# 测试

# Time: 2021.6.17

**Base Testing MAE**

**input crop: just expand the face bouding box with fix rate**

|  |  |  |  |
| --- | --- | --- | --- |
| **dataset name** | **BIWI** | **AFLW2000** | **300W-LP** |
| **box expand rate** | 0 | 0.2 | 0.3 |
| **input crop image 128x128** | [MISSING IMAGE: 8c0f0f72-cfe9-11eb-b9c2-00163e126213.jpg, 8c0f0f72-cfe9-11eb-b9c2-00163e126213.jpg ][MISSING IMAGE: 8c2fc3ac-cfe9-11eb-a8d1-00163e126213.jpg, 8c2fc3ac-cfe9-11eb-a8d1-00163e126213.jpg ] | [MISSING IMAGE: 10c24b6e-cfe3-11eb-8d22-00163e126213.jpg, 10c24b6e-cfe3-11eb-8d22-00163e126213.jpg ][MISSING IMAGE: 10c62f36-cfe3-11eb-927c-00163e126213.jpg, 10c62f36-cfe3-11eb-927c-00163e126213.jpg ] | [MISSING IMAGE: 5cdabad6-cfe8-11eb-8212-00163e126213.jpg, 5cdabad6-cfe8-11eb-8212-00163e126213.jpg ][MISSING IMAGE: 5d8de69c-cfe8-11eb-bf90-00163e126213.jpg, 5d8de69c-cfe8-11eb-bf90-00163e126213.jpg ] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **public dataset** | **BIWI** | **AFLW2000** | **300W-LP** | **Apriltag0927** |
| **former model** | *Pitch:4.0908*  *Yaw:3.6725*  *Roll:4.3129* | *Pitch:19.8124*  *Yaw:29.8557*  *Roll:15.9975* | *Pitch:16.5522*  *Yaw:21.5506*  *Roll:10.2855* |  |

差异分析：主要是AFLW2000和300W-LP的数据不同，其带有黑边且尺度不统一

# Time: 2021.6.20

**model trained on public dataset: 300W-LP(train list）**

***pretrain model: 关键点模型（base model 训练已用到）***

**fc with 5x lr:**

def get\_fc\_params(net):
# Generator function that yields fc layer params.
b = [net.headpose\_fc\_yaw, net.headpose\_fc\_pitch, net.headpose\_fc\_roll,
net.headpose\_fc\_yaw\_1, net.headpose\_fc\_pitch\_1, net.headpose\_fc\_roll\_1,
net.headpose\_fc\_yaw\_2, net.headpose\_fc\_pitch\_2, net.headpose\_fc\_roll\_2,
net.headpose\_fc\_yaw\_3, net.headpose\_fc\_pitch\_3, net.headpose\_fc\_roll\_3]
for i in range(len(b)):
for module\_name, module in b[i].named\_modules():
for name, param in module.named\_parameters():
yield param
optim = torch.optim.Adam([{'params': get\_fc\_params(net),\
'lr': lrvalue[0] \* 5}],lr = lrvalue[0])

**input crop 224x224：**

# lossely\_crop\_face
def loosely\_crop\_face(name,img,k,W,H,\
x\_min,y\_min,x\_max,y\_max):
if name == 'BIWI':
x\_min -= max(0,0.6\*k\*abs(x\_max - x\_min))
y\_min -= max(0,k\*abs(y\_max - y\_min))
x\_max += min(W,0.6\*k\*abs(x\_max - x\_min))
y\_max += min(H,0.6\*k\*abs(y\_max - y\_min))
elif name == 'AFLW2000':
x\_min -= max(0,2\*k\*abs(x\_max - x\_min))
y\_min -= max(0,2\*k\*abs(y\_max - y\_min))
x\_max += min(W,2\*k\*abs(x\_max - x\_min))
y\_max += min(H,0.6\*k\*abs(y\_max - y\_min))
elif name == '300WLP':
x\_min -= max(0,0.6\*k\*abs(x\_max - x\_min))
y\_min -= max(0,2\*k\*abs(y\_max - y\_min))
x\_max += min(W,0.6\*k\*abs(x\_max - x\_min))
y\_max += min(H,0.6\*k\*abs(y\_max - y\_min))
elif name == 'Apriltag':
x\_min -= max(0,0.6\*k\*abs(x\_max - x\_min))
y\_min -= max(0,2\*k\*abs(y\_max - y\_min))
x\_max += min(W,0.6\*k\*abs(x\_max - x\_min))
y\_max += min(H,0.6\*k\*abs(y\_max - y\_min))
img = img.crop((int(x\_min),int(y\_min),\
int(x\_max),int(y\_max)))
return img

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **public dataset** | **BIWI** | **AFLW2000** | **300W-LP** | **Apriltag0927** |
| **k** | -0.1 | 0.2 | 0.2 |  |
| **from scratch** | *Pitch:28.0795 Yaw:33.8223 Roll:14.4082* | *Pitch:17.7958 Yaw:49.2960 Roll:19.6735* | *Pitch:11.9673 Yaw:26.8280 Roll:11.0269* |  |
| **with pretrained model** | Pitch:16.1327 Yaw:8.9417 Roll:10.7793 | *Pitch:15.8278 Yaw:26.5489 Roll:15.4481* | *Pitch:8.4686 Yaw:5.2525 Roll:7.5507* |  |
| **fc layer with 5x lr** | *Pitch:28.0809 Yaw:32.1334 Roll:14.2999* | *Pitch:17.8385 Yaw:37.9189 Roll:19.5473* | *Pitch:11.9673 Yaw:50.1858 Roll:11.2586* |  |
| **fc layer with 5x lr and with pretrained model** | *Pitch:19.8206 Yaw:18.9873 Roll:13.8318* | *Pitch:16.9431 Yaw:28.1756 Roll:17.7836* | *Pitch:9.9950 Yaw:27.1913 Roll:10.0822* |  |

