Deeplearning4j 实战 (9):强化学习 -- Cartpole任务的训练和 效果测试

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在之前的博客中,我用Deeplearning4i构建深度神经网络来解决监督、无监督的机器学习问题。但 除了这两类问题外,强化学习也是机器学习中一个重要的分支,并且Deeplearning4j的子项目--RI4j提供了对部分强化学习算法的支持。这里,就以强化学习中的经典任务--Cartpole问题作为学 习RI4i的入门例子, 讲解从环境搭建、模型训练再到最后的效果评估的结果。

Cartpole描述的问题可以认为是:在一辆小车上竖立一根杆子,然后给小车一个推或者拉的力,使 得杆子尽量保持平衡不滑倒。更详细的描述可参见openai官网上关于Cartpole问题的解释: https://gym.openai.com/envs/CartPole-v0

接着给出强化学习的一些概念: environment, action, reward

environment:描述强化学习问题中的外部环境,比如:Cartpole问题中杆子的角度,小车的位 置、速度等。

action:在不同外部环境条件下采取的动作,比如:Cartpole问题中对于小车施加推或者拉的力。 action可以是离散的集合,也可以是连续的。

reward:对于agent/network作出的action后获取的回报/评价。比如:Cartpole问题中如果施加的 力可以继续让杆子保持平衡,那reward就+1。

在描述reward这个概念时,提到了agent这个概念,在实际应用中,agent可以用神经网络来实

对于强化学习训练后的agent来说,学习到的是如何在变化中的environment和reward选择action的 **(http://weibo.com/u/3933853639)** 能力。通常有两种学习策略可以选择: Policy-Based和Value-Based。 Policy-Based直接学习 action,通过Policy Gradient来更新模型参数,而相对的, Value-Based是最优化action所带来的 reward (action-value function, Q-function)来间接选取action。一般认为如果action是离散的, 那么Value-Based会优于Policy-Based,而连续的action则相反。在这里主要讨论Value-Based的学 习策略,或者更具体的说Q-learning的问题。对于Policy-Based还有Model-Based不做讨论。

Q-learning的概念早在20多年前就已经提出,再与近年来流行的深度神经网络结合产生了DQN的 概念。Q-learning的目标是最大化Q值从而学习到选取action的策略。Q-leaning学习的策略公式:

 $Q(s_{t}, a_{t}) \leftarrow Q(s_{t}, a_{t}) + \alpha[r_{t+1} + \lambda \max_{a} Q(s_{t+1}, a) ? Q(s_{t}, a_{t})]$

对于这里主要讨论的Catpole问题,我们也采用Q-learning来实现。

可以看到,与监督学习相比,强化学习多了action, environment等概念。虽然可以将reward类比 成监督学习中的label(或者反过来,label也可以认为是强化学习中最终的reward),但通过 action与environment不断的交互甚至改变environment这一特点,是监督学习中所没有的。在构建 应用的时候,监督学习的学习的目标:label,灌入的数据都是一个定值。比如,图像的分类的问 题,在用CNN训练的时候,图片本身不发生变化,label也不会发生变化,唯一变化的是神经网络 中的权重值。但强化学习在训练的时候,除了神经网络中的权重会发生变化(如果用NN建模的 话), environment、reward等都会发生动态的变化。这样构建合适正确的训练数据会比较麻烦,



容易出错,所以对于CartPole问题,我们可以采用openAI提供的强化学习开发环境gym来训练/测

gym的官方地址:https://gym.openai.com/

gym提供了棋类、视频游戏等强化学习问题的学习/测试/算法效果比较的环境。这里要处理的 Cartpole问题,gym也提供了环境的支持。但是,除了python,gym对其他语言的支持不是很友 好,所以为了可以获取gym中的数据,RL4i提供了对gym-http-

api (https://github.com/openai/gym-http-api) 调用的包装类。gym-http-api是为了方便除python外 的其他语言也可以使用gym环境数据的一个REST接口。简单来说,对于像RL4i这样以Java实现的 强化学习算法库可以通过gym-http-api获取gym提供的数据。

gym的REST接口的安装可以参见之前给出的github地址,里面有详细的描述。下面先给出gymhttp-api的安装和启动过程的截图:

查看标识获取更多信息 精神病的前兆 种植头发费用 python课程 蛋糕学习班 python 教程 近视眼1000度 抑郁证的症状

6 (http://weibo.com/u/3933853639)





结合上面说的内容,给出RL4i的Catpole实现逻辑

Q-learning的参数以及神经网络结构,两者共同决定DQN的属性

(https://cpro.baidu.com/cpro/ui/uijs.php?

