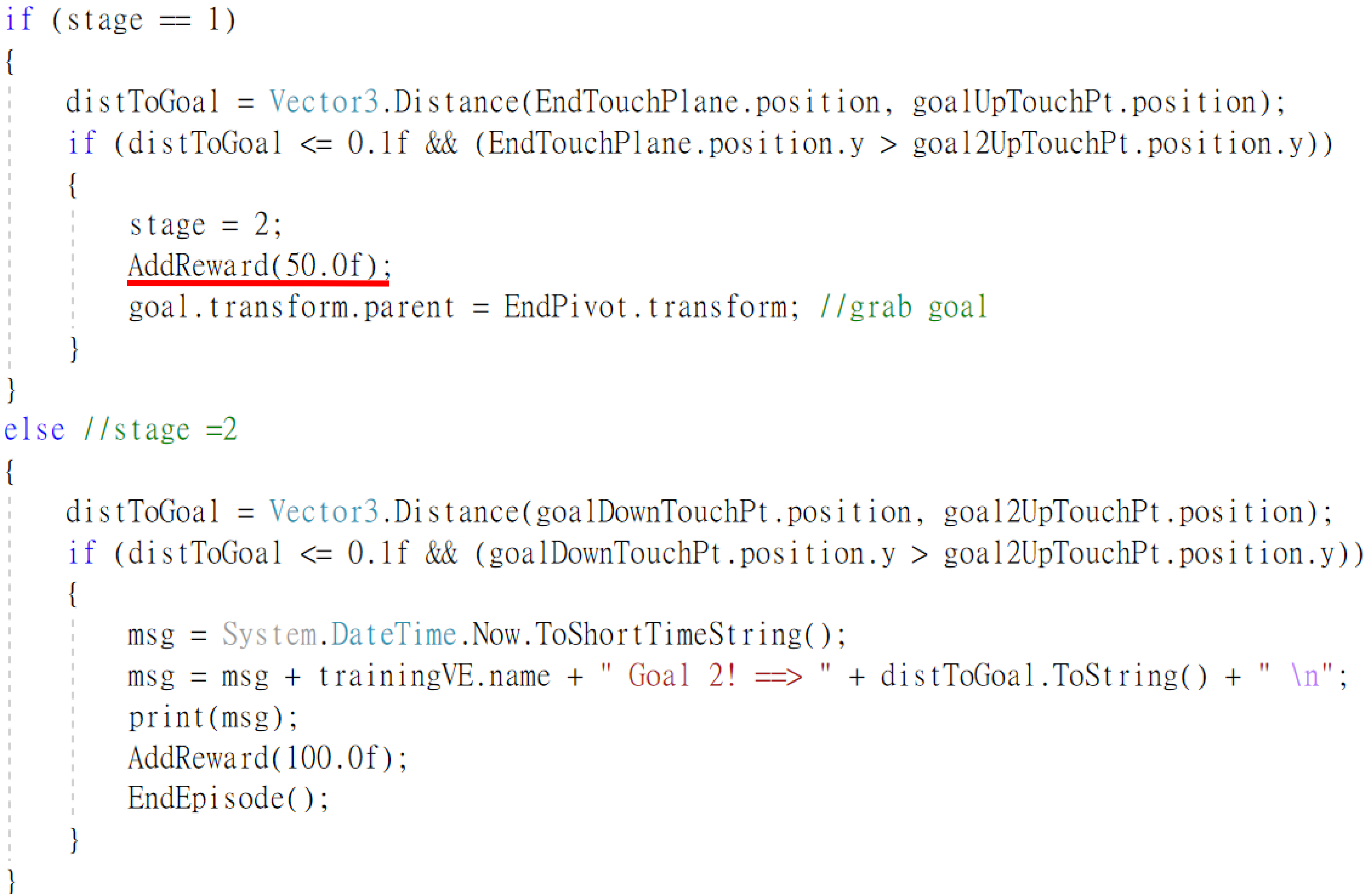
(4) Discussion

Reward engineering

Goal 1 rewards is too large, NN will think it is optimal and not try to reach goal 2

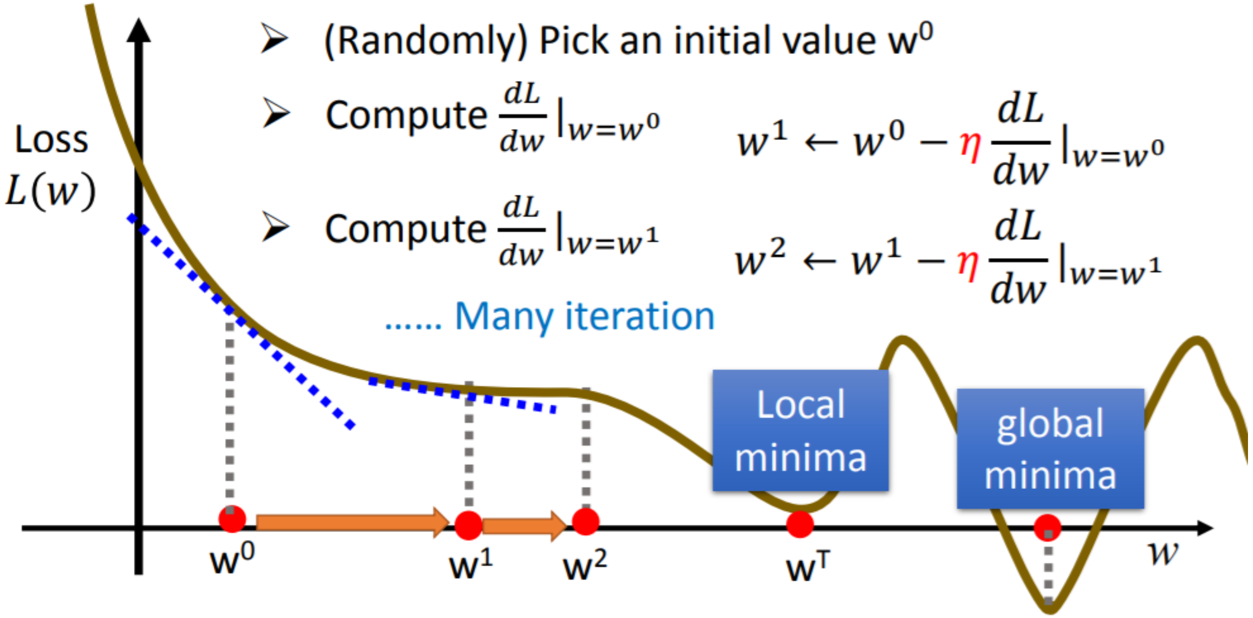


```
if (stage == 1)
{
    distToGoal = Vector3.Distance(EndTouchPlane.position, goalUpTouchPt.position);
    if (distToGoal <= 0.1f && (EndTouchPlane.position.y > goal2UpTouchPt.position.y))
    {
        stage = 2;
        AddReward(50.0f);
        goal.transform.parent = EndPivot.transform; //grab goal
    }
}
else //stage =2
{
    distToGoal = Vector3.Distance(goalDownTouchPt.position, goal2UpTouchPt.position);
    if (distToGoal <= 0.1f && (goalDownTouchPt.position.y > goal2UpTouchPt.position.y))
    {
        msg = System.DateTime.Now.ToShortTimeString();
        msg = msg + trainingVE.name + " Goal 2! ==> " + distToGoal.ToString() + " \n";
        print(msg);
        AddReward(100.0f);
        EndEpisode();
    }
}
```

