Technische Universität Dresden

CPEC
CENTER FOR PERSPICUOUS COMPUTING

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The Concrete Evonne: Visualization Meets Concrete Domain Reasoning

15th International Symposium on Frontiers of Combining Systems (FroCos)

Reykjavik, Iceland, 29 September 2025

Introduction

Description Logic $\mathcal{EL}_{\bot}$

- Atomic Concepts: *DeliveryDrone*, *ChargingStation*
- Complex Concepts: $Component \sqcap \exists\, locatedOn.LandingGear$
- Axioms: $LargeBatteryDrone \sqsubseteq Drone \sqcap \exists\, hasPart.LargeBattery$

Introduction

Concrete Domain $D_{\mathbb{Q},diff}$

- $batteryPercentage_1 = 0.75$
- $batteryPercentage_2 > 0.3$
- $batteryPercentage_1 - 0.2 = batteryPercentage_2$

Introduction

Concrete Domain $D_{\mathbb{Q},diff}$

- $batteryPercentage_1 = 0.75$
- $batteryPercentage_2 > 0.3$
- $batteryPercentage_1 - 0.2 = batteryPercentage_2$

Concrete Domain $D_{\mathbb{Q},lin}$

- $4 * normalDischargeRate + highDischargeRate = 30$
- $8 * normalDischargeRate = 30$

Introduction

Description Logics $EL_{\bot}[D_{\mathbb{Q},diff}]$ & $EL_{\bot}[D_{\mathbb{Q},lin}]$

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- $\exists\, hasPart.(Battery \sqcap [\ batteryPercentage > 0.25\ ])$

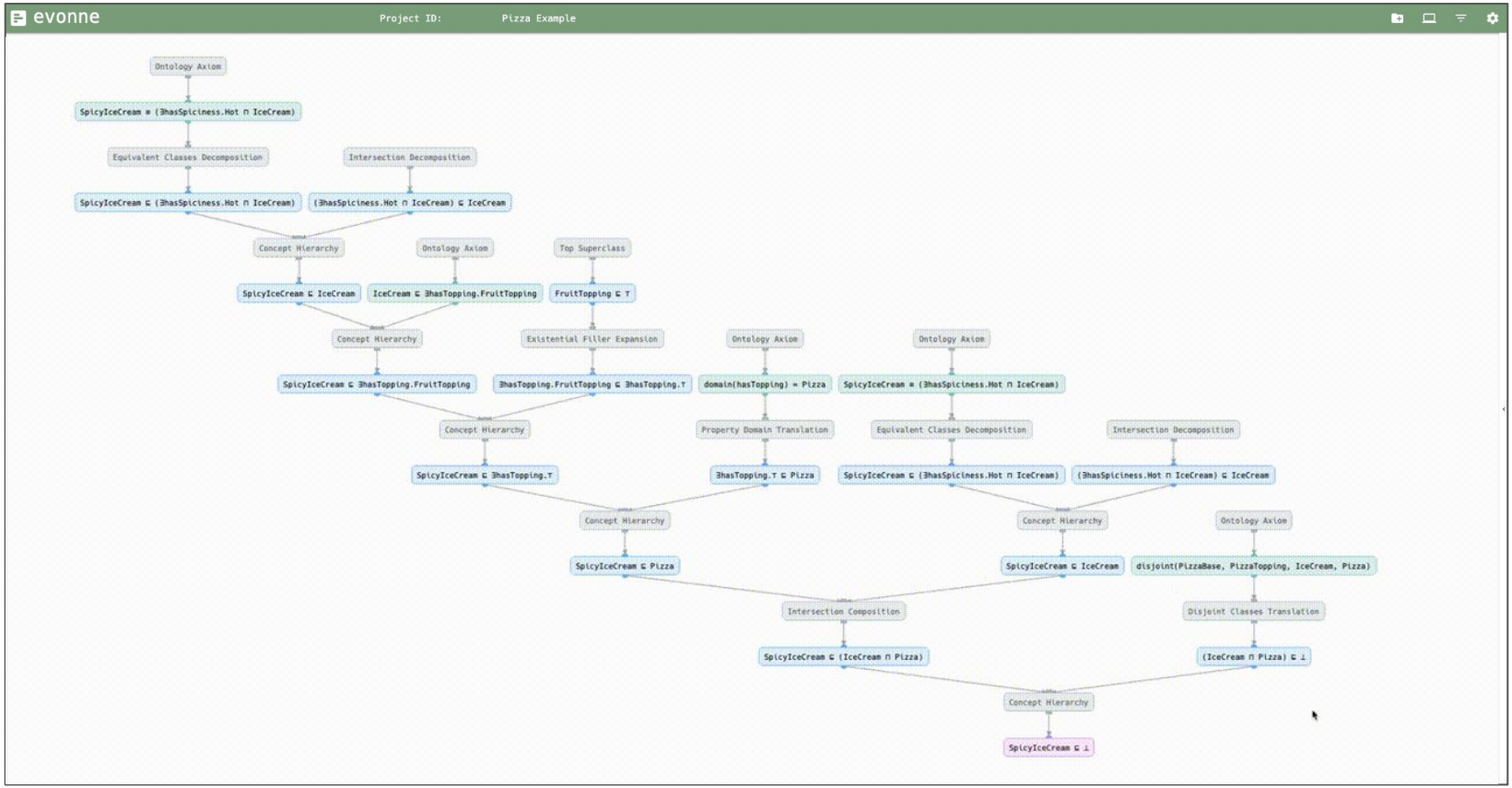
Introduction

Description Logics $EL_{\bot}[D_{\mathbb{Q},diff}]$ & $EL_{\bot}[D_{\mathbb{Q},lin}]$

