Fraunhofer IKS

Fraunhofer Institute for Cognitive Systems IKS

Context-aware, Autonomous and Smart Architecture Workshop, ECSA 2022
20th September 2022

Towards Uncertainty Reduction Tactics for Behavior Adaptation

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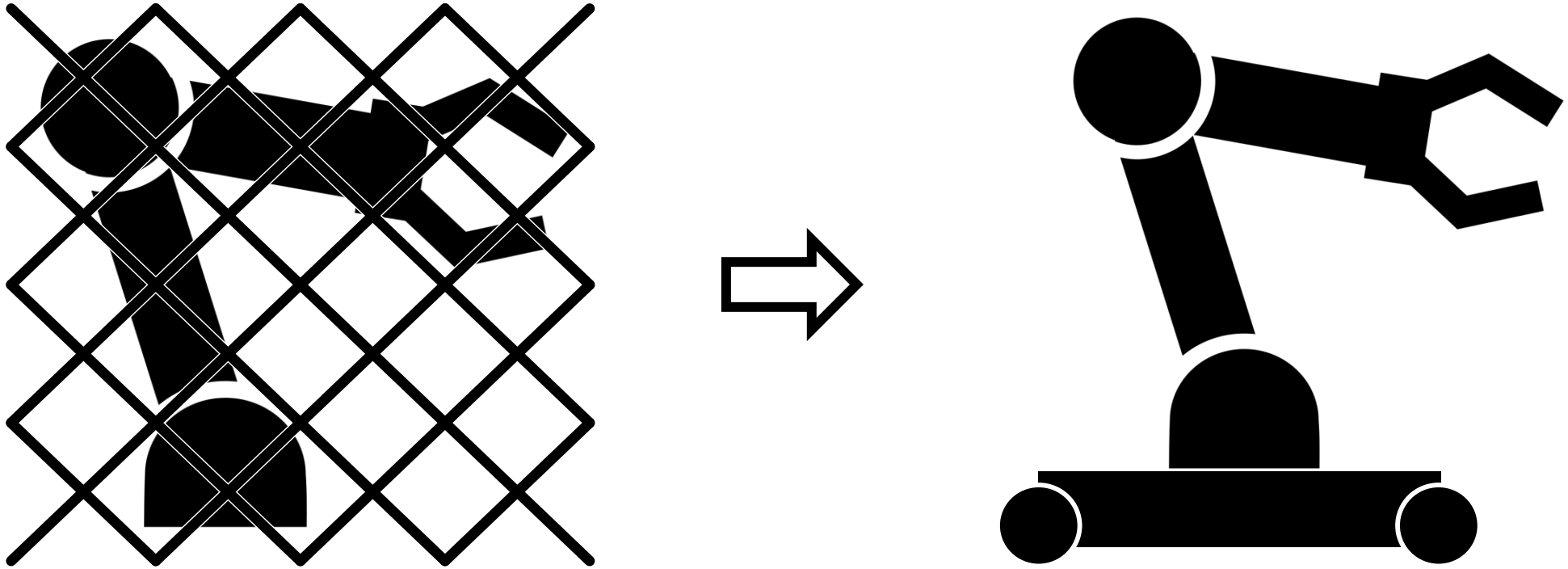
Motivation



