

# *Research in Our Lab*

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## Main Research Topics

Mostly SMT and related problems

- AllSMT (Enumerating all truth assignments of an SMT formula)
- Weighted Model Integration (Probabilistic inference for SMT formulas)
- Knowledge Compilation (Compiling SMT formulas into tractable representations)
- OMT (Optimization Modulo Theories)
- ... and more!

## *AIISMT for Probabilistic Inference: Weighted Model Integration (WMI)*<sup>1,2</sup>

Let a SMT( $\mathcal{LRA}$ ) formula  $\varphi$  and a density  $p(\mathbf{x})$  :  $WMI(\varphi, p) = \int_{\varphi} p(\mathbf{x})d\mathbf{x} \propto \Pr(\varphi, p)$

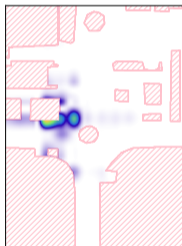
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<sup>1</sup> G. Spallitta, G. Masina, P. Morettin, A. Passerini, and R. Sebastiani (2022). *SMT-based Weighted Model Integration with Structure Awareness*. In: *UAI 2022*

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(a)  $\varphi(\mathbf{x})$  and  $p(\mathbf{x})$

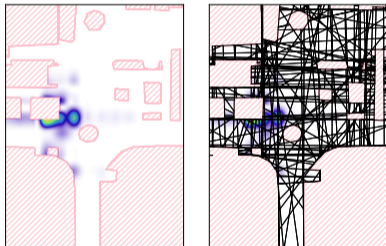
$$\int_{\varphi} p(\mathbf{x})d\mathbf{x}$$

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(a)  $\varphi(\mathbf{x})$  and  $p(\mathbf{x})$  (b) 2821 regions

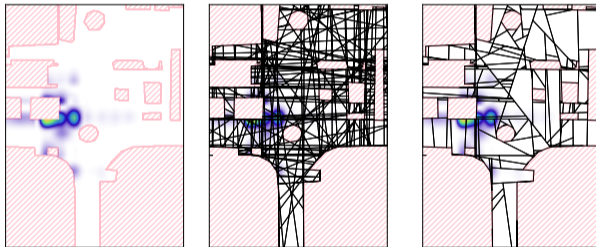
$\int_{\varphi} p(\mathbf{x})d\mathbf{x} \rightarrow$  decomposed in convex regions  $\sum_{\mu \in \text{AIISMT}(\varphi)} \int_{\mu} p(\mathbf{x})d\mathbf{x}$

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## Knowledge Compilation Modulo Theories: Canonical Decision Diagrams<sup>3</sup>

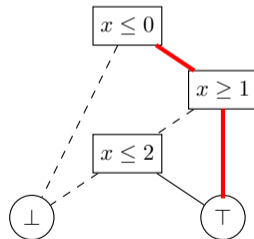
### Decision Diagrams

- OBDDs and SDDs allow for efficient reasoning on propositional formulas
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(a)  $\mathcal{T}$ -OBDD( $\varphi$ )

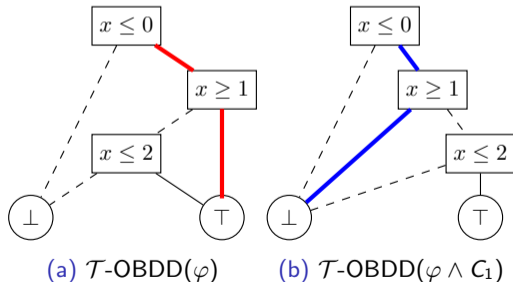
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## Idea

- Enumerate via AllSMT a set of  $\mathcal{T}$ -lemmas  $\{C_i\}_i$  ruling out  $\mathcal{T}$ -inconsistent assignments
- Compile  $\varphi \wedge \bigwedge_i C_i$
- $\mathcal{T}$ -OBDDs and  $\mathcal{T}$ -SDDs are canonical!



