IMPLEMENTATION AND EVALUATION OF A SWEEP-BASED PROPAGATOR FOR DIFFN IN GECODE

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Master Thesis (course 1DT540)
Uppsala University
Sweden

OUTLINE

OUTLINE

- Background
- Sweep Algorithm
- Evaluation Setup
- Results
- Discussion
- Future Work

BACKGROUND

CONSTRAINT PROGRAMMING

6								
	3		2			5		9
	8	7	4		1			
		3		7				
				8	4		2	
2		4		1				3
				4			3	
9			6	3				
						4	8	7

CONSTRAINT PROGRAMMING

- Sudoku
  - All rows must have distinct values
  - All columns must have distinct values
  - Each disjoint 3×3 region must have distinct values

6								
	3		2			5		9
	8	7	4		1			
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				8	4		2	
2		4		1				3
				4			3	
9			6	3				
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CONSTRAINT PROGRAMMING

- Variables

6								
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	8	7	4		1			
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				4			3	
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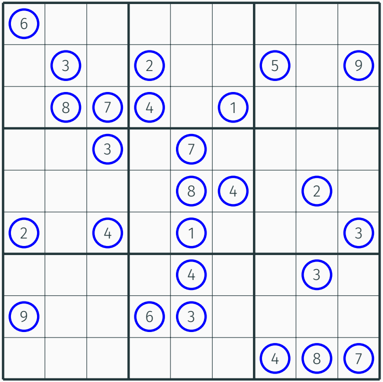
CONSTRAINT PROGRAMMING

- Variables
- Values



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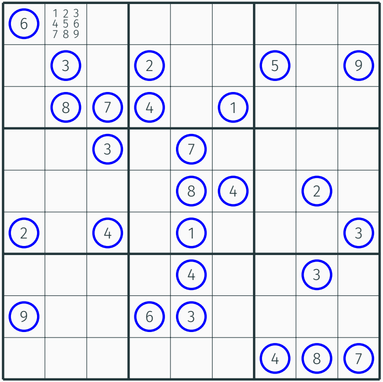

6	1 2 3 4 5 6 7 8 9							
	3		2			5		9
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CONSTRAINT PROGRAMMING

- Variables
- Values
- Constraints

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- Variables
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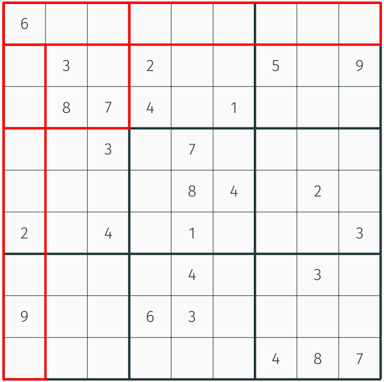
CONSTRAINT PROGRAMMING

- Variables
- Values
- Constraints



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SOLVING A CONSTRAINT PROGRAMMING PROBLEM

- Constraint programming solver
    - Model → Solution

SOLVING A CONSTRAINT PROGRAMMING PROBLEM

- Constraint programming solver
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- Search

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- Inference (through propagation) ☜

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    - Propagator
        - Implements a constraint

SOLVING A CONSTRAINT PROGRAMMING PROBLEM

- Constraint programming solver
    - Model → Solution
- Search
- Inference (through propagation) ☜
    - Propagator
        - Implements a constraint
        - *Infers* what values violate constraints and *prunes* them

SOLVING A CONSTRAINT PROGRAMMING PROBLEM

6	1 2 3 4 5 6 7 8 9							
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GECODE

- Constraint programming solver

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- Constraint programming solver
- Customisable
    - Custom propagators ☜
    - Search heuristics

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- Award winning

GECODE

- Constraint programming solver
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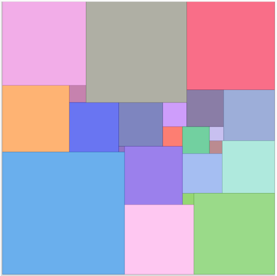
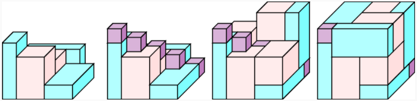
    - Custom propagators ☜
    - Search heuristics
- Award winning
- Copying solver

DIFFN

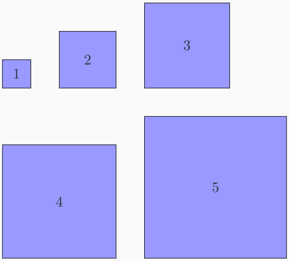




Source: `http://sofdem.github.io/gccat/gccat/KConway_packing_problem.html`

- Hyperrectangles must not overlap

DIFFN



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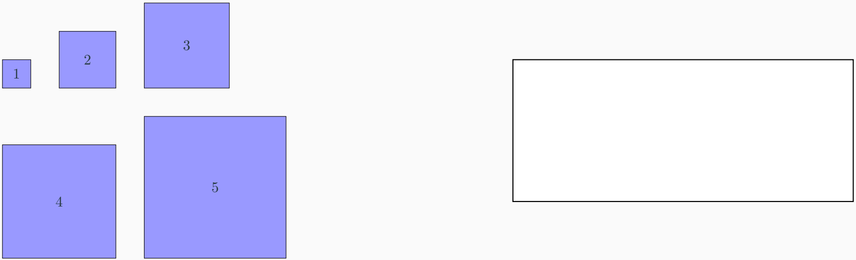

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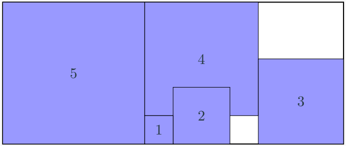

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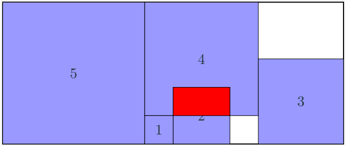