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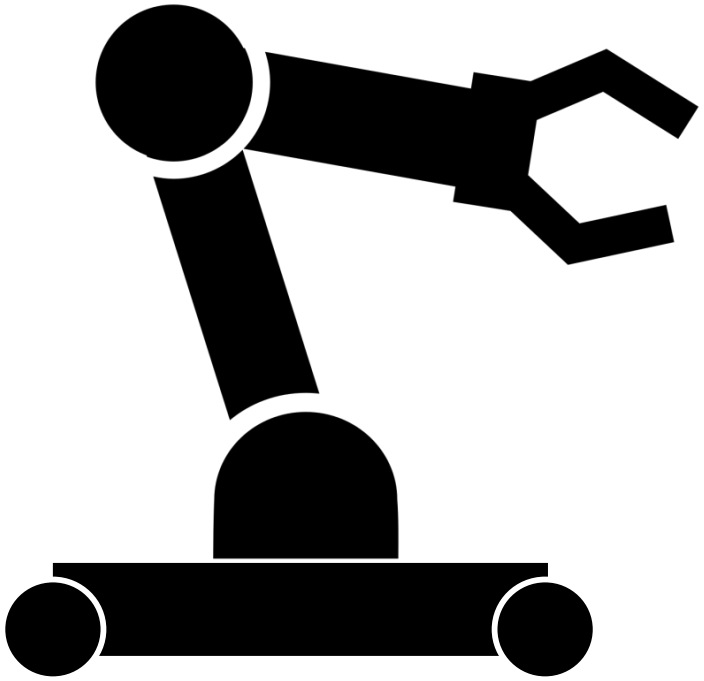
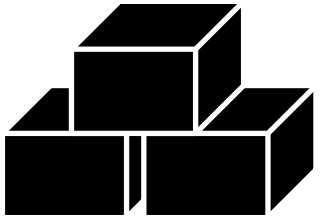
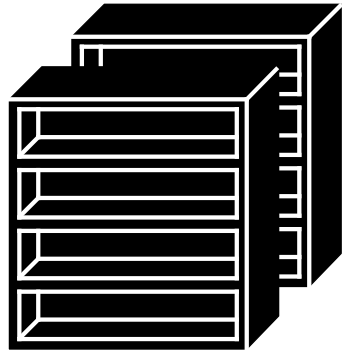
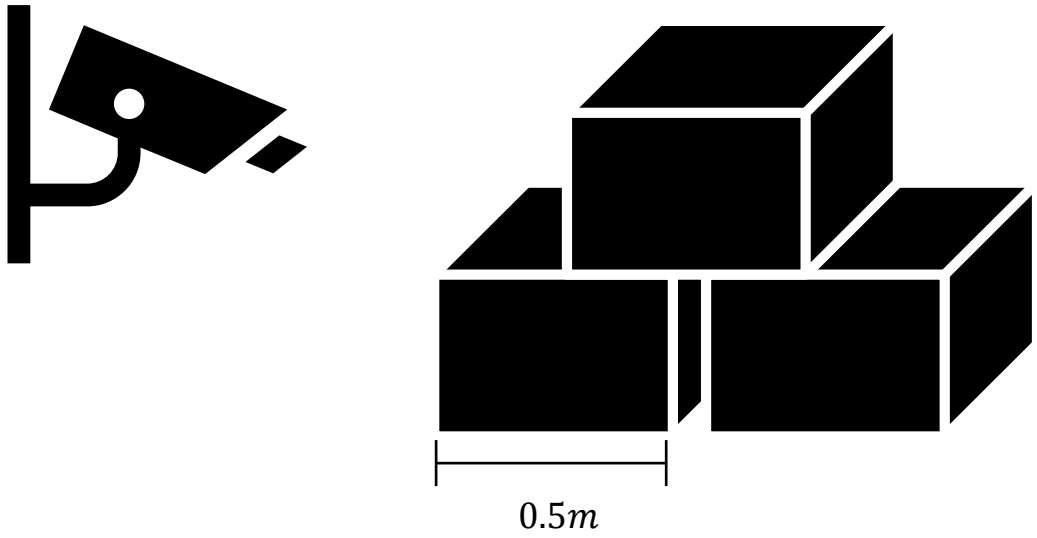






Imprecise Perception Leads to Uncertain Knowledge



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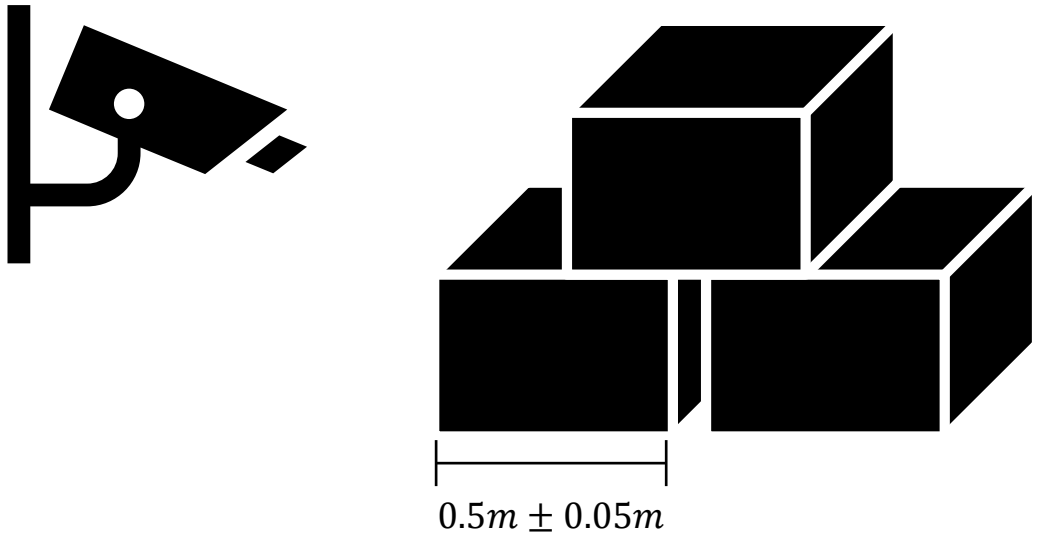

