

# Structured World Belief

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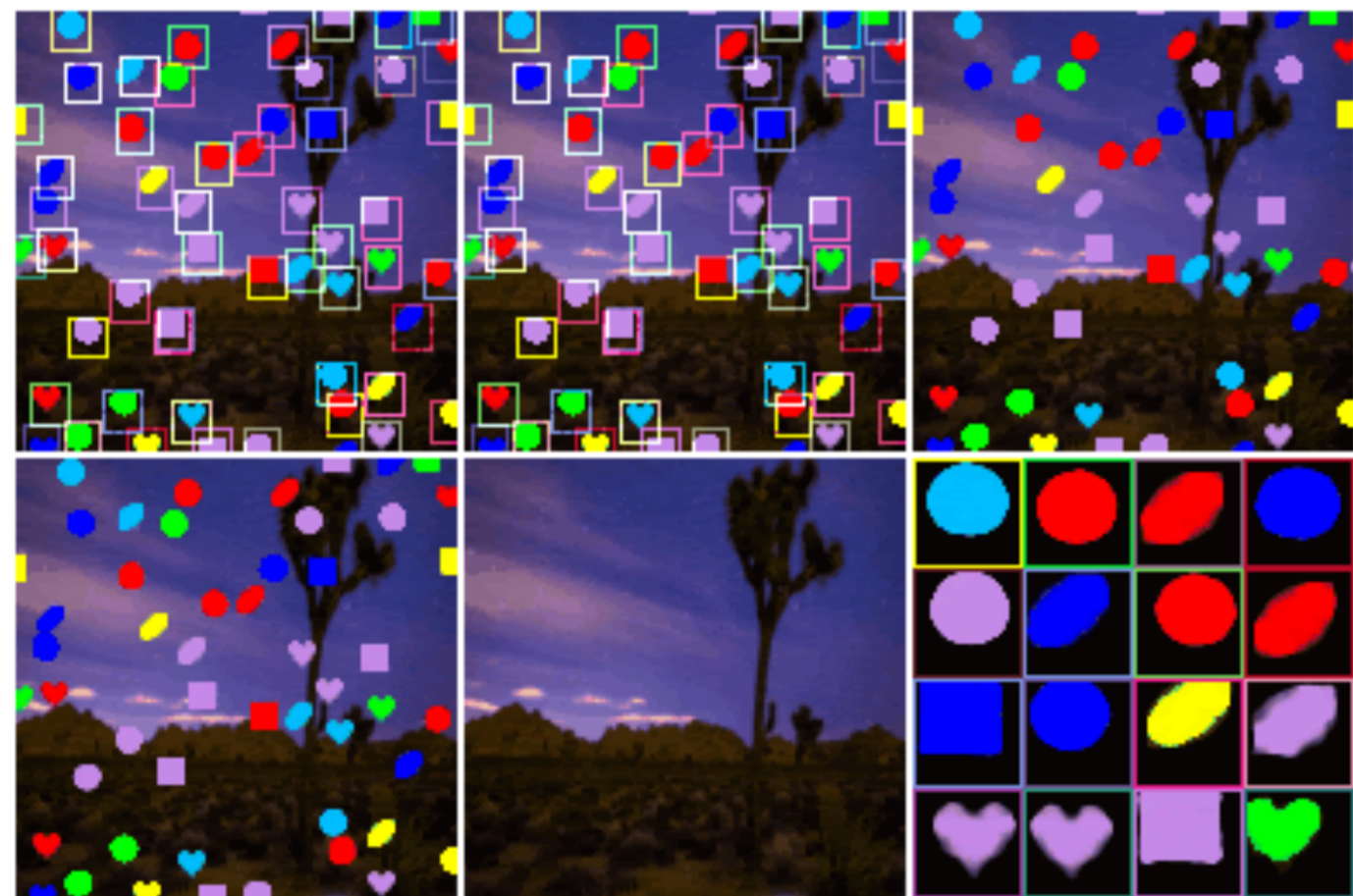
<sup>1</sup>Rutgers University, <sup>2</sup>ETRI



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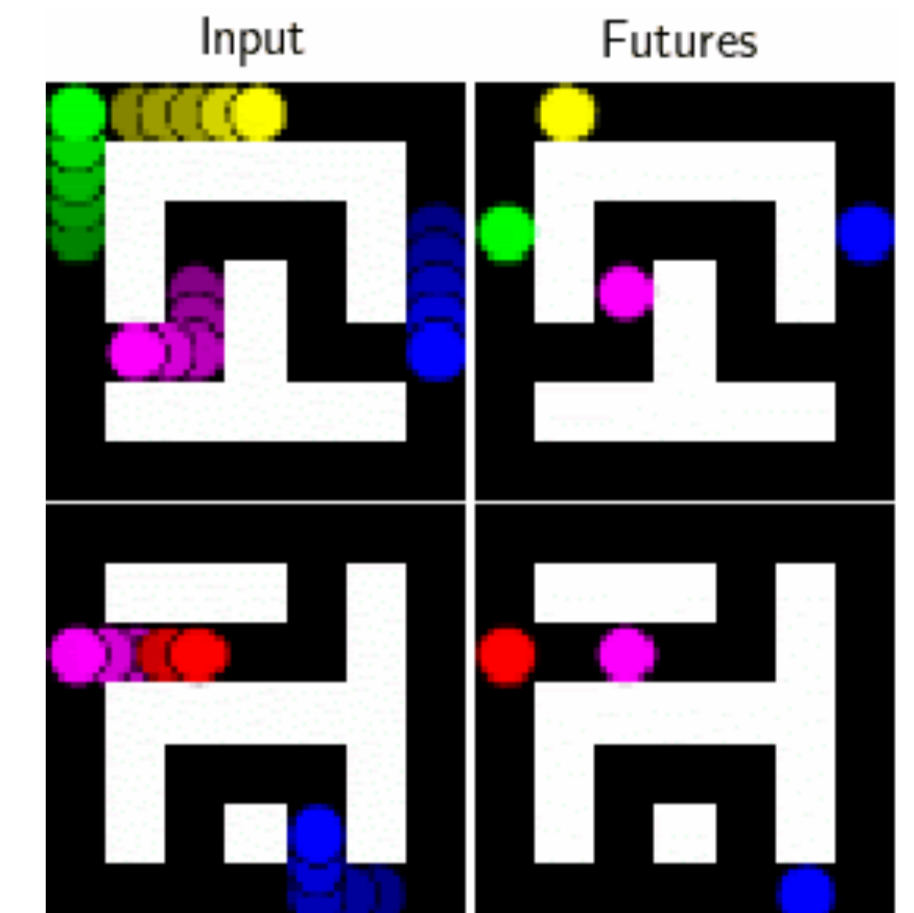
# Object-Centric Temporal Models