读取gym数据的包装类对象

DQN并保存模型

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Deeplearning4j 实战 (9):强化学习 -- Cartpole任务的训练和效果测试-爱编程

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nbul II T-
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                                                                                                      定义两个方法分别用于训练和测试。catpole方法用于训练DON,而loadCartpole则用于
                                                                                                   (https://cpro.baidu.com/cpro/ui/uijs.php?
  en=mvwWUA71T1YsFh7sT7gGuiYsFhPh5HDhmv6gnaubpHY3Fh-1gv7sTiYsFhGo5vnkri9BPARYuADdnvfduWDhp1Y-fbf-wbn-
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b5HRhTv-b5vmkuiRdnvw9uHwBPi63m1DhTLwGuiYznBuY5gwsmvkGmvV-
                                                                                                                                                                                                                                                                                                                           (http://weibo.com/u/3933853639)
 ujPxpAnhlAd15HDdnjTkP1fvrjnhlZRqlHD4nHm1rjfhlHdClZwsFHPKFHFAFHFAlLILFHF7l1FBmzRzwyPEUiuv5HDhpHdbm17-
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 近视眼1000度 (https://cpro.baidu.com/cpro/ui/uijs.php?en=mywWUA71T1YsFh7sT7gGujYsFhPh5HDhmv6qnaubpHY3Fh-
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  wic-fbc-wic-fWm-fYR-wH0-fYf-
fHbhp1fqFRF7FR7aFRn4FRmkFRczFRDkFRcdFRnYFRnLFRcsFRfdFRfLFh_d5iNDPBNDPBNanBNjwaNaPzNApzNKnBNaPzNDniNDnzNjnzu_lyVG5HmhUyPsUHY4rjTYPauk5HbdnjmsnH0sgvPsTBuzmWYkFMF15HDhTvN_UANzgv-
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ujPxpAnhIAd15HDdnjTkP1fvrjnhIZRqlHD4nHm1rjfhlHdCjZwsFHPKFHFAFHFALLIFFHF7l1FBmzRzwyPEUiuv5HDhpHdbm17-
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                                                                                                        //record the training data in rl4j-data in a new folder (save)
                                                                                                        DataManager manager = new DataManager(true);
                                                                                                        //define the mdp from gym (name, render)
    查看标识获取更多信息
                                                                                                      GymEnv<Box, Integer, DiscreteSpace> mdp = null;
https://cpro.baidu.com/cpro/ui/uijs.php?
   零基础自学编程
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                                                                                                                   mdp = new GymEnv<Box, Integer, DiscreteSpace>("CartPole-v0", false, false);
                                                                                                        } catch (RuntimeException e){
  塔罗牌派
                                                                                                                   System.out.print("To run this example, download and start the gym-http-api
                                                                                                        //define the training
    างเกราะ
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                                                                                                     n1mgffy4Pf10finalnpowi2chThcqniuzT1YkEMP-UAk-T-
                                                                                                   ws$/v=akign=1&kgig1=8&kgi1=8&kgi1=8&kgi1=8&kgi1=8&kgi4=8&kgi6=8&gscf-0&gs-10gncf=0&nmv=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0)
uris pbp?earerywYklly73811YsFn7sT7qGujYsFnPh5HDhmv6qnaubpHy3Fh-
                                                                                                     p1Y-wjc-wjm-wjn-wWf-wjm-fHf-fWR-f1f-wjm-fHc-wjT-
                                                                                               dFRMYEBBJeFRDZFIRMJEFRCMSJe KBINJAWANAfzNjfiNDnzNjfiNDPBNjfiNAPiNafiNAnzNDnBNjPiNDPBNKnBuonWY-
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  零基础自学编程 (https://cpro.baidu.com/cpro/ui/uijs.php?en=mywWUA71T1YsFh7sT7qGujYsFhPh5HDhmv6qnaubpHY3Fh-
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http://www.w2bc.com/article/255081

