My Research Journey in 2024 and Vision for 2025

Thibault Falque

Special meeting – 15th January 2025

University of Luxembourg

Contents

Summary of the Research Project

Achievements in 2024

PhD Contributions

- Journal Publication:
  - *Machine learning for predicting off-block delays* in *Data & Knowledge Engineering*.
- Conferences:
  - *IAAI24*, Vancouver: *Check-in Desk Scheduling Optimization*.
  - *ICAART24*, Rome: *Parking Scheduling Optimization*.

Conferences and Events

- Partipated to Abstract Week
- Participated in:
  - JFPC, Lens.
  - NVIDIA Hackathon, Virtual.

Supervision and Teaching

- Supervised two students:
  - GPU algorithms for propagators.
  - Development of Metrics tools.
- Supervised a bachelor project:
  - *Chevrex: A wearable health tracking device*.
- Teaching a course on the AllDifferent constraint.

Octagon Abstract Domain

Objective:

Explore and improve the octagon abstract domain.

Definition:

An octagon constraint is of the form:

$$\pm x_i - \pm x_j \leq c \tag{1}$$

Status:

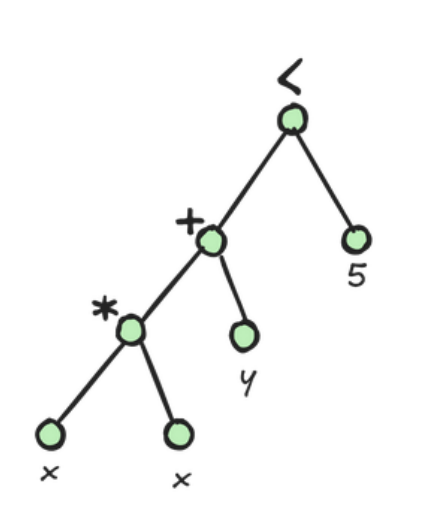
- Existing implementation in `lala-module` using difference bound matrices.
- Next Steps:
  - Refactoring and improving the implementation

Ternary Normal Form

Problem:

Dynamic memory overhead due to deep constraint trees.
Example:

$$x * x + y < 5$$



Solution:

Decompose constraints into fixed-depth propagators.

Ternary Normal Form

Definition:

- TNF Propagators: $x = y < op > z$, where $op \in \{+, -, *, /, min, max, \leq, =\}$.
- Example:

$$t_1 = x * x,$$
$$t_2 = t_1 + y,$$
$$ONE = (t_2 \leq z)$$

Ternary Normal Form

Problem	Data	#Vars	#Vars (TNF)	#Constraints	#Constraints (TNF)
team-assignment	data3_5_31	15932.0	35445.0 (x2.22)	25684.0	45197.0 (x1.76)
generalized-peacable-queens	n8_q3	2940.0	20186.0 (x6.87)	8273.0	25519.0 (x3.08)
spot5	404	1112.0	22053.0 (x19.83)	8124.0	29065.0 (x3.58)
nfc	24_4_2	169.0	527.0 (x3.12)	222.0	580.0 (x2.61)
blocks-world	16-4-5	49447.0	109068.0 (x2.21)	73421.0	133042.0 (x1.81)
triangular	n39	3863.0	207966.0 (x53.84)	105136.0	309239.0 (x2.94)
accap	accap_a4_f30_t15	530.0	2319.0 (x4.38)	993.0	2782.0 (x2.80)
tower	100_100_20_100-04	12547.0	38559.0 (x3.07)	23257.0	49269.0 (x2.12)
roster-sickness	small-4	4980.0	7978.0 (x1.60)	6067.0	9116.0 (x1.50)
accap	accap_a40_f800_t180	28494.0	147451.0 (x5.17)	58616.0	177573.0 (x3.03)
diameterc-mst	c_v20_a190_d4	3045.0	7336.0 (x2.41)	6962.0	11253.0 (x1.62)
triangular	n10	267.0	1370.0 (x5.13)	765.0	1868.0 (x2.44)
wordpress	Wordpress7_Offers500	667.0	92695.0 (x138.97)	30893.0	122921.0 (x3.98)
roster-sickness	large-2	22952.0	29840.0 (x1.30)	25693.0	32653.0 (x1.27)
stripboard	common-emitter-simple	2123.0	14581.0 (x6.87)	4563.0	17093.0 (x3.75)
gfd-schedule	n55f2d50m30k3_10124	32604.0	67749.0 (x2.08)	54575.0	89720.0 (x1.64)

Source: `https://lattice-land.github.io/10-turbo.html`

Lattice Intermediate Representation (LIR)

The Lattice Intermediate Representation is a very low-level representation of the propagator of a constraint.

Logical Extension of the *Ternary Normal Form*

- Objective: Convert all propagators of all constraints into guarded commands using a *compiler*.

Definition of a Guarded Command

A guarded command is a tuple:

$$(b, \texttt{OP}, x, y, r, seq) \tag{2}$$

where: - b, x, y, r: Indexes into the integer array `data`. - `OP`: One of the operators:

$$\{\texttt{ADD}, \texttt{SUB}, \texttt{MUL}, \texttt{TDIV}, \texttt{CDIV}, \texttt{EDIV}, \texttt{MIN}, \texttt{MAX}, \texttt{NEG}, \texttt{AND}, \texttt{OR}, \texttt{EQ}, \texttt{NEQ}, \texttt{EZTE}, \texttt{NZIN}\} \tag{3}$$

- *seq*: A Boolean indicating whether r is only written by one thread.

Next Steps

Interpret the set of guarded commands in parallel until the fixpoint is reached.

Approximation

Goal:

Enhance solving of CSPs and COPs through relaxation techniques.

Steps:

1. Ignore some constraints to simplify the problem.
2. Solve the simplified problem.
3. Restore ignored constraints and use the solution to refine the search.
4. Repeat until the subproblem becomes solvable.

Key Goals for 2025

Key Goals for 2025

- Research:
  - Submit the *Approximation* paper for IJCAI (Deadline: 24th January).
  - Resume work on Lattice Intermediate Representation (LIR).
  - Submit a paper to JFPC (Deadline: 7th March).
- Career:
  - Start searching for new professional opportunities.

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Bibliography