**MEETING NOTE**

**2017/03/08 Nova meeting**

implement before meeting:

try every ckpt for every model

test data in :

**/dataset/Nova**

PQ\_0007

PQ\_V4

PQ\_V11

test\_3

.mat for directly SR is saved in :

XXXXX\_d

**2017/03/14 Nova meeting**

implement before meeting:

deconv\_x4\_big : deeper model just like the ESPCN paper

deconv\_x4\_we : edge punished model

after meeting:

1. SSIM vs PSNR
2. Ringing
3. try VDSR to solve Ringing

**2017/04/12 lab meeting**

implement before meeting:

model

sub-pixel

no residual

residual

scale

x2 x4

feat.

L1 norm, not MSE

loss = sum for all pixels ( abs(gt - output) )

L1 norm then L2 norm

trained on CG

Mix loss function

after meeting:

1. calculate the SSIM on the ringing image
2. implement the Mix loss function
3. find the ringing @ natural image

**2017/05/07 lab meeting**

~~fix the~~ **~~color bias~~** ~~problem:~~

~~1.~~

~~add~~ **~~manga109~~** ~~pic into the~~ **~~LapSR dataset (in peter' PC @ spider2)~~**

~~2.~~

~~regenerate the dataset .mat files by changing the RGB 2 YCbCr formula~~ **~~without using API~~**

~~3.~~

~~change the YCbCr 2 RGB formula in python with the formula corresponding to the step 2~~

~~4.~~

~~train the Model~~

1. ~~DN with gamma, beta~~
2. ~~without DN, but with L1 regular~~

~~replace our result pictures in the slides of~~ **~~0507 Novatek Progress Report~~** ~~with color bias fixed ones (LAPCG\_d)~~

~~higer lr~~

~~test on Set5 Set14~~

~~regenerate the test .mat~~

**2017/05/23 Nova meeting**

0807

**To do七月底 :**

- : done

@ : doing

**Weekly report**

~~KPI~~

~~{old, new, IBS, other SR models}~~

~~Overall / NI / CG~~

~~Gradient loss : 跑比較圖@natural image detail, gradient map with IBS, old~~

*這項loss是常數嗎@@??*

~~@TV loss: 跑比較圖with IBS, old lambda = 0.25, 0.5~~

~~@Prove DN’s power : train ESPCN on the same dataset~~

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| Run SRCNN(9, 5, 5) | |  | |
| Fix bugs | | pReLu  Loss\_v1 | |
| Change arch. | | 5x5x1x32 -> 5x5x1x48  1x1->3x3 (?) | |
|  | |  | |
|  | |  | |
| **Overall** | | | |
| TV loss | 1/ tune lambda:  0.32/0.38: *ringing again, WTF???*  2/ on strong edge only:  *Still tuning*  *0.4 seems to be good*  ~~3/ on residual only:~~  *worse, much blurry*  4/ no DN, no l1  5/ more directions  **6/ on 4x** | |  |
| Grad loss | ~~1/ tune lambda~~: *worse*  ~~2/ check uniformity~~: *worse* | |  |
| ~~ESPCN on nova ID: 1/23/31/14~~ | ~~Check jaggie~~  *Still has jaggie* | |  |
| replace bicubic with IBS / transpose conv | to solve jaggie | |  |
| edge detection and higher penalty |  | |  |
| ~~EDSR offset~~ |  | |  |
| Nearest-neighbor up-scaling |  | |  |
| Trained on DIV 2k |  | |  |
| *~~Replace PReLU with SU~~* | *increase # of parameters too much… (2\*32^2+2\*5^2~2000)* | |  |
| Inception |  | |  |
| MSE calculation using gamma correction |  | |  |
| **Minor work** | | | |
| fine tune on CG |  | |  |
| more layers |  | |  |
| The best one in the whole candidate models **+ …** | 1/ gradient loss  2/ more layers  3/ float16 | |  |