Local optimization problem

$$w^* = arg\min_{w} L(w)$$

- Consider loss function $L(w)$ with one parameter w:

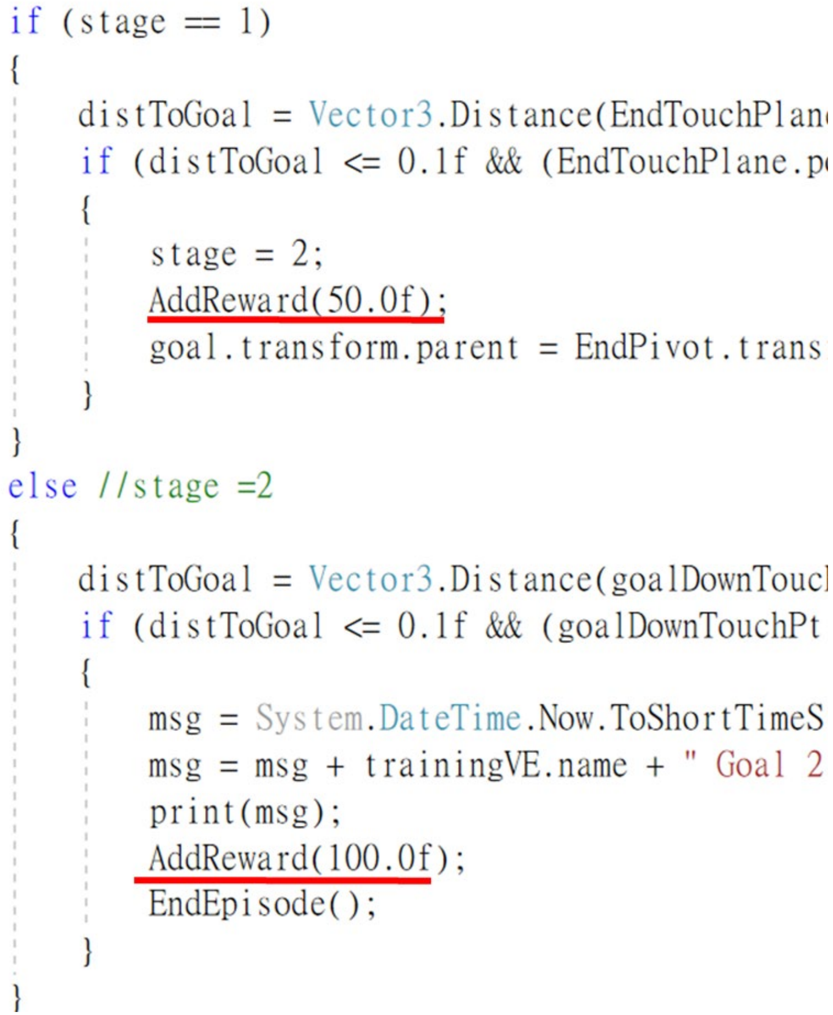


- ➢ (Randomly) Pick an initial value w^0
- ➢ Compute $\frac{dL}{dw}|_{w=w^0}$ $\quad w^1 \leftarrow w^0 - \eta \frac{dL}{dw}|_{w=w^0}$
- ➢ Compute $\frac{dL}{dw}|_{w=w^1}$ $\quad w^2 \leftarrow w^1 - \eta \frac{dL}{dw}|_{w=w^1}$