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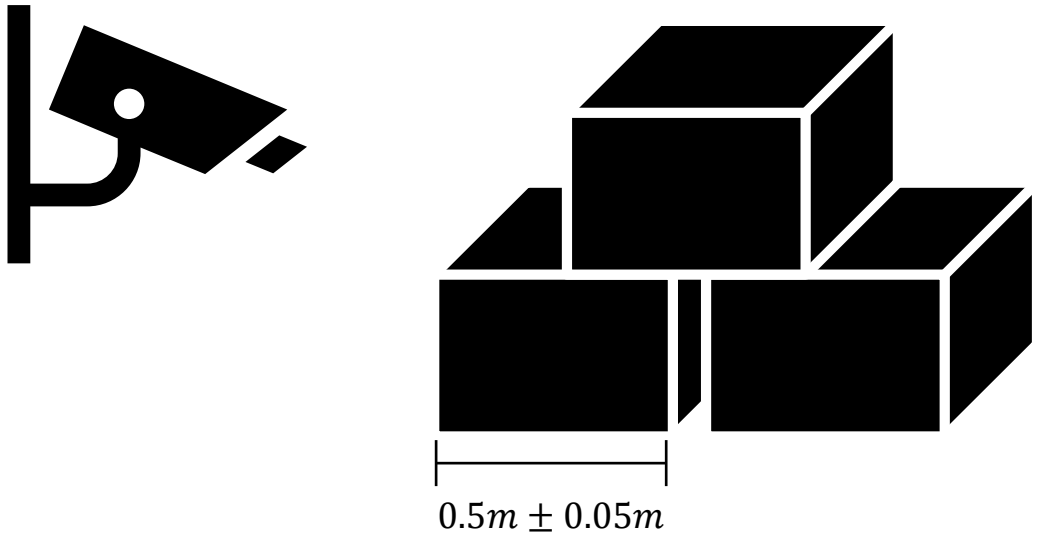
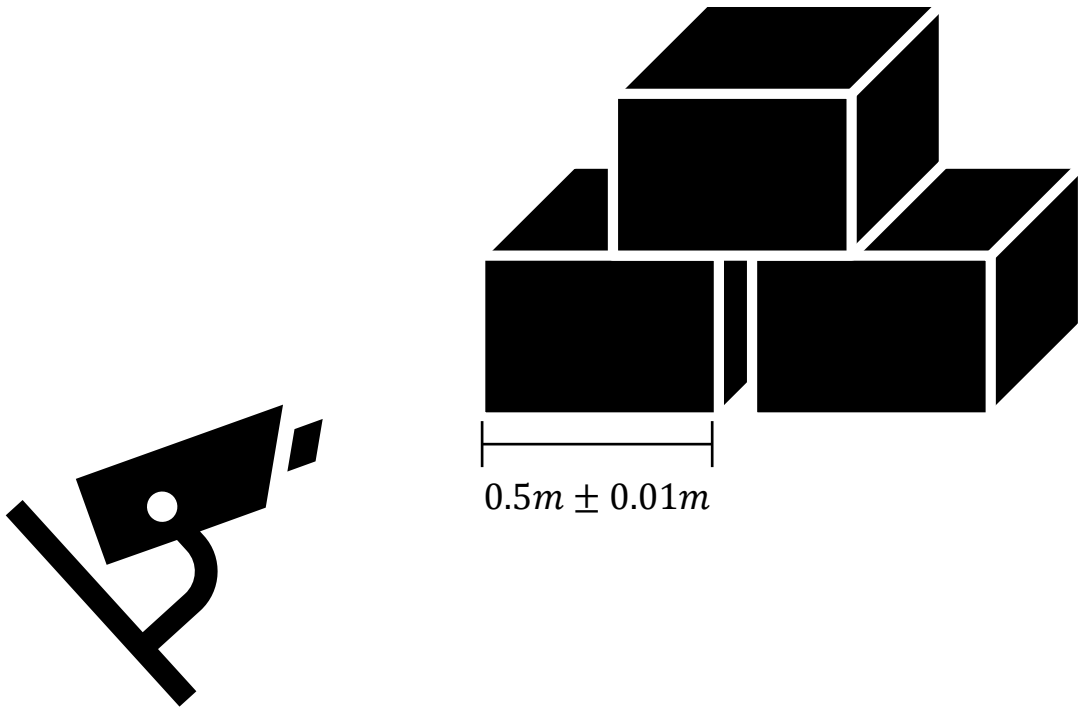


[1] G.A. Moreno et al.: “Uncertainty Reduction in Self-Adaptive Systems”, 2018

Uncertainty Reduction Tactics

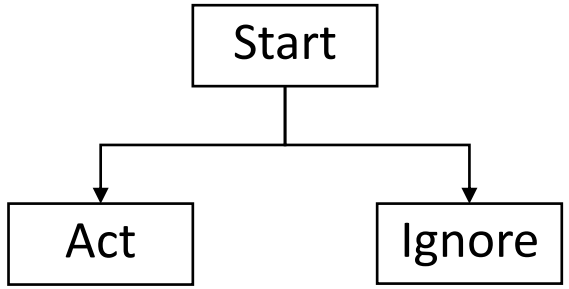


Contributions of this Work

1. Analyze the **potential benefit** of uncertainty reduction.
2. Propose a **context model** that supports the use of tactics.
3. Present **proof-of-concept** that demonstrates feasibility.

Potential Benefit of Uncertainty Reduction

Without uncertainty reduction



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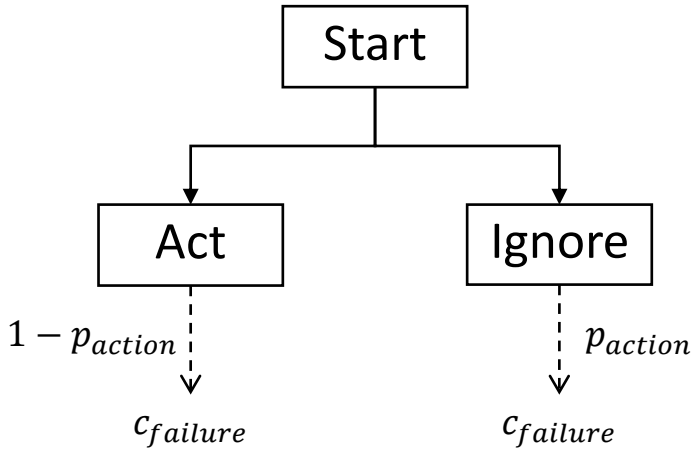