~~TV\_11 loss : lambda = 0.25, 0.5, 0.75~~

~~LV\_11 loss : lambda = 0.5, 1.0, 1.5~~

~~tanh\_m model~~

~~ReLU activation~~

~~跑圖 (original -> 2 by SR -> compared with IBS, SRCNN, FSRCNN)~~

~~pixel value range shallowing - done,~~

*useless*

~~low vs high contrast uniformity - done,~~

*useless*

~~rotate pattern – done~~

*旋轉就沒ringing問題，因為pattern不是在y channel上*

~~DN (no gamma and beta) + L1 on LAPSR\_more\_manga~~

*整體效果變好但是某些極端case(e.q. 白底黑字)會劣化(更多噪點)*

**收尾 (demo on film)**

**Other issue:**

**~~OL\_Lunch\_x4\_GT in 35manga109 <-> LAPCG~~**

**~~302003.png in LAPSR <-> Set5~~**

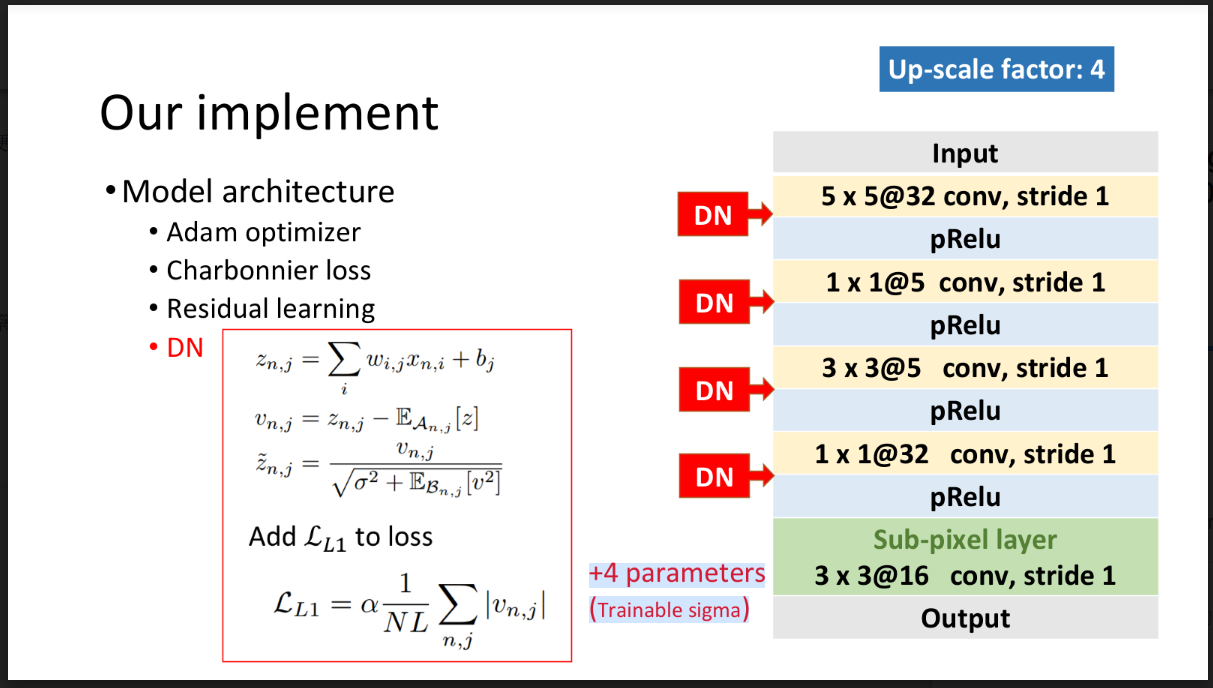
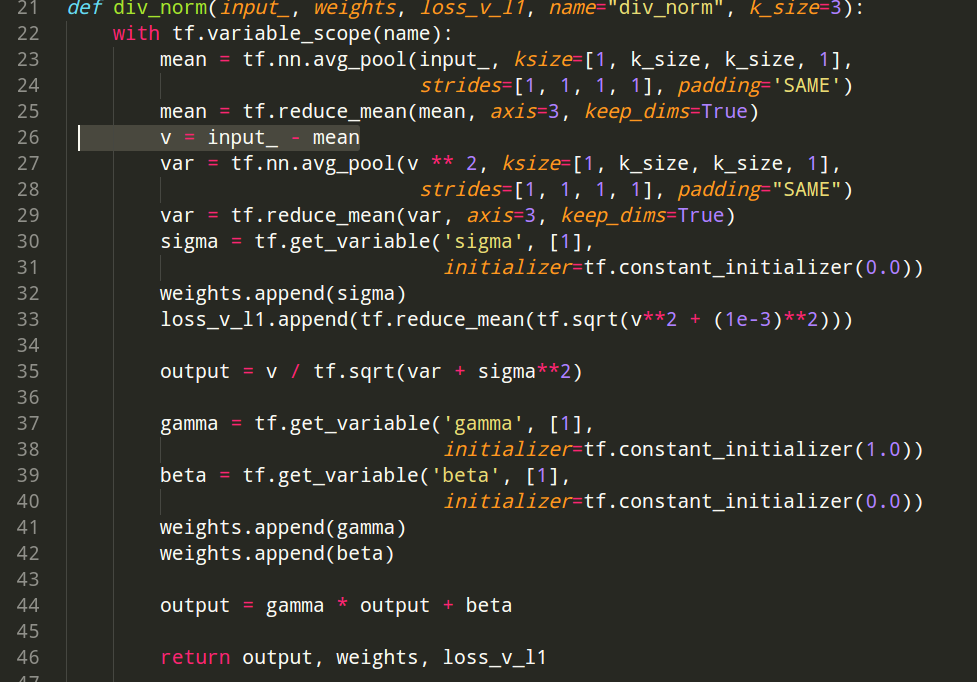
~~PSNR formula difference http://forum.slime.com.tw/thread102222.html~~