- $\exists\, hasPart.(Battery \sqcap [\ batteryPercentage > 0.25\ ])$

- $Drone \sqcap [\ 2 * highDischargeRate = 30\ ] \sqsubseteq LargeBatteryDrone$

Evonne


evonne
Project ID:
Pizza Example
Ontology Axiom
SpicyIceCream ≡ (∃hasSpiciness.Hot ⊓ IceCream)
Equivalent Classes Decomposition
Intersection Decomposition
SpicyIceCream ⊑ (∃hasSpiciness.Hot ⊓ IceCream)
(∃hasSpiciness.Hot ⊓ IceCream) ⊑ IceCream
Concept Hierarchy
Ontology Axiom
Top Superclass
SpicyIceCream ⊑ IceCream
IceCream ⊑ ∃hasTopping.FruitTopping
FruitTopping ⊑ ⊤
Concept Hierarchy
Existential Filler Expansion
Ontology Axiom
Ontology Axiom
SpicyIceCream ⊑ ∃hasTopping.FruitTopping
∃hasTopping.FruitTopping ⊑ ∃hasTopping.⊤
domain(hasTopping) ≡ Pizza
SpicyIceCream ≡ (∃hasSpiciness.Hot ⊓ IceCream)
Concept Hierarchy
Property Domain Translation
Equivalent Classes Decomposition
Intersection Decomposition
SpicyIceCream ⊑ ∃hasTopping.⊤
∃hasTopping.⊤ ⊑ Pizza
SpicyIceCream ⊑ (∃hasSpiciness.Hot ⊓ IceCream)
(∃hasSpiciness.Hot ⊓ IceCream) ⊑ IceCream
Concept Hierarchy
Concept Hierarchy
Ontology Axiom
SpicyIceCream ⊑ Pizza
SpicyIceCream ⊑ IceCream
disjoint(PizzaBase, PizzaTopping, IceCream, Pizza)
Intersection Composition
Disjoint Classes Translation
SpicyIceCream ⊑ (IceCream ⊓ Pizza)
(IceCream ⊓ Pizza) ⊑ ⊥
Concept Hierarchy
SpicyIceCream ⊑ ⊥

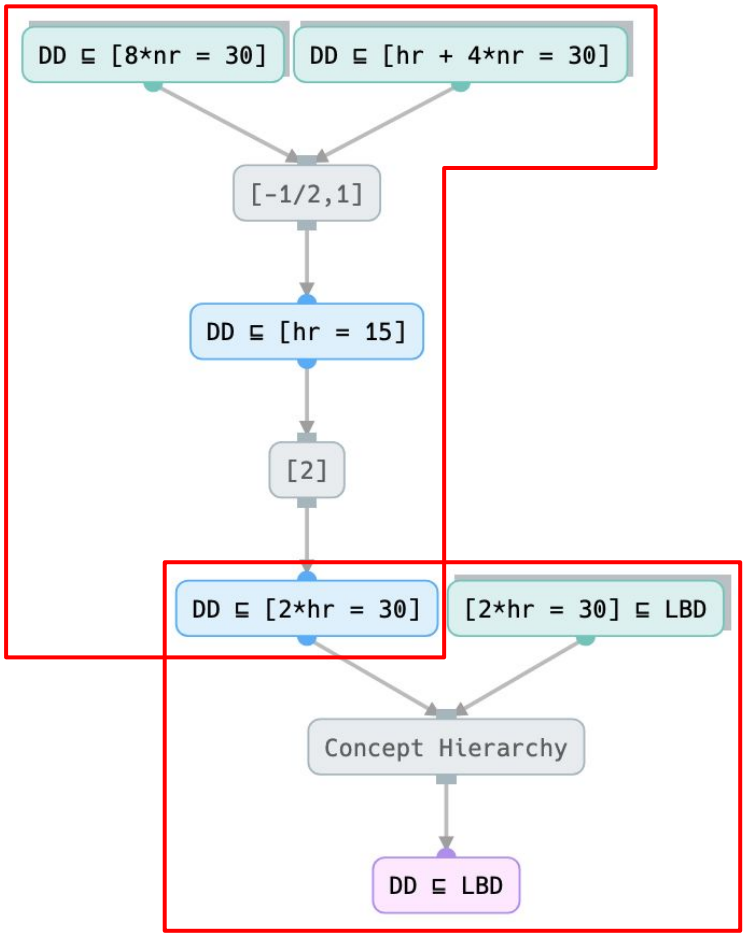
$EL_\bot[D_{\mathbb{Q},lin}]$ Explanations