…… Many iteration

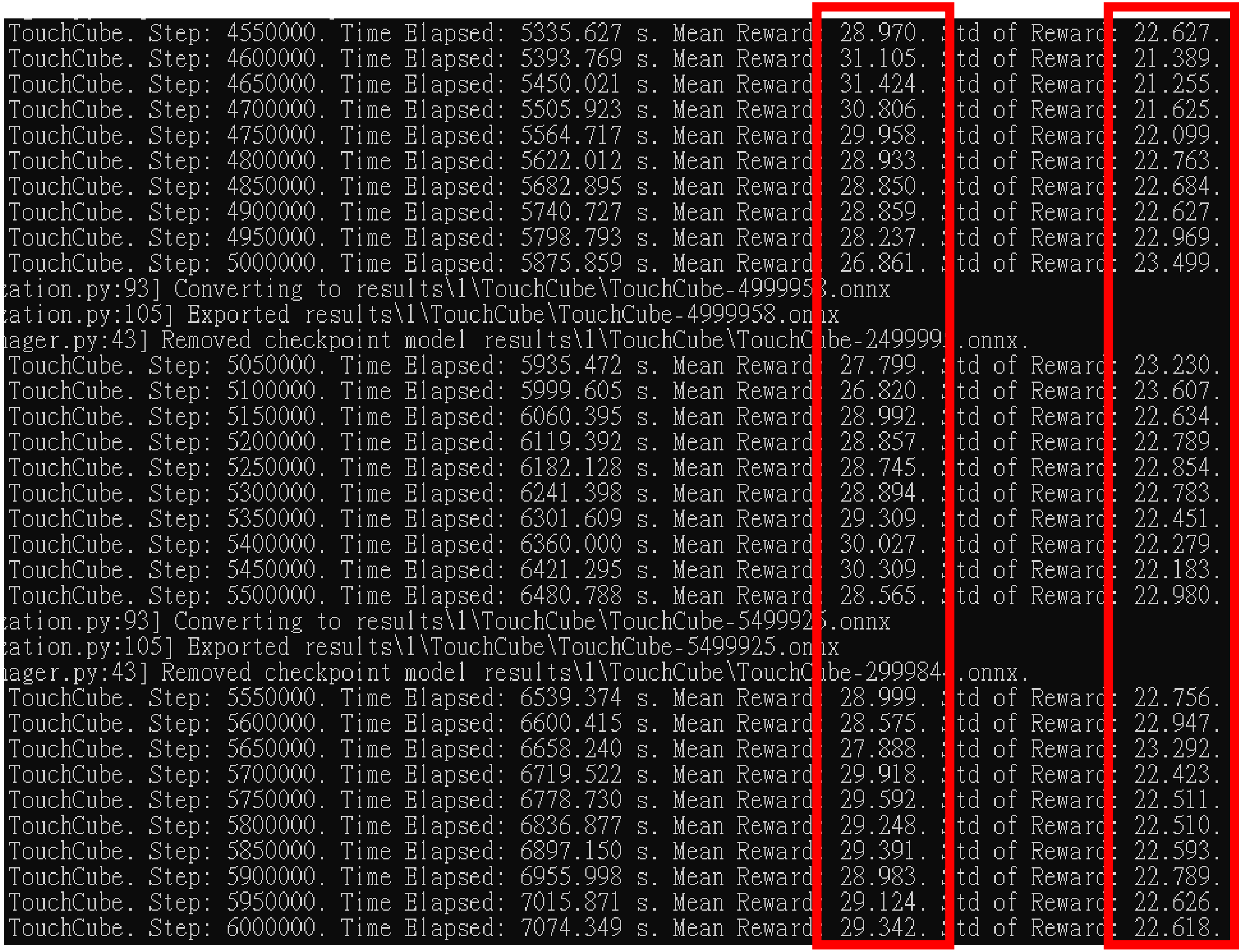
Reference: 李弘毅 ML Lecture 1 https://youtu.be/CXgbekl66jc

AI lecture 1. Introduction.pdf



```
if (stage == 1)
{
    distToGoal = Vector3.Distance(EndTouchPlan
    if (distToGoal <= 0.1f && (EndTouchPlane.p
    {
        stage = 2;
        AddReward(50.0f);
        goal.transform.parent = EndPivot.trans
    }
}
else //stage =2
{
    distToGoal = Vector3.Distance(goalDownTouc
    if (distToGoal <= 0.1f && (goalDownTouchPt
    {
        msg = System.DateTime.Now.ToShortTimeS
        msg = msg + trainingVE.name + " Goal 2
        print(msg);
        AddReward(100.0f);
        EndEpisode();
    }
}
```

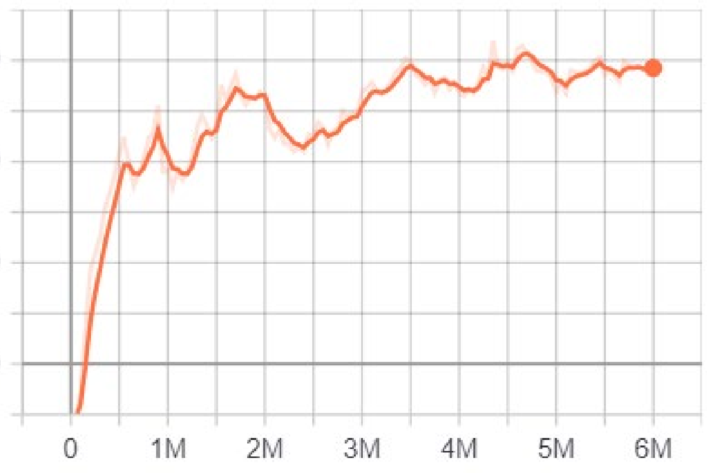
Results after 6M, not trying to reach goal 2