現在的任務還是接續產學合作的計畫用深度學習做image super resolution。目前碰到的問題主要還是在CG image上產生的shoot ring現象。目前討論出的解決辦法不外乎是在網路訓練的時候加入更多額外的constraints來偵測shoot ring產生的區域，再施加更多的懲罰在這些區域上。目前討論出的方法有：

1. Strong edge detection : 因為shoot ring通常發生在strong edge 附近，所以偵測出strong edge ，並調高在這些區域犯錯的penalty。
2. Local variance map consistency : local variance map算的是圖片裡各個局部區域的梯度值總和，實驗發現這能反映ringing的位置。所以希望網路預測的local variance map能跟ground truth的越像越好。
3. Total variance loss : total variance 算的是整張圖片梯度值的加總。把這個當成loss算是在圖片銳利度跟ringing的產生之間做個trade-off。
4. Thresholding : ring信號通常數值微弱，所以把output裡，強度不在某個區間的信號砍掉會有幫助。但是會讓圖片變得不那個銳利。
5. ReLU activation func. : ReLU能把小於0的response濾成0，或許能濾掉ring這種數值微弱的信號，也可以試試。跟第四點不同的是這是在feature map上做的。

這些方法目前都在嘗試。雖然因為網路需要時間來訓練，不過最近就能看到結果。

**Question:**

1. **In normalization, gamma and beta is shared by all neurons or belonging to one neuron?**
   1. **Ans : in DN, shared by all neurons.**
2.  **~~trainable sigma is ?~~** 
   1. **~~Ans: Just the sigma in the denominator!~~**
3. **how to do DN at inference time?**
   1. **Ans: Just do in a single image.**
4. **(in MODEL\_div\_l1.py) line 26 really does the divisive normalization?**
5. **Is more CG images in the training set really help the performance? (on perceptron)**