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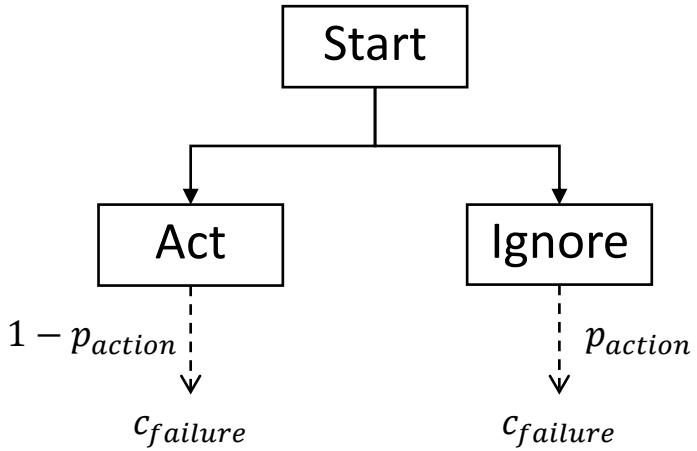
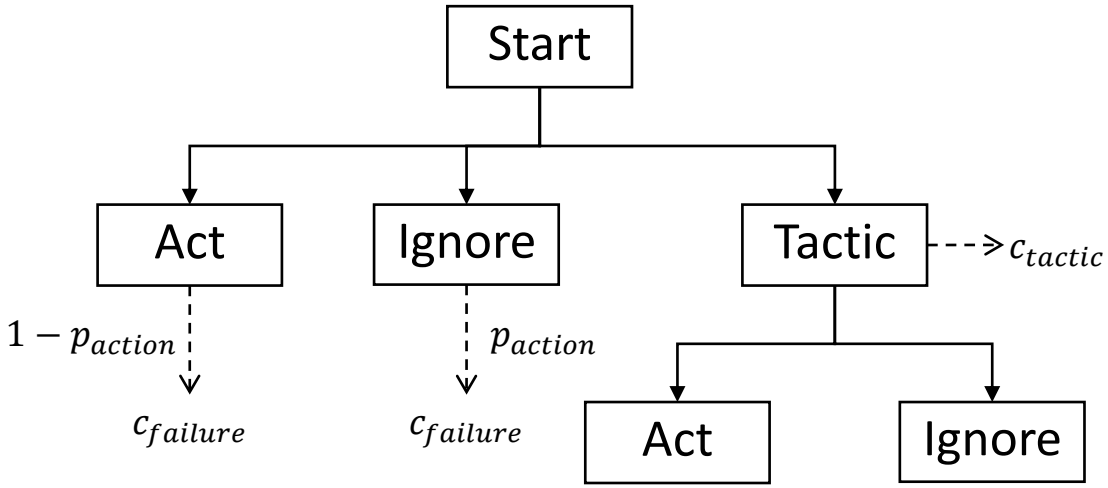


With uncertainty reduction



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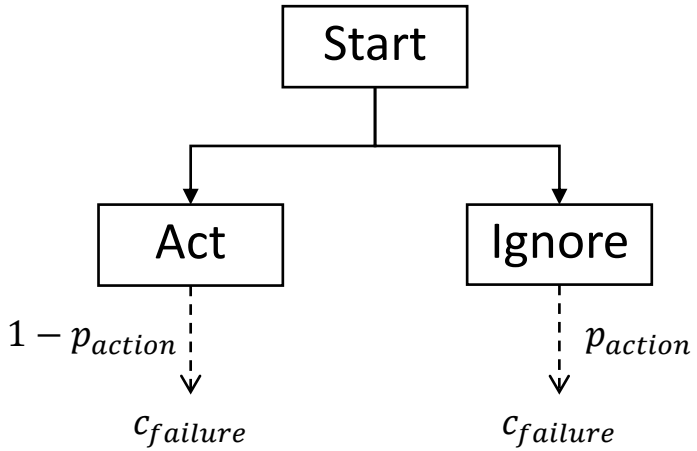
Without uncertainty reduction



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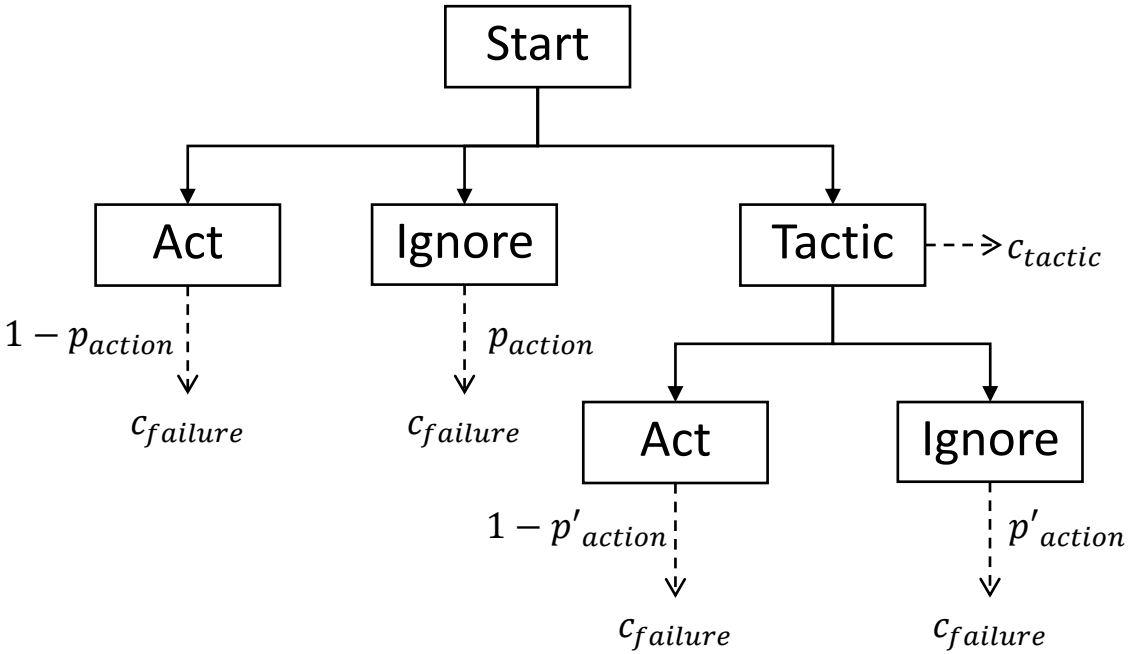

