KU LEUVEN

DeepProbLog: Neural Probabilistic Logic Programming

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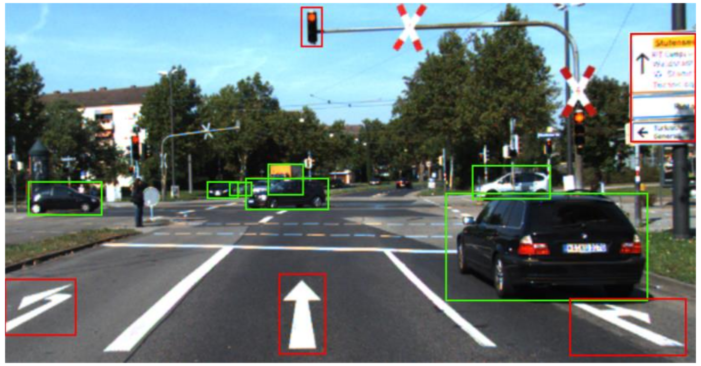
Real-life problems involve two important aspects.

Sub-symbolic perception



Deep Learning

Reasoning with knowledge under uncertainty

Stop in front of a red light Obey the speed limit Be in the correct lane …	P(light = red) = 0.9 P(obj1 = car) = 0.8 P(obj1 turn right) = 0.7

