



**ICLR**

International Conference On  
Learning Representations

# Predicate Hierarchies Improve Few-Shot State Classification

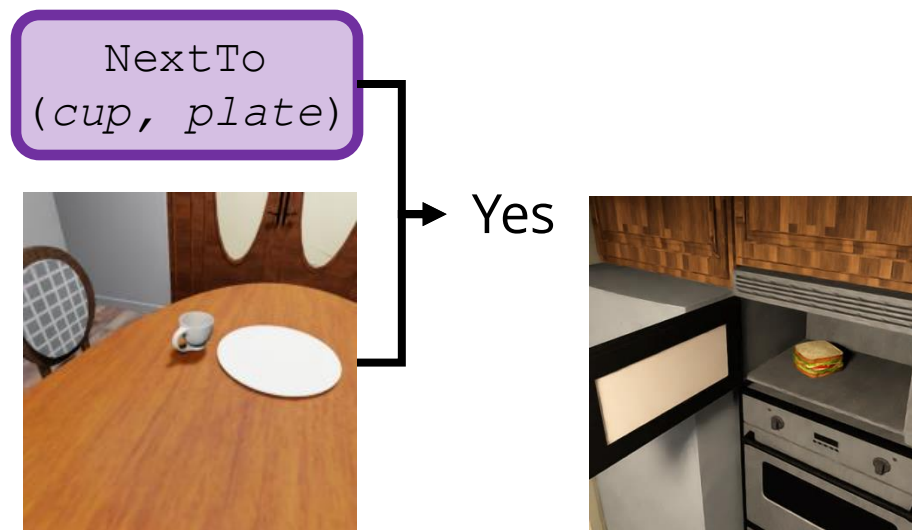
Emily Jin\*, Joy Hsu\*, Jiajun Wu



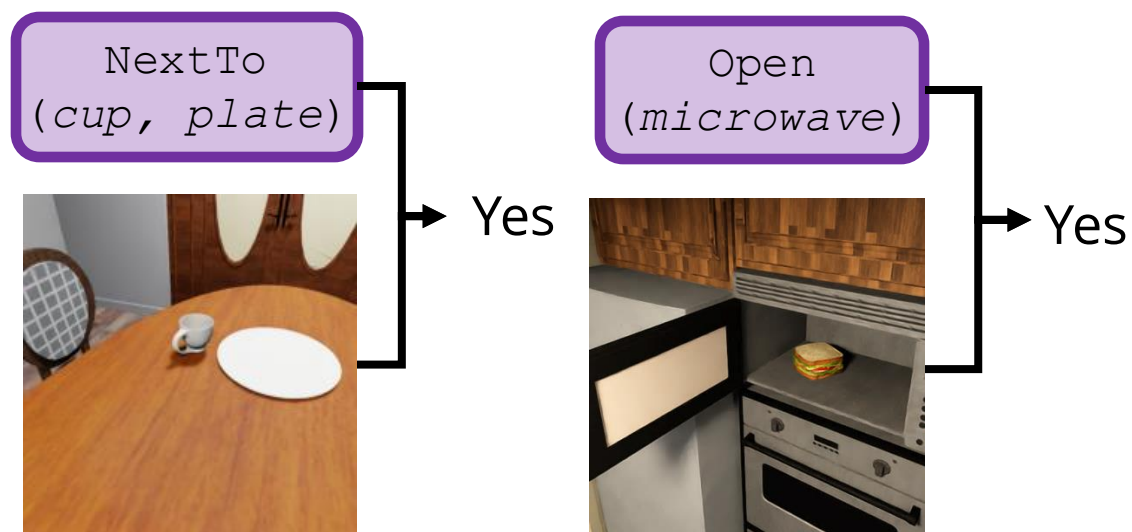
# State Classification



# State Classification



# State Classification



## Training State Classification

NextTo  
(*cup*, *plate*)



Yes

Open  
(*microwave*)



Yes

## Few-Shot Test with Novel Predicates

## Training State Classification

NextTo  
(*cup*, *plate*)



Yes

Open  
(*microwave*)



Yes

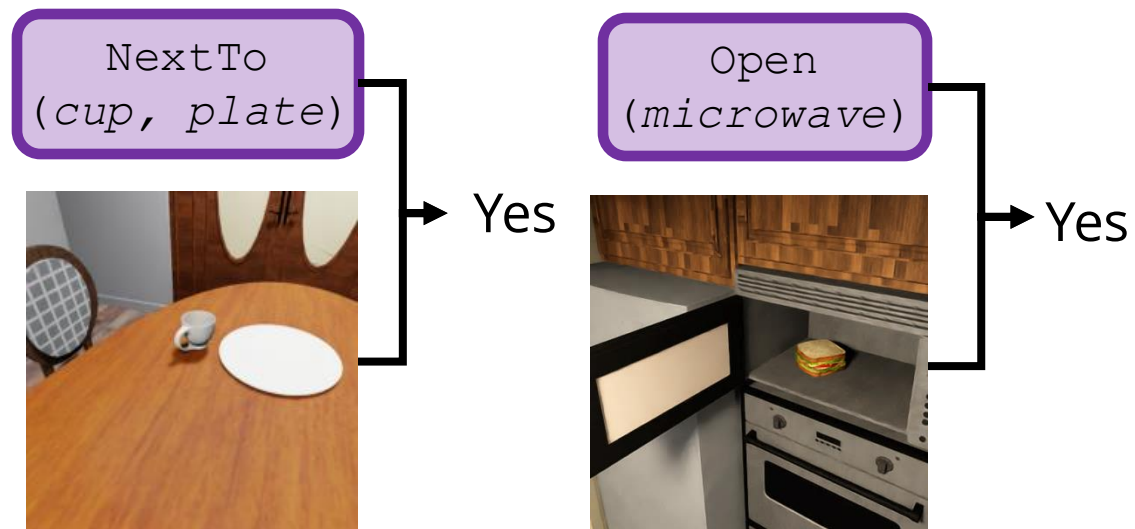
## Few-Shot Test with Novel Predicates

OnLeft  
(*cup*, *plate*)