Deeplearning4j 实战 (9):强化学习 -- Cartpole任务的训练和效果测试-爱编程 fYnhp10gFRnkFRR1FRFaFRm4FRcYFRDkFRfLFRfyFRfkFRDLFRckFRRsFRc1FRPiFh k5iNawiNKfBNiriNAniNanBNKniNaPiNiPaNiPzNanaNDPiNDPzuonWYwjT-wDc-fbD-fYm-fWc-fbn-fYmwDmhp1nqFRPaFRu7FRnzFRw7FRndFRnvFRczFRRzFRPKFRfYFh_Y5iNaPiNanaNaraN7nBNDniNKPzNjwBNanaNanaN7nauoPHYwic-wim-win-wWf-wim-fHf-fWR-f1f-wim-fHc-wiTfWfhUZNopHYkFhdWTAYqnH0YPj0YFMDqrHRsPW0knjKxmLKzFMFB5HDhTMnqniu1uyk uqFxpyfqPiu1pyfqryDknW7WnhR1Pv79m1n4uBu1IAb5HczFMfgIZKWUA-WpyNbndgCmzuYUgngnHRsP1DLPim3PauYIHddnHbkPWn3Paud5y9YIZ0-nYD-nbm-nbuLlLTnbNLnhFWFHF7mvqVFMmgniuG5ywhmymvnHP9&c=news&fv=9&itm=0&kdi0=8&kdi1=8&kdi2=8&kdi3=8&kdi4=8&kdi5=8&mscf=0&n=10&ncf=0&nmv=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0) (http://weibo.com/u/3933853639) 查看标识获取更多信息 塔罗牌测试 (https://cpro.baidu.com/cpro/ui/uiis.php? 高度近视 蛋糕学习 non 教程 en=mywWUA71T1YsFh7sT7qGujYsFhPh5HDhmv6qnaubpHY3Fh-1qv7sTjYsFhGo5H-hm1P9mHnLnhRkm1DzryDhp1Y-fbRfRc-f1b-wWD-fWc-fHD-fWR-f1f-f1T-fW0-wjR-FRCSFRfdFRfLFh_k5iNDPzNDfBNafiNjwBNanBNafzNjwBNDwBuonWYwjThp10qFRF fYc-wbR-f1c-w wjfhp1nqFRcd RRSER: XSN QABANDRBNDRANAPANDPBNKRANARNINIRANDRBNKABNDRZNARRugaRHdeXgwCUv3oFRFDFRPjFnkdpvbqnBuVmLKV5HRvrjR3FMDqrHRsPW0knjKxmLKzFMFB5HDhTMnqniu1uyk ugFxpyfqPiu1pyfqryDknW7WnhR1Pv79m1n4uBu11Ab5HczFMfqlZł 13PauYIHddnHbkPWn3Paud5y9YIZ0-nYD-nbm-nbuLILT-3(<u>te98iftm=0&kdj@y8&kdiim=8&kdii@e8&k</u>di3=8&kdi4=8&kdi5=8&mscf=0&n=10&ncf=0&nmv=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0) nbNLnhFWFH (https://cpro.baidiccom/cpro/u/ujjs.php? WWWWAFQ年175FHSSTFCESWASFAPMBHADAnnwagnRxW时刊YBFM,Integer,DiscreteSpa 精神病的前兆 1gv7sTjYsFh0 ?c-f1b-wWD-fWc-fHD-fWR-f1f-f1T-fW0-wjR wjThp10qFRF wjftp1nqFRcd
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WDcknj0sFRcvWRhdelngeSIRDWeNNATERNKRDD12NGKRDPBAFRRNAPPRIMFRRNANDMENRPINDRBFRKGEFRRNANDSPYBALNKRASHEVIPO1DdPauk5HbdnjmsnH0sgvPsTBuzmWYkFMF15HDhTvN UANzgv-

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Deeplearning4j 实战 (9):强化学习 -- Cartpole任务的训练和效果测试-爱编程

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o.d.o.l.ScorelterationListener - Score at iteration 54500 is 2.843149413820356E-4

o.d.o.l.ScorelterationListener - Score at iteration 54550 is 2.3328783572651446E-4