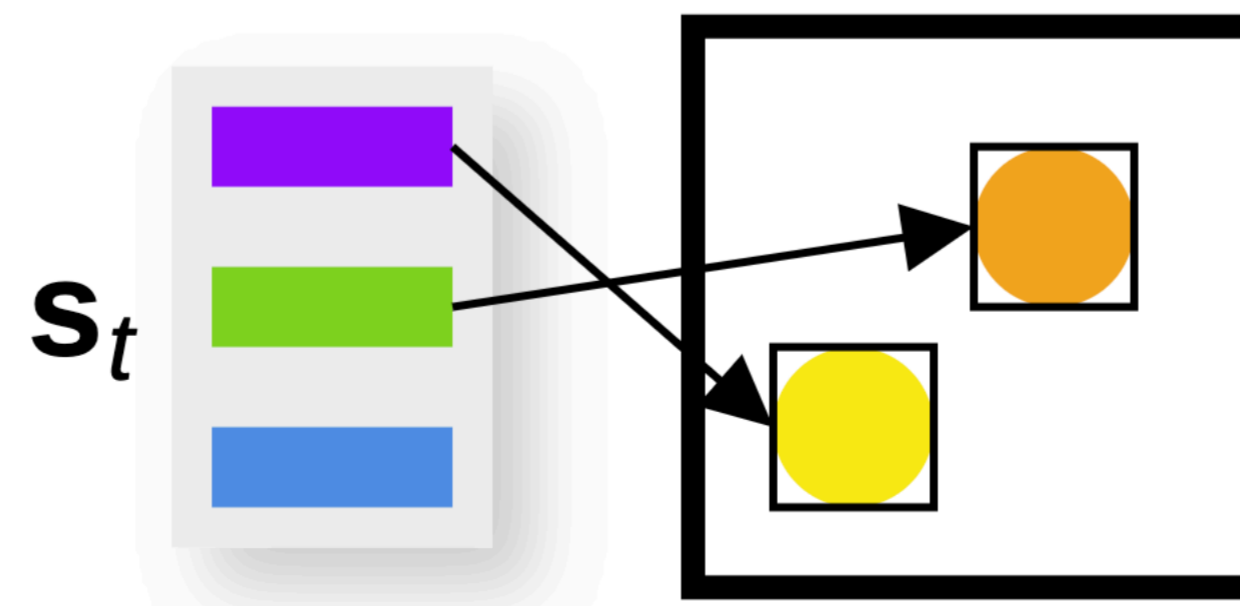
*SCALOR (Jiang et al., 2020)*



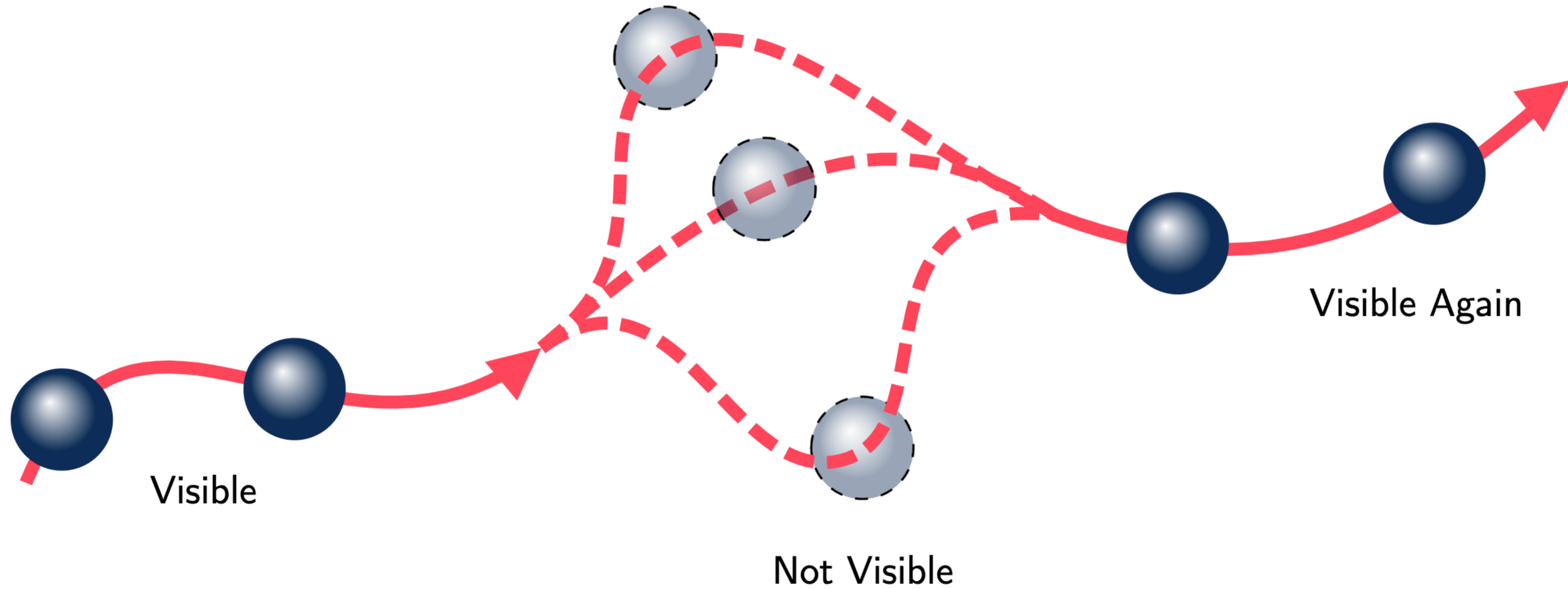
*SILOT (Crawford et al., 2020)*



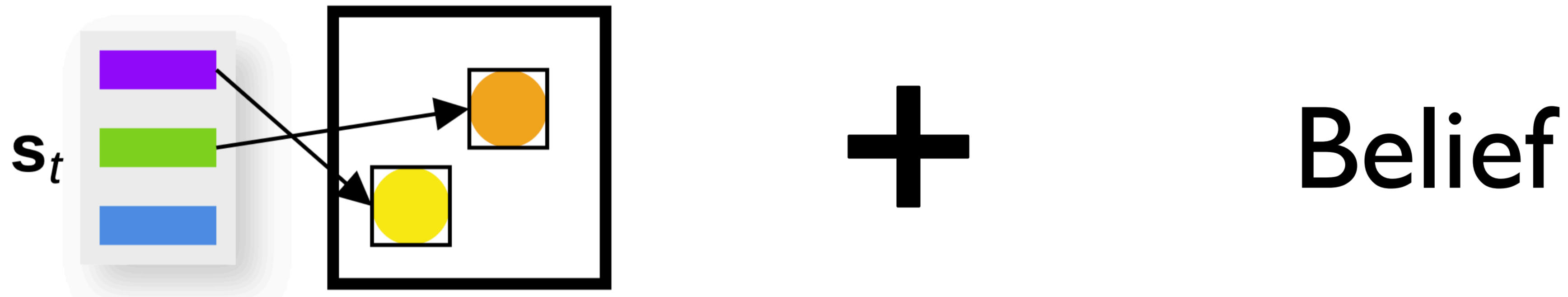
*GSWM (Lin et al., 2020)*



