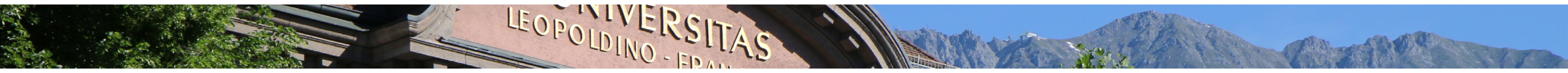

Decreasing Uncertainty in Planning with State Prediction

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Abstract

In the real world the state is never completely known. Exploration is often expensive. Planning is more difficult and less robust. We propose an approach for predicting information by exploiting the existing knowledge on the state. Our approach enhances the scalability of our planners, and leads to less time spent on sensing actions.

Problem description

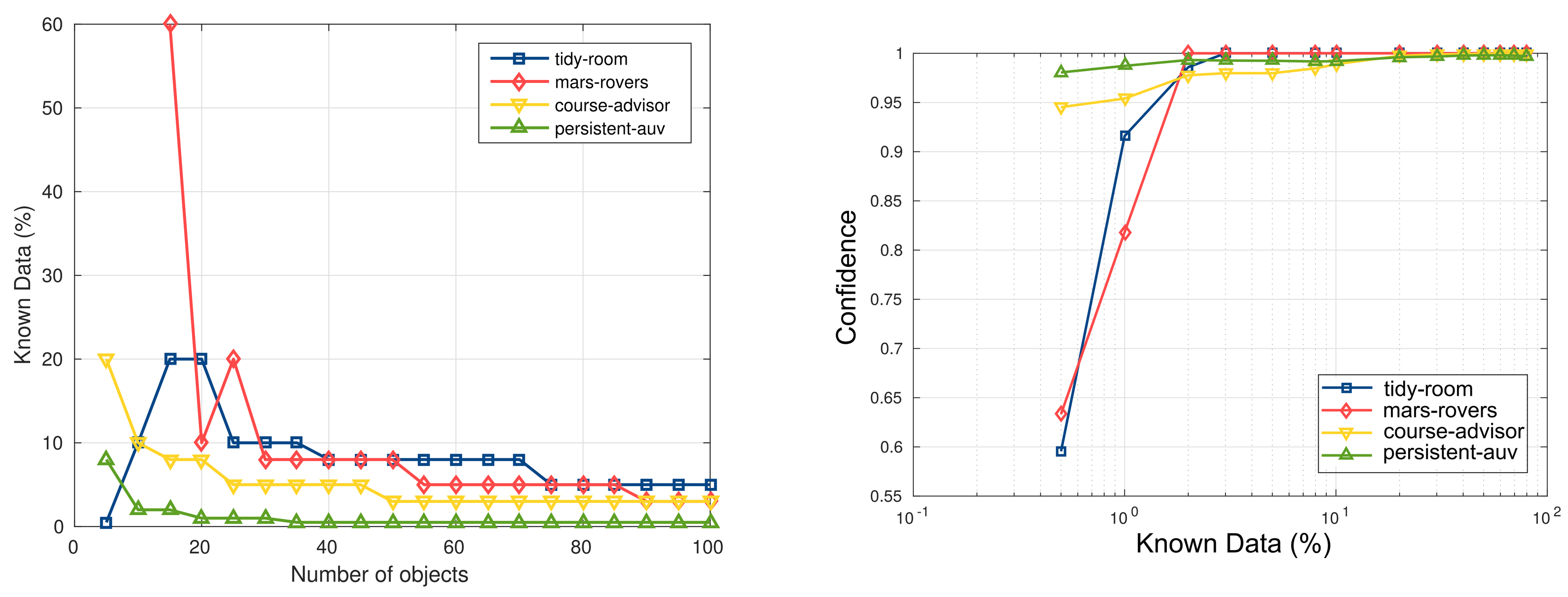
Planning for real world environments often means planning with incomplete and uncertain information. For example, in robotic domains and other dynamic environments there can be large numbers of unknown areas and objects. Moreover, in dynamic environments planning has to be completed quickly. However, exploration and observation in these scenarios can be costly. This uncertainty has severe consequences for planning. The planning problem becomes more complex, taking longer to solve, and exacerbating the issue of scalability.