**这里BIWI和AFLW2000数据集测试MAE很高，原因未知？**

**validation：**

**1.from scratch:**

INFO:root:MAE: Pitch:12.0030 Yaw:54.0287 Roll:11.2907

INFO:root:MAE: Pitch:11.9882 Yaw:51.8985 Roll:11.2369

INFO:root:MAE: Pitch:11.9881 Yaw:46.0381 Roll:11.1632

INFO:root:MAE: Pitch:11.9809 Yaw:41.2233 Roll:11.1404

INFO:root:MAE: Pitch:11.9830 Yaw:37.4842 Roll:11.1125

INFO:root:MAE: Pitch:11.9772 Yaw:35.6280 Roll:11.1025

INFO:root:MAE: Pitch:11.9749 Yaw:34.6071 Roll:11.0879

INFO:root:MAE: Pitch:11.9714 Yaw:33.4403 Roll:11.0858

INFO:root:MAE: Pitch:11.9722 Yaw:32.4143 Roll:11.0874

INFO:root:MAE: Pitch:11.9678 Yaw:31.4669 Roll:11.0631

INFO:root:MAE: Pitch:11.9690 Yaw:30.9000 Roll:11.0617

INFO:root:MAE: Pitch:11.9688 Yaw:30.3153 Roll:11.0643

INFO:root:MAE: Pitch:11.9647 Yaw:29.7080 Roll:11.0520

INFO:root:MAE: Pitch:11.9619 Yaw:29.5680 Roll:11.0588

INFO:root:MAE: Pitch:11.9621 Yaw:28.5775 Roll:11.0472

2.**with pretrained model**

INFO:root:MAE: Pitch:11.7802 Yaw:48.7262 Roll:11.0860

INFO:root:MAE: Pitch:11.7263 Yaw:36.4387 Roll:10.9887

INFO:root:MAE: Pitch:11.8724 Yaw:25.2196 Roll:10.9409

INFO:root:MAE: Pitch:11.8746 Yaw:16.5506 Roll:10.8606

INFO:root:MAE: Pitch:11.8277 Yaw:11.3411 Roll:10.7756

INFO:root:MAE: Pitch:11.7400 Yaw:8.2385 Roll:10.6658

INFO:root:MAE: Pitch:11.6330 Yaw:7.8221 Roll:10.5433

INFO:root:MAE: Pitch:11.4193 Yaw:6.6468 Roll:10.2620

INFO:root:MAE: Pitch:11.1569 Yaw:7.3941 Roll:9.9830

INFO:root:MAE: Pitch:10.7746 Yaw:6.1455 Roll:9.5641

INFO:root:MAE: Pitch:10.3677 Yaw:5.8820 Roll:9.2241

INFO:root:MAE: Pitch:9.7474 Yaw:6.9122 Roll:8.7922

INFO:root:MAE: Pitch:9.3714 Yaw:8.5597 Roll:8.4759

INFO:root:MAE: Pitch:8.8843 Yaw:5.1902 Roll:8.0824

INFO:root:MAE: Pitch:8.4745 Yaw:5.3581 Roll:7.6354

3.**fc layer with 5x lr**

INFO:root:MAE: Pitch:11.9737 Yaw:54.3472 Roll:11.3039

INFO:root:MAE: Pitch:11.9740 Yaw:54.1453 Roll:11.3010

INFO:root:MAE: Pitch:11.9698 Yaw:53.9000 Roll:11.2967

INFO:root:MAE: Pitch:11.9715 Yaw:53.6242 Roll:11.2927

INFO:root:MAE: Pitch:11.9684 Yaw:53.3041 Roll:11.2883

INFO:root:MAE: Pitch:11.9665 Yaw:53.0637 Roll:11.2879

INFO:root:MAE: Pitch:11.9705 Yaw:52.8376 Roll:11.2850

INFO:root:MAE: Pitch:11.9667 Yaw:52.4115 Roll:11.2817

INFO:root:MAE: Pitch:11.9671 Yaw:52.3442 Roll:11.2797

INFO:root:MAE: Pitch:11.9670 Yaw:51.9790 Roll:11.2765

INFO:root:MAE: Pitch:11.9672 Yaw:51.7650 Roll:11.2738

INFO:root:MAE: Pitch:11.9658 Yaw:51.7069 Roll:11.2798

INFO:root:MAE: Pitch:11.9675 Yaw:51.3822 Roll:11.2711

INFO:root:MAE: Pitch:11.9622 Yaw:51.2247 Roll:11.2728

INFO:root:MAE: Pitch:11.9638 Yaw:51.1146 Roll:11.2666

4.**fc layer with 5x lr and with pretrained model**

INFO:root:MAE: Pitch:11.6854 Yaw:52.4616 Roll:11.0817

INFO:root:MAE: Pitch:11.2752 Yaw:50.0761 Roll:10.9232

INFO:root:MAE: Pitch:10.9654 Yaw:47.5173 Roll:10.8042

INFO:root:MAE: Pitch:10.7267 Yaw:44.9902 Roll:10.7017

INFO:root:MAE: Pitch:10.5808 Yaw:42.1726 Roll:10.5998

INFO:root:MAE: Pitch:10.4481 Yaw:40.0102 Roll:10.5219

INFO:root:MAE: Pitch:10.3356 Yaw:37.5839 Roll:10.4404

INFO:root:MAE: Pitch:10.2049 Yaw:35.3502 Roll:10.3629

INFO:root:MAE: Pitch:10.1602 Yaw:33.9336 Roll:10.3299

INFO:root:MAE: Pitch:10.0863 Yaw:32.3063 Roll:10.2516

INFO:root:MAE: Pitch:10.0362 Yaw:30.9663 Roll:10.2321

INFO:root:MAE: Pitch:9.9852 Yaw:29.6300 Roll:10.1919

INFO:root:MAE: Pitch:9.9748 Yaw:29.0189 Roll:10.1533

INFO:root:MAE: Pitch:9.9102 Yaw:28.0064 Roll:10.0932

INFO:root:MAE: Pitch:9.9213 Yaw:27.2796 Roll:10.0896

# Time: 2021.6.22

**调整输入大小为128x128，以及learning rate decay 采用step 方式进行decay，并增加max epoch到100**

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| **public dataset** | **BIWI** | **AFLW2000** | **300W-LP** | **Apriltag0927** |
| **k** | -0.1 | 0.2 | 0.2 |  |
| **with pretrain model and 128x128 input** | Pitch:10.9029 Yaw:37.5553 Roll:14.3918 | Pitch:13.5844 Yaw:45.3958 Roll:19.6845 | Pitch:7.1373 Yaw:52.3643 Roll:11.2600 |  |
| **with pretrained model and 128x128 input and max epoch=100 and lr decay is steps** | Pitch:9.3012 Yaw:43.6675 Roll:15.9301 | Pitch:12.9356 Yaw:65.1330 Roll:21.9260 | Pitch:6.3041 Yaw:51.7552 Roll:10.8908 |  |

