Московский государственный технический университет им. Н.Э. Баумана

Факультет «Информатика, искусственный интеллект и системы управления»

Кафедра «Системы обработки информации и управления»

Отчет по рубежному контролю №2

по дисциплине «Методы машинного обучения»

Методы обучения с подкреплением
(тема работы)

ИСПОЛНИТЕЛЬ:
Якубов А.Р.
группа ИУ5-24М

ПРЕПОДАВАТЕЛЬ:
Гапанюк Ю.А.

Москва, 2023

Задание

Для одного из алгоритмов временных различий, реализованных Вами в соответствующей лабораторная работе:

- SARSA
- Q-обучение
- Двойное Q-обучение

осуществите подбор гиперпараметров. Критерием оптимизации должна являться суммарная награда.

Выполнение

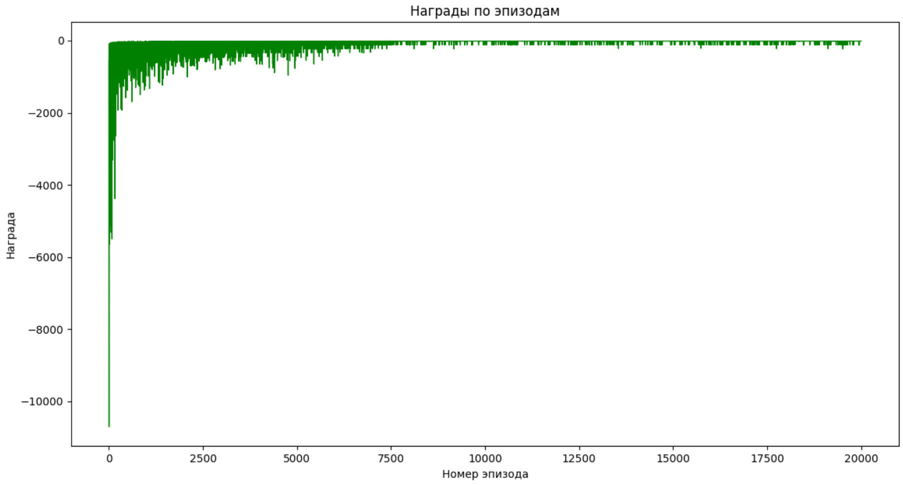
Подбор гиперпараметров для алгоритма двойное Q-обучение для среды Toy Text / CliffWalking-v0.

Начальные значения параметров:

```
eps=0.5, lr=0.001, gamma=0.99, num_episodes=10000
```