o.d.r.l.s.q.d.QLearningDiscreteDense - reward:155.0

o.d.r.l.s.q.d.QLearningDiscreteDense - psoch: 1319 FO .d.d.r.l.s.q.d.QuearmingDiscreteDense - Epoch: 1319
FO .d.d.o.l.scorelleralionListener - Score at iteration 54600 is 5.307210376406182E-4
FO .d.o.l.scorelleralionListener - Score at iteration 54600 is 1.344265407155146E-4
135 [main] INVO .d.o.l.scorelleralionListener - Score at iteration 54700 is 1.776725905109800E-4
135 [main] INVO .d.o.l.s.q.d.geeningPiscreteDense - reward:110.0
136 [main] INVO .d.r.l.s.q.d.QuearmingPiscreteDense - Epoch: 1320 www.JA71T1YsFh7sT7g0,135 Far 1gv7sTjYsFhGo5HPWPH6LnjN winhn10gFRc3FRwAFRcvFR fbf-wbn-fYD-wjn-wjD-wDc-fYI en=mvwWUA7/h7AhA97/NZavZaNGzNY fWO-fW6-wHc-fwi/Dhfb-tDRfb/frR-ffw/FR-fb/W9 wH0hn10gFRddfffRdsFRbSFRRdFRW tsXgwCUv3oFRFDFRPjFRc1FRPjFh 15iNawaNAfzNjfiNDnzNDniNDfWDsnj0uiPxnAnhIAd15HDdniT &c=news&fy=9&itm=0&kdi0=8&kdi1=8&kdi2=8&kdi3=8&kdi4=8&kdi5=8&mscf=0&n=10&ncf=0&nmy=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0) [main] IMFO EpsGreedy - EP: 0.1 55001 [main] IMFO a.d.o.l.ScoreIterationListener - Score at iteration 55000 is 2.56320611427906165-4 f16hp1fgFRFD高度证例PKKRR\$1/FGRPK niN7naNanzNjfzu IyVG5HRhUyPsUHY3nH64rauk5HbdnjmsnH0sqvPsTBuzmWYkFMF15HDhTvN UANzqv | main| INFO o.d.r.l.s.q.d.QLearningDiscreteDense reward:200.0 | main| 1MFO o.d.r.l.s.q.d.QLearningDiscreteDense Epoch: 1322 | main| 1MFO o.d.d. | SagniferationListers - Score at iteration h5HRhTv-h5He9mHrkmWFI4h719mVrsfe Score at iteration 55050 is 1.3063664564514363E-4 kitm=0&kdi0=8&kdi1=8&kdi2=8&kdi3=8&kdi4=8&kdi5=8&mscf=0&n=10&ncf=0&nmv=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0) uiPxpAnhIAd15hIDdniiMdPhQnifsIIVRMI 蛋糕学习班 (http://doi.org/10.001 1qv7sTiYsFhGb5WHmfYP9wiHmViDhRDrc-IDDevOlne(IYDAWR/RA/IDHWD-ovNV9wiDVIDHTeO/naRIZ/O-fW0-WHOhp10gFRXIDARASERNASFRNIZFRIKARIDUGRPX/EEROSERSESERNISFRWRSHWRSHNDIDZNAPANDDENKPANAPINIPANDPBNKNBNDPZNAPAUONWdsXgwCUv3oFRFDFRPJFRc1FRPJFh 15iNawaNAfzNjfiNDnzNDniNDfWDsnj0 $fW0hp1RqFRfkFRDLFRPAFRcsFRnkFRNjFRf1FRmzFhkdpvbqnzuVmLKV5HDkPWb1Piuk5HbdnjmsnH0sgvPsTBuzmWYkFMF15HDhTvN_UANzgv-Reference (National Control of Control of$ NAGANKGINDP2NDP3NDp1NKB2NAGINTPANAG2NJfzu_IyVG5HRhUyPsUHY3nH64rauk5HbdnjmsnH0sgvPsTBuzmWYkFMF15HDhTvN_UANzgv-旧的数值大分可能并不是非常的 足术WPEUNivSHDF0HY2mVB3ivn4nf8c=news&fv=9&im=0&kdi0=8&kdi2=8&kdi3=8&kdi3=8&kdi4=8&kdi5=8&mscf=0&n=10&ncf=0&nmv=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0} ま記念は12=8&kdi2=8&kdi5= (https://cpro.baidu.com/cpro/ui/uijs.php? aidu.com/cpro/ui/uiis.php? WUA71T1YsFh7sT7qGujYsFhPh5HDhmv6qnaubpHY3Fh