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Deep Reinforcement Learning on Robots

An Evaluation of Models, Demonstration and Rewards

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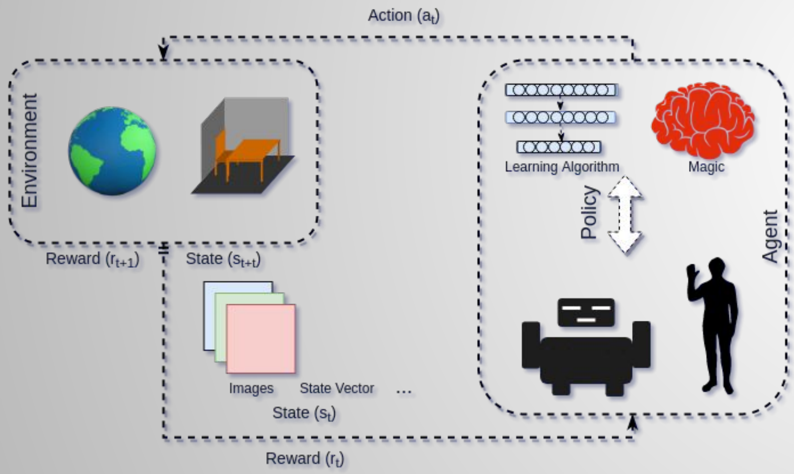
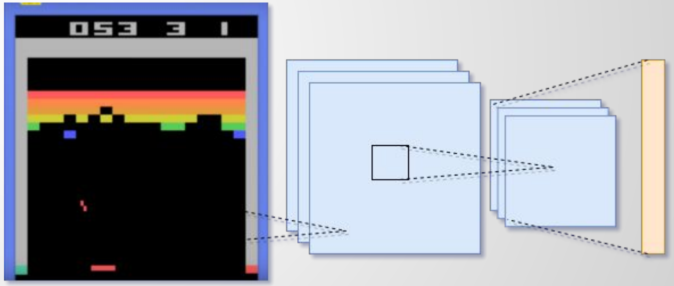
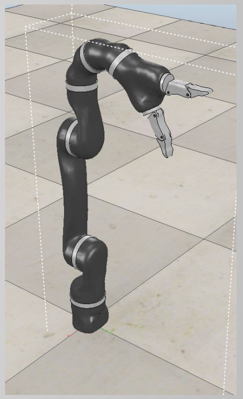
Deep Reinforcement Learning



Reinforcement Learning



DRL learns to play Atari Games



Mico Robot Arm

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DRL on Robotics: Challenges

Training on real robots

- Safety
- Interaction time/Sample efficiency

Training in simulation

- Transferring from simulation to real-world. Reality Gap.

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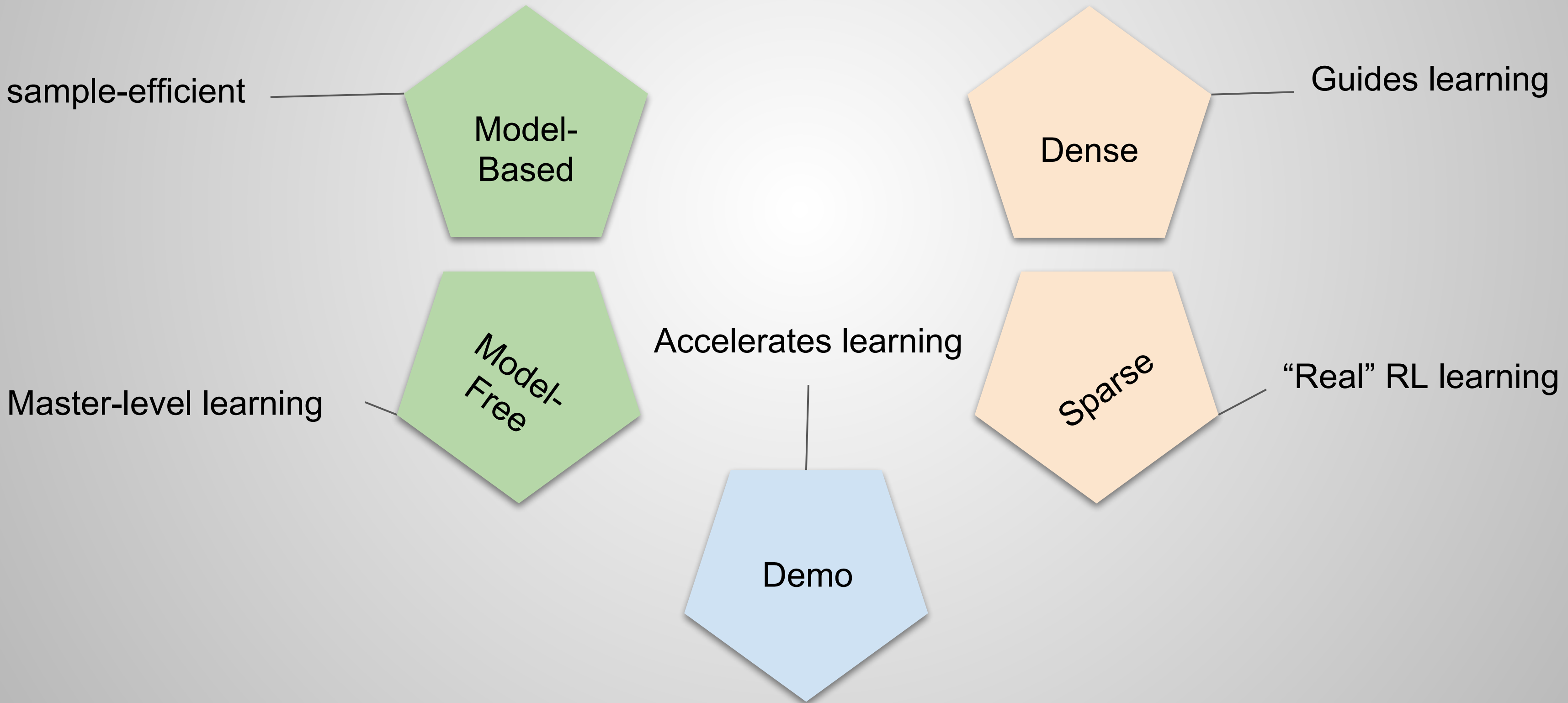
Models, Rewards and Demonstrations



