Online Learning of Reusable Abstract Models for Object Goal Navigation

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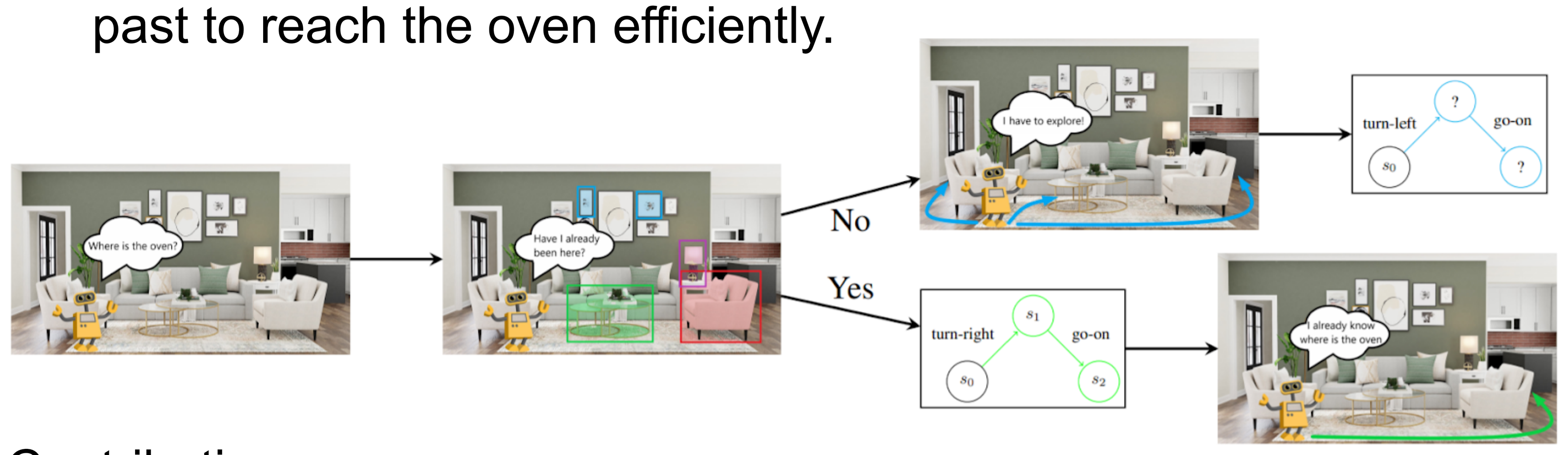
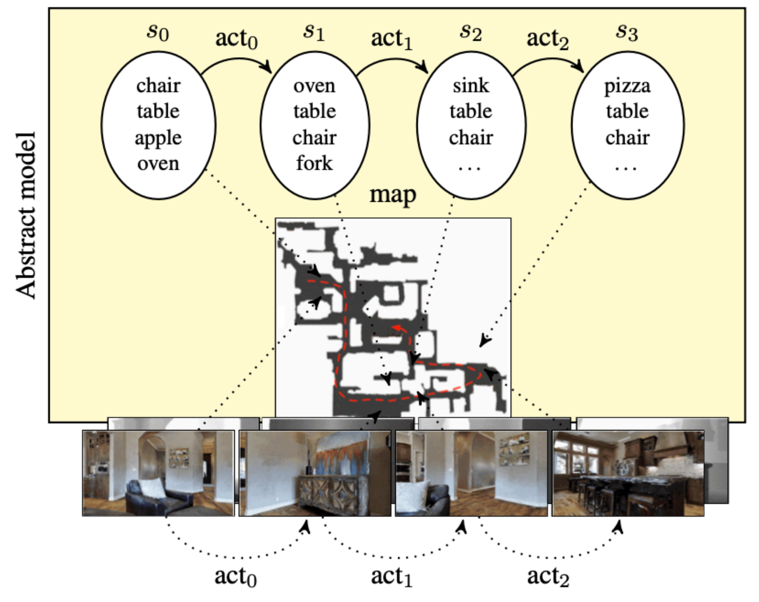
1. Core Idea & Contributions

A robot has to find the oven:
- ✦ If it is in a new environment, it must explore to build a knowledge base;
- ✦ Otherwise, we expect it to leverage the knowledge learned in the past to reach the oven efficiently.