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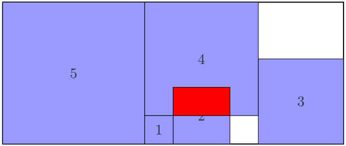
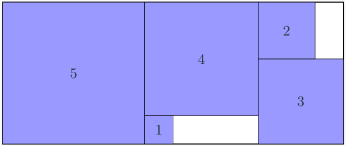
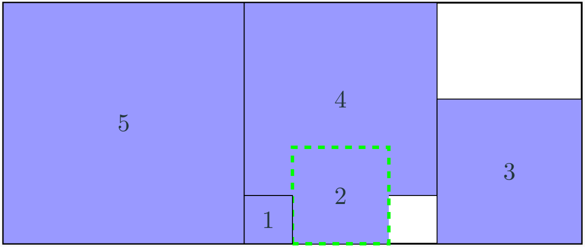




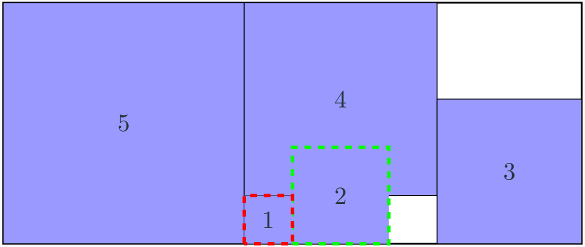
DIFFN

- Common approach to DIFFN: pairwise reasoning

DIFFN - PAIRWISE



DIFFN - PAIRWISE



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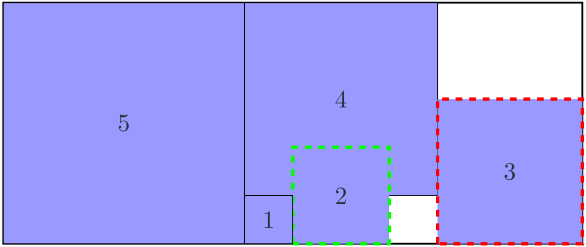

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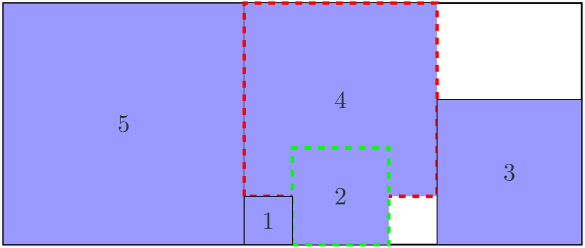

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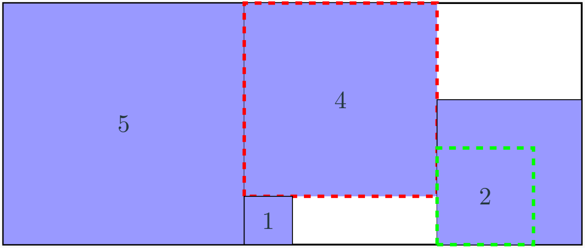

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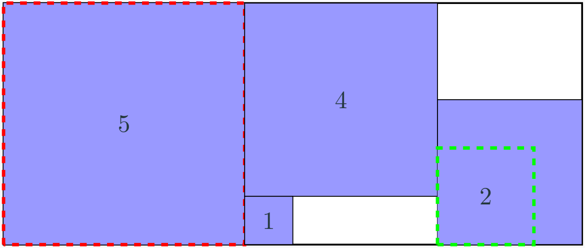

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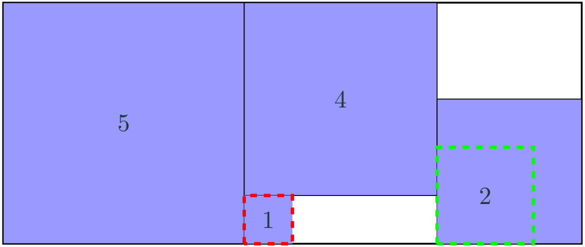

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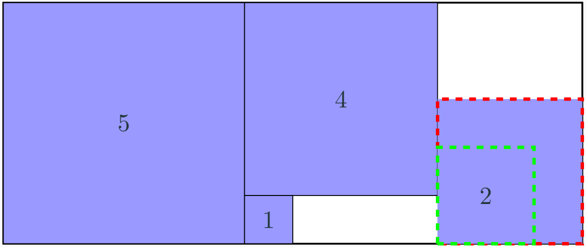

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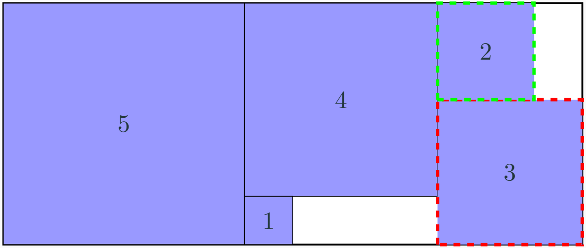

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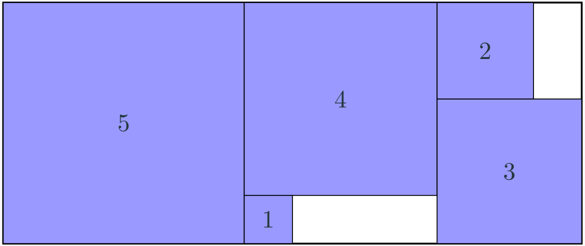

SWEEP ALGORITHM

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- Proposed by Nicolas Beldiceanu and Mats Carlsson (2001)

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- Potential for stronger inference ($\Rightarrow$ less search)

