ASSESSING TRACKING ASSESSMENT MEASURES

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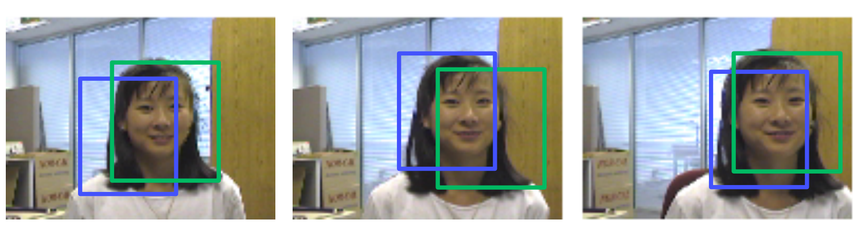
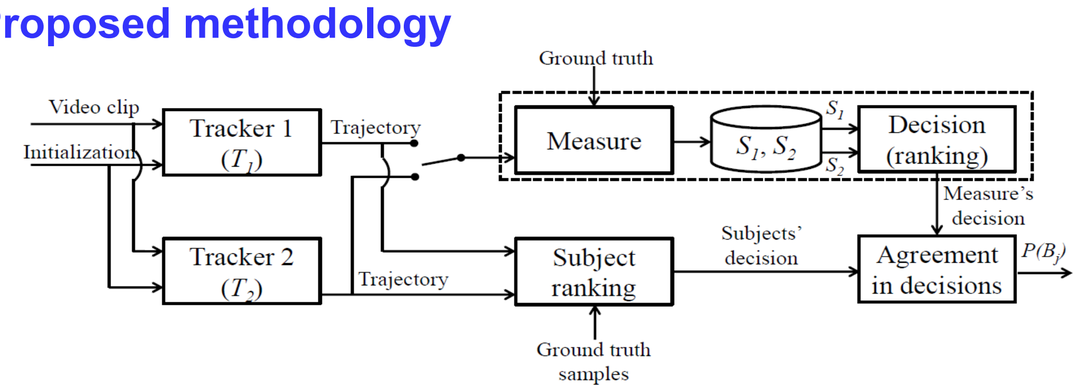
1. Motivation



- Measure A: tracker 1 performs better than tracker 2
- Measure B: tracker 2 performs better than tracker 1
- Measure C: tracker 1 and tracker 2 perform the same
- How to quantitatively assess performance of measures?

2. Proposed methodology



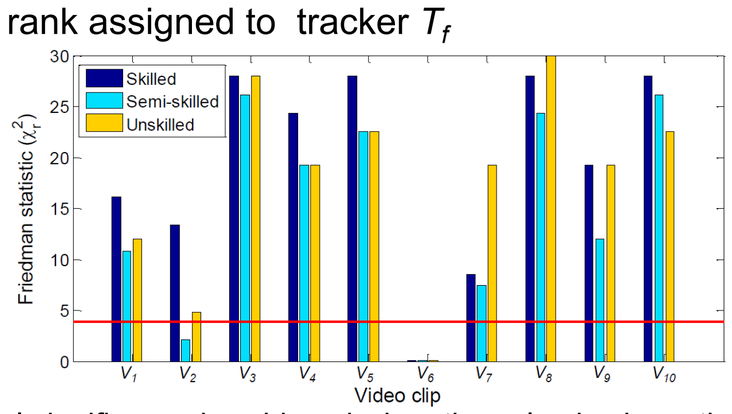
- S_1: evaluation score of tracker 1 using the measure
- $P(B_j)$: agreement of measure's decision w.r.t. decisions of human subjects

3. Subjective evaluation

- Judgements of (skilled, semi-skilled, unskilled) of human subjects on ranking tracker pairs collected on ten video clips (V_1, …, V_{10})
- Statistical significance testing using Friedman's test:

$$\chi^2 = \frac{12}{NF(F+1)} \sum_{f=1}^{F} \left(\sum_{l=1}^{N} \hat{R}_{il}(f) \right)^2 - 3N(F+1)$$

N: number of (human) judges; F: number of trackers;
$\hat{R}_{il}(f)$: rank assigned to tracker T_f



Statistical significance is achieved when the value is above the red line.

4. Measures

- Mean Overlap ($\overline{O}$)

$$O_k = \frac{|\hat{A}_{ik} \cap A_{ik}|}{|\hat{A}_{ik} \cup A_{ik}|}$$

A_{ik}: area (bounding box) information of the estimation
$\hat{A}_{ik}$: area (bounding box) information of the ground truth

- Precision ($\hat{P}$)

$$\hat{P} = \frac{|TP|}{|TP|+|FP|}$$

$|TP|$: number of true positives
$|FP|$: number of false positives

- Track Detection Rate (TDR) [1]

$$\text{TDR} = \frac{|TC|}{\bar{K}_i}$$

$|TC|$: number of true positive coincidences
$\bar{K}_i$: number of ground-truth points