* **In the case a. , NO**

6. tensorboard loss visual problem (launch logs @ AI)

7. feature maps montage

8. tensor actual values

**data Detail:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dataset | # of raw images | # of .mat in x2 | # of .mat in x4 | # of .mat/3 in x4 |
| 21manga109 | 21 |  | 88704 | 29568 |
| 35manga109 | 35 |  | 546840 | 182280 |
| LAPSR (stride = 9) | 390 |  | **723192** | **241064** |
| LAPSR\_stride\_17 (stride = 17) |  | 234168 | 78056 |
| **collected dataset** |  |  |  |  |
| **LAPSR\_manga**  (LAPSR + 21manga109) | ***411*** |  | ***813912*** | ***271304*** |
| **LAPSR\_more\_manga**  (LAPSR + 35manga109) | ***425*** |  | ***1270032*** | ***423344*** |

**model Detail:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **DN** | Y | **gamma, beta** | Y | **L1 regular** | Y | a. |
| N |  |
| N | Y | c.  (Guan) |
| N |  |
| N | **L1 regular** | Y | b. |  |  |
| N | d. |  |  |

|  |
| --- |
| **Setting** |
| **start training** |
| **python {train\_scipt}** |
| **restart training** |
| ex:  *epoch\_130.ckpt-1632784.meta* in checkpoint folder  **python {train\_scipt} --model\_path epoch\_130.ckpt-1632784** |
| **hyper** |
| IN\_IMG\_SIZE = (17, 17)  OUT\_IMG\_SIZE = (17 \* SCALE\_FACTOR, 17 \* SCALE\_FACTOR)  BATCH\_SIZE = 128  MOMENTUM = 0.9  USE\_ADAM\_OPT = True  BASE\_LR = **2e-4**  LR\_RATE = 0.02  LR\_STEP\_SIZE = 300  LAMBDA(edge\_tv) = 0.25/0.0713 = 3.5063 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **idx** | **feat.** | **Model** | **.py** | **ckpt** |
| a | DN with gamma, beta, l1 |  | TEST\_div\_l1 | xSCALE\_div\_l1\_gamma\_beta\_plus\_manga |
| b | without DN, but with L1 regular |  | TEST\_div\_l1\_no\_DN | xSCALE\_div\_l1\_no\_DN\_plus\_manga |
| c | DN without gamma, beta; but with l1 | MODEL\_div\_l1\_original | TRAIN\_div\_l1\_original | 1. xSCALE\_div\_l1\_original\_plus\_(more\_)manga 2. xSCALE\_div\_l1\_original (trained on LAPSR\_stride\_17 3. x4\_div\_l1\_adam\_1(trained on wrong YCbCr LAPSR\_stride\_17) by Guan |
| d | no DN + no L1 | MODEL\_div\_l1\_no\_DN\_no\_l1 (MODEL\_no\_DN\_no\_l1) | TEST\_no\_DN\_no\_l1 | xSCALE\_no\_DN\_no\_L1\_plus\_(more)\_manga |
| e | DN without gamma, beta; but with l1 + gradient loss | MODEL\_div\_l1\_original | TRAIN\_div\_l1\_original\_gra | xSCALE\_div\_l1\_original\_{lamda\_value}grad\_plus\_more\_manga |
| f | DN without gamma, beta; but with l1 + Deeper model | MODEL\_div\_l1\_original\_deeper | TRAIN\_div\_l1\_original\_deeper | x%d\_div\_l1\_original\_deeper\_plus\_manga |
| g | DN without gamma, beta; but with l1 + gradient loss + Deeper model | MODEL\_div\_l1\_original\_deeper | TRAIN\_div\_l1\_original\_grad\_deeper | x%d\_div\_l1\_original\_grad\_deeper\_plus\_manga |