# Partial Observability and Belief



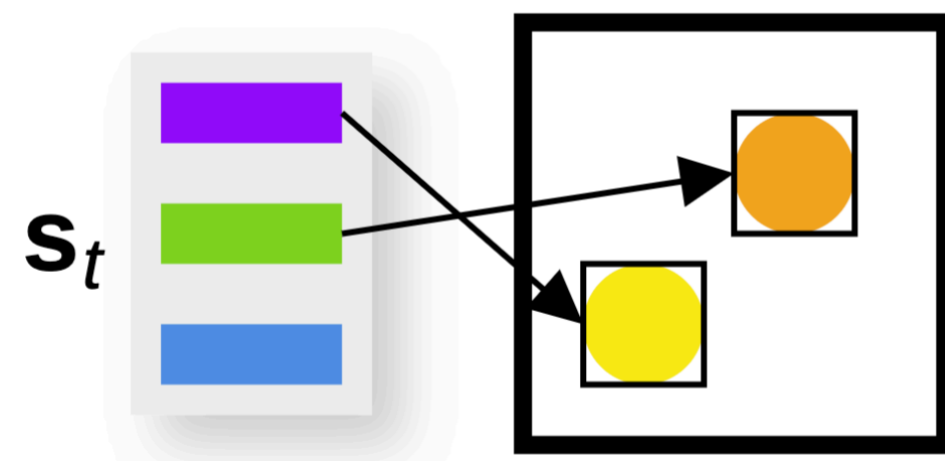
# Partial Observability and Belief



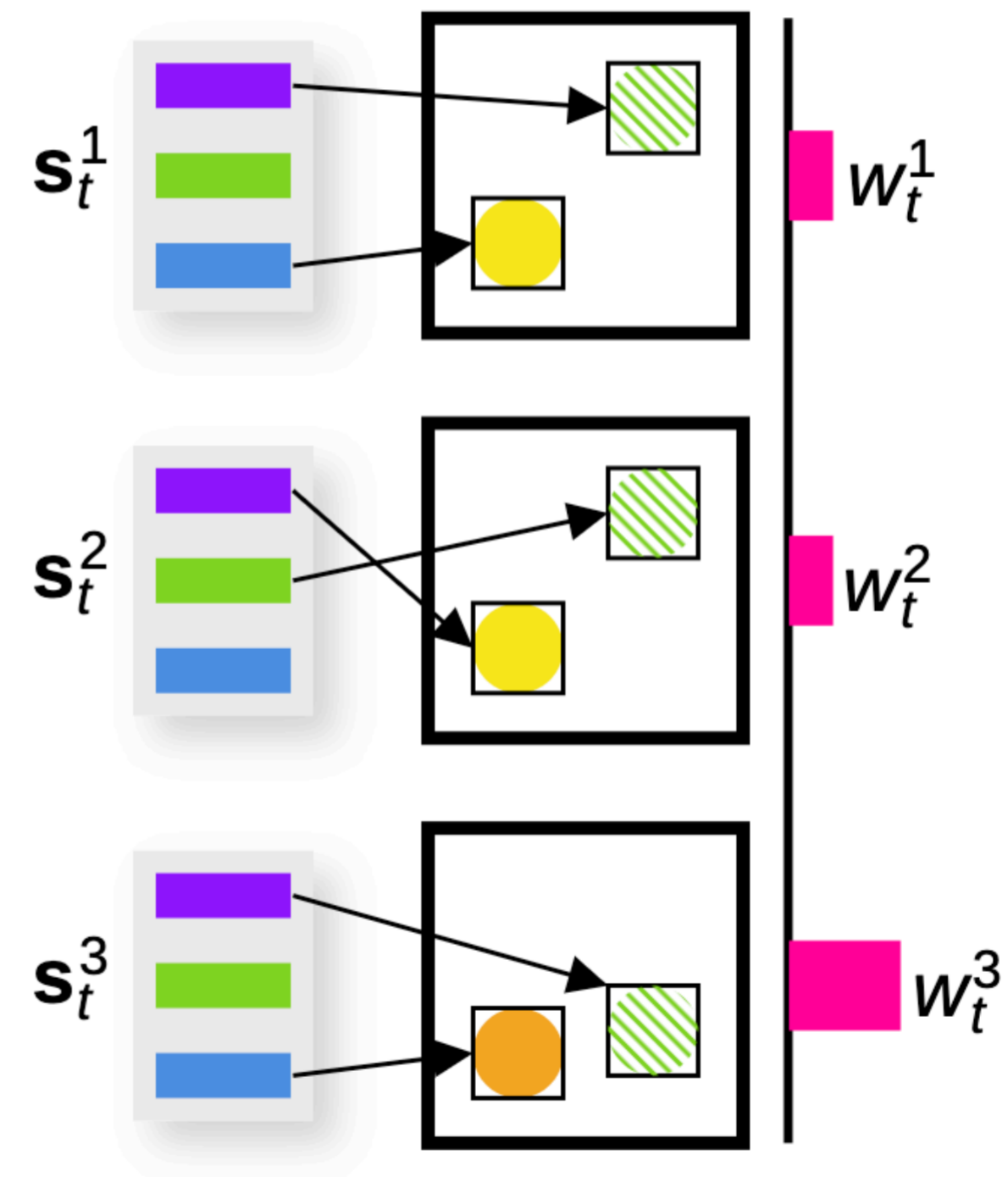
Can we integrate **object-centric** and **belief** representations into one model?

