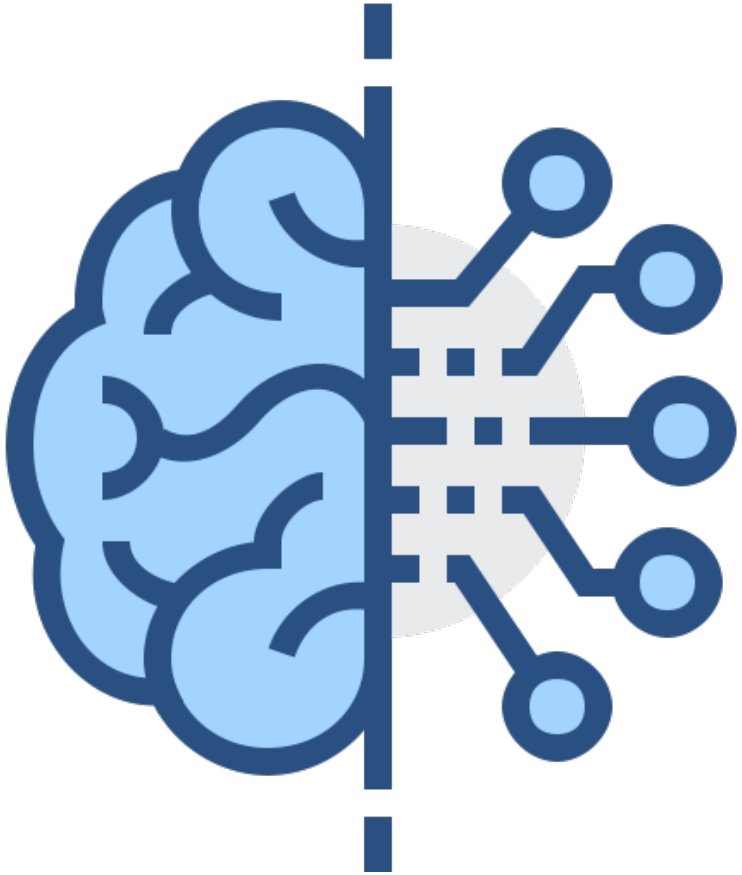
Unity ML-Agents
Pong 만들기

2019. 10. 26 민규식



Unity ML-agents

유니티

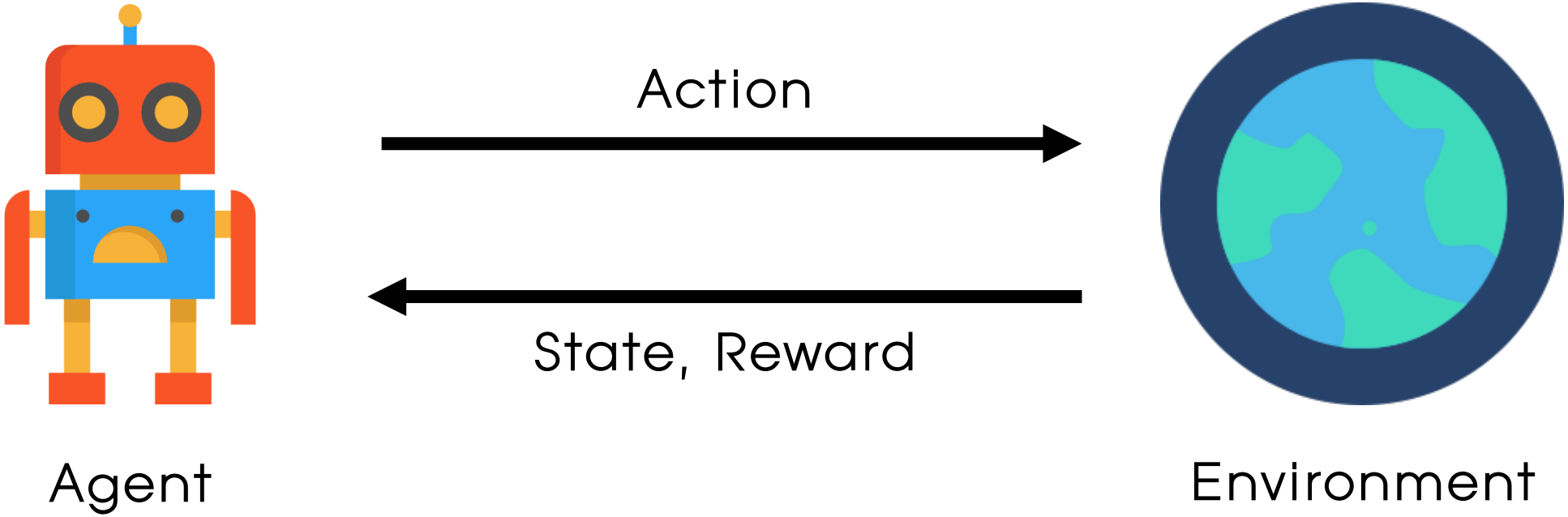
- 2D/3D 게임 개발 환경을 제공하는 게임 엔진
- 자동차, 애니메이션, 건축, 인공지능 등 다양한 분야를 위한 솔루션 제공
- 전세계 게임 엔진 시장의 절반 정도를 차지하며 등록 개발자 수가 500만명 이상
- C#과 자바스크립트를 스크립트 언어로 사용

Unity ML-agents

유니티의 인터페이스

Unity ML-agents

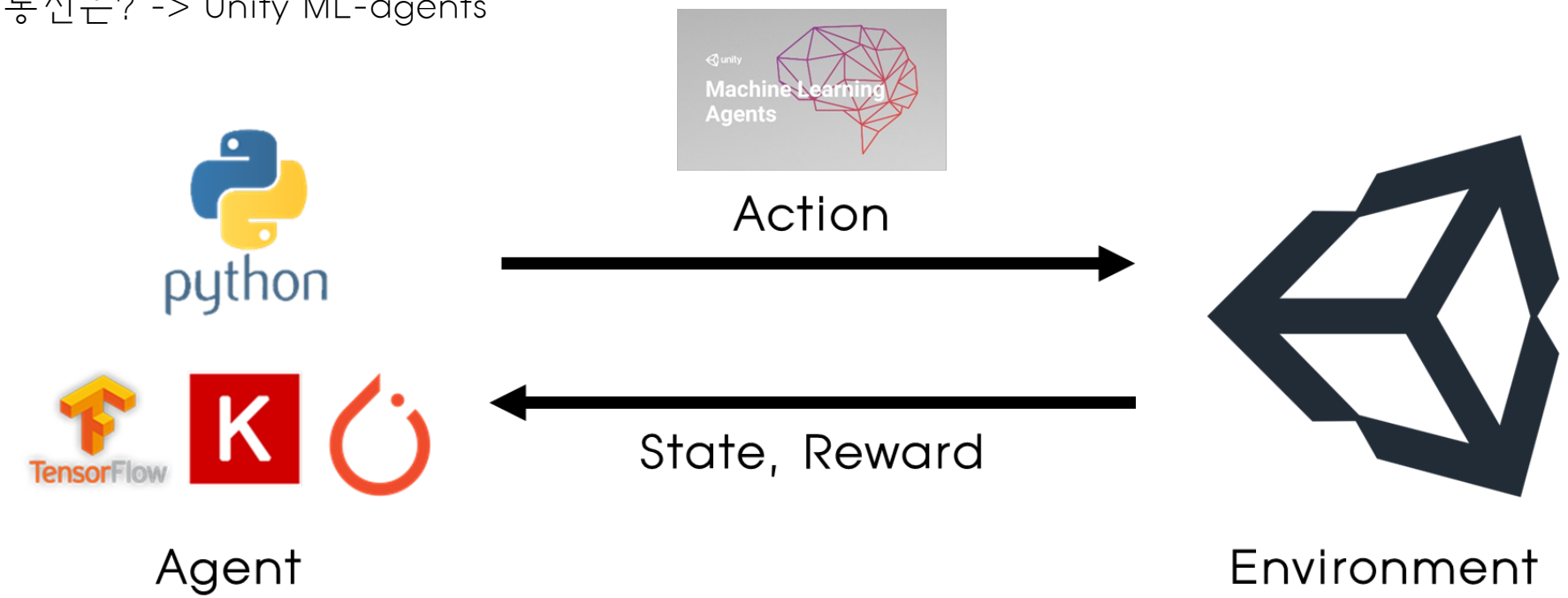
- 강화학습을 구성하는 요소: 강화학습 알고리즘, 환경
- 환경과 에이전트가 서로 정보를 주고 받으며 학습 수행



Unity ML-agents

- 일반적으로 딥강화학습 알고리즘은 python을 이용하여 구성
- 환경은 유니티를 이용하여 제작

  => 둘 간의 통신은? -> Unity ML-agents

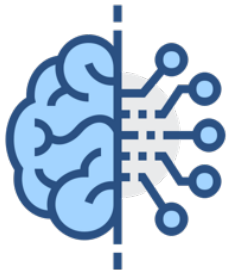


Unity ML-agents

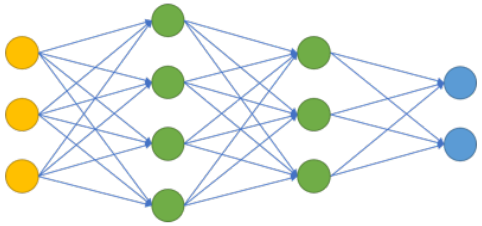
- 학습 방법 1
  - 빌드된 유니티 환경을 mlagent에서 제공하는 알고리즘을 통해 학습
  - 학습된 딥러닝 모델을 유니티 내부의 에이전트에 이식하여 환경을 다시 빌드

    => 학습된대로 에이전트가 행동 (다른 플랫폼에 적용 가능)

빌드된 유니티 환경



mlagent에서 제공하는
강화학습 알고리즘



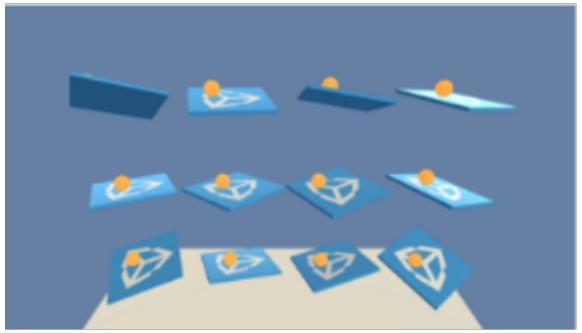
학습된 딥러닝 모델

유니티 내부의 에이전트에
학습된 모델 이식

Unity ML-agents

- 학습 방법 2
  - 빌드된 유니티 환경과 구성한 파이썬 코드가 서로 통신하며 에이전트를 학습

    => 이번 강의에서는 이 방법을 이용할 예정입니다!



빌드된 유니티 환경

상태, 보상

액션

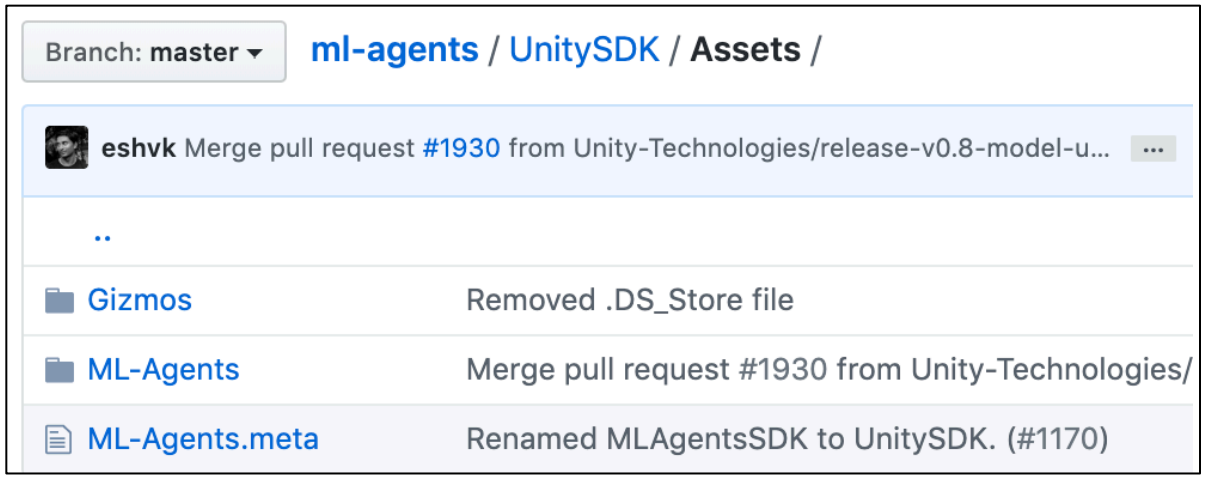
파이썬 알고리즘

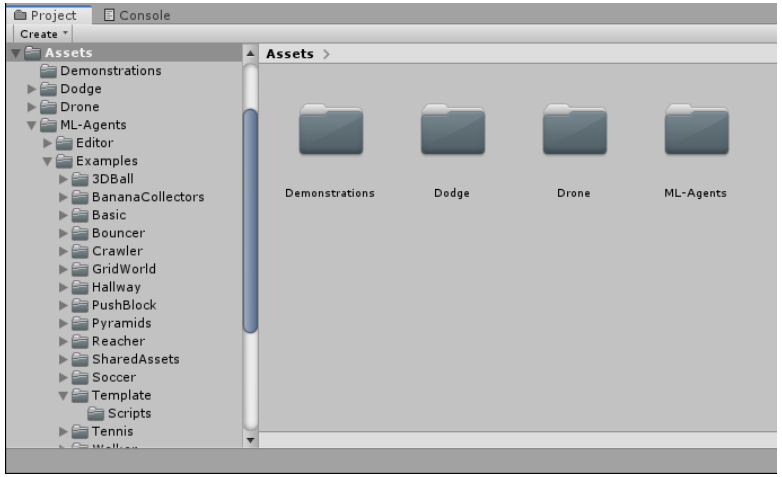
Unity ML-agents

- 유니티 환경 내에 강화학습을 위한 설정을 할 수 있음
- Python과 Unity 환경 간 통신 가능 (state, action, reward)
- Agent, Brain, Academy로 구성
  - Agent: Agent에 대한 코드 작성, Observation, reward, done에 대한 코드 작성
  - Brain: Brain을 통해 agent를 제어하는 방법 결정 및 Observation, action에 대한 설정 가능
    - Player: 직접 사람이 플레이 할 수 있는 brain 설정
    - Heuristic: 사람이 설정한 규칙을 통해 action을 선택하는 brain 설정
    - Internal: 학습된 모델을 통해 Unity 내부에서 환경을 플레이하는 brain 설정
    - External: 외부 Python 코드와 Unity 환경 간 통신을 할 수 있게 하는 설정
  - Academy: Brain을 통합 관리하며 환경에 대한 다양한 설정 가능

Unity ML-agents

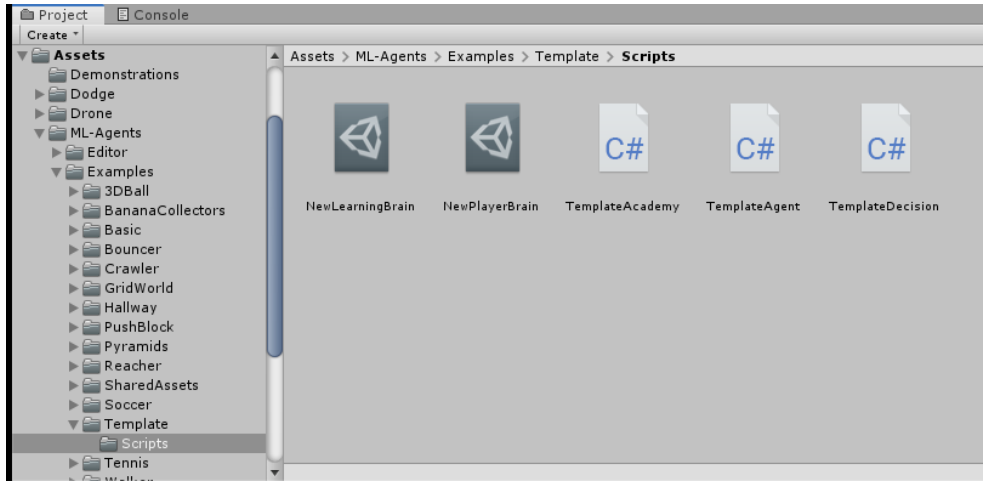
- ML-agents 깃허브에서 ML-agents 프로젝트 받기
  - https://github.com/Unity-Technologies/ml-agents/releases (beta 0.8.1)
- ML-agents 프로젝트의 [UnitySDK 폴더 -> Assets 폴더] 내부의 폴더를 유니티의 Assets 내부에 복사

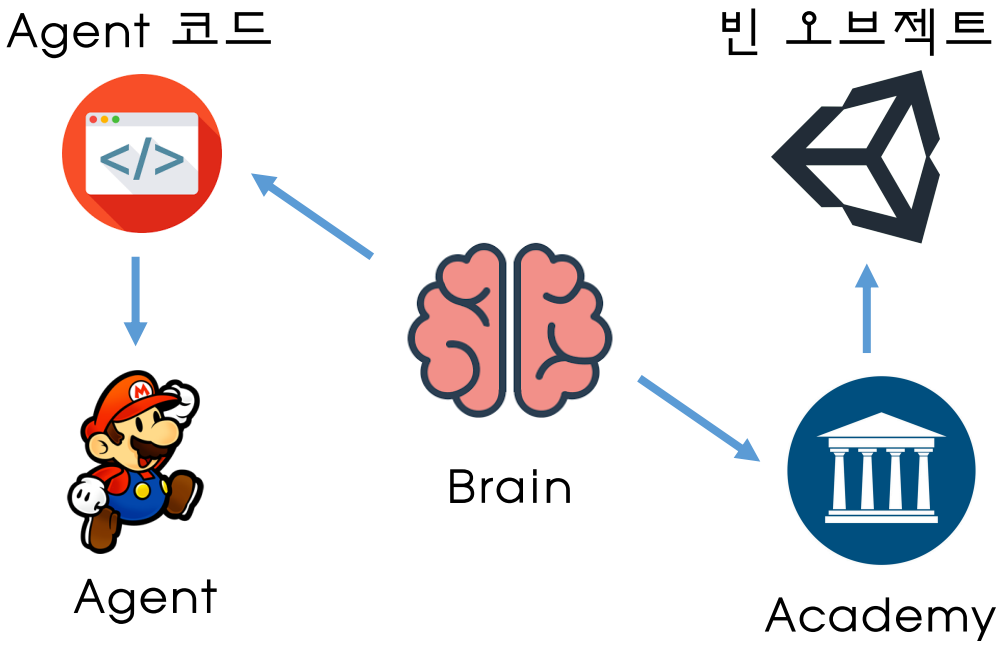




Unity ML-agents

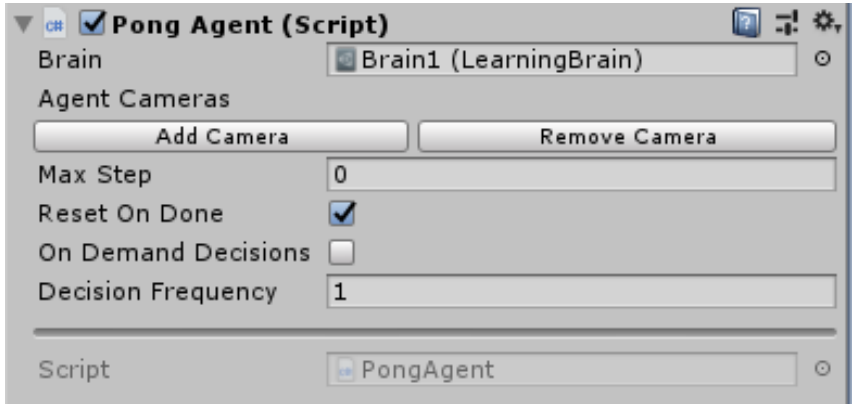
- Assets 내부의 [ML-Agents 폴더 -> Examples 폴더 -> Template 폴더]의 코드들을 이용하면 편해요!
  - Agent 스크립트는 게임 내에서 제어할 대상에게 연결
  - 각 Agent 스크립트에 해당하는 Brain 할당
  - 빈 오브젝트를 생성 후 Academy 스크립트를 연결