| h | DN without gamma, beta; but with l1 + total\_var\_loss | MODEL\_div\_l1\_original | TRAIN\_div\_l1\_original\_total\_var + MODEL\_div\_l1\_original | x%d\_div\_l1\_original\_%.2ftv\_ON\_{training\_data\_set} |
| i | DN without gamma, beta; but with l1 + edge\_modulation | MODEL\_div\_l1\_original | TRAIN\_div\_l1\_original\_edge\_ver2 | x%d\_div\_l1\_original\_%.2fedge\_ON\_{training\_data\_set} |
| j | DN without gamma, beta; but with l1 + lv loss | MODEL\_div\_l1\_original | TRAIN\_div\_l1\_original\_local\_var | x%d\_div\_l1\_original\_%.2flv\_ON\_{training\_data\_set} |
| k | DN without gamma, beta; but with l1 + total\_var\_loss @ strong edge | MODEL\_div\_l1\_original | TRAIN\_div\_l1\_original\_edge\_ver2\_tv | x2\_div\_l1\_original\_edge\_0.88tv\_ON\_LAPSR\_manga\_edge |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel  +  residual | |  | train | | cal. PSNR | | | | visual | | | | | | |
|  | **LAPSR\_manga** | | Set5 | | Set14 | | LAPCG\_d | nova\_d | testForValidation\_d | nova0.25\_d | LAPCG\_plus\_  tFV\_d |  |  |
|  | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 |  |  |  |  |  |  |  |
| a. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | v, ha | x | bic: **28.43**  SR: 30.54  (stop increasing @ epoch 190) | x | bic: **26.10**  SR: 27.64  (stop increasing @ epoch 120) | vo, ha, epoch 500 |  | vo, ha, epoch 190 |  |  |  |  |
| b. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | v, ha | x | bic: **28.43**  SR: 30.34  (stop increasing @ epoch 120) | x | bic: **26.10**  SR: 27.47  (stop increasing @ epoch 190) | vo, ha, epoch 450 |  |  |  |  |  |  |
| c.-1  (div\_l1\_original\_plus\_manga) | x2 |  | -,ha |  | bic: **33.69**  SR: 36.96  (stop increasing @ epoch 170) |  | bic: **30.34**  SR: 32.64  (stop increasing @ epoch 130) |  |  | -,no, epoch 180 |  |  |  |  |  |
| x4 |  | v, ha | v, ha | x | bic: **28.43**  SR: 30.60  (stop increasing @ epoch 220) | x | bic: **26.10**  SR: 27.64  (stop increasing @ epoch 180) |  | v, no, epoch 230 | vo, ha, epoch 220 | v, no, epoch 230 |  |  |  |
| c.-2  (div\_l1\_original) | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | v, ha  (train on LAPSR\_stride\_17 only) | x | bic: **28.43**  SR: 30.52  (stop increasing @ epoch 330) | x | bic: **26.10**  SR: 27.61  (stop increasing @ epoch 330) |  |  |  |  |  |  |  |
| d. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | x | bic: **28.43**  SR: 30.38  (stop increasing @ epoch 190) | x | bic: **26.10**  SR: 27.52  (stop increasing @ epoch 220) | x | vo, ha, epoch 200 |  |  |  |  |  |  |
| f. | x2 |  | -,ha |  |  |  | bic: **30.34**  SR: 32.78  (stop increasing @ epoch 190) |  |  |  |  |  |  |  |  |
| g. | x2 |  | -,ha |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | labmbda |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. | x4 | 0.25 |  |  |  |  | bic: **26.10**  SR: 27.50  (stop increasing @ epoch 150) |  |  |  |  |  |  |  |  |