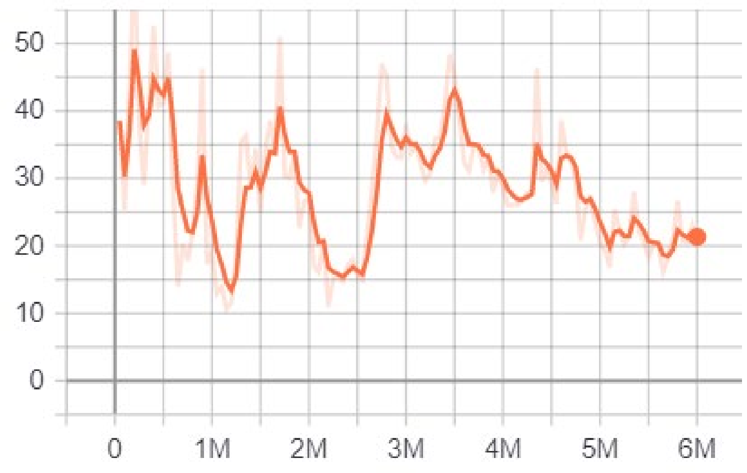
```
 TouchCube. Step: 4550000. Time Elapsed: 5335.627 s. Mean Reward: 28.970. Std of Reward: 22.627.
 TouchCube. Step: 4600000. Time Elapsed: 5393.769 s. Mean Reward: 31.105. Std of Reward: 21.389.
 TouchCube. Step: 4650000. Time Elapsed: 5450.021 s. Mean Reward: 31.424. Std of Reward: 21.255.
 TouchCube. Step: 4700000. Time Elapsed: 5505.923 s. Mean Reward: 30.806. Std of Reward: 21.625.
 TouchCube. Step: 4750000. Time Elapsed: 5564.717 s. Mean Reward: 29.958. Std of Reward: 22.099.
 TouchCube. Step: 4800000. Time Elapsed: 5622.012 s. Mean Reward: 28.933. Std of Reward: 22.763.
 TouchCube. Step: 4850000. Time Elapsed: 5682.895 s. Mean Reward: 28.850. Std of Reward: 22.684.
 TouchCube. Step: 4900000. Time Elapsed: 5740.727 s. Mean Reward: 28.859. Std of Reward: 22.627.
 TouchCube. Step: 4950000. Time Elapsed: 5798.793 s. Mean Reward: 28.237. Std of Reward: 22.969.
 TouchCube. Step: 5000000. Time Elapsed: 5875.859 s. Mean Reward: 26.861. Std of Reward: 23.499.
zation.py:93] Converting to results\1\TouchCube\TouchCube-4999958.onnx
zation.py:105] Exported results\1\TouchCube\TouchCube-4999958.onnx
nager.py:43] Removed checkpoint model results\1\TouchCube\TouchCube-2499999.onnx.
 TouchCube. Step: 5050000. Time Elapsed: 5935.472 s. Mean Reward: 27.799. Std of Reward: 23.230.
 TouchCube. Step: 5100000. Time Elapsed: 5999.605 s. Mean Reward: 26.820. Std of Reward: 23.607.
 TouchCube. Step: 5150000. Time Elapsed: 6060.395 s. Mean Reward: 28.992. Std of Reward: 22.634.
 TouchCube. Step: 5200000. Time Elapsed: 6119.392 s. Mean Reward: 28.857. Std of Reward: 22.789.
 TouchCube. Step: 5250000. Time Elapsed: 6182.128 s. Mean Reward: 28.745. Std of Reward: 22.854.
 TouchCube. Step: 5300000. Time Elapsed: 6241.398 s. Mean Reward: 28.894. Std of Reward: 22.783.
 TouchCube. Step: 5350000. Time Elapsed: 6301.609 s. Mean Reward: 29.309. Std of Reward: 22.451.
 TouchCube. Step: 5400000. Time Elapsed: 6360.000 s. Mean Reward: 30.027. Std of Reward: 22.279.
 TouchCube. Step: 5450000. Time Elapsed: 6421.295 s. Mean Reward: 30.309. Std of Reward: 22.183.
 TouchCube. Step: 5500000. Time Elapsed: 6480.788 s. Mean Reward: 28.565. Std of Reward: 22.980.
zation.py:93] Converting to results\1\TouchCube\TouchCube-5499925.onnx
zation.py:105] Exported results\1\TouchCube\TouchCube-5499925.onnx
nager.py:43] Removed checkpoint model results\1\TouchCube\TouchCube-2999844.onnx.
 TouchCube. Step: 5550000. Time Elapsed: 6539.374 s. Mean Reward: 28.999. Std of Reward: 22.756.
 TouchCube. Step: 5600000. Time Elapsed: 6600.415 s. Mean Reward: 28.575. Std of Reward: 22.947.
 TouchCube. Step: 5650000. Time Elapsed: 6658.240 s. Mean Reward: 27.888. Std of Reward: 23.292.
 TouchCube. Step: 5700000. Time Elapsed: 6719.522 s. Mean Reward: 29.918. Std of Reward: 22.423.
 TouchCube. Step: 5750000. Time Elapsed: 6778.730 s. Mean Reward: 29.592. Std of Reward: 22.511.
 TouchCube. Step: 5800000. Time Elapsed: 6836.877 s. Mean Reward: 29.248. Std of Reward: 22.510.
 TouchCube. Step: 5850000. Time Elapsed: 6897.150 s. Mean Reward: 29.391. Std of Reward: 22.593.
 TouchCube. Step: 5900000. Time Elapsed: 6955.998 s. Mean Reward: 28.983. Std of Reward: 22.789.
 TouchCube. Step: 5950000. Time Elapsed: 7015.871 s. Mean Reward: 29.124. Std of Reward: 22.626.
 TouchCube. Step: 6000000. Time Elapsed: 7074.349 s. Mean Reward: 29.342. Std of Reward: 22.618.
```

Results after 6M, not trying to reach goal 2

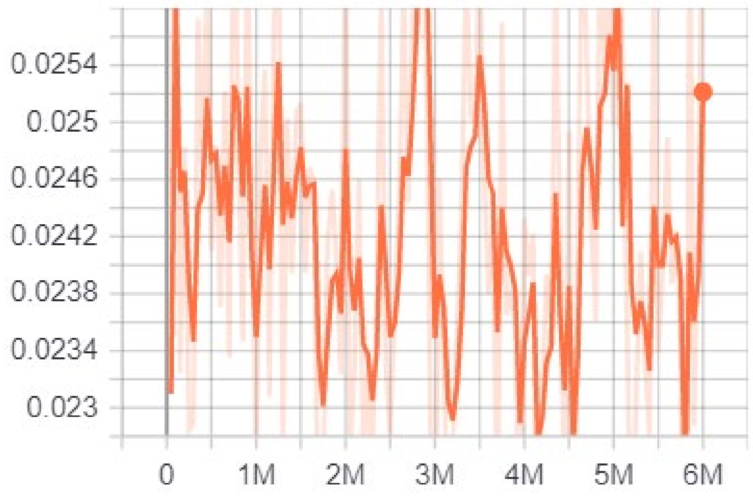
Cumulative Reward
tag: Environment/Cumulative Reward