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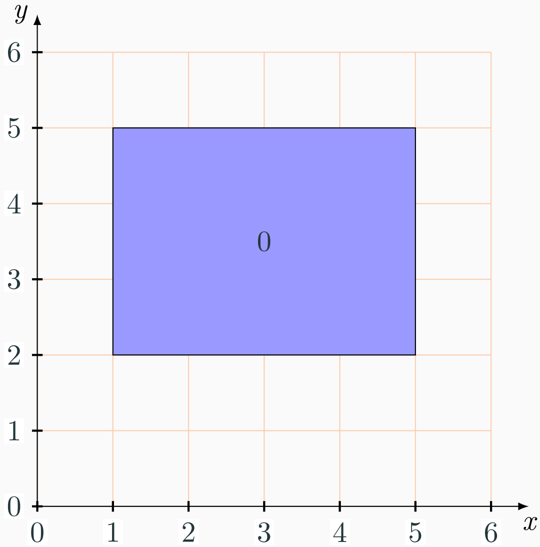
- Potential for stronger inference ($\Rightarrow$ less search)
- Aggregated reasoning

FORBIDDEN REGIONS



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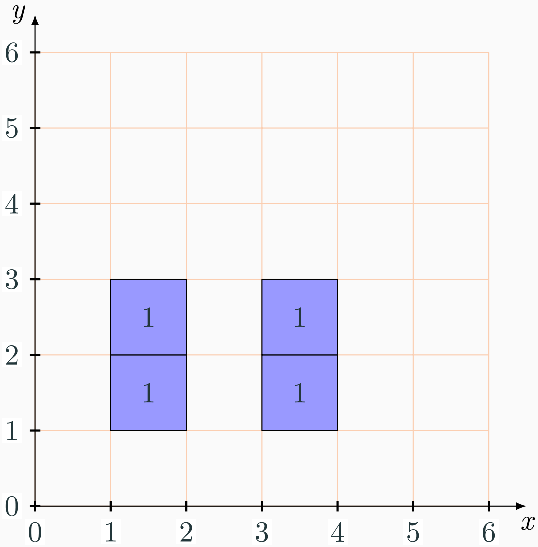

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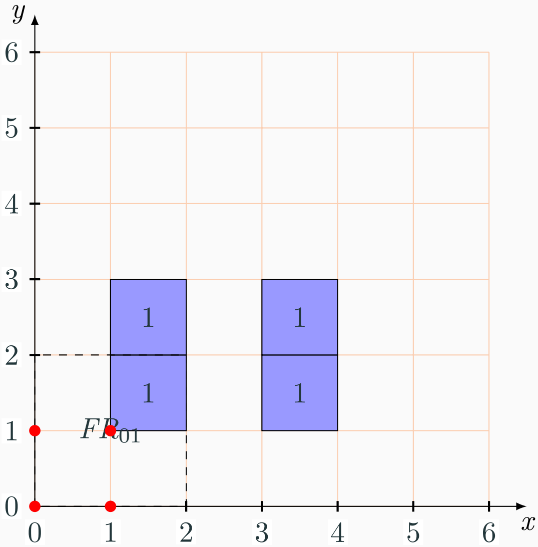

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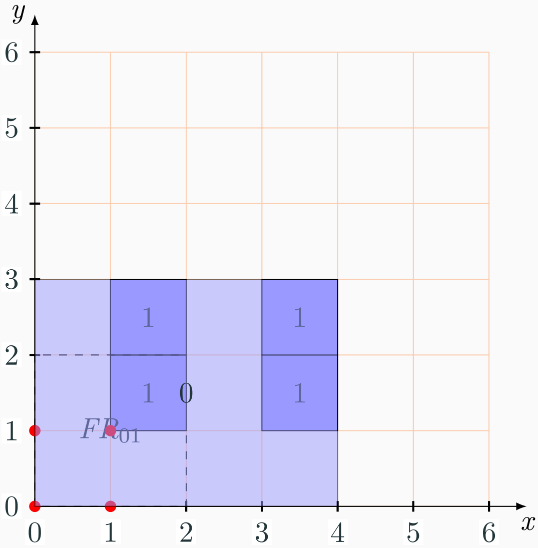

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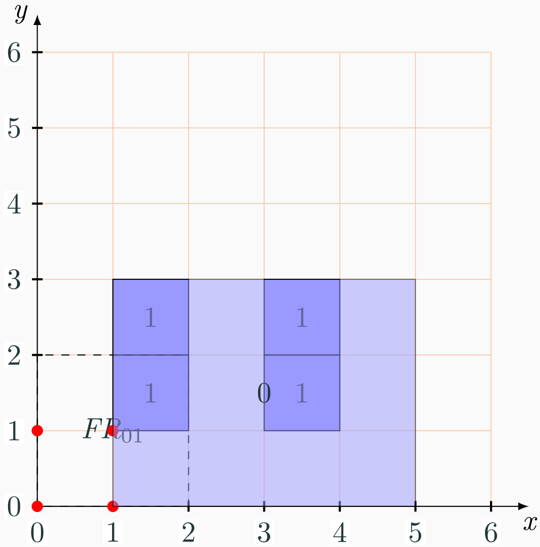

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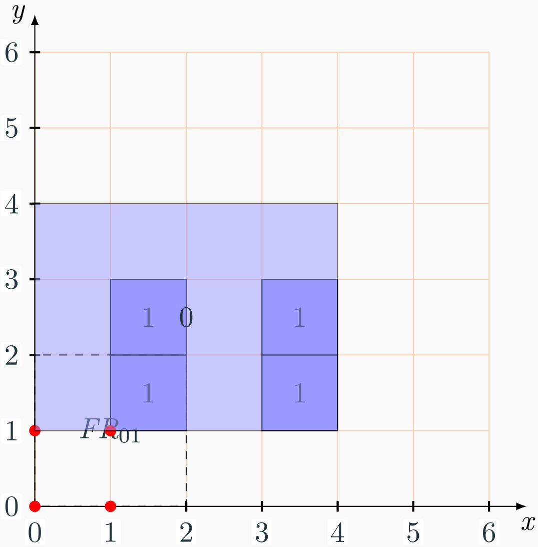

