



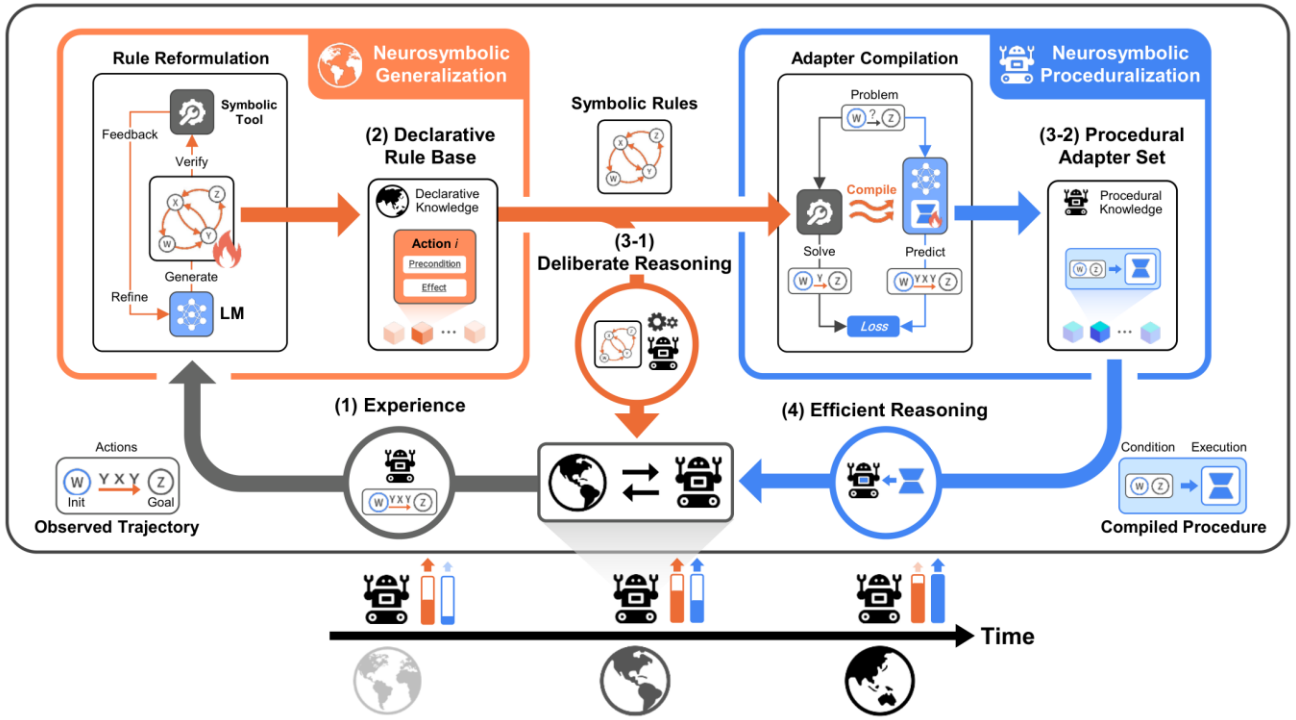
NeSyKC: Neurosymbolic Knowledge Compilation For Lifelong Learning Embodied Agents