1.**with pretrain model and 128x128 input**

INFO:root:MAE: Pitch:11.4977 Yaw:54.4957 Roll:11.3070

INFO:root:MAE: Pitch:9.8061 Yaw:54.4705 Roll:11.3031

INFO:root:MAE: Pitch:8.8788 Yaw:54.4879 Roll:11.3027

INFO:root:MAE: Pitch:8.3220 Yaw:54.4714 Roll:11.3019

INFO:root:MAE: Pitch:8.1261 Yaw:54.4807 Roll:11.3021

INFO:root:MAE: Pitch:7.6965 Yaw:54.5047 Roll:11.2982

INFO:root:MAE: Pitch:7.4649 Yaw:54.4314 Roll:11.2999

INFO:root:MAE: Pitch:7.3331 Yaw:54.2385 Roll:11.2897

INFO:root:MAE: Pitch:7.2887 Yaw:54.3334 Roll:11.2946

INFO:root:MAE: Pitch:7.3343 Yaw:53.5487 Roll:11.2719

INFO:root:MAE: Pitch:7.2651 Yaw:53.1410 Roll:11.2719

INFO:root:MAE: Pitch:7.3092 Yaw:52.2059 Roll:11.2536

INFO:root:MAE: Pitch:7.2023 Yaw:52.6970 Roll:11.2619

INFO:root:MAE: Pitch:7.2758 Yaw:51.5743 Roll:11.2464

INFO:root:MAE: Pitch:7.1373 Yaw:52.3643 Roll:11.2600

2.**with pretrained model and 128x128 input and max epoch=100 and lr decay is steps**

INFO:root:MAE: Pitch:6.9590 Yaw:53.4963 Roll:11.5312

INFO:root:MAE: Pitch:6.6968 Yaw:52.3360 Roll:11.5406

INFO:root:MAE: Pitch:6.6983 Yaw:51.0339 Roll:11.3684

INFO:root:MAE: Pitch:6.5723 Yaw:50.9683 Roll:11.3222

INFO:root:MAE: Pitch:6.6223 Yaw:51.6835 Roll:11.3457

INFO:root:MAE: Pitch:6.5549 Yaw:51.2367 Roll:11.2808

INFO:root:MAE: Pitch:6.5418 Yaw:51.8284 Roll:11.3105

INFO:root:MAE: Pitch:6.5904 Yaw:51.3870 Roll:11.1860

INFO:root:MAE: Pitch:6.6131 Yaw:50.2576 Roll:11.1445

INFO:root:MAE: Pitch:6.5687 Yaw:51.9297 Roll:11.2655

INFO:root:MAE: Pitch:6.4891 Yaw:52.1001 Roll:11.2630

INFO:root:MAE: Pitch:6.5291 Yaw:51.3970 Roll:11.1891

INFO:root:MAE: Pitch:6.5468 Yaw:52.4556 Roll:11.3058

INFO:root:MAE: Pitch:6.6675 Yaw:51.1026 Roll:11.1606

INFO:root:MAE: Pitch:6.5184 Yaw:50.9704 Roll:11.1398

INFO:root:MAE: Pitch:6.6192 Yaw:51.3823 Roll:11.1334

INFO:root:MAE: Pitch:6.5346 Yaw:51.4894 Roll:11.1815

INFO:root:MAE: Pitch:6.5475 Yaw:51.4470 Roll:11.1348

INFO:root:MAE: Pitch:6.4769 Yaw:52.3872 Roll:11.2711

INFO:root:MAE: Pitch:6.6247 Yaw:51.9675 Roll:11.1637

# Time: 2021.6.24

***定位到2021.6.20和2021.6.22 AFLW2000和BIWI测试集上和300WLP测试集gap过大原因！！！***

***1.数据载入逻辑中，flip操作后yaw值并未进行及时跟新***

***2.learning rate 过小，学习的比较慢需要更多的轮数才能才看效果（使用 1e-6---->5e-5）***

***3.AFLW2000的bounding box 并不正确，导致crop 出的 输入图像和300WLP存在很大的区别***

def loosely\_crop\_face(name,img,k,\
¦ x\_min,y\_min,x\_max,y\_max):
if name == 'BIWI':
¦ w = abs(x\_max - x\_min)
¦ h = abs(y\_max - y\_min)
¦ x\_0 = x\_min-(-0.05)\*w
¦ y\_0 = y\_min-(-0.12)\*h
¦ x\_1 = x\_max+(-0.05)\*w
¦ y\_1 = y\_max+(-0.1)\*h
¦ x\_min,y\_min,x\_max,y\_max = \
¦ ¦ ¦ x\_0,y\_0,x\_1,y\_1
elif name == 'AFLW2000':
¦ x\_min -= -1.6\*k\*abs(x\_max - x\_min)
¦ y\_min -= 2\*k\*abs(y\_max - y\_min)
¦ x\_max += 0.6\*k\*abs(x\_max - x\_min)
¦ y\_max += 0.6\*k\*abs(y\_max - y\_min)
elif name == '300WLP':
¦ x\_min -= 0.6\*k\*abs(x\_max - x\_min)
¦ y\_min -= 2\*k\*abs(y\_max - y\_min)
¦ x\_max += 0.6\*k\*abs(x\_max - x\_min)
¦ y\_max += 0.6\*k\*abs(y\_max - y\_min)
elif name == 'Apriltag':
¦ x\_min -= 0.6\*k\*abs(x\_max - x\_min)
¦ y\_min -= k\*abs(y\_max - y\_min)
¦ x\_max += 0.6\*k\*abs(x\_max - x\_min)
¦ y\_max += 0.6\*k\*abs(y\_max - y\_min)
img = img.crop((int(x\_min),int(y\_min),\
¦ ¦ int(x\_max),int(y\_max)))
return img