Agent

- 스크립트 내부는 4개의 함수로 구성
  - CollectObservations 함수: 현재의 상태로 이용할 정보들을 저장 (ex. 위치 좌표 (x, y, z), 각도 정보 (x, y, z), 속도 등)
  - AgentAction 함수: Action을 입력으로 받고 해당 Action에 따라 어떻게 에이전트를 제어할지 결정 -> 이동, 회전 등등 행동을 코딩
  - AgentReset 함수: 게임 한판이 끝난 경우 (Done) 에이전트에 대한 설정을 코딩 (ex. 위치 초기화, 회전 초기화)
  - AgentOnDone 함수: 에이전트를 더이상 사용하지 않을 때 해당 함수 내부에 Destroy를 사용하여 에이전트를 제거
- Inspector View
  - Brain: 해당 에이전트를 위해 사용할 브레인을 설정
  - Agent Cameras: 이미지 입력을 받을 경우 사용할 카메라를 설정
  - Max Step: 게임이 Max Step만큼 진행되면 게임 한판을 끝냄!
  - Reset On Done: 이 설정이 체크되어야 Done이 된 경우 AgentReset 함수 호출
  - On Demand Decisions: 특정 이벤트가 발생했을 때만 액션을 위하도록 설정
  - Decision Frequency: 해당 스텝마다 한번씩 액션을 취하도록 설정

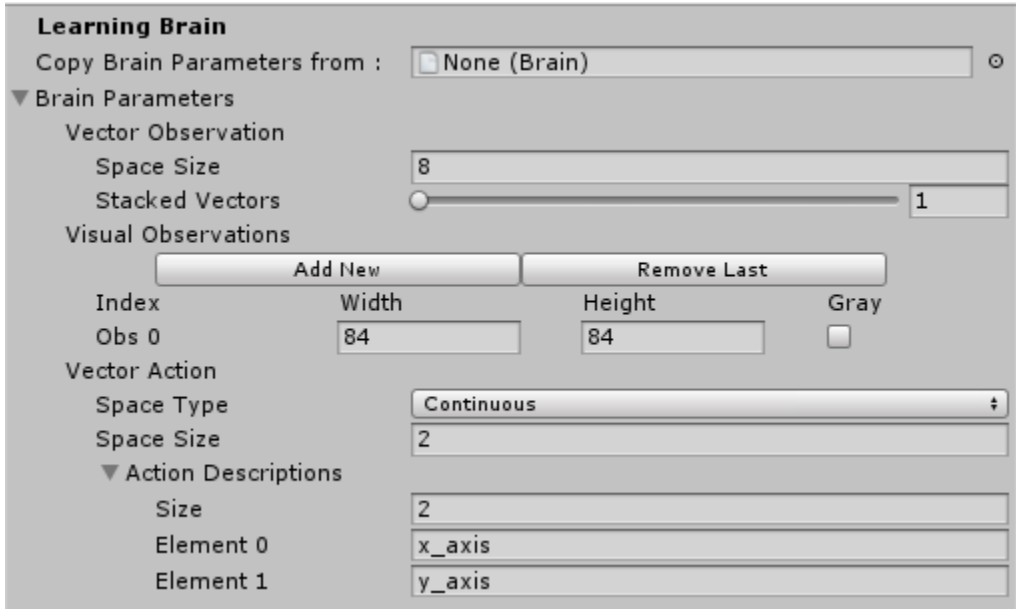


Brain

- 3가지 종류의 브레인
  - Player: 직접 사람이 플레이 할 수 있는 brain 설정
    - 키보드와 액션을 직접 설정해서 에이전트를 키보드를 제어할 수 있음
  - Heuristic: 사람이 설정한 규칙을 통해 action을 선택하는 brain 설정
    - Decisions 스크립트에 상태에 대한 규칙을 설정하고 해당 규칙에 따라 액션을 반환하도록 설정
  - Training (Internal): Unity에 학습된 모델을 내장하고 환경을 플레이하는 brain 설정
    - ML-agents에서 기본적으로 제공하는 코드로 환경을 학습하면 nn 파일 생성
    - nn 파일을 training brain에 연결해주면 학습된 대로 에이전트가 행동
  - Training (External): 외부 Python 코드와 Unity 환경 간 통신을 할 수 있게 하는 설정
    - Python 코드에 observation, reward, done 정보를 전달하고 python 코드로부터 action 정보를 받음

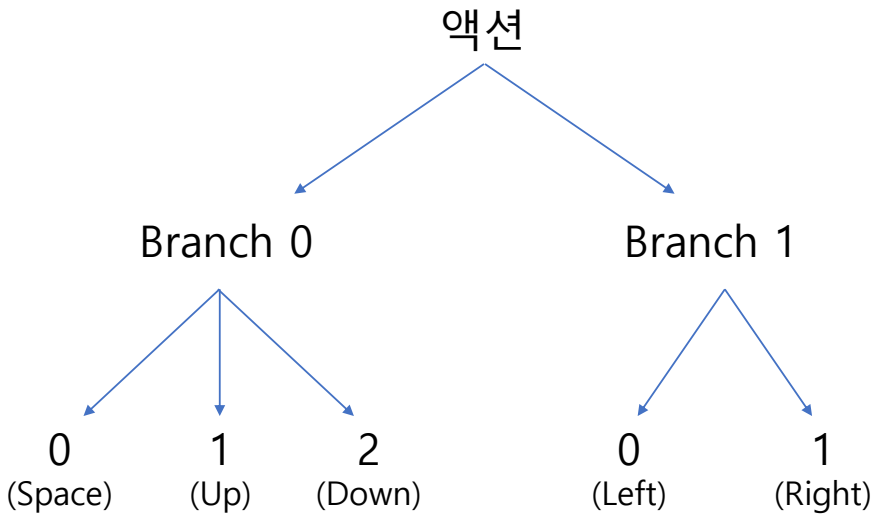
Brain

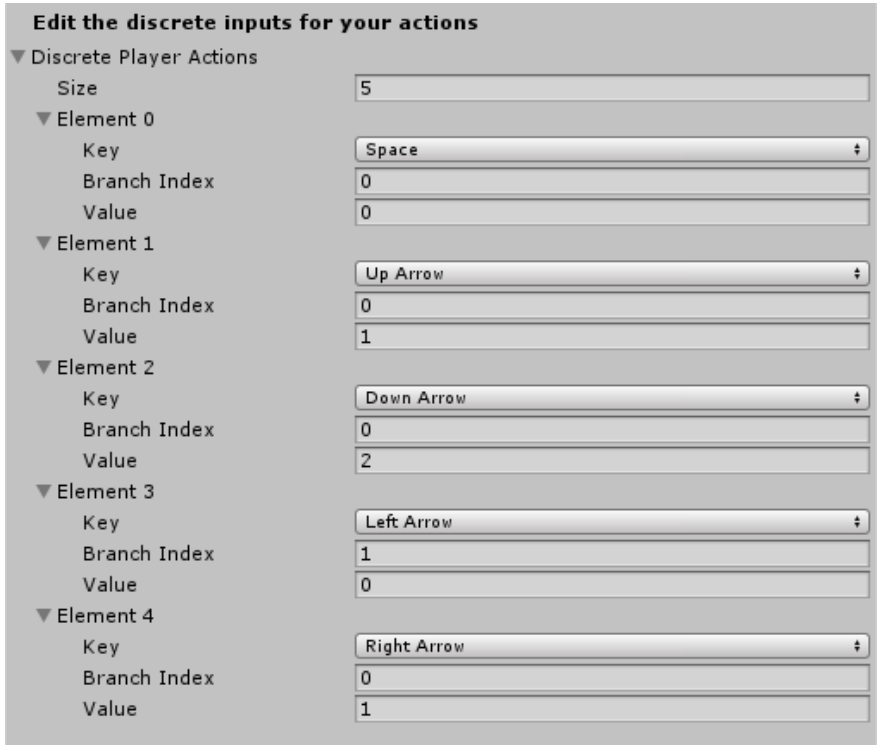
- 브레인 설정 (모든 브레인에 공통적으로 적용)
- Inspector View
  - Copy Brain Parameters from: 브레인의 파라미터 복사
  - Vector Observation
    - Space Size: Vector Observation의 크기 결정
    - Stacked Vectors: 설정한 스텝만큼 vector 정보를 stack
  - Visual Observation
    - Visual observation의 크기와 grayscale 여부 결정
  - Vector Action
    - 액션의 종류 및 개수 결정 -> Action Descriptions에 액션에 대한 설명 작성

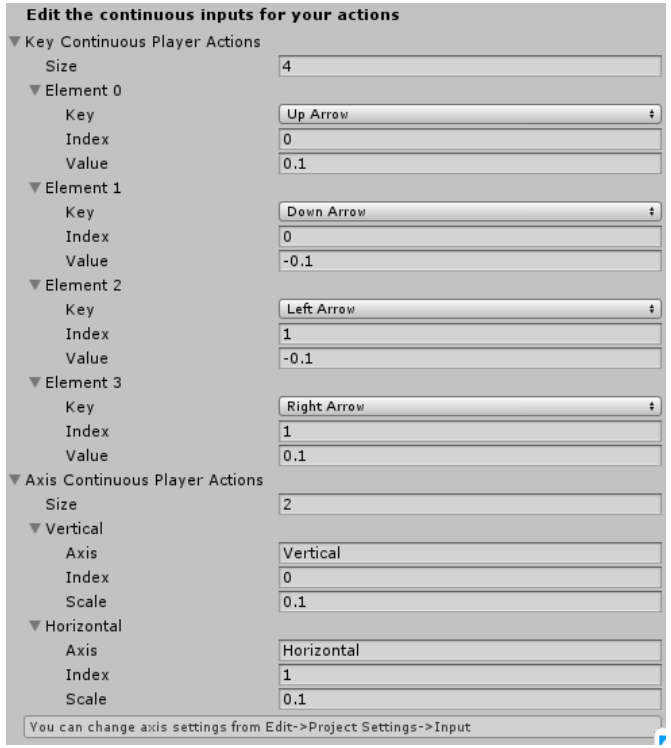


Brain

- Player 브레인 설정

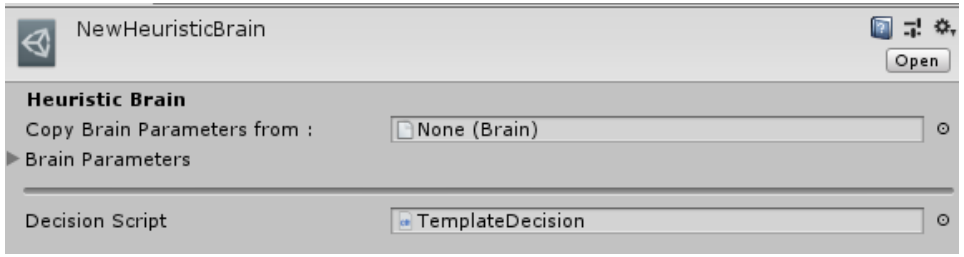




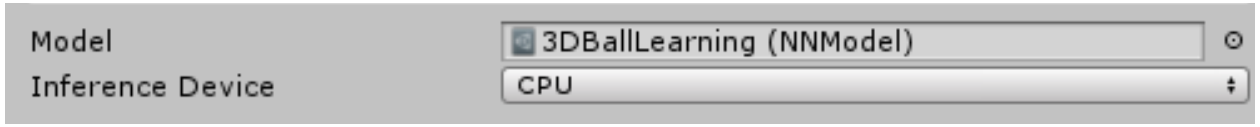


Brain

- Heuristic 브레인 설정
  - Decision Script에 코딩된 Decision 스크립트 파일 연결

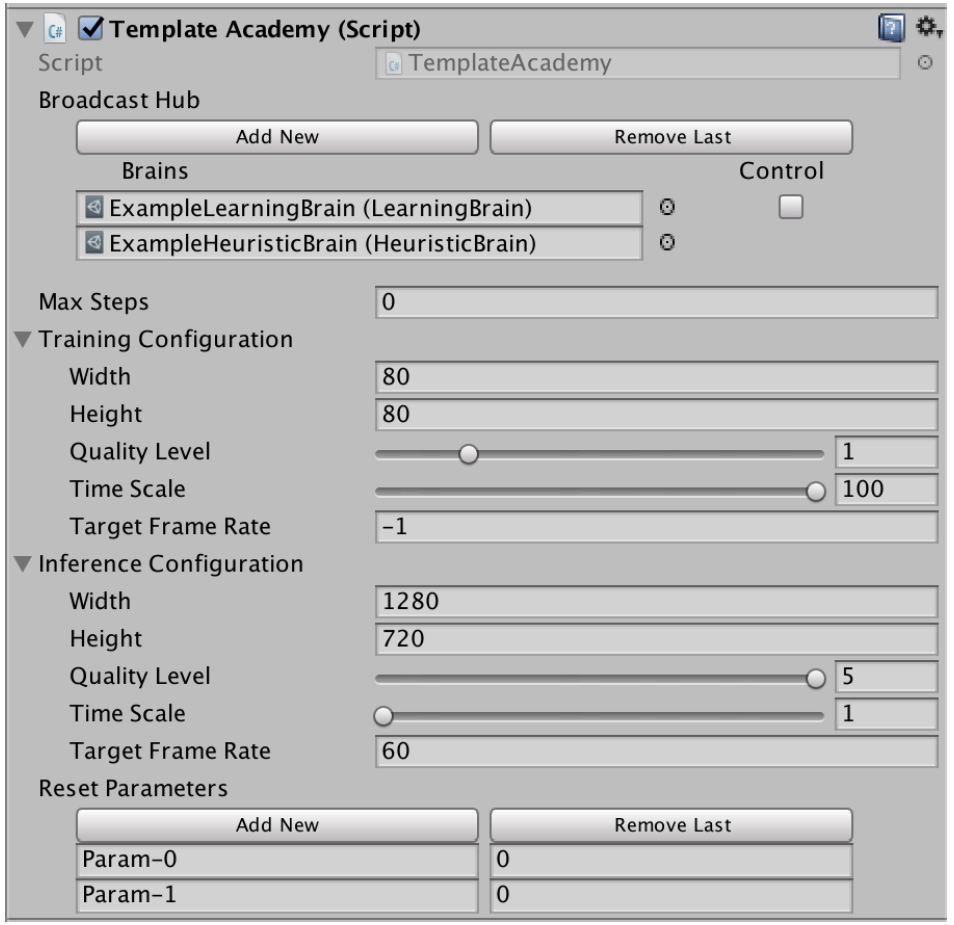


- Training 브레인 설정
  - 유니티 내부에서 사용할 nn 모델 연결 및 연산 장치 결정



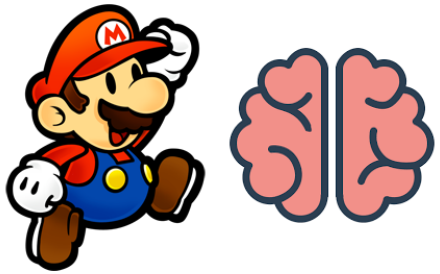
Academy

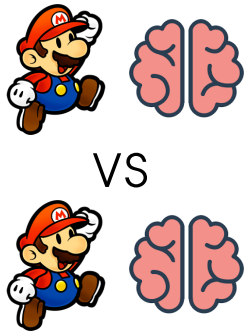
- 스크립트 내부는 3개의 함수로 구성
  - InitializeAcademy 함수: 환경이 처음 실행될 때 딱 한번 호출되는 함수
  - AcademyReset 함수: 매 에피소드가 끝날 때마다 한번씩 호출되는 함수
  - AcademyStep 함수: 매 스텝마다 호출되는 함수
- Inspector View
  - Broadcast Hub: 해당 환경에서 사용할 브레인을 추가
    - Learning brain의 control을 체크하면 external, 체크하지 않으면 internal
  - Max Steps: Global done을 위한 최대 스텝 (모든 에이전트를 초기화)
  - Configuration: 화면의 크기, 그래픽 품질, 화면 업데이트 주기 등 결정
    - Training Configuration: 학습할 때 환경에 대한 설정
    - Inference Configuration: 학습이 끝나고 테스트 할 때 환경에 대한 설정
  - Reset Parameters: 외부 (python)에서 조절할 수 있는 파라미터 설정



