Simultaneously Learning Transferable Symbols and Language Groundings from Perceptual Data for Instruction Following

Nakul Gopalan[1] Eric Rosen[2] George Konidaris[2] Stefanie Tellex[2]

[1]Georgie Institute of Technology [2]Brown University

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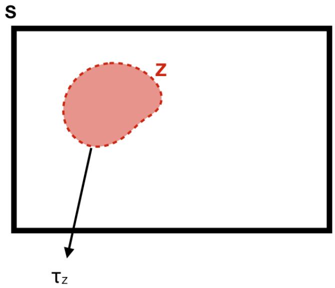
Introduction

- Problem: translate natural language to actions (policies).
- Option 1: end-to-end learning, language $\rightarrow$ actions.
  - Data intensive
- Option 2: language $\rightarrow$ pre-defined states.
  - Pre-defined states
- Option 3:
  1. Learn portable symbols as in James et al. [2]
  2. Map language to symbols with Seq2seq [3]

Symbols

Definition

A propositional symbol σ_Z is the name associated with a test τ_Z, and the corresponding set of states $Z = \{s \in S | \tau_Z(s) = 1\}$.



Symbols

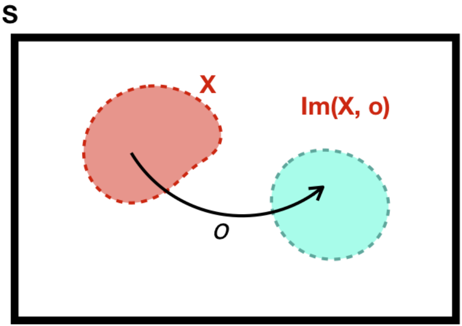


Figure: "Image" of option o from a set of states X.

Options framework

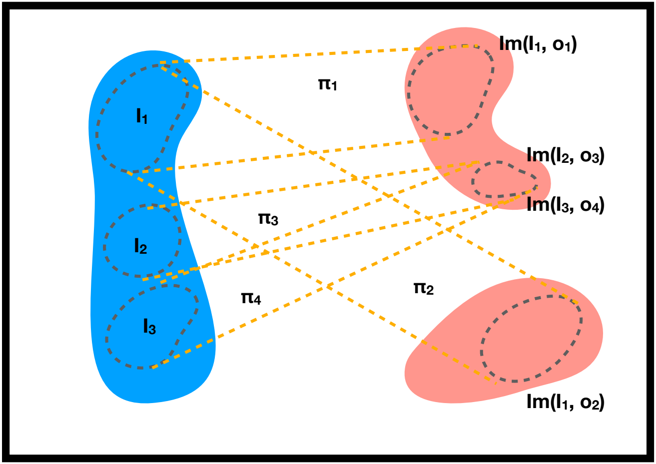


Figure: Example of options framework.

Problem with Environment Specific State Space

Figure: We cannot use the symbol learned in the left environment for the right environment. Reprinted from [2].

Symbolic Representations in Egocentric Space

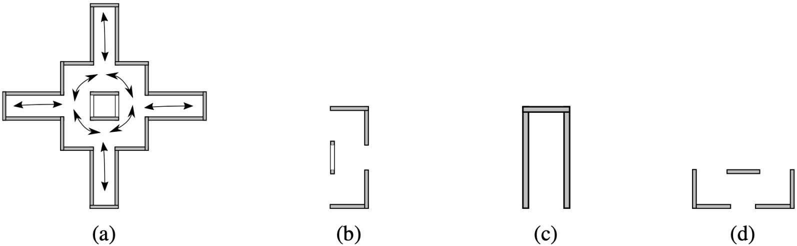


Figure: (a) Possible actions are shown with arrows. (b-d) Local egocentric observations. Reprinted from [2].

Symbolic Representations in Egocentric Space

Option	**Precondition**	**Effect**
`Clockwise1`	`wall-junction`	`window-junction`
`Clockwise2`	`window-junction`	`wall-junction`
`Anticlockwise1`	`wall-junction`	`window-junction`
`Anticlockwise2`	`window-junction`	`wall-junction`
`Outward`	`wall-junction` $\vee$ `window-junction`	`dead-end`
`Inward`	`dead-end`	$\begin{cases}\texttt{window-junction}\text{ w.p. } 0.5\\ \texttt{wall-junction}\text{ w.p. } 0.5\end{cases}$

Figure: Subgoal options learned in egocentric space. Reprinted from [2].

Transferring Egocentric Symbols

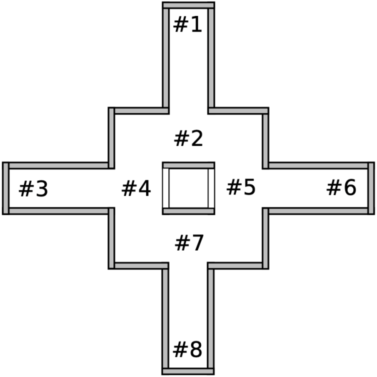


Figure: Environment-specific states are clustered. Reprinted from [2].