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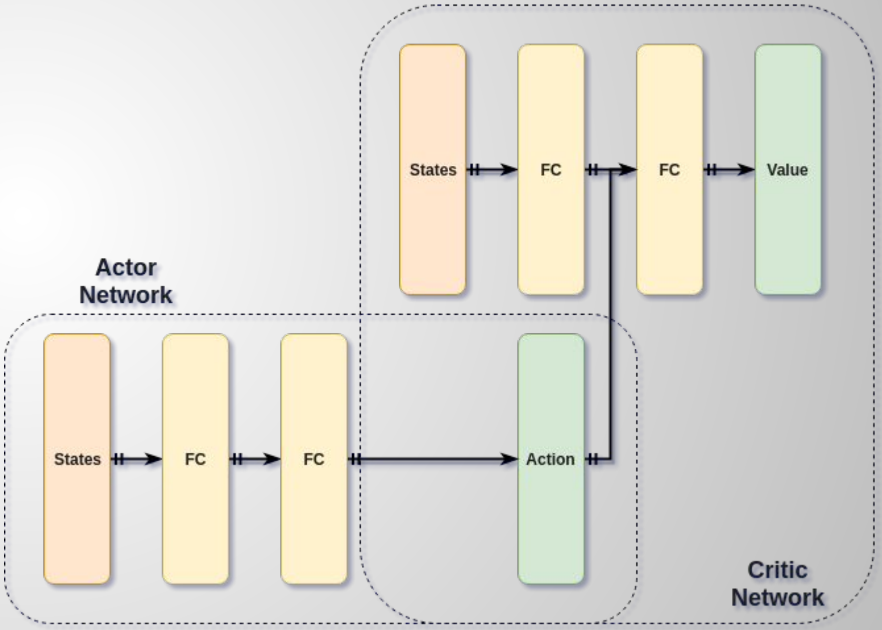
Agents: Model-Free

DDPGfD

- Actor-Critic
- Demonstration loaded to agent's experience replay



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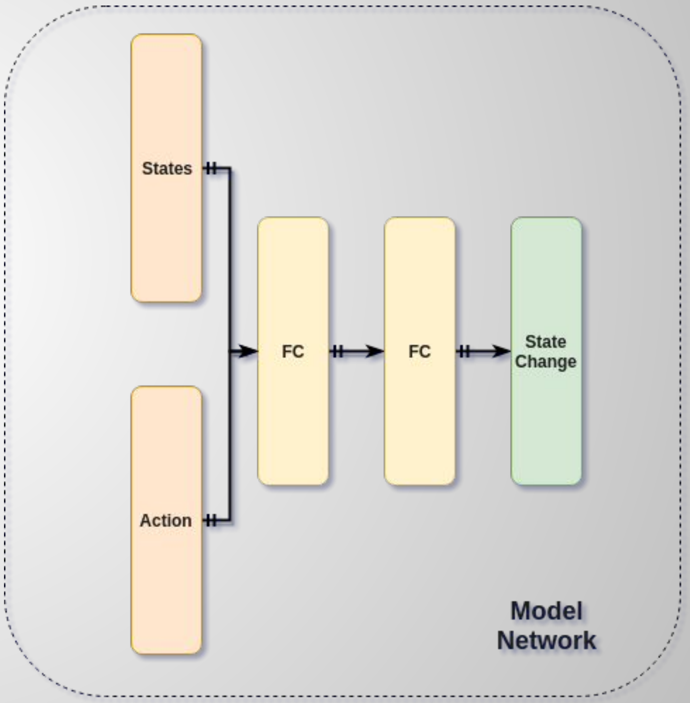
Agents: Model-Based

Neural Network Dynamics Model with Model Predictive Control(MPC)

- Only Model Networks
- Sampling-based MPC
- Demonstration loaded to agent's experience replay



Tasks

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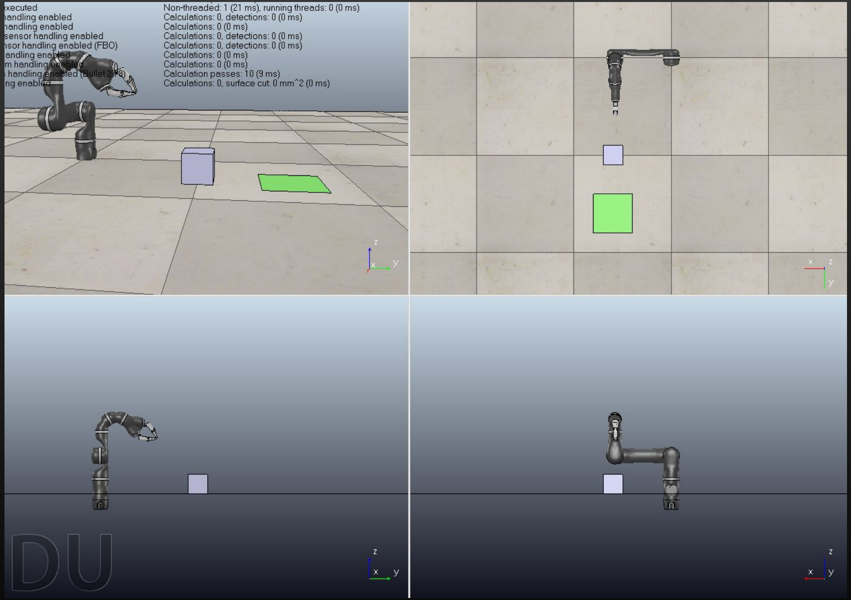
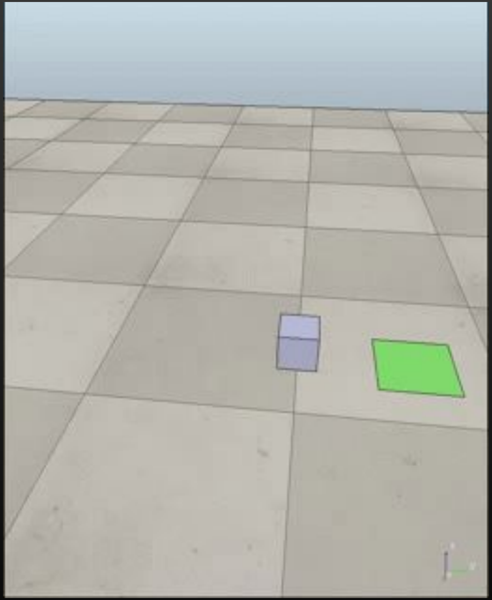
Tasks: Push