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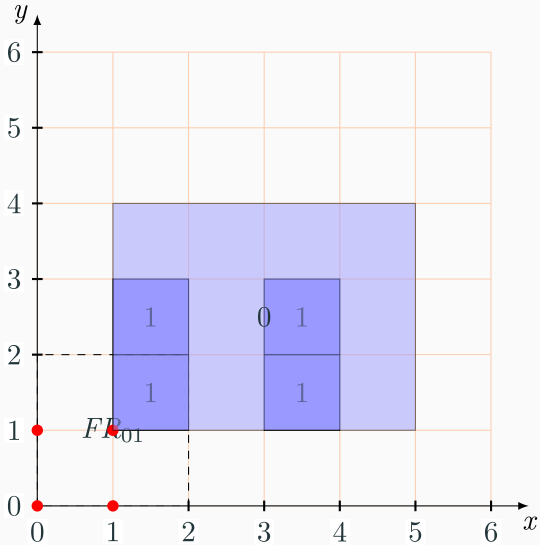

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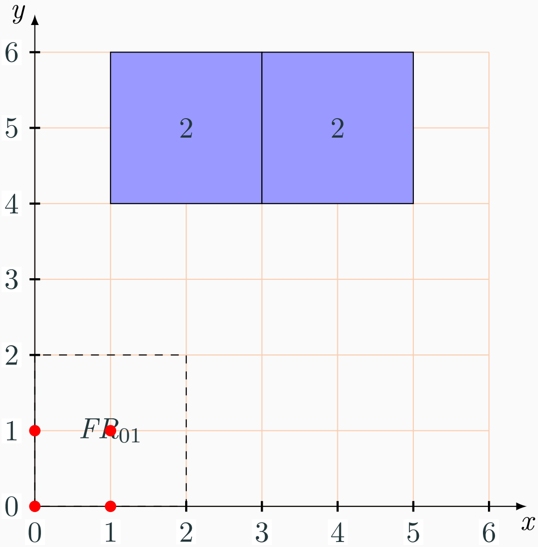

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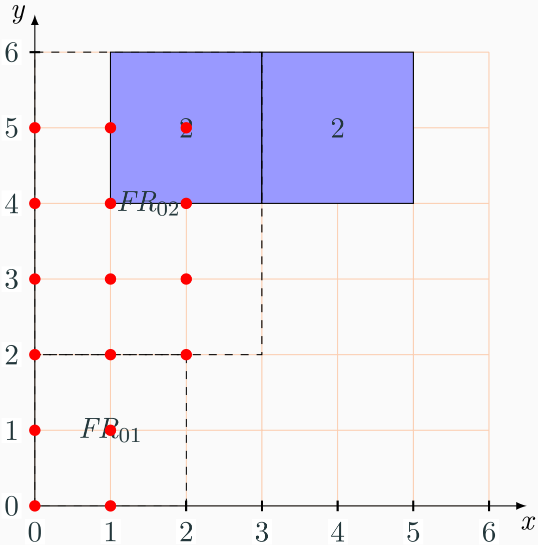

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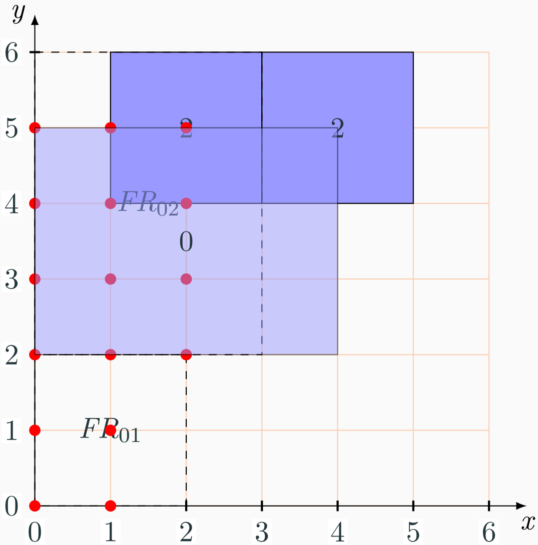

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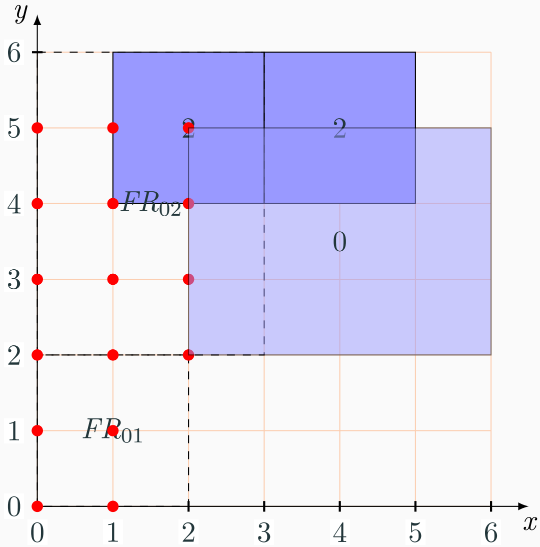