Результат работы программы для алгоритма двойное Q-обучение:

```
Суммарная награда:  -1 364 805
Вывод Q-матриц для алгоритма  Двойное Q-обучение
Q1
[[ -10.09289085  -10.05236375  -10.06661421  -10.05735569]
 [  -9.71581234   -9.73462015   -9.75893961   -9.76248178]
 [  -9.20171654   -9.15979638   -9.12146606   -9.11167113]
 [  -8.63566668   -8.63519216   -8.66457317   -8.63401819]
 [  -7.98680156   -7.94002267   -7.84642037   -7.84955342]
 [  -7.367545     -7.3177254    -7.33854801   -7.33750851]
 [  -6.64671873   -6.5917705    -6.57839412   -6.46176356]
 [  -5.87492013   -5.81049733   -5.88691874   -5.81181292]
 [  -5.09154321   -5.11917163   -5.1355987    -5.21879047]
 [  -4.40171783   -4.35688049   -4.24478732   -4.29833392]
 [  -3.52301773   -3.60464091   -3.56958825   -3.63954656]
 [  -2.88511185   -2.91032281   -2.86508486   -2.87708437]
 [ -10.48024056  -10.49745569  -10.51655902  -10.44920163]
 [  -9.96535803   -9.81722866   -9.93429739  -10.00811644]
 [  -9.36394517   -9.37690307   -9.3595449    -9.63528841]
 [  -8.59449177   -8.62334513   -8.66033629   -8.59899088]
 [  -8.01929493   -7.98289361   -8.07404167   -7.99682761]
 [  -7.26646017   -7.19817033   -7.25095966   -7.20935484]
 [  -6.49400171   -6.51214251   -6.46780122   -6.54922636]
 [  -5.53491379   -5.64586131   -5.62541019   -5.52589125]
 [  -4.78415057   -4.69002989   -4.76720792   -4.97131056]
 [  -4.03705047   -3.84944952   -3.83877637   -4.24189274]
 [  -3.13561396   -2.91389716   -2.92618607   -3.15328547]
 [  -2.656748     -2.22634054   -1.97981038   -2.59211793]
 [ -11.00557409  -10.76416381  -11.85701092  -11.29618101]
 [ -10.49072883   -9.96343246 -110.55624232  -10.98223467]
 [  -9.71875505   -9.14635966 -109.98786692  -10.18519696]
 [  -9.07175399   -8.31261189 -108.93028503   -9.43290233]
 [  -8.22365029   -7.46184887 -107.72317206   -8.6161662 ]
 [  -7.60964924   -6.59372334 -106.30573095   -7.79251125]
 [  -6.74440505   -5.70788096 -106.13930259   -6.98440691]
 [  -5.94309344   -4.80396016 -104.08830981   -6.12166608]
 [  -5.17961435   -3.881592   -102.96398032   -5.32232631]
 [  -4.34524825   -2.9404     -104.00078648   -4.4418403 ]
 [  -3.41063132   -1.98       -102.83486016   -3.53742476]
 [  -2.75113889   -1.86781992   -1.           -2.73993195]
 [ -11.54888054 -110.94993464  -12.09385316  -12.10577493]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]]
Q2
[[ -10.08725201  -10.12520674  -10.1195806   -10.11902158]