Initial State



Demonstration
Collection

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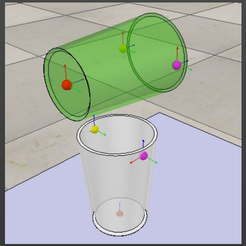
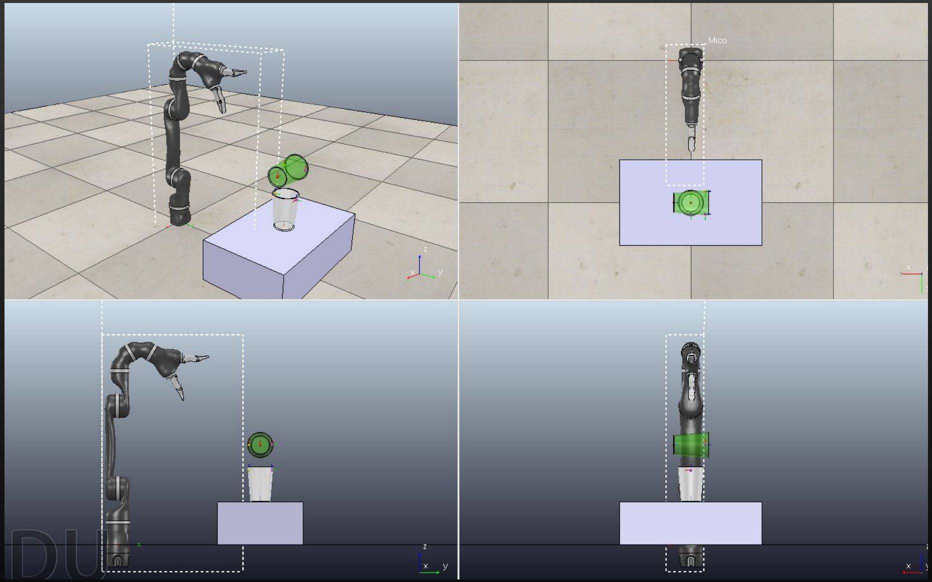
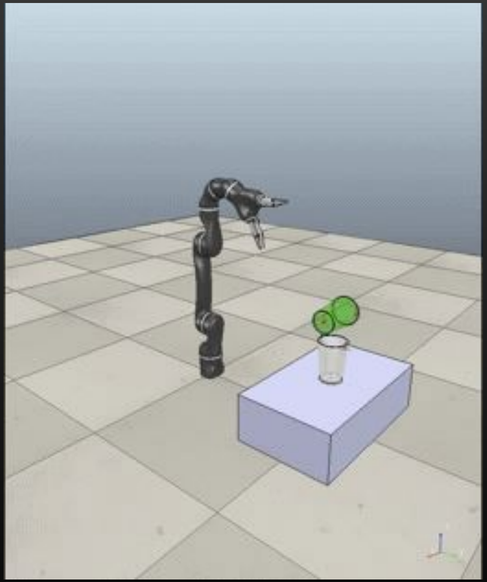
Task: Grasp

Surface points





Initial State



Demonstration
Collection

Experiments and Evaluation

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Push Task

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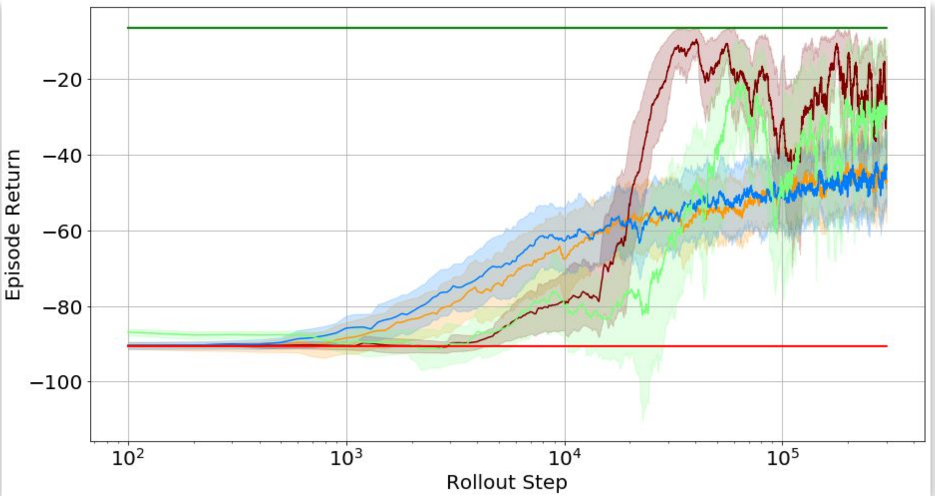
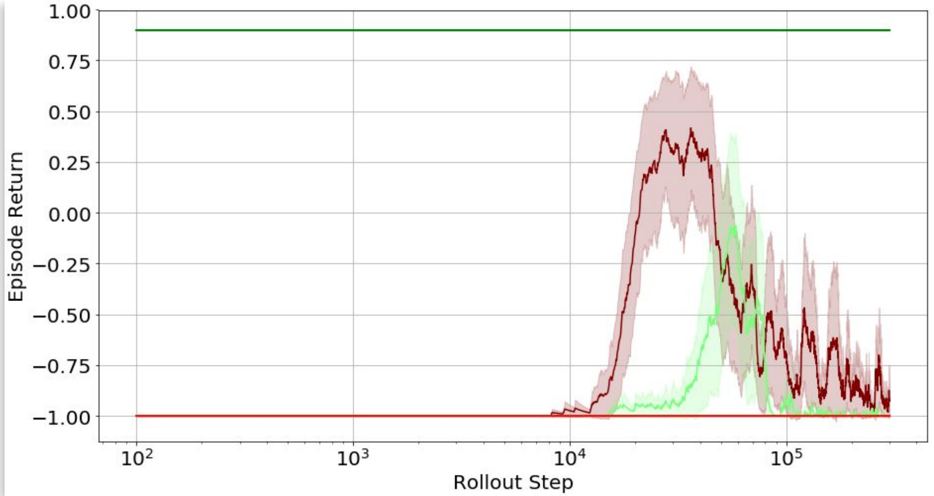
Training Statistics: Episode Return