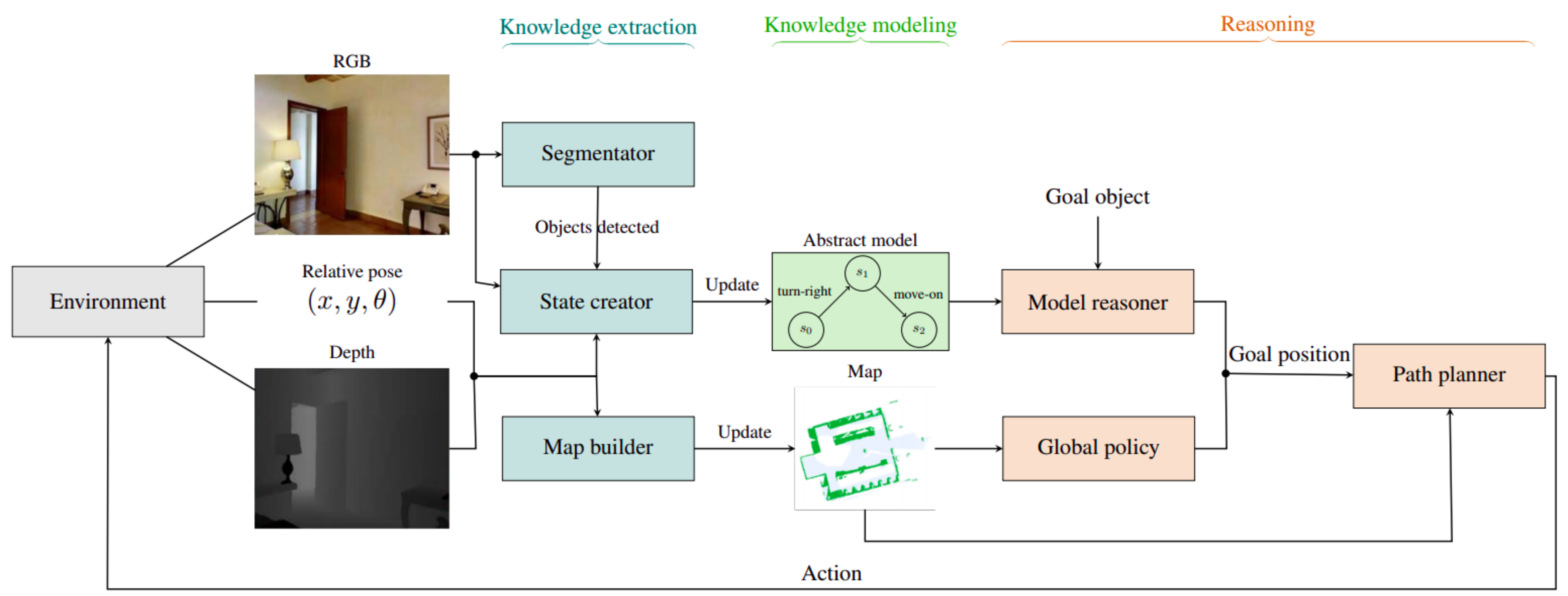
Contributions:
- ✦ Incrementally enhance and reuse previously acquired knowledge, relevant to the current environment;
- ✦ Integrate sub-symbolic techniques with symbolic reasoning on Abstract Models
- ✦ The experiments shows that learning and reusing Abstract Models is an effective way to exploit previously acquired knowledge

2. Abstract Model



- ✦ Encodes semantic insights about objects, scene elements, and their relations;
- ✦ The elements of the Abstract Model are grounded to the perceptions
- ✦ Is dynamically updated to incorporate the information the agent acquires
- ✦ The models learned should be reusable whenever the agent is in an environment that corresponds to the stored model

Method



- ✦ Knowledge extraction: creates an Abstract State from the inputs and updates the egocentric map from the Depth image;
- ✦ Knowledge modeling: updates the current Abstract Model and the global map of the environment;
- ✦ Reasoning: if there is information about the Object Goal in the Abstract Model, its position is set as the target. Otherwise is sampled a target point from the Global Policy. The action is sampled with a Path Planner on the Map.