# Our Approach

How can we represent the object-level uncertainty?



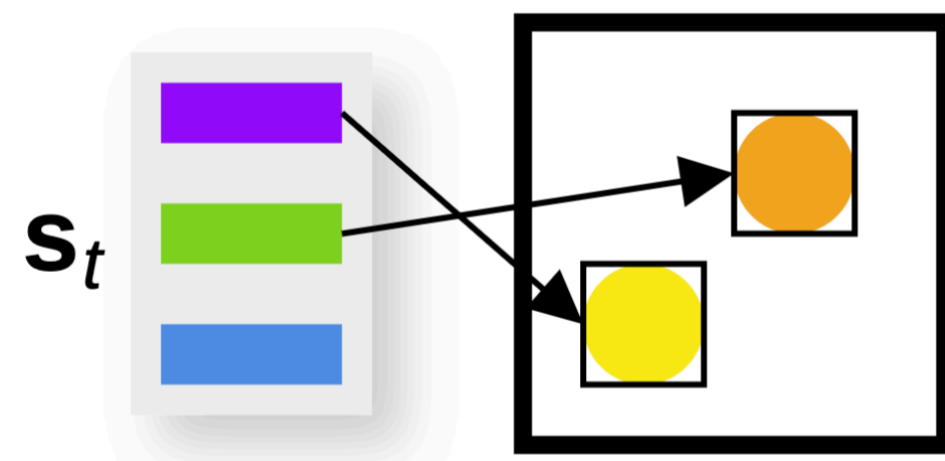
Previous Object-Centric Models



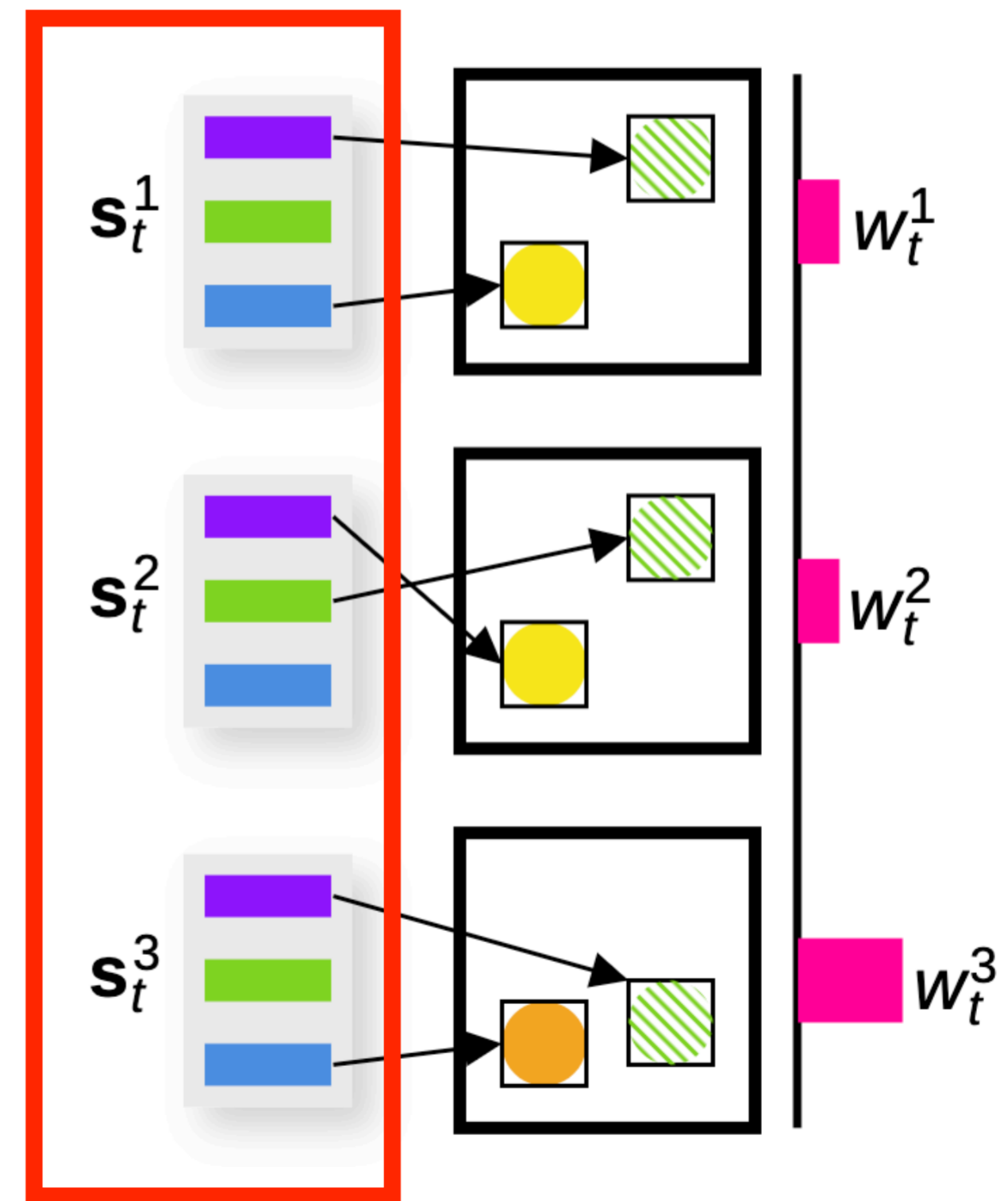
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# Our Approach

How can we represent the object-level uncertainty?