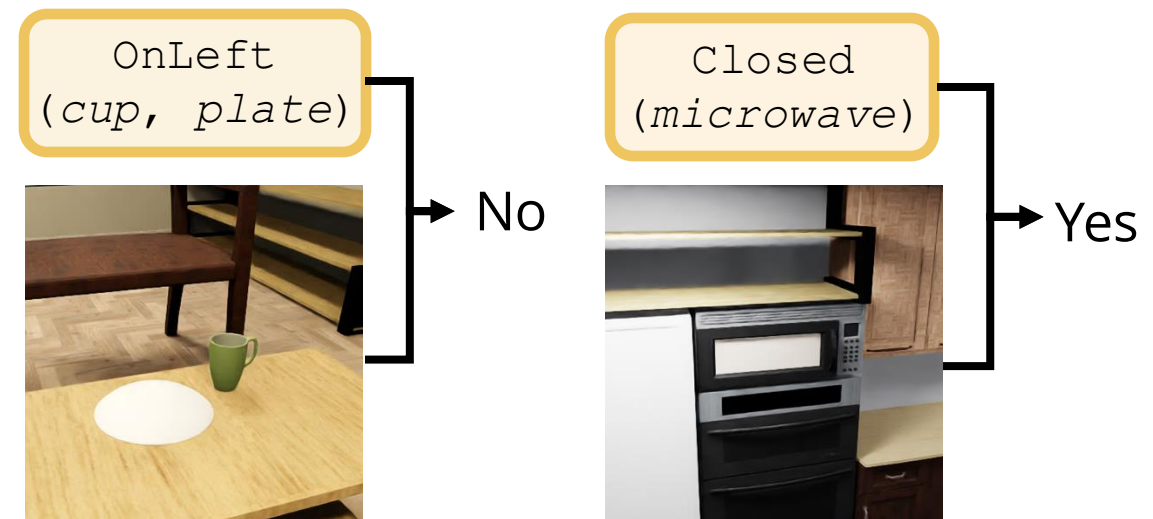


No

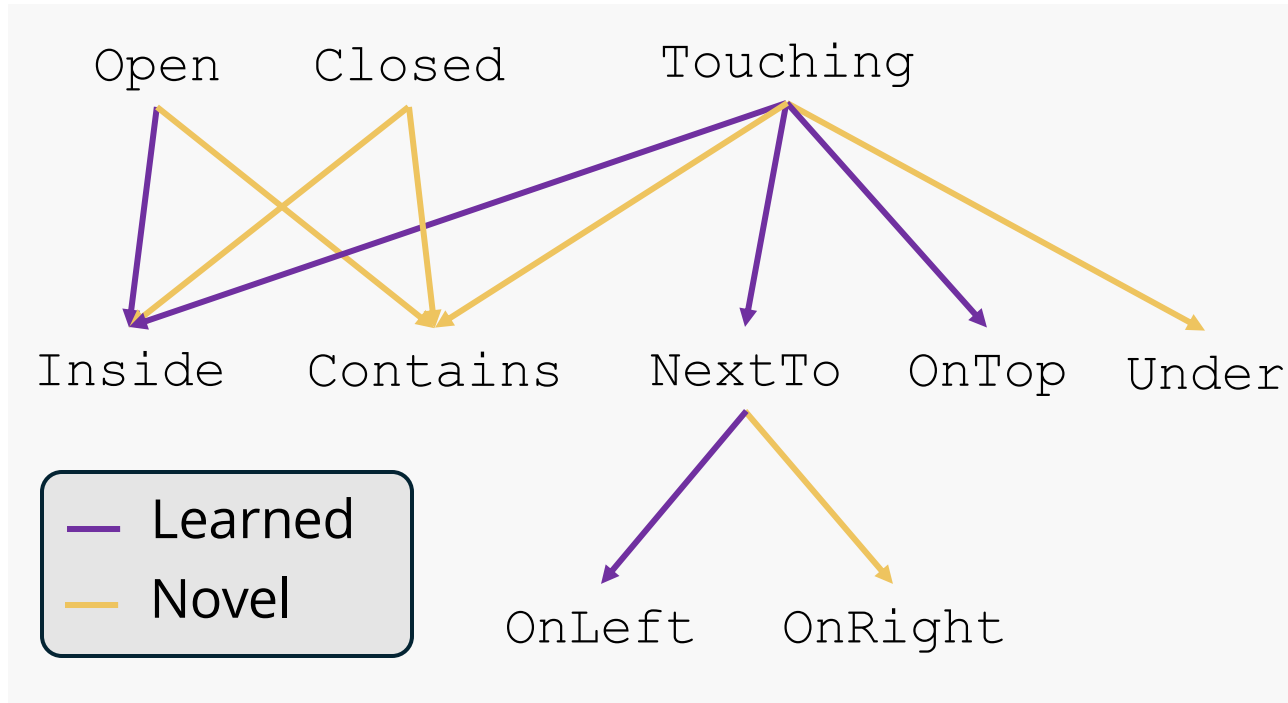
## Training State Classification



## Few-Shot Test with Novel Predicates

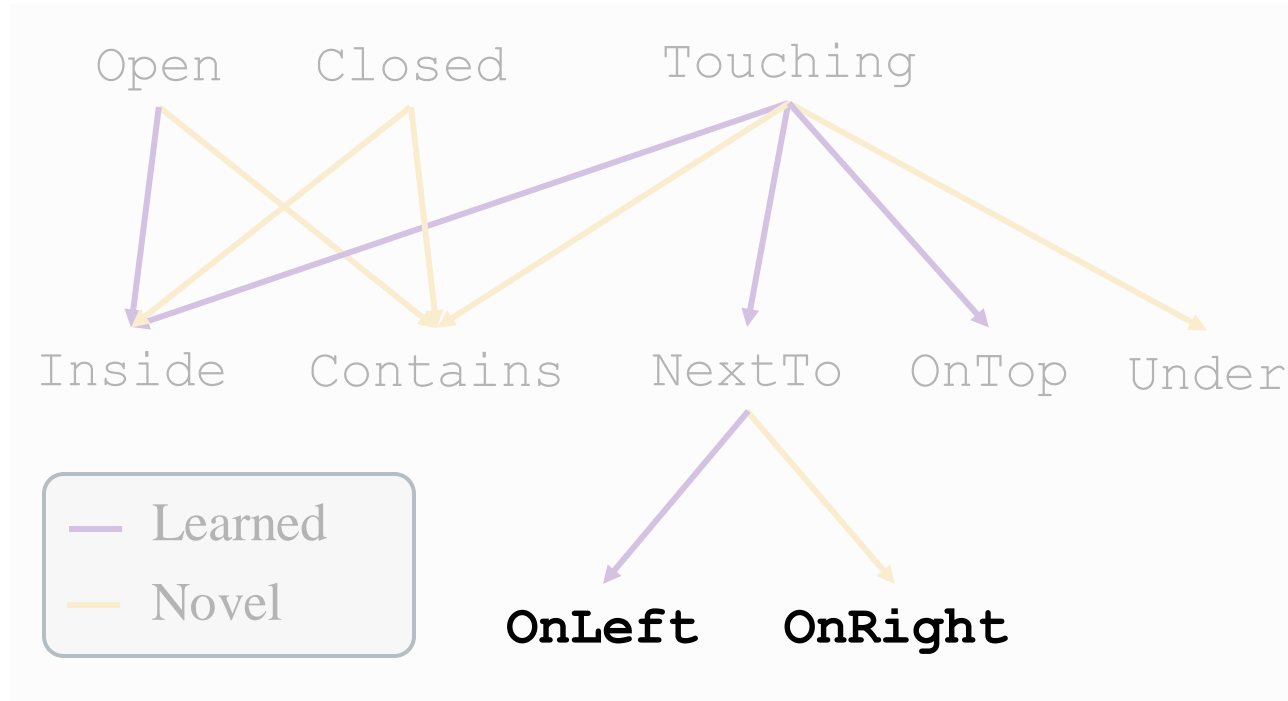


# We propose to reason with **Predicate Hierarchies.