**输入样本：**

|  |  |  |  |
| --- | --- | --- | --- |
| **​** | **BIWI** | **300WLP** | **Apriltag** |
| **Train dataset: BIWI** | [MISSING IMAGE: frame\_00335.jpg, frame\_00335.jpg ][MISSING IMAGE: frame\_00463.jpg, frame\_00463.jpg ] | **-** | [MISSING IMAGE: 115.jpg, 115.jpg ][MISSING IMAGE: 41.jpg, 41.jpg ]  k=0.4 |
| **Train dataset: 300WLP** | [MISSING IMAGE: frame\_00003.jpg, frame\_00003.jpg ][MISSING IMAGE: frame\_00155.jpg, frame\_00155.jpg ] | [MISSING IMAGE: AFW\_237815567\_2\_1.jpg, AFW\_237815567\_2\_1.jpg ][MISSING IMAGE: AFW\_18489332\_5\_4.jpg, AFW\_18489332\_5\_4.jpg ] | [MISSING IMAGE: 115.jpg, 115.jpg ][MISSING IMAGE: 41.jpg, 41.jpg ]  k=0.2 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **public dataset/MAE** | **BIWI** | **AFLW2000** | **300W-LP** | **Apriltag0927** |
| **1.retrain on BIWI with pretrain model**  **2.Lr: 5e-5,5e-5,1e-5,5e-6,1e-6**  **epoch=99** | Pitch:4.3479  Yaw:3.9417  Roll:4.5506 | - | - | **Pitch:13.3380** Yaw:9.3301 Roll:14.6517  **Mean:12.4** |
| **1.train on 300WLP with pretrain model**  **2.Lr: 5e-5,5e-5,1e-5,5e-6,1e-6**  **epoch=99** | Pitch:9.2500 Yaw:11.2008 Roll:4.6171 | Pitch:9.8650 Yaw:7.9431 Roll:8.8411 | Pitch:6.3162 Yaw:3.5616 Roll:5.4360 | Pitch:15.3315 Yaw:11.1013 Roll:11.8021 |
| **1.train on 300WLP with pretrain model**  **2.Lr: fix to 1e-6**  **epoch=99** | Pitch:8.0855 Yaw:10.3198 Roll:4.7093 | Pitch:8.8723 Yaw:6.7597 Roll:7.7795 | Pitch:5.1932 Yaw:2.4586 Roll:4.6198 | Pitch:16.2932 Yaw:9.3044 Roll:13.2729 |
| **1.train on 300WLP with hopenet and use resnet50 as pretrain model**  **2.Lr: fix to 1e-6**  **epoch=49** | **Pitch:8.1564 Yaw:6.8876 Roll:4.5144** | **Pitch:8.4907 Yaw:5.9508 Roll:7.7355** | **Pitch:3.2405 Yaw:1.5329 Roll:3.1319** | **Pitch:14.9612 Yaw:8.3754 Roll:11.1522**  **Mean:11.5** |
| **1.train on 300WLP with pretrain model**  **2.Lr:5e-5,5e-5,1e-5,5e-6,1e-6**  **3.with flip and blur augment**  **epoch=99** | Pitch:9.0211 Yaw:7.6620 Roll:4.3321 | Pitch:8.8045 Yaw:6.6484 Roll:7.9538 | Pitch:5.2700 Yaw:2.5920 Roll:4.6965 | **Pitch:15.7933** Yaw:8.9899 Roll:11.2553  **Mean:12.0** |

**欧拉角MSE Loss 曲线---->以最后一个模型为例：偏航角Yaw更容易学习到**

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**整个学习过程中：MSE回归损失学习更难（红色曲线振荡幅度大），交叉熵分类损失更容易（绿色系曲线振荡小）**

[MISSING IMAGE: image.png, image.png ]

**Apriltag0927实车测试结果分析：**

**1.Wheel视角下的Pitch角误差大，影响了整体的Pitch角的MAE值**

**2.整体上RGB结果优于IR，训练数据由RGB转成Gray训练的，符合预期**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Apriltag0927** | **IR** | **RGB** | **Wheel** | **MirrorDirver** |
| **1.retrain on BIWI with pretrain model**  **2.Lr: 5e-5,5e-5,1e-5,5e-6,1e-6**  **epoch=99** | Pitch:14.3848 Yaw:9.4045 Roll:16.0712 | Pitch:12.3406 Yaw:9.3247 Roll:13.5215 | Pitch:13.5538 Yaw:6.2876 Roll:11.9682 | Pitch:13.1266 Yaw:12.1541 Roll:17.1008 |
| **1.train on 300WLP with pretrain model**  **2.Lr:5e-5,5e-5,1e-5,5e-6,1e-6**  **3.with flip and blur augment**  **epoch=99** | Pitch:16.1086 Yaw:8.5177 Roll:12.2166 | Pitch:15.5553Yaw:9.3937 Roll:10.5506 | **Pitch:20.9934** Yaw:7.8222 Roll:9.3880 | Pitch:10.8277 Yaw:10.0274 Roll:12.9235 |

# Time: 2021.6.29

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| --- | --- | --- | --- | --- |
| **public dataset/MAE** | **BIWI** | **AFLW2000** | **300W-LP** | **Apriltag0927** |
| **1.trained on Apriltag0927, sampled 20% data**  **2.pretrained on 300WLP**  **3.flip and blur**  **4.Lr:5e-5,1e-5,5e-6,1e-6**  **5.epoch:50**  **6.step:5,10,25** | Pitch:26.1606 Yaw:13.9405 Roll:20.3347 | Pitch:30.3744 Yaw:16.6114 Roll:18.5269 | Pitch:27.9969 Yaw:25.2462 Roll:21.0682 | **Pitch:3.3959 Yaw:3.0838 Roll:2.1479** |
| **1.trained on Apriltag0927, sampled 20% data**  **2.flip and blur**  **3.Lr:5e-5,1e-5,5e-6,1e-6**  **4.epoch:50**  **6.step:5.10.25** | Pitch:19.9222 Yaw:23.3598 Roll:14.5103 | Pitch:19.6354 Yaw:28.4829 Roll:20.6467 | Pitch:15.6979 Yaw:50.7490 Roll:11.9797 | Pitch:6.5399 Yaw:5.8143 Roll:3.9314 |
| **1.trained on Apriltag0927, sampled 20% data**  **2.pretrained on BIWI**  **3.flip and blur**  **4.Lr:5e-5,1e-5,5e-6,1e-6**  **5.epoch:50**  **6.step:5,10,25** | Pitch:25.1240 Yaw:11.8316 Roll:14.7094 | Pitch:34.8735 Yaw:16.7506 Roll:17.2500 | Pitch:33.7892 Yaw:28.9962 Roll:16.5851 | Pitch:5.6475 Yaw:4.6938 Roll:2.8571 |