Abstract Model Reusage

- ✦ Learned Abstract Model of each episode is stored by the agent for future re-use;
- ✦ When the agent starts a new episode it initializes a new model;
- ✦ At each step the agent checks if the current state is already present in a previously learned model by exploiting cosine distance:

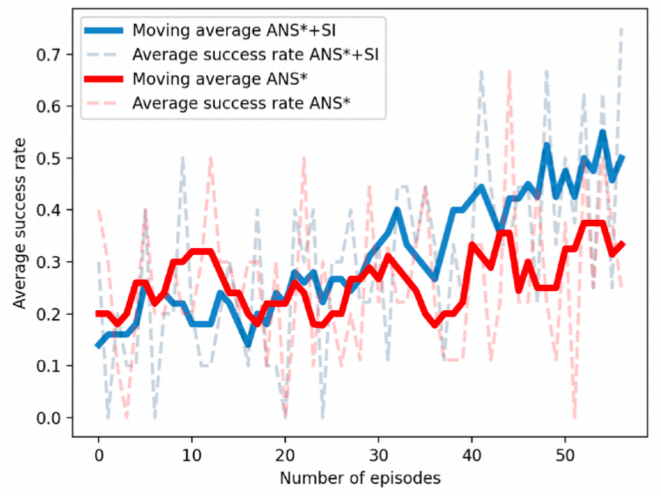
$$s^* = \underset{\substack{s^{(i)} \in S_d^{(i)} \\ i \in 1,\dots,n}}{\operatorname{argmin}} \; cos\_dist(\mathcal{F}_s, \mathcal{F}_{s^{(i)}})$$

- ✦ If a match is found the current model is merged with the older one and current agent's pose is rescaled to match the older Abstract Model coordinate system.

3. Experiments

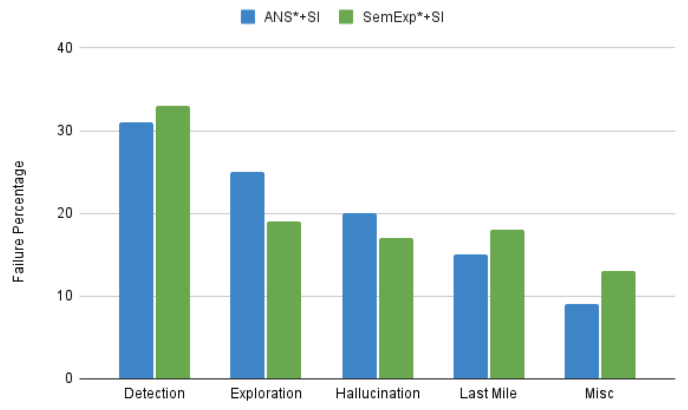
- ANS*[(1)]: Active Neural SLAM with no Abstract Model reuse across episodes;
- ANS*+HP/SP: pre-computed and fixed reusable Abstract Models;
- ANS*+SI: ANS* + Incrementally learned Abstract Models.
- SemExp*+SI: SemExp[(2)] + Incrementally learned Abstract Models.

Reusing Abstract Models



Method	DTS	Success	SPL	SoftSPL
ANS*	6.417	0.240	0.102	0.191
ANS*+HP	6.352	0.251	0.105	0.206
ANS*+SP	6.294	0.258	0.117	0.214
ANS*+IL	**6.155**	**0.279**	**0.131**	**0.233**

Semantic Maps and Abstract Models



Method	DTS	Success	SPL	SoftSPL
SMNet	7.316	0.096	0.057	0.087
SMNet(GT)	5.658	0.312	0.207	0.282
ANS*+IL	6.155	0.279	0.131	0.233
SemExp*+IL	**5.785**	**0.347**	**0.151**	**0.274**

References:

(1) Chaplot et al., "*Learning to explore using active neural SLAM*" In ICLR, 2019.
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(5) Savva et al., "Habitat: A plat- form for embodied ai research" In ICCV, 2019

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