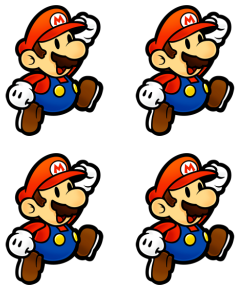
Unity ML-agents

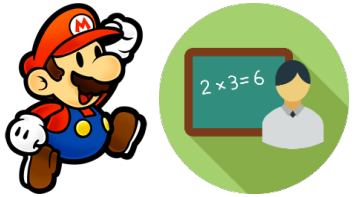
Unity ML-agents


: Single Agent



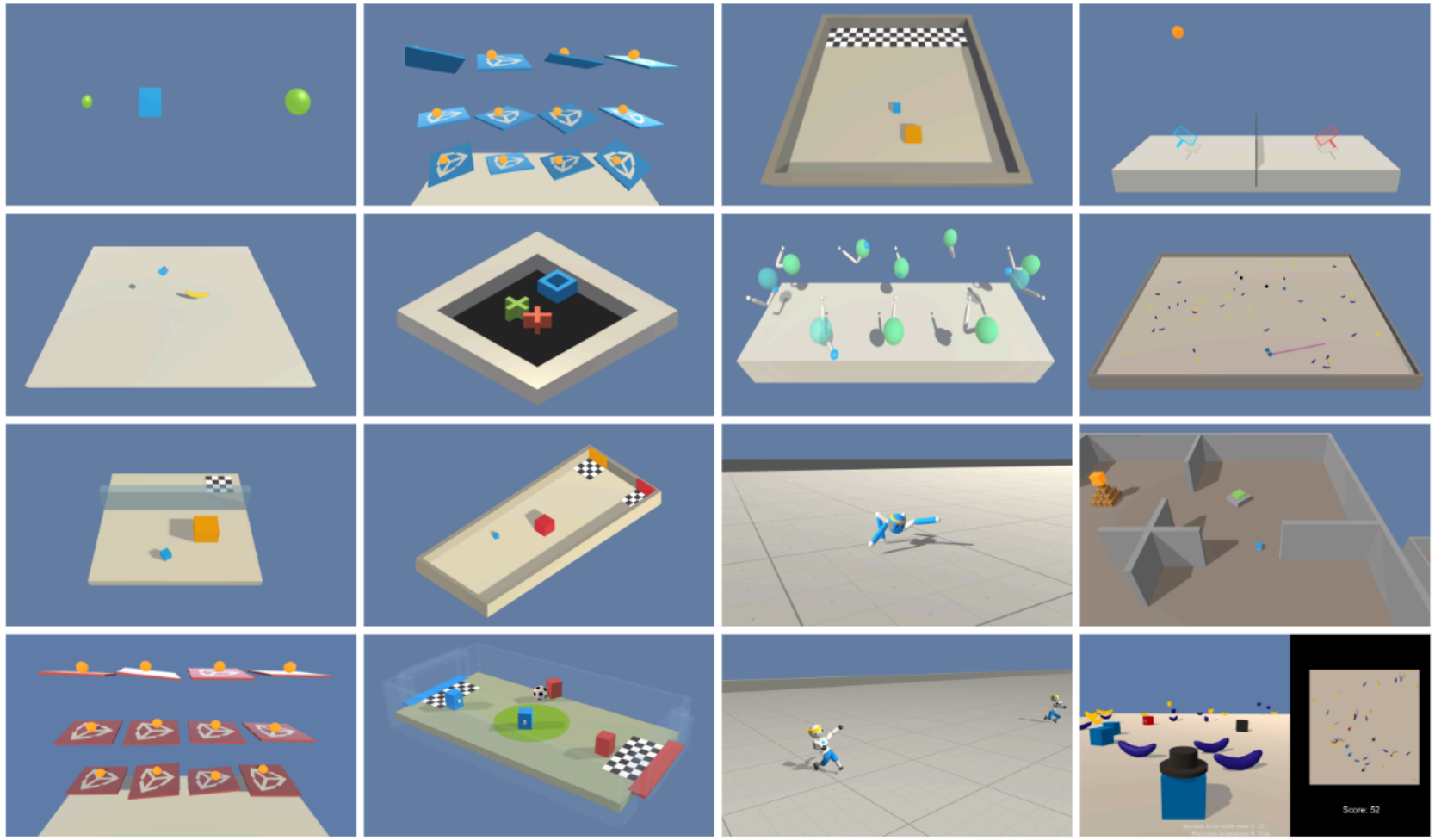
: Adversarial Agents


: Multi-agents

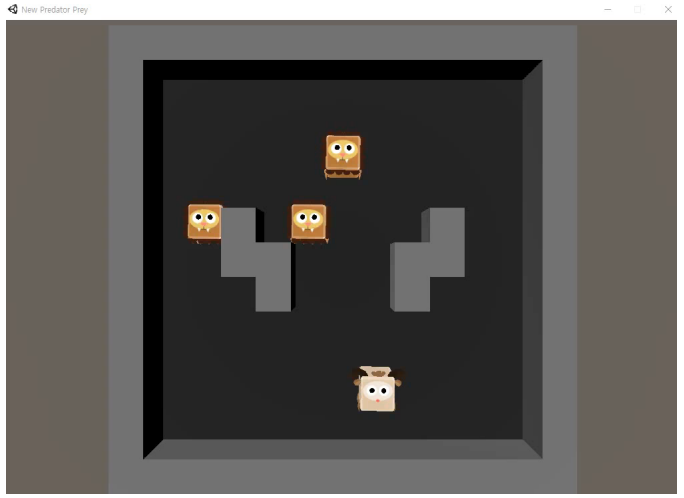


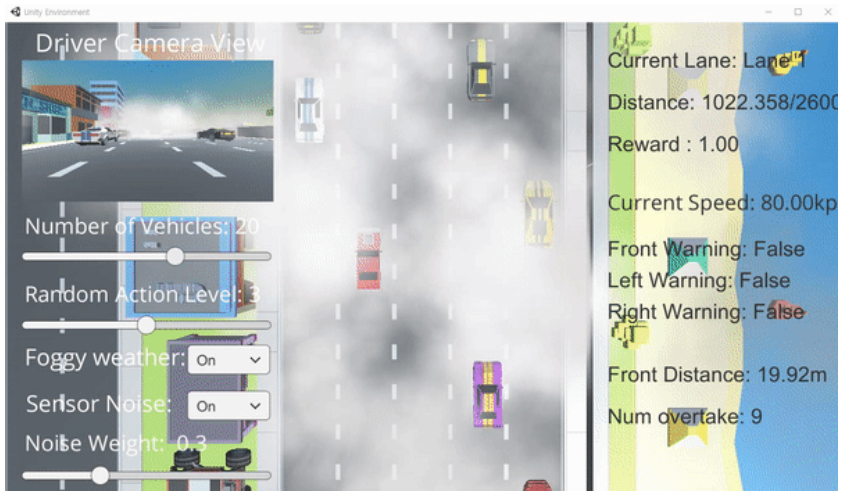
: Imitation Learning

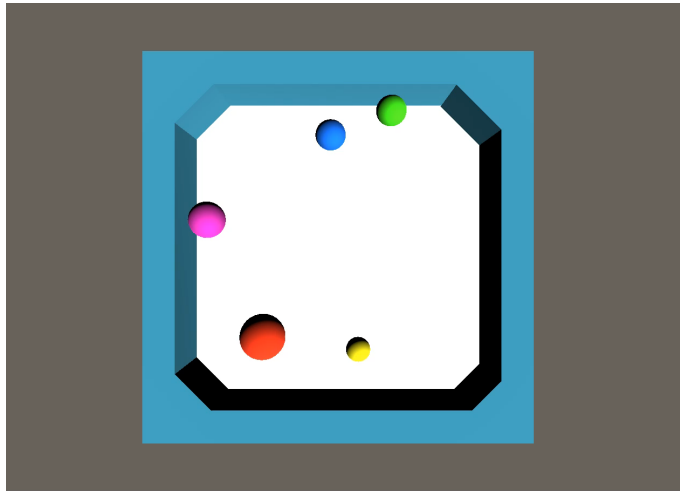
Unity ML-agents

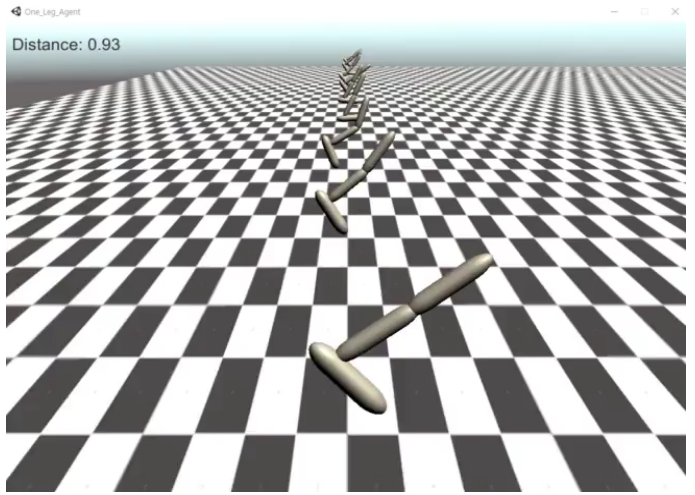


Unity ML-agents





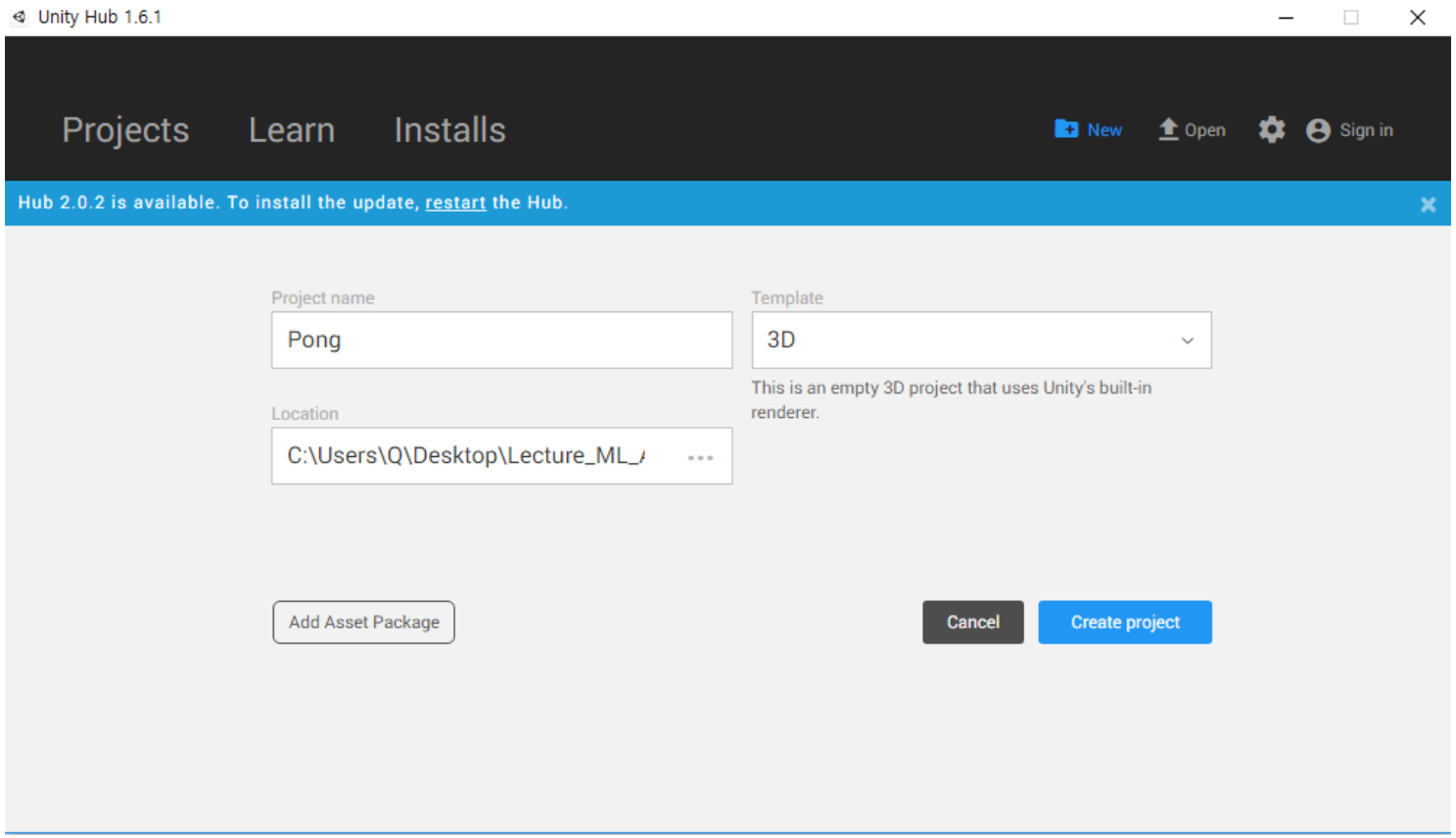




Unity ML-agents 예제

Learning (External)

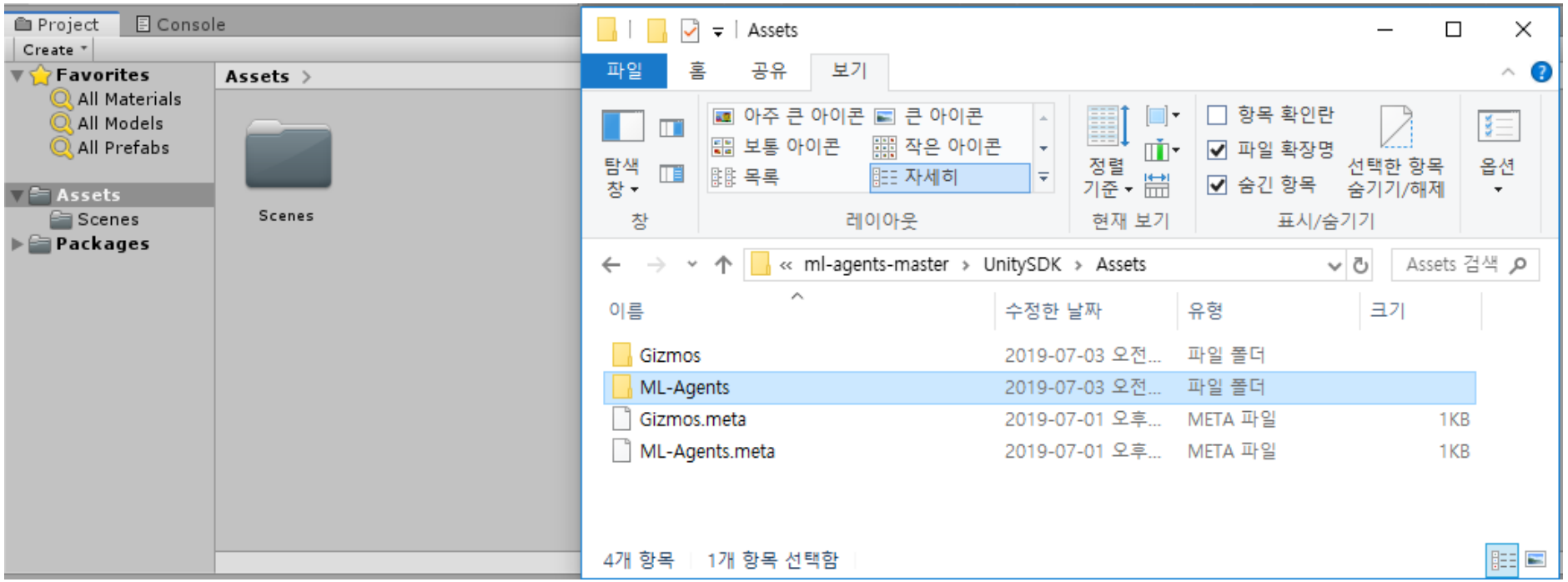
- Pong 환경 만들기!!
- 새 프로젝트 제작



Unity ML-agents 예제

Learning (External)

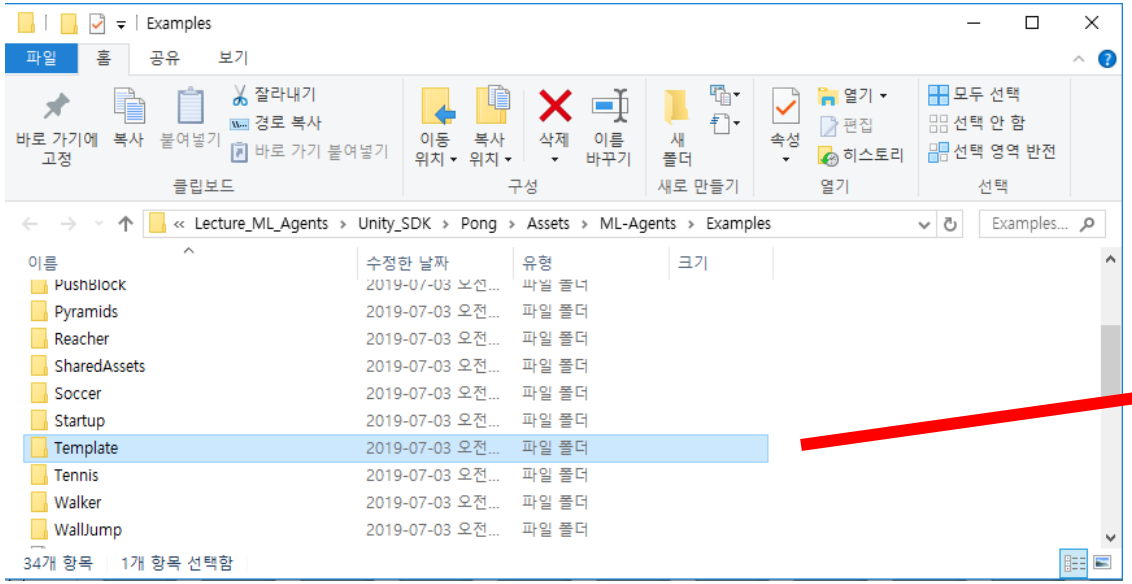
- UnitySDK -> Assets -> ML-Agents를 유니티 프로젝트 뷰의 Assets에 복사

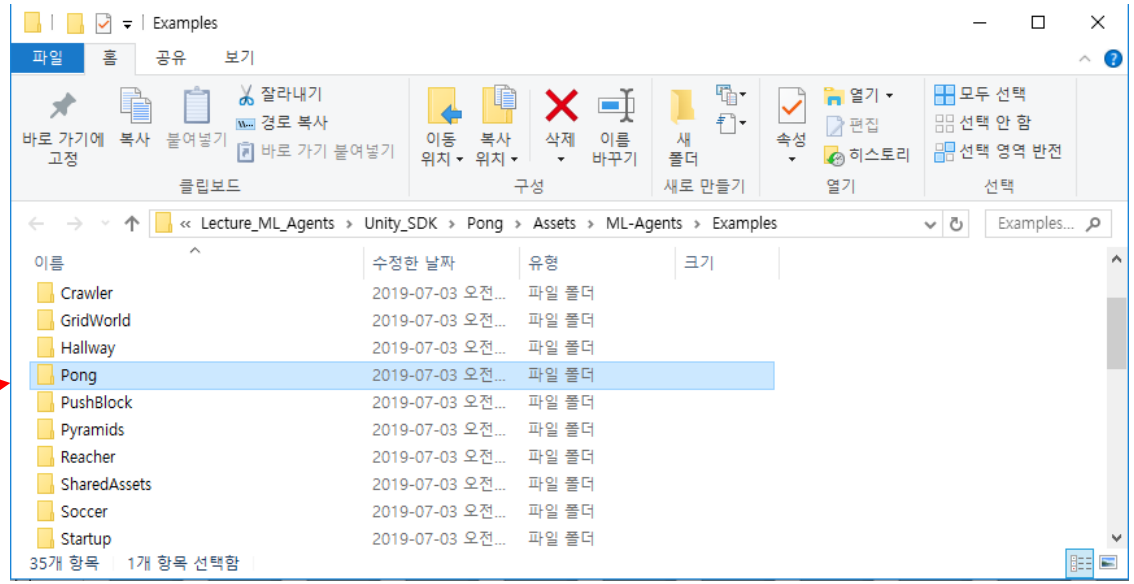


Unity ML-agents 예제

Learning (External)

- Assets -> ML-agents 내부의 Template을 동일 폴더내에 복사&붙여넣기 후 Pong으로 폴더명 변경





Unity ML-agents 예제

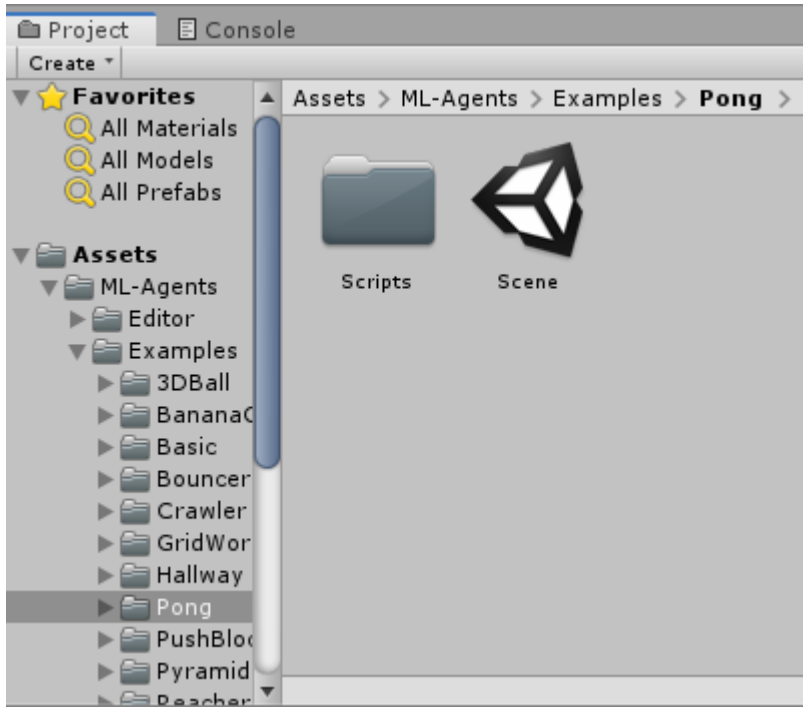
Learning (External)

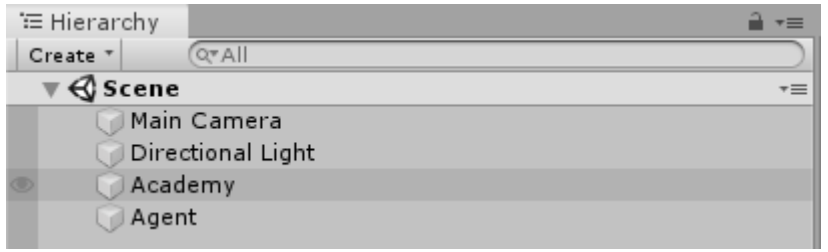
- 다시 유니티로 돌아오면 에러가 한가득!! -> 스크립트 파일들의 namespace 변경 필요!

