MHT Retrieval

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前期算法流程

- Gating
- TreeToGraph
- MWIS
- Pruning
- SendResult

前期问题与设想

- MWIS求解速度慢，偶尔错解
- 目标消失与漏检
- ID 过多
- Pruning策略
- Gating：检测框如何更好地匹配到树

解决方案

- 修改MWIS解法为贪心算法（mwsi_greedy）提高求解速度

解决方案

- 问题：目标消失与漏检

  引入miss_time变量, miss_time threshold = N+10：

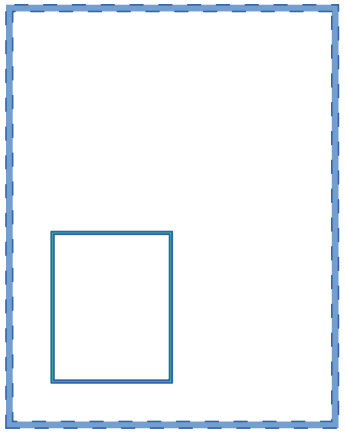
  ```
  if（Tree i 未被分配到检测框 or Tree i 未被选择路径) {
      miss_time ++;
  }

  if（miss_time > threshold）{
     erase（Tree）;
  }
  ```

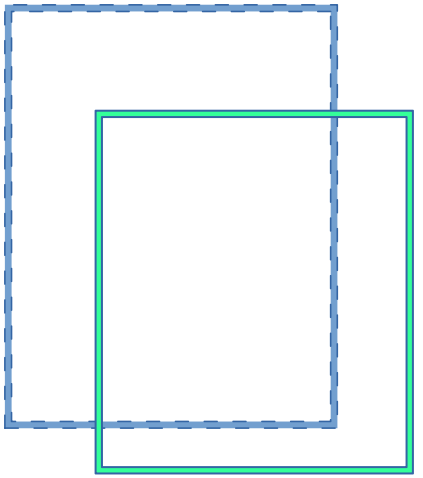
解决方案

- 问题：ID过多
- I. 引入miss_time有助于解决ID过多问题，因为在第K帧漏检的框可能会在K+1帧重新出现，保留对应的树一段时间有助于gating到此类检测框，防止生成新树太快、ID过多
- II. NMS
- III. Pruning
- IV. Gating

解决方案

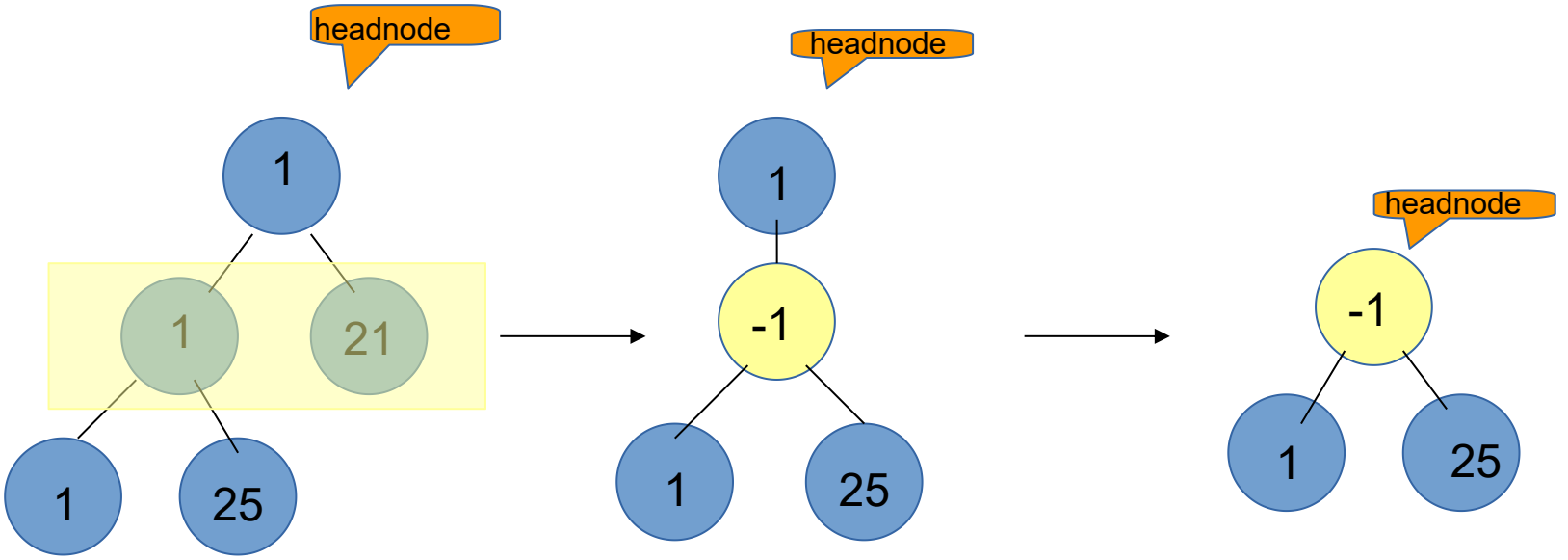
- NMS
- I. 跟踪前去掉相互嵌套的两个检测框中的一个
- II. Hungarian algorithm：去掉重叠率大于0.4的两个检测框中分数低的一个