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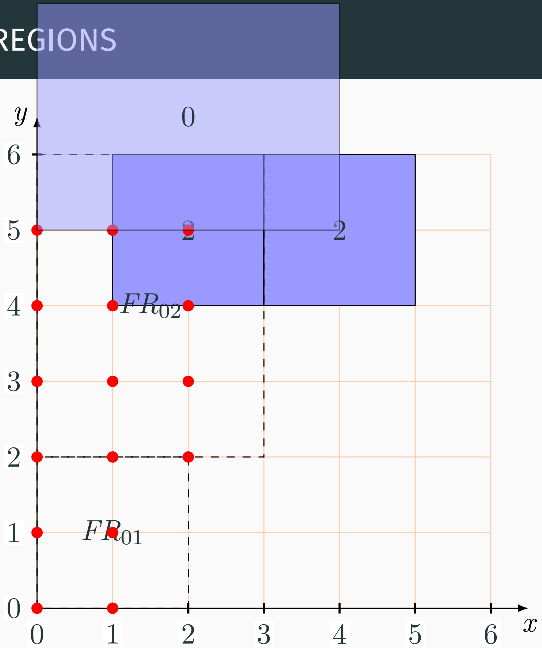

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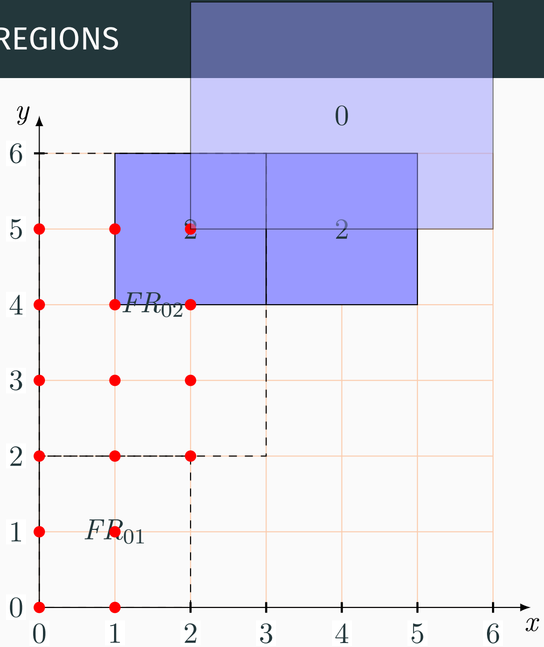

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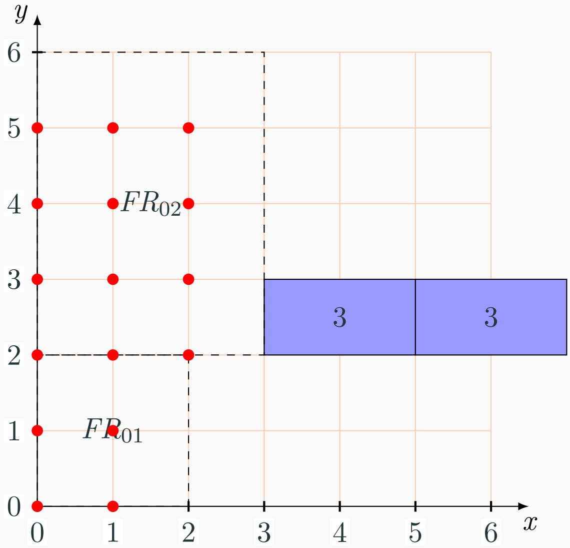

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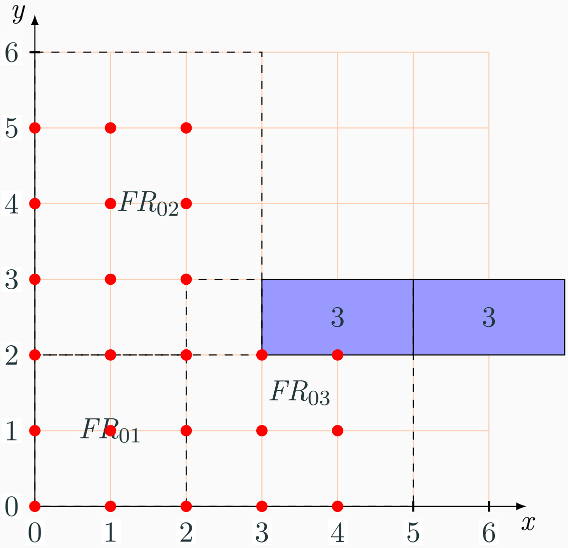

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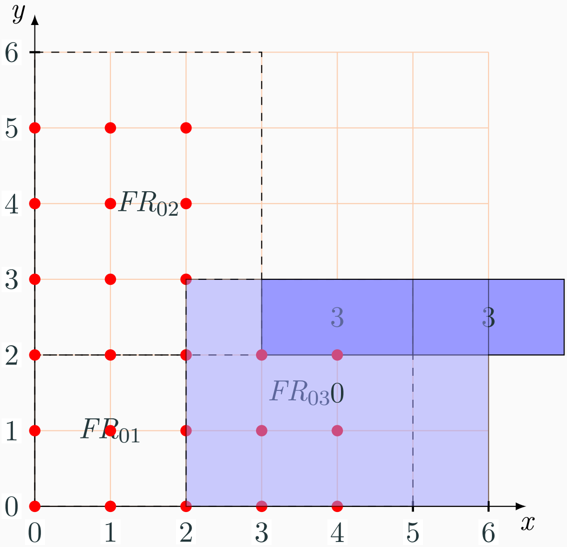

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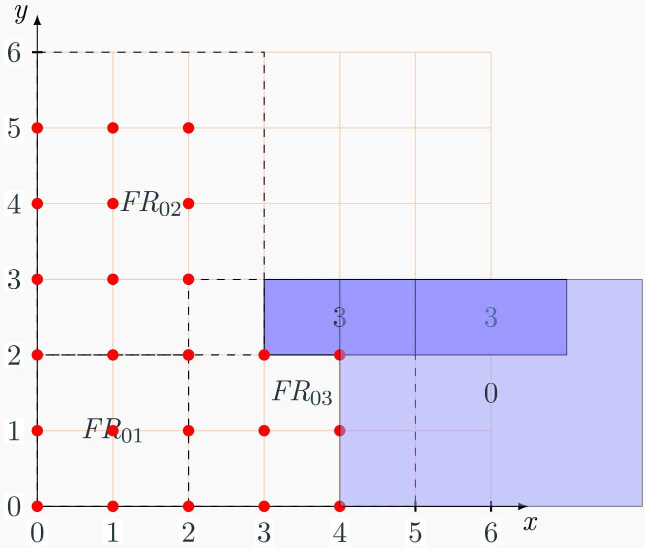