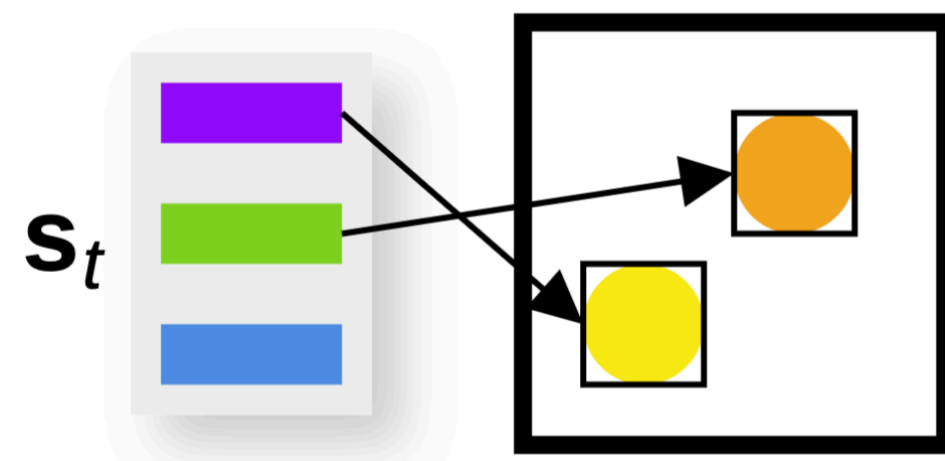
Previous Object-Centric Models



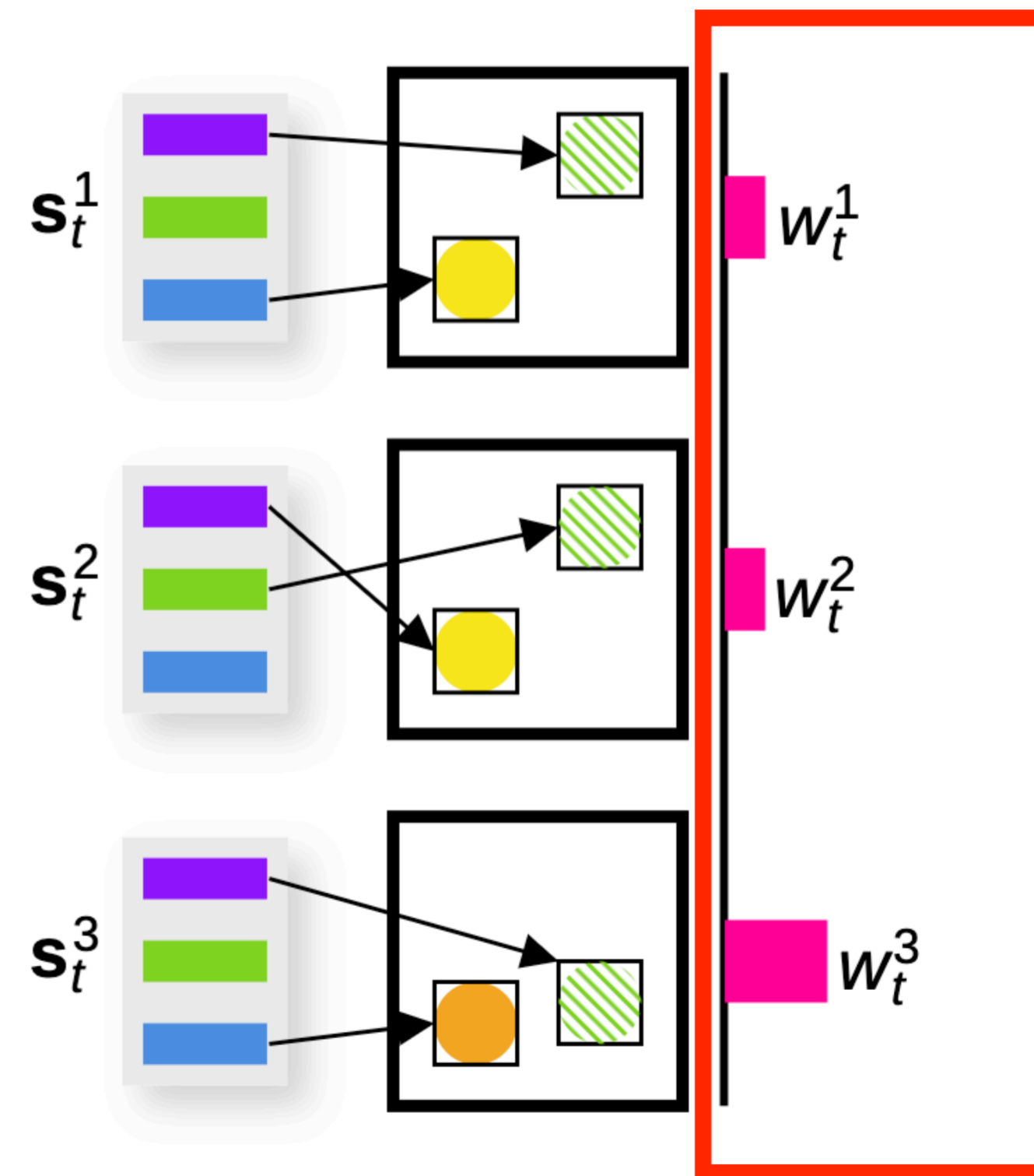
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# Our Approach

How can we represent the object-level uncertainty?



