CIS centre for intelligent sensing

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# ASSESSING TRACKING ASSESSMENT MEASURES

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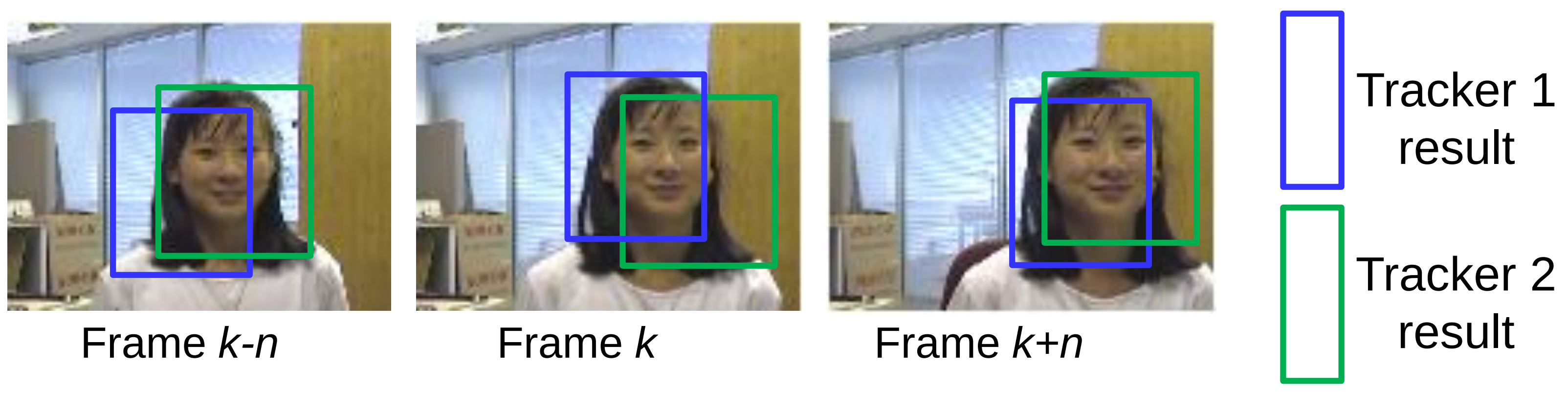
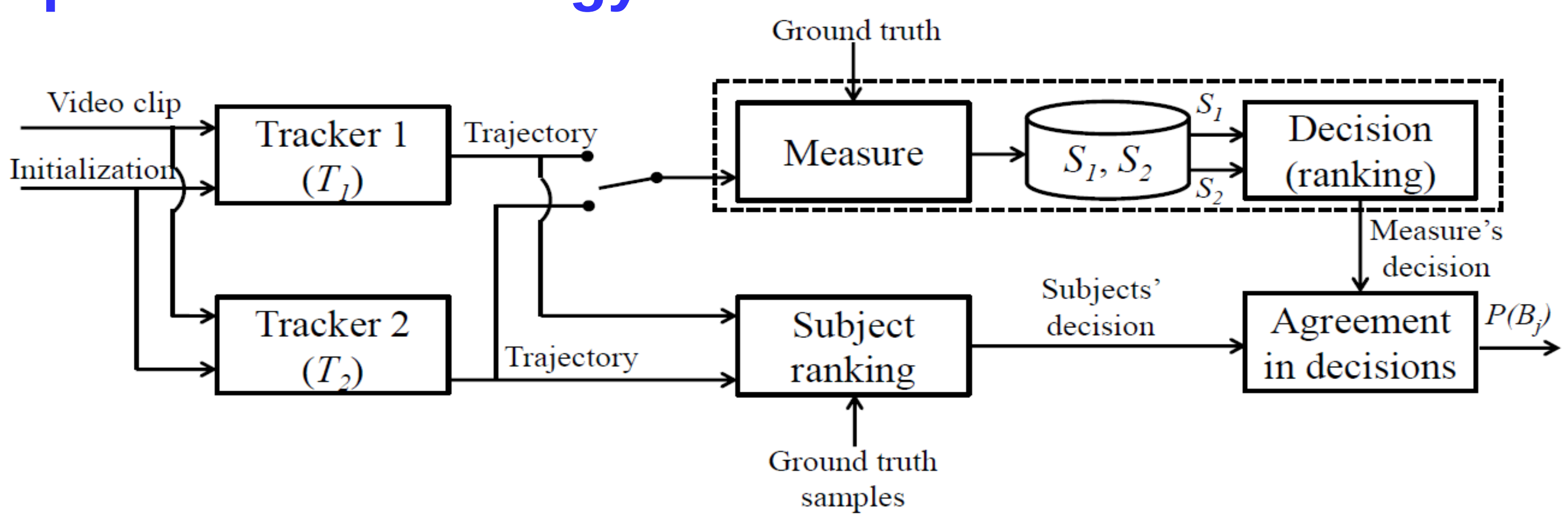
## 1. Motivation