Potential Benefit of Uncertainty Reduction

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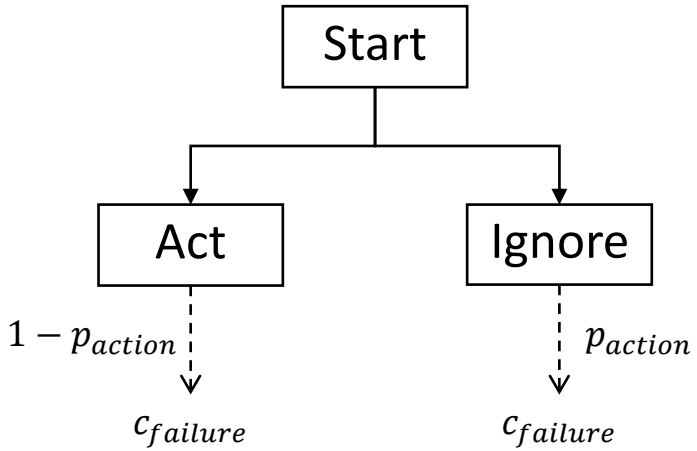
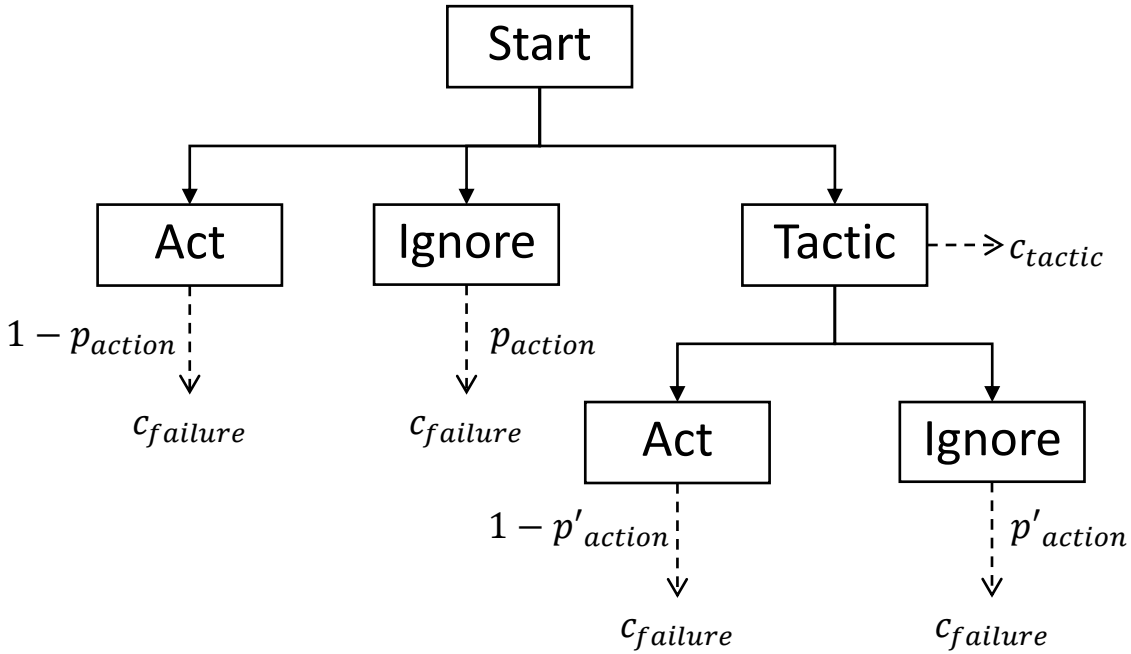