解决方案

- Pruning
- I. MWIS求解后，选出前100个最优路径，减除剩下的路径
- II. 对于没有选中的树，为保证所有路径的长度相同，避免对路径分数的影响，引入ICH结点：
  index=-1，score=0.01，box继承headnode.box，level+1：



解决方案

- Gating and scoring
- Previous plan：gating：L2 distance, scoring：IOU .检测框有大有小，L2 distance不普适。
- Plan A：gating：IOU, scoring：IOU×exp(-L2 distance) .
- Plan B：gating：IOU×exp(-L2 distance), scoring：IOU.
- Plan C：gating：Mahalanobis distance, scoring：IOU×exp(-M distance) .
- Plan D：gating：IOU/(1+L2 distance), scoring：IOU.

解决方案

- Plan A：gating：IOU, scoring：IOU×exp(-L2 distance) .
- 在MOT16-02～11 上表现出色：

MOT16-02

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
22.2	51.4	14.2	23.7	86.0	1.15	54	5	16	33	688	13603	85	105	19.4	74.3	19.9

MOT16-04

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
43.8	65.0	33.0	45.7	90.0	2.31	83	8	43	32	2424	25832	181	201	40.2	77.6	40.6

MOT16-05

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
38.3	48.2	31.7	42.4	64.3	1.92	125	10	65	50	1603	3929	127	125	17.0	73.8	18.8

MOT16-09

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
41.4	46.2	37.5	61.9	76.4	1.92	25	5	18	2	1006	2001	94	110	41.0	72.1	42.8

MOT16-10

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
29.6	39.0	23.8	42.3	69.2	3.54	54	6	23	25	2318	7107	245	221	21.5	73.1	23.5

MOT16-11

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
47.4	57.2	40.5	57.3	80.9	1.38	69	11	27	31	1242	3917	57	60	43.1	77.7	43.7

********** Your MOT16 Results **********

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
38.5	55.9	29.3	43.0	82.1	2.03	410	45	192	173	9281	56389	789	822	32.8	76.1	33.6

- 在MOT16-13数据集上求解MWIS遇到问题，跑不通。原因：score太小

解决方案

- Plan B：gating：IOU×exp(-L2 distance), scoring：IOU.

```
MOT16-02
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 20.1 42.7 13.2| 24.4  78.9  1.94|   54   6   14   34|  1162 13487   106   103|  17.3  73.8  17.8


MOT16-04
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 44.4 66.5 33.4| 45.5  90.6  2.14|   83   9   43   31|  2249 25916   176   214|  40.4  77.5  40.8


MOT16-05
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 33.4 45.3 26.5| 39.5  67.5  1.55|  125   7   63   55|  1300  4124    92   119|  19.1  73.8  20.4


MOT16-09
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 30.4 29.5 31.3| 62.1  58.6  4.39|   25   6   17    2|  2305  1991   178   130|  14.9  70.8  18.2


MOT16-10
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 30.1 41.2 23.7| 40.6  70.5  3.20|   54   6   21   27|  2091  7314   151   203|  22.4  73.1  23.6


MOT16-11
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 29.8 30.5 29.1| 58.0  60.9  3.79|   69  12   28   29|  3413  3855   163    53|  19.0  75.9  20.8


MOT16-13
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 17.8 35.8 11.8| 18.4  55.9  2.22|  107   6   30   71|  1667  9340   204   205|   2.1  71.1   3.8


 ********************* Your MOT16 Results *********************
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 33.9 48.9 25.9| 40.2  75.8  2.67|  517  52  216  249| 14187 66027  1070  1027|  26.4  75.5  27.3
```