Probabilistic logic program

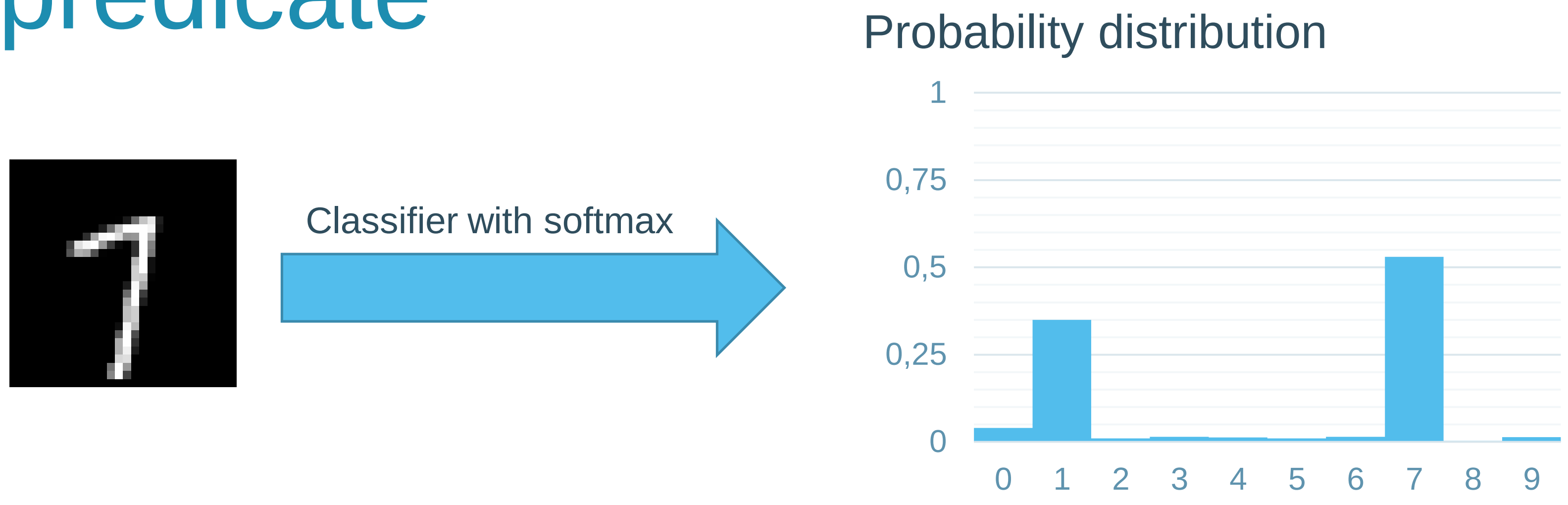
ProbLog

DeepProbLog

= ProbLog + neural predicate

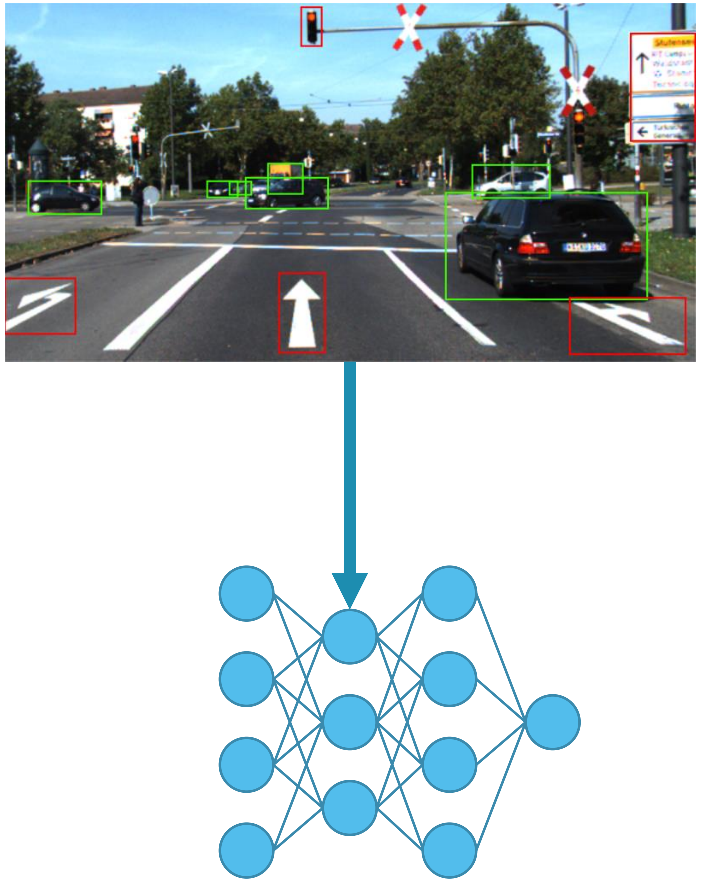
Geiger, Andreas, et al. "Vision meets robotics: The KITTI dataset." The International Journal of Robotics Research (2013)

The neural predicate

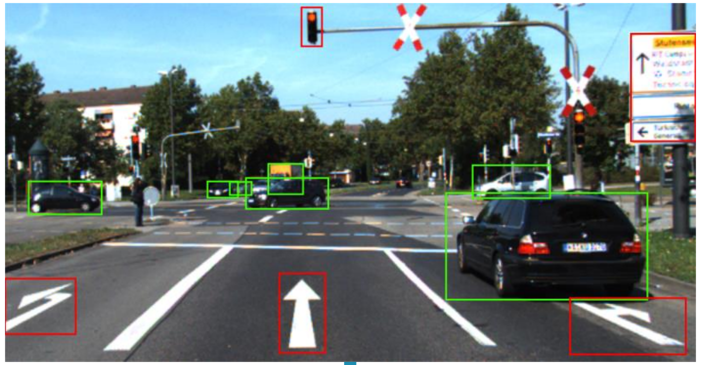


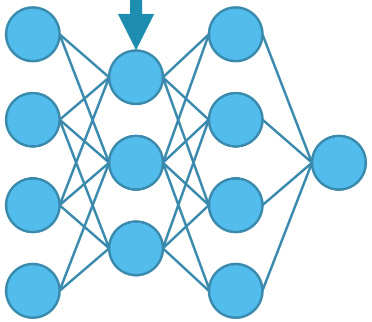
- Classifier defines a probability distribution over its output
- Uncertainty in the prediction
- Neural predicate: output = probabilistic choices in program
- No changes needed in the ProbLog inference or its semantics
- ProbLog can natively calculate the gradient

Perception



Perception





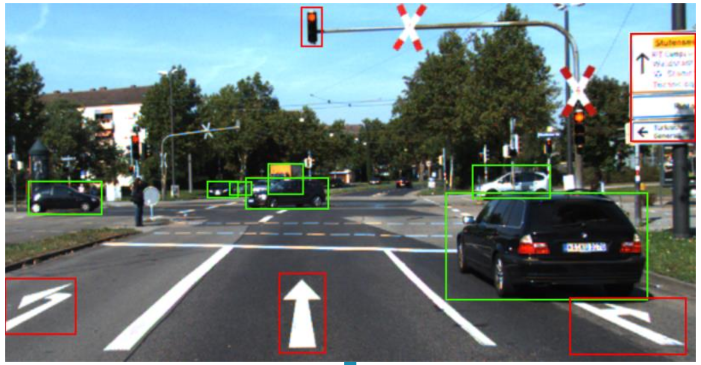
Reasoning

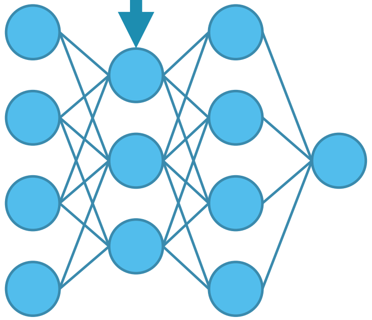
Stop in front of a red light
Obey the speed limit
Be in the correct lane
P(light = red) = 0.9