 [  -9.71225524   -9.68958033   -9.66908317   -9.67130278]
 [  -9.18152206   -9.21987742   -9.25975732   -9.2689325 ]
 [  -8.59901649   -8.59776443   -8.57436691   -8.60525873]
 [  -7.92750984   -7.97279723   -8.07464665   -8.06597641]
 [  -7.25584046   -7.30401695   -7.28732536   -7.2989119 ]
 [  -6.51751331   -6.57148497   -6.59175349   -6.7033622 ]
 [  -5.84858482   -5.9082715    -5.83290626   -5.9153179 ]
 [  -5.12142191   -5.09302443   -5.08228751   -5.00239973]
 [  -4.28001894   -4.31715554   -4.42759652   -4.3873417 ]
 [  -3.64950912   -3.56744837   -3.60515033   -3.53928069]
 [  -2.8666946    -2.83678597   -2.88052962   -2.91558382]
 [ -10.43087191  -10.41097794  -10.40213938  -10.46437916]
 [  -9.97858795  -10.12237541  -10.01065767   -9.94380216]
 [  -9.28857852   -9.27584111   -9.29802879   -9.02624789]
 [  -8.78931355   -8.76093983   -8.72711492   -8.79930542]
 [  -7.94182926   -7.97707646   -7.88998857   -7.96616803]
 [  -7.20800997   -7.26848581   -7.21814166   -7.26869932]
 [  -6.43181951   -6.40954264   -6.4540916    -6.38100473]
 [  -5.7043716    -5.58265138   -5.60338121   -5.74290532]
 [  -4.81478883   -4.84343715   -4.76589759   -4.8147614 ]
 [  -3.76967598   -3.8300691    -3.84104215   -3.82656552]
 [  -3.1775973    -2.93630598   -2.92410092   -3.34788014]
 [  -2.31075539   -2.38671612   -1.97983451   -2.35762701]
 [ -11.0430105   -10.76416381  -11.86581843  -11.31649696]
 [ -10.42761154   -9.96343246 -110.10299523  -11.00761557]
 [  -9.83474167   -9.14635966 -109.2817179   -10.24362237]
 [  -8.95959349   -8.31261189 -108.58168375   -9.33229126]
 [  -8.25563215   -7.46184887 -108.10547576   -8.59900418]
 [  -7.58326826   -6.59372334 -106.74402458   -7.72472949]
 [  -6.72891051   -5.70788096 -106.36275122   -6.94088559]
 [  -5.85231886   -4.80396016 -102.38917141   -6.16923341]
 [  -5.21306041   -3.881592   -103.56646553   -5.18198297]
 [  -4.54895799   -2.9404     -101.52384438   -4.46791789]
 [  -3.52607338   -1.98       -103.68426844   -3.58669366]
 [  -2.7474357    -1.87122489   -1.           -2.74728571]
 [ -11.54888054 -111.00242428  -12.09113087  -12.09010116]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [   0.           0.           0.           0.        ]
 [  0.          0.          0.          0.        ]
 [  0.          0.          0.          0.        ]
 [  0.          0.          0.          0.        ]
 [  0.          0.          0.          0.        ]
 [  0.          0.          0.          0.        ]]
```