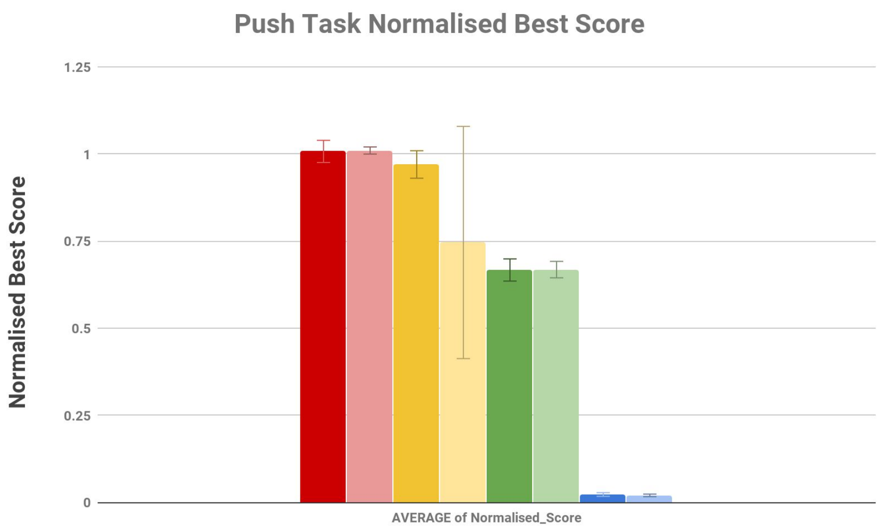
Dense

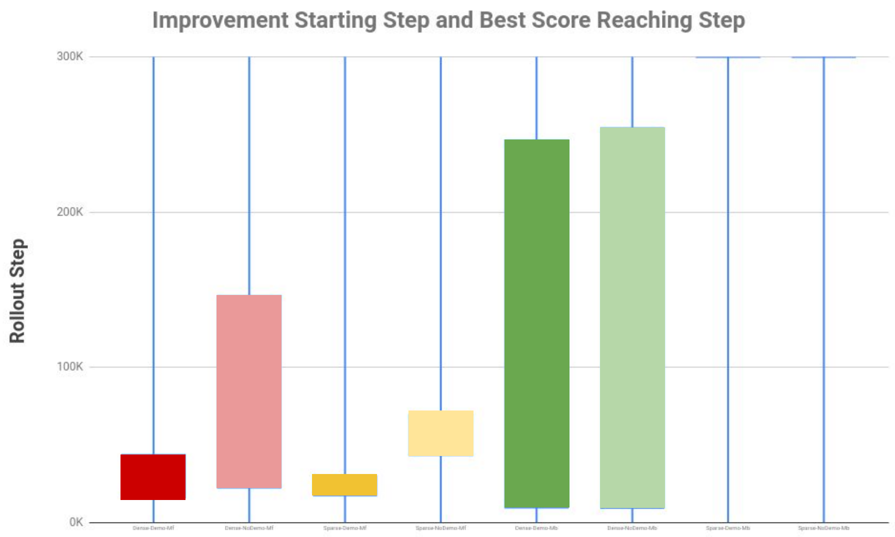


Sparse

Mf-Demo **Mf-NoDemo** **Mb-Demo** **Mb-NoDemo**

Benchmark-Demo **Benchmark-Worst**





Mf-Dense-Demo
Mf-Dense-NoDemo
Mf-Sparse-Demo
Mf-Sparse-NoDemo
Mb-Dense-Demo
Mb-Dense-NoDemo
Mb-Sparse-Demo
Mb-Sparse-NoDemo

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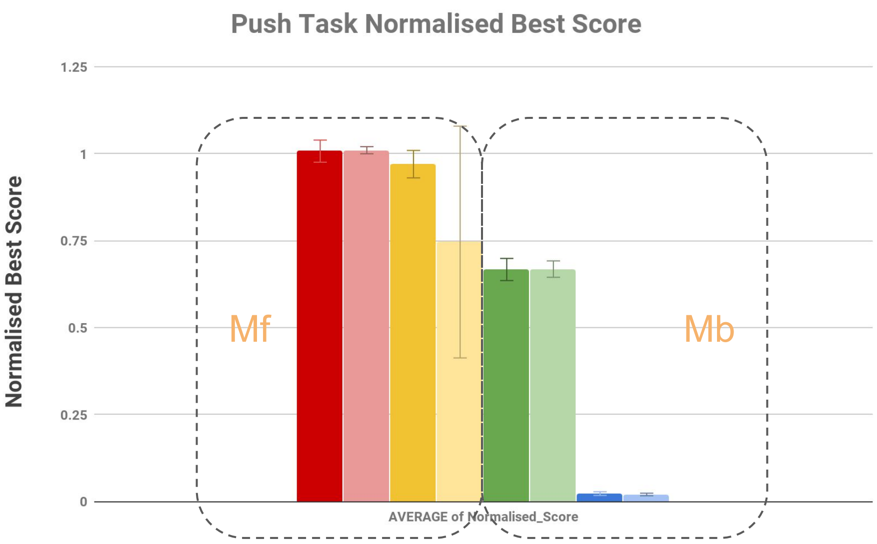

