

Chronosymbolic Learning

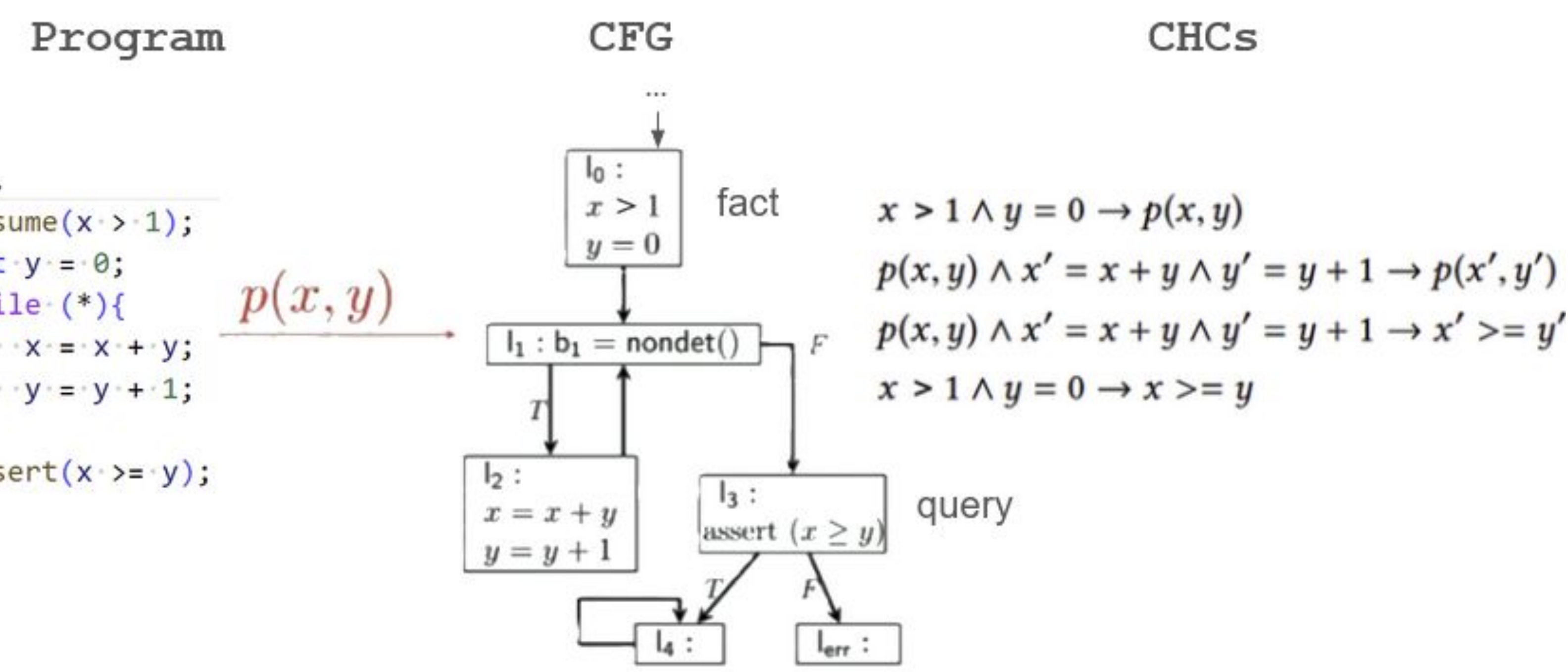
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BACKGROUND