- gating策略受L2 distance影响很大，导致11数据集指标下降很快

解决方案

- Plan C：gating：Mahalanobis distance, scoring：IOU×exp(-M distance) .
- 速度非常慢！

解决方案

- Plan D：gating：IOU/(1+L2 distance), scoring：IOU.
  使用MWIS_greedy算法的情况下

MOT16-02

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
21.6	47.6	14.0	24.2	82.3	1.54	54	5	16	33	925	13522	86	96	18.5	74.2	19.0

MOT16-04

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
44.4	65.9	33.5	45.6	89.7	2.37	83	9	43	31	2488	25875	161	194	40.0	77.5	40.4

MOT16-05

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
41.1	52.9	33.6	41.9	66.0	1.76	125	11	59	55	1476	3958	89	110	19.0	73.9	20.3

MOT16-09

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
40.1	42.2	38.3	61.7	68.0	2.90	25	6	17	2	1523	2015	102	102	30.8	72.1	32.7

MOT16-10

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
35.6	48.6	28.1	41.8	72.2	3.02	54	6	23	25	1977	7173	159	193	24.4	73.3	25.7

MOT16-11

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
50.3	58.2	44.3	57.8	76.0	1.86	69	12	26	31	1672	3867	72	49	38.8	77.4	39.6

MOT16-13

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
16.5	27.5	11.8	19.7	45.9	3.55	107	6	33	68	2662	9196	334	219	-6.5	70.8	-3.6

********** Your MOT16 Results **********

IDF1	IDP	IDR	Rcll	Prcn	FAR	GT	MT	PT	ML	FP	FN	IDs	FM	MOTA	MOTP	MOTAL
37.6	54.9	28.6	40.6	77.9	2.39	517	55	217	245	12723	65606	1003	963	28.1	75.7	29.1

- 整体IDs减少，MOTA和MOTAL提升两个点
- MOT16-13依然有很多IDs，MOTA比较低

结果对比

- 原文

Table 2. Results from 2*D* MOT 2015 Challenge (accessed on 9/25/2015)

Method	MOTA	MOTP	FAF	MT	ML	FP	FN	IDS	FM	Hz
MHT-DAM	**32.4**	**71.8**	1.6	**16.0%**	**43.8%**	9,064	**32,060**	**435**	826	0.7
MHT	**29.2**	**71.7**	1.7	**12.1%**	53.3%	9,598	**33,467**	**476**	**781**	0.8
LP_SSVM [41]	25.2	**71.7**	**1.4**	5.8%	53.0%	8,369	36,932	646	849	**41.3**
ELP [27]	25.0	71.2	**1.3**	7.5%	**43.8%**	**7,345**	37,344	1,396	1,804	5.7
MotiCon [23]	23.1	70.9	1.8	4.7%	52.0%	10,404	35,844	1,018	1,061	1.4
SegTrack [28]	22.5	**71.7**	**1.4**	5.8%	63.9%	**7,890**	39,020	697	**737**	0.2
CEM [29]	19.3	70.7	2.5	8.5%	46.5%	14,180	34,591	813	1,023	1.1
RMOT [43]	18.6	69.6	2.2	5.3%	53.3%	12,473	36,835	684	1,282	7.9
SMOT [13]	18.2	71.2	1.5	2.8%	54.8%	8,780	40,310	1,148	2,132	2.7
TBD [15]	15.9	70.9	2.6	6.4%	47.9%	14,943	34,777	1,939	1,963	0.7
TC_ODAL [2]	15.1	70.5	2.2	3.2%	55.8%	12,970	38,538	637	1,716	1.7
DP_NMS [35]	14.5	70.8	2.3	6.0%	**40.8%**	13,171	34,814	4,537	3,090	**444.8**