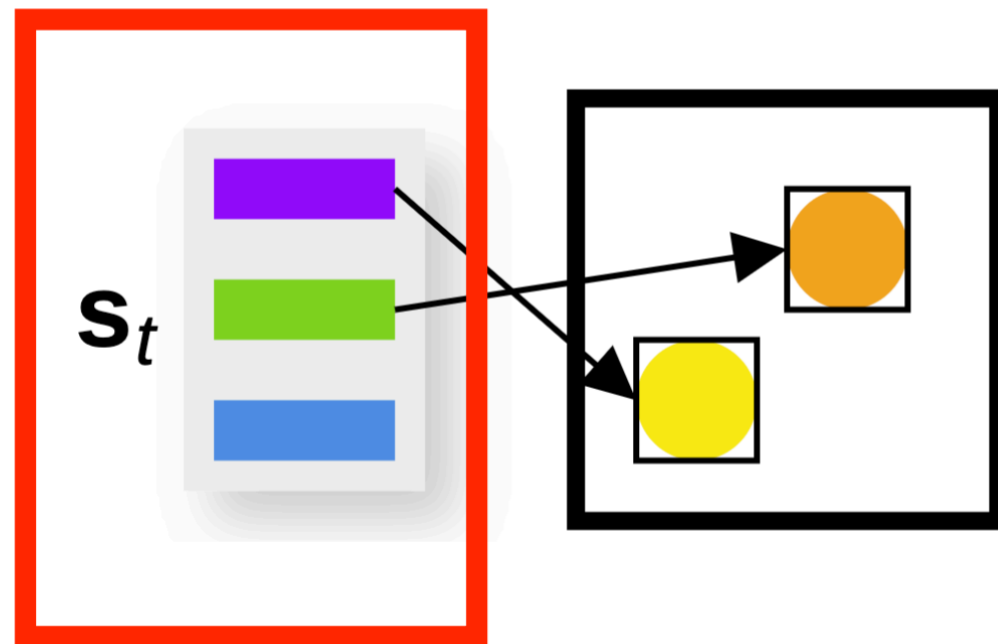
Previous Object-Centric Models



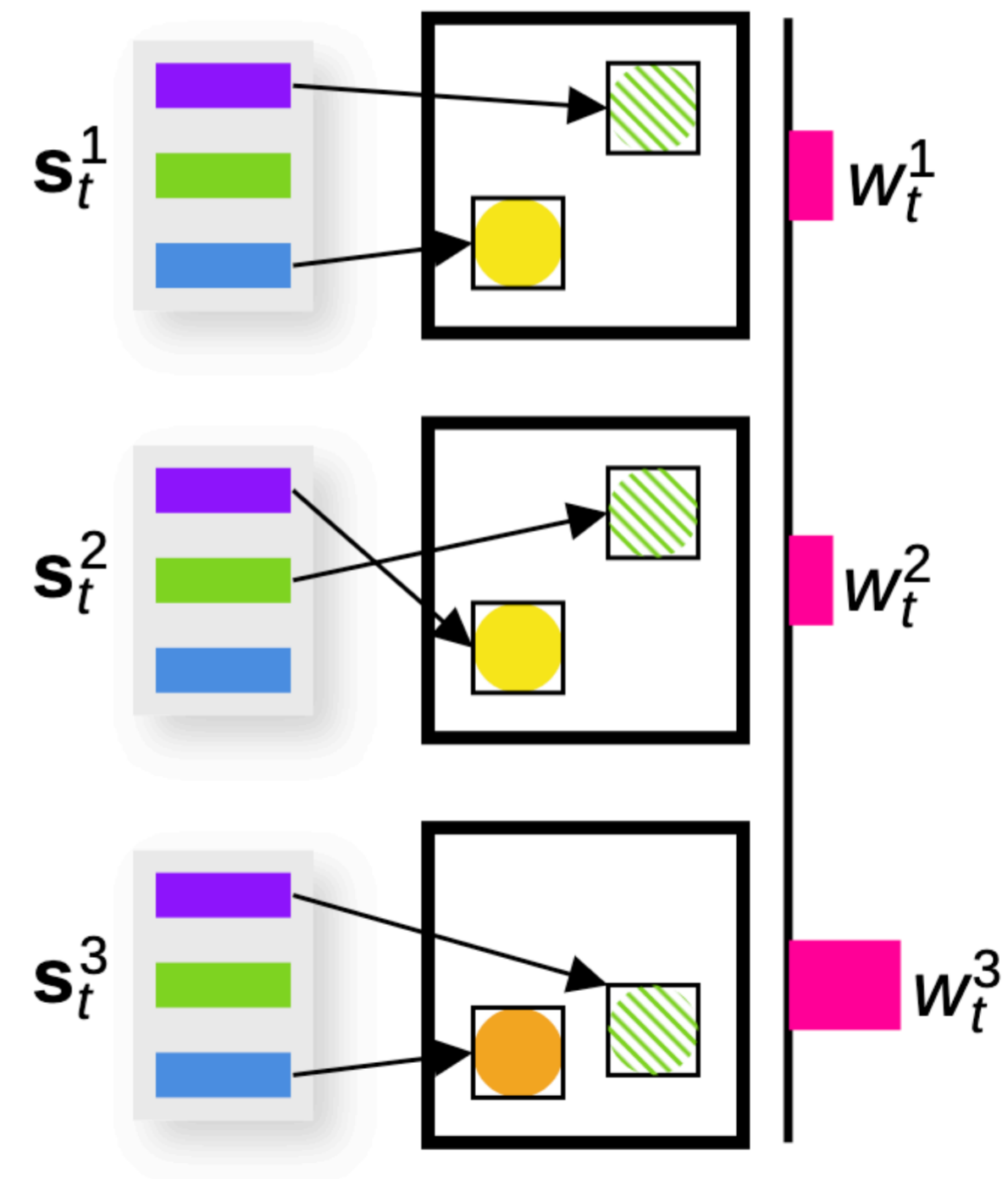
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# Our Approach

How can we represent the object-level uncertainty?



