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Distilling and Retrieving Generalizable Knowledge for Robot Manipulation via Language Corrections

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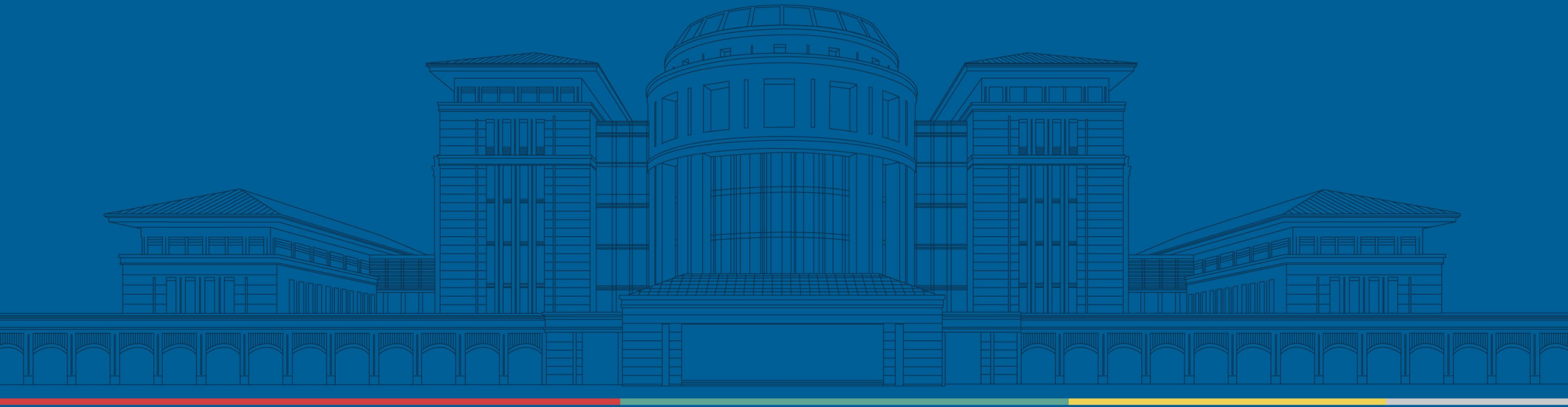


Distillation and Retrieval of Online Corrections

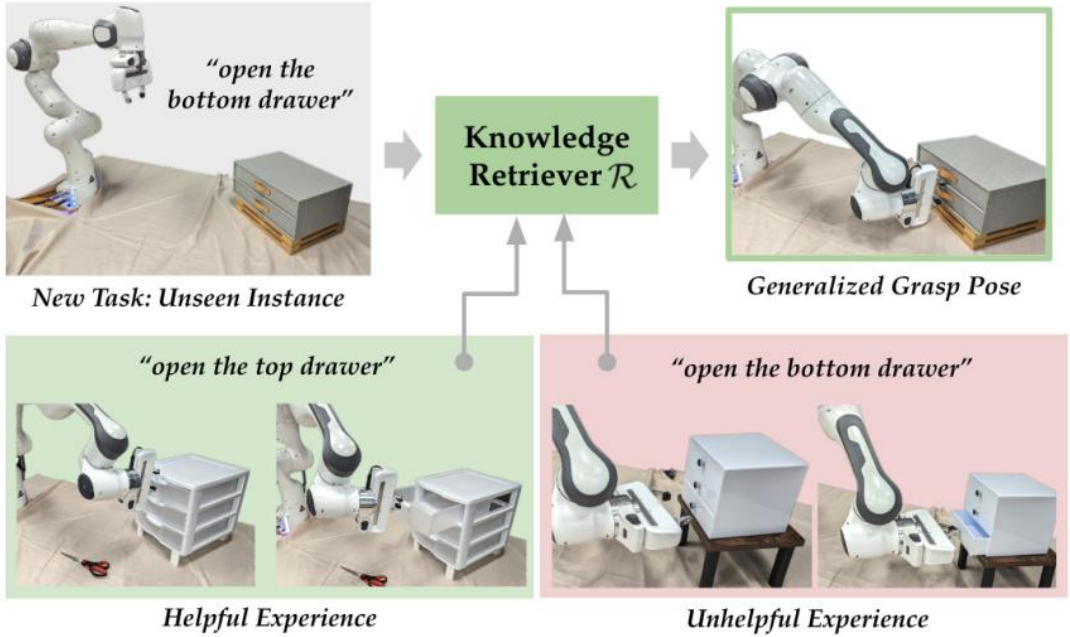
- Based on a large language model
- Respond to online corrections
- Adapt to new objects and configurations while reduce the number of human corrections needed
- Achieve higher success rates and requires fewer corrections in new tasks