$DD \sqsubseteq [\ 8 * nr = 30\ ]$

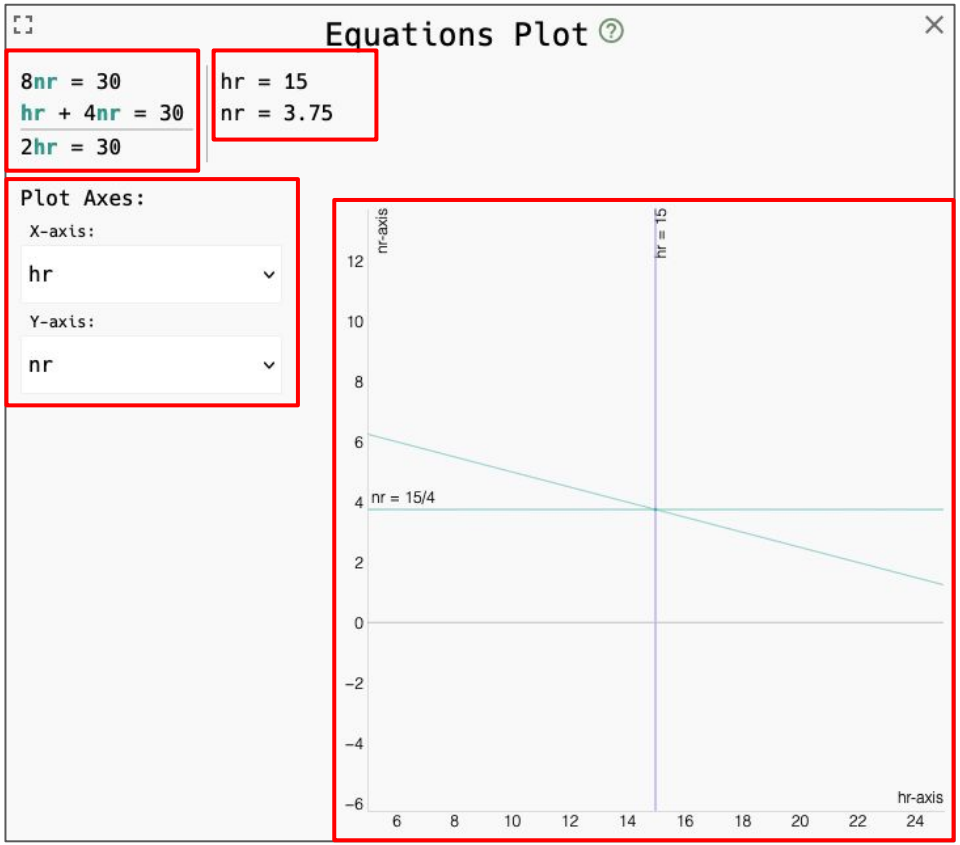
$DD \sqsubseteq [\ hr + 4 * nr = 30\ ]$

$[\ 2 * hr = 30\ ] \sqsubseteq LBD$

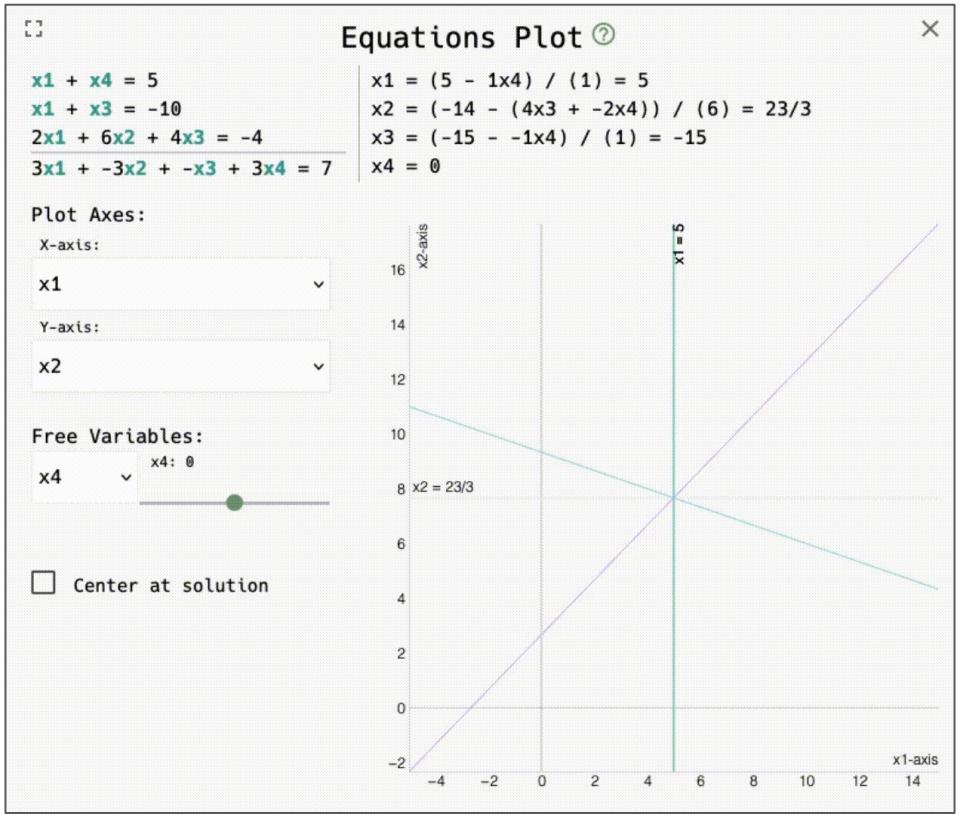