## KC Modulo Theories: Efficient $\mathcal{T}$ -Lemma Enumeration<sup>4</sup> & $d$ -DNNFs<sup>5</sup>

### Efficient $\mathcal{T}$ -lemma enumeration

- We can use AllSMT to enumerate  $\mathcal{T}$ -lemmas  $C_i$  in a theory-agnostic way
- Propose advanced AllSMT techniques to scale beyond naive AllSMT (divide&conquer, projection, partitioning)

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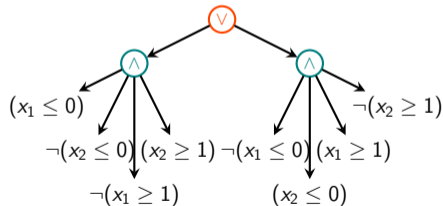
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## d-DNNFs Modulo Theories

- Extend  $\mathcal{T}$ -DDs work to general  $\mathcal{T}$ -d-DNNFs
- Queries are polytime on  $\mathcal{T}$ -d-DNNFs! ( $\mathcal{T}$ -SAT, clausal entailment, counting/enumerating  $\mathcal{T}$ -SAT truth assignments, ...)



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## Knowledge Compilation Modulo Theories for WMI

### Goal

- Use  $\mathcal{T}$ -d-DNNFs for enumerating truth assignments (convex polytopes)
- Sum up the integrals to compute WMI as  $\sum_{\mu \in \text{AllSMT}(\varphi)} \int_{\mu} p(\mathbf{x}) d\mathbf{x}$

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### Takeaways

- $\mathcal{T}$ -reduced d-DNNFs *are not* very suitable for enumerating few, short assignments
- Nice insights and ideas on SMT enumeration with  $\mathcal{T}$ -d-DNNFs

## *OMT( $\mathcal{NRA}$ ) and OMT( $\mathcal{NTA}$ ) via Logic-To-Optimization*

- $\mathcal{NRA}$ : Quantifier-free theory of Nonlinear Arithmetic over the Reals
- $\mathcal{NTA}$ :  $\mathcal{NRA}$  augmented with exponential and trigonometric functions

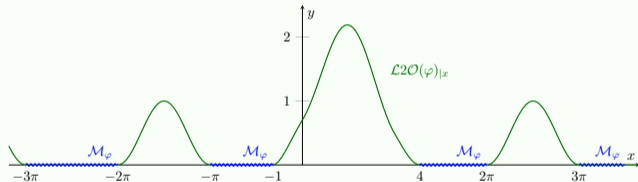
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### $\mathcal{L2O}$ for SMT

$$\varphi \stackrel{\text{def}}{=} \sin(x) \leq 0 \wedge$$

$$(-e^{-x-1} + 1 \leq 0 \vee -\arctan(x - 4) \leq 0)$$

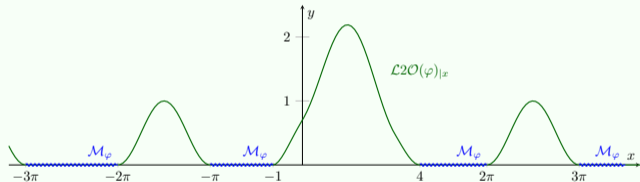


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### Extend Logic-To-Optimization to OMT

- Combine  $\mathcal{L2O}$  with the objective
- Use numerical optimizers to find candidate solutions
- Use SMT solvers to check

## Bibliography I

-  Civini, E., G. Masina, G. Spallitta, and R. Sebastiani (2026). *Beyond Eager Encodings: A Theory-Agnostic Approach to Theory-Lemma Enumeration in SMT*. In: *IJCAR 2026*. Also arXiv preprint [arXiv.2602.14634](https://arxiv.org/abs/2602.14634).
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-  Spallitta, G., G. Masina, P. Morettin, A. Passerini, and R. Sebastiani (2024). *Enhancing SMT-based Weighted Model Integration by Structure Awareness*. In: *Artif Intell 328*, p. 104067.