Model **relative costs**: $c_{failure} = 1$,
$c_{tactic} \in [0, 1]$

With uncertainty reduction



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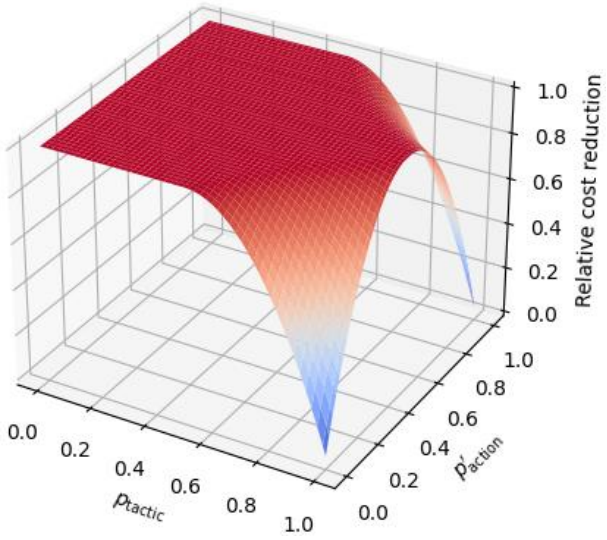
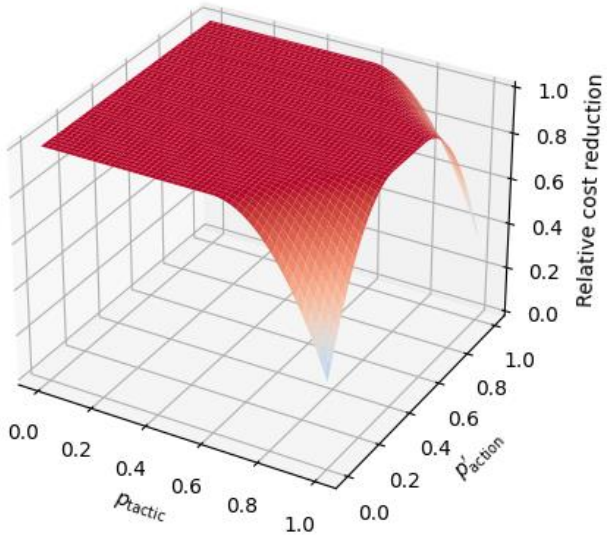
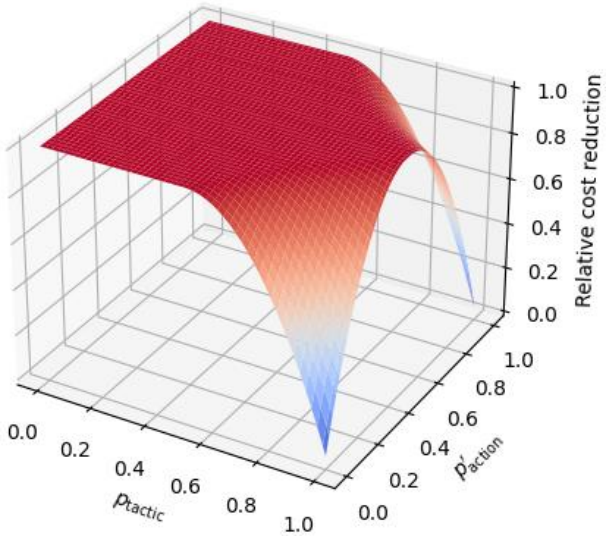


$c_{tactic} = 0.005$



$c_{tactic} = 0.1$

Potential Benefit of Uncertainty Reduction



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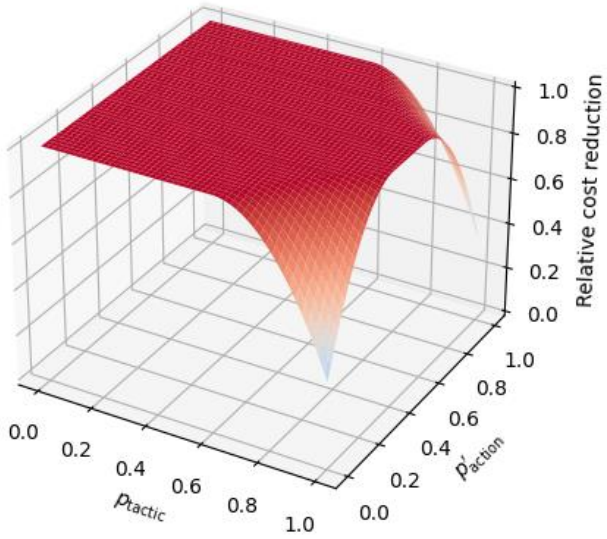


$c_{tactic} = 0.1$

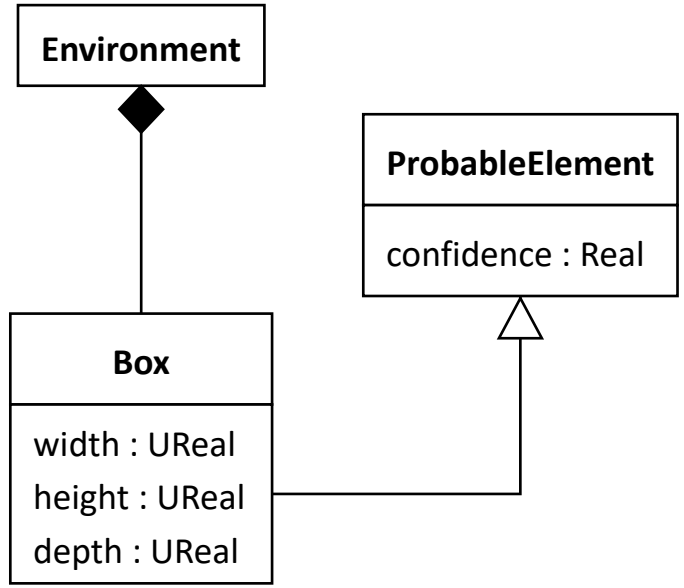
This means …

- Only tactics with a low relative cost are beneficial
  → Great potential when cost of failure is very high
- Need to be able to estimate p_{action}, p_{tactic} and p'_{action} at run-time