- Area under the lost-track ratio curve (AUC_λ) [2]

$$AUC_\lambda = \Delta\tau_2 \sum_{\tau_2=0}^{1} \lambda(\tau_2)$$

$\lambda(\tau_2)$: lost-track ratio corresponding to τ_2

- Combined Tracking Performance Score (CoTPS) [3]

$$\text{CoTPS} = \beta\Omega + (1-\beta)\lambda_0$$

Ω: tracking accuracy
λ_0: tracking failure
β: adaptive weighting factor

- Tracking Success Probability ($\overline{\text{TSP}}$) [4]

$$\text{TSP}_k = \frac{\exp(\nu \cdot a(\hat{A}_{ik}, A_{ik}))}{1+\exp(\nu \cdot a(\hat{A}_{ik}, A_{ik}))}$$

$a(\hat{A}_{ik}, A_{ik})$: amount of overlap
ν: fixed parameter

- Correct Track Ratio ($CTR_{0.7}$) [5]

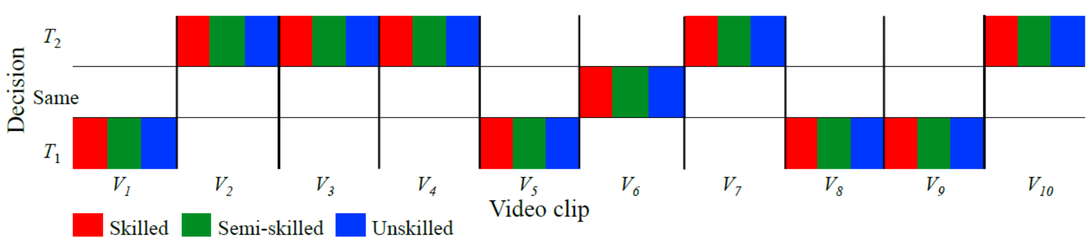
Dice score: $D_k = \frac{2|\hat{A}_{ik} \cap A_{ik}|}{|\hat{A}_{ik}|+|A_{ik}|}$

CTR: %age of frames with D_k > threshold

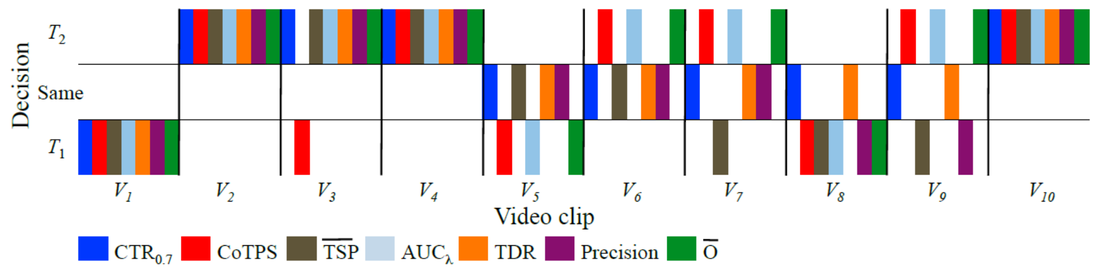
$CTR_{0.7}$: CTR value corresponding Mean D_k (MD) of atleast 0.7 in MD vs CTR plot [5]

5. Measure-subject agreement

- **Decision (ranking) of subjects for tracker pairs (T_1, T_2) on V_1, …, V_{10}**



- **Decision (ranking) of measures for tracker pairs (T_1, T_2) on V_1, …, V_{10}**



- **Amount of agreement ($P(B_j)$) between decisions of a measure and decisions of subjects on $M=10$ clips**

$$P(B_j) = \frac{1}{M} \sum_{i=1}^{M} \sum_{r=1}^{3} P(B_j^i | E_r^i) P(E_r^i)$$

The events (E^i_r) of a sample of subjects (skilled, semi-skilled, unskilled) where the symbol $\succ$ indicates the preference and $\equiv$ means the two results are indistinguishable.

$$E_1^i = \{T_1(V_i) \succ T_2(V_i)\};\ E_2^i = \{T_2(V_i) \succ T_1(V_i)\};\ E_3^i = \{T_1(V_i) \equiv T_2(V_i)\}$$

B^i_j: event of measure j with the same probability space as E^i_r

Measure	$\overline{\text{TSP}}$	$\hat{P}$	$CTR_{0.7}$	CoTPS	AUC_λ	$\overline{O}$	TDR
Skilled	0.74	0.74	0.58	0.61	0.71	0.71	0.58
Semi-skilled	0.68	0.67	0.52	0.57	0.66	0.66	0.52
Unskilled	0.70	0.71	0.53	0.61	0.70	0.70	0.53

References

[1] Black *et al.*, *A novel method for video tracking performance evaluation*, in Proc. of VS-PETS Workshop, 2003.
[2] Nawaz and Cavallaro, *PFT: a protocol for evaluating video trackers*, in Proc. of IEEE ICIP, 2011.
[3] Nawaz and Cavallaro, *A protocol for evaluating video trackers under real-world conditions*, IEEE Trans. on IP, 22(4), 2013.
[4] Li *et al.*, *Real-time visual tracking using compressive sensing*, in Proc. of CVPR, 2011.
[5] Salti *et al.*, *Adaptive appearance modeling for video tracking: Survey and evaluation*, IEEE Trans. on IP, 21(10), 2012.

Acknowledgement

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Code available: http://www.eecs.qmul.ac.uk/~andrea/pft2/
http://www.eecs.qmul.ac.uk/~andrea/mtte.html