Изменим следующие параметры:

lr=0.5, num_episodes=30000

```
Суммарная награда:  -1 439 135
Вывод Q-матриц для алгоритма  Двойное Q-обучение
Q1
[[ -11.9657858   -11.87042023  -11.86732539  -11.83872938]
 [ -11.41332339  -11.39771521  -11.4175467   -11.74805093]
 [ -10.68288564  -10.71451528  -10.67901651  -10.91284192]
 [  -9.89879522   -9.86997088   -9.93874431  -10.33062944]
 [  -9.51627825   -9.23844394   -9.13758822   -9.6380229 ]
 [  -8.48133609   -8.5216577    -8.28248331   -8.823221  ]
 [  -7.61497493   -7.87381806   -8.1313079    -7.66800254]
 [  -7.23893188   -6.72829976   -6.41499778   -7.0540342 ]
 [  -5.40910339   -6.24544729   -6.52080154   -5.86225381]
 [  -5.34673589   -4.73160967   -4.20692848   -4.83008464]
 [  -3.90981407   -3.925385     -4.52694793   -4.34713804]
 [  -3.44020774   -3.27828083   -2.93761498   -3.54764939]
 [ -12.46313118  -11.61054848  -11.54888054  -12.19742999]
 [ -11.91560349  -10.75625267  -10.76416381  -12.22470474]
 [ -11.23176454   -9.97286426   -9.96343246  -11.53577846]
 [ -10.55222519   -9.17263827   -9.14635966  -10.6015    ]
 [  -9.8356837    -8.31490101   -8.31261189   -9.80883516]
 [  -9.44160891   -8.18802267   -7.46184887   -8.93985243]
 [  -8.25889616   -6.52998622   -6.59372333   -8.07883231]
 [  -7.77040861   -6.76957049   -5.70788099   -7.66870773]
 [  -6.23967876   -4.45823857   -4.80395985   -6.14192221]
 [  -5.92363029   -4.77522461   -3.88159231   -6.30472527]
 [  -4.25804498   -2.93969628   -2.93976962   -3.72663587]
 [  -3.55458229   -2.72681421   -1.98         -3.9549554 ]
 [ -12.31790293  -10.76416381  -12.31790293  -11.54888054]
 [ -11.57873915   -9.96343246 -111.31790293  -11.54888054]
 [ -10.76416381   -9.14635966 -111.31790293  -10.76416381]
 [  -9.96343246   -8.31261189 -111.31790293   -9.96343246]
 [  -9.14635966   -7.46184887 -111.31790293   -9.14635966]
 [  -8.31261189   -6.59372334 -111.3179029    -8.31261189]
 [  -8.31503634   -5.70788096 -111.31790282   -7.46184887]
 [  -6.59372283   -4.80396016 -111.31790276   -6.59372322]
 [  -6.80705805   -3.881592   -111.31789958   -5.70788098]
 [  -4.80395568   -2.9404     -111.31789651   -4.80395934]
 [  -3.88234228   -1.98       -111.31788262   -3.88159162]
 [  -2.94039874   -1.97999827   -1.           -2.94039945]
 [ -11.54888054 -111.31790293  -12.31790293  -12.31790293]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]]
Q2