**

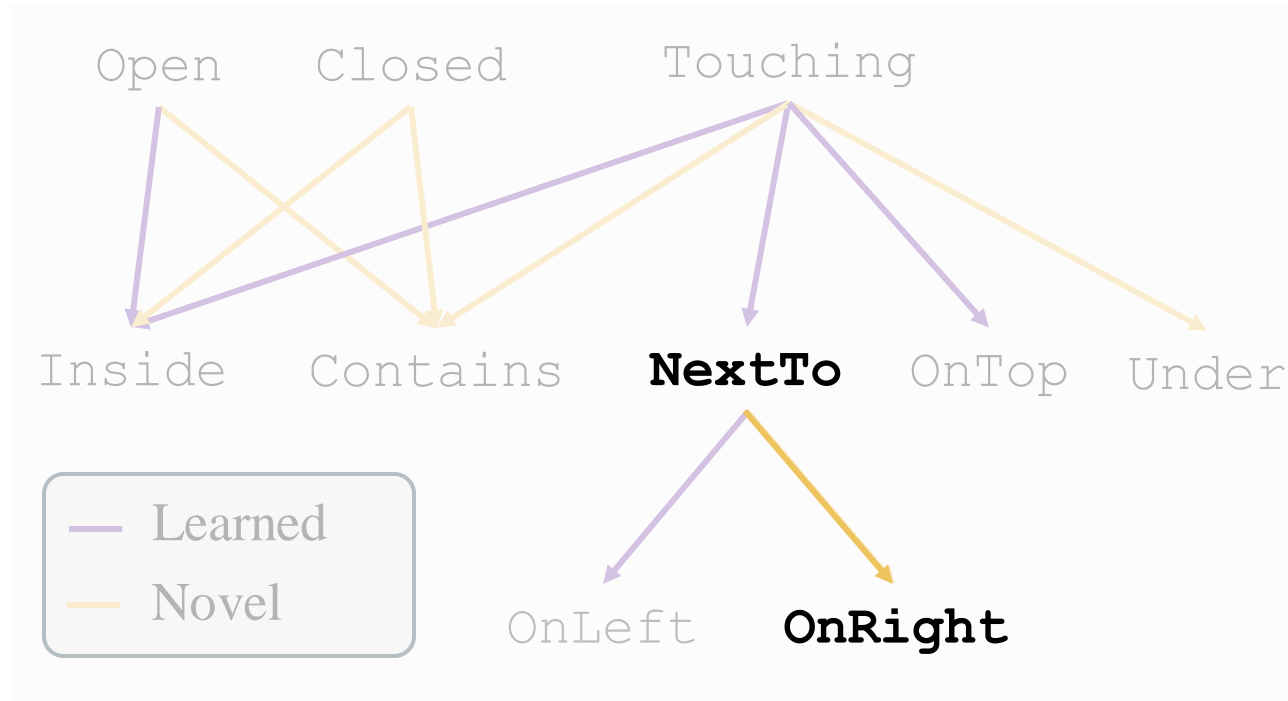




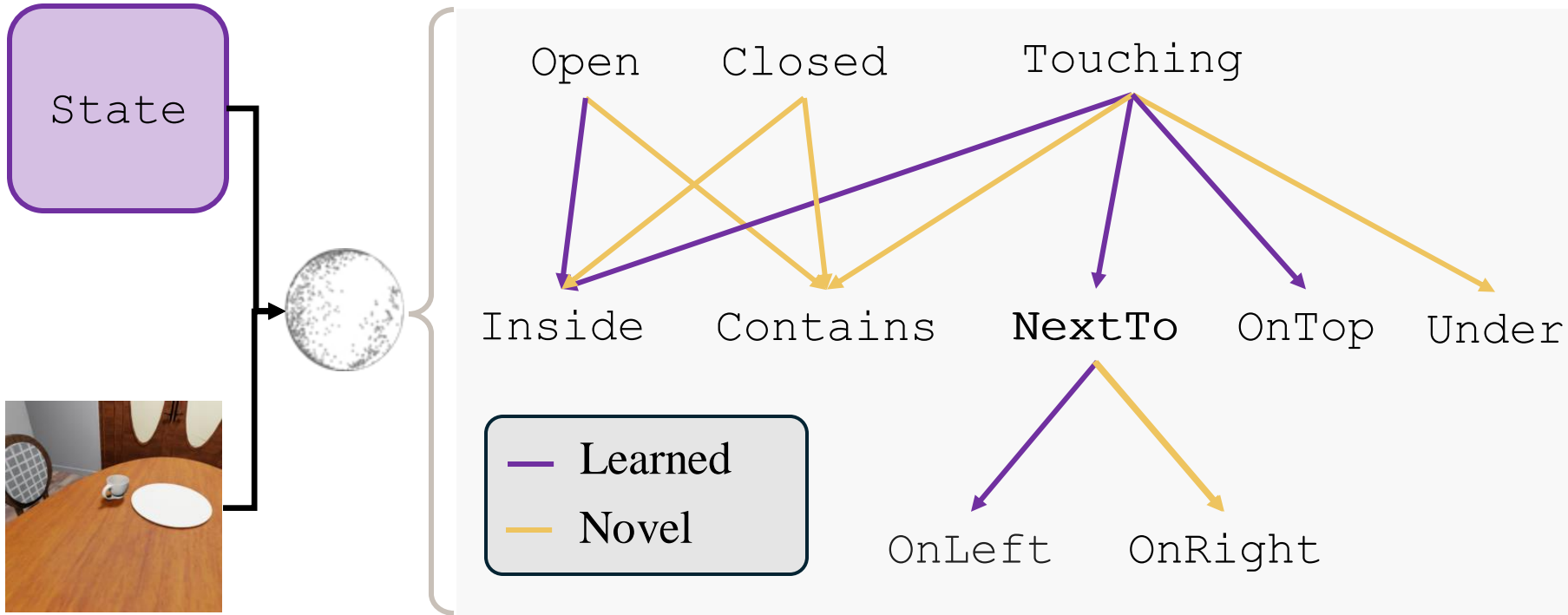
# We propose to reason with **Predicate Hierarchies.**



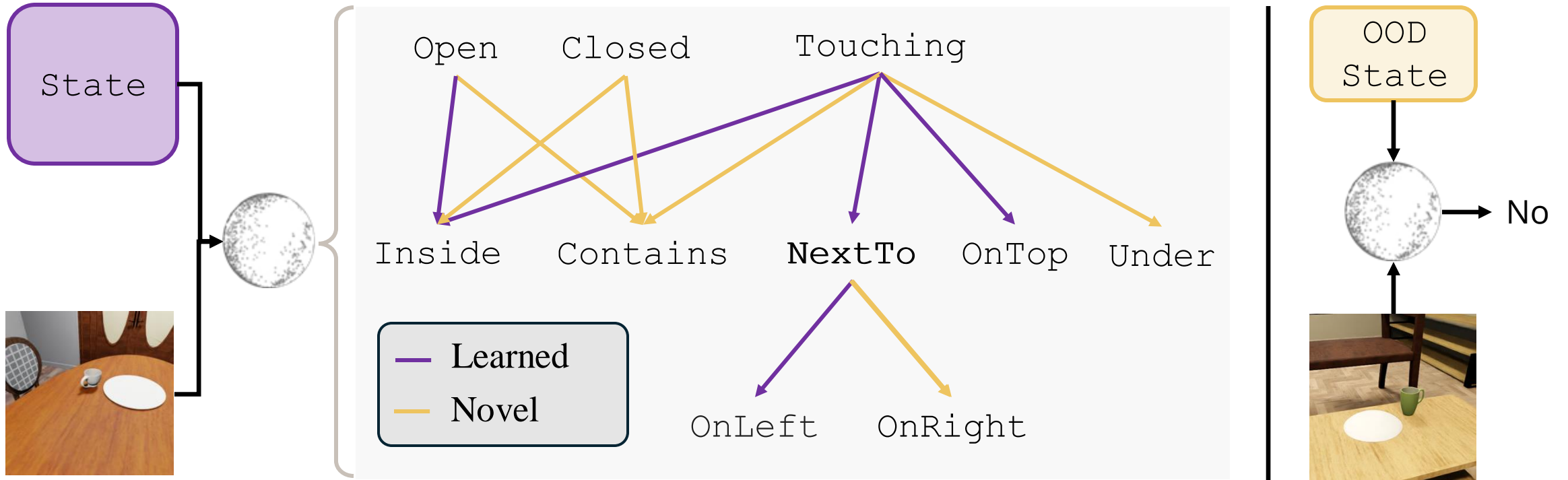
# We propose to reason with **Predicate Hierarchies.**