Previous Object-Centric Models



Structured World Belief



# Learning Objective

We maximize the log probability of the image sequence i.e.  $\log p(x_{1:T})$  via the AESMC ELBO objective.

$$\mathcal{L}_{\theta, \phi} = \frac{1}{T} \sum_{t=1}^T \log \sum_{k=1}^K w_t^k$$

where,

$$w_t^k = \tilde{w}_{t-1}^{a_{t-1}^k} \cdot p_{\theta}(x_t | s_t^k) \frac{p_{\theta}(s_t^k | s_{t-1}^{a_{t-1}^k})}{q_{\theta, \phi}(s_t^k | s_{t-1}^{a_{t-1}^k}, x_t)}.$$

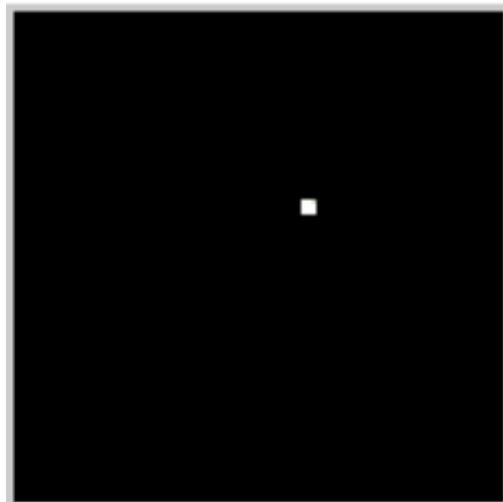
# Experiments

Belief tracking in 2D Branching Sprites data set.

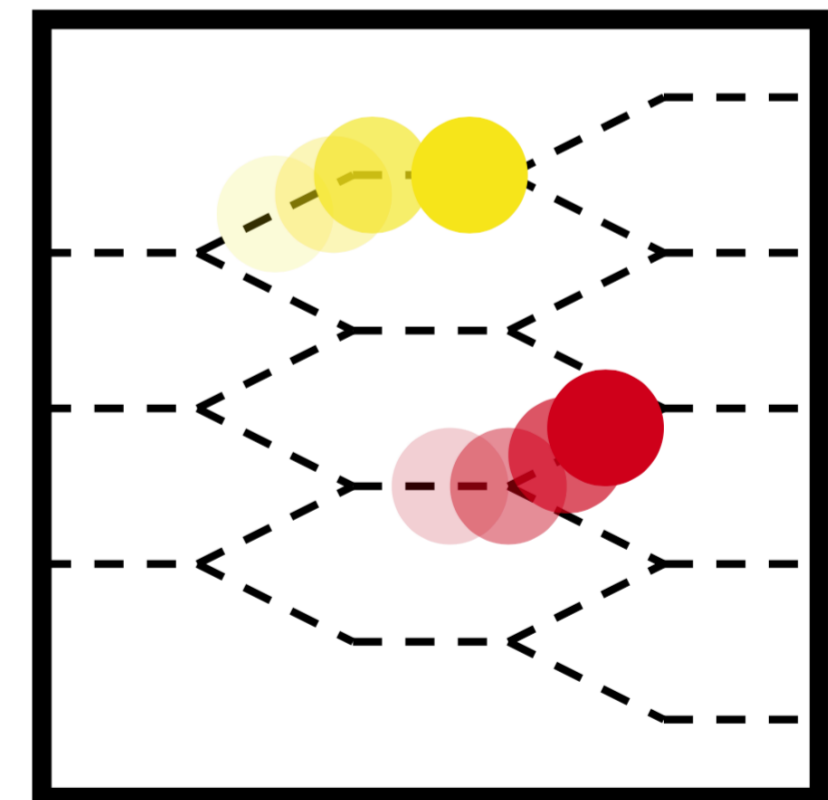
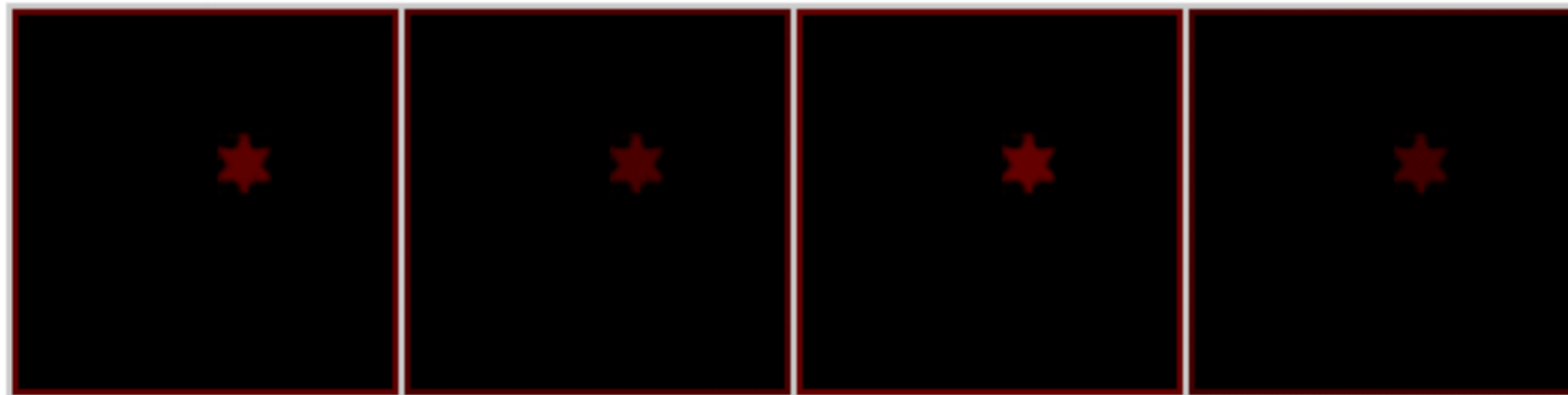
Observation