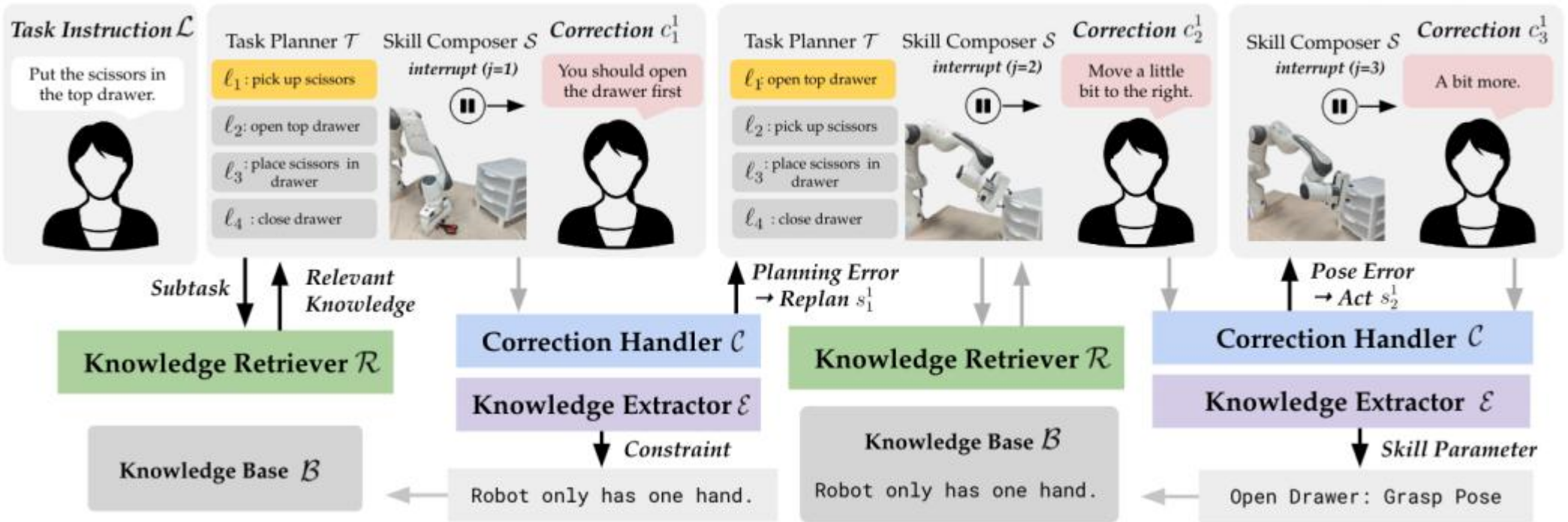
DROC

- A natural language instruction L
- A task planner T: L = (l^1, l^2 ….)
- Follow the policy S
- Human correction: c^i_j (j stands the round of corrections)
- Solution to correction: s^i_j
- Interaction history: H^i_j
- Goal: reduce $\bar{J} = \frac{1}{N}\sum_{k=1}^{N} J_k$