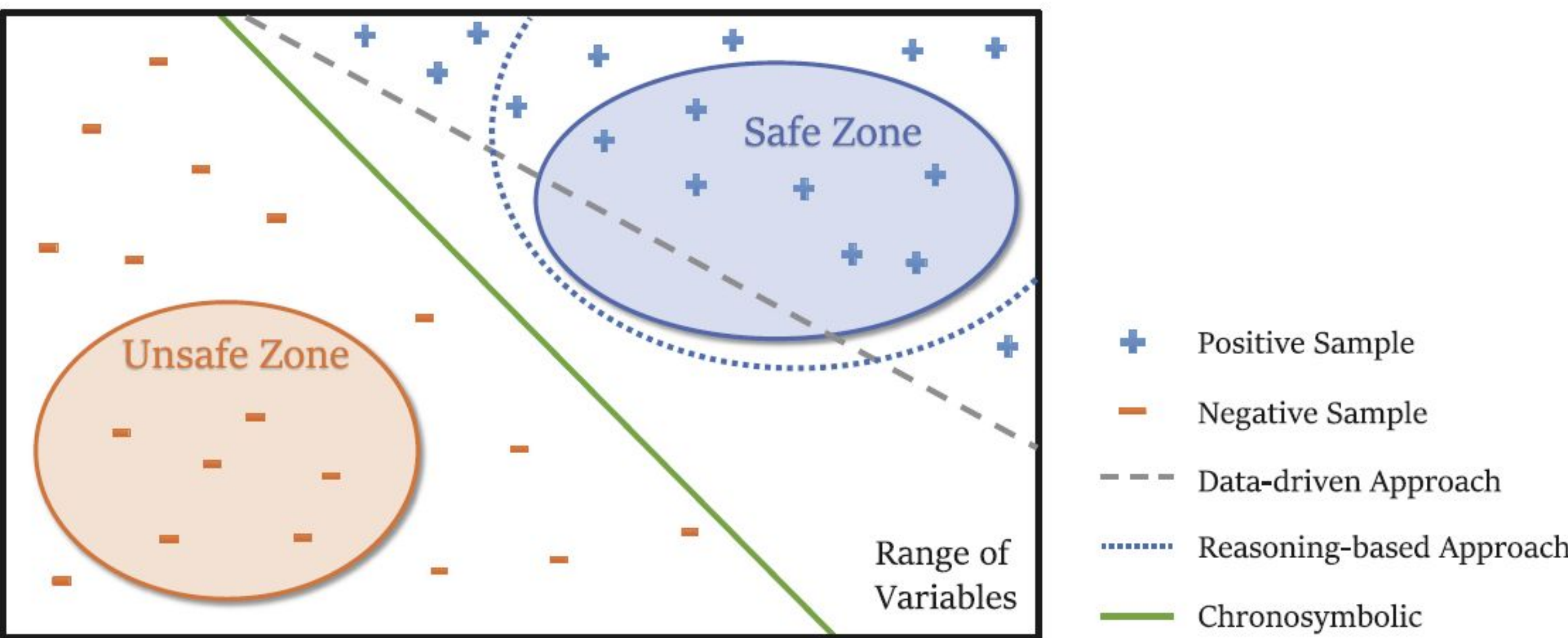
- Program verification => CHC solving (a fragment of FOL)
- Black-box data-driven methods are sample-inefficient and agnostic to the symbolic information within the CHCs
- White-box symbolic approaches struggles to identify essential patterns from data samples



CONTRIBUTION

- Design a modular framework, Chronosymbolic Learning, to efficiently leverage symbolic information (zones, representing a set of data samples) and data samples
- Propose a minimal instance (SVM+DT+BMC), exemplifying how components interact in our framework (artifact available)
- A new perspective of unifying approaches (see paper for more)
- Promising experimental result though simplistic instantiation

Overview of different approaches through the lens of learning from samples and zones.