***结果分析：利用apriltag实车数据训练，apriltag实车测试集表较好，其他公开测试集则很差 --- ->模型过拟合了此数据集。下一阶段训练集应该包含不同数据集数据增强泛化性。***

## Loss curve：

***total loss:***

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***subloss: regression loss + classification loss***

[MISSING IMAGE: image.png, image.png ]

**1.总Loss看上去还可以下降一定轮数**

**2.apriltag0927数据上roll比yaw学习的更好----->此数据的roll角绝大部分分布在0°附近(**[apriltag0927训练集roll角分布图](https://yuque.antfin-inc.com/zppdqz/tgx3in/ol9f72)**）**

# Time: 2021.6.30

***1.三个模型均在BIWI，300WLP，Apriltag0927三个数据集构成的融合数据集上训练***

***2.与训练模型均采用300WLP上训练的模型作为预训练模型***

***3.数据融合方法：***

***batch: 一个batch内每个数据集按照给定比例填充batch***

***probability: 每次dataloader按照给定概率采样不同数据集数据***

***normal: 直接融合所有数据随机采样***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **public dataset/MAE** | **BIWI** | **AFLW2000** | **300W-LP** | **Apriltag0927** |
| **1.data balance way: batch**  **2.LR=5e-5,1e-5,5e-6,1e-6**  **3.steps=5,10,25**  **4.epoch=59**  **6.weights for BIWI,300WLP,Apriltag:**  **0.2,0.3,0.5**  ​ | Pitch:3.7601 Yaw:4.0011 Roll:3.6475 Mean:3.8029 | Pitch:9.6366 Yaw:6.5293 Roll:9.2754 Mean:8.4805 | Pitch:6.4963 Yaw:3.3697 Roll:5.7978 Mean:5.2213 | Pitch:4.5143 Yaw:4.0892 Roll:2.8704 Mean:3.8246 |
| **1.data balance way: prob**  **2.LR=5e-5,1e-5,5e-6,1e-6**  **3.steps=5,10,25**  **4.epoch=59**  **6.weights for BIWI,300WLP,Apriltag:**  **0.2,0.3,0.5** | Pitch:3.7360 Yaw:3.8889 Roll:3.2860 **Mean:3.6370** | Pitch:9.8008 Yaw:6.3510 Roll:9.2497 Mean:8.4672 | Pitch:6.5224 Yaw:3.3448 Roll:5.8395 Mean:5.2355 | Pitch:4.4392 Yaw:4.0906 Roll:2.7973 Mean:3.7757 |
| **1.data balance way: norm**  **2.LR=5e-5,1e-5,5e-6,1e-6**  **3.steps=5,10,25**  **4.epoch=59** | Pitch:3.7856 Yaw:4.9397 Roll:3.5973 Mean:4.1075 | Pitch:9.6007 Yaw:6.7065 Roll:8.9124 **Mean:8.4065** | Pitch:6.0225 Yaw:2.8403 Roll:5.4236 **Mean:4.7621** | Pitch:3.6827 Yaw:3.5056 Roll:2.5436 **Mean:3.2440** |

**结果分析：**

***1.norm 方法在AFLW2000和300W-LP上表现最好的原因是300WLP数据量最大***

***2.norm 方法在Apriltag0927上表现好，说明使用过多的实车数据集可能泛化性反而会差，使用更多的复杂数据集泛化性会更好***

## 大角度/hard case 测试：

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Apriltag0927\_large\_pose/Camera** | **Wheel** | | | **MirrorDriver** | | |
| **Samples from angle>threshold** | **Pitch** | **Yaw** | **Roll** | **PItch** | **Yaw** | **Roll** |
| **MAE(>=45°)**  **number of Pich,Yaw,Roll:**  **Wheel: 393,10,2**  **MirrorDriver: 95,137,4** | Pitch:11.5575 Yaw:7.4553 Roll:7.4582 Mean:8.8237 | **Pitch:37.8397 Yaw:28.3084 Roll:30.6111 Mean:32.2531** | **Pitch:69.7169 Yaw:48.1987 Roll:53.7515 Mean:57.2224** | Pitch:5.5091 Yaw:4.1371 Roll:6.2077 Mean:5.2846 | Pitch:7.0377 Yaw:6.2167 Roll:6.4362 Mean:6.5635 | Pitch:15.6207 Yaw:2.5321 Roll:21.7482 Mean:13.3004 |
| **MAE(>=30°)**  **number of Pich,Yaw,Roll:**  **Wheel: 1628,247,34**  **MirrorDriver: 381,388,27** | Pitch:5.8034 Yaw:3.9231 Roll:3.3870 Mean:4.3712 | Pitch:11.6525 Yaw:7.3996 Roll:7.5103 Mean:8.8541 | **Pitch:22.9994 Yaw:13.4893 Roll:17.2076 Mean:17.8988** | Pitch:5.1182 Yaw:4.2129 Roll:4.3567 Mean:4.5626 | Pitch:5.2738 Yaw:5.7035 Roll:4.7683 Mean:5.2486 | Pitch:8.0364 Yaw:3.7452 Roll:8.7971 Mean:6.8596 |
| **MAE(>=15°)**  **number ofPich,Yaw,Roll:**  **Wheel: 2722,1167,538**  **MirrorDriver: 1706,1798,222** | Pitch:5.0018 Yaw:3.5663 Roll:2.9141 Mean:3.8274 | Pitch:6.8054 Yaw:4.9421 Roll:4.8145 Mean:5.5207 | Pitch:8.3719 Yaw:6.0857 Roll:5.9336 Mean:6.7971 | Pitch:3.7889 Yaw:4.1604 Roll:2.9982 Mean:3.6491 | Pitch:3.9454 Yaw:4.4630 Roll:3.0864 Mean:3.8316 | Pitch:5.4676 Yaw:4.6745 Roll:5.4625 Mean:5.2015 |

***结果分析：***

***1.大角度下，Wheel视角预测结果比MirrrorDirver差***

***2.大角度下，Wheel视角中>45°时yaw,roll结果很差，应该和测试样本少有关***

***可视化分析：***

***Wheel视角下，某些测试样本 GT label 出现错误：***

|  |  |  |
| --- | --- | --- |
| [MISSING IMAGE: Foreword\_62.jpg, Foreword\_62.jpg ] | [MISSING IMAGE: LeftMirror\_87.jpg, LeftMirror\_87.jpg ] | [MISSING IMAGE: Speedometer\_105.jpg, Speedometer\_105.jpg ] |