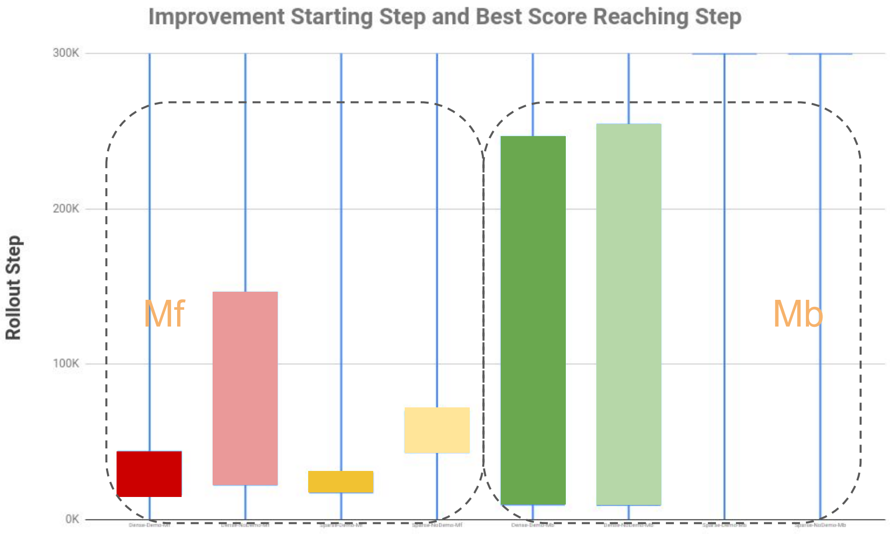

Mf-Dense-Demo Mf-Dense-NoDemo Mf-Sparse-Demo Mf-Sparse-NoDemo

Mb-Dense-Demo Mb-Dense-NoDemo Mb-Sparse-Demo Mb-Sparse-NoDemo

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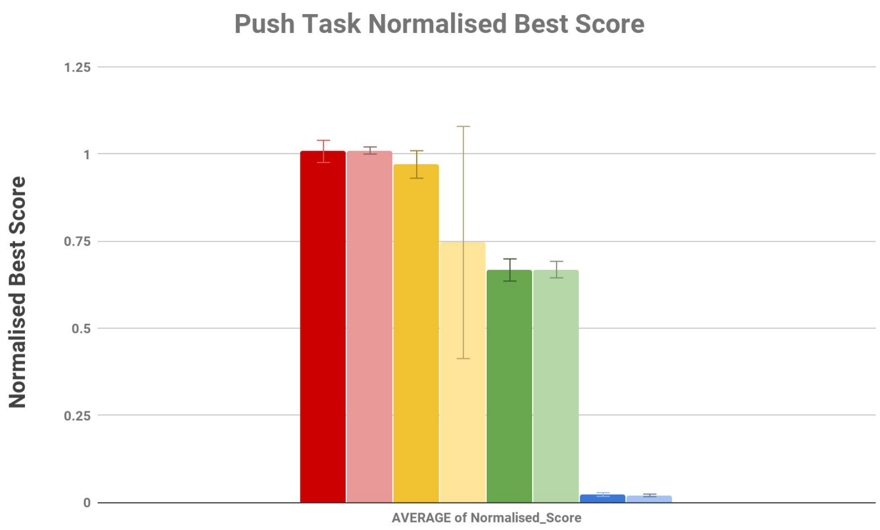

