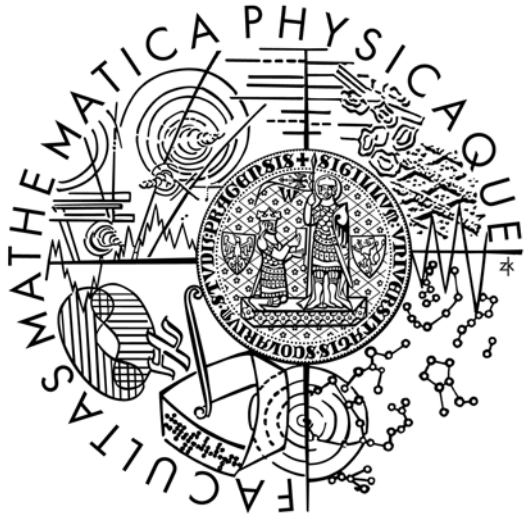
Interactive Heuristic Search Algorithm



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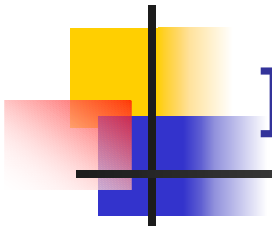
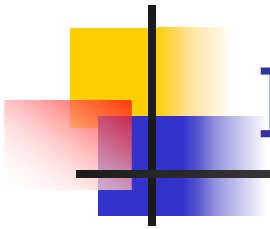


Introduction

- for Finite Constraint Satisfaction Problems
  - variables with finite domains, constraints between variables
- Generalization of Timetabling Algorithm
  - lecture timetabling
  - activities, resources, various soft & hard constrains
  - promising results *presented at PATAT 2002*
    - large randomly generated problems *~ 2000 activities*
    - timetable at Faculty of Mathematics and Physics
- Interactivity
  - combination of automated solving with user interaction
  - solution is built step by step
  - presentation of sub-results during execution
    - working with feasible partial solutions

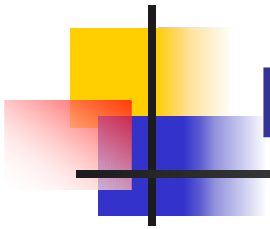


Interactive Heuristic Search Algorithm

- Basic Approaches
  - local search
  - backtracking based search
- Interactive Solving Algorithm
  - forward based search
  - works in iterations
  - extending feasible partial solution
  - interactivity
  - can provide a sub-result even in over-constrained problem

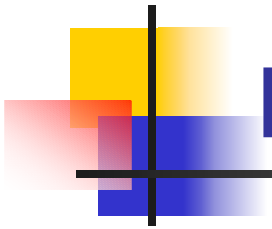
Interactive Heuristic Search Algorithm

```
procedure solve(unassigned, solution, max_iter)
    // unassigned is a list of un-assigned variables
    // solution is a partial solution (empty at the beginning)
    //     e.g. a list (variable, assigned value)
    iterations=0;
    while unassigned non empty & iterations<max_iter
      & non user interruption do
        iterations ++;
        variable = selectVariable(unassigned, solution);
        unassigned -= variable;
        value = selectValue(variable, solution);
        unassigned += assign(solution, variable, value)
          // assign the variable and return violated variables
    end while;
    return solution;
end solve
```



Remarks

- Variable Selection Criterion
  - first-fail principle
    - improvement: Select randomly 20% of un-assigned variables first.
- Value Selection Criterion
  - best-fit value
    - improvement: Random selection of the top N values.
- Prevent Cycles
  - tabu-list
  - randomisation
- Soft Constraints
  - extension of variable and value selection criteria