- 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



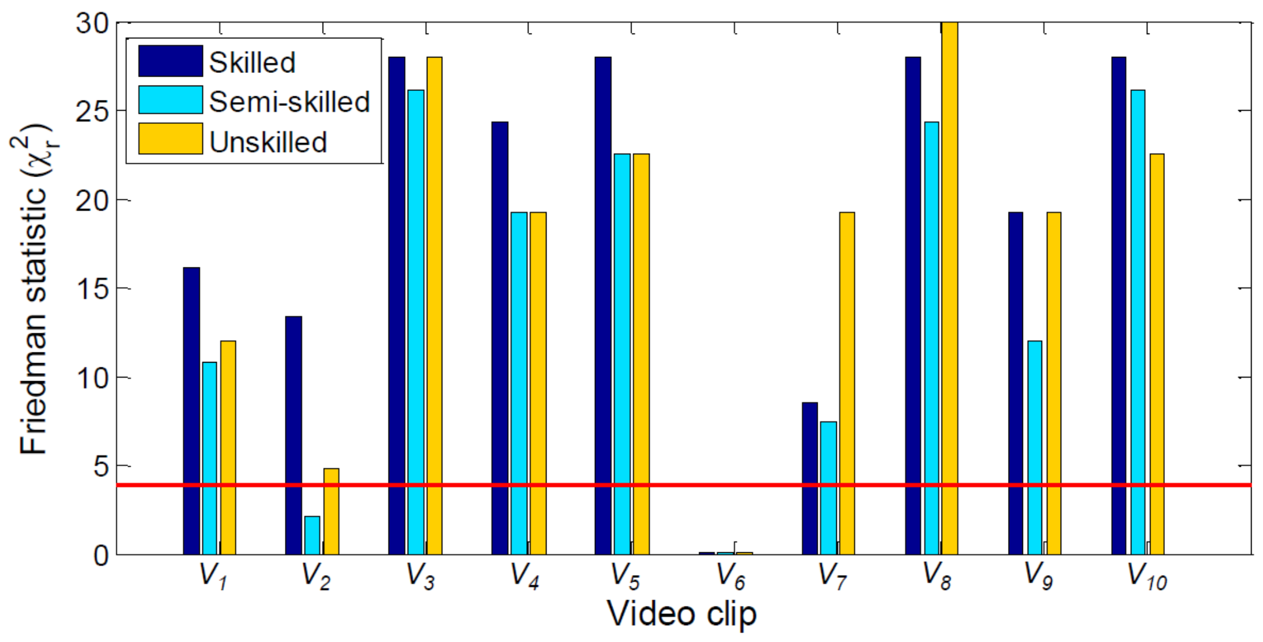
- $S_1$: evaluation score of tracker 1 using the measure
- $P(B_j)$: agreement of measure's decision w.r.t. decisions of human subjects