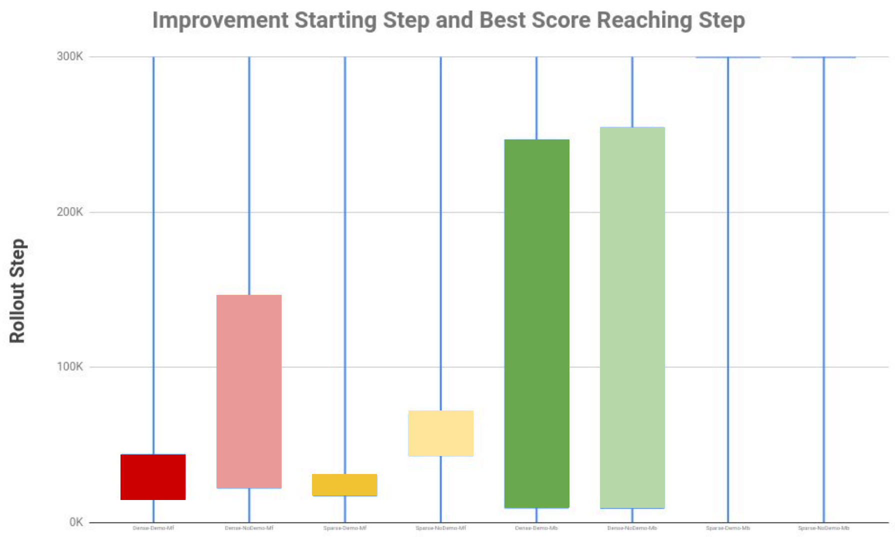

Mf-Dense-Demo Mf-Dense-NoDemo Mf-Sparse-Demo Mf-Sparse-NoDemo

Mb-Dense-Demo Mb-Dense-NoDemo Mb-Sparse-Demo Mb-Sparse-NoDemo

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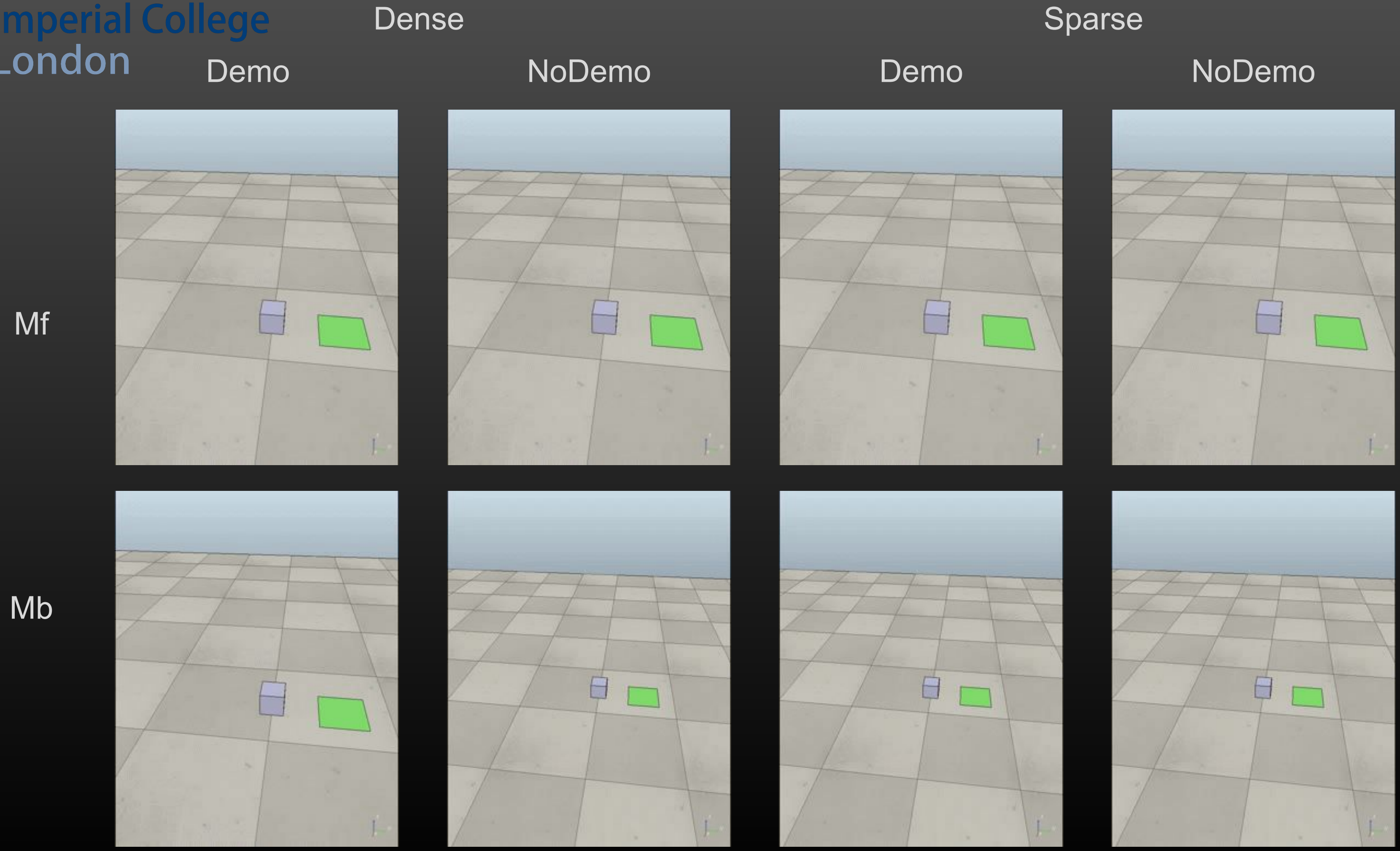