$DD \sqsubseteq LBD$



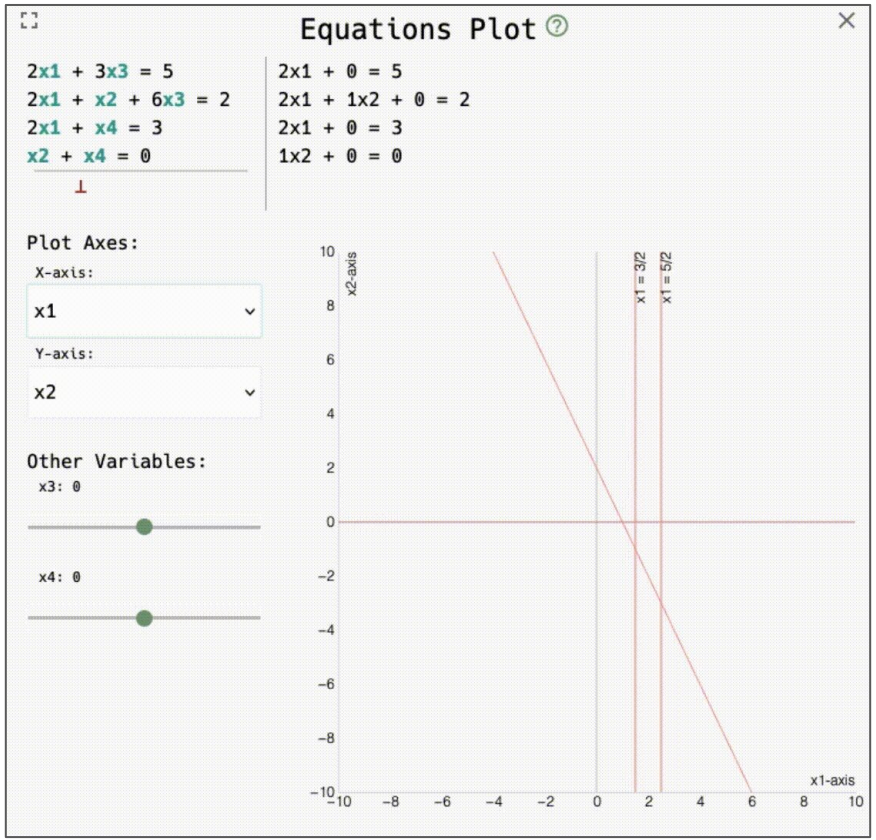
$EL_{\perp}[D_{\mathbb{Q},lin}]$ Explanations



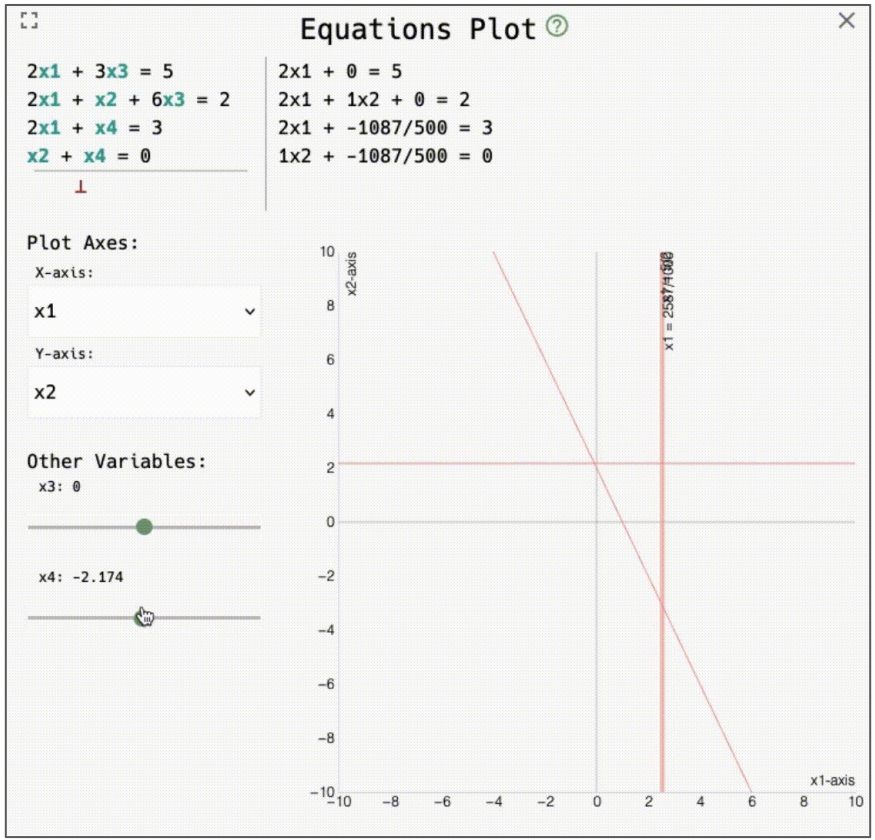
$EL_{\perp}[D_{\mathbb{Q}lin}]$ Explanations