Experimental results

Prediction tests - Accuracy results

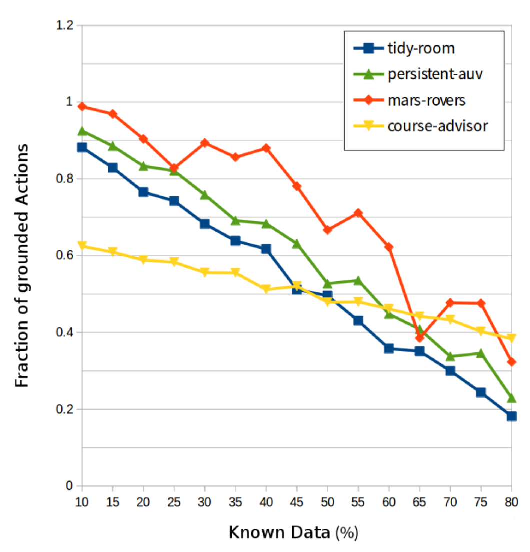
Minimal percentage of initial knowledge

Minimal percentage of knowledge which gives prediction accuracy equal to or higher than 90% (left) and mean confidence values for 20 objects (right).

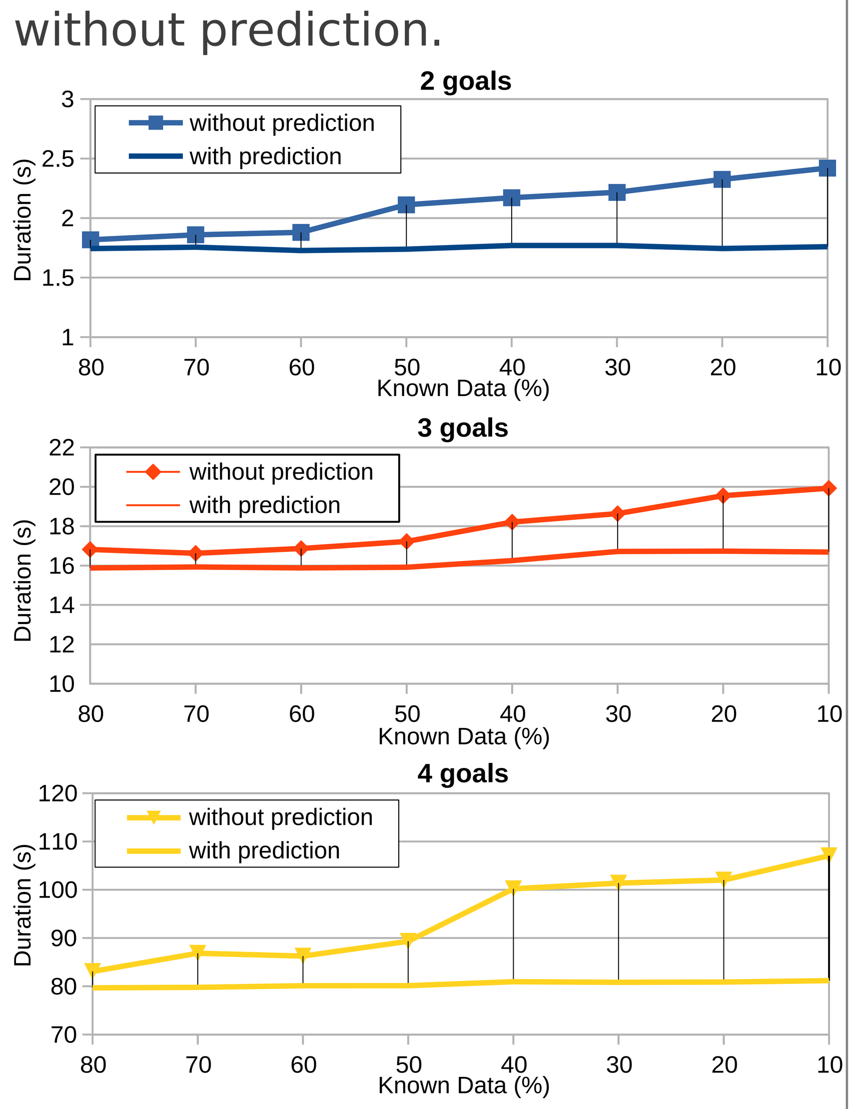


Evaluating robustness and efficiency

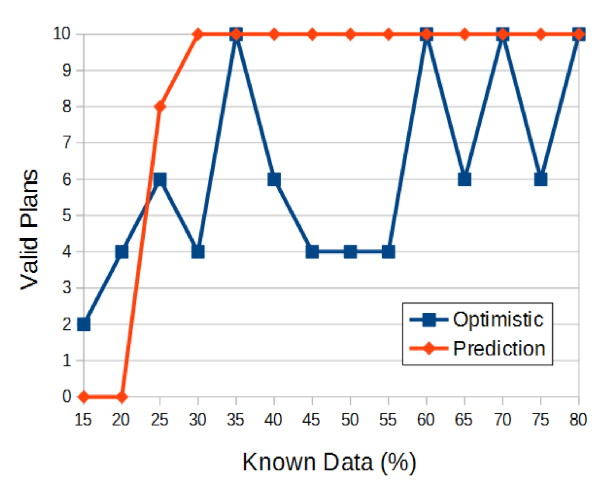
Number of newly reachable actions after prediction for 20 objects.



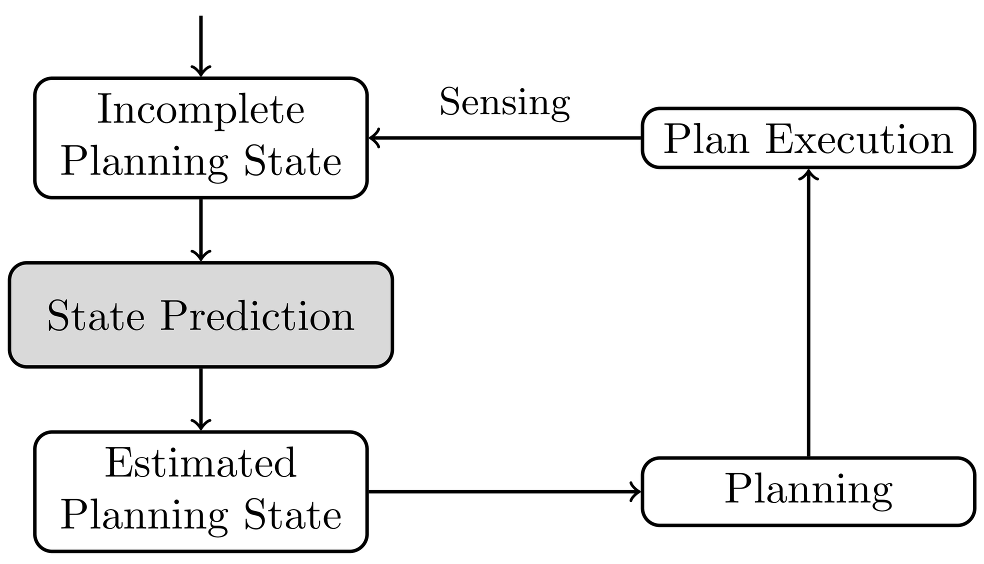
The time taken by CLG [Albore and Geffner] to solve problems with and without prediction.