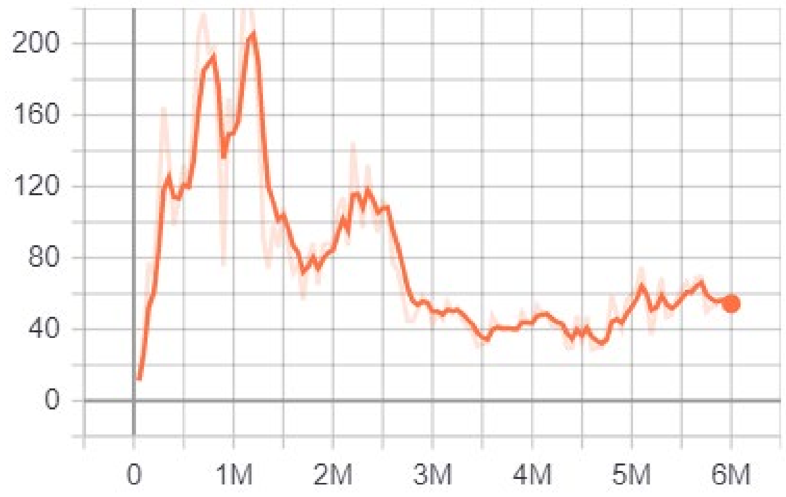
Episode Length
tag: Environment/Episode Length