| x2 | 0.25 | -,ha |  | bic: **33.69**  SR: 36.27  @ epoch 25 now |  | bic: **30.34**  SR: 32.24  @ epoch 30 now |  |  |  |  |  |  |  |  |
| 0.32 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 0.38 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 0.5 | -,ha |  |  |  | bic: **30.34**  SR: 30.93  (stop increasing @ epoch -) |  |  |  |  |  |  |  |  |
| i. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| j. | x2 | 0.5 | -,ha |  |  |  | bic: **30.34**  SR: 32.57  (stop increasing @ epoch -) |  |  |  |  |  |  |  |  |
| 1.0 | -,ha |  |  |  | bic: **30.34**  SR: 32.53  (stop increasing @ epoch -) |  |  |  |  |  |  |  |  |
| 1.5 | -,ha |  |  |  | bic: **30.34**  SR: 32.52  (stop increasing @ epoch -) |  |  |  |  |  |  |  |  |
| k. | x4 | 0.2 |  |  |  |  | bic: **26.10**  SR: 27.62  (stop increasing @ epoch 110) |  |  |  |  |  |  |  |  |
|  | 0.4 |  |  |  |  | bic: **26.10**  SR: 27.59  (stop increasing @ epoch 110) |  |  |  |  |  |  |  |  |
| x2 | 0.4 | -,ha |  | bic: **33.69**  SR: 36.76  @ epoch 35 now |  | bic: **30.34**  SR: 32.50  @ epoch 35 now |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel  +  residual | |  | train | | cal. PSNR | | | | visual | | | | | |
| **LAPSR\_more\_manga** | | Set5 | | Set14 | | nova\_d | LAPCG\_plus\_tFV\_d | Set5\_d | Set14\_d | nova0.25\_d | testForValidation\_d |
| to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 |  |  |  |  |  |  |
| a. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | v, ha | x | bic: **28.43**  SR: 30.59  (stop increasing @ epoch 180) | x | bic: **26.10**  SR: 27.67  (stop increasing @ epoch 170) |  |  |  |  |  | vo, ha, epoch 170 |
| c.-1 | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | v, ha | x | bic: **28.43**  SR: 30.54  (stop increasing @ epoch 120) | x | bic: **26.10**  SR: 27.63  (stop increasing @ epoch 170) |  |  |  |  |  | vo, ha, epoch 200 |
| d. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 |  | v, ha | x | bic: **28.43**  SR: 30.47  (stop increasing @ epoch 160) | x | bic: **26.10**  SR: 27.62  (stop increasing @ epoch 140) | x |  |  |  |  |  |  |
|  | | lambda |  | | | | | | | | | | |  |
| e. | x2 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| x4 | 0.75 | v, ha | x | bic: **28.43**  SR: 30.51  (stop increasing @ epoch 150) | x | bic: **26.10**  SR: 27.63  (stop increasing @ epoch 120) | x |  | v, no, epoch 200 |  |  |  |  |
| 0.5 | -, ha(to epoch 240) | x | bic: **28.43**  SR: 30.52  (stop increasing @ epoch 110) | x | bic: **26.10**  SR: 27.64  (stop increasing @ epoch 100) | x |  | v, no, epoch 200 |  |  | v, no, epoch 150 |  |
| 0.25 | -, ha(to epoch 240) | x | bic: **28.43**  SR: 30.52  (stop increasing @ epoch 110) | x | bic: **26.10**  SR: 27.63  (stop increasing @ epoch 120) | x |  | v, no, epoch 200 |  |  |  |  |