## 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:

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

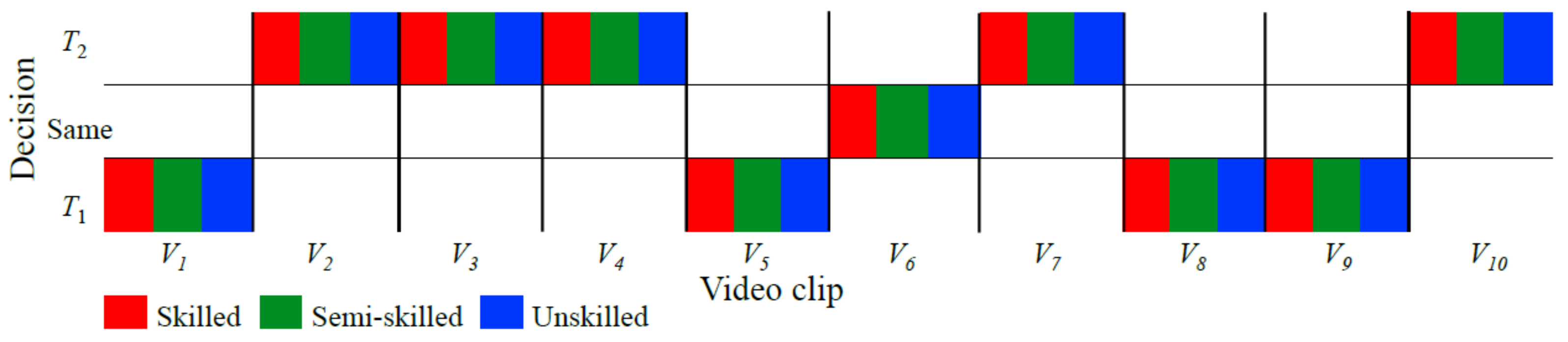
*N*: number of (human) judges; *F*: number of trackers; $\hat{R}_{il}(f)$: rank assigned to tracker $T_f$



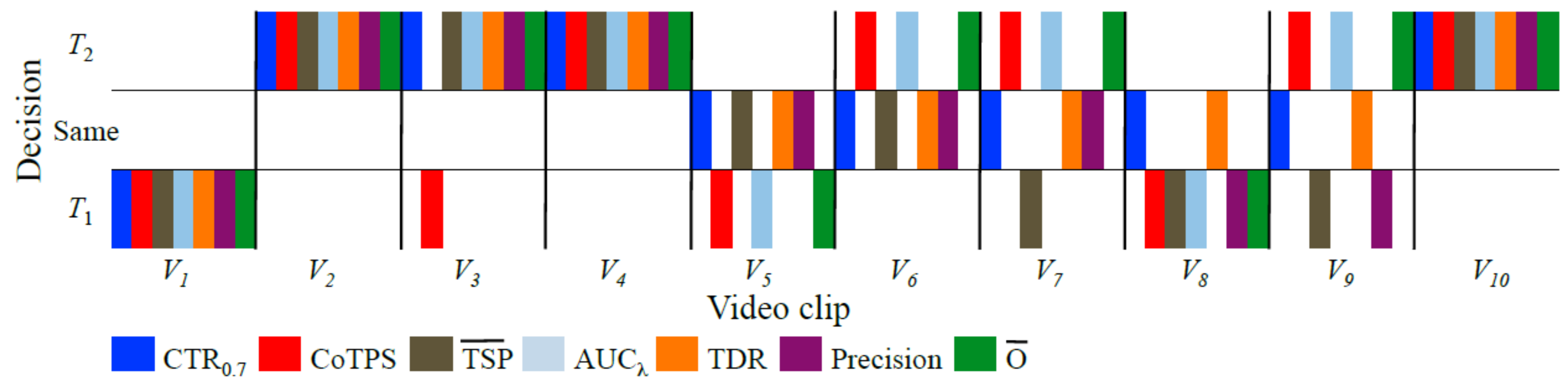
Statistical significance is achieved when the value is above the red line.

## 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 | $AUC_\lambda$ | $\bar{O}$ | 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 |

## 4. Measures

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

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

$A_{ik}$: 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 ($AUC_\lambda$) [2]

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

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

- Combined Tracking Performance Score (CoTPS) [3]

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

$\Omega$: tracking accuracy

$\lambda_0$: tracking failure

$\beta$: 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

$\nu$: 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]

## 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