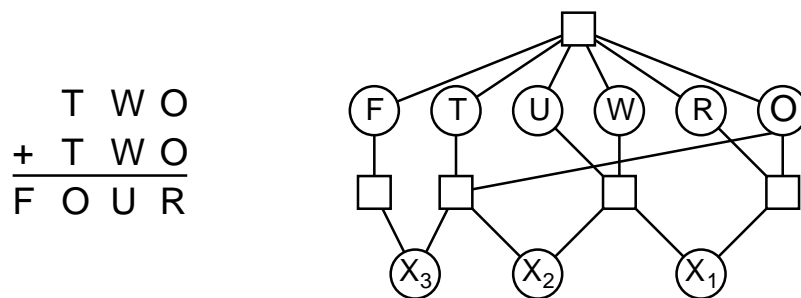


Figure 1: Cryptarithmic puzzle.

4. Show a trace of the backtracking algorithm with forward checking to solve the cryptarithmic problem shown in Figure 1. Use the most constrained variable heuristic, and assume that the domain values (digits) are tried in ascending order (i.e., 0, 1, 2, ...).