**STATUS**

~

stopped (not finish)

-

processing

v

done

vo

done and the data is transferred to my pc

**LOCATION**

ha

hank AI server

me

my pc

no

no

**TO DO**

**no residual**

**L1**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel | train | | | cal. PSNR | | | visual | | | | | |
| 91G100 | | | Set5 | | | nova\_d | | | testForValidation\_d | | |
| to epoch 300 | to epoch 500 | to epoch 700( with L2 loss) | to epoch 300 | to epoch 500 | to epoch 700( with L2 loss) | to epoch 300 | to epoch 500 | to epoch 700( with L2 loss) | to epoch 300 | to epoch 500 | to epoch 700( with L2 loss) |
| x2 | vo, AI | vo, AI | vo, AI(hank2) | vo |  | ~, AI | vo |  |  | vo | vo, AI | vo, AI |
| x4 | vo, AI | vo, PC | v, AI(hank) | vo |  |  | vo |  |  | vo | vo, me | vo, AI |

**MSE**

|  |  |  |
| --- | --- | --- |
|  | visual | |
| sub-pixel | validation\_d | nova\_d |
| x2 | vo | vo |
| x4 | vo | vo |

**residual**

**L1, trian on 91G100**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel | train | | cal. PSNR | | visual | | | |
| 91G100 | | Set5 | | nova\_d | | testForValidation\_d | |
| to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 |
| x2 | vo, PC |  |  |  |  |  |  |  |
| x4 | vo, PC |  |  |  |  |  | vo,PC |  |

**L1, trian on CG**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel | train | | cal. PSNR | | visual | | | |
| Nova\_CG | | Set5 | | nova\_d | | testForValidation\_d | |
| to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 |
| x2 | -, me |  |  |  |  |  |  |  |
| x4 |  |  |  |  |  |  |  |  |

**SSIM**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel | train | | cal. PSNR | | visual | | | |
| 91G100 | | Set5 | | nova\_d | | testForValidation\_d | |
| to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 |
| x2 | ~o  (3 epoch), me |  |  |  |  |  |  |  |
| x4 |  |  |  |  |  |  |  |  |

**Mix ( MS-SSIM + L1)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sub-pixel | train | | cal. PSNR | | visual | | | |
| 91G100 | | Set5 | | nova\_d | | testForValidation\_d | |
| to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 | to epoch 300 | to epoch 500 |
| x2 | ~o  (25 epoch), me |  |  |  |  |  |  |  |
| x4 |  |  |  |  |  |  |  |  |

**pc**

**peter pc**

**AI**

**server, peter account**

**me**

**my pc**

**~**

**not finish**

**-**

**processing**

**v**

**done**

**vo**

**done and transferred to my pc**

**result**

**table**

dataset

train

91G100

test

Set5

visual

testForValidation\_d

Nova

|  |  |  |  |
| --- | --- | --- | --- |
| PSNR | sub-pixel, x2 | | |
| bicubic | L1 | MSE |
| no residual | - | best, epochs 290 | best, epochs 220 |
| 33.69158847816106 | 36.16 | 36.5 |

|  |  |  |  |
| --- | --- | --- | --- |
| PSNR | sub-pixel, x4 | | |
| bicubic | L1 | MSE |
| no residual | - | best, epochs 290 | best, epochs 240 |
| 28.43633544780433 | 29.73 | 30.24 |

**SUPPLEMENT**

**Model**

**scale : x2 x3 x4**

|  |  |  |
| --- | --- | --- |
|  | **sub-pixel** | **deconv** |
| **residual** |  |  |
| **no residual** |  |  |

number of model = 2 \* 2 \* 3 = 12

**Code**

**peteryu PC IP : 140.114.28.179 -p 7735**

1 GTX 1070

**residual**

/SR/spider

**peteryu server IP : 140.114.28.200 -p 7735**

4 GTX 1080

**no residual**

/Disk1/peteryu/FSRCNN\_our

**2017/03/08**

try every ckpt for every model

test data in

**/dataset/Nova**

PQ\_0007

PQ\_V4

PQ\_V11

test\_3

.mat for directly SR is saved in :

XXXXX\_d

ckpt :

x2

|  |  |  |
| --- | --- | --- |
|  | sub-pixel | deconv |
| residual | fsrcnn\_sub\_x2  不小心覆蓋掉原本psnr資料夾裡的ckpt = = |  |
| no residual |  |  |

x3

|  |  |  |
| --- | --- | --- |
|  | sub-pixel | deconv |
| residual |  |  |
| no residual |  |  |

x4

|  |  |  |
| --- | --- | --- |
|  | sub-pixel | deconv |
| residual |  |  |
| no residual |  |  |