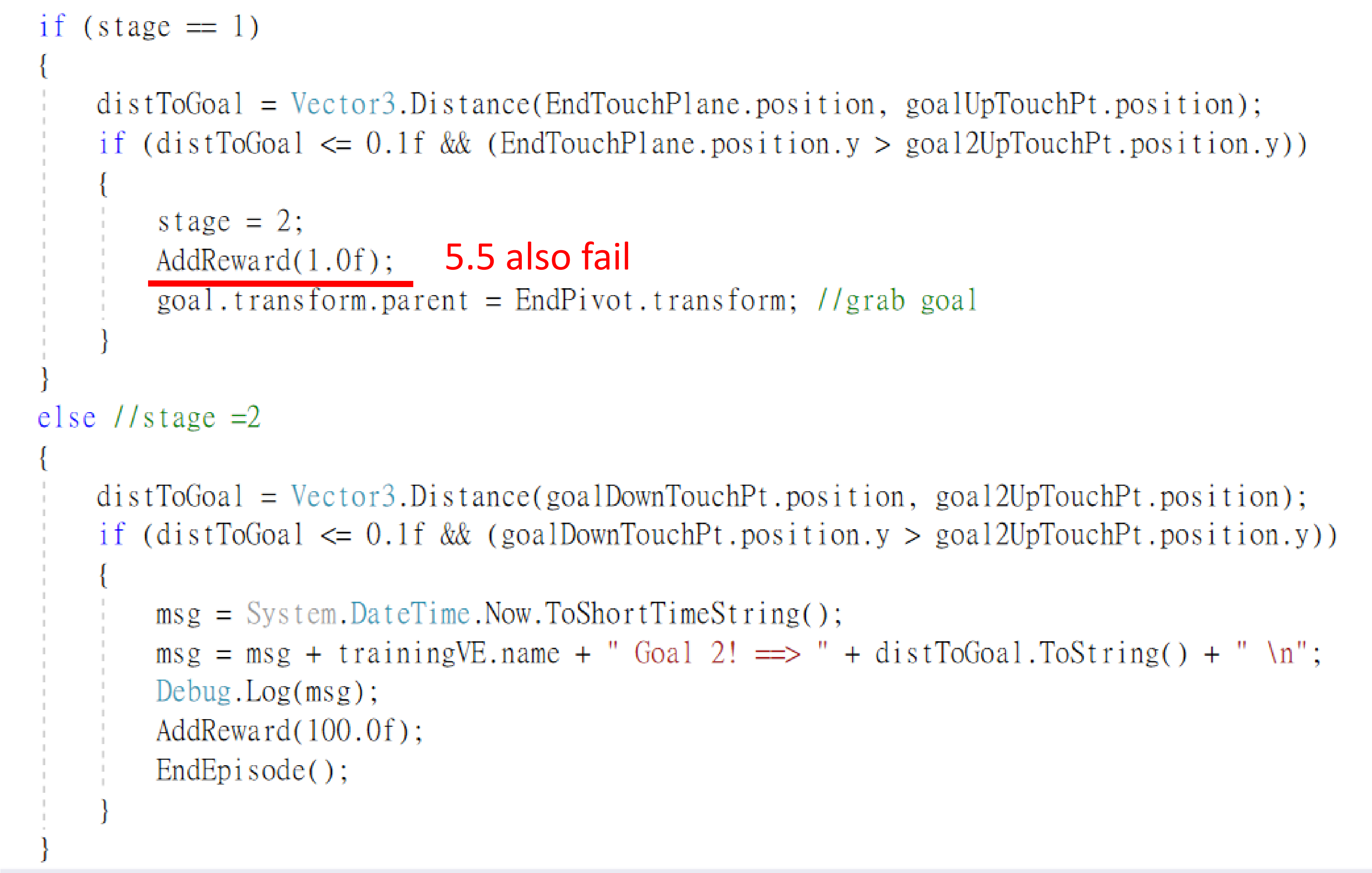
Policy Loss
tag: Losses/Policy Loss



Value Loss
tag: Losses/Value Loss



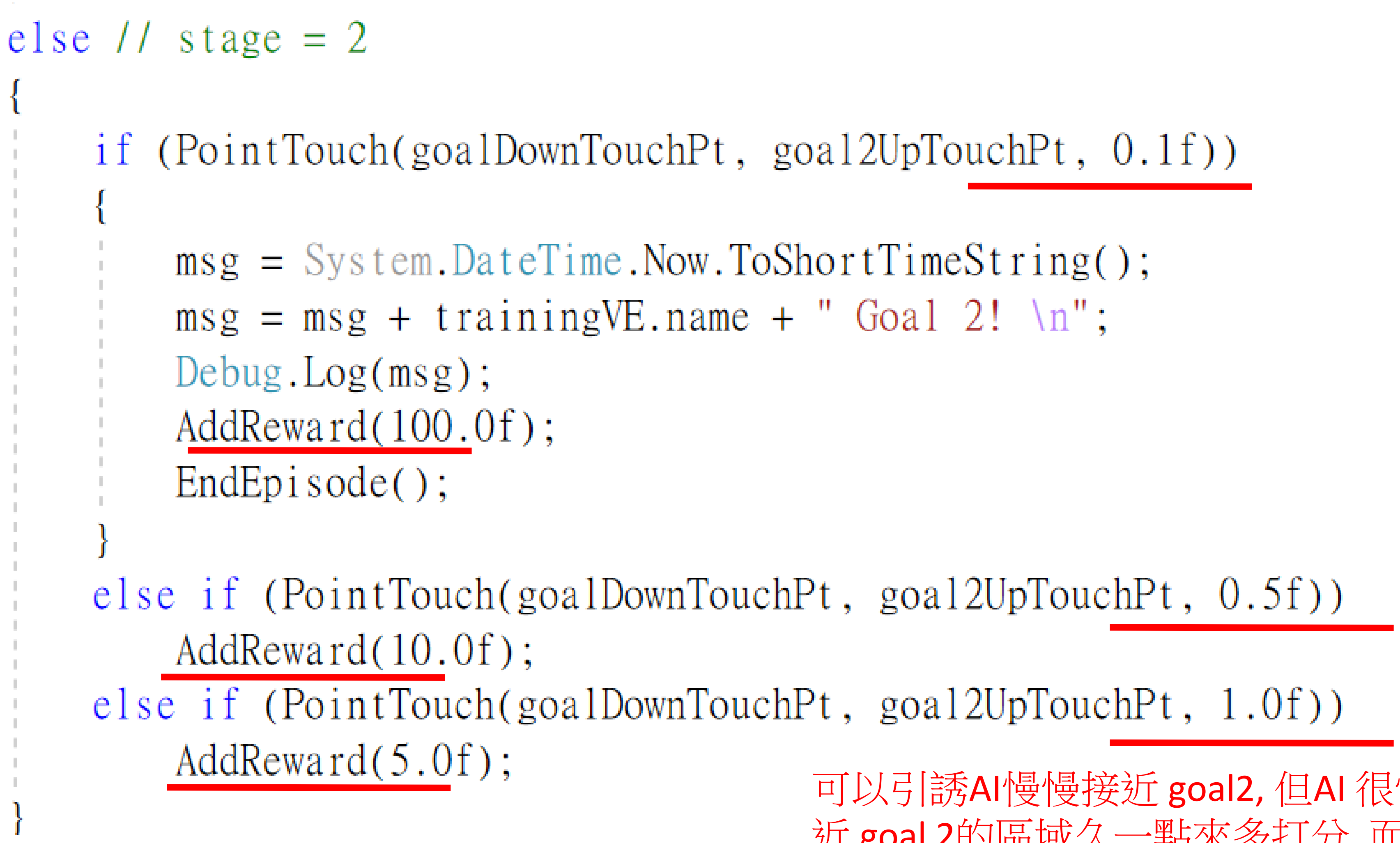
Reward is too small to encourage reach goal 1



```
if (stage == 1)
{
    distToGoal = Vector3.Distance(EndTouchPlane.position, goalUpTouchPt.position);
    if (distToGoal <= 0.1f && (EndTouchPlane.position.y > goal2UpTouchPt.position.y))
    {
        stage = 2;
        AddReward(1.0f);
        goal.transform.parent = EndPivot.transform; //grab goal
    }
}
else //stage =2
{
    distToGoal = Vector3.Distance(goalDownTouchPt.position, goal2UpTouchPt.position);
    if (distToGoal <= 0.1f && (goalDownTouchPt.position.y > goal2UpTouchPt.position.y))
    {
        msg = System.DateTime.Now.ToShortTimeString();
        msg = msg + trainingVE.name + " Goal 2! ==> " + distToGoal.ToString() + " \n";
        Debug.Log(msg);
        AddReward(100.0f);
        EndEpisode();
    }
}
```

5.5 also fail

This reward design will guild AI to reach goal2, but AI learns to stay at sweet zone to get higher rewards rather than touch goal2

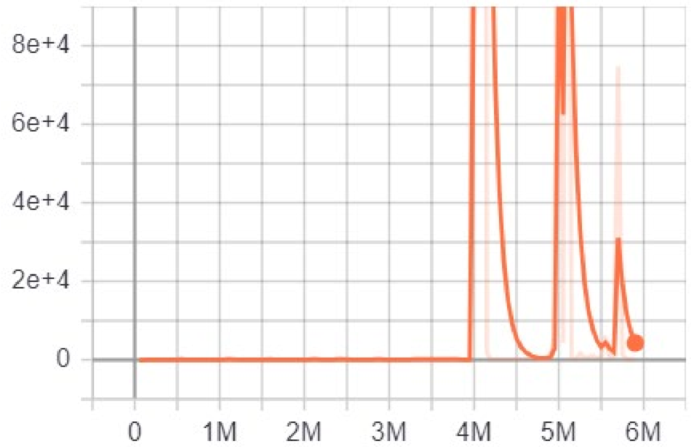


```
else // stage = 2
{
    if (PointTouch(goalDownTouchPt, goal2UpTouchPt, 0.1f))
    {
        msg = System.DateTime.Now.ToShortTimeString();
        msg = msg + trainingVE.name + " Goal 2! \n";
        Debug.Log(msg);
        AddReward(100.0f);
        EndEpisode();
    }
    else if (PointTouch(goalDownTouchPt, goal2UpTouchPt, 0.5f))
        AddReward(10.0f);
    else if (PointTouch(goalDownTouchPt, goal2UpTouchPt, 1.0f))
        AddReward(5.0f);
}
```

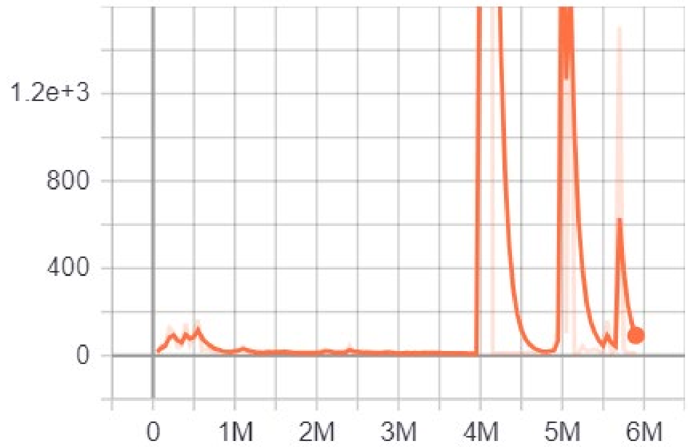
可以引誘AI慢慢接近 goal2, 但AI 很快就學會停在接近 goal 2的區域久一點來多打分, 而不去 touch goal2!