Number of problems for which valid plans were generated ('tidy-room', 70 objects, POPF [Coles et al.], ground truth by VAL [Fox et al.])

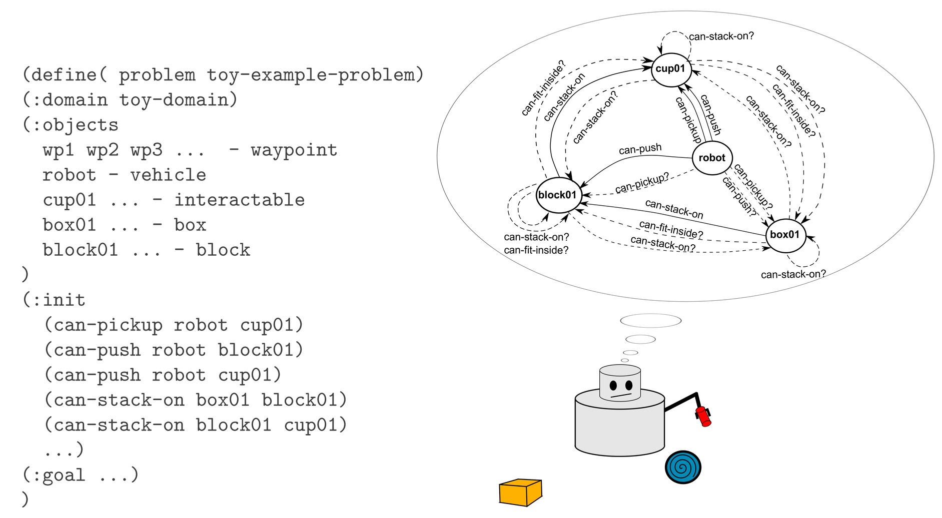


Proposed approach

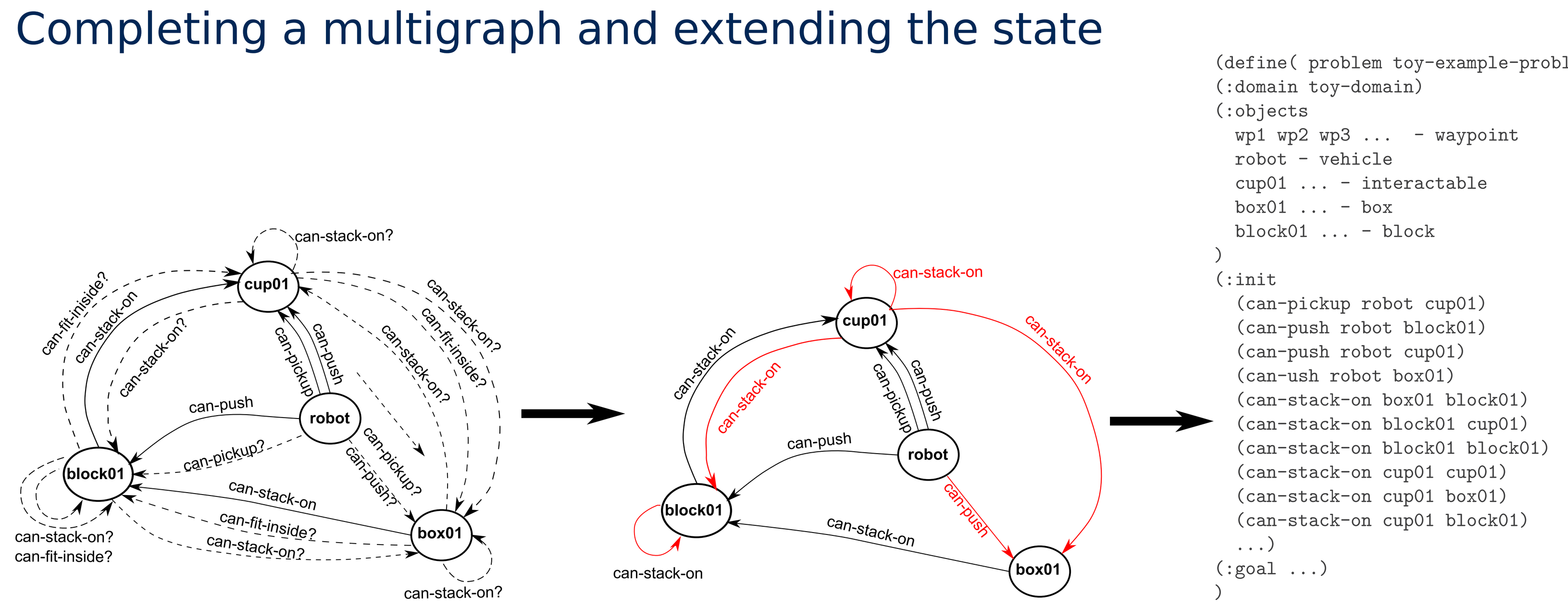


Proposed approach for decreasing uncertainty in planning. A partially-known state is updated through both sensing actions and prediction.