Grasp Task

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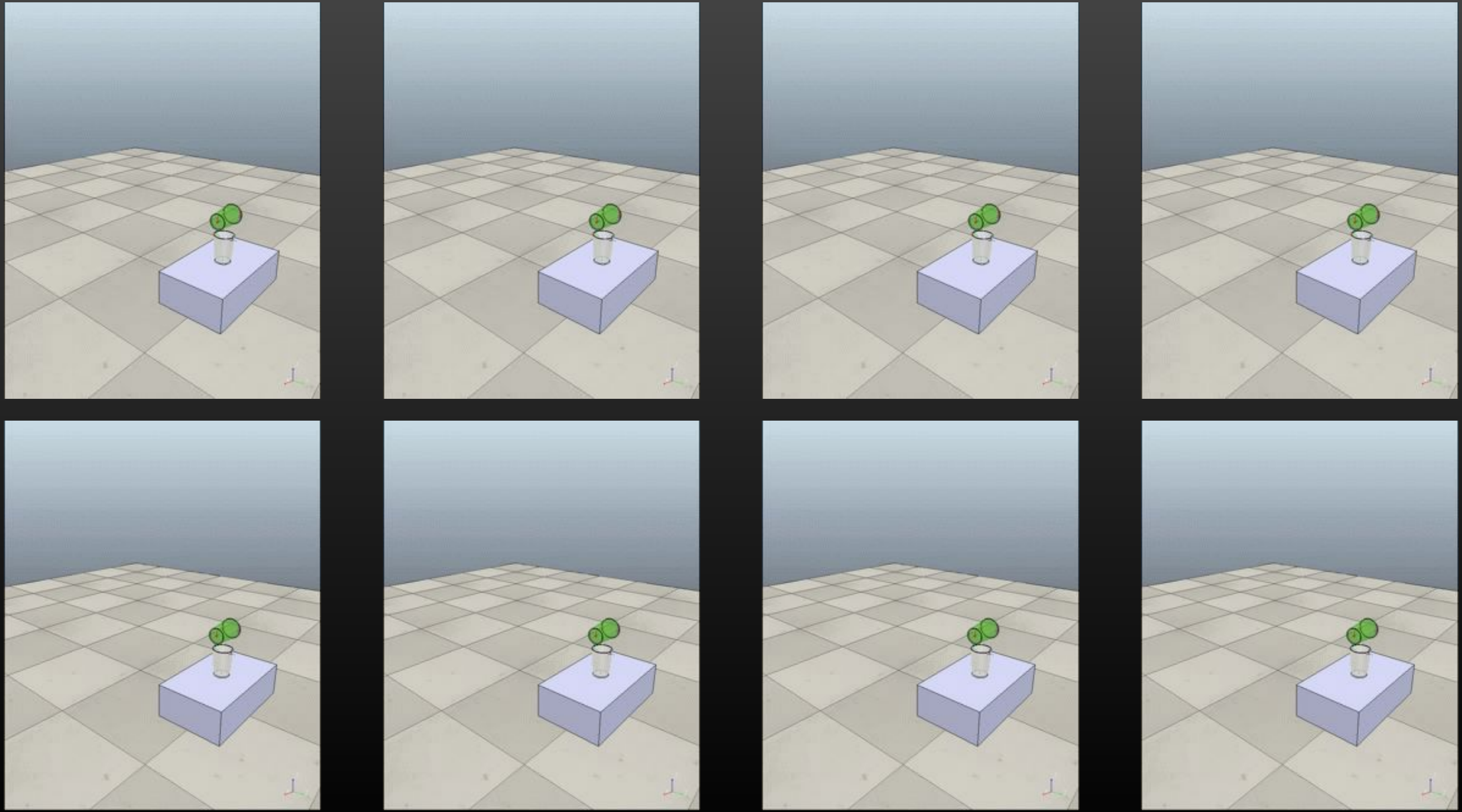
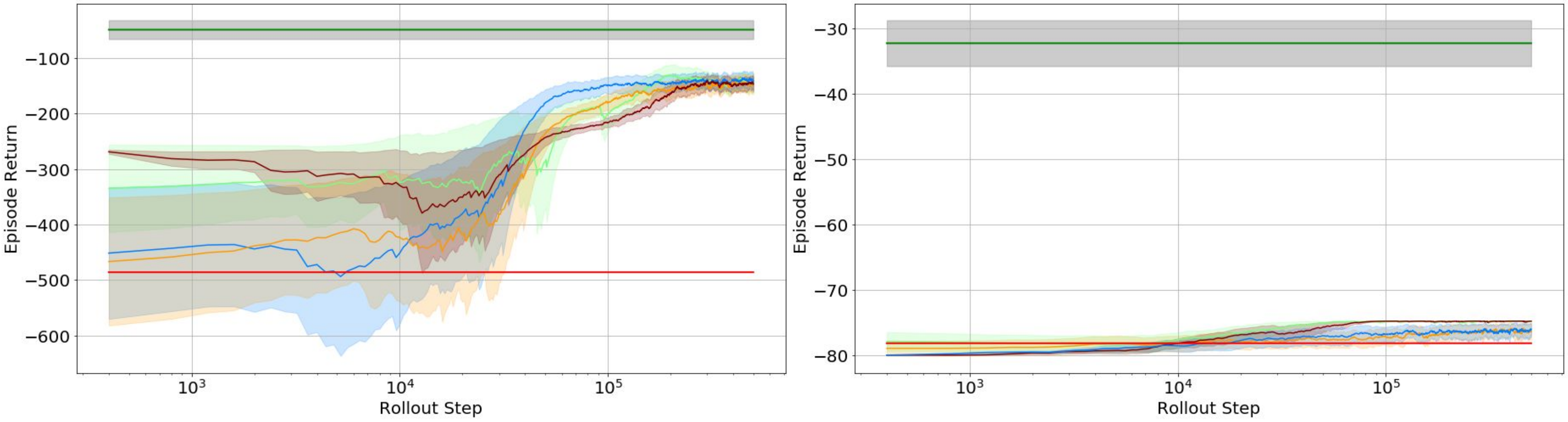
	Dense		Sparse	
	Demo	NoDemo	Demo	NoDemo
Mf				
Mb				



Training Statistics: Episode Return



Dense

Sparse

Mf-Demo

Mf-NoDemo

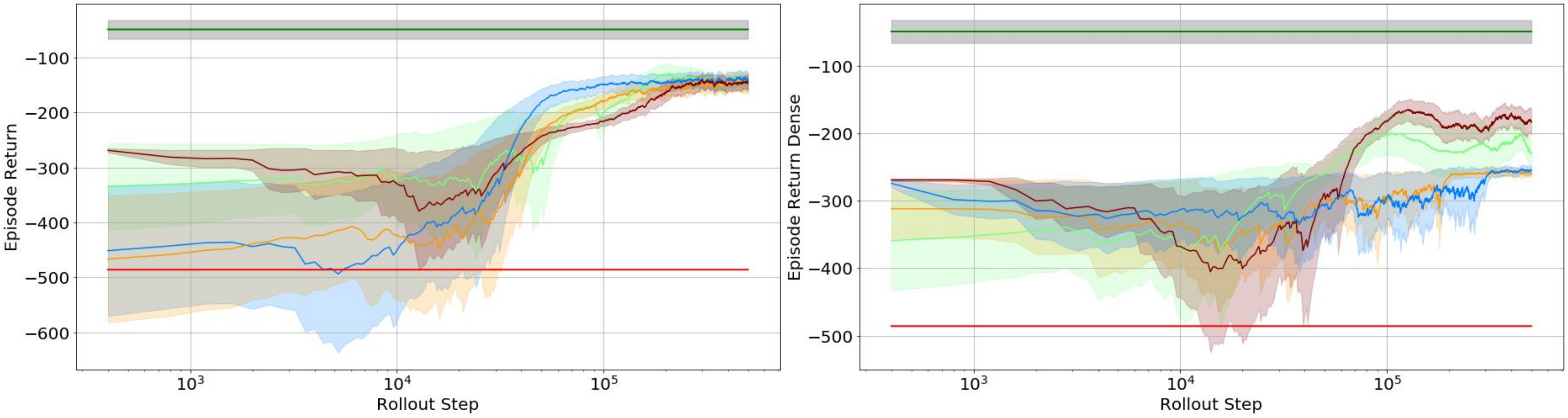
Mb-Demo

Mb-NoDemo

Benchmark-Demo

Benchmark-Worst

Training Statistics: Episode Return



Dense

Sparse (With Dense Score)