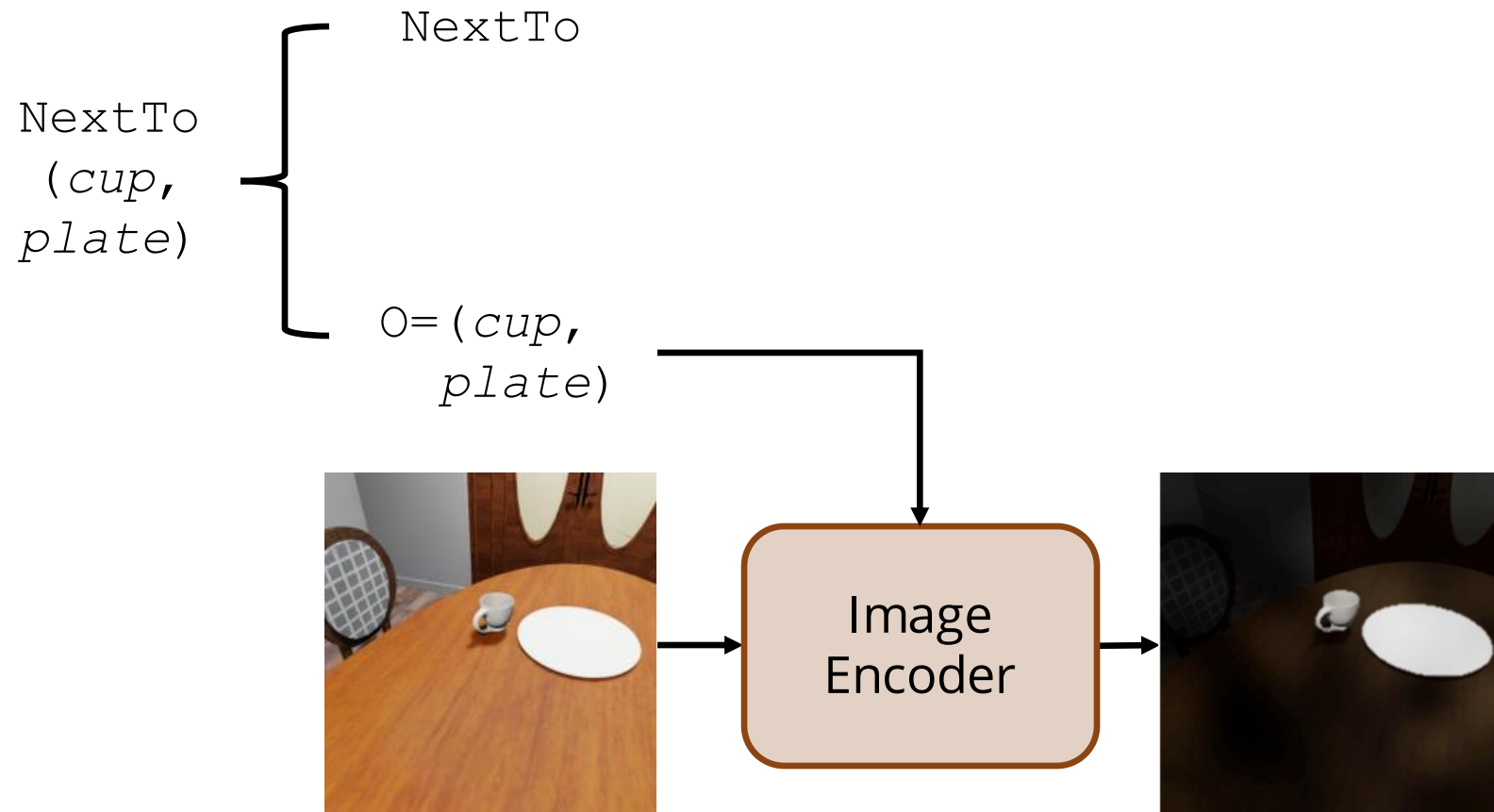
# We propose to reason with **Predicate Hierarchies.**



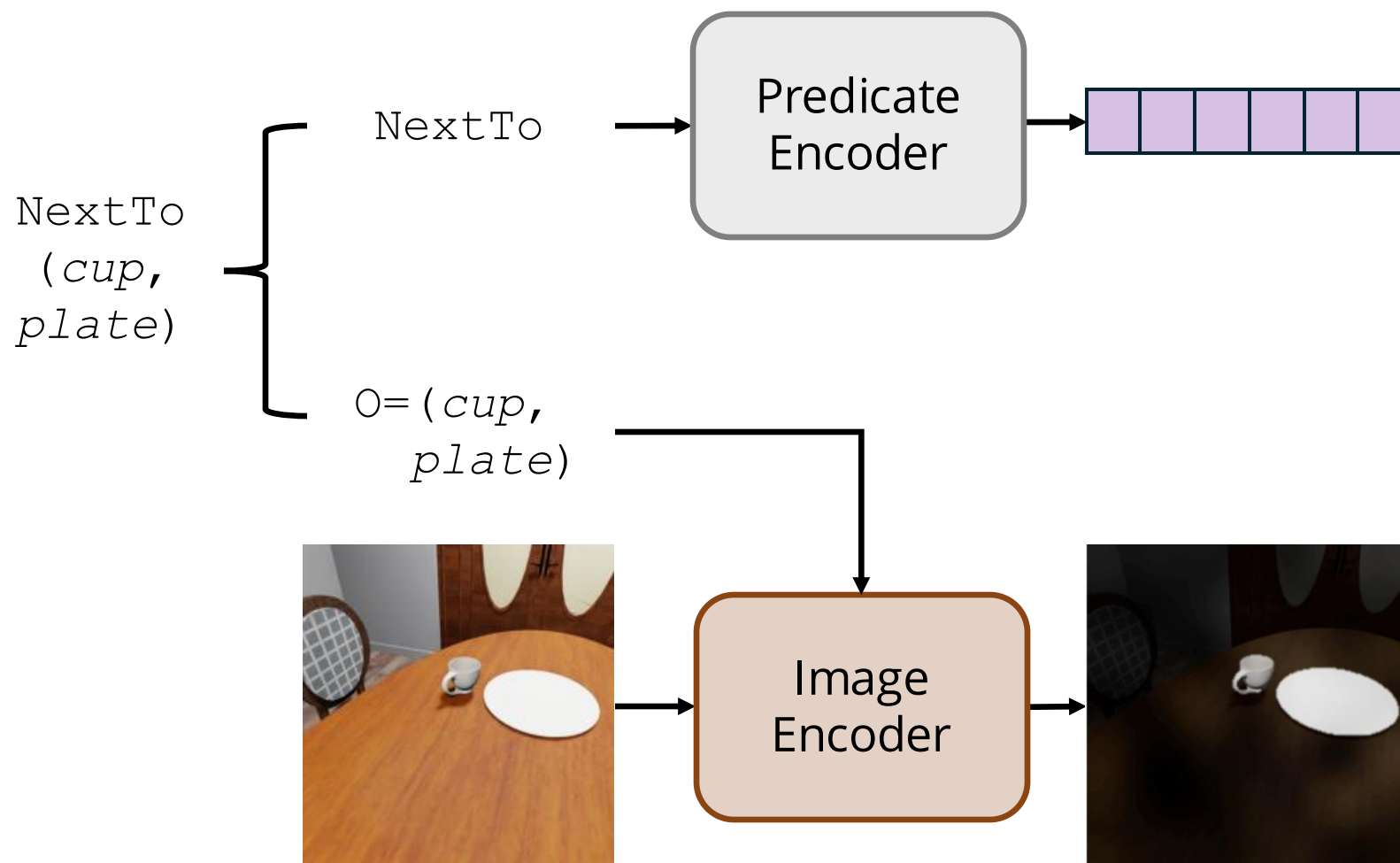
# We propose to reason with **Predicate Hierarchies.**