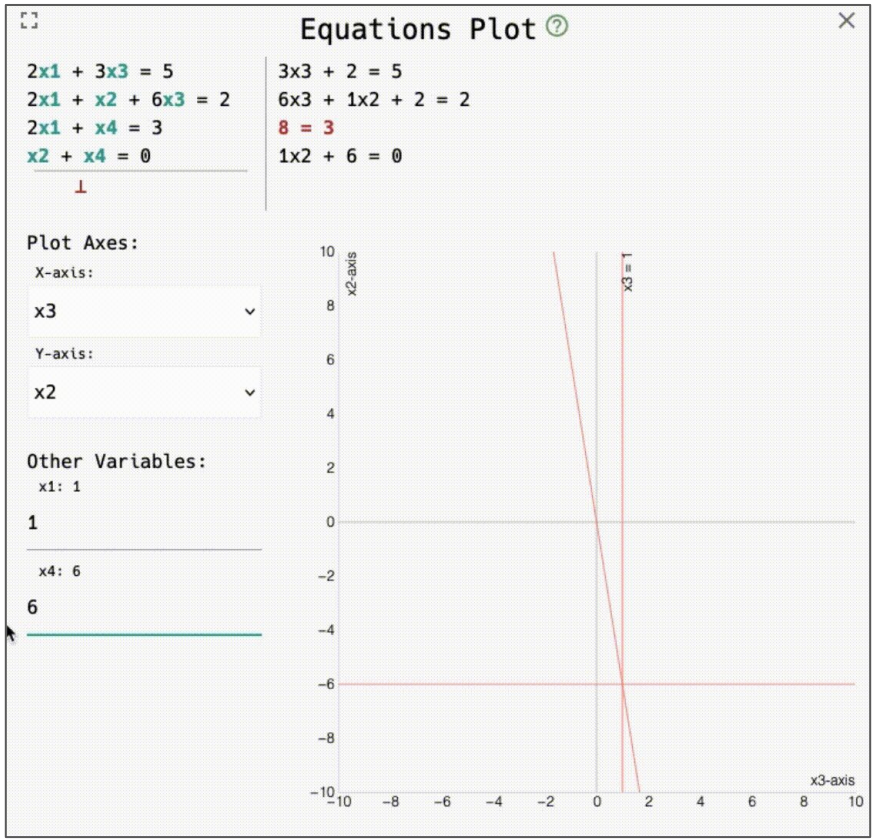
$EL_{\perp}[D_{\mathbb{Q},lin}]$ Explanations



$EL_{\perp}[D_{\mathbb{Q},lin}]$ Explanations



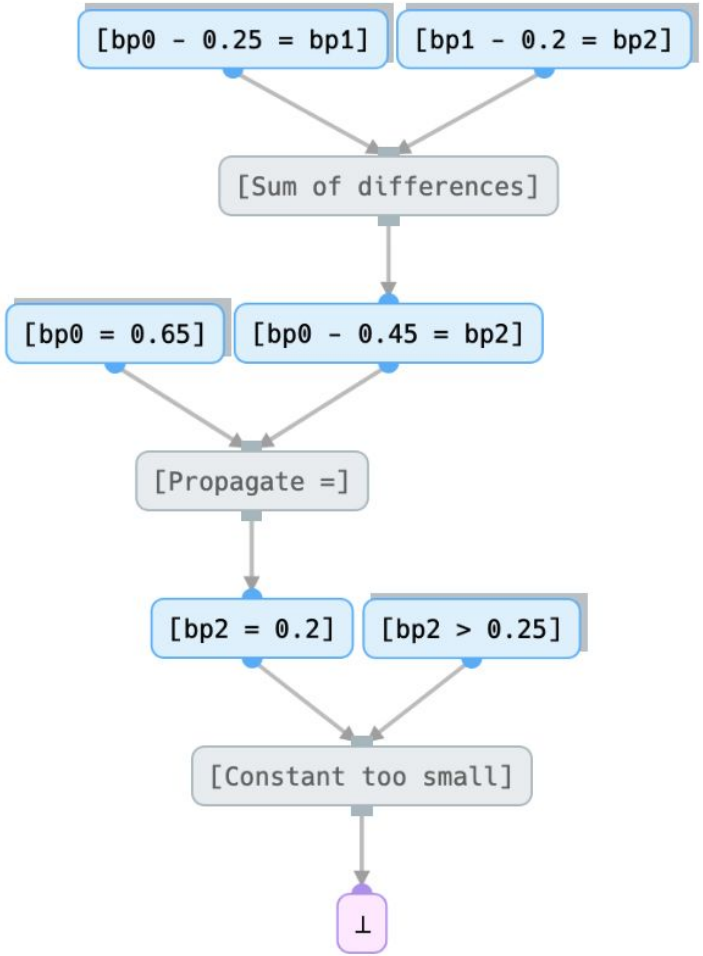
$EL_{\perp}[D_{\mathbb{Q},lin}]$ Explanations



$EL_{\perp}[D_{\mathbb{Q},diff}]$ Explanations

$[\, bp_0 - 0.25 = bp_1 \,]$ $[\, bp_1 - 0.2 = bp_2 \,]$

$[\, bp_2 > 0.25 \,]$ $[\, bp_0 = 0.65 \,]$



Saturation Rules

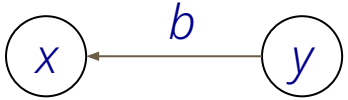
$$\frac{x = q \quad x = p}{\perp}\, R_{\neq} : q \neq p \qquad \frac{x + q = y \quad y + p = z}{x + (q + p) = z}\, R_{+} \qquad \frac{}{x + 0 = x}\, R_0$$

$$\frac{x + q = y \quad x + p = y}{\perp}\, R^{+}_{\neq} : q \neq p \qquad \frac{x = q \quad y = p}{x + (p - q) = y}\, R_{-} \qquad \frac{x + q = y}{y + (-q) = x}\, R_{\leftrightarrow}$$

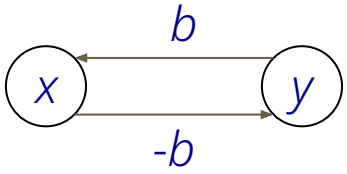
$$\frac{x = q \quad x > p}{\perp}\, R_{<} : q < p \qquad \frac{x = q \quad x + p = y}{y = q + p}\, R_{=} \qquad \frac{x > q \quad x + p = y}{y > q + p}\, R_{>}$$