en=mywWUAZIIIVIXSF/hSF3TGQGHIPWMPHR815HfWhmWoqManHbp1Hy8Fb11qWWFJ/WSFHWV65M-Horwip9MHRflYnhRkm1DzryDhp1Y-wjchttp://weibo.com/u/3933853639) wjm-wjn-wWf-**ŵy/0/fjit/0y/rrk(t/f-wjos/ffic29fjir**RzzFRfkFRDLFRPAFRcsFh_k5iNawaNAfzNjfiNDnzNDniNDfBNjfiNDPBNjfiNDPBNjfiNAPiNafzNDfBNaraNAniuc fWfhp10aFRfz**\(\mathrel{k}\)\(\mathr** h5HRhTv-h5HpnnHtklm1F-n1I9mvn1rvmhTI wGuiYznBuY5gwsmvkGmvVujPxpAnhlAd16bludtijFN9TM9ffltiZqqfFD4aqhfuuG5ff9P0d0Zbvsfi9Bxf=hbfwst3Mp48clufiH93XbfBsh&Rdiuy9Bbbili29bBvbij3sbBcbili29bBvb 抑郁证的症状 面纖學及p(tottps:id/cpcont/aipto/co/mijsppbp/Abrijs:ppb/Abrijs:ppb 1qv7sTiYsFhQcr5thskm\QR9\711lfiLMsRki7sIDzrQDh\qsP\sRir5\dDhxwi6qv\d\thvirh\Y8fft\WR-f1f-wim-fHc-wiTfWfhp10qFRfzEqrivsFRiMSFhgv5FRWWREWERiNdFiRMWWRfWFRDyzFfqfLYFRWYRFW055hW&HwBiEWQD-fbfTPYYrfhWnfYnhp1cqFRFDMPdwptIRPfKRedERBSHTRQ9FiRh0SpiRiDSHRMBRAHIPCSHrIvbEnViraPiXDAWAykdfXDyNybEnViraPiXDpiNybEnViraPiXD fhchp1fqFnnk**wirrihfnafawaffavyffr**Qbffr(LFRfyFRfkFRDLFrckFRRsFRc1FRPiFh d5iNawiNKfBNjriNAniNapBNKniNaPiNjPaNjp2NanaNDPiNDPzu IV/G5hmhUyPsUHYdrlbzrauk5Hbdnjmsnh0sgvPsTBuzmWYkFMF15HDhTvN UANzgv-ujPxpAnhlAd155HpzhffWffZfvjWuZRqujbDuhndqqQffluYWQLQZqrdrfffR9F3EUYLFfWHFPBLYBHWzBPqy8f5j9Wz5ePDMpHabmm10knWn3n0&c=news&fv=9&itm=0&kdi0=8&kdi2=8&kdi3=8&kdi3=8&kdi5=8&mscf=0&n=10&ncf=0&nmv=0&ntmp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0) tryMmgniuG5yP9mhDkuh79&c=news&fv=9&itm=0&kdi0=8&kdi1=8&kdi2=8&kdi3=8&kdi4=8&kdi5=8&mscf=0&n=10&ncf=0&nmv=0&nttp=1&p=baidu&ssp2=1&tsf=dtp:1&u=%2Farticle%2F255081&urlid=0) is true aidu.com/cpro/ui/uijs.php? https://cpro.baidu.com/cpro/ui/uiis.php? s5gK4IA9EUB_-fbf-fYn-fWnhm1P9mHnI n fYnhp1DqFRF**@f=RwjKRYUKKFXTERSKFFRwTaTdqOsjYdStkluPBSHADtonVSQffb(bybHYS)E**hwjn-fYD-wjm-fYD-wWR-fbD-wWn-wjc-f1R-1gv7sTjYsFhGo5HPWPH6LnjNhmWwWnHn1uychp1Y-fbf-wbn-fYD-wjn-wjD-wDc-fYD-wjm-fYD-wWR-fbnfHchp1ngFRnkmPRfWFRFAFRm4FRcYFRDkFRfLFRfYFRfkFRDLFRckFRRsFRc1FRPjFh Y5iNawiNKfBNjriNAniNanBNKniNaPiNjPaNiPzNanaNDPiNDPzuoPHYwjT-wDc-fbD-fww**t0wj0gffXffDivRajf6B2N6j0ffbffRfk6PWa/F6pfN6ER10ffRPKFRHKØFRK6NFRRA**SFR**QAFTZCBFRcgkfilzT6XKF4M**9BIAB-TgGuiYdEMPGffii¥-#YmHfMxmvnzuHnLmv7Wn1hFMPYpyfqnWkinljigVZ6JFRp\$PBioyKE6W8WRZMWWXZdFRR28FRx8FRRXBFRWWWWWAZGFRAFDC9EBYZ9WRQDZWKYZ8AFJA6RIAMBRjaWWIZZBZzygAzaBboPjY-1gv7sTjYsFhQu5HRhin189ghHBh11PNWMWYMADADIn1900分钟及到1590的中国1500的中国

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Deeplearning4j 实战 (9):强化学习 -- Cartpole任务的训练和效果测试-爱编程

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Python 教程 (https://cpro.baidu.com/cpro/ui/uijs.php?

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