Mf-Demo **Mf-NoDemo** **Mb-Demo** **Mb-NoDemo**

Benchmark-Demo **Benchmark-Worst**

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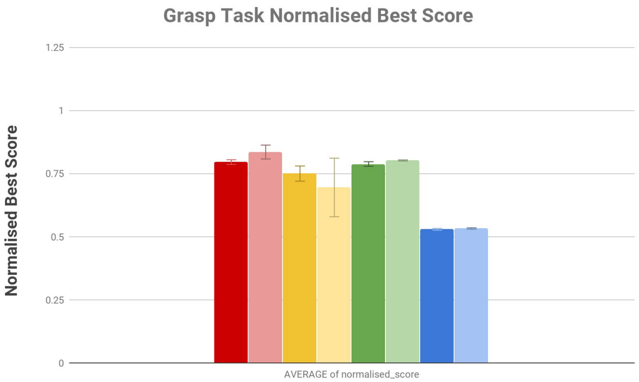

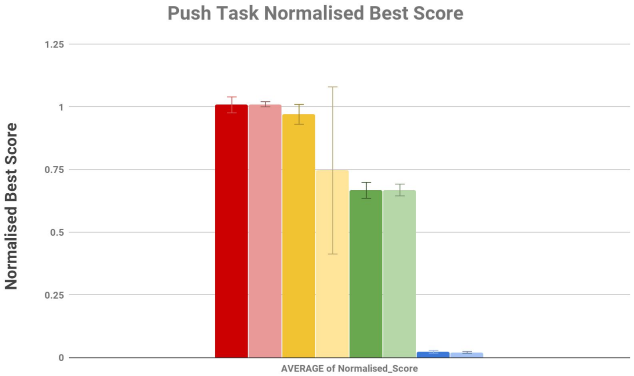

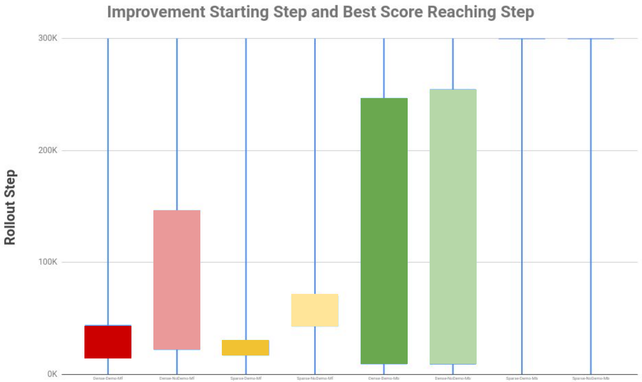

Mf-Dense-Demo Mf-Dense-NoDemo Mf-Sparse-Demo Mf-Sparse-NoDemo

Mb-Dense-Demo Mb-Dense-NoDemo Mb-Sparse-Demo Mb-Sparse-NoDemo

Conclusion

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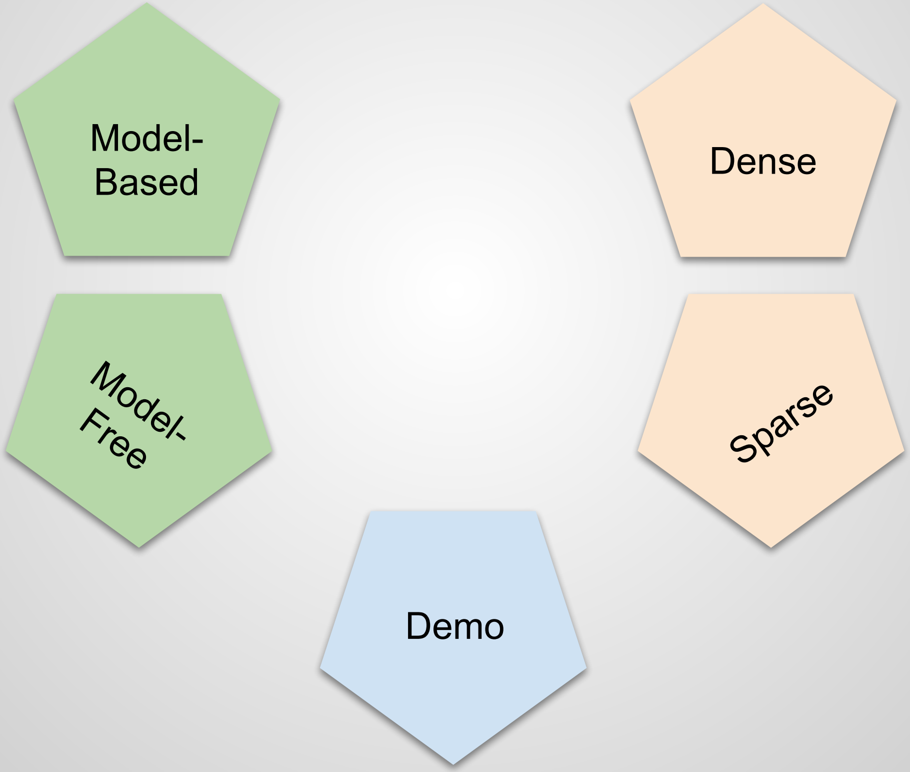

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Future Work

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Thank you very much!

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Appendix

Model

Model-Based	Model-Free
+ Sample-efficient + Stable training process	+ Master-level learning + Operates under sparse rewards
- Typically worse asymptotic performance - Requires dense reward function	- Needs a lot more training data - Training can be unstable

Rewards

Dense Reward	Sparse Reward
+ Provides a strong reward signal	+ Intuitive to define + Real autonomous learning
- May be impractical to define in complex tasks - May lead to sub-optimal solutions	- Hard to learn

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Demonstration

+	Accelerates learning
-	May be hard to collect