Portable symbol learning pipeline

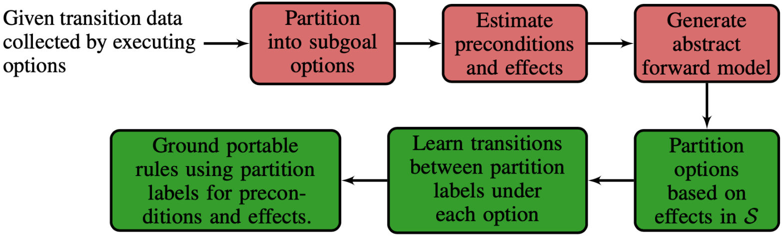
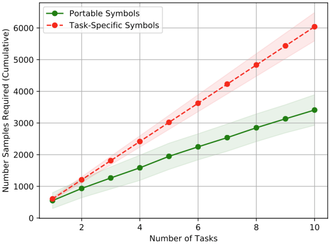
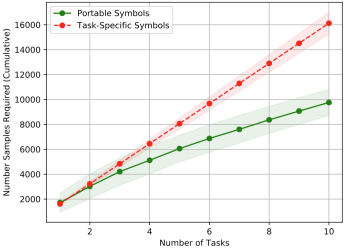


Figure: General pipeline for learning portable representations. Reprinted from [2].



(a) Results for the *Rod-and-Block* domain.



(b) Results for the *Treasure Game* domain.

Figure: The usage of egocentric state space reduces the necessary sample size. Reprinted from [2].

Method

- $\tau_j = \{(s_0, a_0), (s_1, a_1), \ldots, (s_T, a_T)\}$ and $l_j =$"go straight and turn left"
- Cluster a_i with HDP-HMM.

Skill segmentation

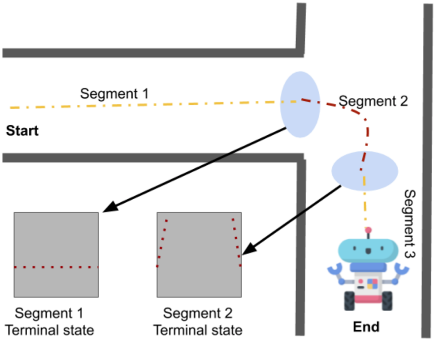


Figure: Reprinted from [1].

Seq2seq translation

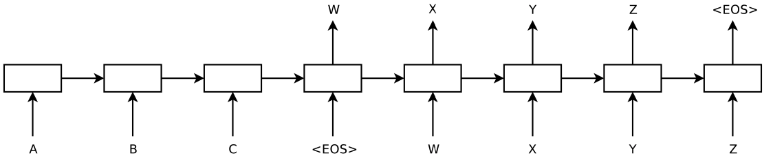


Figure: Reprinted from [3].

Method pipeline

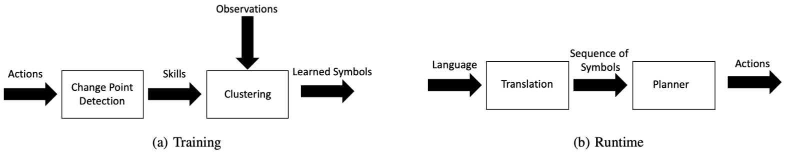


Figure: Reprinted from [1].

Data

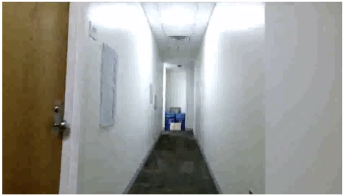


Figure: The NPS Neighborhood dataset (left) [4], the Movo mobile manipulator (right) [1].

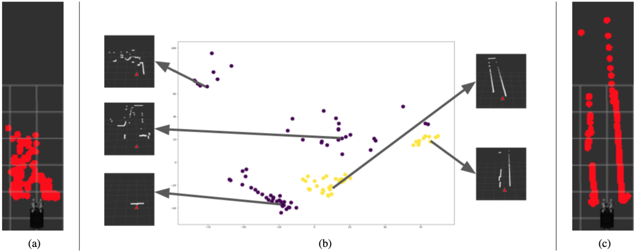


Figure: Reprinted from [1].

- No planning is done for this domain, only language translation.
- Translation exact match accuracy: 96.51 ± 0.46.
- There are 3 output symbols with maximum sequence length of 2 (random guess probability: $\frac{1}{3^2} = 12.5$).

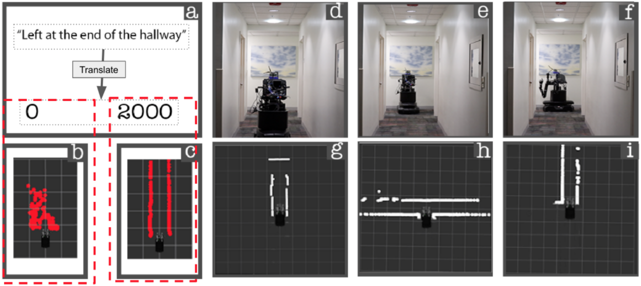


Figure: Reprinted from [1].

- Translation exact match accuracy: 75.71 ± 0.37.
- There are 5 output symbols with maximum sequence length of 3 (random guess probability: $\frac{1}{5^3} = 0.41$).

[1] Nakul Gopalan, Eric Rosen, George Konidaris, and Stefanie Tellex. Simultaneously learning transferable symbols and language groundings from perceptual data for instruction following. *Robotics: Science and Systems XVI*, 2020.

[2] Steven James, Benjamin Rosman, and George Konidaris. Learning portable representations for high-level planning. *arXiv preprint arXiv:1905.12006*, 2019.

[3] Ilya Sutskever, Oriol Vinyals, and Quoc V Le. Sequence to sequence learning with neural networks. In *Advances in neural information processing systems*, pages 3104–3112, 2014.

[4] Andrew K Watson. Automated creation of labeled pointcloud datasets in support of machine-learning based perception. Technical report, Naval Postgraduate School Monterey United States, 2017.