Particles



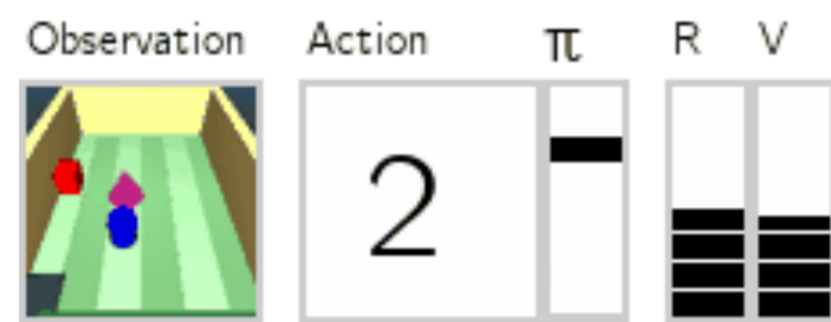
Object Files



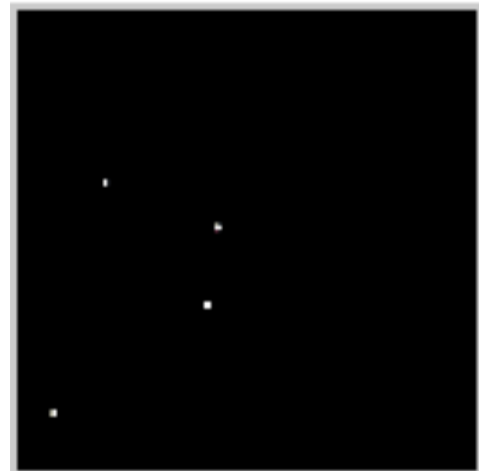
True Paths

# Experiments

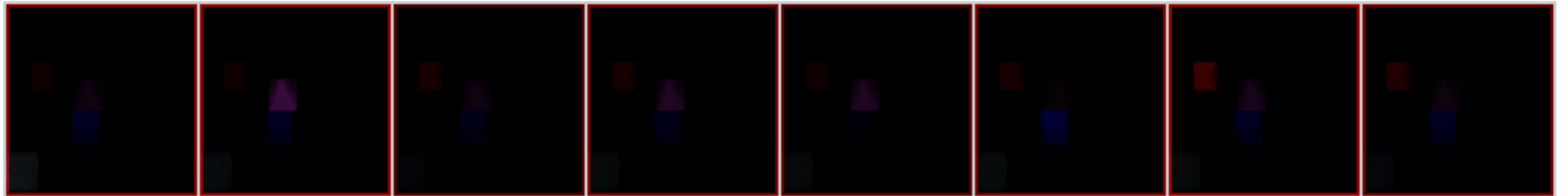
Belief tracking and gameplay in 3D Food Chase.



Particles

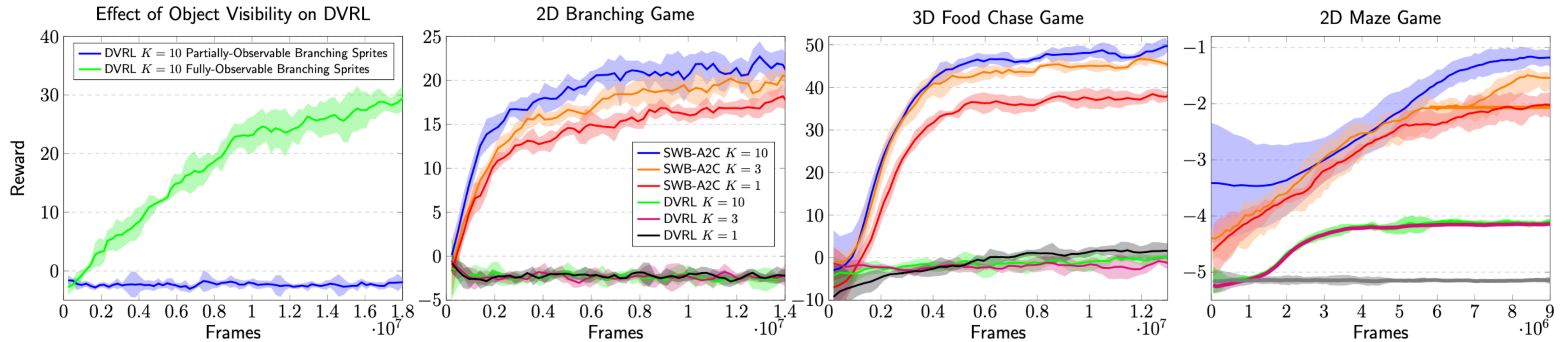


Object Files



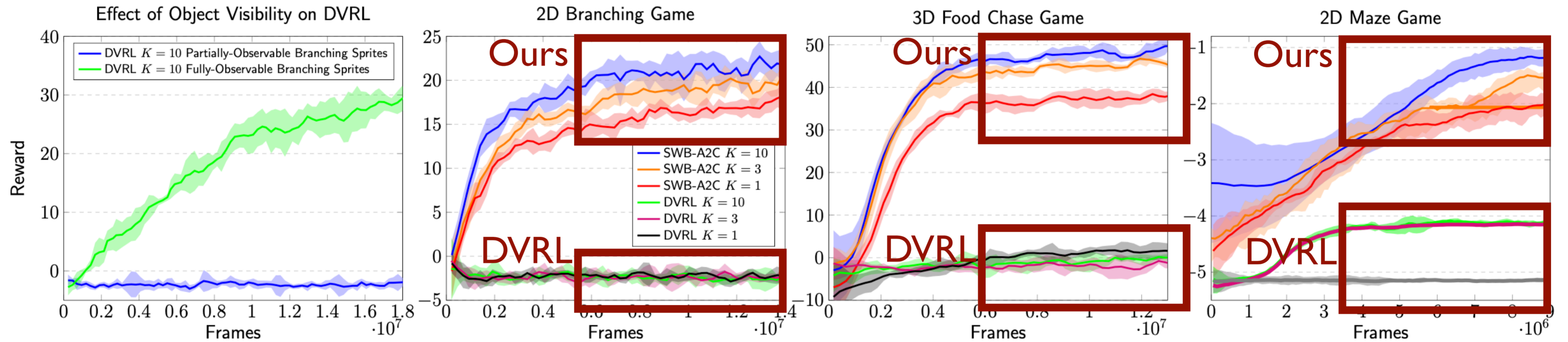
# Experiments

Benefits of structured belief for A2C agents.



# Experiments

Benefits of structured belief for A2C agents.



# Conclusion

1. Propose scene representation learning model combining object-centric representation and belief.
2. Show benefits in world modeling, RL, planning and supervised reasoning.
3. Solve the object matching problem without inductive biases such as spatial locality.