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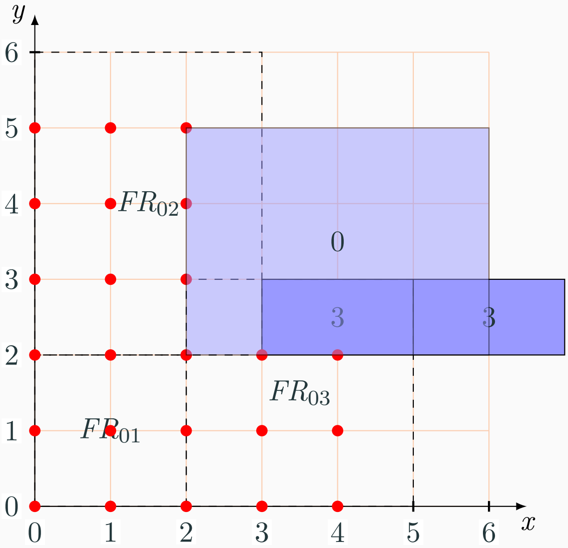

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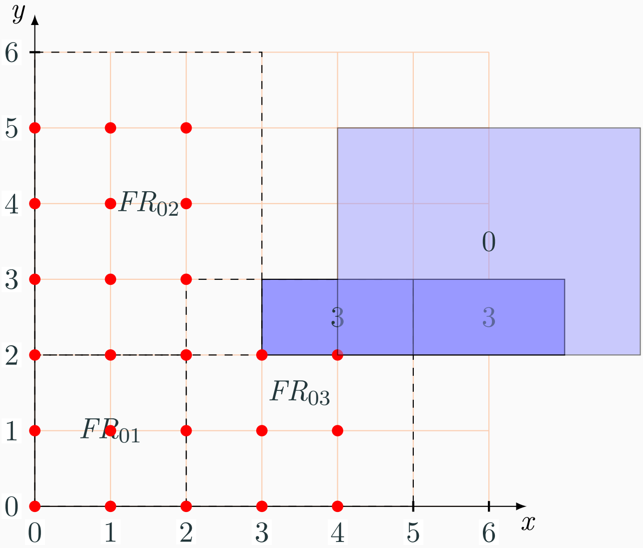
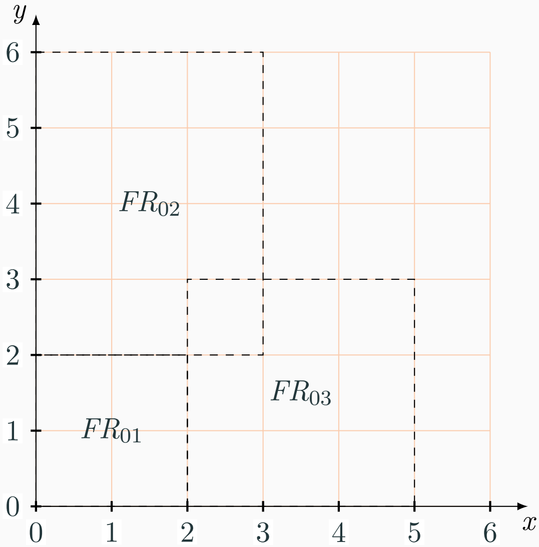


SWEEP ALGORITHM



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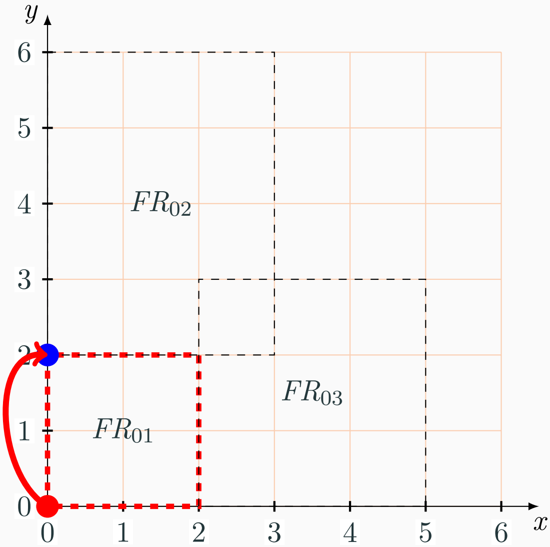

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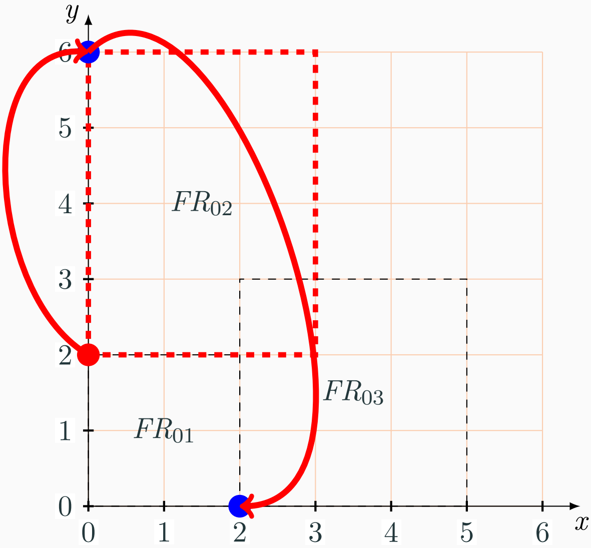