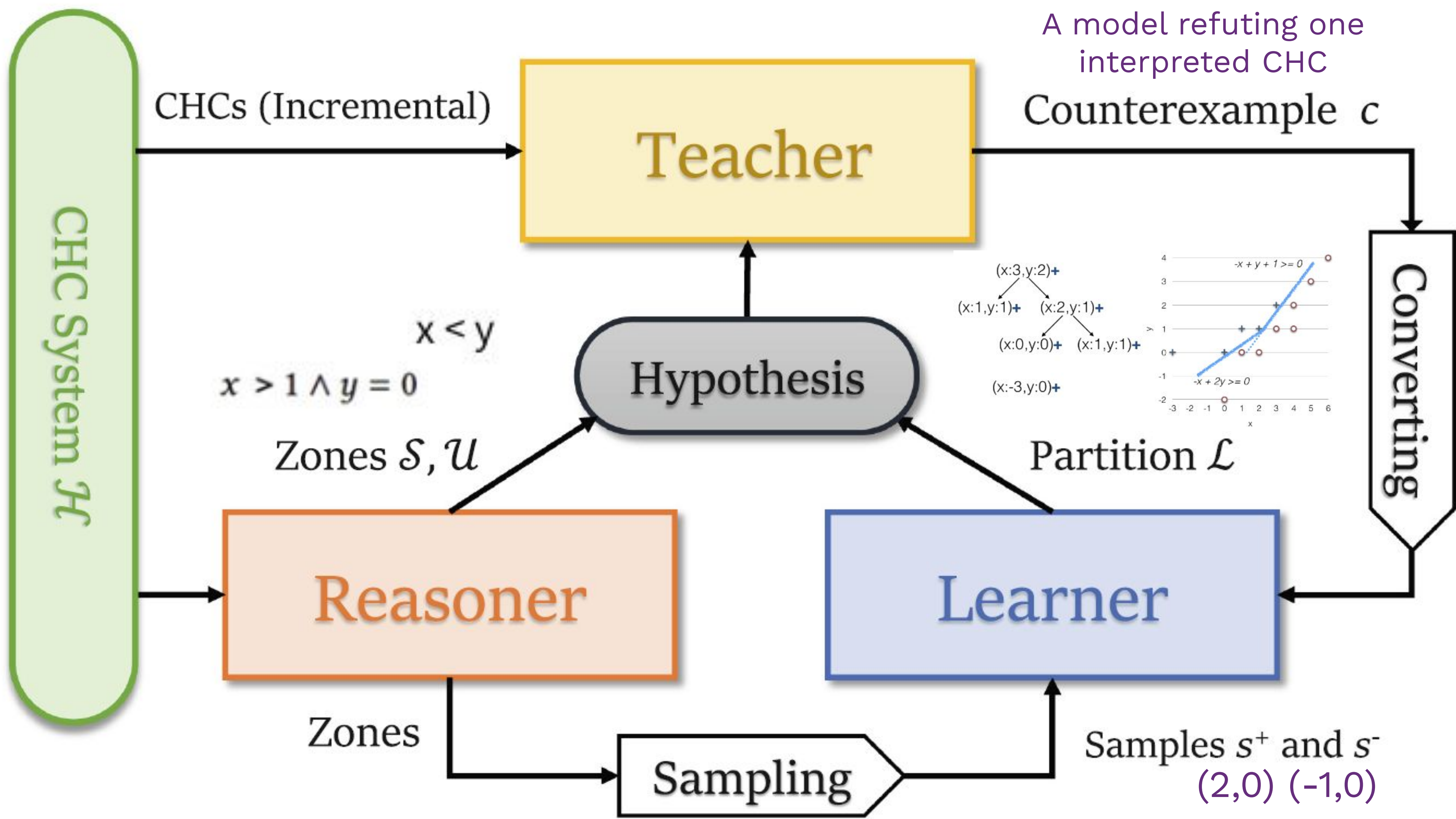
“CHRONOSYMBOLIC”:

Constrained Horn Clause

Efficient CHC solver =

Symbolic Reasoner + Data-driven Learner

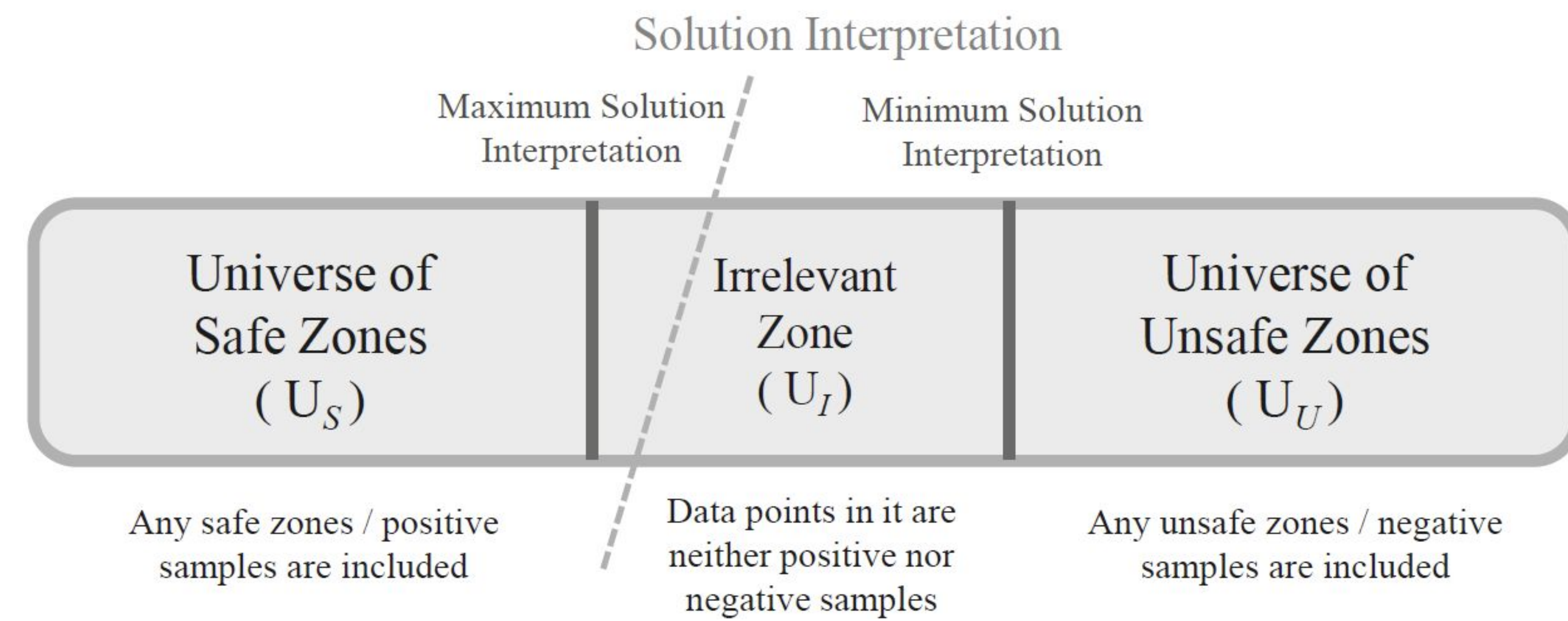
Zones Synchronously Samples



INSTANCES

Methods	Candidate Hypothesis
BMC-styled	$\tilde{\mathcal{I}}_s[p_i] = \mathcal{S}_{p_i}$
LinearArbitrary-styled	$\tilde{\mathcal{I}}_l[p_i] = \mathcal{L}_{p_i}$
Chronosymbolic w/o safe zones	$\tilde{\mathcal{I}}_{lu}[p_i] = \mathcal{L}_{p_i} \wedge \neg \mathcal{U}_{p_i}$
Chronosymbolic w/o unsafe zones	$\tilde{\mathcal{I}}_{sl}[p_i] = \mathcal{S}_{p_i} \vee \mathcal{L}_{p_i}$
Chronosymbolic	$\tilde{\mathcal{I}}_{slu}[p_i] = \mathcal{S}_{p_i} \vee (\mathcal{L}_{p_i} \wedge \neg \mathcal{U}_{p_i})$

SOLUTION SPACE



MAIN RESULT

- 288 arithmetic instances collected by FreqHorn
- Timeout = 360s
- Chronosymbolic-single: one config for all instances
- Chronosymbolic-cover: for each instance, best result over 13 configs
- parallel: learner and reasoner running individually and simultaneously for 360s

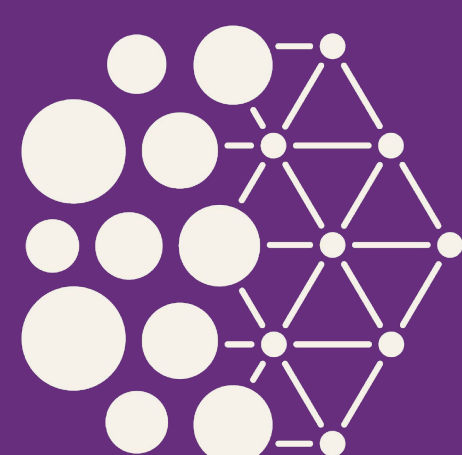
Method	#total	percentage	#safe	#unsafe
LinearArbitrary	187	64.93%	148	39
FreqHorn	191	66.32%	191	0
FreqHorn-expl	50	17.36%	0	50
Spacer	184	63.89%	132	52
GSpacer	220	76.39%	174	46
Chronosymbolic-single	237	82.29%	189	48
Chronosymbolic-cover	252	87.50%	204	48

Configuration	#total	percentage	#safe	#unsafe
without safe zones	228	79.17%	183	45
without unsafe zones	218	75.69%	173	45
without both zones	211	73.26%	166	45
without learner	131	45.49%	96	35
parallel	216	75.00%	180	36
Chronosymbolic-single	237	82.29%	189	48

Paper:



Github:
(with running examples)



Mila



McGill



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TORONTO