## Loss curve for "batch" data balance:

***total loss:***

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***subloss: regression loss + classification loss***

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***分析：pitch角依然是最难学习的角度，yaw和roll已经下降到相似的级别了！！！***

# Time:2021.7.12

## 大角度结果MAE异常分析：

利用img2pose 进行数据过滤：挑选前期测试roll>30°和roll<30°时数据，发现Apriltag 计算的结果在>30°时候出错较多，<30°出错较少。

***sample:***

***GT: Apriltag***

***Pred: img2pose***

***上方坐标：Apriltag***

***下方坐标：img2pose***

***Res==True: 任意一个角度MAE>20°***

|  |  |  |
| --- | --- | --- |
| bad roll | bad pitch | bad yaw |
| [MISSING IMAGE: 49\_DistractedGaze\_MirrorDriver\_None\_RGB\_LeftMirror\_53.jpg, 49\_DistractedGaze\_MirrorDriver\_None\_RGB\_LeftMirror\_53.jpg ] | [MISSING IMAGE: 44\_DistractedGaze\_Whell\_Glass\_IR\_RightMirror\_82.jpg, 44\_DistractedGaze\_Whell\_Glass\_IR\_RightMirror\_82.jpg ] | [MISSING IMAGE: 32\_DistractedGaze\_Whell\_None\_IR\_Foreword\_62.jpg, 32\_DistractedGaze\_Whell\_None\_IR\_Foreword\_62.jpg ] |
| [MISSING IMAGE: 36\_DistractedGaze\_MirrorDriver\_None\_IR\_LeftMirror\_112.jpg, 36\_DistractedGaze\_MirrorDriver\_None\_IR\_LeftMirror\_112.jpg ] | [MISSING IMAGE: 38\_DistractedGaze\_Whell\_Glass\_RGB\_RightMirror\_60.jpg, 38\_DistractedGaze\_Whell\_Glass\_RGB\_RightMirror\_60.jpg ] | [MISSING IMAGE: 24\_DistractedGaze\_MirrorDriver\_None\_RGB\_CenterStack\_130.jpg, 24\_DistractedGaze\_MirrorDriver\_None\_RGB\_CenterStack\_130.jpg ] |

# Time: 2021.7.19

**模型更新：**

*1.增加A柱视角数据*

*2.两种更改实车数据GT值方案:*

*a，当apriltag结果和img2pose的MAE>20°时采用img2pose结果作为GT*

*b，实车数据全部采用img2pose计算结果*

## Loss curve : img2pose as part GT

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## 整体测试（回归测试）：

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **public dataset/MAE** | **Apriltag0927（wheel+MirrorDriver+all img2pose GT)** | **Apriltag0927（wheel+MirrorDriver+part img2pose GT)** | **Apriltag210705(A+all img2pose GT)** | **Apriltag210705(A+part img2pose GT)** | **BIWI** | **AFLW2000** | **300W-LP** |
| **previous best** | Pitch:11.4586 Yaw:4.9800 Roll:7.4448 Mean:7.9611 | **Pitch:3.6827 Yaw:3.5056 Roll:2.5436 Mean:3.2440** | Pitch:15.9868 Yaw:8.7086 Roll:8.3670 Mean:11.0208 | **Pitch:17.4743 Yaw:16.7420 Roll:6.3154 Mean:13.5106** | Pitch:3.7856 Yaw:4.9397 Roll:3.5973 Mean:4.1075 | Pitch:9.6007 Yaw:6.7065 Roll:8.9124 Mean:8.4065 | Pitch:6.0225 Yaw:2.8403 Roll:5.4236 Mean:4.7621 |
| **model1**  **1.use img2pose as GT**  **2.data balance way: norm**  **3.LR=5e-5,1e-5,5e-6,1e-6**  **4.steps=5,10,25**  **5.epoch=79** | Pitch:4.8780 Yaw:3.6578 Roll:3.6479 Mean:4.0612 | **Pitch:13.4479 Yaw:6.3486 Roll:9.0871 Mean:9.6278** | Pitch:3.0840 Yaw:2.7203 Roll:2.1944 Mean:2.6662 | **Pitch:14.9826 Yaw:14.2159 Roll:7.0730 Mean:12.0905** | Pitch:3.6265 Yaw:5.0346 Roll:3.7132 Mean:4.1247 | Pitch:8.9124 Yaw:6.5394 Roll:8.3063 Mean:7.9194 | Pitch:5.6187 Yaw:2.5557 Roll:5.1037 Mean:4.4260 |
| **model2**  **1.use img2pose as GT (MAE>20°)**  **2.data balance way: norm**  **3.LR=5e-5,1e-5,5e-6,1e-6**  **4.steps=5,10,25**  **5.epoch=79** | Pitch:4.8092 Yaw:3.7007 Roll:3.6913 Mean:4.0671 | **Pitch:13.1884 Yaw:6.4410 Roll:9.1505 Mean:9.5933** | Pitch:3.1767 Yaw:2.6775 Roll:2.1893 Mean:2.6812 | **Pitch:14.9032 Yaw:14.0204 Roll:6.9226 Mean:11.9487** | Pitch:3.5918 Yaw:4.7200 Roll:3.6876 Mean:3.9998 | Pitch:8.8150 Yaw:6.4663 Roll:8.4422 Mean:7.9078 | Pitch:5.6597 Yaw:2.5887 Roll:5.1388 Mean:4.4624 |

结果分析：

1.3个公开数据集上泛化性并未有明显改变

2.无论在apriltag和img2pose MAE>20°时，以img2pose 作为GT，还是直接用img2pose 作为GT训练，在以img2pose作为GT的实车测试集上都表现较好。

