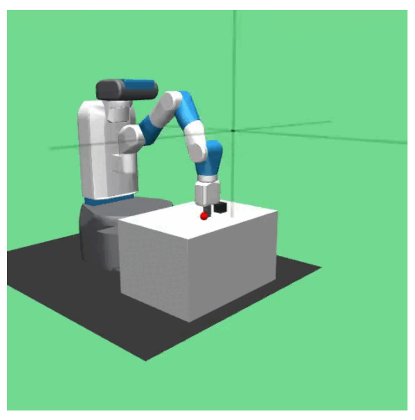
Push



Description

This environment was introduced in "Multi-Goal Reinforcement Learning: Challenging Robotics Environments and Request for Research".

The task in the environment is for a manipulator to move a block to a target position on top of a table by pushing with its gripper. The robot is a 7-DoF Fetch Mobile Manipulator with a two-fingered parallel gripper. The robot is controlled by small displacements of the gripper in Cartesian coordinates and the inverse kinematics are computed internally by the MuJoCo framework. The gripper is locked in a closed configuration in order to perform the push task. The task is also continuing which means that the robot has to maintain the block in the target position for an indefinite period of time.

The control frequency of the robot is of `f = 25 Hz`. This is achieved by applying the same action in 20 subsequent simulator step (with a time step of `dt = 0.002 s`) before returning the control to the robot.

Action Space

The action space is a `Box(-1.0, 1.0, (4,), float32)`. An action represents the Cartesian displacement dx, dy, and dz of the end effector. In addition to a last action that controls closing and opening of the gripper.

Num	Action	Control Min	Control Max	Name (in corresponding XML file)	Joint	Unit
0	Displacement of the end effector in the x direction dx	-1	1	robot0:mocap	hinge	position (m)
1	Displacement of the end effector in the y direction dy	-1	1	robot0:mocap	hinge	position (m)
2	Displacement of the end effector in the z direction dz	-1	1	robot0:mocap	hinge	position (m)
3	-	-1	1	-	hinge	position (m)

Observation Space

The observation is a `goal-aware observation space`. It consists of a dictionary with information about the robot's end effector state and goal. The kinematics observations are derived from Mujoco bodies known as sites attached to the body of interest such as the block or the end effector. Also to take into account the temporal influence of the step time, velocity values are multiplied by the step time dt=number_of_sub_steps*sub_step_time. The dictionary consists of the following 3 keys:

- `observation`: its value is an `ndarray` of shape `(25,)`. It consists of kinematic information of the block object and gripper. The elements of the array correspond to the following:

Num	Observation	Min	Max	Site Name (in corresponding XML file)	Joint Name (in corresponding XML file)	Joint Type	Unit
0	End effector x position in global coordinates	-Inf	Inf	robot0:grip	-	-	position (m)
1	End effector y position in global coordinates	-Inf	Inf	robot0:grip	-	-	position (m)
2	End effector z position in global coordinates	-Inf	Inf	robot0:grip	-	-	position (m)
3	Block x position in global coordinates	-Inf	Inf	object0	-	-	position (m)
4	Block y position in global coordinates	-Inf	Inf	object0	-	-	position (m)
5	Block z position in global coordinates	-Inf	Inf	object0	-	-	position (m)
6	Relative block x position with respect to gripper x position in globla coordinates. Equals to $x_{gripper}$ - x_{block}	-Inf	Inf	object0	-	-	position (m)
7	Relative block y position with respect to gripper y position in globla coordinates. Equals to $y_{gripper}$ - y_{block}	-Inf	Inf	object0	-	-	position (m)
8	Relative block z position with respect to gripper z position in globla coordinates. Equals to $z_{gripper}$ - z_{block}	-Inf	Inf	object0	-	-	position (m)
9	Joint displacement of the right gripper finger	-Inf	Inf	-	robot0:r_gripper_finger_joint	hinge	position (m)
10	Joint displacement of the left gripper finger	-Inf	Inf	-	robot0:l_gripper_finger_joint	hinge	position (m)
11	Global x rotation of the block in a XYZ Euler frame rotation	-Inf	Inf	object0	-	-	angle (rad)
12	Global y rotation of the block in a XYZ Euler frame rotation	-Inf	Inf	object0	-	-	angle (rad)