Wonje Choi, Jooyoung Kim, Sera Choi, Younguk Song, Honguk Woo

Department of Computer Science and Engineering, Sungkyunkwan University

{wjchoi1995, onsaemiro, ouioui2, syw2045, hwoo}@skku.edu

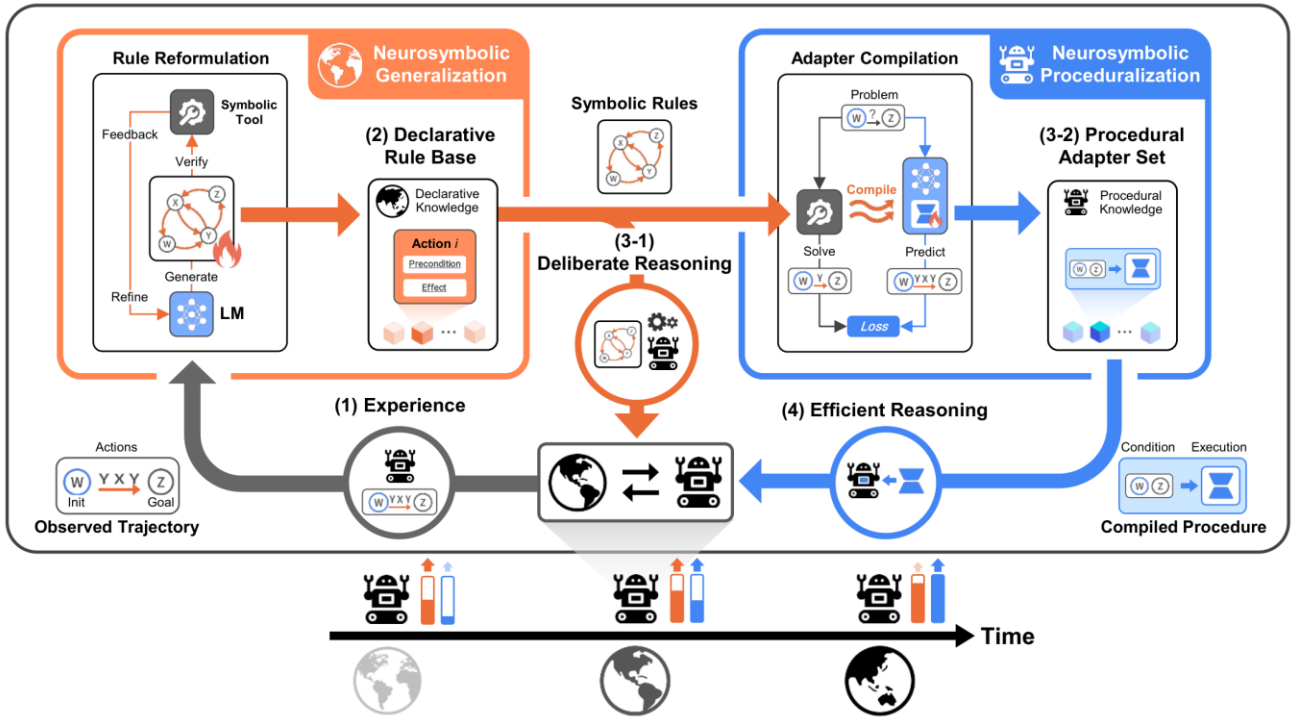
Introduction



1. Neurosymbolic knowledge compilation for lifelong learning embodied agents

- Agents generalize experience into symbolic rules and compile rule-derived procedures into neural adapters
- This enables lifelong learning that shifts from deliberate reasoning to efficient reasoning within the LM