3.误差>20 时img2pose 作为GT的测试集表现的均不好：主要还是apriltag计算结果不正确导致

## 大角度/hard case 测试：

**Use all img2pose as GT**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **model2/Camera** | **A** | | | **Wheel** | | | **MirrorDriver** | | |
| **Samples from angle>threshold** | **Pitch** | **Yaw** | **Roll** | **Pitch** | **Yaw** | **Roll** | **PItch** | **Yaw** | **Roll** |
| **MAE(>=45°)**  **number of Pich,Yaw,Roll:**  **Wheel: 393,10,2**  **MirrorDriver: 95,137,4**  **A:** | Pitch:16.5321 Yaw:13.0060 Roll:11.0085 Mean:13.5155 | Pitch:3.3937 Yaw:3.4216 Roll:3.8777 Mean:3.5643 | - | Pitch:2.5744 Yaw:2.0675 Roll:1.5432 Mean:2.0617 | Pitch:1.2896 Yaw:3.1220 Roll:1.6852 Mean:2.0322 | Pitch:1.4715 Yaw:1.1101 Roll:1.0315 Mean:1.2044 | Pitch:5.8571 Yaw:3.8307 Roll:13.6451 Mean:7.7776 | Pitch:5.0929 Yaw:8.5319 Roll:4.8587 Mean:6.1612 | Pitch:5.3741 Yaw:1.3342 Roll:1.6868 Mean:2.7984 |
| **MAE(>=30°)**  **number of Pich,Yaw,Roll:**  **Wheel: 1628,247,34**  **MirrorDriver: 381,388,27**  **A:** | Pitch:6.0794 Yaw:4.7529 Roll:4.8562 Mean:5.2295 | Pitch:4.0288 Yaw:3.5783 Roll:3.3865 Mean:3.6645 | **Pitch:38.1379 Yaw:31.3341 Roll:14.8555 Mean:28.1092** | Pitch:2.2482 Yaw:2.1292 Roll:1.5310 Mean:1.9695 | Pitch:2.3838 Yaw:2.0911 Roll:1.7875 Mean:2.0875 | Pitch:2.7413 Yaw:1.9045 Roll:2.3305 Mean:2.3254 | Pitch:9.1288 Yaw:5.0234 Roll:11.7165 Mean:8.6229 | Pitch:7.9621 Yaw:7.2778 Roll:8.8349 Mean:8.0250 | Pitch:3.9014 Yaw:2.3179 Roll:3.0349 Mean:3.0847 |
| **MAE(>=15°)**  **number ofPich,Yaw,Roll:**  **Wheel: 2722,1167,538**  **MirrorDriver: 1706,1798,222**  **A:** | Pitch:3.5112 Yaw:2.9387 Roll:2.5088 Mean:2.9862 | Pitch:3.4220 Yaw:2.7790 Roll:2.3767 Mean:2.8592 | Pitch:10.1015 Yaw:8.1156 Roll:6.9897 Mean:8.4023 | Pitch:2.2157 Yaw:2.1381 Roll:1.3856 Mean:1.9132 | Pitch:2.3324 Yaw:2.0875 Roll:1.5828 Mean:2.0009 | Pitch:2.5086 Yaw:2.0016 Roll:1.7238 Mean:2.0780 | Pitch:7.6732 Yaw:4.9562 Roll:7.5146 Mean:6.7147 | Pitch:7.1690 Yaw:5.7319 Roll:7.2757 Mean:6.7255 | Pitch:5.6534 Yaw:4.3835 Roll:6.9168 Mean:5.6512 |

结果分析：

1.A柱Roll>30°时候，结果异常是因为img2pose 此帧并未检出

2.img2pose的检测结果可以一定程度上弥补apriltag计算失误问题

**​**

**Use part img2pose as GT**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **model2/Camera** | **A** | | | **Wheel** | | | **MirrorDriver** | | |
| **Samples from angle>threshold** | **Pitch** | **Yaw** | **Roll** | **Pitch** | **Yaw** | **Roll** | **PItch** | **Yaw** | **Roll** |
| **MAE(>=45°)**  **number of Pich,Yaw,Roll:**  **Wheel: 393,10,2**  **MirrorDriver: 95,137,4**  **A:** | Pitch:65.4845 Yaw:69.8609 Roll:30.4570 Mean:55.2675 | Pitch:17.9939 Yaw:17.9528 Roll:18.3750 Mean:18.1072 | - | Pitch:78.4368 Yaw:49.3485 Roll:54.4792 Mean:60.7548 | Pitch:46.6022 Yaw:31.6419 Roll:33.3660 Mean:37.2033 | Pitch:27.6582 Yaw:10.5723 Roll:18.3531 Mean:18.8612 | Pitch:8.5286 Yaw:5.1298 Roll:33.2683 Mean:15.6422 | Pitch:13.2135 Yaw:10.9422 Roll:35.4670 Mean:19.8743 | Pitch:34.6276 Yaw:12.8237 Roll:94.4029 Mean:47.2847 |
| **MAE(>=30°)**  **number of Pich,Yaw,Roll:**  **Wheel: 1628,247,34**  **MirrorDriver: 381,388,27**  **A:** | Pitch:37.1549 Yaw:37.3474 Roll:15.7052 Mean:30.0692 | Pitch:18.0384 Yaw:21.1981 Roll:11.5276 Mean:16.9214 | Pitch:87.6085 Yaw:84.0119 Roll:49.7033 Mean:73.7746 | Pitch:18.8236 Yaw:6.2593 Roll:10.3548 Mean:11.8126 | Pitch:27.7578 Yaw:10.1595 Roll:18.9777 Mean:18.9650 | Pitch:42.1787 Yaw:19.9999 Roll:27.2740 Mean:29.8175 | Pitch:11.6777 Yaw:6.6939 Roll:22.0096 Mean:13.4604 | Pitch:12.3156 Yaw:12.2413 Roll:24.8977 Mean:16.4848 | Pitch:3.9014 Yaw:2.3179 Roll:3.0349 Mean:3.0847 |
| **MAE(>=15°)**  **number ofPich,Yaw,Roll:**  **Wheel: 2722,1167,538**  **MirrorDriver: 1706,1798,222**  **A:** | Pitch:18.7656 Yaw:18.1264 Roll:8.9571 Mean:15.2830 | Pitch:15.6781 Yaw:15.7267 Roll:7.8100 Mean:13.0716 | Pitch:43.2155 Yaw:50.8082 Roll:21.6369 Mean:38.5536 | Pitch:16.0534 Yaw:5.3982 Roll:7.8873 Mean:9.7796 | Pitch:20.2366 Yaw:7.7288 Roll:13.6812 Mean:13.8822 | Pitch:24.8051 Yaw:10.0369 Roll:17.5895 Mean:17.4771 | Pitch:10.7971 Yaw:6.9530 Roll:14.2205 Mean:10.6569 | Pitch:10.8103 Yaw:8.6441 Roll:14.2178 Mean:11.2240 | Pitch:10.6826 Yaw:8.7813 Roll:32.8009 Mean:17.4216 |