Framework

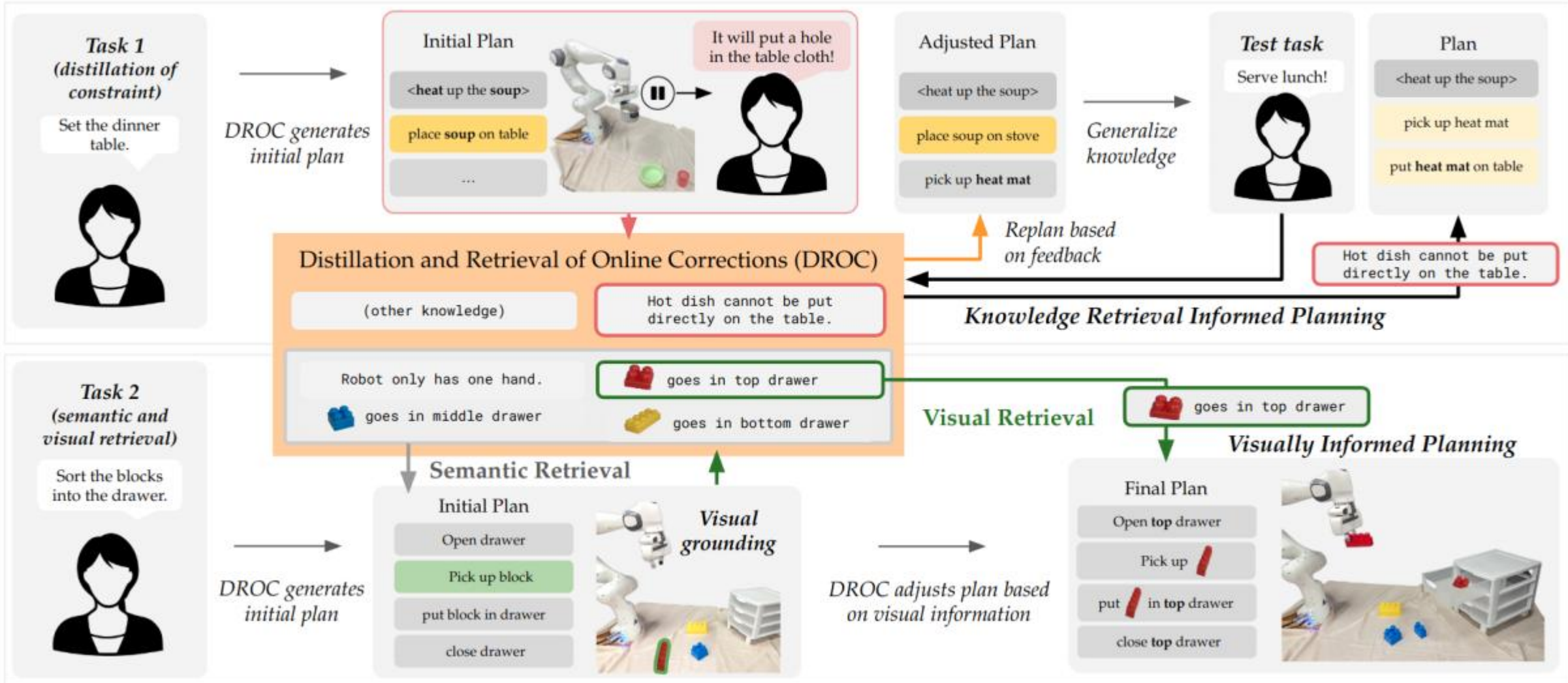
- Correction handler C
  - To generate s: C extract knowledge from H ($s^i_j = C(H^i_{j-1})$)
- Knowledge extractor ε (what to remember)
- Knowledge retriever R (what to retrieve)
- Knowledge base B (after a full H)