$EL_{\perp}[D_{\mathbb{Q},diff}]$ Explanations

$x - y \leq b$



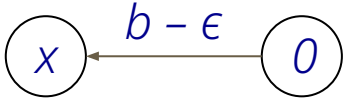
$x - y = b$



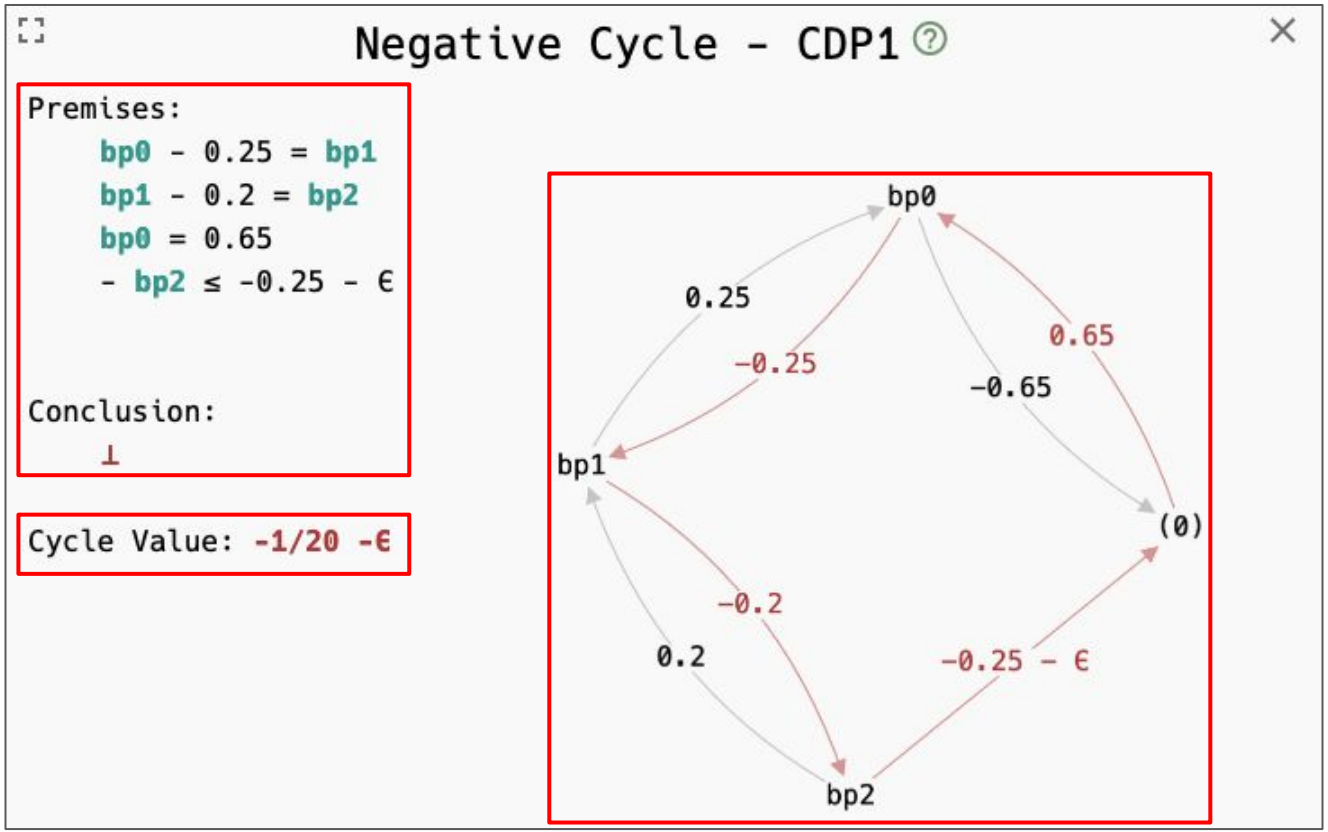
$x < b$