ProbLog

Perception

Reasoning





P(obj1 = car) = 0.8
P(obj1 turn right) = 0.7

Neural predicate

Stop in front of a red light
Obey the speed limit
Be in the correct lane
P(light = red) = 0.9

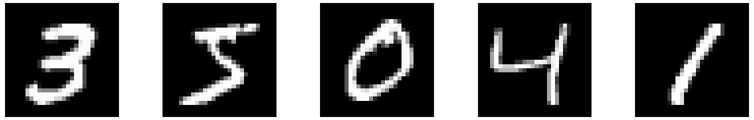
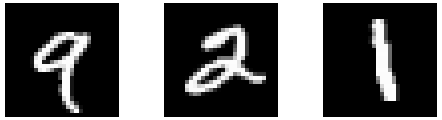
ProbLog

Related work

Related work	DeepProbLog
Logic is made less expressive	Full expressivity is retained
Logic is pushed into the neural part	Clean separation
Fuzzy logic	Probabilistic logic
Language semantics is unclear	Clear semantics

- Neural-symbolic integration (Garcez)
- Logical constraints as a regularizer (Xu, Diligenti, …)
- Differentiable logical framework (Rocktäschel and Riedel, Evans and Grefenstette)
- Differentiable interpreters (Graves, Bosnjak)
- …

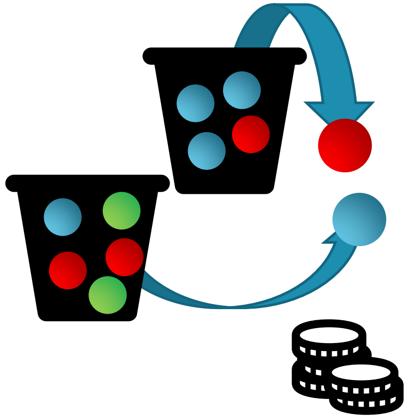
Example task: MNIST addition

 +  = ?

- Only labeled sums, not single digits
- Train using only neural networks? Not suited!
- DeepProbLog can solve this:
  - Neural predicate
    - From pixels to distribution over digits
    - NN trained from scratch
  - Logic:
    - Combine predictions into larger numbers
    - Perform addition