AI learns to stay at sweet zone to get higher rewards rather than touch goal2

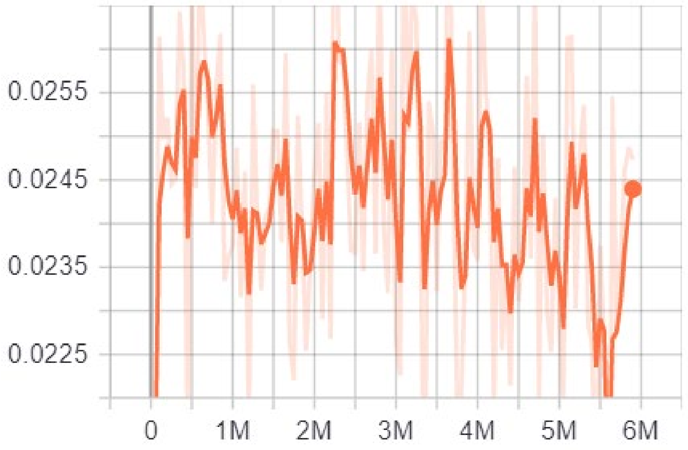
Cumulative Reward
tag: Environment/Cumulative Reward



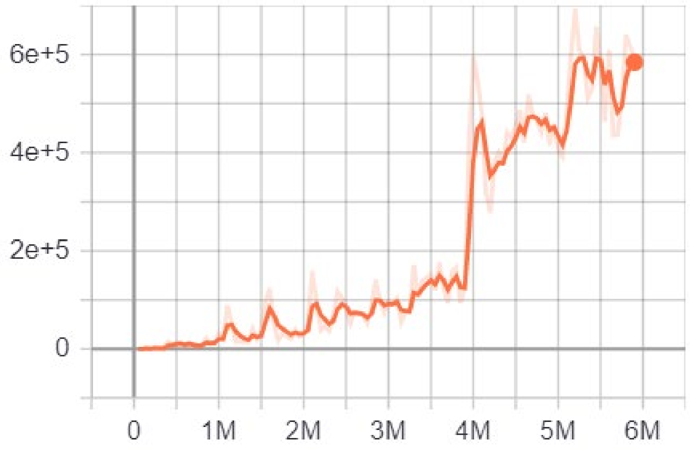
Episode Length
tag: Environment/Episode Length