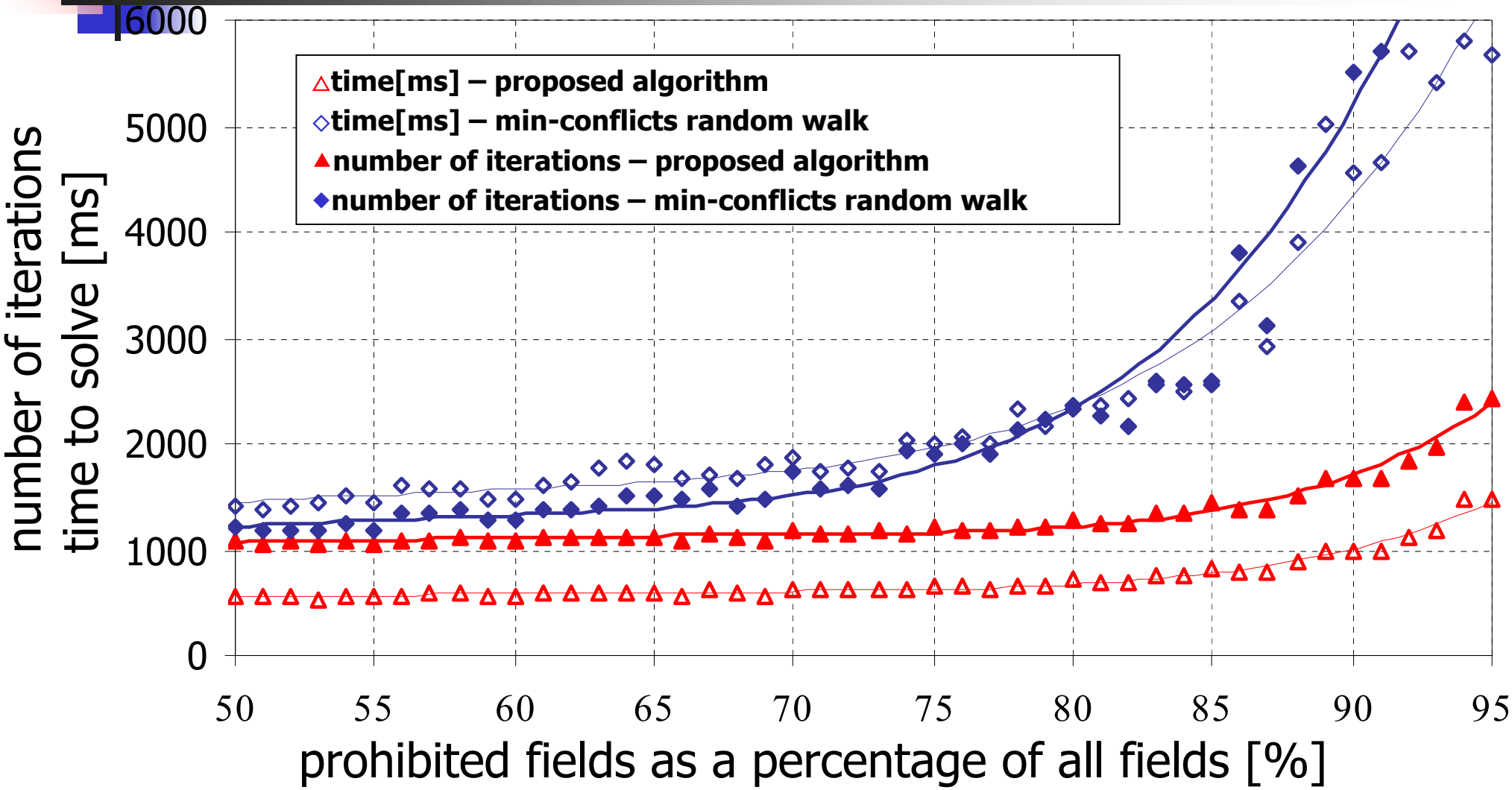
Example: N-queens Problem

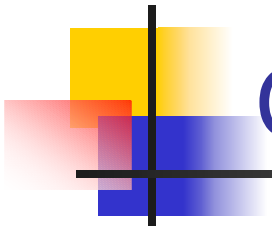
- Chessboard N × N
- N Queens
  - Task: Place queens on chessboard so that no queen is under a direct attack from any other one.
- Holes
  - prohibited fields on the chessboard
- Algorithm
  - select not-placed queen *~ column with no queen*
  - place selected queen *~ choose row*
  - remove conflicting queens *~ queens under a direct attack*

N-queens Problem - Results

number of queens	presented algorithm I.H.S.A.		min-conflict random walk		backtracking full look ahead
	time	# iter.	time	# iter.	time
100	4 ms	126	6 ms	151	113 ms
500	24 ms	552	18 ms	392	2 236 ms
1 000	86 ms	1041	68 ms	733	25 422 ms
2 000	338 ms	2039	266 ms	1328	---
5 000	2 055 ms	5058	1 688 ms	3242	---
10 000	8 603 ms	10063	7 250 ms	6482	---
25 000	49 061 ms	25039	65 664 ms	15819	---
50 000	198 074 ms	50035	473 980 ms	31535	---

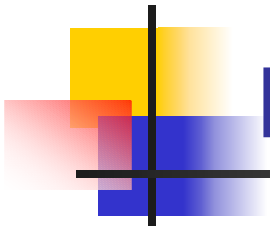
N-queens Problem – Results (1000 Queens)





Conclusions, Further Work

- Interactive Heuristic Search Algorithm
  - intuitive generalization of lecture timetabling algorithm
  - interactivity
  - easily applicable to many CSPs
  - very promising results
  - easily extensible
    - new constraints, dependencies between activities, ...
- Further Work
  - lecture timetabling
    - tuning heuristics
    - more results (another real-world problems)
    - parallelism



References

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