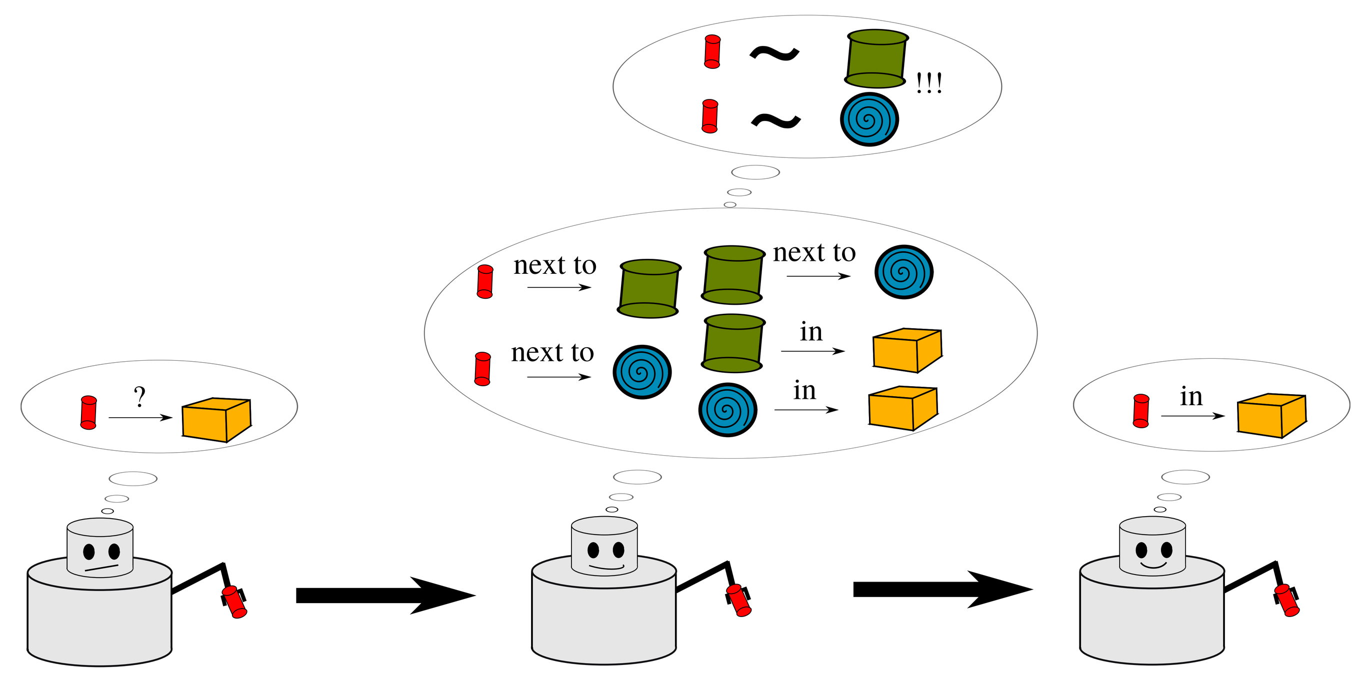
Creating a partially-known multigraph



Completing a multigraph and extending the state



Prediction by exploiting similarities

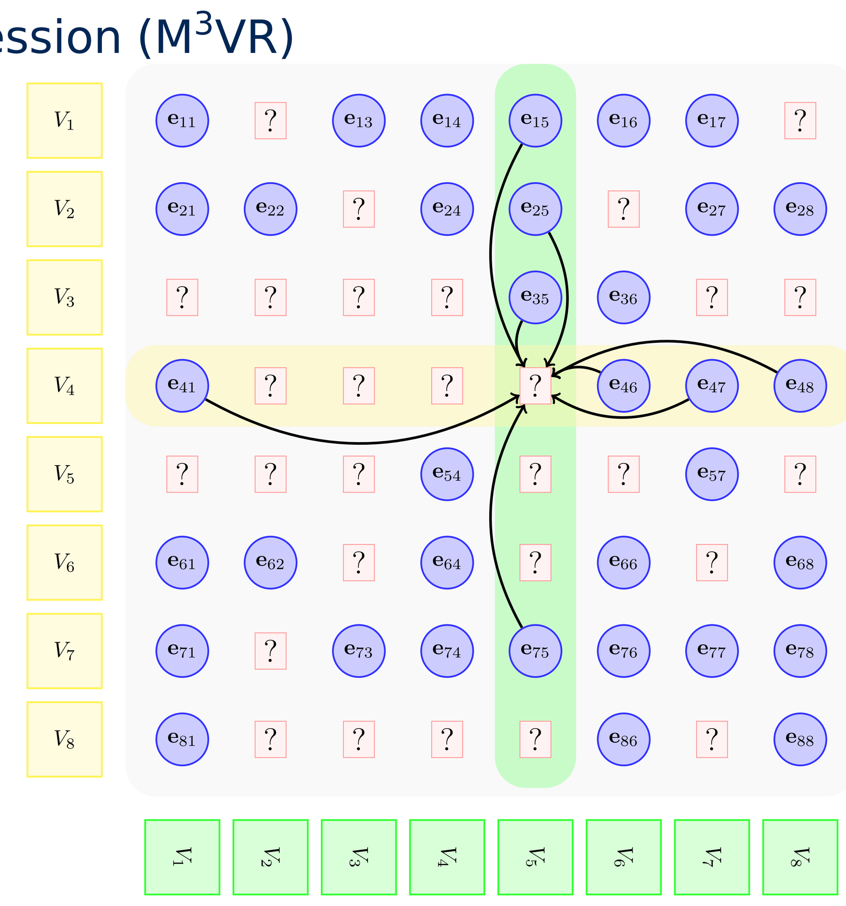


Methodology

Maximum Margin Multi-Valued Regression (M^3VR)

- Partially-given multigraph representing relations
- Semi-supervised learning
- Large-scale problems
- Sparse, skewed, imbalanced and inhomogeneous datasets

$$\min \ \tfrac{1}{2}\sum_u \|\mathbf{W}_b\|^2_{Frobenius} + C\sum_u \xi_u$$
$$\text{w.r.t.}\{\mathbf{W}_b\} : \mathcal{H}_\phi \rightarrow \mathcal{H}_\psi, u \in \mathcal{U}$$
$$\boldsymbol{\xi} \in \mathbb{R}^u,$$
$$\text{s.t.} \ \ \langle \psi(\mathbf{e}_{bu}), \mathbf{W}_b \phi(u) \rangle_{\mathcal{H}_\psi} \geq 1 - \xi_u$$
$$\xi_u \geq \mathbf{0}, \ (b,u) \in \mathcal{D},$$



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