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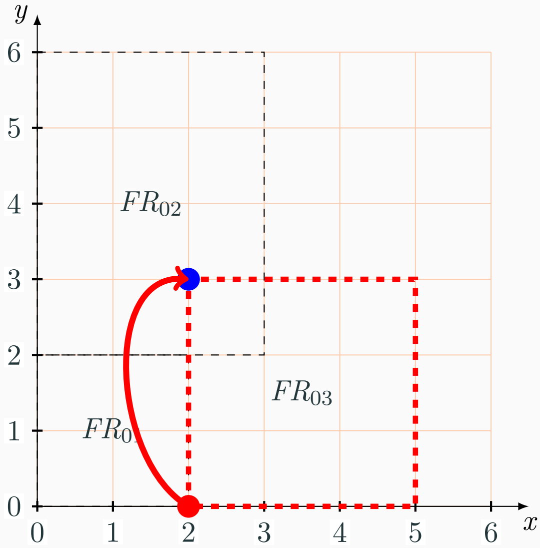

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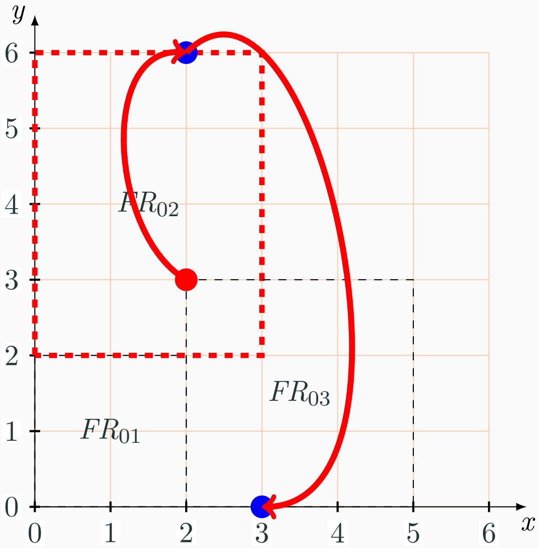

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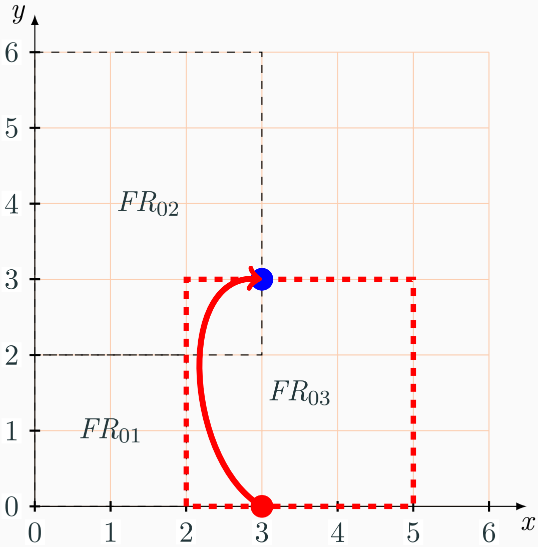

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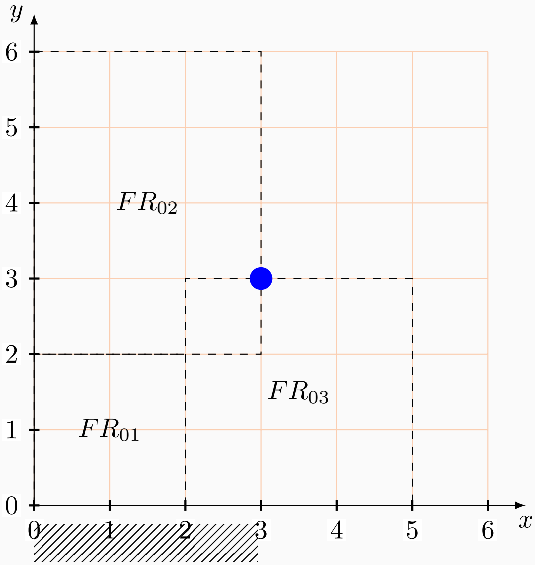

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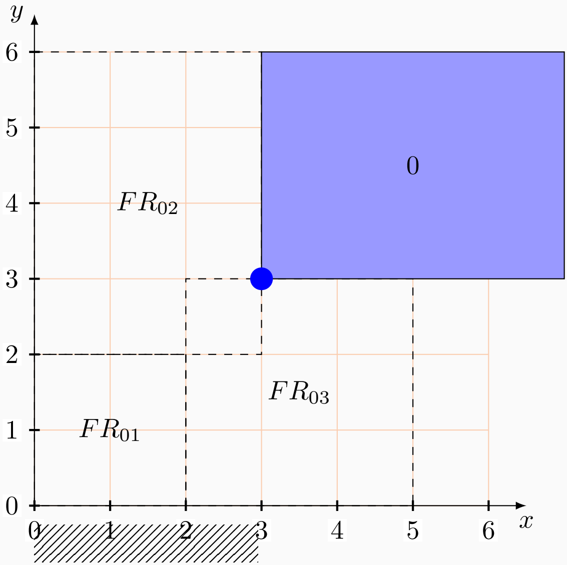

EVALUATION

EVALUATION SETUP

- The best DIFFN configuration against Gecode's NOOVERLAP propagator.