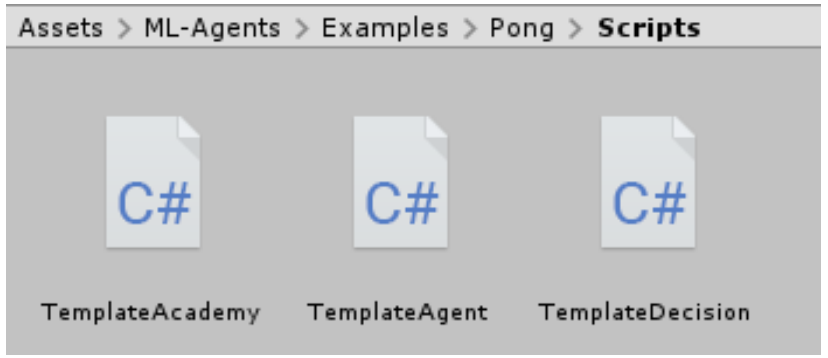
Unity ML-agents 예제

Learning (External)

- 우선 [ML-Agents -> Examples -> Pong] 내부의 Scene 파일을 열어줌! (기본적인 Template 파일들)







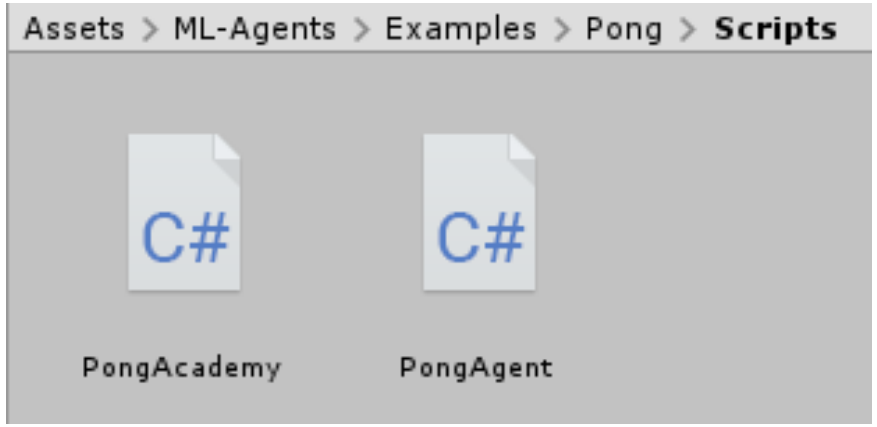
Unity ML-agents 예제

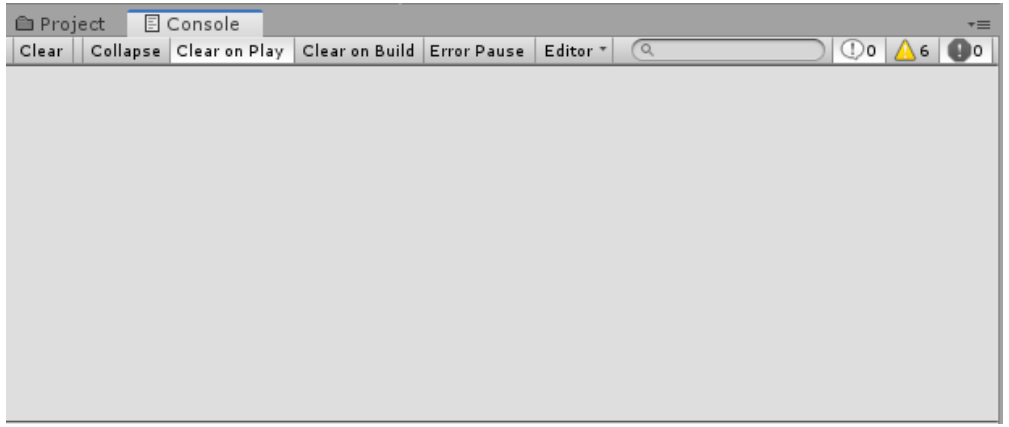
Learning (External)

- Decision은 삭제하고 각 스크립트 파일을 이름 변경 후 열어서 namespace 변경 -> 에러가 사라졌어요~

```
1   using System.Collections;
2   using System.Collections.Generic;
3   using UnityEngine;
4   using MLAgents;
5
6   public class PongAcademy : Academy {
```

```
1   using System.Collections;
2   using System.Collections.Generic;
3   using UnityEngine;
4   using MLAgents;
5
6   public class PongAgent : Agent {
```

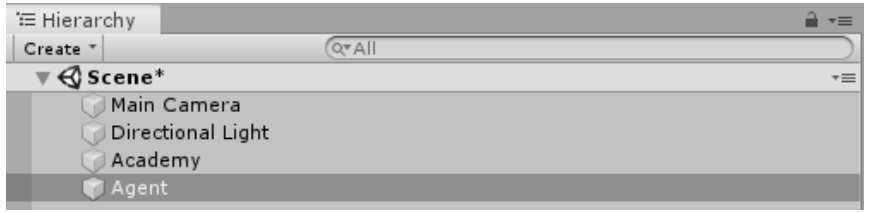


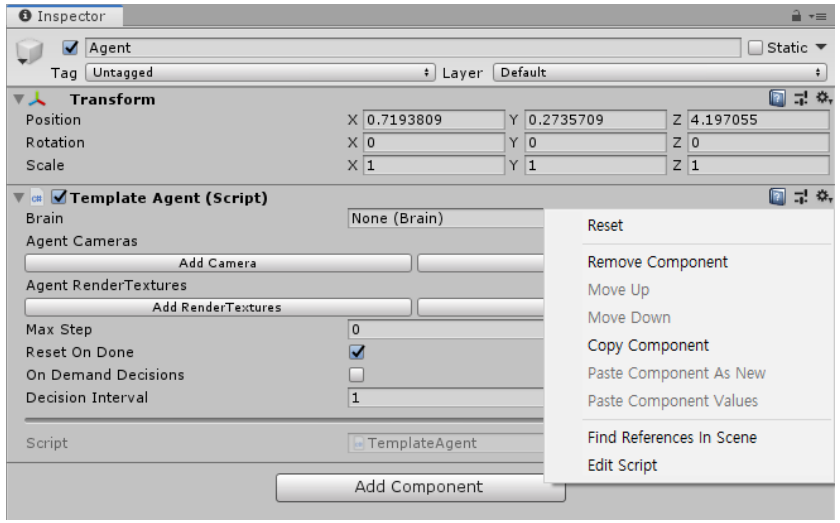


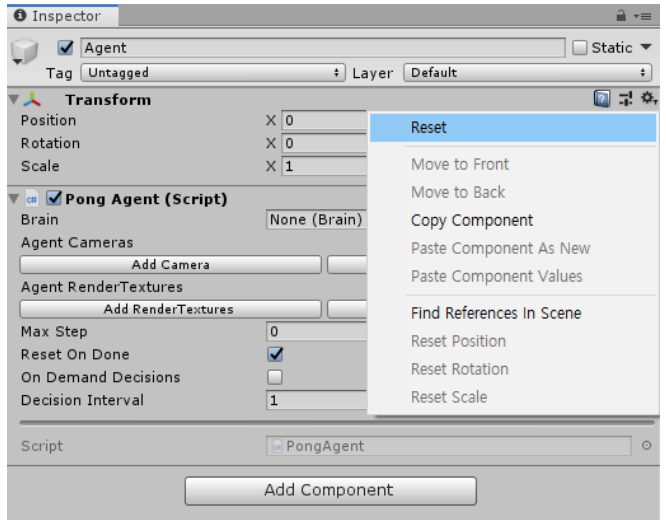
Unity ML-agents 예제

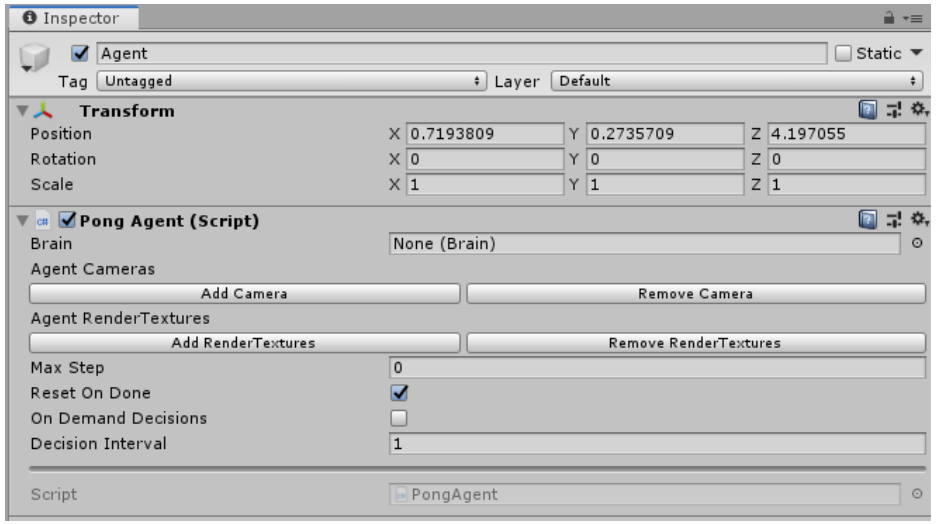
Learning (External)

- Agent에 있던 스크립트 파일을 없애고 PongAgent로 변경 (Transform 리셋)





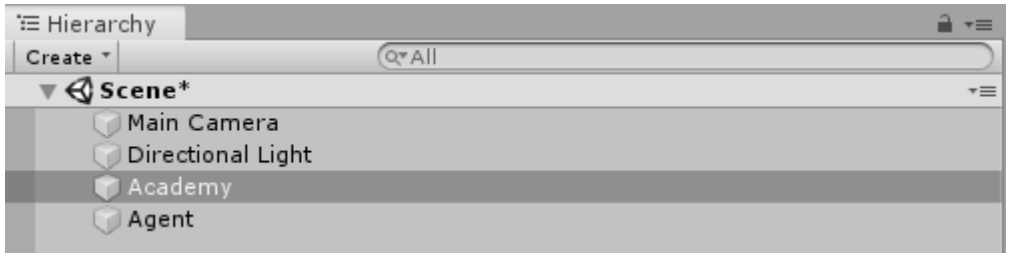


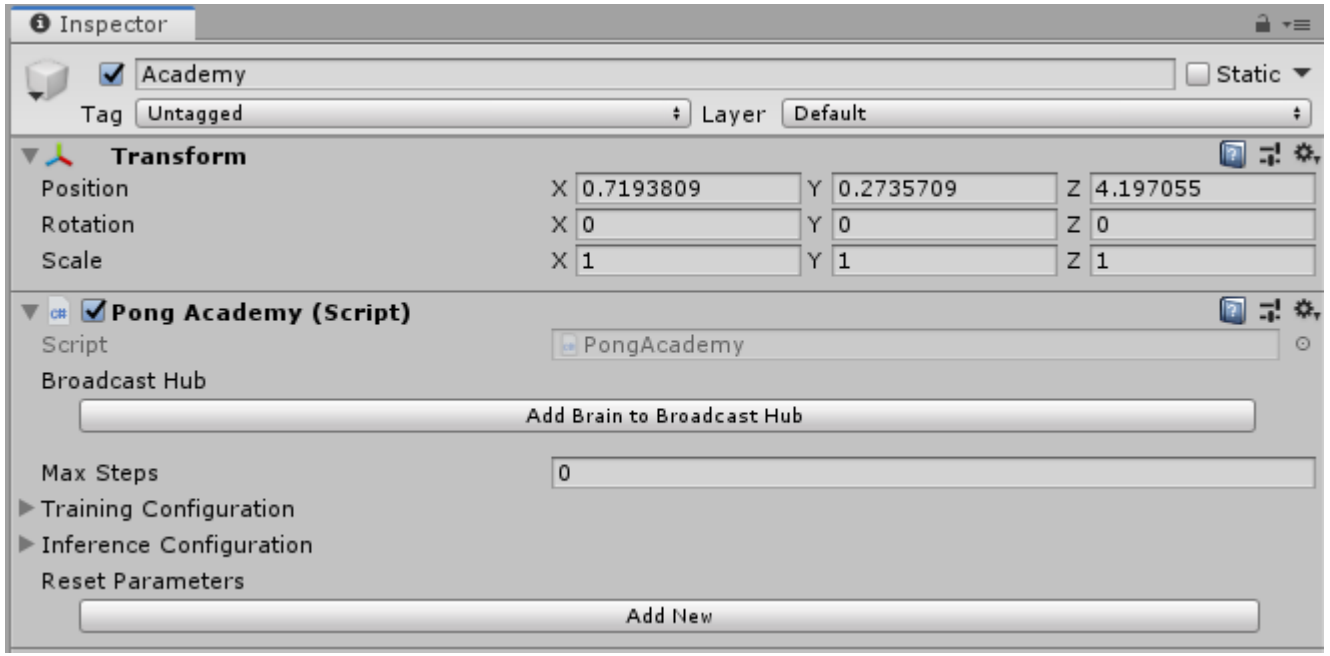


Unity ML-agents 예제

Learning (External)

- Academy도 스크립트 파일을 PongAcademy로 변경

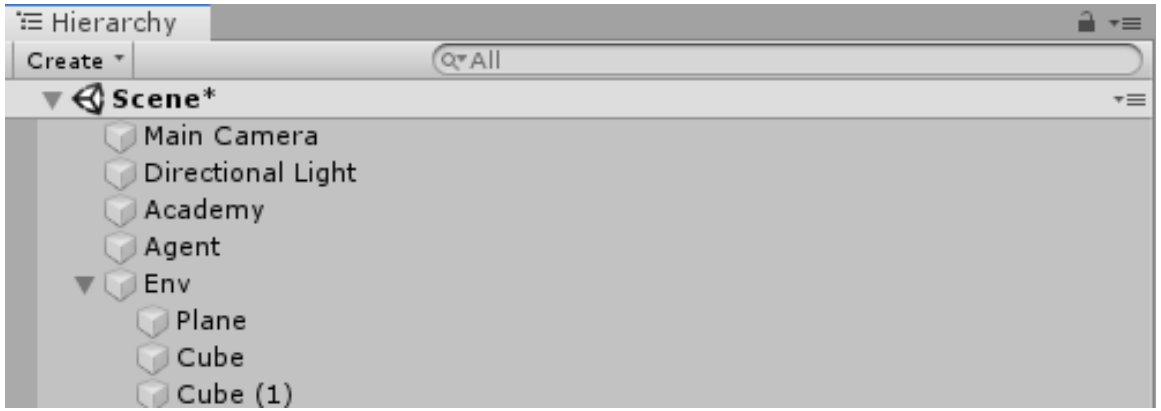


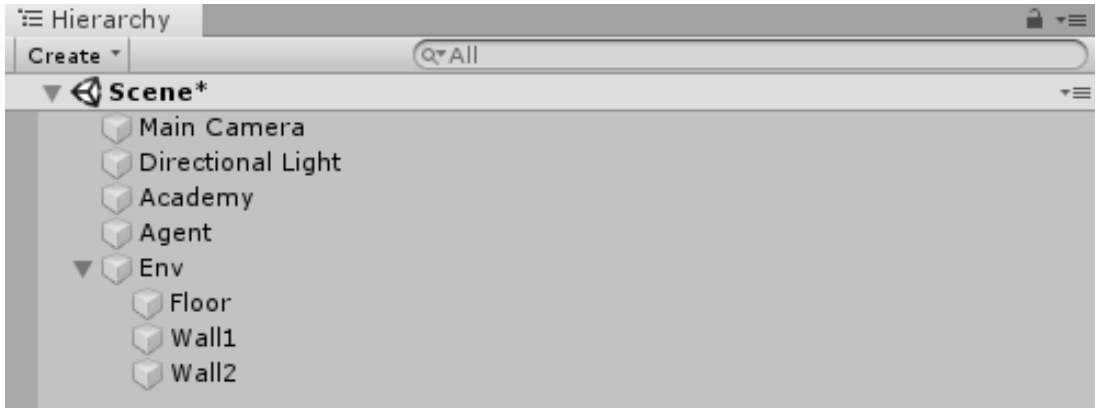


Unity ML-agents 예제

Learning (External)

- 빈 오브젝트인 Env 생성 후 내부에 Plane 1개와 Cube 2개 생성 후 이름 변경
  - Plane -> Floor
  - Cube -> Wall1
  - Cube -> Wall2

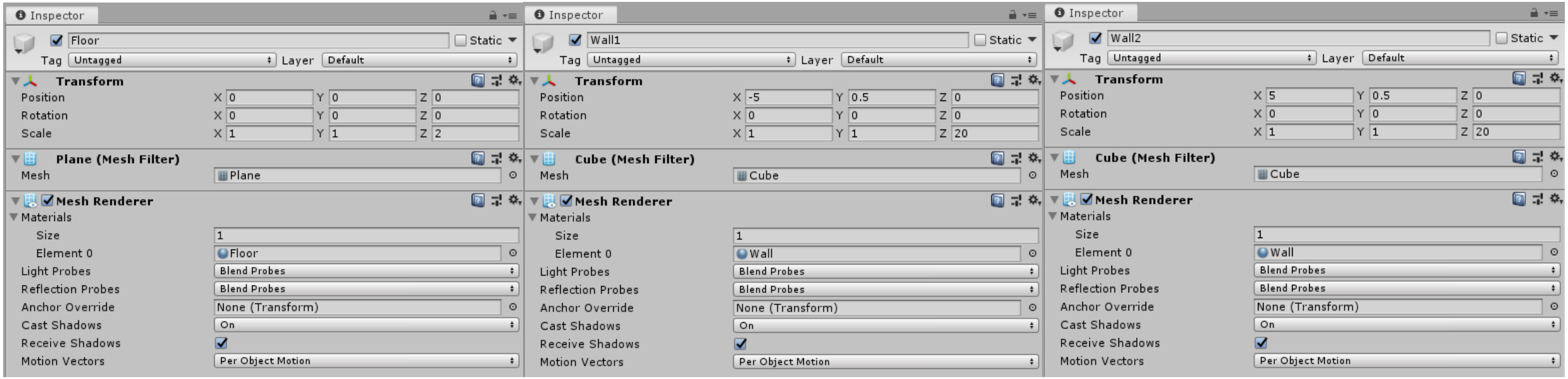




Unity ML-agents 예제

Learning (External)

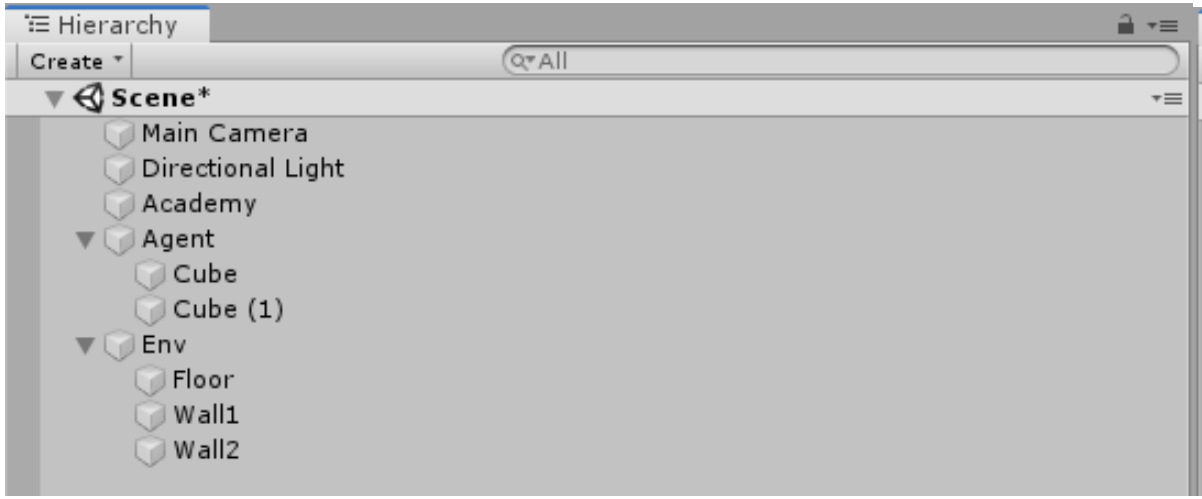
- 각 Object의 Inspector view 설정 (Transform, Mesh renderer -> element)