Combined reasoning

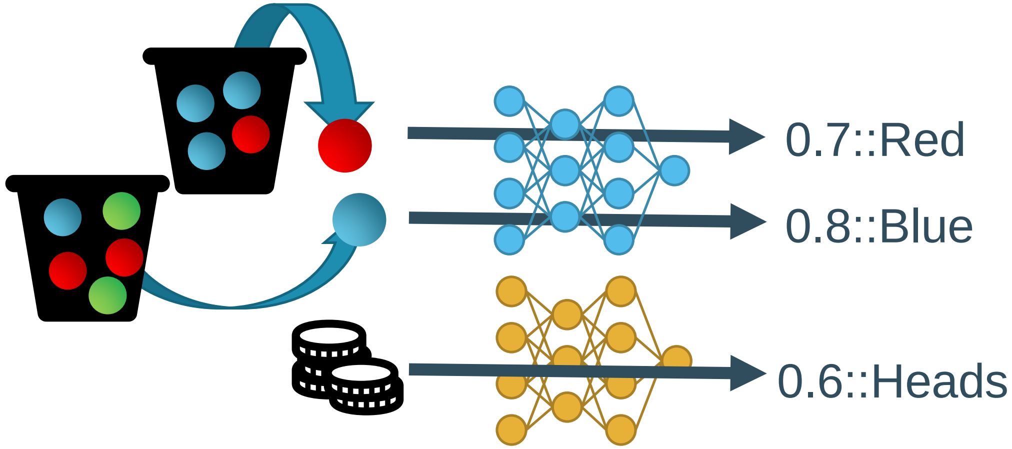
Unknown distribution



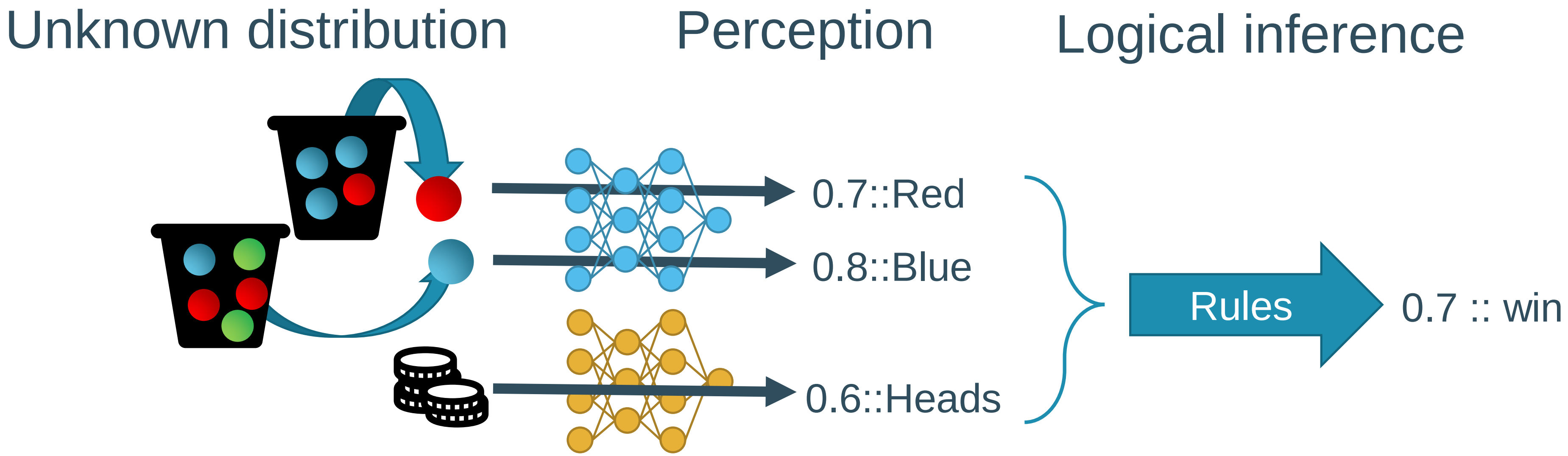
Combined reasoning

Unknown distribution

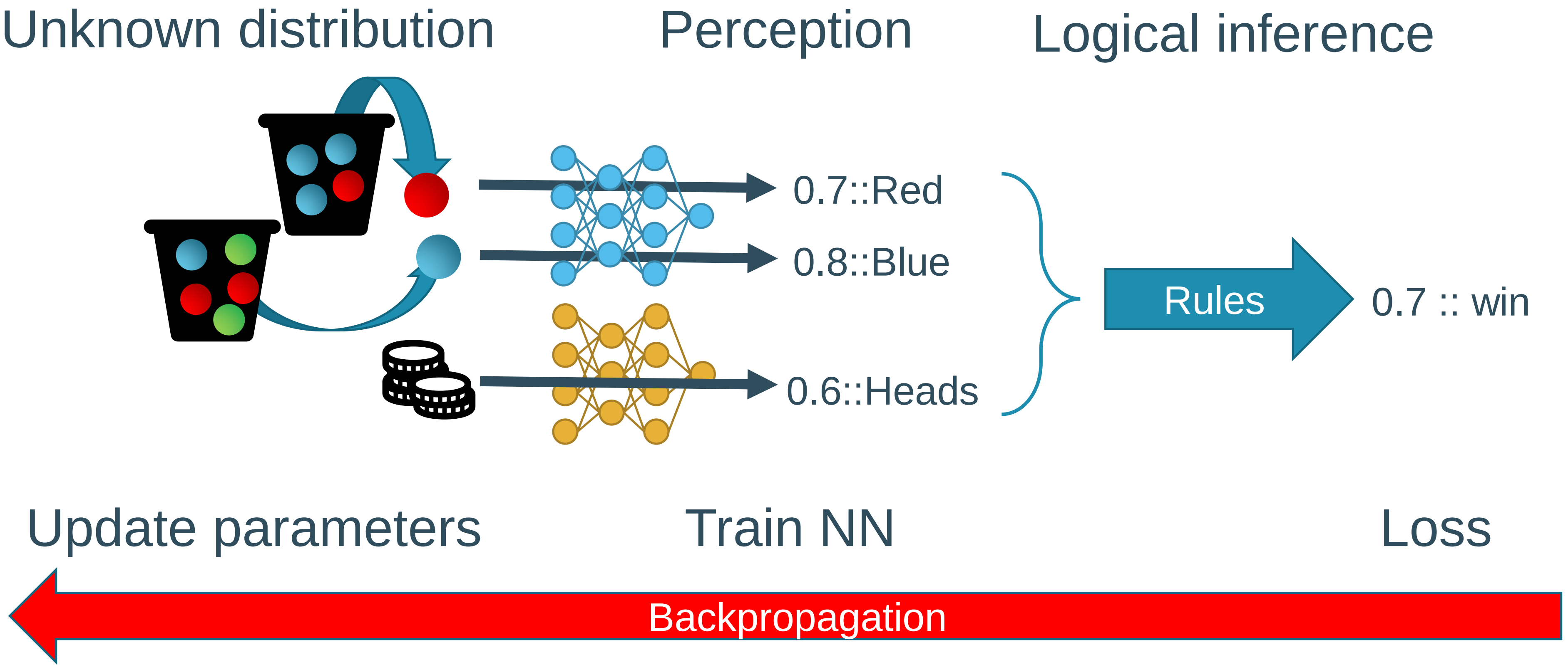
Perception



Combined reasoning

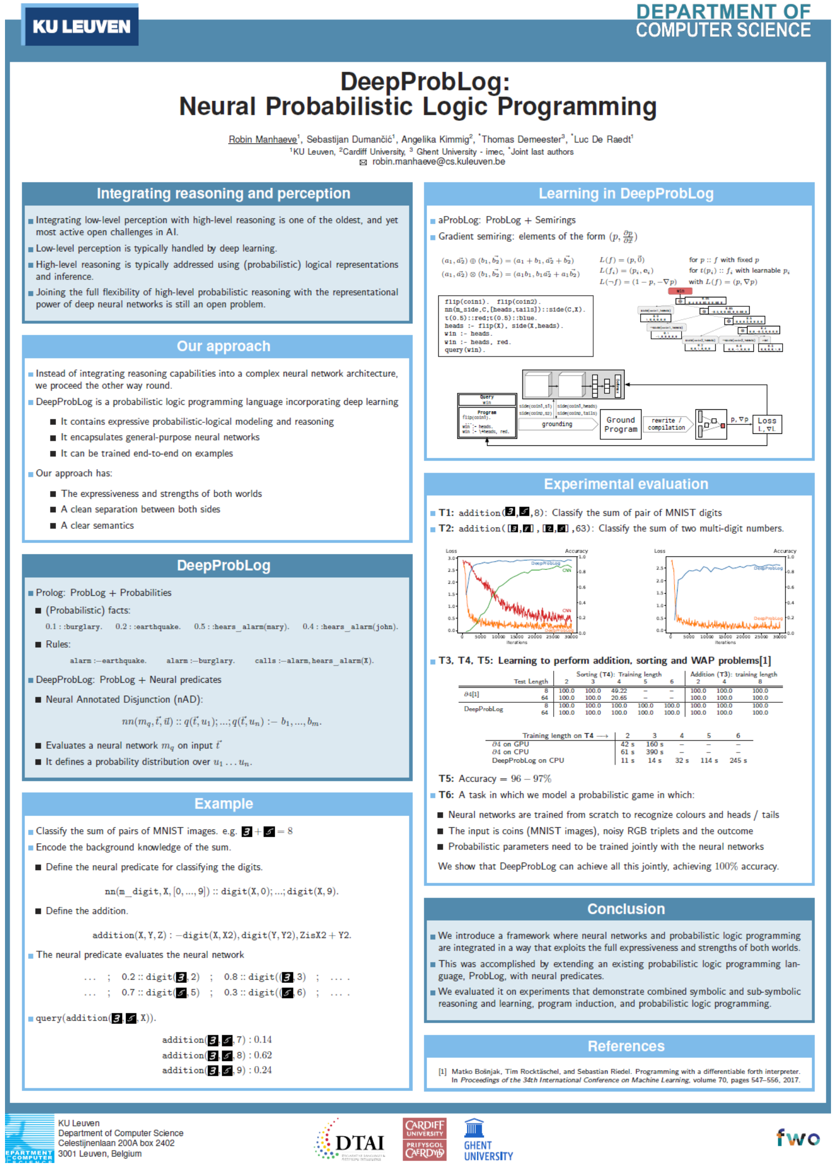


Combined reasoning



Conclusion

Poster #118



DeepProbLog: Neural Probabilistic Logic Programming

- Integration of DL and PLP
- Probabilistic
- Clean semantics, clear separation
- Retain power of both worlds
- Power of ProbLog

Code is available at:

https://bitbucket.org/problog/deepproblog