Factory Manipulation with Cooperative Multi-agent Reinforcement Learning

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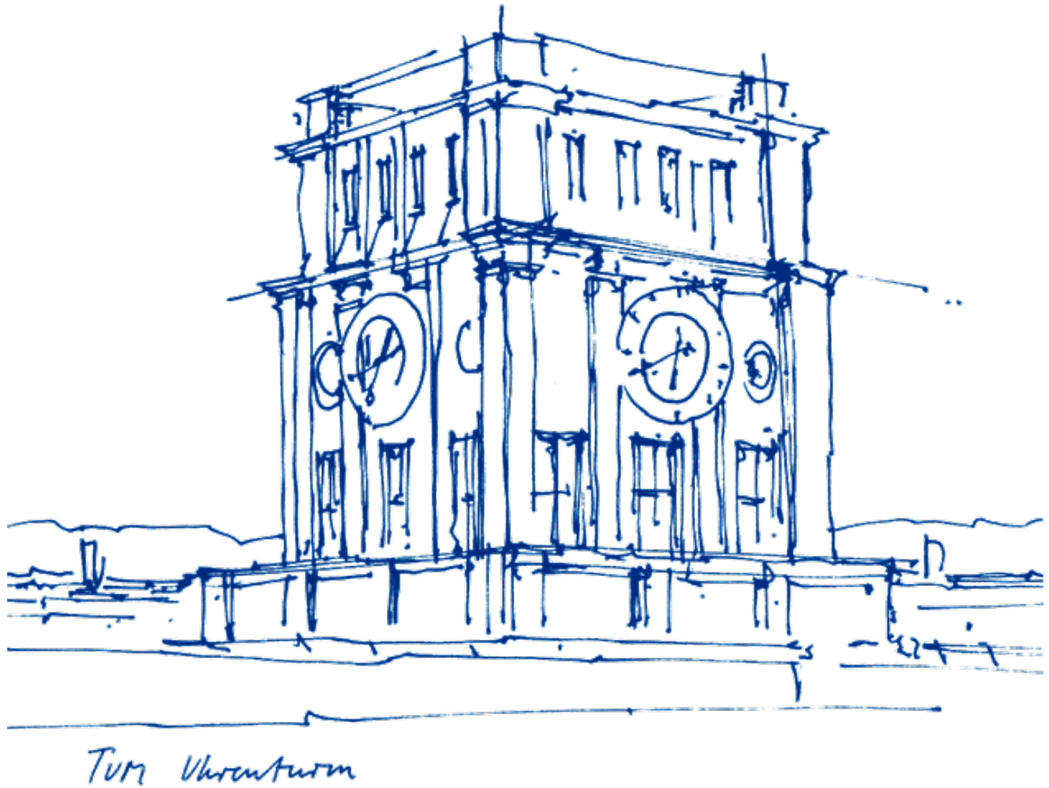
Kirschstein, Köck



The Reward Function

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Which reward should we use?

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1st intention:

Reward of 1, if a block is thrown in the basket, 0 in all other cases

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Reward of 1, if a block is thrown in the basket, 0 in all other cases

But: **Almost no learning possible**

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Which reward should we use?

2nd intention:

Function that **increases monotonously with *progress to target***

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Which reward should we use?

2nd intention:

Function that **increases monotonously with *progress to target***

Parameters to include:

- d_c: Distance to closest cube
- d_r: Distance to closest robot arm
- d_b: Distance to basket
- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

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Desirable Incentives:

Possible reward function:

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Desirable Incentives:

- Reward vicinity to closest cube

Possible reward function:

$+ \quad 0.40 \cdot d_c$

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Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms

Possible reward function:

$+ \quad 0.40 \cdot d_c$

$- \quad 0.30 \cdot d_r$

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- d_b: Distance to basket
- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms
- Reward grasping while very close to cube

Possible reward function:

$$+ \quad 0.40 \cdot d_c$$
$$- \quad 0.30 \cdot d_r$$
$$+ \quad 0.20 \cdot 1_{d_c=0} \cdot (1 - g)$$

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Parameters to include:

- d_c: Distance to closest cube
- d_r: Distance to closest robot arm
- d_b: Distance to basket
- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms
- Reward grasping while very close to cube
- Reward vicinity to basket with grasped cube

Possible reward function:

$$+ \; 0.40 \cdot d_c$$
$$- \; 0.30 \cdot d_r$$
$$+ \; 0.20 \cdot 1_{d_c=0} \cdot (1 - g)$$
$$+ \; 0.20 \cdot 1_{d_c=0} \cdot (1 - g) \cdot d_b$$

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Function that **increases monotonously with *progress to target***

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- d_c: Distance to closest cube
- d_r: Distance to closest robot arm
- d_b: Distance to basket
- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms
- Reward grasping while very close to cube
- Reward vicinity to basket with grasped cube
- Reward relaxing grasp over basket position

Possible reward function:

$$+ \; 0.40 \cdot d_c$$
$$- \; 0.30 \cdot d_r$$
$$+ \; 0.20 \cdot 1_{d_c=0} \cdot (1 - g)$$
$$+ \; 0.20 \cdot 1_{d_c=0} \cdot (1 - g) \cdot d_b$$
$$+ \; 0.30 \cdot 1_{d_b=0} \cdot g$$

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- d_r: Distance to closest robot arm
- d_b: Distance to basket
- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms
- Reward grasping while very close to cube
- Reward vicinity to basket with grasped cube
- Reward relaxing grasp over basket position
- Punish hectic motion

Possible reward function:

$$+\ 0.40 \cdot d_c$$
$$-\ 0.30 \cdot d_r$$
$$+\ 0.20 \cdot 1_{d_c=0} \cdot (1 - g)$$
$$+\ 0.20 \cdot 1_{d_c=0} \cdot (1 - g) \cdot d_b$$
$$+\ 0.30 \cdot 1_{d_b=0} \cdot g$$
$$-\ 0.10 \cdot \|a\|_2$$

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- d_b: Distance to basket
- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms
- Reward grasping while very close to cube
- Reward vicinity to basket with grasped cube
- Reward relaxing grasp over basket position
- Punish hectic motion

Possible reward function:

$$+\ 0.40 \cdot f_1(d_c)$$
$$-\ 0.30 \cdot f_2(d_r)$$
$$+\ 0.20 \cdot 1_{d_c=0} \cdot f_3(1-g)$$
$$+\ 0.20 \cdot 1_{d_c=0} \cdot f_4(1-g) \cdot f_5(d_b)$$
$$+\ 0.30 \cdot 1_{d_b=0} \cdot f_6(g)$$
$$-\ 0.10 \cdot f_7(\|a\|_2)$$

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Function that **increases monotonously with *progress to target***

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- g: Gripper state
- $a \in [-1, 1]^{\mathrm{DOF}}$: action vector

Desirable Incentives:

- Reward vicinity to closest cube
- Punish distance to other robot arms
- Reward grasping while very close to cube
- Reward vicinity to basket with grasped cube
- Reward relaxing grasp over basket position
- Punish hectic motion

Possible reward function:

$$+\ 0.40 \cdot f_1(d_c)$$
$$-\ 0.30 \cdot f_2(d_r)$$
$$+\ 0.20 \cdot 1_{d_c<\varepsilon_1} \cdot f_3(1-g)$$
$$+\ 0.20 \cdot 1_{d_c<\varepsilon_2} \cdot f_4(1-g) \cdot f_5(d_b)$$
$$+\ 0.30 \cdot 1_{d_b<\varepsilon_3} \cdot f_6(g)$$
$$-\ 0.10 \cdot f_7(\|a\|_2)$$