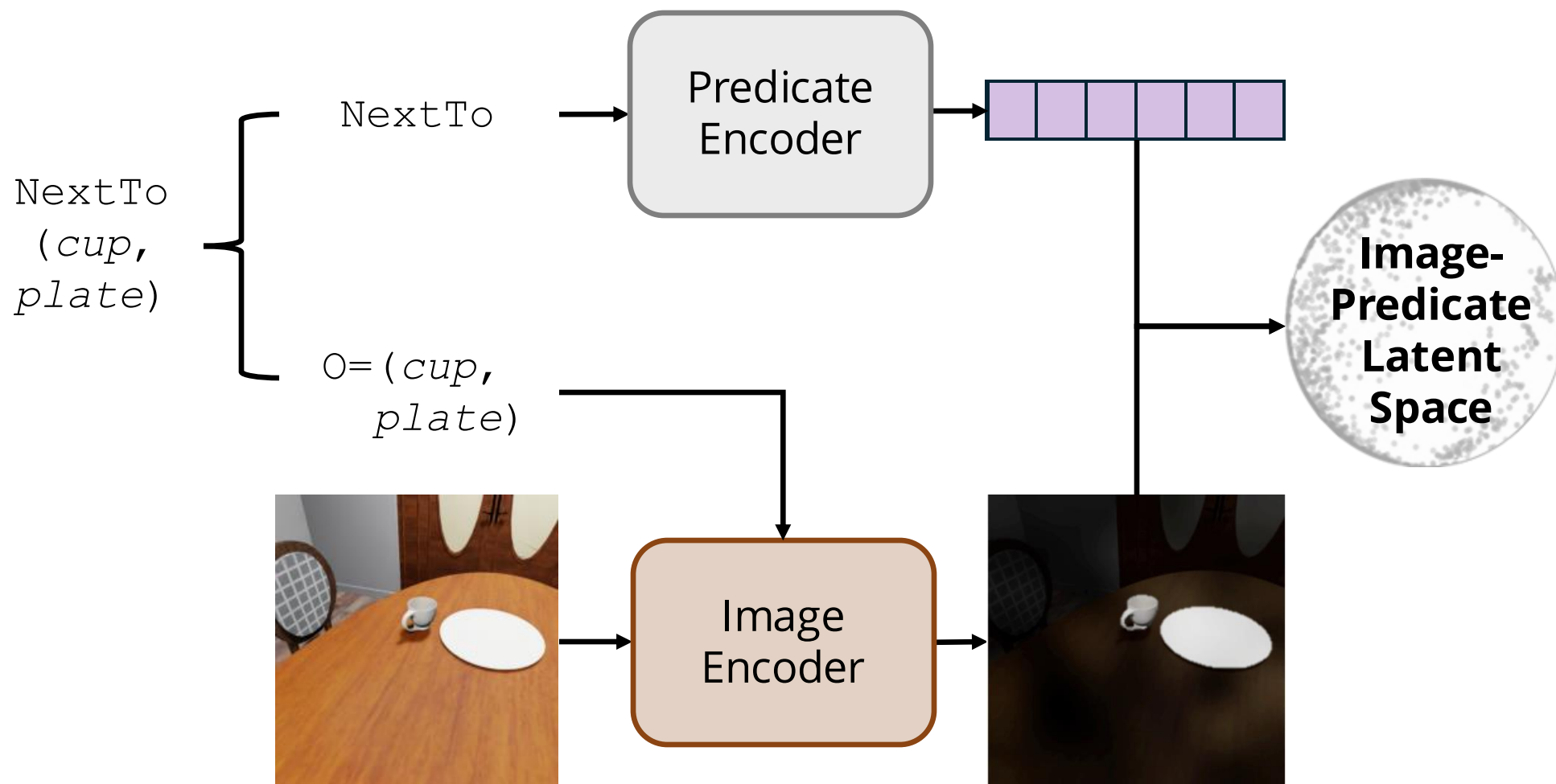
PHIER localizes relevant **entities** in the scene based on the state classification query.



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Self-supervised losses encourage learning  
**pairwise predicate relations** queried from LLMs.



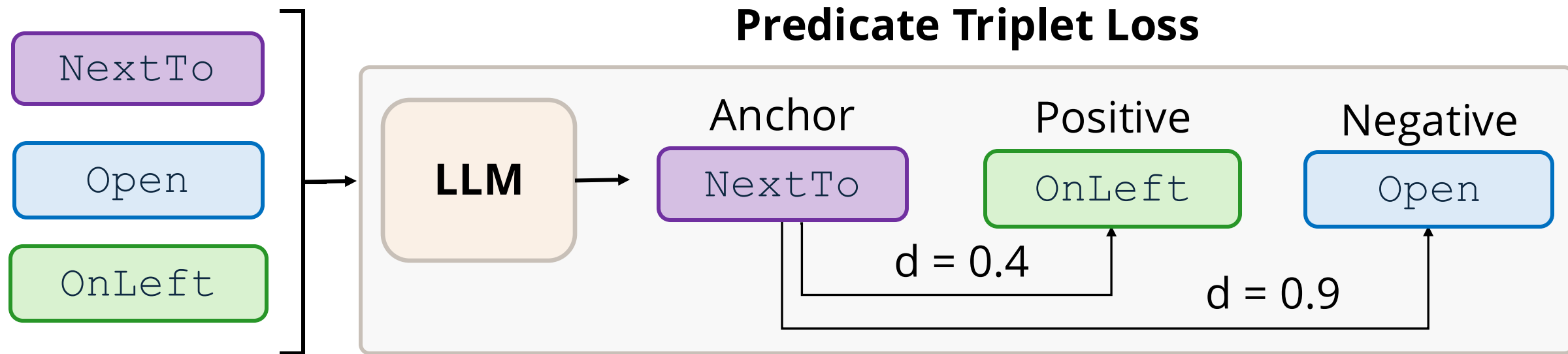
Self-supervised losses encourage learning  
**pairwise predicate relations** queried from LLMs.

NextTo

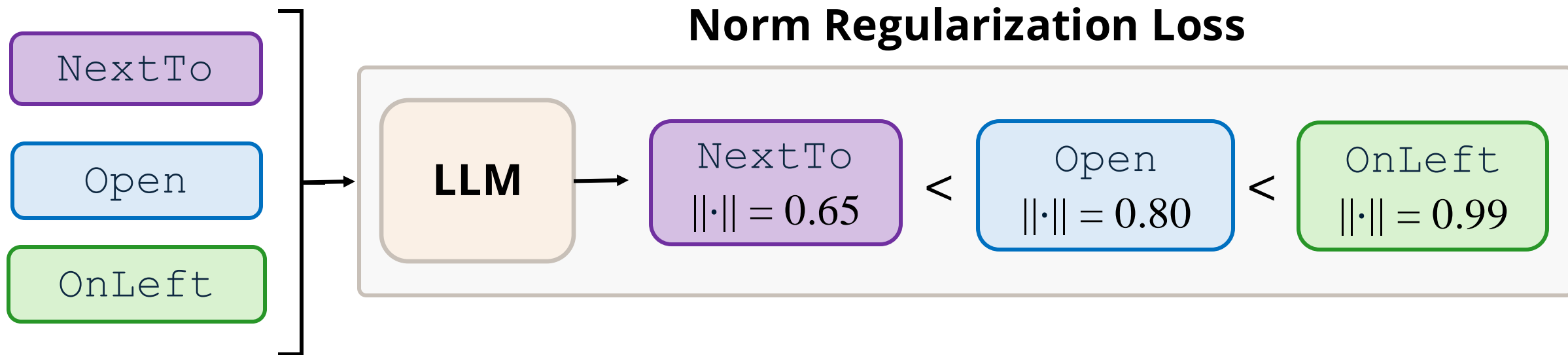
Open

OnLeft

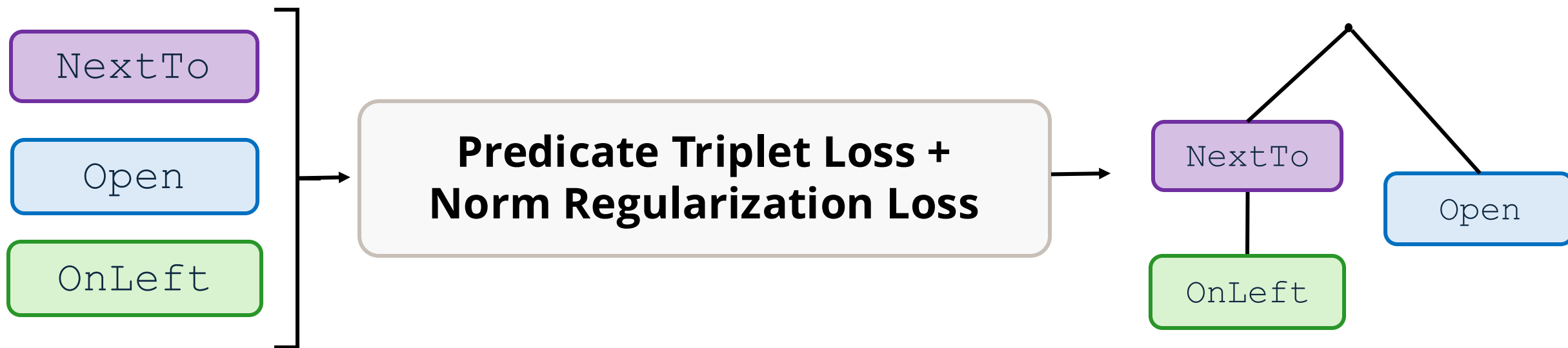
Self-supervised losses encourage learning **pairwise predicate relations** queried from LLMs.



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A hyperbolic distance metric encodes the **hierarchical nature** of predicates in continuous space.