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- Microbenchmarks and Macrobenchmarks

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- The best DIFFN configuration against Gecode's NOOVERLAP propagator.
- Microbenchmarks and Macrobenchmarks
- Measured each instance 5 times.
- Number of failures to evaluate propagation strength

RESEARCH QUESTIONS

1. How much extra pruning does the sweep-based algorithm achieve compared to the pairwise algorithm?

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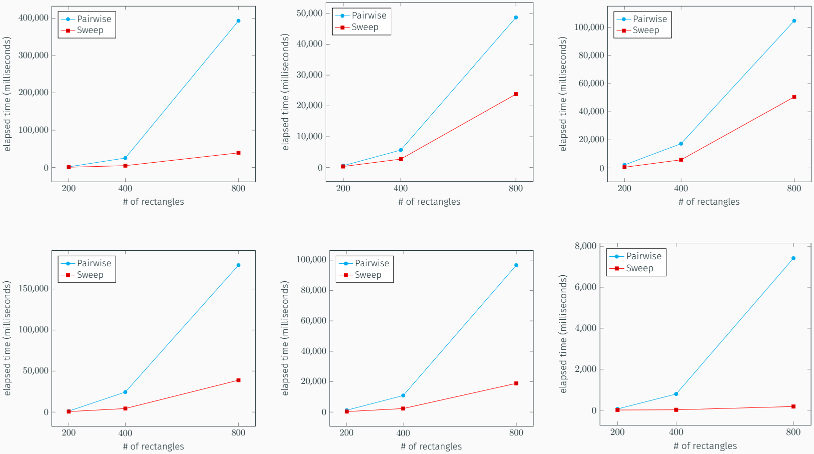
1. How much extra pruning does the sweep-based algorithm achieve compared to the pairwise algorithm?
2. What is the performance of the sweep-based algorithm compared to the pairwise algorithm?

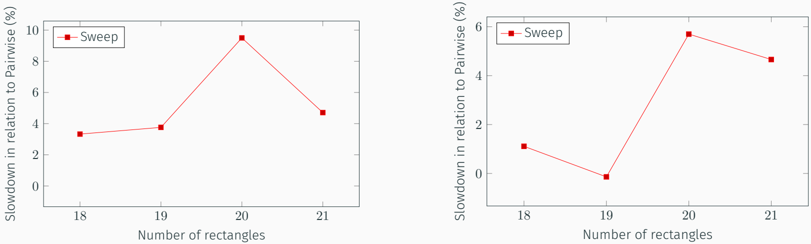
RESULTS

RESULTS - MICROBENCHMARKS



Elapsed time for the microbenchmarks. (Lower is better)

RESULTS - MACROBENCHMARKS: RECTANGLE PACKING PROBLEM



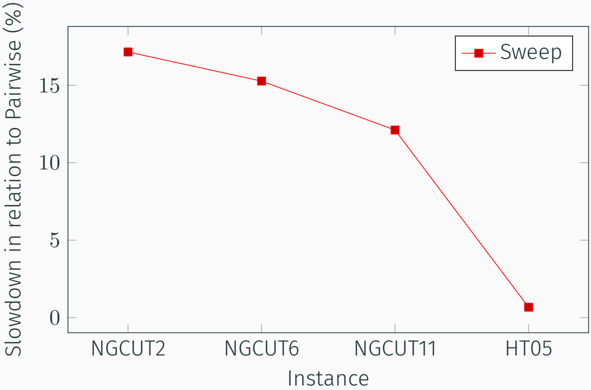
(a) Not considering the 1-unit square.

(b) Considering the 1-unit square.

Slowdown percentages for sweep relative to the pairwise implementation. (Lower is better)

Constraints: DIFFN, CUMULATIVE, arithmetical constraints.

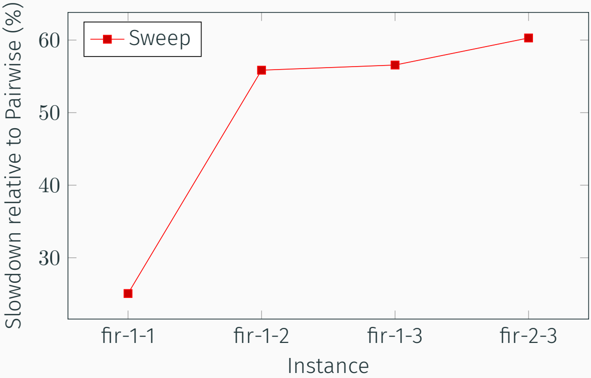
RESULTS - MACROBENCHMARKS: 2D STRIP PACKING



Slowdown percentages for sweep relative to the pairwise implementation. (Lower is better)

Constraints: DIFFN, CUMULATIVE, MEMBER, LEX_LESS.

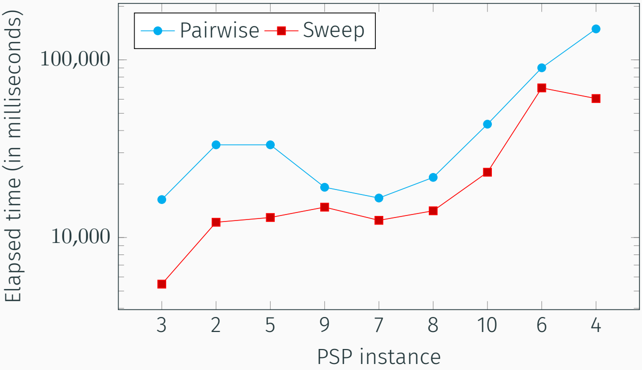
RESULTS - MACROBENCHMARKS: FILTER



Elapsed time (ms) for different instances of the Filter benchmark. (Lower is better)

Constraints: Diffn, arithmetical constraints.

RESULTS - MACROBENCHMARKS: PERFECT SQUARE PACKING



Elapsed times (ms) for the Perfect Square Packing benchmark. (Lower is better)

Constraints: DIFFN, arithmetical constraints.

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    - Identical pruning $\Rightarrow$ slowdowns between 2 to 60 %
    - At least 1.47 times more pruning $\Rightarrow$ Sweep outperforms Pairwise

WHAT'S NEXT?

FUTURE WORK

- Extend the implementation to support variable lengths
- Evaluate performance in 3 dimensions

THANK YOU!