$x - (0) < b$

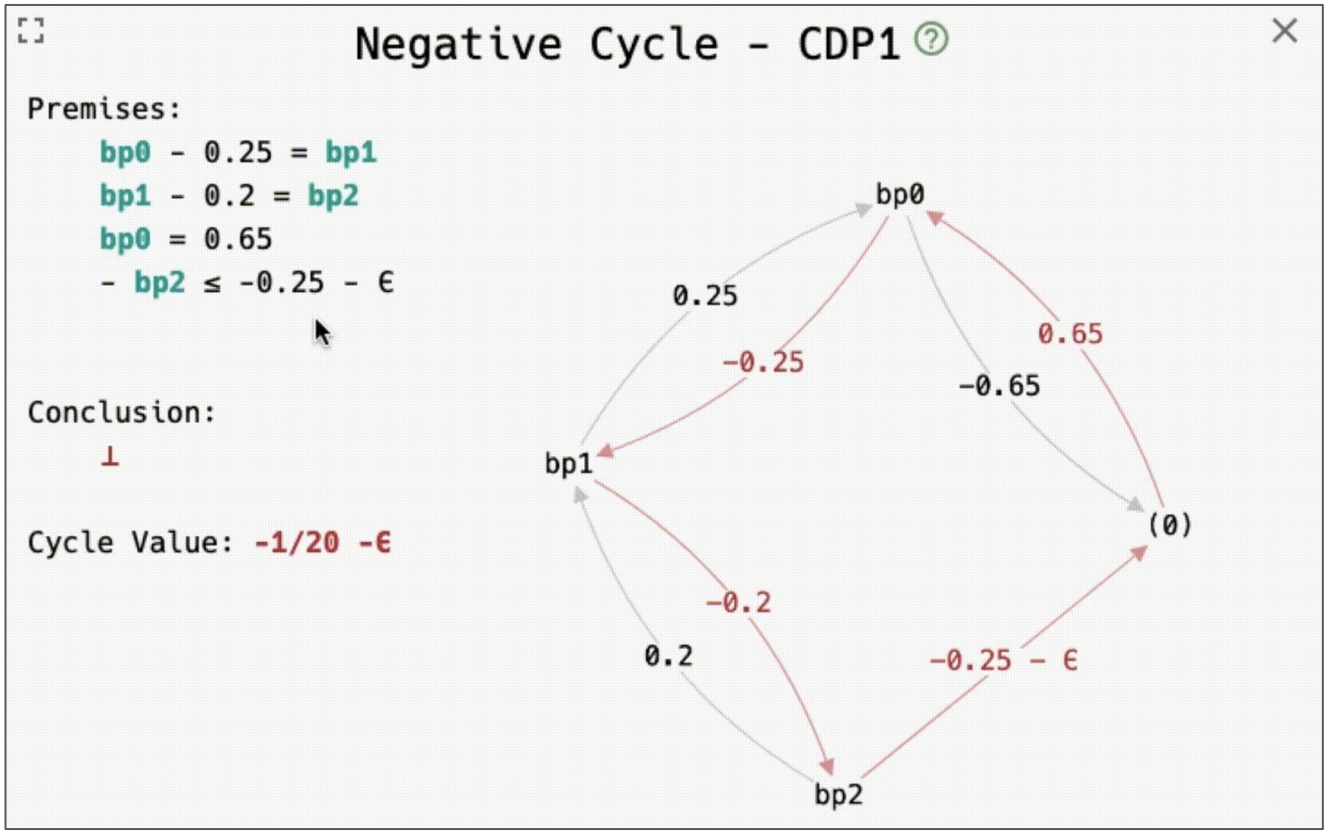
$x - (0) \leq b - \epsilon$



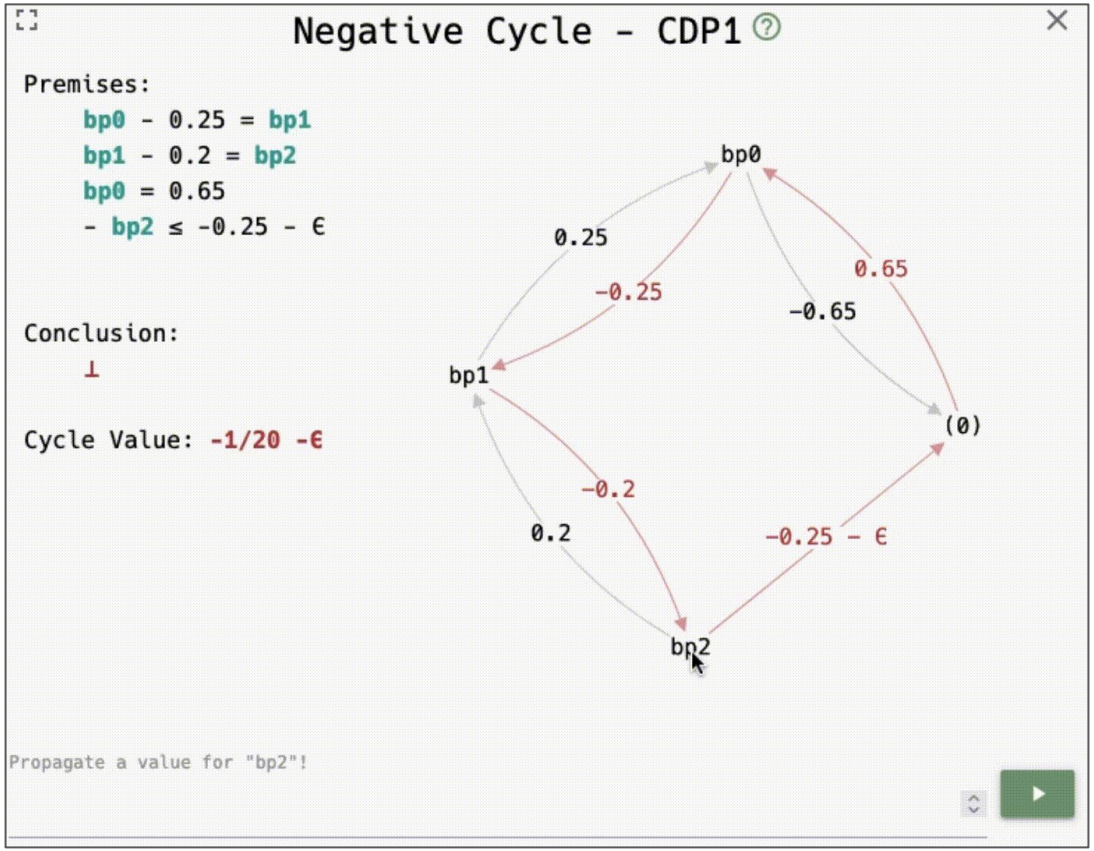
$EL_{\perp}[D_{\mathbb{Q},diff}]$ Explanations