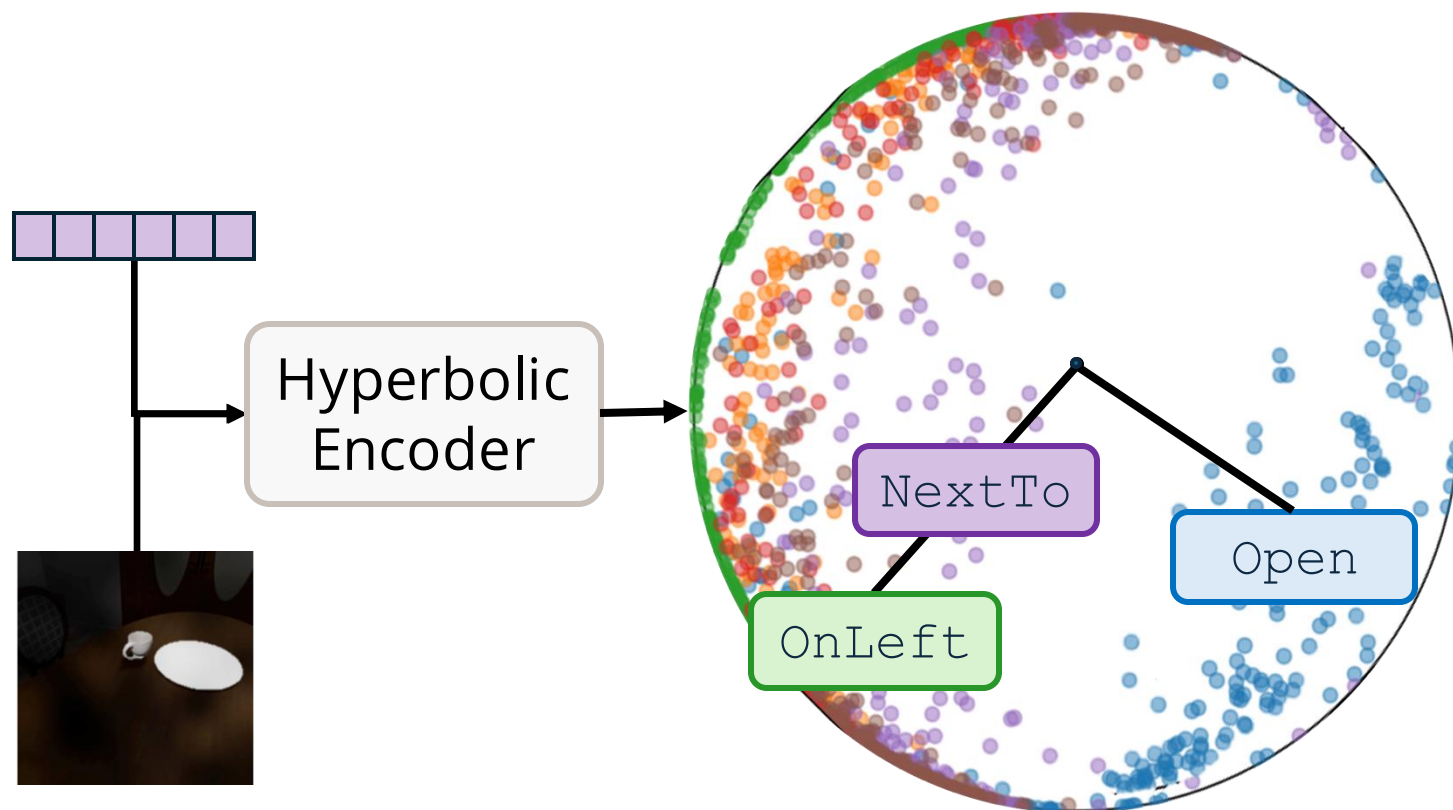
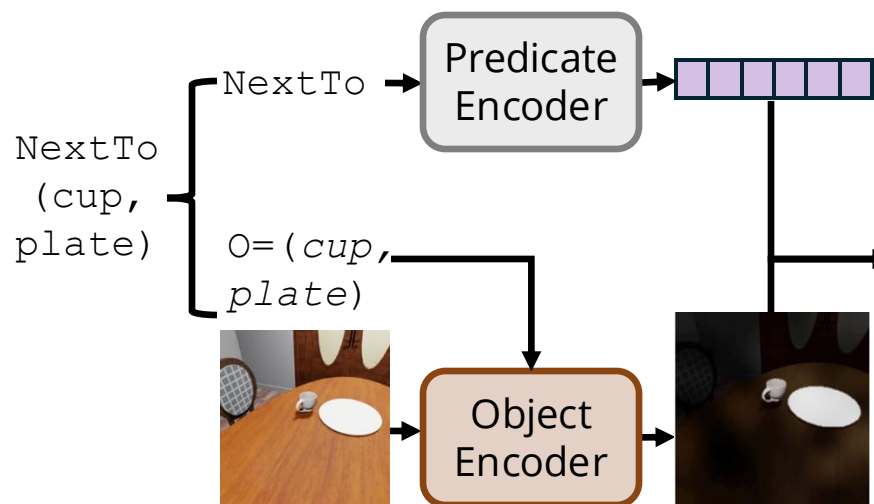


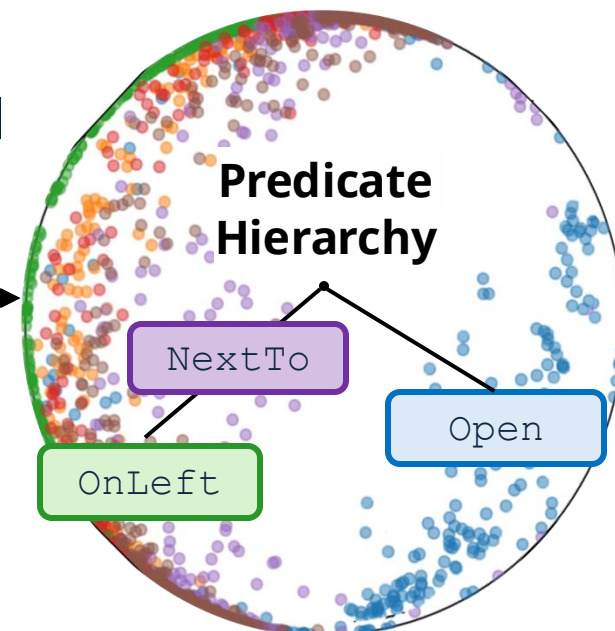
Image-Predicate Space  
on the Poincaré Ball  
with Distance Metric

$$d_p(x, y) = \cosh^{-1} \left( 1 + 2 \frac{\|x - y\|^2}{(1 - \|x\|^2)(1 - \|y\|^2)} \right)$$

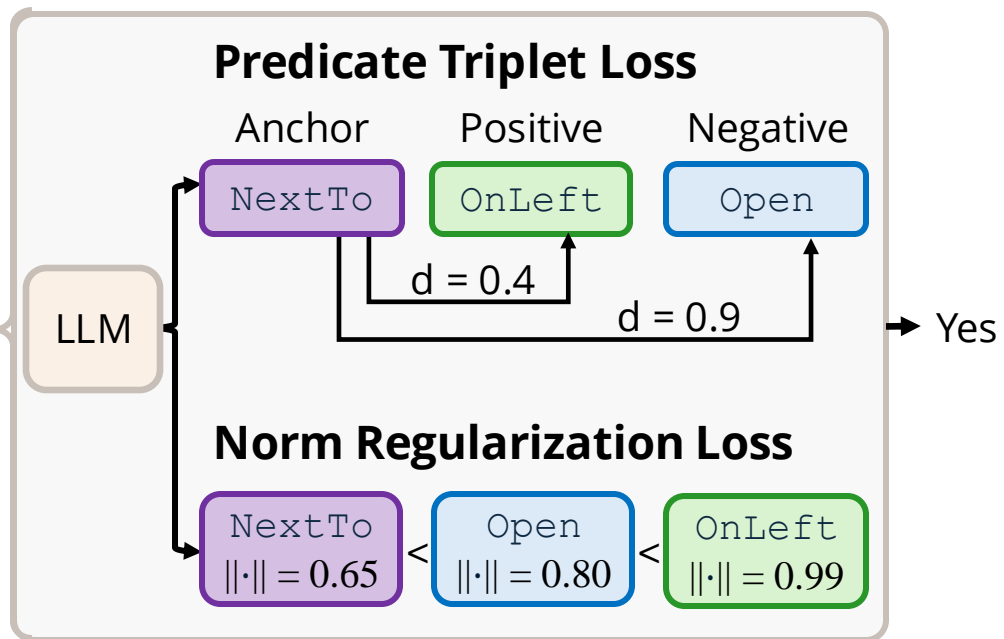
## Object & Predicate Encoders



## Image-Predicate Space on Poincaré Ball



## Self-Supervised Losses



# OOD Generalization

CALVIN

Open (drawer)