Num	Observation	Min	Max	Site Name (in corresponding XML file)	Joint Name (in corresponding XML file)	Joint Type	Unit
13	Global z rotation of the block in a XYZ Euler frame rotation	-Inf	Inf	object0	-	-	angle (rad)
14	Relative block linear velocity in x direction with respect to the gripper	-Inf	Inf	object0	-	-	velocity (m/s)
15	Relative block linear velocity in y direction with respect to the gripper	-Inf	Inf	object0	-	-	velocity (m/s)
16	Relative block linear velocity in z direction	-Inf	Inf	object0	-	-	velocity (m/s)
17	Block angular velocity along the x axis	-Inf	Inf	object0	-	-	angular velocity (rad/s)
18	Block angular velocity along the y axis	-Inf	Inf	object0	-	-	angular velocity (rad/s)
19	Block angular velocity along the z axis	-Inf	Inf	object0	-	-	angular velocity (rad/s)
20	End effector linear velocity x direction	-Inf	Inf	robot0:grip	-	-	velocity (m/s)
21	End effector linear velocity y direction	-Inf	Inf	robot0:grip	-	-	velocity (m/s)
22	End effector linear velocity z direction	-Inf	Inf	robot0:grip	-	-	velocity (m/s)
23	Right gripper finger linear velocity	-Inf	Inf	-	robot0:r_gripper_finger_joint	hinge	velocity (m/s)
24	Left gripper finger linear velocity	-Inf	Inf	-	robot0:l_gripper_finger_joint	hinge	velocity (m/s)

- `desired_goal`: this key represents the final goal to be achieved. In this environment it is a 3-dimensional `ndarray`, `(3,)`, that consists of the three cartesian coordinates of the desired final block position `[x,y,z]`. In order for the robot to perform a push trajectory, the goal position can only be placed on top of the table. The elements of the array are the following:

Num	Observation	Min	Max	Site Name (in corresponding XML file)	Unit
0	Final goal block position in the x coordinate	-Inf	Inf	target0	position (m)
1	Final goal block position in the y coordinate	-Inf	Inf	target0	position (m)
2	Final goal block position in the z coordinate	-Inf	Inf	target0	position (m)

- `achieved_goal`: this key represents the current state of the block, as if it would have achieved a goal. This is useful for goal orientated learning algorithms such as those that use Hindsight Experience Replay (HER). The value is an `ndarray` with shape `(3,)`. The elements of the array are the following:

Num	Observation	Min	Max	Site Name (in corresponding XML file)	Unit
0	Current block position in the x coordinate	-Inf	Inf	object0	position (m)
1	Current block position in the y coordinate	-Inf	Inf	object0	position (m)
2	Current block position in the z coordinate	-Inf	Inf	object0	position (m)

Rewards

The reward can be initialized as `sparse` or `dense`:

- *sparse*: the returned reward can have two values: `-1` if the block hasn't reached its final target position, and `0` if the block is in the final target position (the block is considered to have reached the goal if the Euclidean distance between both is lower than 0.05 m).
- *dense*: the returned reward is the negative Euclidean distance between the achieved goal position and the desired goal.

To initialize this environment with one of the mentioned reward functions the type of reward must be specified in the id string when the environment is initialized. For `sparse` reward the id is the default of the environment, `FetchPush-v2`. However, for `dense` reward the id must be modified to `FetchPush-v2` and initialized as follows:

```
import gymnasium as gym

env = gym.make('FetchPushDense-v2')
```

Starting State

When the environment is reset the gripper is placed in the following global cartesian coordinates `(x,y,z) = [1.3419 0.7491 0.555] m`, and its orientation in quaternions is `(w,x,y,z) = [1.0, 0.0, 1.0, 0.0]`. The joint positions are computed by inverse kinematics internally by MuJoCo. The base of the robot will always be fixed at `(x,y,z) = [0.405, 0.48, 0]` in global coordinates.

The block's position has a fixed height of `(z) = [0.42] m` (on top of the table). The initial `(x,y)` position of the block is the gripper's x and y coordinates plus an offset sampled from a uniform distribution with a range of `[-0.15, 0.15] m`. Offset samples are generated until the 2-dimensional Euclidean distance from the gripper to the block is greater than `0.1 m`. The initial orientation of the block is the same as for the gripper, `(w,x,y,z) = [1.0, 0.0, 1.0, 0.0]`.

Finally the target position where the robot has to move the block is generated. The target can be in mid-air or over the table. The random target is also generated by adding an offset to the initial grippers position `(x,y)` sampled from a uniform distribution with a range of `[-0.15, 0.15] m`. The height of the target is initialized at `(z) = [0.42] m` on the table.

Episode End

The episode will be `truncated` when the duration reaches a total of `max_episode_steps` which by default is set to 50 timesteps. The episode is never `terminated` since the task is continuing with infinite horizon.

Arguments

To increase/decrease the maximum number of timesteps before the episode is `truncated` the `max_episode_steps` argument can be set at initialization. The default value is 50. For example, to increase the total number of timesteps to 100 make the environment as follows:

```
import gymnasium as gym

env = gym.make('FetchPush-v2', max_episode_steps=100)
```

Version History

- v2: the environment depends on the newest mujoco python bindings maintained by the MuJoCo team in Deepmind.
- v1: the environment depends on `mujoco_py` which is no longer maintained.