结果分析：

1.仅在apriltag 计算值与img2pose 值MAE>20时用img2pose作为GT，但是还是有不少apriltagGT计算错误，或者因为img2pose未检出的原因导致MAE偏差大！！

## 均衡样本测试：

***data distribution: sampled 20 datas at each 10 dgree***

**Wheel: [20, 20, 20, 20, 1, 1, 0, 0, 0]**

**Mirror: [20, 20, 20, 15, 1, 1, 2, 1, 0]**

**A: [20, 20, 20, 5, 0, 0, 0, 0, 0]**

**实车测试集大于40°的数据很少**

|  |  |  |  |
| --- | --- | --- | --- |
| **GT: all use img2pose** | **A** | **Wheel** | **MirrorDriver** |
| **previous best** | Pitch:25.4575 Yaw:15.2806 Roll:13.6370 Mean:18.1250 | Pitch:31.0648 Yaw:10.4556 Roll:11.6175 Mean:17.7126 | Pitch:14.9294 Yaw:9.1698 Roll:30.4533 Mean:18.1842 |
| **model1** | **Pitch:3.8276 Yaw:3.2816 Roll:2.9155 Mean:3.3416** | **Pitch:2.0881 Yaw:1.8967 Roll:1.2488 Mean:1.7446** | **Pitch:2.9092 Yaw:2.0291 Roll:2.2464 Mean:2.3949** |
| **model2** | Pitch:7.0471 Yaw:6.5906 Roll:4.3654 Mean:6.0010 | Pitch:2.8738 Yaw:2.3683 Roll:1.2825 Mean:2.1749 | Pitch:3.5227 Yaw:2.4988 Roll:2.5821 Mean:2.8679 |
| **GT: part use img2pose** | **A** | **Wheel** | **MirrorDriver** |
| **previous best** | Pitch:38.4444 Yaw:40.9085 Roll:11.0034 Mean:30.1188 | Pitch:10.4491 Yaw:7.6227 Roll:12.2094 Mean:10.0938 | Pitch:3.9743 Yaw:6.4058 Roll:4.5439 Mean:4.9746 |
| **model1** | Pitch:30.5540 Yaw:36.8480 Roll:18.7300 Mean:28.7107 | Pitch:34.9083 Yaw:15.2045 Roll:19.5736 Mean:23.2288 | Pitch:15.3823 Yaw:12.1945 Roll:28.8387 Mean:18.8051 |
| **model2** | Pitch:30.8509 Yaw:36.8648 Roll:18.5797 Mean:28.7651 | Pitch:34.5403 Yaw:15.2877 Roll:19.5477 Mean:23.1252 | Pitch:15.1377 Yaw:12.2343 Roll:29.0526 Mean:18.8082 |

结果分析：

1.测试数据在40°以下，按照每10°进行均衡采样的情况下。目前结果在以img2pose 作为GT的数据集上表现正常。

2.仅使用部分img2pose作为GT数据集（img2pose和Apirltag的任意角度的绝对误差>20°）上，结果异常因为：当误差<20°时，apriltag仍然会计算失败。

# Time: 20210917

## 基于关键点和模型的HeadPose效果对比：

***data distribution: sampled 20 datas at each 10 dgree***

**Wheel: [20, 20, 20, 20, 1, 1, 0, 0, 0]**

**Mirror: [20, 20, 20, 15, 1, 1, 2, 1, 0]**

**A: [20, 20, 20, 5, 0, 0, 0, 0, 0]**

**实验采用相同的人脸框输入（RetinaFace）;landmark使用@党婉婷当前最优模型；pose欧拉角采用img2pose方法计算的值**

### MAE

|  |  |  |  |
| --- | --- | --- | --- |
| **GT: all use img2pose** | **A** | **Wheel** | **MirrorDriver** |
| **unknow online mnn** | Pitch:18.8208 Yaw:14.5005 Roll:13.9211 Mean:15.7475 | Pitch:44.5211 Yaw:17.0044 Roll:17.6472 Mean:26.3909 | Pitch:23.7380 Yaw:32.0196 Roll:20.5288 Mean:25.4288 |
| **former BIWI model** | Pitch:11.9384 Yaw:33.4110 Roll:9.1035 Mean:18.1510 | Pitch:5.7195 Yaw:25.5801 Roll:14.5364 Mean:15.2786 | Pitch:10.9842 Yaw:21.4617 Roll:36.1666 Mean:22.8708 |
| **landmark based** | Pitch:9.4274 Yaw:11.9694 Roll:20.1223 Mean:38.9701 | Pitch:6.6591 Yaw:21.3030 Roll:19.9790 Mean:31.9750 | Pitch:19.9161 Yaw:20.5649 Roll:25.9205 Mean:22.1339 |
| **model based** | **Pitch:3.8276 Yaw:3.2816 Roll:2.9155 Mean:3.3416** | **Pitch:2.0881 Yaw:1.8967 Roll:1.2488 Mean:1.7446** | **Pitch:2.9092 Yaw:2.0291 Roll:2.2464 Mean:2.3949** |

## 自测集整体测试：

### MAE

|  |  |  |
| --- | --- | --- |
| **GT: all use img2pose** | **wheel+MirrorDriver** | **A** |
| **current model** | Pitch:4.8600 Yaw:3.5916 Roll:3.5234 Mean:3.9917 | Pitch:3.0315 Yaw:2.6589 Roll:2.1773 Mean:2.6226 |

# Time:20211216

***大角度测试：任意角度>=60°***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MAE** | **pitch** | **yaw** | **roll** | **mean** |
| **BIWI** | 3.9779 | 4.4667 | 4.7521 | 4.3989 |
| **300WLP** | 6.5411 | 2.6205 | 6.3194 | 5.1603 |
| **AFLW2000** | 16.9994 | 7.4779 | 18.4726 | 14.3166 |

**平均MAE=7.96**

***​***

***普通角度测试：所有角度<60°***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MAE** | **pitch** | **yaw** | **roll** | **mean** |
| **BIWI** | 3.5450 | 5.1020 | 3.6267 | 4.0912 |
| **300WLP** | 3.1710 | 2.4820 | 1.9487 | 2.5339 |
| **AFLW2000** | 5.7811 | 6.0705 | 3.4985 | 5.1167 |

**平均MAE=3.9**