Open (slider)



OnTop (pink block, table)



OnTop (blue block, table)



Inside (blue block, slider)

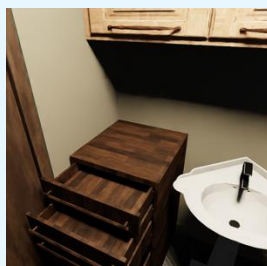


Inside (blue block, drawer)

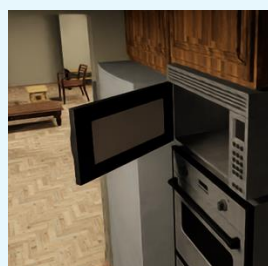


BEHAVIOR

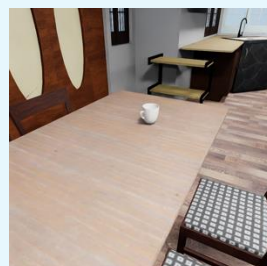
Open (drawer)



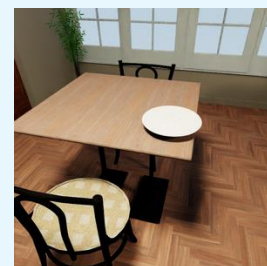
Open (microwave)



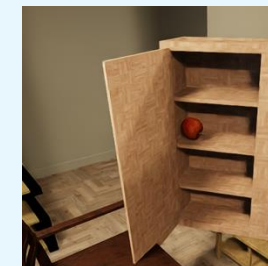
OnTop (coffee cup, table)



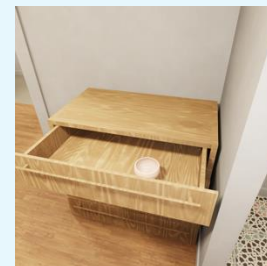
OnTop (plate, table)



Inside (apple, cabinet)



Inside (coffee cup, drawer)



Real-World

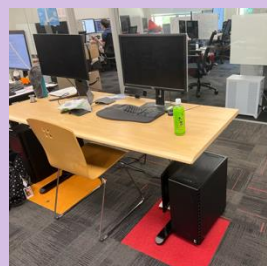
Open (drawer)



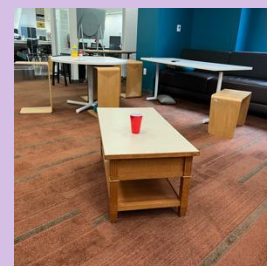
Open (cabinet)



OnTop (bottle, table)



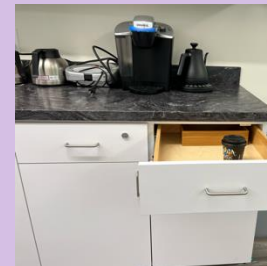
OnTop (cup, table)



Inside (bottle, microwave)



Inside (coffee cup, drawer)





CALVIN

Open (drawer)



Open (slider)



OnTop (pink block, table)



OnTop (blue block, table)



Inside (blue block, slider)

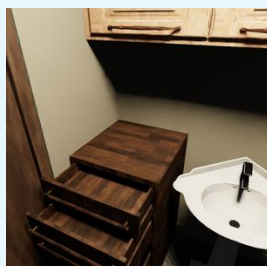


Inside (blue block, drawer)

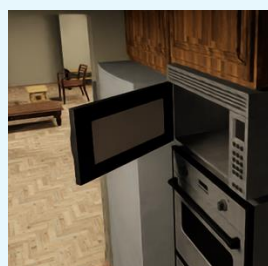


BEHAVIOR

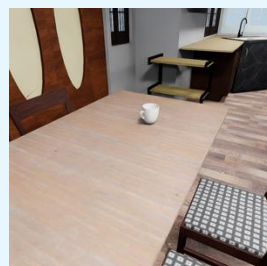
Open (drawer)



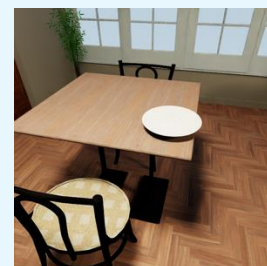
Open (microwave)



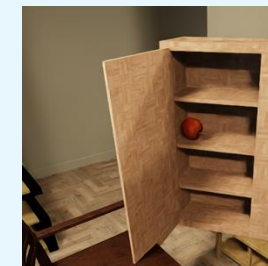
OnTop (coffee cup, table)



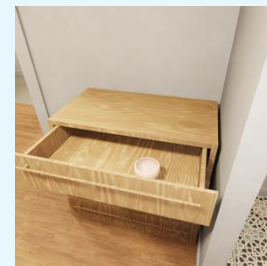
OnTop (plate, table)



Inside (apple, cabinet)



Inside (coffee cup, drawer)



Real-World

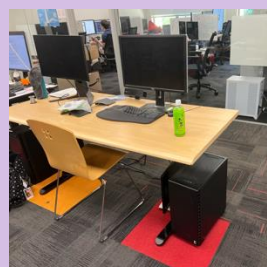
Open (drawer)



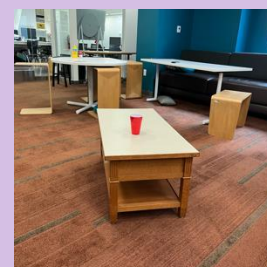
Open (cabinet)



OnTop (bottle, table)



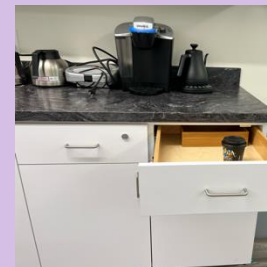
OnTop (cup, table)



Inside (bottle, microwave)



Inside (coffee cup, drawer)