[[ -11.85627492  -11.94110353  -11.9363446   -11.99527241]
 [ -11.36027433  -11.37766876  -11.36031981  -11.43012568]
 [ -10.86007128  -10.67902143  -10.71419049  -10.98906902]
 [ -10.1923441    -9.98868682   -9.91805686  -10.12927801]
 [  -9.27187704   -9.12713996   -9.14280062   -9.41085218]
 [  -8.65797006   -8.60423479   -8.82751155   -8.91765225]
 [  -7.97369461   -7.55849936   -7.27363464   -8.16736263]
 [  -6.60225054   -7.0606398    -7.38036484   -7.18632466]
 [  -6.37431163   -5.54550214   -5.27335876   -5.96152807]
 [  -4.58692606   -5.18077096   -5.72128062   -5.07707573]
 [  -4.4184448    -3.87579005   -3.29689175   -3.75823006]
 [  -3.27503977   -3.44707523   -2.97224921   -4.02028411]
 [ -12.45459829  -11.54111113  -11.54888054  -12.31752148]
 [ -11.9839398   -10.79408928  -10.76416381  -12.31187581]
 [ -11.33397228   -9.97643058   -9.96343246  -11.35295927]
 [ -10.58371301   -9.17226326   -9.14635966  -10.69708238]
 [  -9.7791513    -8.92942703   -8.31261189   -9.75464004]
 [  -8.99759174   -7.43786749   -7.46184887   -9.03609304]
 [  -8.54176048   -7.46532353   -6.59372335   -8.75105883]
 [  -7.25428594   -5.46389192   -5.70788095   -7.05279609]
 [  -6.62521953   -5.92414795   -4.80396035   -7.09797239]
 [  -5.19738991   -3.50014841   -3.88159183   -4.76958849]
 [  -4.66393968   -2.94055435   -2.94053608   -5.60003678]
 [  -3.52231315   -2.76888829   -1.98         -3.26747307]
 [ -12.37932653  -10.76416381  -12.31790293  -11.54888054]
 [ -11.54888054   -9.96343246 -111.31790293  -11.54888054]
 [ -10.76416381   -9.14635966 -111.31790293  -10.76416381]
 [  -9.96343246   -8.31261189 -111.31790292   -9.96343246]
 [  -9.14635966   -7.46184887 -111.31790293   -9.14635966]
 [  -9.0213795    -6.59372334 -111.31790289   -8.31261189]
 [  -7.46184875   -5.70788096 -111.31790291   -7.46184883]
 [  -7.63384947   -4.80396016 -111.31789907   -6.59372339]
 [  -5.7078732    -3.881592   -111.31789988   -5.70788031]
 [  -5.68231557   -2.9404     -111.31789954   -4.80396006]
 [  -3.88055672   -1.98       -111.31775528   -3.8815909 ]
 [  -2.94045074   -1.97999764   -1.           -2.94039934]
 [ -11.54888054 -111.31790293  -12.31790293  -12.31790293]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.          0.          0.          0.        ]]
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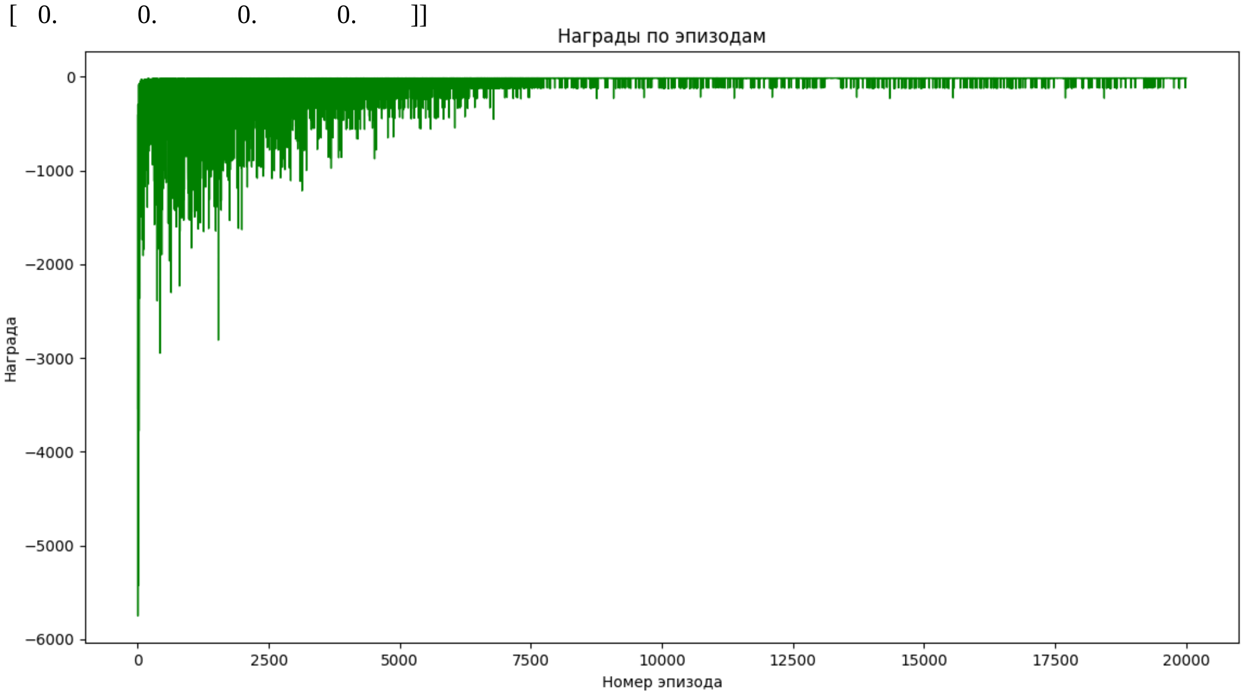

Изменим следующие параметры:

lr=0.8, num_episodes=10000