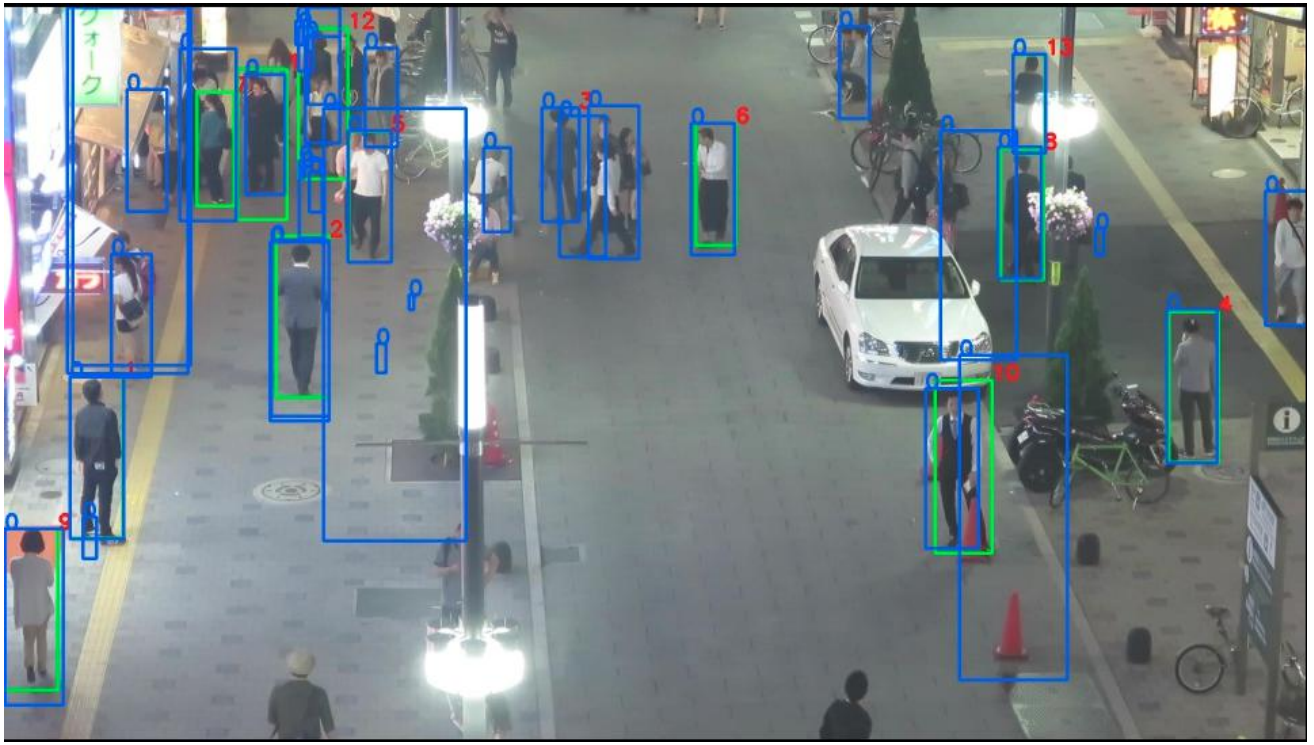
结果对比

- mht.py

```
MOT16-02
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 18.6 58.7 11.0| 16.9  89.9  0.56|   54   2   16   36|   339 14820    70   118|  14.6  73.8  15.0

MOT16-04
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 35.1 61.0 24.6| 38.5  95.2  0.87|   83   2   36   35|   918 29267   167   305|  36.2  78.3  36.5

MOT16-05
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 20.4 44.6 13.2| 20.3  68.7  0.76|  125   1   31   93|   633  5431    55    87|  10.3  71.2  11.0

MOT16-09
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 29.9 47.1 21.9| 40.7  87.5  0.58|   25   0   20    5|   305  3118    89   128|  33.2  72.3  34.8

MOT16-10
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 23.1 42.0 15.9| 29.7  78.4  1.54|   54   1   16   34|  1010  8660    87   186|  20.8  71.3  21.5

MOT16-11
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 25.2 41.3 18.1| 36.7  83.6  0.73|   69   2   24   41|   661  5810   131   187|  28.0  74.9  29.4

MOT16-13
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 18.0 56.9 10.7| 12.5  66.6  0.96|  107   2   23   82|   718 10020    30    56|   6.0  69.6   6.2

 ******************** Your MOT16 Results ********************
 IDF1  IDP  IDR| Rcll  Prcn   FAR|   GT  MT   PT   ML|    FP    FN   IDs    FM|  MOTA  MOTP MOTAL
 27.8 54.4 18.6| 30.1  87.9  0.86|  517  10  166  326|  4584 77126   629  1067|  25.4  75.7  26.0
```

其他尝试

- 加入Kalman Filter： 预测不准



Summary

- 算法流程：NMS – Gating – TreeToGraph – MWIS – SendResult – Pruning
- NMS: Hungarian algorithm
- Gating：IOU/(1+distance), scoring:IOU
- MWIS：mwis_greedy
- SentResult: add miss_time
- Pruning： add ICH
- Result：mht-cpp/build/tracking_result_0925/
- Complexity:：$O(n^2)$
- FPS：6.04 frames/s （6.04Hz）

建议尝试

- Gating使用CNN feature 和 Mahalanobis distance, 同时满足两个条件时更新树的叶子结点
- Scoring也引入CNN feature, 详见原文Multiple Hypothesis Tracking Revised.

Thanks