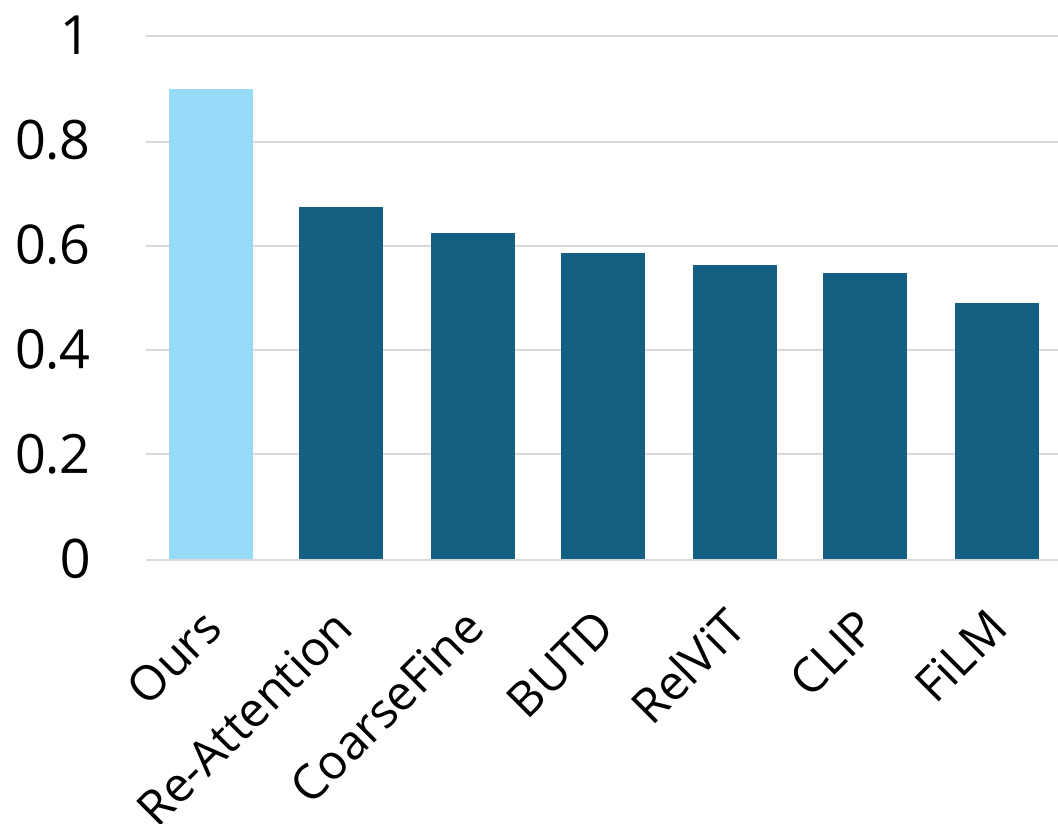


Transfer to  
Real-World

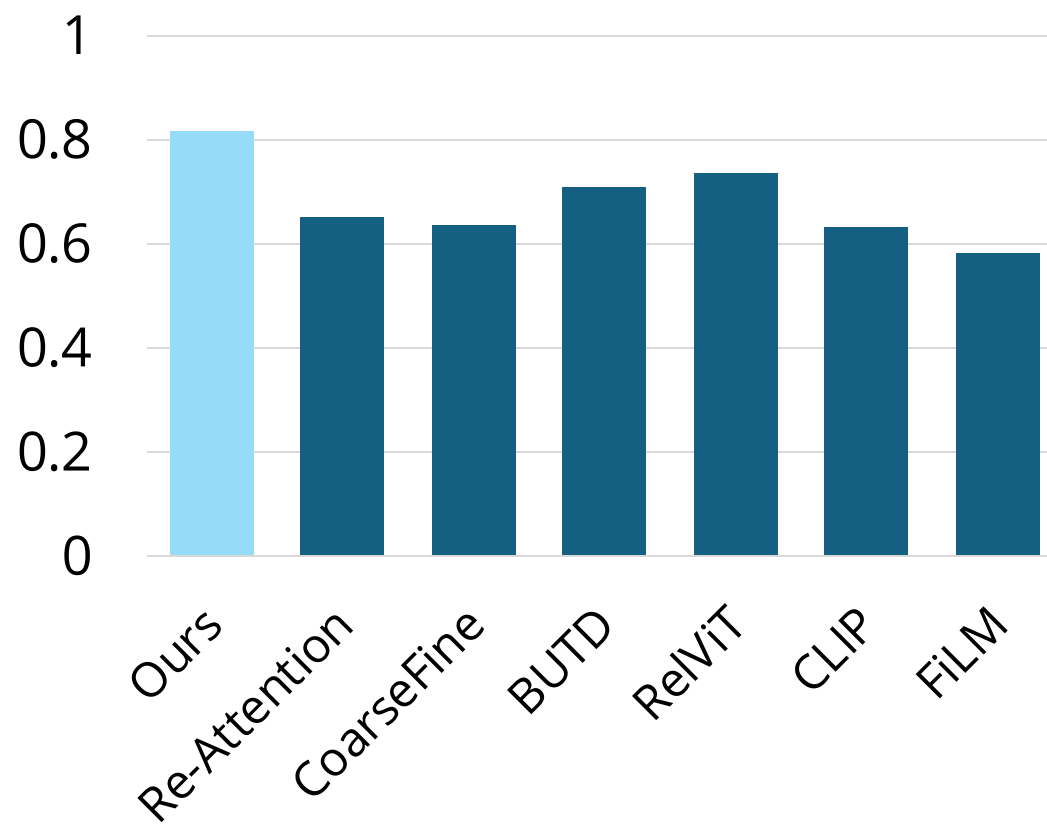


# Generalization to OOD States

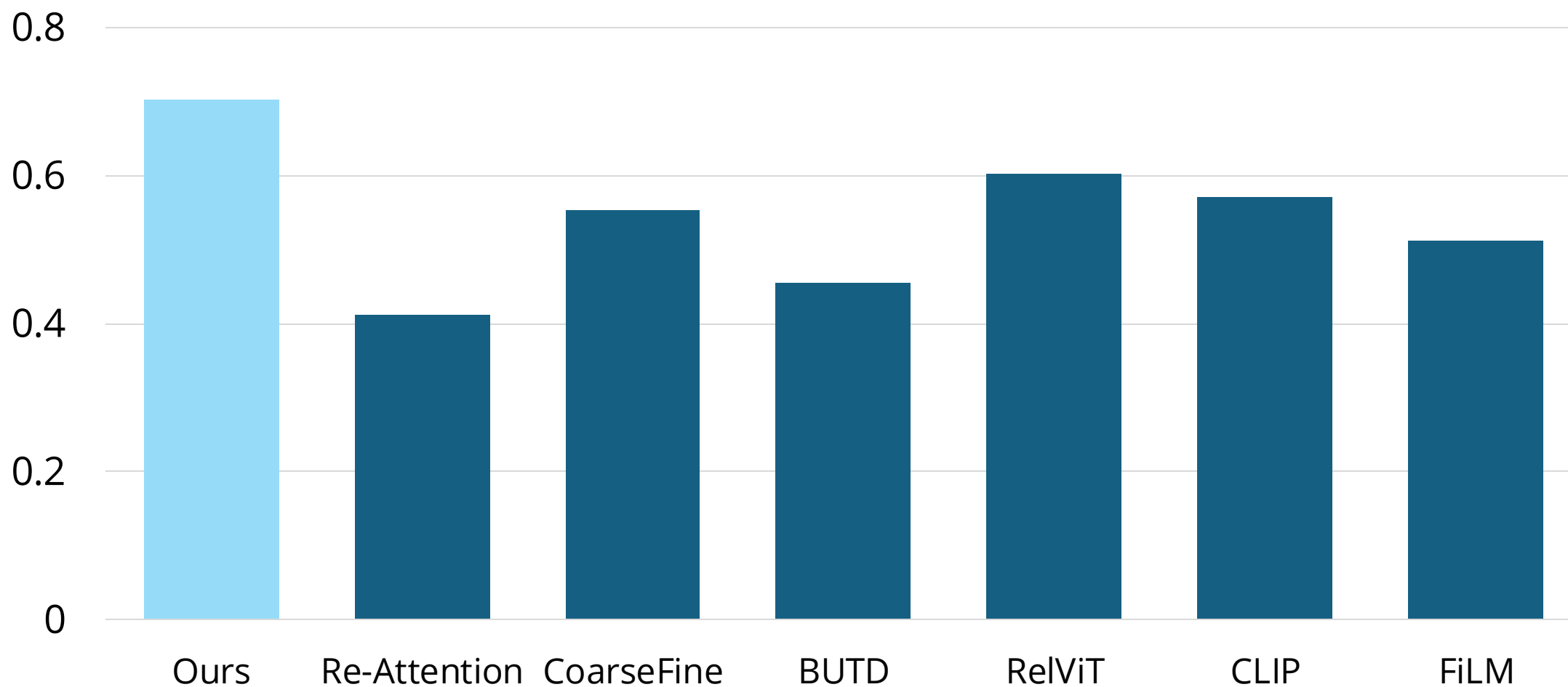
CALVIN



BEHAVIOR



# Transfer to Real-World Tasks



Overall, we see PHIER as a promising solution to **few-shot state classification**, enabling **generalization** by leveraging representations grounded in **predicate hierarchies**.

# Predicate Hierarchies



Project page: <https://emilyzjin.github.io/projects/phier.html>

Paper: <https://www.arxiv.org/pdf/2502.12481>

Code: <https://github.com/emilyzjin/phier>