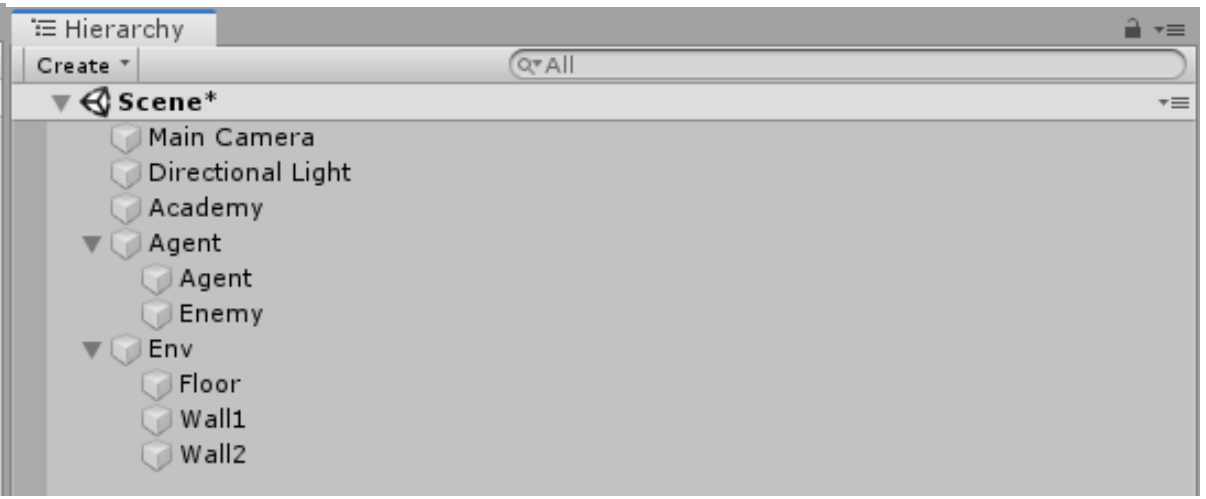


Unity ML-agents 예제

Learning (External)

- Agent 내부에 2개의 Cube 생성 후 이름 변경
  - Cube -> Agent
  - Cube -> Enemy

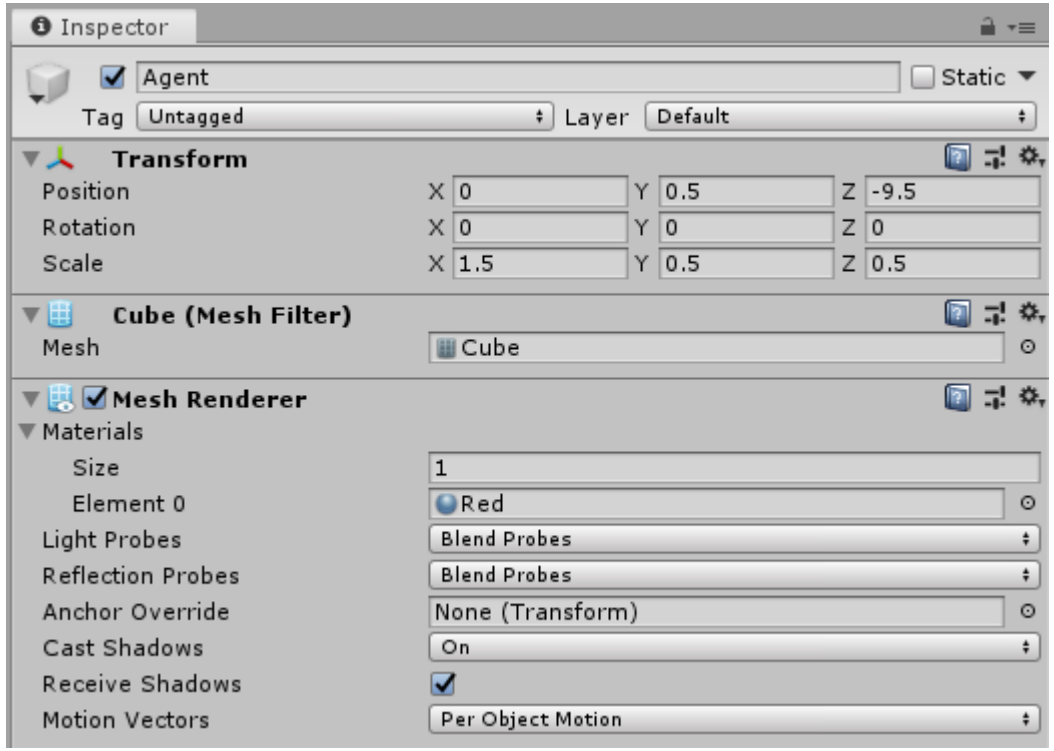


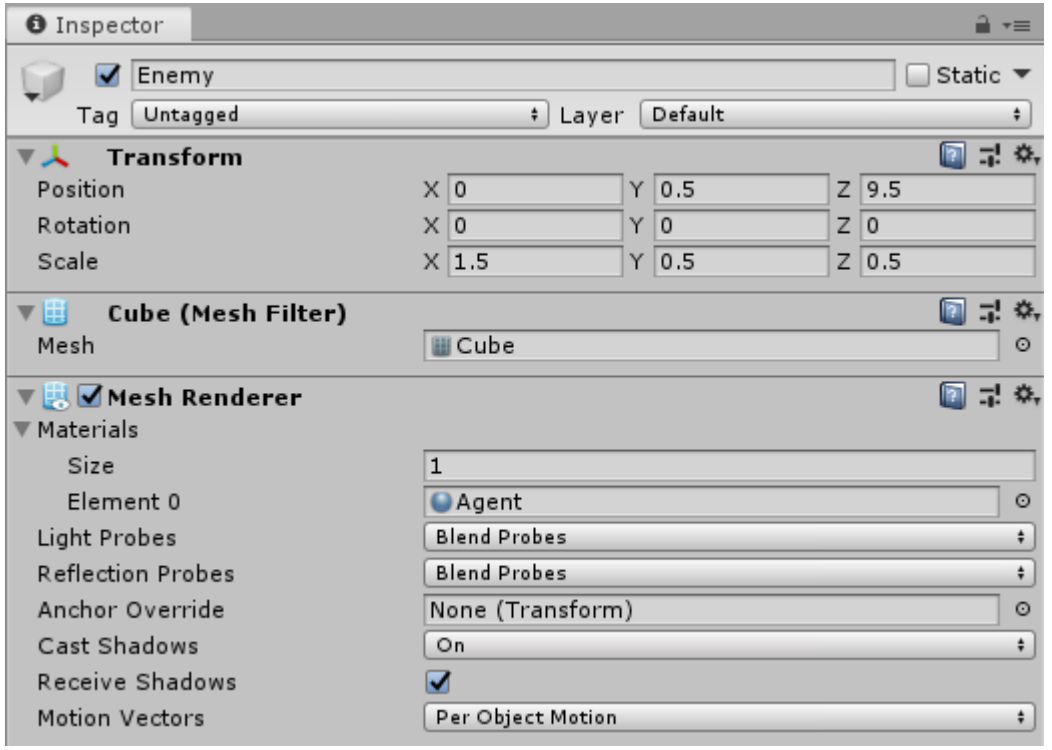


Unity ML-agents 예제

Learning (External)

- 2개의 오브젝트의 인스펙터뷰 설정 (Transform, Mesh Renderer -> Element)

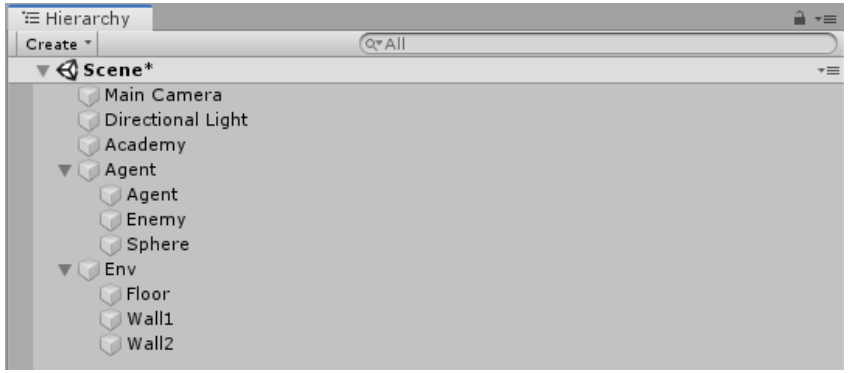


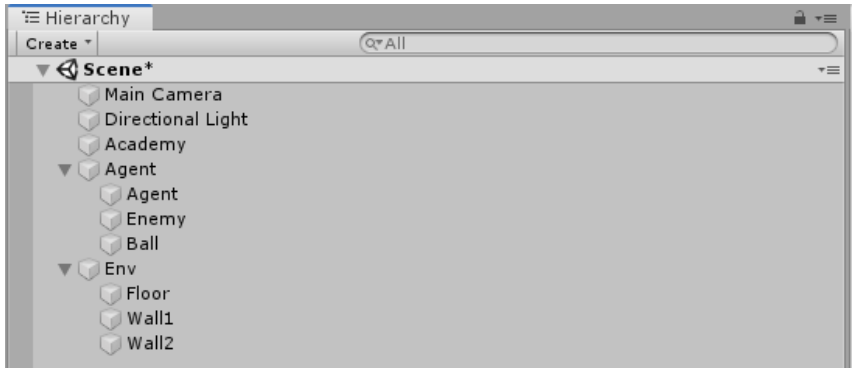


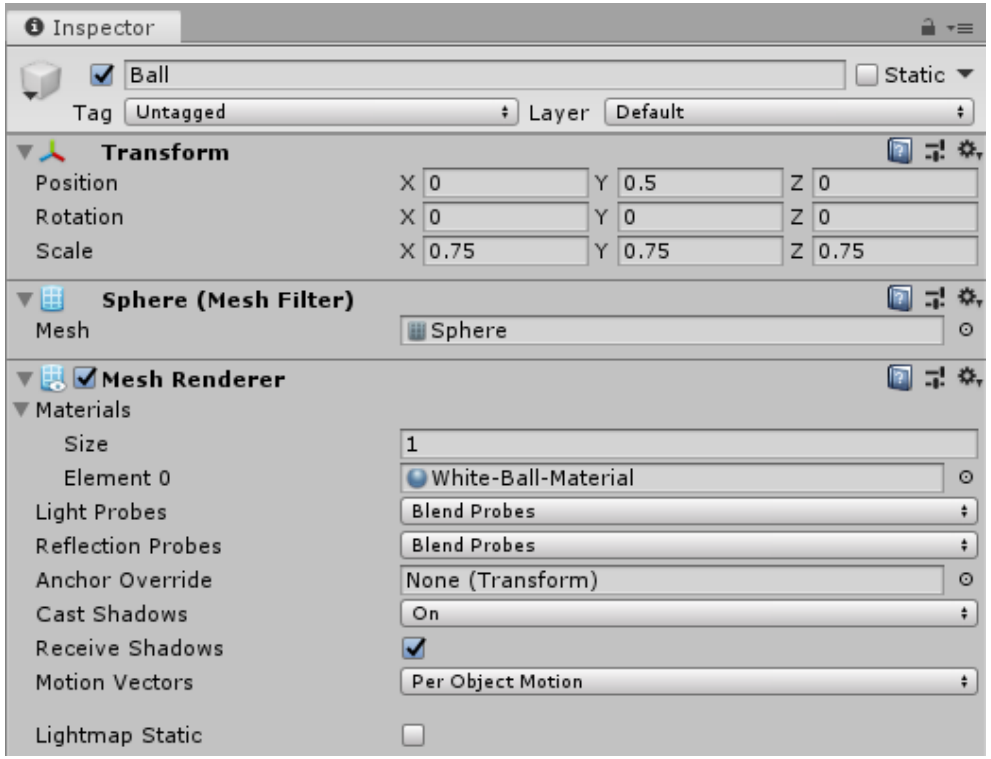
Unity ML-agents 예제

Learning (External)

- Agent 내부에 Sphere 추가 -> 이름을 Ball로 변경 후 인스펙터뷰 수정 (Transform, Mesh Renderer -> Element



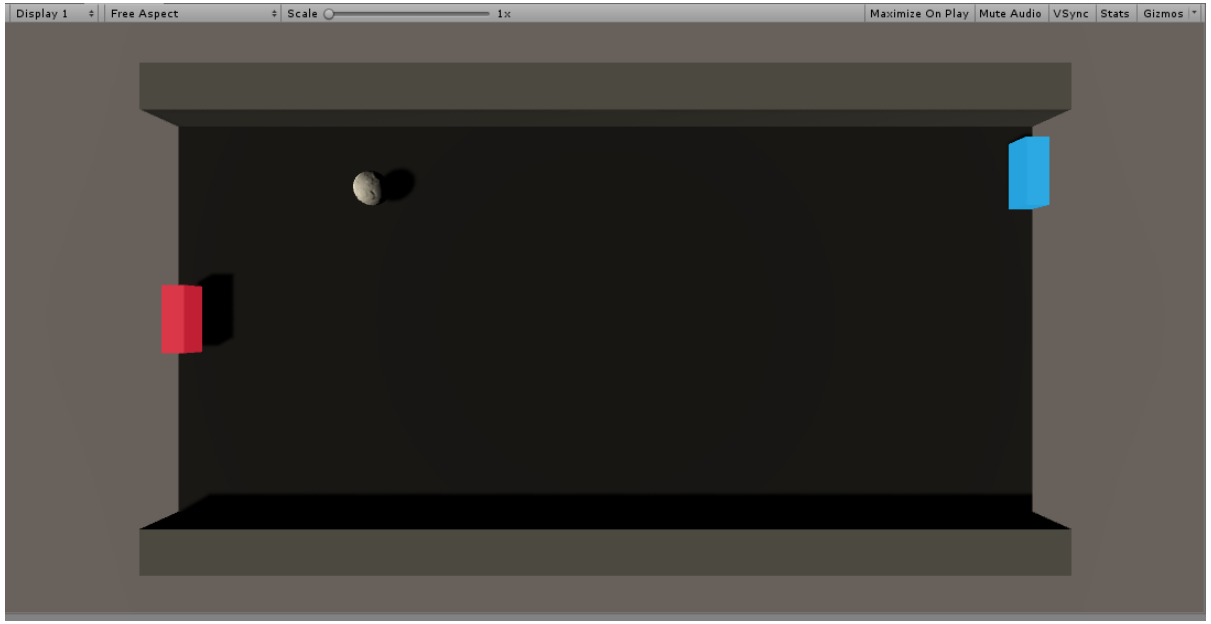


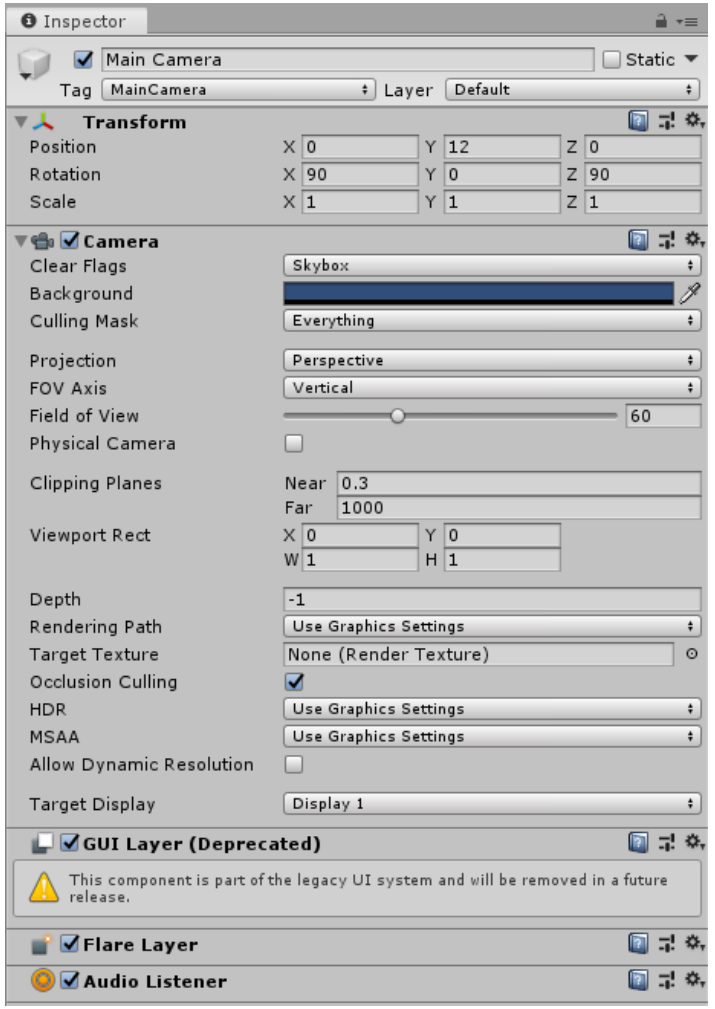


Unity ML-agents 예제

Learning (External)

- Main 카메라 위치 변경 (인스펙터뷰 설정 변경)

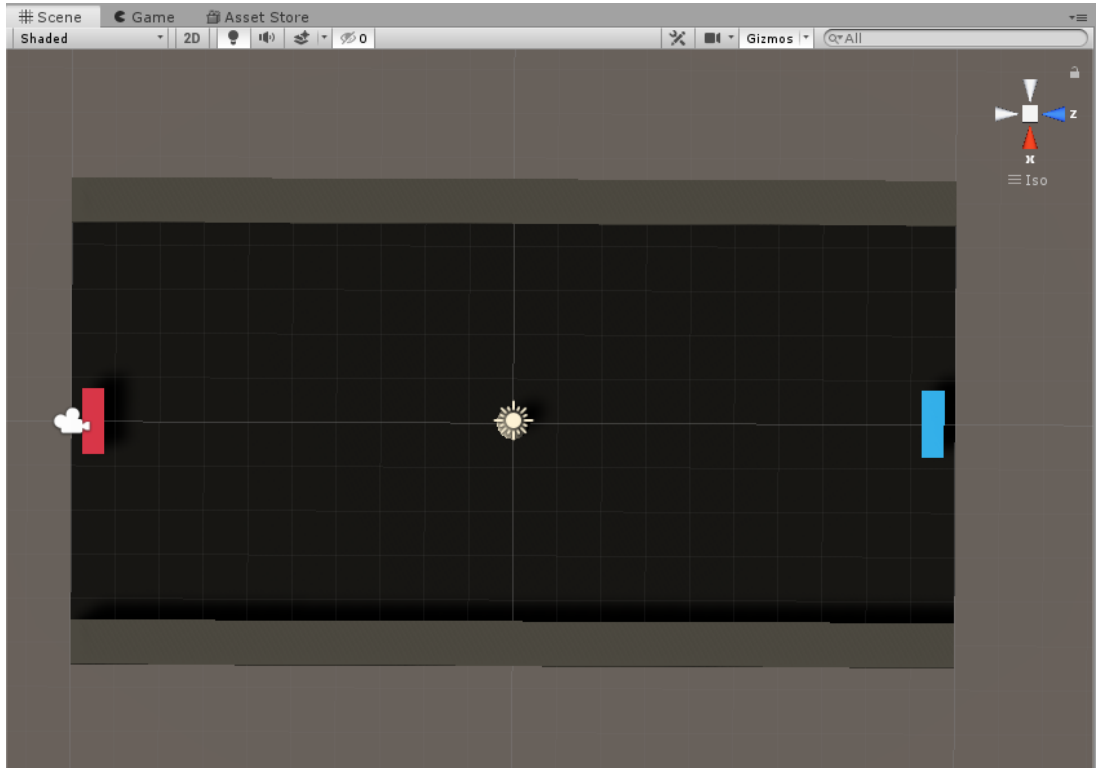




Unity ML-agents 예제

Learning (External)

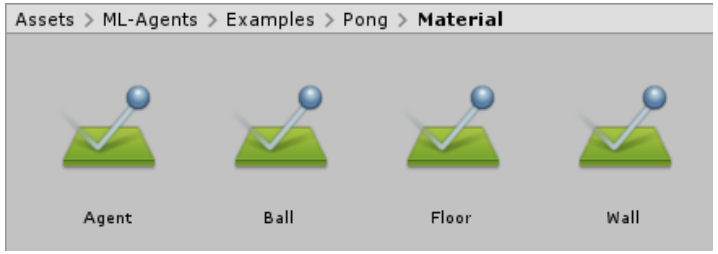
- 환경 완성!!

