New foundations for probabilistic separation logic

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https://john-ml.github.io/lilac.pdf

How to modularly verify probabilistic programs?

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- How to perform verification and inference at scale?

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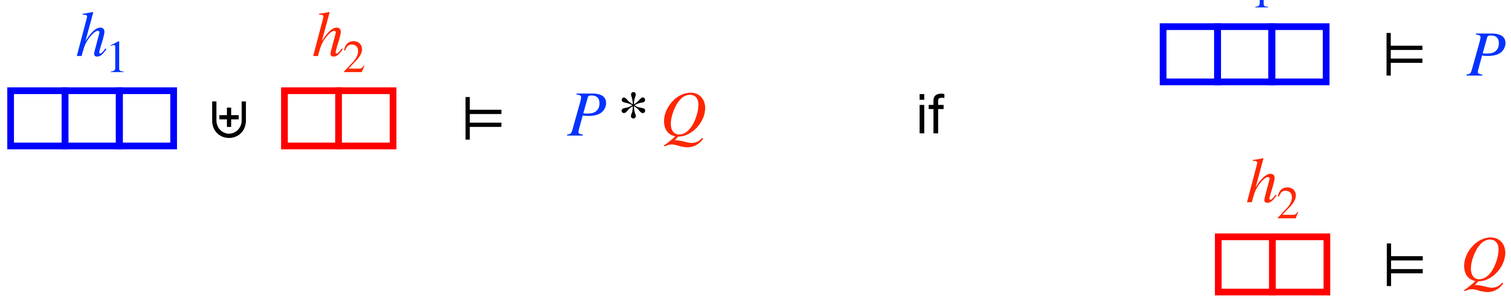

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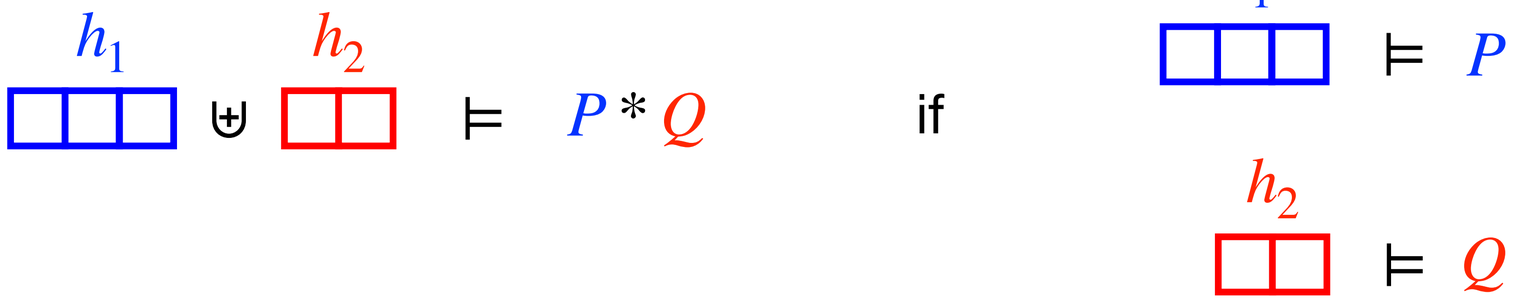

- Can we adapt this to probabilistic setting?

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Traditional heap-separation is not enough

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A Separation Logic for Concurrent Randomized Programs

JOSEPH TASSAROTTI, Carnegie Mellon University, USA
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Quantitative Separation Logic

A Logic for Reasoning about Probabilistic Pointer Programs

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- With randomness, there's a second resource to account for: probability.
- Heap-separation doesn't support modular reasoning about this resource.

Separation as statistical independence

Separation as statistical independence

A Probabilistic Separation Logic

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A Separation Logic for Negative Dependence

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A Bunched Logic for Conditional Independence

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- Propositions modeled by distributions on stores

A new notion of separation

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$$\mathscr{P}_1 \bullet \mathscr{P}_2 \models P * Q \quad \text{if} \quad \mathscr{P}_1 \models P \quad \mathscr{P}_2 \models Q$$

A new notion of separation

- Propositions modeled by *probability spaces*

$\mathscr{P}_1 \bullet \mathscr{P}_2 \models P * Q$ if

$\mathscr{P}_1 \models P$

$\mathscr{P}_2 \models Q$

"independent combination"

What does this buy us?

- Standard frame rule
- Continuous variables & equational reasoning
- Conditioning modality $\mathsf{D}_{x \leftarrow X}$
    - Conditional independence: $\mathsf{D}_{x \leftarrow X}(Y * Z)$
    - Other connectives also have intuitive "conditional" readings
- Verified challenging weighted sampling algorithm
- Full paper: https://john-ml.github.io/lilac.pdf