```
Суммарная награда:  -859 934
Вывод Q-матриц для алгоритма  Двойное Q-обучение
Q1
[[ -13.07239812  -12.31790978  -12.31790293  -13.07240228]
 [ -12.31790293  -11.54888056  -11.54888054  -13.07154487]
 [ -11.54888059  -10.76416381  -10.76416381  -12.31790294]
 [ -10.76416381   -9.96346368   -9.96343246  -11.54888054]
 [  -9.96343246   -9.14635966   -9.14635966  -10.76416381]
 [  -9.14635966   -8.31261189   -8.31261189   -9.96343472]
 [  -8.31261189   -7.46184887   -7.46184887   -9.14635966]
 [  -7.46184887   -6.59372334   -6.59372334   -8.31261189]
 [  -6.59372334   -5.70788099   -5.70788096   -7.46184887]
 [  -5.70788096   -4.80396016   -4.80396016   -6.59372334]
 [  -4.80396016   -3.881592     -3.881592     -5.70788096]
 [  -3.881592     -3.881592     -2.9404       -4.80396016]
 [ -13.07154487  -11.54888054  -11.54888054  -12.31790293]
 [ -12.31790293  -10.76416381  -10.76416381  -12.31790293]
 [ -11.54888054   -9.96343246   -9.96343246  -11.54888054]
 [ -10.76416381   -9.14635966   -9.14635966  -10.76416381]
 [  -9.96343246   -8.31261189   -8.31261189   -9.96343246]
 [  -9.14635966   -7.46184887   -7.46184887   -9.14635966]
 [  -8.31261189   -6.59372334   -6.59372334   -8.31261189]
 [  -7.46184887   -5.70788096   -5.70788096   -7.46184887]
 [  -6.59372334   -4.80396016   -4.80396016   -6.59372334]
 [  -5.70788096   -3.881592     -3.881592     -5.70788096]
 [  -4.80396016   -2.9404       -2.9404       -4.80396016]
 [  -3.881592     -2.9404       -1.98         -3.881592  ]
 [ -12.31790293  -10.76416381  -12.31790293  -11.54888054]
 [ -11.54888054   -9.96343246 -111.31790293  -11.54888054]
 [ -10.76416381   -9.14635966 -111.31790293  -10.76416381]
 [  -9.96343246   -8.31261189 -111.31790293   -9.96343246]
 [  -9.14635966   -7.46184887 -111.31790293   -9.14635966]
 [  -8.31261189   -6.59372334 -111.31790293   -8.31261189]
 [  -7.46184887   -5.70788096 -111.31790293   -7.46184887]
 [  -6.59372334   -4.80396016 -111.31790293   -6.59372334]
 [  -5.70788096   -3.881592   -111.31790293   -5.70788096]
 [  -4.80396016   -2.9404     -111.31790293   -4.80396016]
 [  -3.881592     -1.98       -111.31790293   -3.881592  ]
 [  -2.9404       -1.98         -1.           -2.9404    ]
 [ -11.54888054 -111.31790293  -12.31790293  -12.31790293]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]
 [   0.            0.            0.            0.        ]]
Q2
[[ -13.07154492  -12.31790433  -12.31790293  -13.07154492]
 [ -12.31790294  -11.54888054  -11.54888054  -13.07154488]
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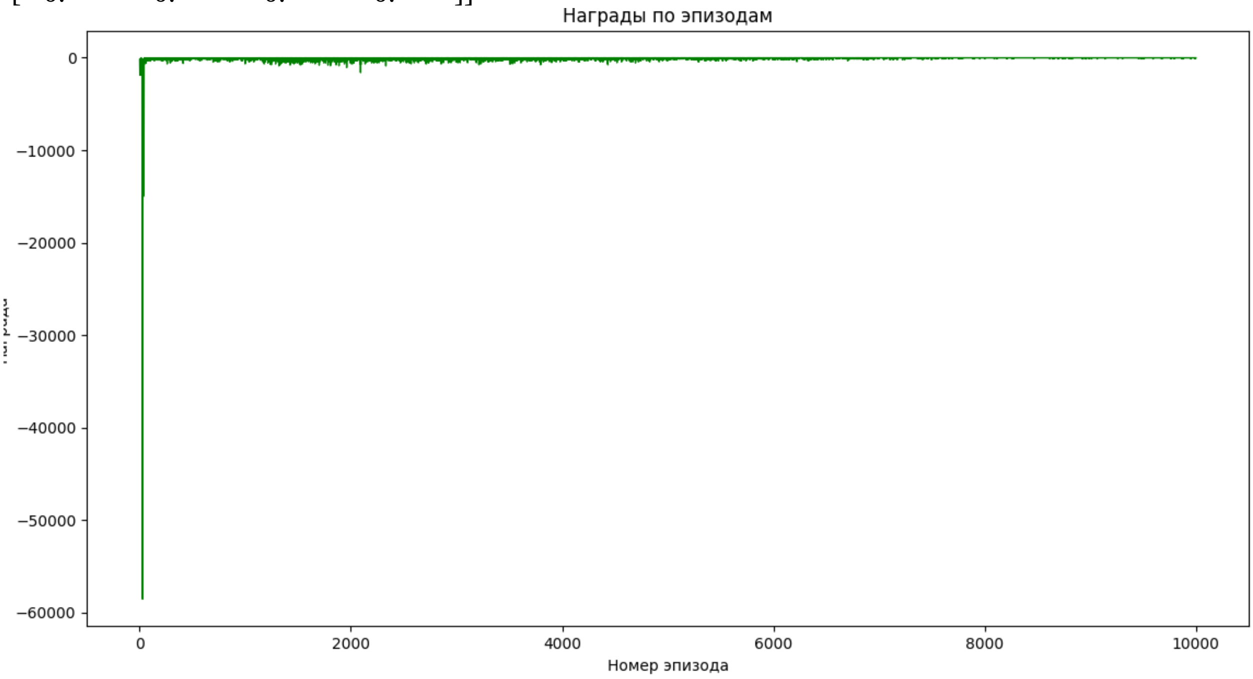
Награды по эпизодам
Награда
Номер эпизода