Context Model for Uncertainty Reduction

Expressing different types of uncertainty

- Measurement uncertainty: UML class diagram with **uncertain OCL data types** [2]
- Occurrence uncertainty: added class **ProbableElement** [3]



[2] M.F. Bertoa et al.: “Incorporating measurement uncertainty into OCL/UML primitive datatypes”, 2020
[3] L. Burgeño et al.: “Expressing Confidence in Models and in Model Transformation Elements”, 2018

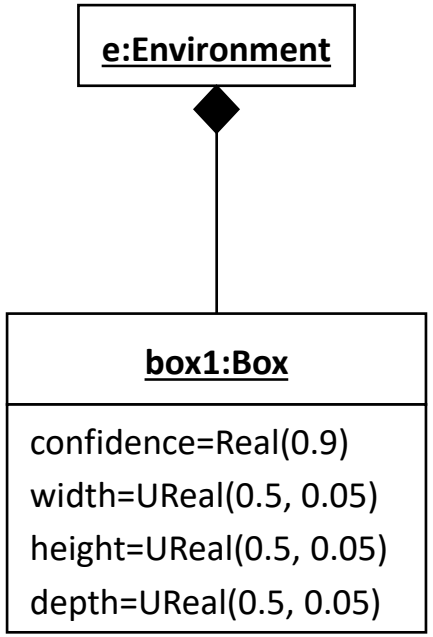
Estimating p_{action} and p_{tactic}

Constraints to express action admissibility

Action a_{pick}:

context Box: width ≤ 0.45 and width ≥ 0.55

$\rightarrow$ (True, 0.708)



Towards Estimating p'_{action}

2

context Box: width ≤ 0.45 and width $\geq 0.55 \rightarrow$ (True, 0.708)

Towards Estimating p'_{action}

2

context Box: width $\leq$ 0.45 and width $\geq$ 0.55 $\rightarrow$ (True, 0.708)

Towards Estimating p'_{action}

context Box: width $\leq$ 0.45 and width $\geq$ 0.55 $\rightarrow$ (True, 0.708)

Tactic	Reposition
Improves attribute	`Box.width`

Proof-of-Concept for Constraint Evaluation

Mission

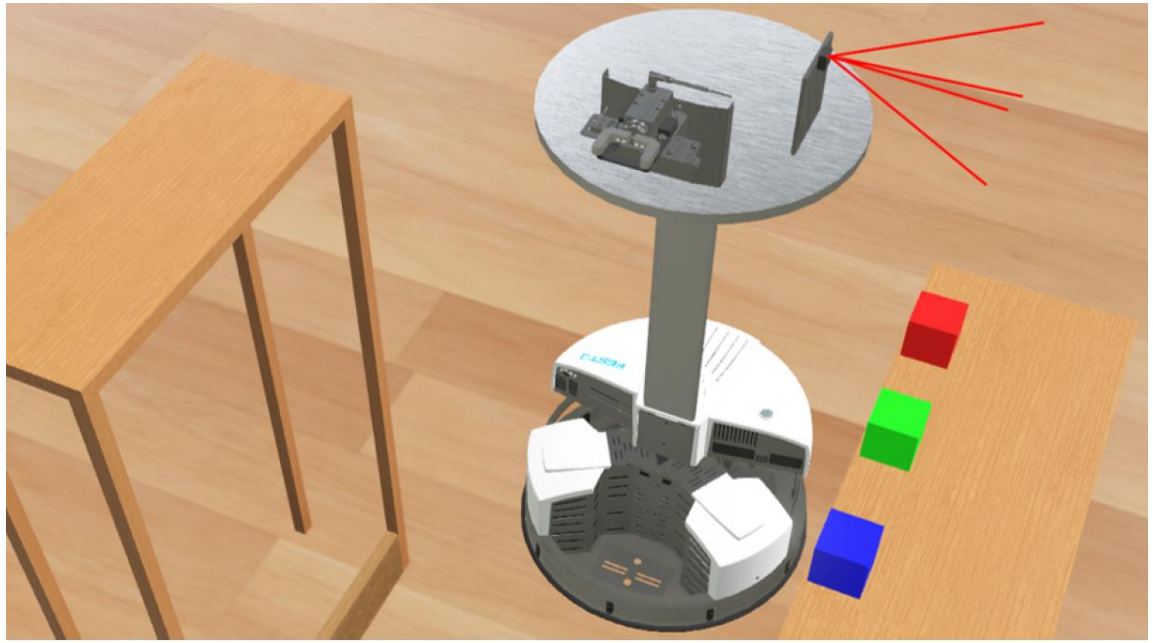
- Move boxes from the left table to the right table using the action a_{pick}