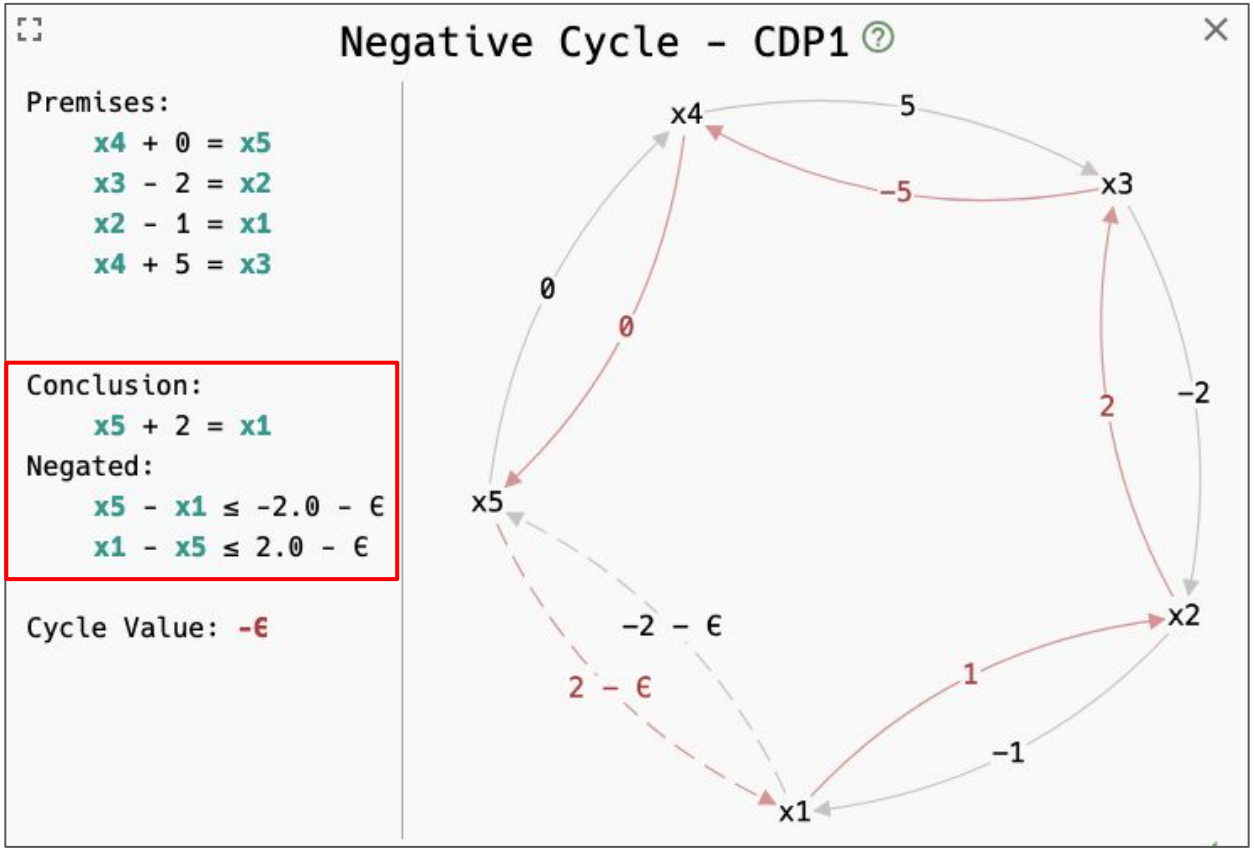
$EL_{\bot}[D_{\mathbb{Q},diff}]$ Explanations



$EL_{\bot}[D_{\mathbb{Q},diff}]$ Explanations



$EL_{\perp}[D_{\mathbb{Q},diff}]$ Explanations



Evaluation

- Performance benchmark
  - ~100 proofs
- Two qualitative user studies
- Proofs vs alternative CD explanations
- 11 participants
- Results:
  - Visual explanations enhance understanding of numerical reasoning
  - Plots were preferred in the simple cases
  - Cycles were preferred over proofs

Summary & Future Work

- Extend Evonne with $EL_{\bot}[D_{\mathbb{Q},diff}]$ & $EL_{\bot}[D_{\mathbb{Q},lin}]$ Proofs
- Alternative visual Explanations
  - Negative cycles
  - Equations plots
- Evaluation
  - Qualitative user studies
  - Performance benchmark

- Address issues from participants
- Explanation of CD non-entailments

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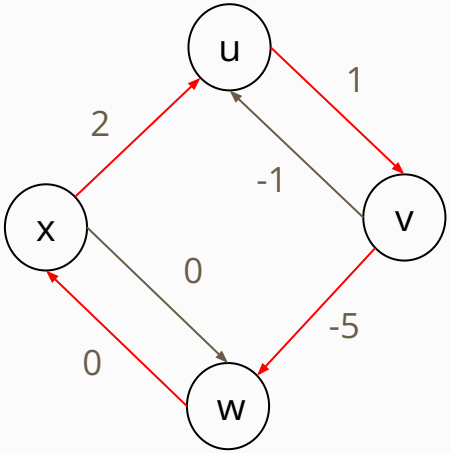
$$\begin{cases} w - v \leq -5 \\ x - w \leq 0 \\ u - x \leq 2 \\ v - u \leq 1 \end{cases} \rightarrow \bot$$

$0 \leq -2$



Weight = -2