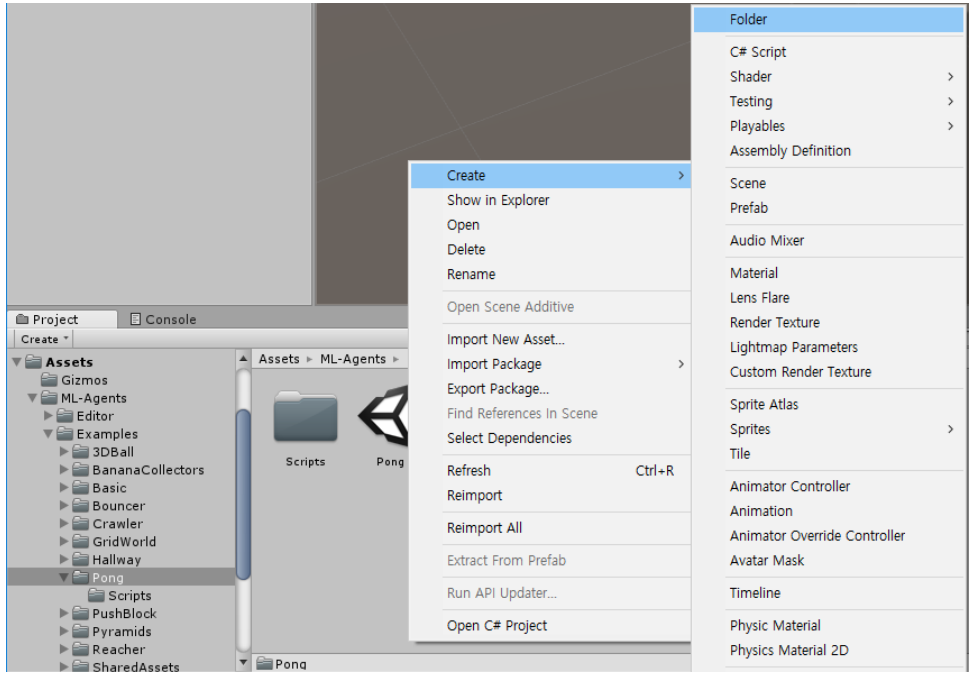


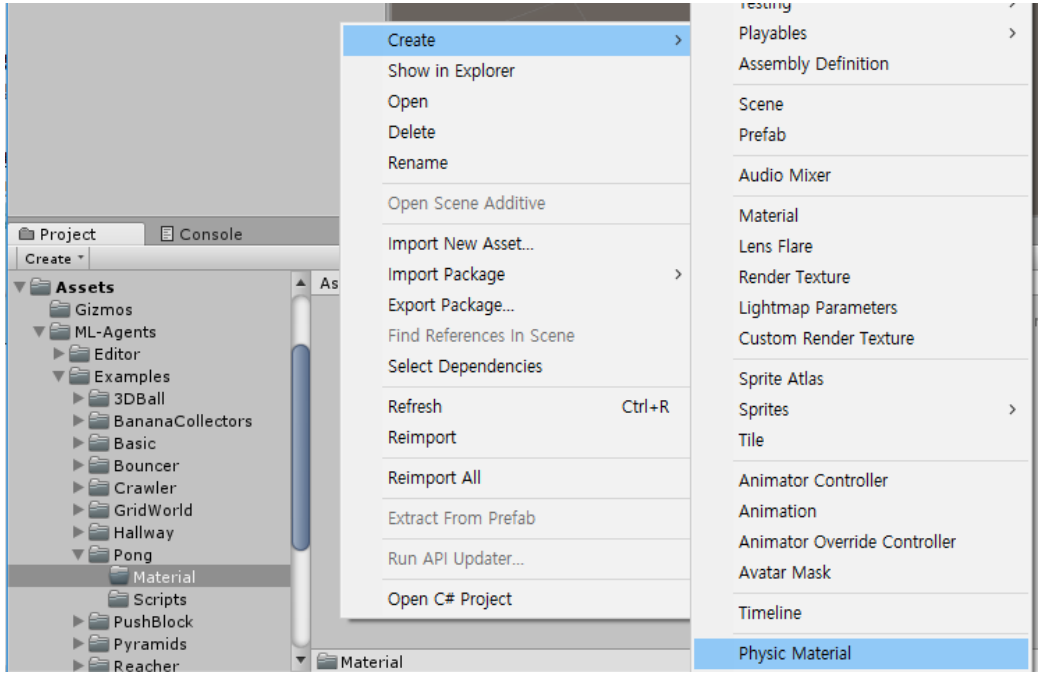
Unity ML-agents 예제

Learning (External)

- 물리적 특성 부여 -> Pong 내부에 Material 폴더 생성 후 Physic Material 4개 생성 (Agent, Ball, Floor, Wall)



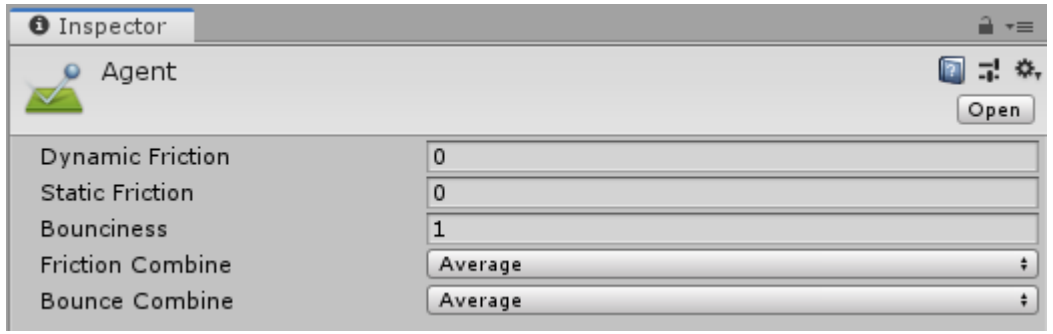


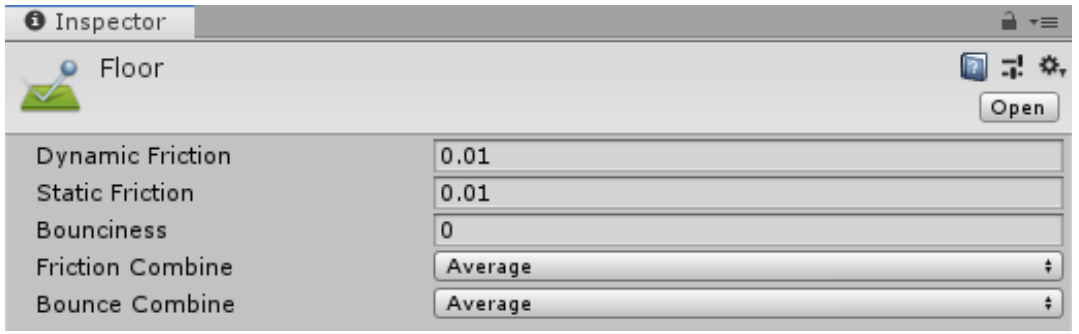


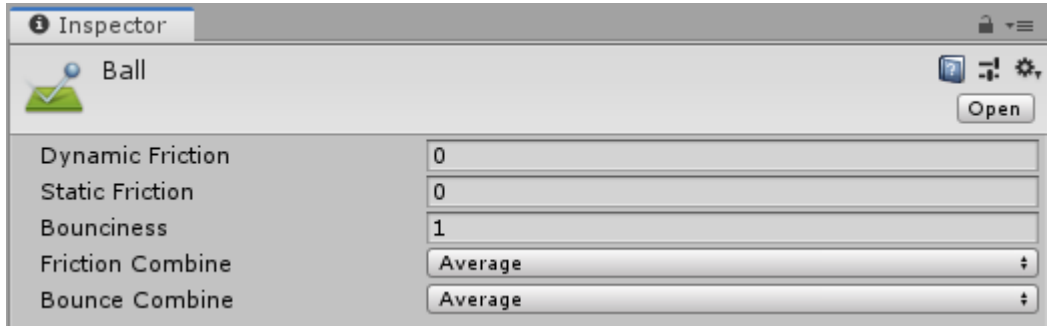
Unity ML-agents 예제

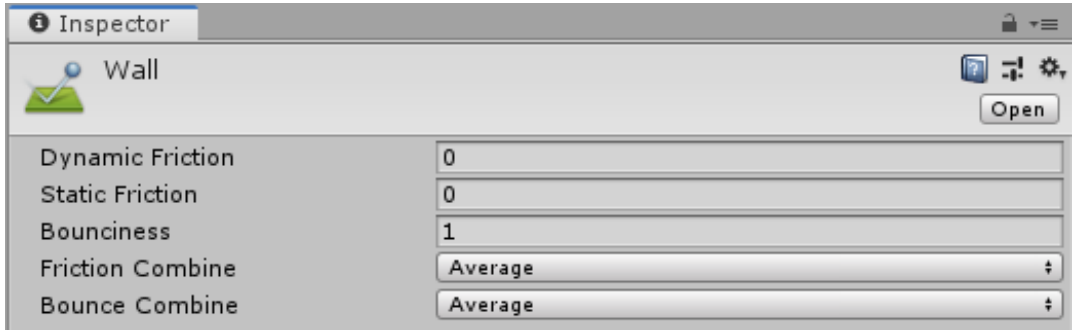
Learning (External)

- 각 Physic Material의 인스펙터뷰 설정 (정지마찰력, 운동마찰력, 탄성)





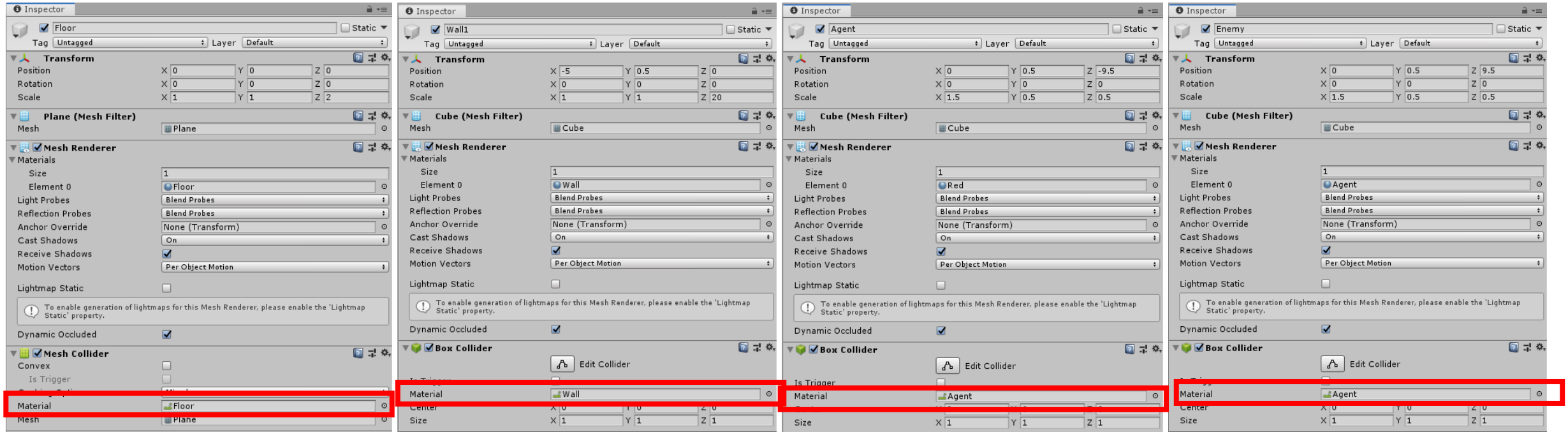




Unity ML-agents 예제

Learning (External)

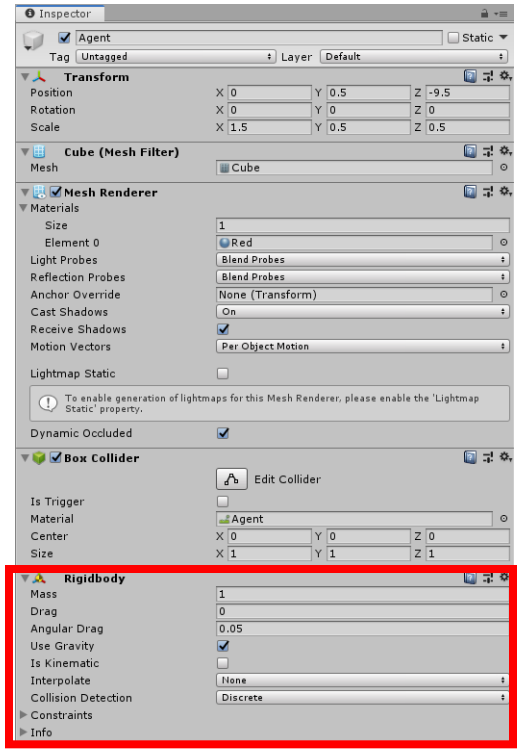
- 각 Physic Material을 각각 대응하는 오브젝트에 연결 (Mesh Collider -> Material) (Agent, Enemy, Wall1, Wall2, Ball)

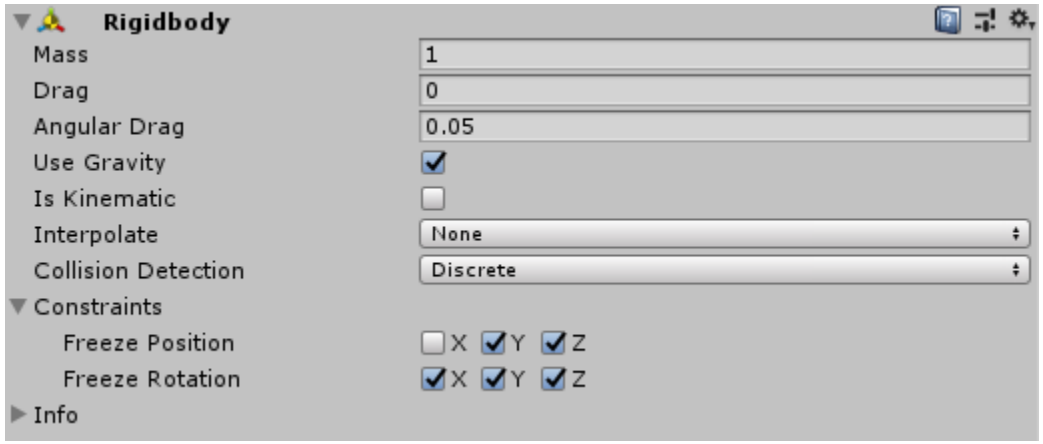


Unity ML-agents 예제

Learning (External)

- Rigidbody 생성 및 Contraints 설정 (Agent) -> x축으로만 이동하도록

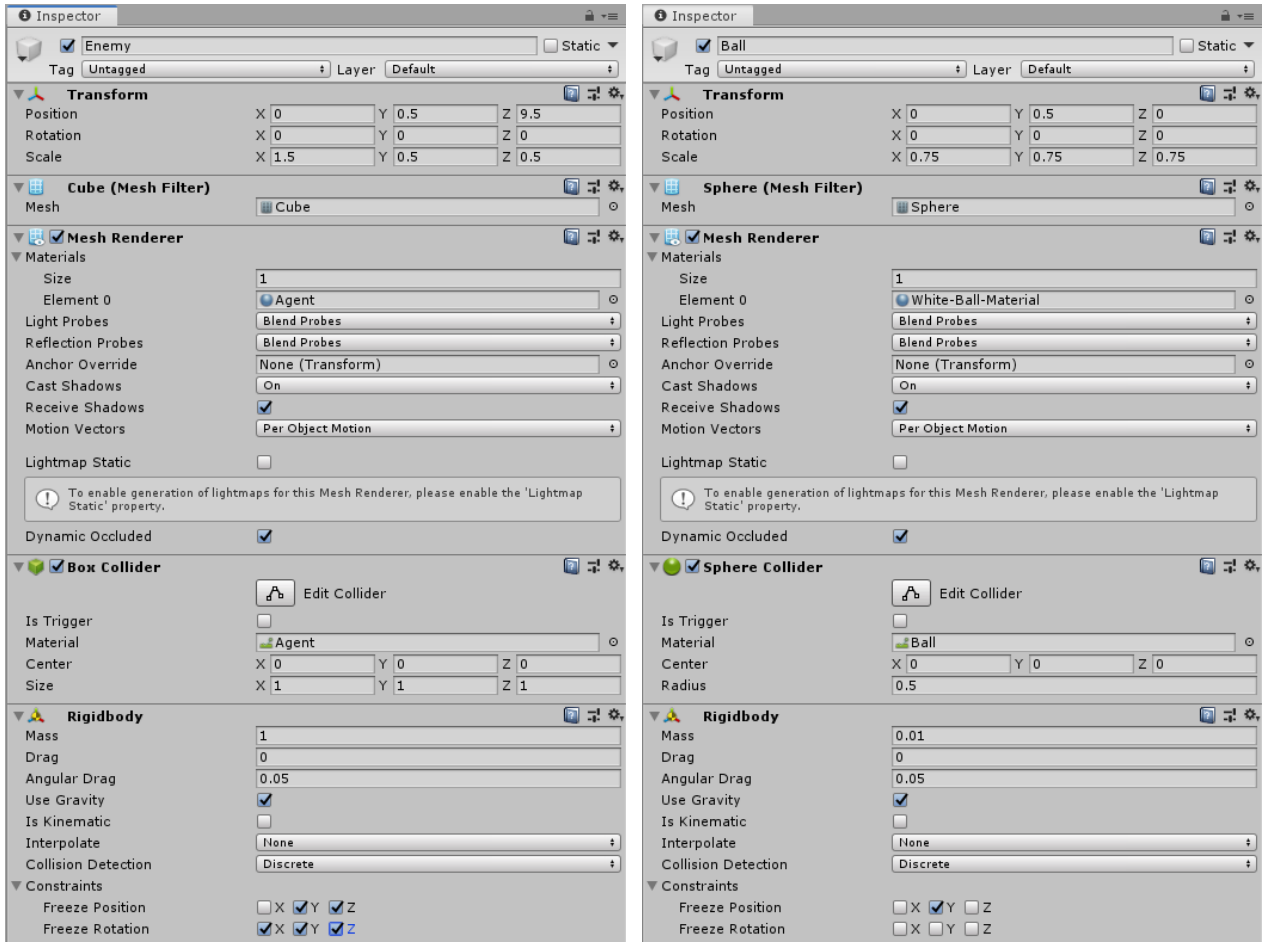




Unity ML-agents 예제

Learning (External)

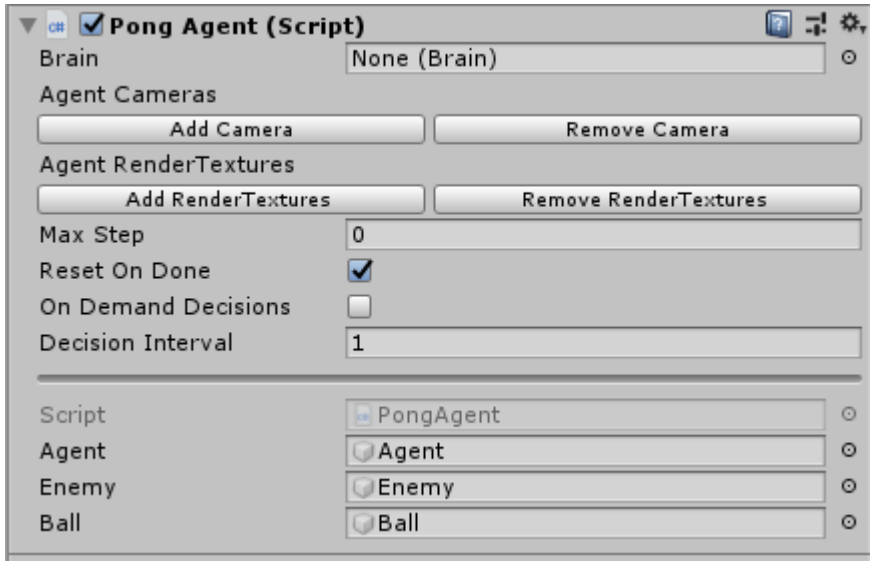
- Rigidbody 생성 및 Contraints 설정 (Enemy, Ball)
- Ball의 mass는 0.01로 설정
- Enemy -> X축으로만 이동
- Ball -> Y축으로 이동 제한



Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - 파라미터 설정 및 오브젝트 선언




```
6   public class PongAgent : Agent {
7
8       public GameObject agent;
9       public GameObject enemy;
10      public GameObject ball;
11
12      private Rigidbody RbAgent;
13      private Rigidbody RbEnemy;
14      private Rigidbody RbBall;
15
16      private const int Stay = 0;
17      private const int Up = 1;
18      private const int Down = 2;
19
20      private Vector3 ResetPos;
21      private Vector3 velocity;
22
23      private float ball_vel_z = 0f;
24      private float ball_vel_z_old = 0f;
25
26      private float max_ball_speed = 10f;
27      private float min_ball_speed = 7f;
28
29      private Vector3 ResetPosBall;
30      private Vector3 ResetPosAgent;
31      private Vector3 ResetPosEnemy;
```

Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - InitializeAgent: 에이전트가 가장 처음 초기화 될때 한번 호출되는 함수
  - CollectObservations: 수치적 관측값들을 저장할 때 사용하는 함수

```
30      public override void InitializeAgent()
31      {
32          ResetPosBall = ball.transform.position;
33          ResetPosAgent = agent.transform.position;
34          ResetPosEnemy = enemy.transform.position;
35
36          RbAgent = agent.GetComponent<Rigidbody>();
37          RbEnemy = enemy.GetComponent<Rigidbody>();
38          RbBall = ball.GetComponent<Rigidbody>();
39      }
```

```
41      public override void CollectObservations()
42      {
43          AddVectorObs(agent.transform.position.x);
44          AddVectorObs(enemy.transform.position.x);
45          AddVectorObs(ball.transform.position.x);
46          AddVectorObs(ball.transform.position.z);
47          AddVectorObs(RbAgent.velocity.x);
48          AddVectorObs(RbAgent.velocity.z);
49          AddVectorObs(RbEnemy.velocity.x);
50          AddVectorObs(RbEnemy.velocity.z);
51          AddVectorObs(RbBall.velocity.x);
52          AddVectorObs(RbBall.velocity.z);
53      }
```

Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - AgentAction 함수
    - 액션을 받아오고 이에 따라 에이전트를 행동하게 만드는 함수
    - 보상 및 게임 종료 조건 설정

```
58  public override void AgentAction(float[] vectorAction, string textAction)
59  {
60      int action = Mathf.FloorToInt(vectorAction[0]);
61      switch (action)
62      {
63          case Stay:
64              agent.transform.position = agent.transform.position + 0f * Vector3.right;
65              break;
66          case Up:
67              agent.transform.position = agent.transform.position + 0.3f * Vector3.left;
68              break;
69          case Down:
70              agent.transform.position = agent.transform.position + 0.3f * Vector3.right;
71              break;
72      }
73
74      enemy.transform.position = new Vector3(ball.transform.position.x, enemy.transform.position.y, enemy.transform.position.z);
75
76      if (ball.transform.position.z < -10)
77      {
78          AddReward(-1.0f);
79          Done();
80      }
81
82      if (ball.transform.position.z > 10)
83      {
84          AddReward(1.0f);
85          Done();
86      }
87
88      ball_vel_z = RbBall.velocity.z;
89
90      if (ball_vel_z > 0 && ball_vel_z_old < 0)
91      {
92          AddReward(0.5f);
93      }
94
95      ball_vel_z_old = ball_vel_z;
96
97      AddReward(0f);
98  }
```

Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - AgentAction 함수
    - 액션 선택에 따라 에이전트 이동 및 적 이동

```
58      public override void AgentAction(float[] vectorAction, string textAction)
59      {
60          int action = Mathf.FloorToInt(vectorAction[0]);
61          switch (action)
62          {
63              case Stay:
64                  agent.transform.position = agent.transform.position + 0f * Vector3.right;
65                  break;
66              case Up:
67                  agent.transform.position = agent.transform.position + 0.3f * Vector3.left;
68                  break;
69              case Down:
70                  agent.transform.position = agent.transform.position + 0.3f * Vector3.right;
71                  break;
72          }
73
74          enemy.transform.position = new Vector3(ball.transform.position.x, enemy.transform.position.y, enemy.transform.position.z);
```

Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - AgentAction 함수
    - 보상 및 게임 종료 조건 설정

```
76      if (ball.transform.position.z < -10)
77      {
78          AddReward(-1.0f);
79          Done();
80      }
81
82      if (ball.transform.position.z > 10)
83      {
84          AddReward(1.0f);
85          Done();
86      }
87
88      ball_vel_z = RbBall.velocity.z;
89
90      if (ball_vel_z > 0 && ball_vel_z_old < 0)
91      {
92          AddReward(0.5f);
93      }
94
95      ball_vel_z_old = ball_vel_z;
96
97      AddReward(0f);
98  }
```

Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - AgentReset 함수: 게임이 새로 시작될 때 호출되는 코드

```
100     public override void AgentReset()
101     {
102         ball.transform.position = ResetPosBall;
103         agent.transform.position = ResetPosAgent;
104         enemy.transform.position = ResetPosEnemy;
105         RbBall.velocity = Vector3.zero;
106         ball.transform.rotation = Quaternion.identity;
107         RbAgent.velocity = Vector3.zero;
108         RbAgent.angularVelocity = Vector3.zero;
109         RbEnemy.velocity = Vector3.zero;
110         RbEnemy.angularVelocity = Vector3.zero;
111
112         float rand_num = Random.Range(-1f, 1f);
113
114         if (rand_num < -0.5f)
115         {
116             // 우상단으로 공을 움직입니다.
117             velocity = new Vector3(Random.Range(min_ball_speed, max_ball_speed), 0, Random.Range(min_ball_speed, max_ball_speed));
118         }
119         else if (rand_num < 0f)
120         {
121             // 우하단으로 공을 움직입니다.
122             velocity = new Vector3(Random.Range(min_ball_speed, max_ball_speed), 0, Random.Range(-max_ball_speed, -min_ball_speed));
123         }
124         else if (rand_num < 0.5f)
125         {
126             // 좌상단으로 공을 움직입니다.
127             velocity = new Vector3(Random.Range(-max_ball_speed, -min_ball_speed), 0, Random.Range(min_ball_speed, max_ball_speed));
128         }
129         else
130         {
131             // 좌하단으로 공을 움직입니다.
132             velocity = new Vector3(Random.Range(-max_ball_speed, -min_ball_speed), 0, Random.Range(-max_ball_speed, -min_ball_speed));
133         }
134         RbBall.AddForce(velocity);
135     }
```

Unity ML-agents 예제

Learning (External)

- PongAgent 스크립트
  - AgentReset 함수
    - 에이전트, 적, 공의 위치 및 속도 초기화

```
100     public override void AgentReset()
101     {
102         ball.transform.position = ResetPosBall;
103         agent.transform.position = ResetPosAgent;
104         enemy.transform.position = ResetPosEnemy;
105         RbBall.velocity = Vector3.zero;
106         ball.transform.rotation = Quaternion.identity;
107         RbAgent.velocity = Vector3.zero;
108         RbAgent.angularVelocity = Vector3.zero;
109         RbEnemy.velocity = Vector3.zero;
110         RbEnemy.angularVelocity = Vector3.zero;
```

Unity ML-agents 예제

Learning (External)

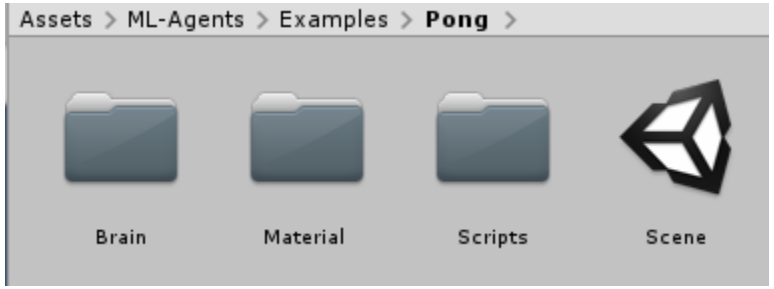
- PongAgent 스크립트
  - AgentReset 함수
    - 초기 공의 방향 및 속도를 임의로 설정

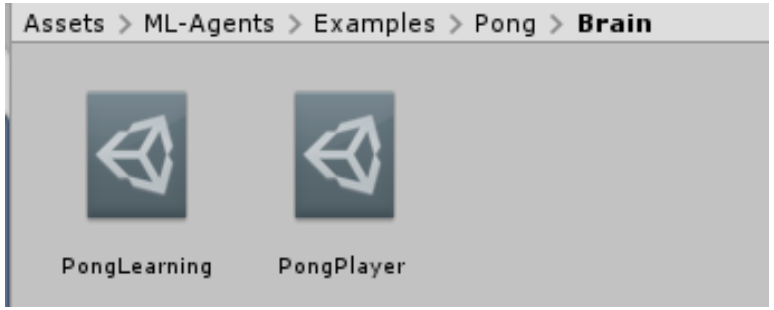
```
114         if (rand_num < -0.5f)
115         {
116             // 우상단으로 공을 움직입니다.
117             velocity = new Vector3(Random.Range(min_ball_speed, max_ball_speed), 0, Random.Range(min_ball_speed, max_ball_speed));
118         }
119         else if (rand_num < 0f)
120         {
121             // 우하단으로 공을 움직입니다.
122             velocity = new Vector3(Random.Range(min_ball_speed, max_ball_speed), 0, Random.Range(-max_ball_speed, -min_ball_speed));
123         }
124         else if (rand_num < 0.5f)
125         {
126             // 좌상단으로 공을 움직입니다.
127             velocity = new Vector3(Random.Range(-max_ball_speed, -min_ball_speed), 0, Random.Range(min_ball_speed, max_ball_speed));
128         }
129         else
130         {
131             // 좌하단으로 공을 움직입니다.
132             velocity = new Vector3(Random.Range(-max_ball_speed, -min_ball_speed), 0, Random.Range(-max_ball_speed, -min_ball_speed));
133         }
134         RbBall.AddForce(velocity);
135     }
```

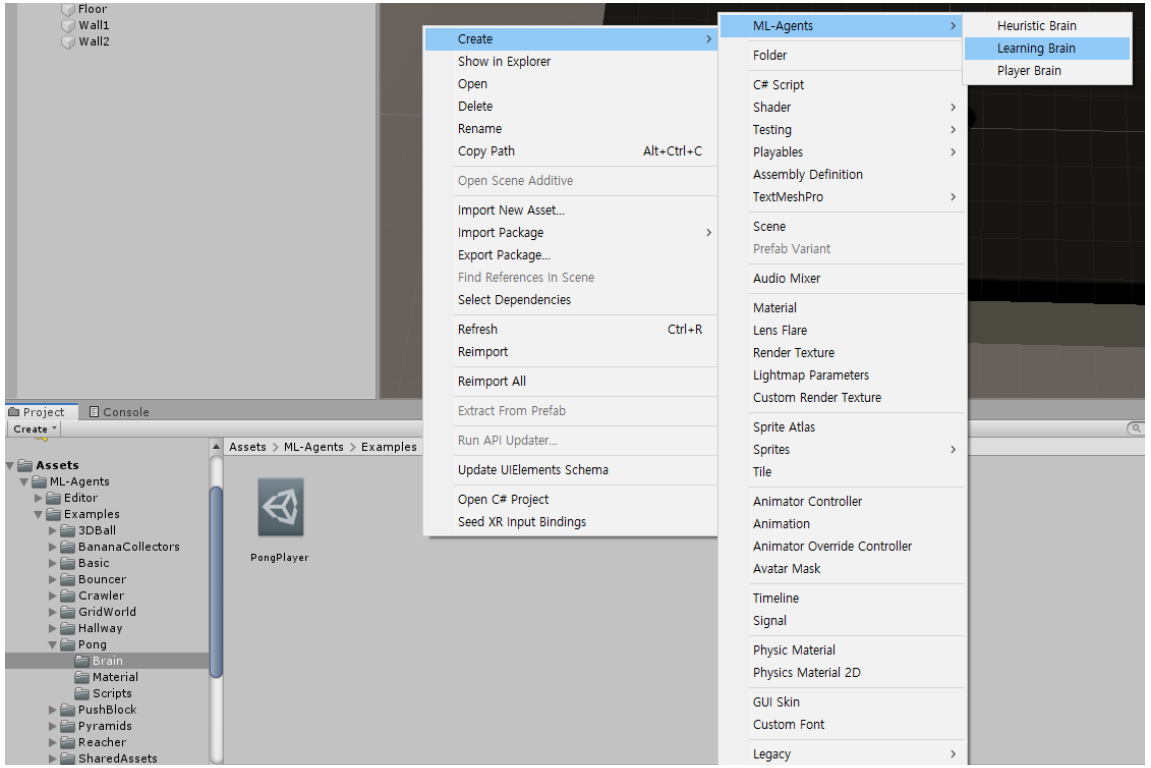
Unity ML-agents 예제

Learning (External)

- Pong -> Brain 폴더 생성 및 Learning Brain, Player Brain 생성 (마우스 오른쪽 클릭 -> ML-Agents)



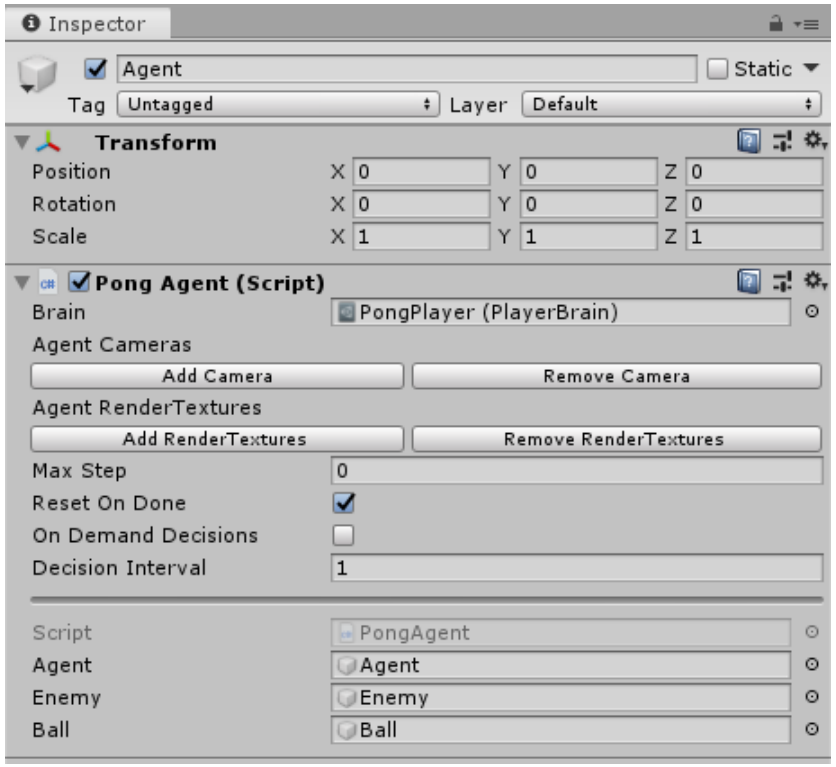


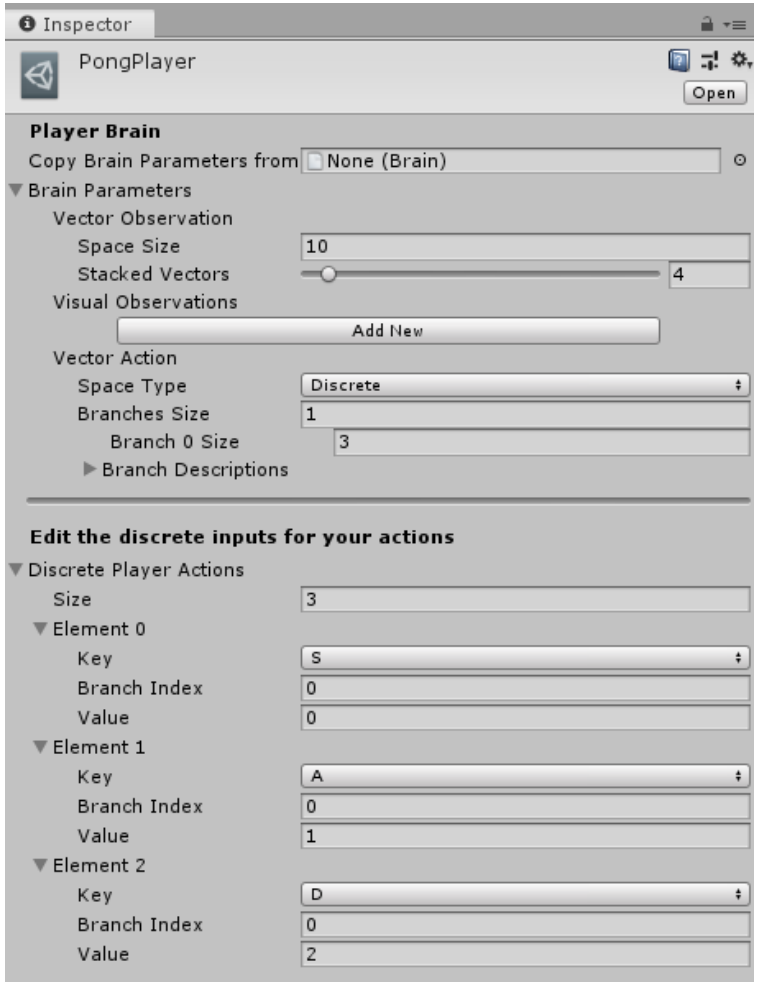


Unity ML-agents 예제

Learning (External)

- Player Brain 설정 및 Agent에 연결 (Agent, Enemy, Ball에 오브젝트 연결)

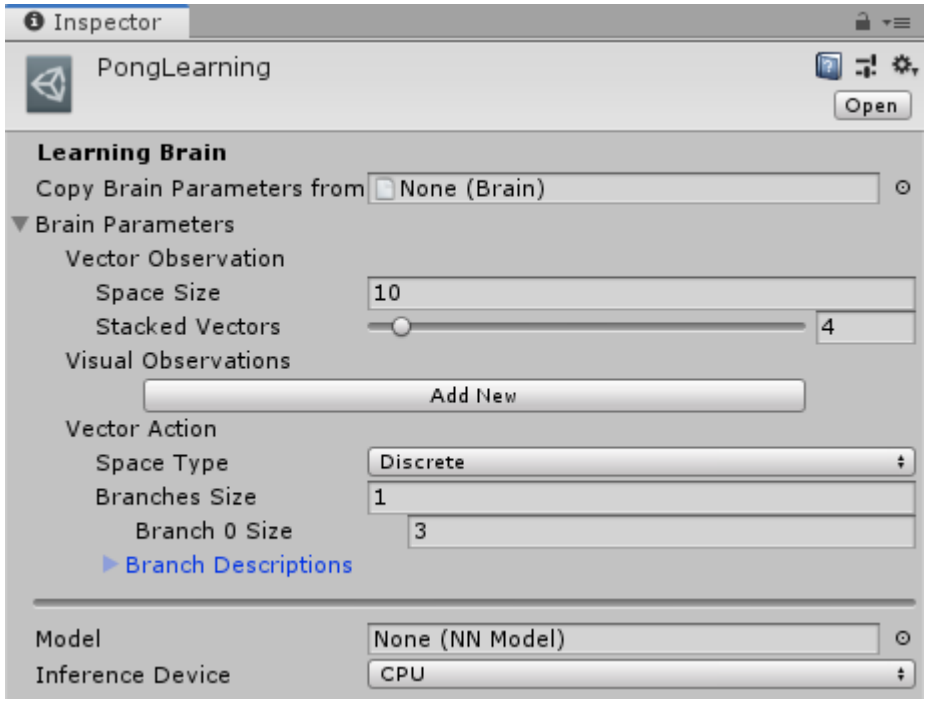


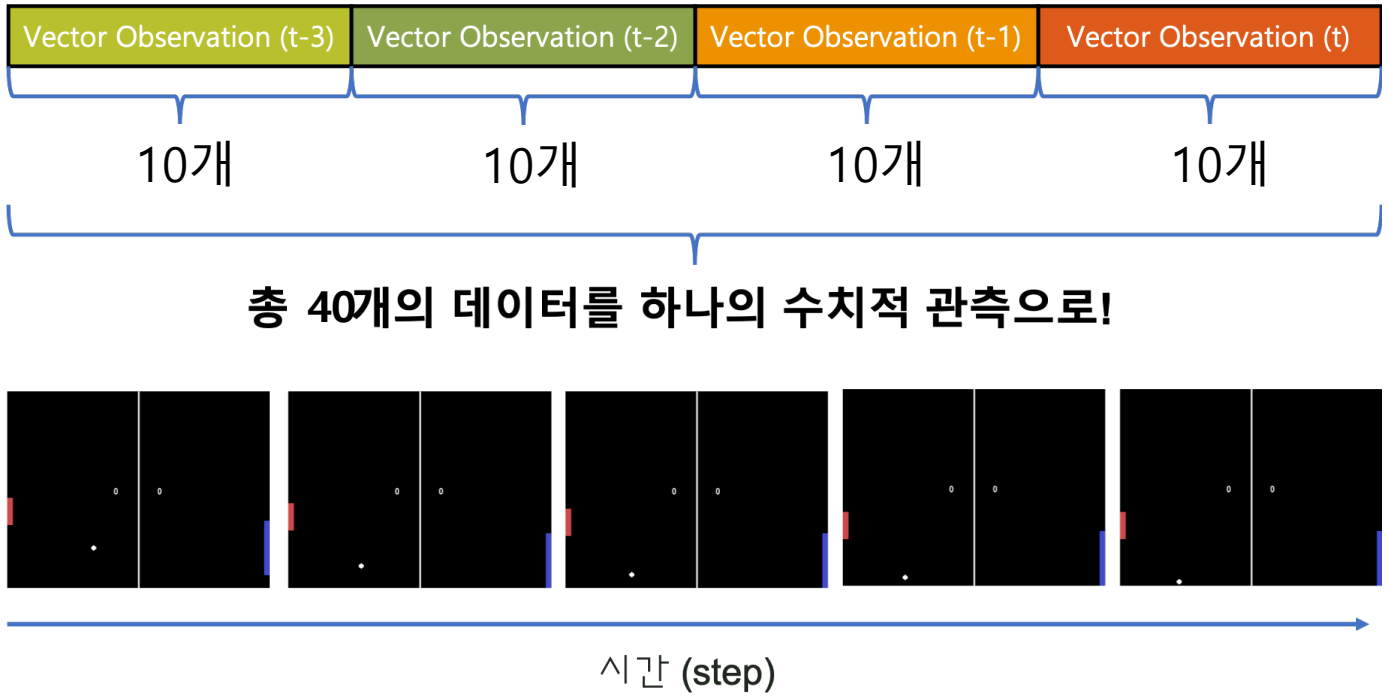


Unity ML-agents 예제

Learning (External)