Policy Loss
tag: Losses/Policy Loss

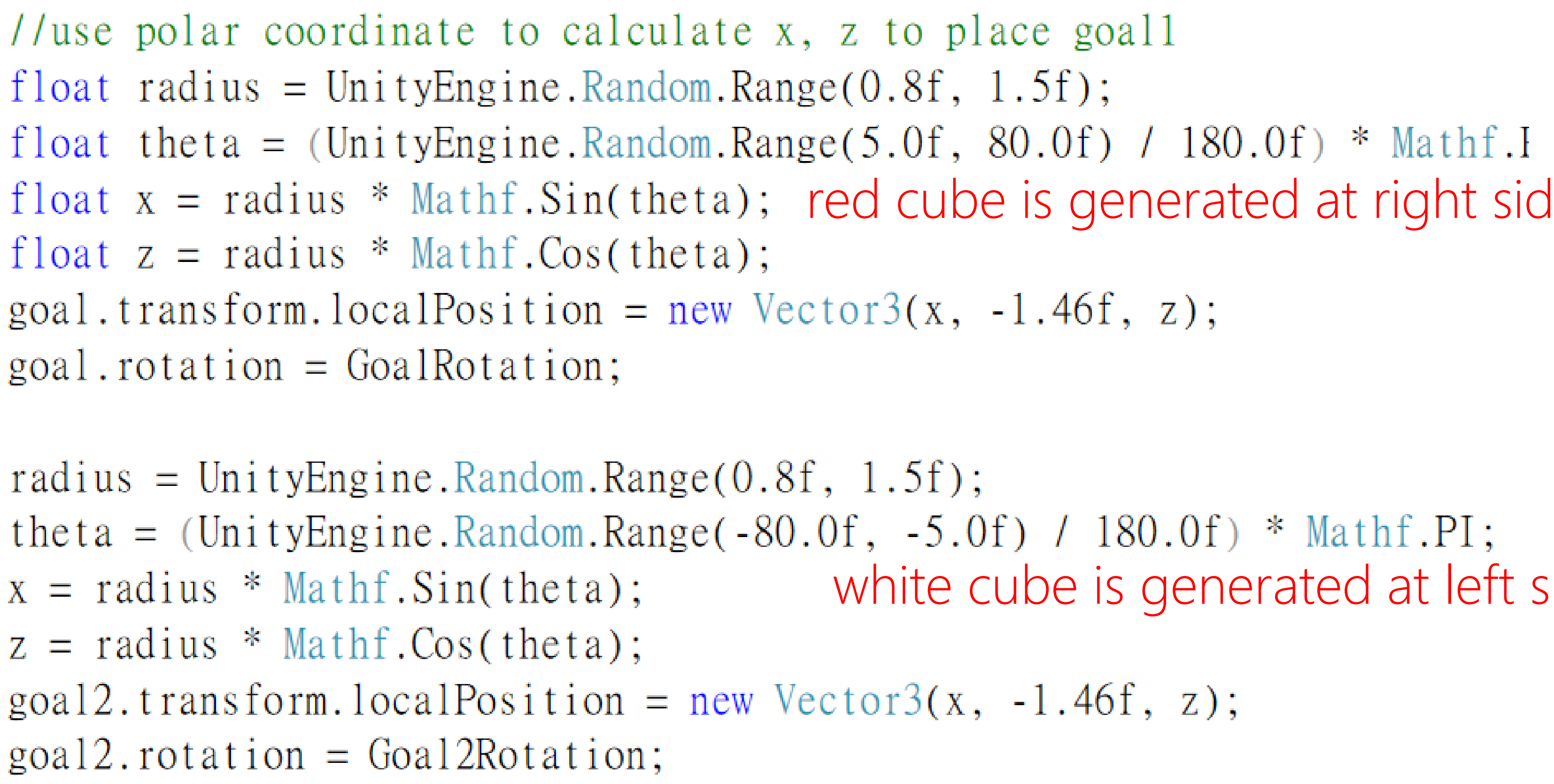


Value Loss
tag: Losses/Value Loss



Improper initial position will result in biased behavior

Improper initial position design



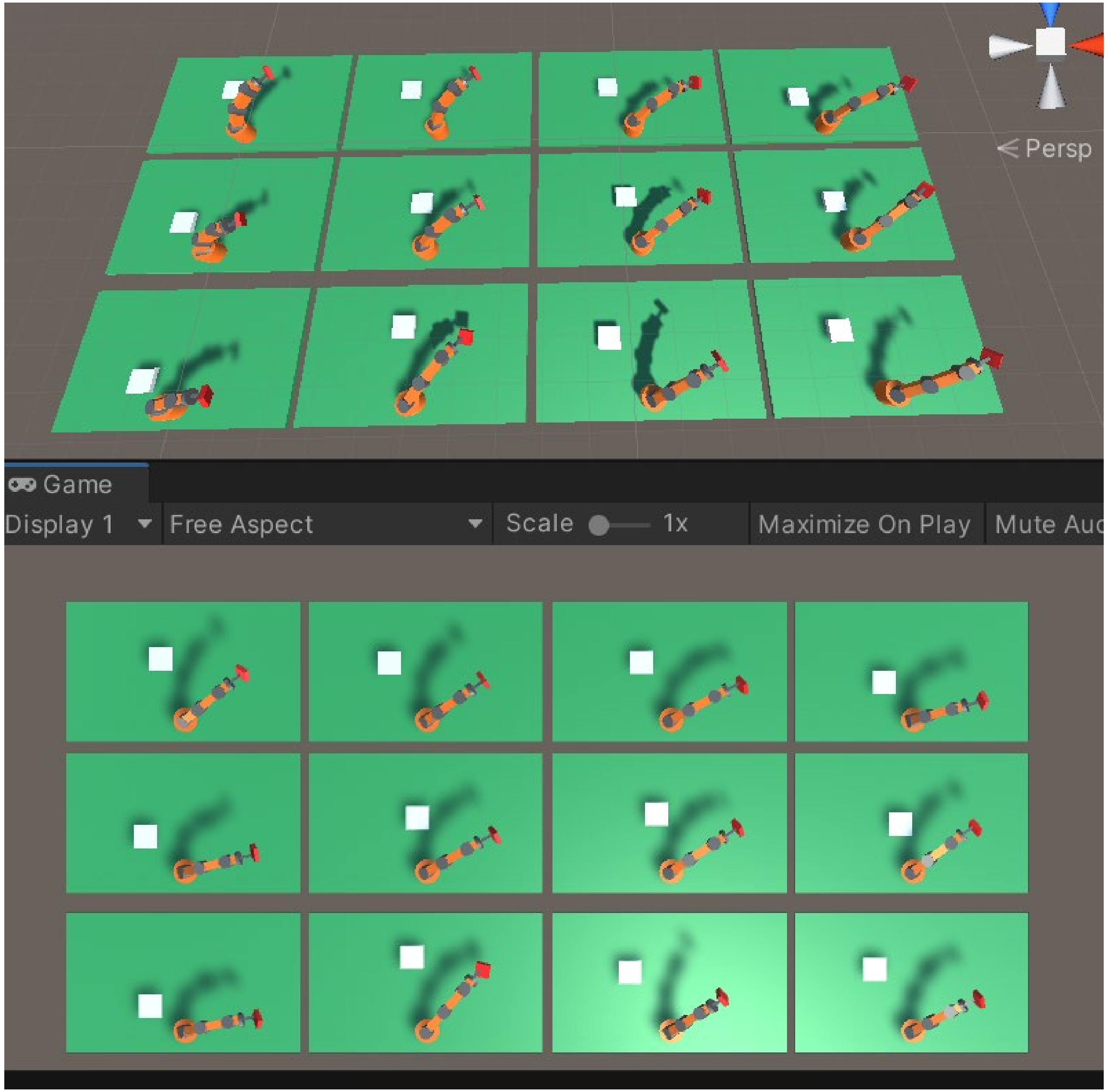
```
//use polar coordinate to calculate x, z to place goal1
float radius = UnityEngine.Random.Range(0.8f, 1.5f);
float theta = (UnityEngine.Random.Range(5.0f, 80.0f) / 180.0f) * Mathf.I
float x = radius * Mathf.Sin(theta);
float z = radius * Mathf.Cos(theta);
goal.transform.localPosition = new Vector3(x, -1.46f, z);
goal.rotation = GoalRotation;

radius = UnityEngine.Random.Range(0.8f, 1.5f);
theta = (UnityEngine.Random.Range(-80.0f, -5.0f) / 180.0f) * Mathf.PI;
x = radius * Mathf.Sin(theta);
z = radius * Mathf.Cos(theta);
goal2.transform.localPosition = new Vector3(x, -1.46f, z);
goal2.rotation = Goal2Rotation;
```

red cube is generated at right side

white cube is generated at left side

Biased behavior


< Persp
Game
Display 1
Free Aspect
Scale
1x
Maximize On Play
Mute Auc