Leveraging Low-Rank and Sparse Recurrent Connectivity for Robust Closed-Loop Control

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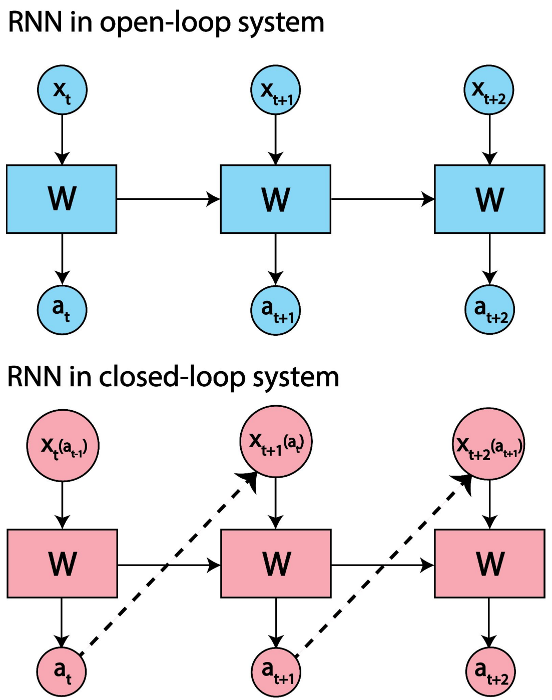
Spotlight Paper [Top 5%]

Setting of interest: closed-loop systems

1. Open-loop systems receive ground-truth observations **(offline training)**

2. Closed-loop systems receive observations that are a function of the previous actions taken by the agent **(online evaluation)**



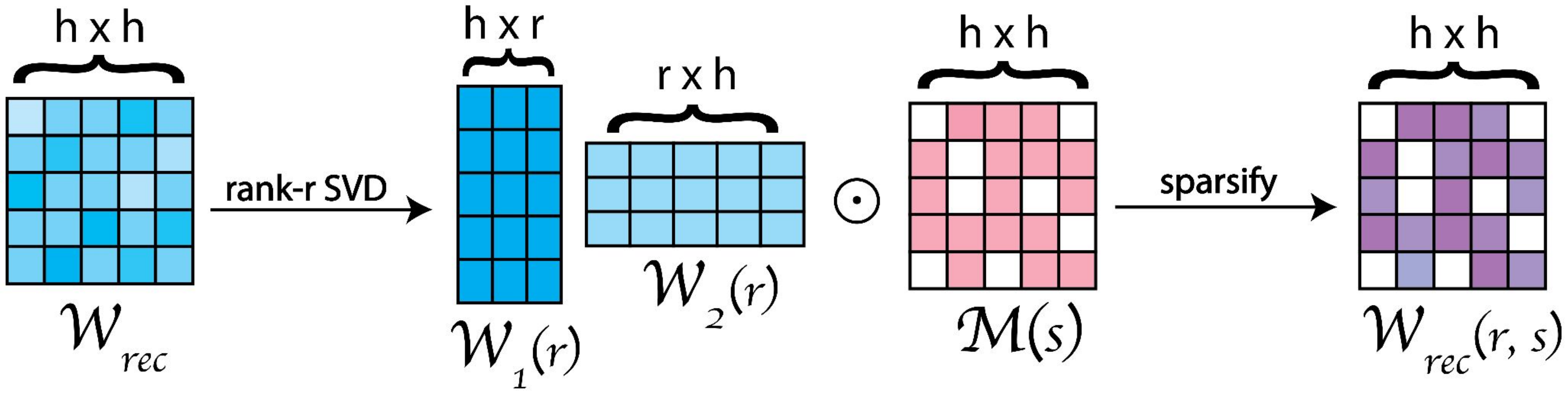
What do we mean by robust?

We care about two aspects of the agent in particular.

1. Is the agent robust against learning **spurious long-term dependencies**?
2. Is the agent robust **in the face of distribution shifts** applied to the input?

Modulating connectivity in the recurrent weights

Consider the following parameterization of the recurrent weights as a function of rank and sparsity.



Properties of parameterization

Using a combination of theoretical and empirical arguments, we can show the following:

1. Both the **spectral radius** and **spectral norm** of Wrec increase with rank and decrease with sparsity
2. The **rate at which the singular values of Wrec decay** increases with both rank and sparsity

Summary of main findings

- The spectral properties of the parameterization at initialization persist in the trained models
- Empirically, we find that the proposed low-rank and sparse parameterization of recurrent connectivity improves robustness