- Learning Brain 설정

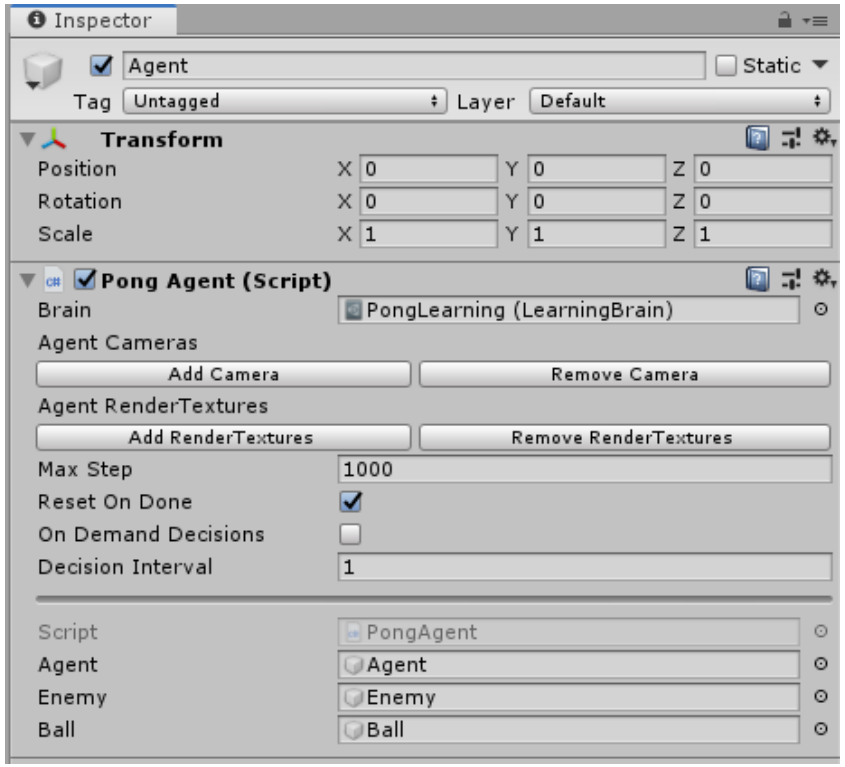


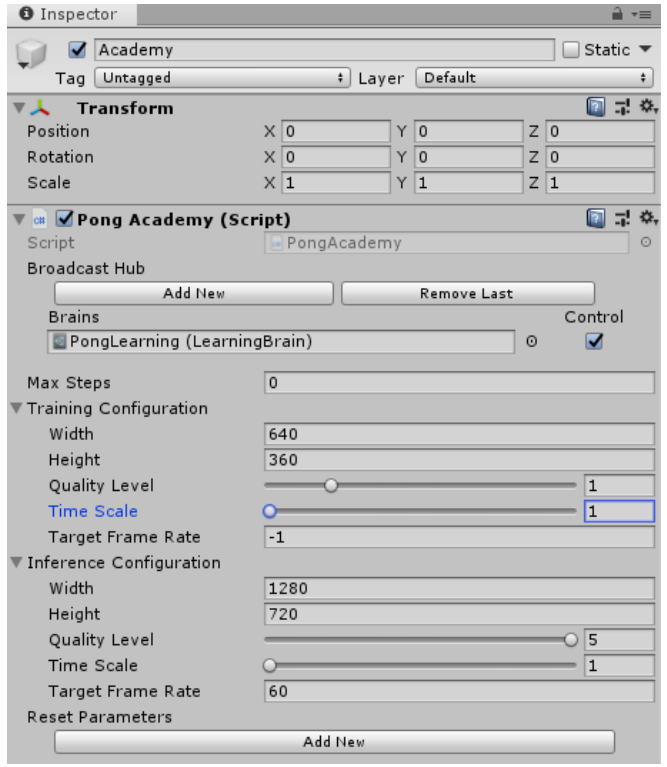


Unity ML-agents 예제

Learning (External)

- Learning Brain을 Agent에 연결 및 Academy의 Brains에 추가 후 Academy 설정 변경

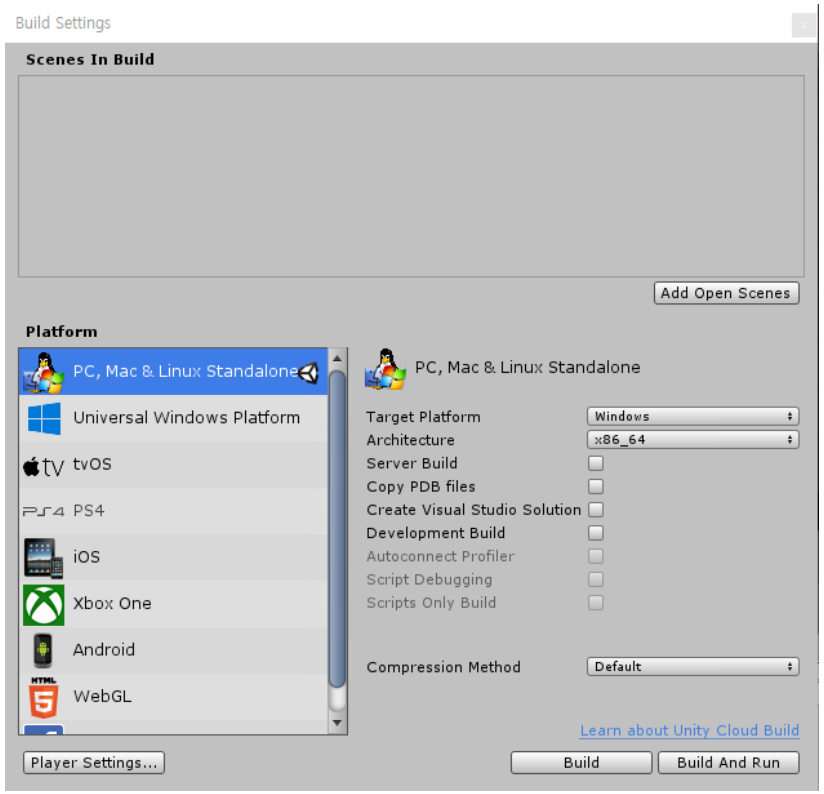


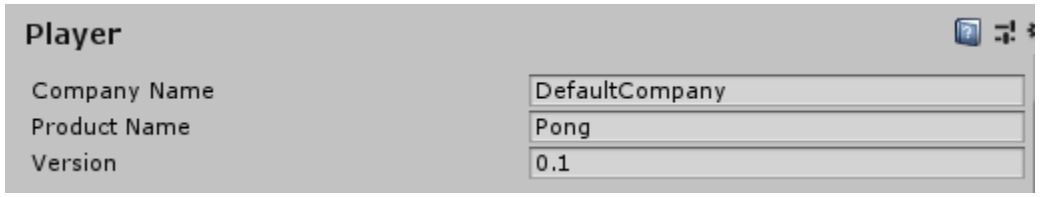


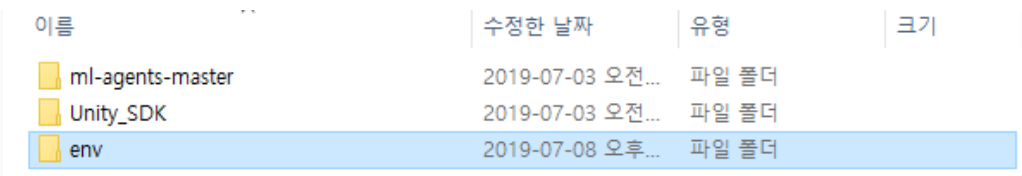
Unity ML-agents 예제

Learning (External)

- 환경 빌드



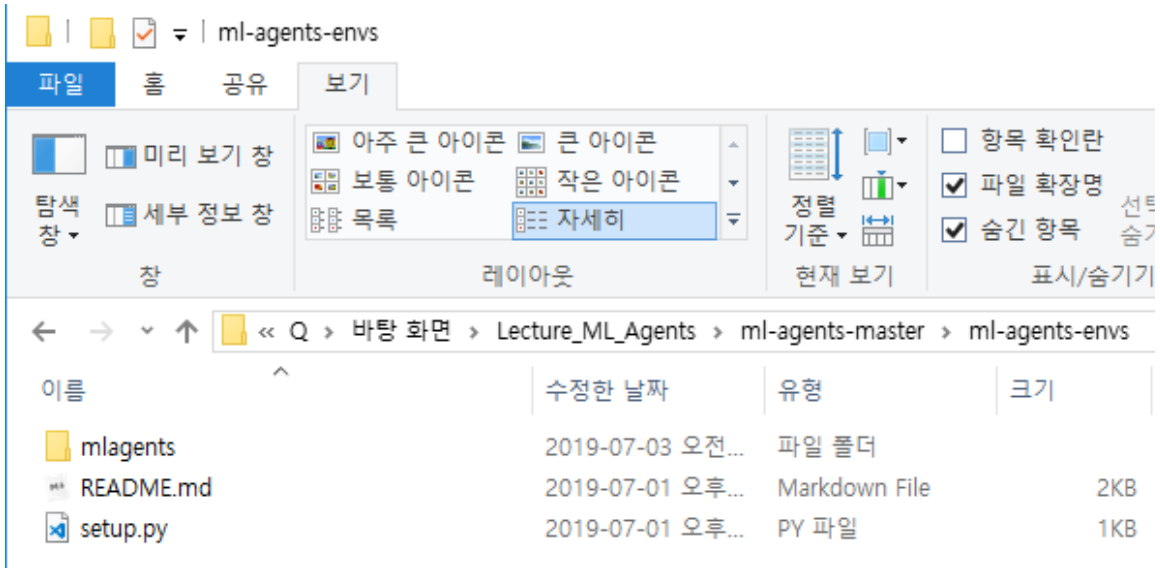


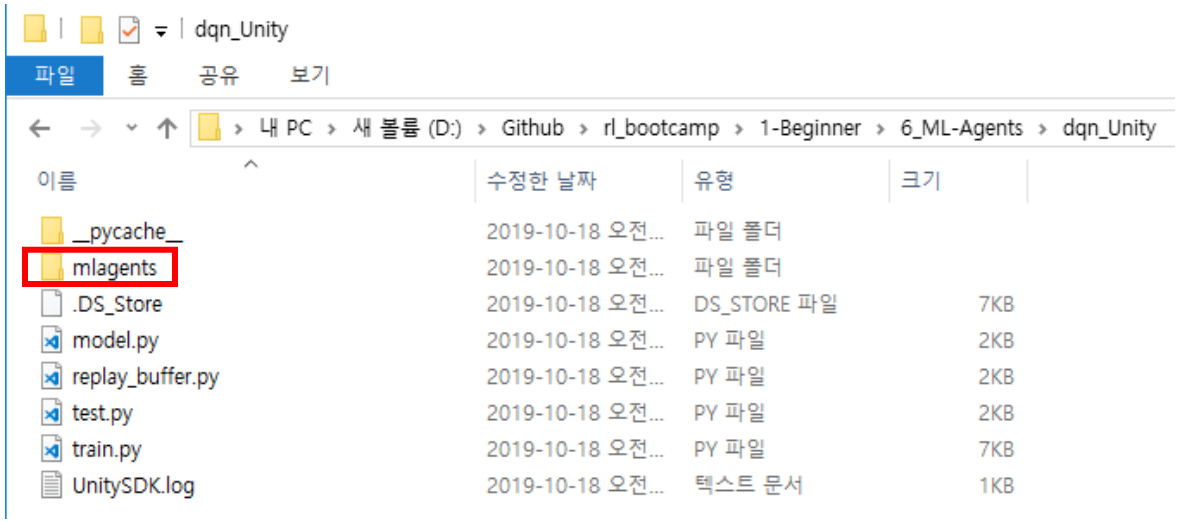


Unity ML-agents 예제

Learning (External)

- ML-agents 깃허브 폴더 -> ml-agents-env -> mlagents를 알고리즘과 동일한 폴더로 복사





Unity ML-agents 예제

DQN 코드 변경 (train.py)

```
1  import os
2  import gym
3  import time
4  import argparse
5  from collections import deque
```

```
1  import os
2  import time
3  import argparse
4  from collections import deque
5  from mlagents.envs import UnityEnvironment
```

Unity ML-agents 예제

DQN 코드 변경 (train.py)

```python
parser = argparse.ArgumentParser()
parser.add_argument('--training_eps', type=int, default=500)
parser.add_argument('--threshold_return', type=int, default=495)
parser.add_argument('--render', action="store_true", default=False)
parser.add_argument('--gamma', type=float, default=0.99)
parser.add_argument('--epsilon', type=float, default=1.0)
parser.add_argument('--epsilon_decay', type=float, default=0.995)
parser.add_argument('--buffer_size', type=int, default=10000)
parser.add_argument('--batch_size', type=int, default=64)
parser.add_argument('--target_update_period', type=int, default=100)
args = parser.parse_args()
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
```

```python
parser = argparse.ArgumentParser()
parser.add_argument('--episode_num', type=int, default=500)
parser.add_argument('--threshold_return', type=int, default=495)
parser.add_argument('--gamma', type=float, default=0.99)
parser.add_argument('--epsilon', type=float, default=1.0)
parser.add_argument('--epsilon_decay', type=float, default=0.995)
parser.add_argument('--buffer_size', type=int, default=10000)
parser.add_argument('--batch_size', type=int, default=64)
parser.add_argument('--target_update_steps', type=int, default=100)
args = parser.parse_args()
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
```

Unity ML-agents 예제

DQN 코드 변경 (train.py)

```python
78  def main():
79      # Initialize environment
80      env = gym.make('CartPole-v1')
81      obs_dim = env.observation_space.shape[0]
82      act_num = env.action_space.n
83      print('State dimension:', obs_dim)
84      print('Action number:', act_num)
85
86      # Set a random seed
87      env.seed(0)
88      np.random.seed(0)
89      torch.manual_seed(0)
```

```python
77  def main():
78      # Initialize environment
79      env = UnityEnvironment(file_name='../env/Pong/Pong')
80
81      default_brain = env.brain_names[0]
82      brain = env.brains[default_brain]
83
84      env_info = env.reset(train_mode=True)[default_brain]
85
86      obs_dim = env_info.vector_observations[0].shape[0]
87      act_num = brain.vector_action_space_size[0]
88      print('State dimension:', obs_dim)
89      print('Action number:', act_num)
90
91      # Set a random seed
92      np.random.seed(0)
93      torch.manual_seed(0)
```

Unity ML-agents 예제

DQN 코드 변경 (train.py)

```
123         while not done:
124             if args.render:
125                 env.render()
126
127             step_count += 1
128
129             # Collect experience (s, a, r, s') using some policy
130             action = select_action(torch.Tensor(obs).to(device), act_num, qf)
131             next_obs, reward, done, _ = env.step(action)
```

```
128         while not done:
129             step_count += 1
130
131             # Collect experience (s, a, r, s') using some policy
132             action = select_action(torch.Tensor(obs).to(device), act_num, qf)
133
134             env_info = env.step(int(action))[default_brain]
135
136             next_obs = env_info.vector_observations[0]
137             reward = env_info.rewards[0]
138             done = env_info.local_done[0]
```

Unity ML-agents 예제

DQN 코드 변경 (train.py)

```
173
174  if __name__ == '__main__':
175      main()
```

```
180
181      env.close()
182
183  if __name__ == '__main__':
184      main()
```

Unity ML-agents 예제

DQN 코드 변경 (test.py)

```
1   import os
2   import gym
3   import argparse
4   import numpy as np
5   import torch
6   from model import MLP

8   # Configurations
9   parser = argparse.ArgumentParser()
10  parser.add_argument('--load', type=str, default=None,
11                      help='load the saved model')
12  parser.add_argument('--render', action="store_true", default=True,
13                      help='if you want to render, set this to True')
14  args = parser.parse_args()
```

```
1   import os
2   import argparse
3   import numpy as np
4   import torch
5   from model import MLP
6   from mlagents.envs import UnityEnvironment

8   # Configurations
9   parser = argparse.ArgumentParser()
10  parser.add_argument('--load', type=str, default=None,
11                      help='load the saved model')
12  args = parser.parse_args()
```

경로 지정!

Unity ML-agents 예제

DQN 코드 변경 (test.py)

```
18  def main():
19      env = gym.make('CartPole-v1')
20      obs_dim = env.observation_space.shape[0]
21      act_num = env.action_space.n
```

```
16  def main():
17      env = UnityEnvironment(file_name='../env/Pong/Pong')
18
19      default_brain = env.brain_names[0]
20      brain = env.brains[default_brain]
21
22      env_info = env.reset(train_mode=False)[default_brain]
23
24      obs_dim = env_info.vector_observations[0].shape[0]
25      act_num = brain.vector_action_space_size[0]
```

Unity ML-agents 예제

DQN 코드 변경 (test.py)

```
33      for episode in range(1, 10001):
34          total_reward = 0.
35
36          obs = env.reset()
37          done = False
38
39          while not done:
40              if args.render:
41                  env.render()
42
43              action = mlp(torch.Tensor(obs).to(device)).argmax().detach().cpu().numpy()
44              next_obs, reward, done, _ = env.step(action)
```

```
37      for episode in range(1, 10001):
38          total_reward = 0.
39
40          obs = env_info.vector_observations[0]
41          done = False
42
43          while not done:
44              action = mlp(torch.Tensor(obs).to(device)).argmax().detach().cpu().numpy()
45              env_info = env.step(int(action))[default_brain]
46
47              next_obs = env_info.vector_observations[0]
48              reward = env_info.rewards[0]
49              done = env_info.local_done[0]
```

```
59
60  if __name__ == "__main__":
61      main()
```

```
65      env.close()
66
67  if __name__ == "__main__":
68      main()
```

학습 결과