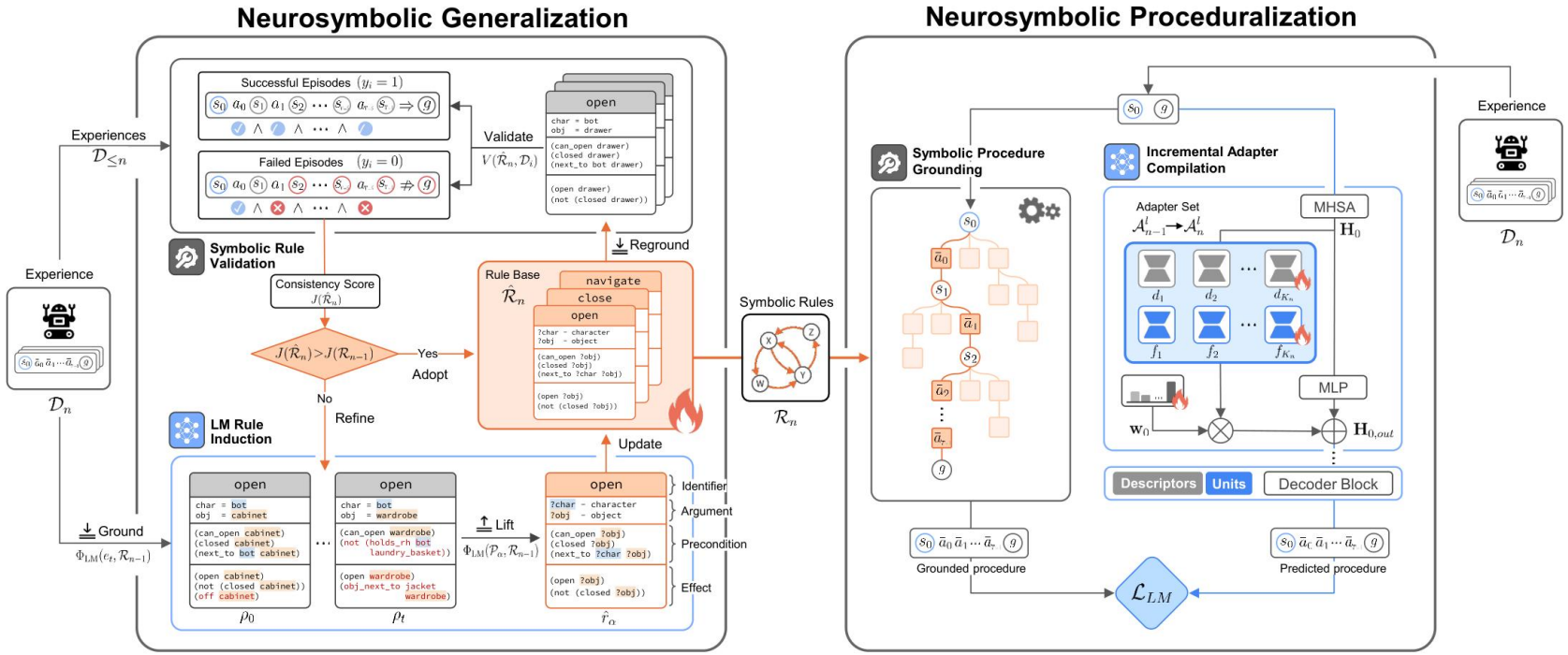
Introduction



2. Neurosymbolic knowledge compilation for lifelong learning embodied agents

- Based on ACT theory, where declarative knowledge is progressively compiled into procedural knowledge
- NeSyKC realizes this via i) Neurosymbolic Generalization and ii) Neurosymbolic Proceduralization

Neurosymbolic Knowledge Compilation



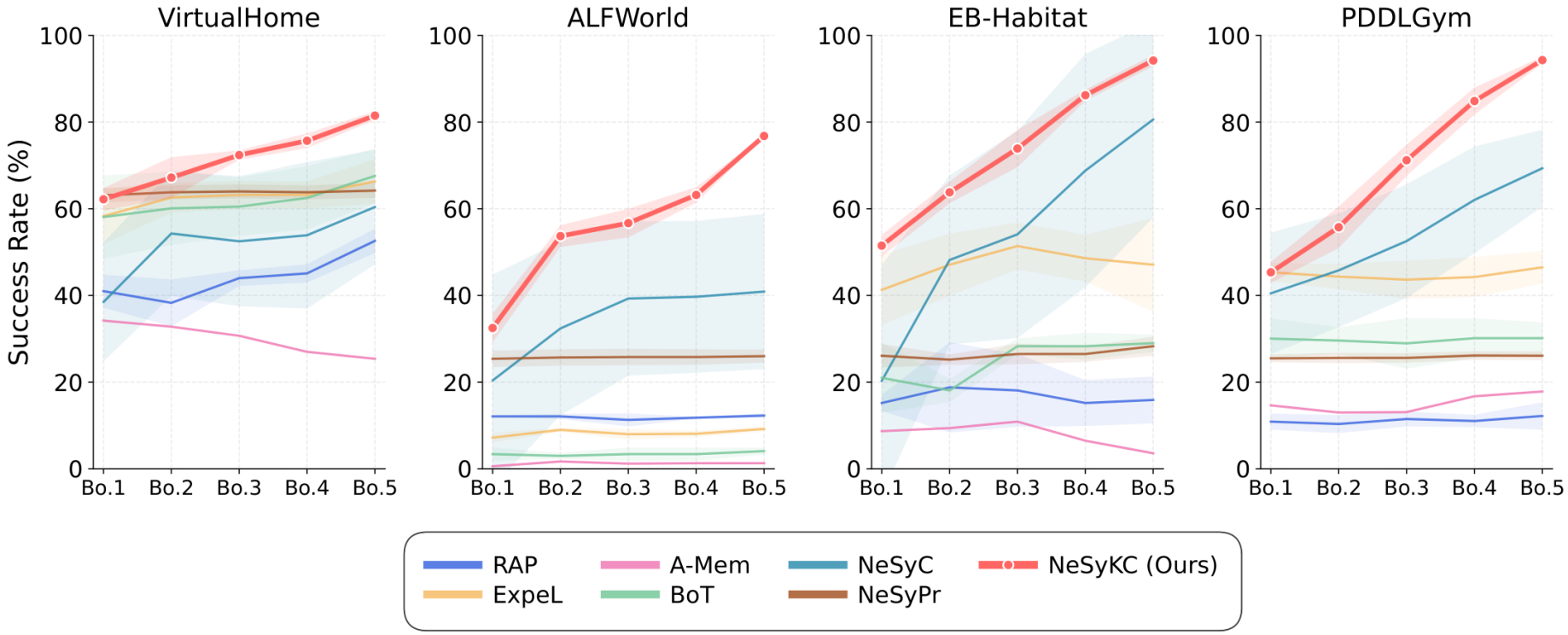
1. NeSyKC consists of two neurosymbolic learning processes:

- i) Neurosymbolic Generalization: Learns declarative knowledge by inducing symbolic rules from experience with the LM and validating them with symbolic tools
- ii) Neurosymbolic Proceduralization: Learns procedural knowledge by compiling verified procedures derived from the rule base into neural adapters attached to a frozen LM

Evaluation: Setting

- Environment
  - Evaluated on open-ended environments from VirtualHome, ALFWorld, EB-Habitat, and PDDLGym
  - Tasks arrive as a lifelong stream, and unseen tasks with novel scenes and goals test generalization
- Baselines
  - Compared with experience retrieval: RAP
  - Declarative memory: ExpeL, A-Mem, NeSyC
  - Procedural memory: BoT, ReasonFlux, NeSyPr
  - Oracle setting: Gideon, given complete environment knowledge
- Metrics
  - SR, GC, SPL: evaluate task completion, goal satisfaction, and path efficiency respectively
  - AP, AIP: measure final performance and how early and consistently the agent performs over the stream

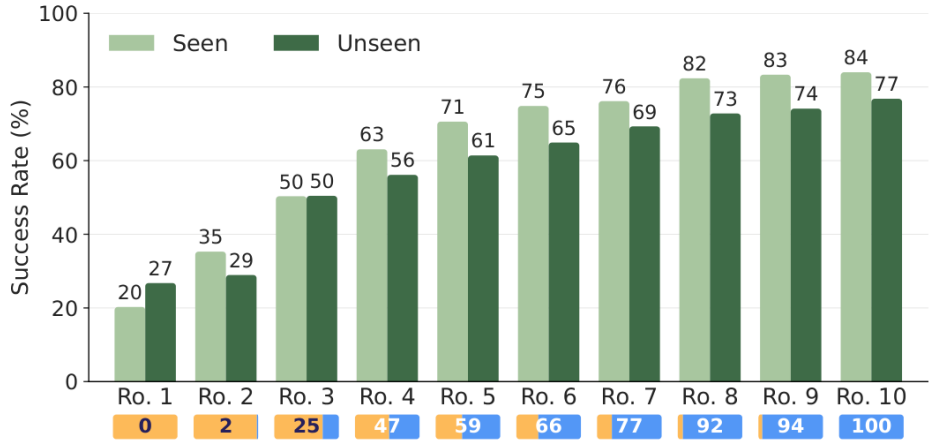
Evaluation: Performance



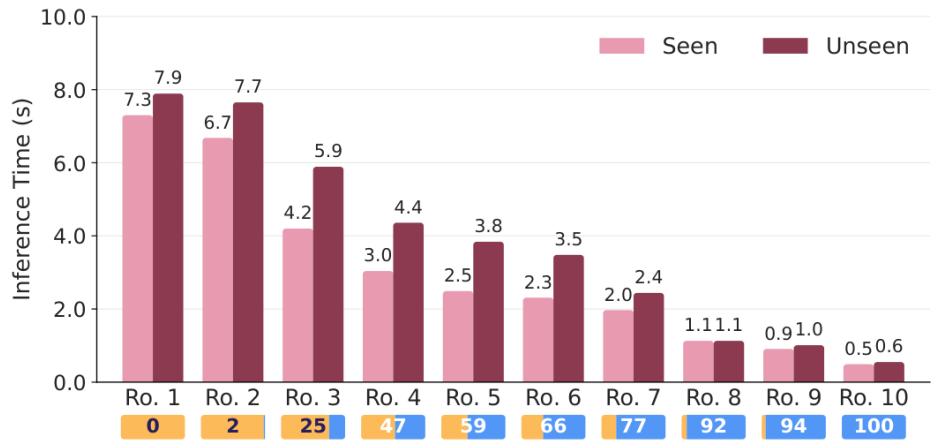
- Experiment results

- NeSyKC consistently improves SR in all four environments during lifelong learning (e.g., 76.8% vs. 40.9% for NeSyC in ALFWorld), while baselines show less consistent trends

Evaluation: Performance



(a) Success rate across compilation rounds



(b) Inference time across compilation rounds

- Experiment results

- (a) Repeated knowledge compilation steadily raises SR from 20% to 84% on seen tasks and from 27% to 77% on unseen tasks across ten rounds
- (b) Inference time decreases by over 90% (7.3s → 0.5s on seen and 7.9s → 0.6s on unseen tasks) as reasoning shifts from deliberate to efficient

Conclusion

- A Novel Framework: NeSyKC

- NeSyKC enables generalizable and efficient lifelong learning by forming symbolic rules from experience and compiling them into neural adapters through neurosymbolic knowledge compilation

- Future Direction

- Future work will extend NeSyKC to multi-agent settings through systematic cross-agent experience sharing, where knowledge acquired by one agent can be transferred to and reused by another