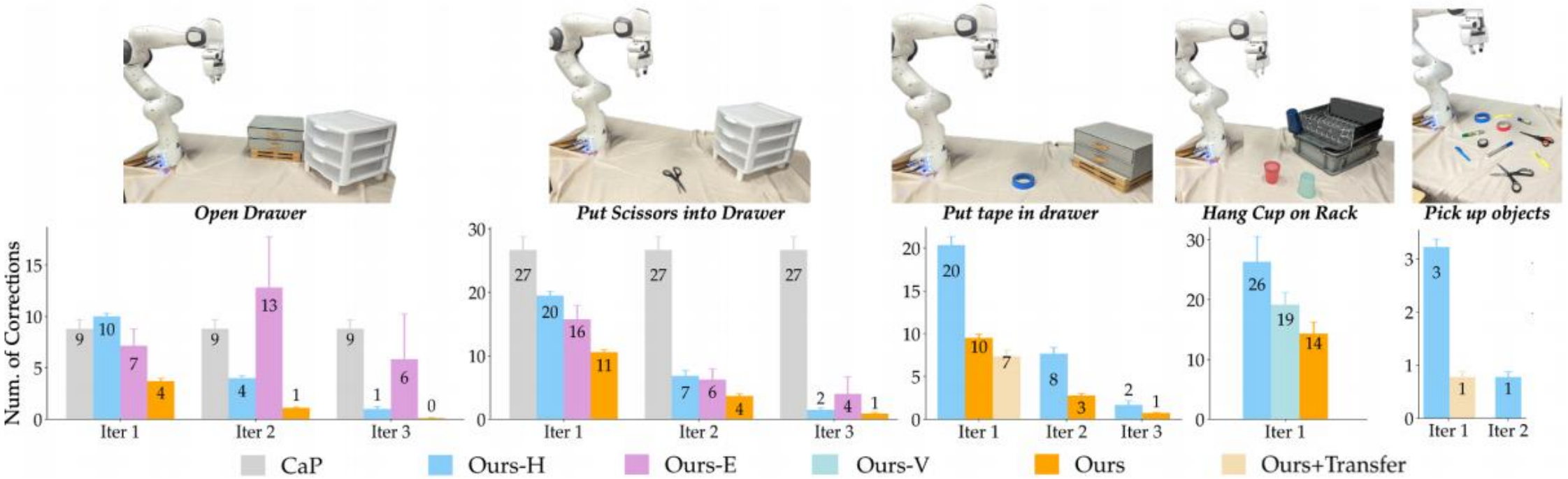

Task Instruction $\mathcal{L}$
Put the scissors in the top drawer.
Task Planner $\mathcal{T}$
ℓ_1 : pick up scissors
ℓ_2: open top drawer
ℓ_3 : place scissors in drawer
ℓ_4 : close drawer
Skill Composer $\mathcal{S}$
interrupt (j=1)
Correction c_1^1
You should open the drawer first
Task Planner $\mathcal{T}$
ℓ_1: open top drawer
ℓ_2 : pick up scissors
ℓ_3 : place scissors in drawer
ℓ_4 : close drawer
Skill Composer $\mathcal{S}$
interrupt (j=2)
Correction c_2^1
Move a little bit to the right.
Skill Composer $\mathcal{S}$
interrupt (j=3)
Correction c_3^1
A bit more.
Subtask
Relevant Knowledge
Knowledge Retriever $\mathcal{R}$
Knowledge Base $\mathcal{B}$
Correction Handler $\mathcal{C}$
Knowledge Extractor $\mathcal{E}$
Constraint
Robot only has one hand.
Planning Error → Replan s_1^1
Knowledge Retriever $\mathcal{R}$
Knowledge Base $\mathcal{B}$
Robot only has one hand.
Pose Error → Act s_2^1
Correction Handler $\mathcal{C}$
Knowledge Extractor $\mathcal{E}$
Skill Parameter
Open Drawer: Grasp Pose

Task

- Instruction: put the spoon into the drawer
- Plan:
  - 1: "Open the top drawer"
  - 2: "Pick up the spoon"
  - 3: "Put down the spoon into the top drawer"
  - 4: "Close the top drawer"
- Correction:
  - “move right a little bit"


Task 1
(distillation of constraint)
Set the dinner table.
DROC generates initial plan
Initial Plan
<heat up the soup>
place soup on table
...
It will put a hole in the table cloth!
Adjusted Plan
<heat up the soup>
place soup on stove
pick up heat mat
Generalize knowledge
Test task
Serve lunch!
Plan
<heat up the soup>
pick up heat mat
put heat mat on table
Distillation and Retrieval of Online Corrections (DROC)
(other knowledge)
Hot dish cannot be put directly on the table.
Replan based on feedback
Hot dish cannot be put directly on the table.
Knowledge Retrieval Informed Planning
Task 2
(semantic and visual retrieval)
Sort the blocks into the drawer.
Robot only has one hand.
goes in middle drawer
goes in top drawer
goes in bottom drawer
Visual Retrieval
goes in top drawer
Visually Informed Planning
Semantic Retrieval
DROC generates initial plan
Initial Plan
Open drawer
Pick up block
put block in drawer
close drawer
Visual grounding
DROC adjusts plan based on visual information
Final Plan
Open top drawer
Pick up
put in top drawer
close top drawer

Control Group Experiment



Thank You!

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