Means of perception

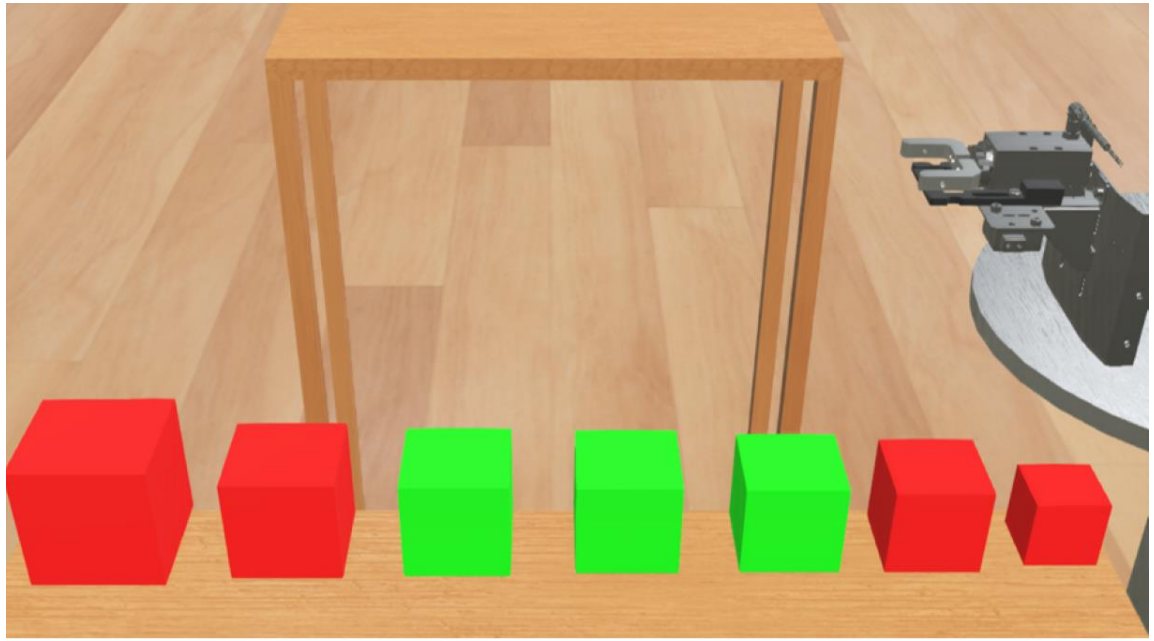
- Camera for noisy measurements of box widths

Uncertainty reduction

- Tactic *Reposition* moves closer to the box to obtain a more accurate measurement



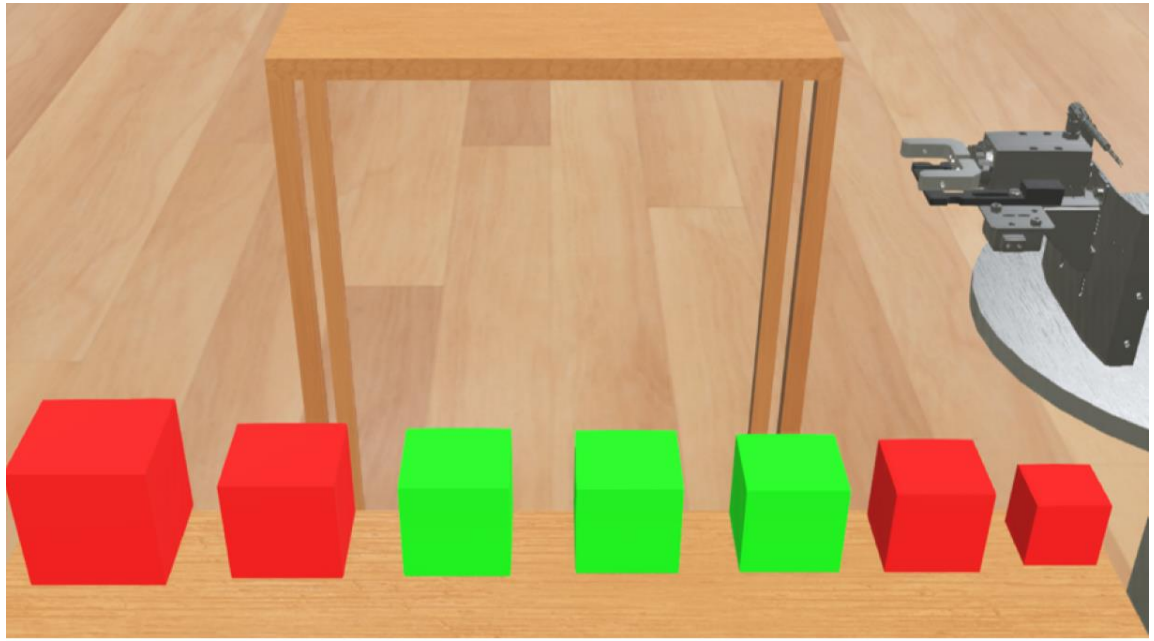
Initial Results



	No tactic
Total cost	1.98 ± 1.07

	c_{tactic}		
	0.05	0.1	0.25
Total cost	0.41 ± 0.37	0.71 ± 0.54	1.58 ± 0.88

Initial Results



Conclusion

- Uncertainty reduction has great potential to improve the performance of autonomous systems
- Admissibility constraints can be expressed and evaluated with the proposed model

Future Work

- Extension for estimating benefit of uncertainty reduction tactics
- Evaluation by means of a realistic use case

Thank you! Questions?

Contact

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