

Offline Multiple Object Tracking Using Candidate Selection And The Viterbi Algorithm

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Tracking Approaches

- Particle Filtering
 - ▶ Stochastic tracking
 - ▶ Mainly used online and real time
- Our method:
 - ▶ Offline applications: past-present-future observations available
 - ▶ Deterministic selection of candidates
 - ▶ Path inferred by Viterbi
 - ▶ Extension to Multitracking

Notations and Problem

- \mathbf{x}_n object position at time n (hidden state)
- \mathbf{y}_n measurements at time n (observed images)
- $\mathbf{x}_{1:N}$ and $\mathbf{y}_{1:N}$ sequences of positions and measurements in between the time $[1; N]$
- **Objective**: find the best sequence $\hat{\mathbf{x}}_{1:N}$ that maximizes

$$\underbrace{p(\mathbf{x}_{1:N}|\mathbf{y}_{1:N})}_{\text{posterior}} \propto \underbrace{p(\mathbf{x}_{1:N})}_{\text{prior}} \times \underbrace{p(\mathbf{y}_{1:N}|\mathbf{x}_{1:N})}_{\text{likelihood}}$$

Modelling the likelihood

- Memory less sensory system:

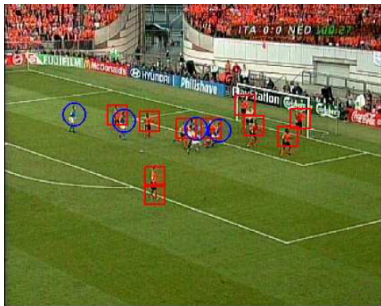
$$p(\mathbf{y}_{1:N}|\mathbf{x}_{1:N}) = \prod_n p(\mathbf{y}_n|\mathbf{x}_n)$$

- Modelling of the likelihood:

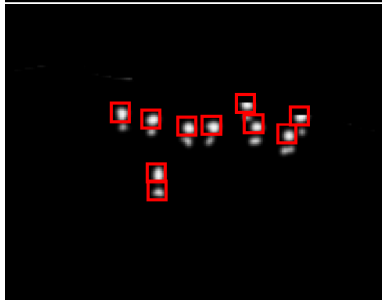
$$p(\mathbf{y}_n|\mathbf{x}_n) = \sum_{i=1}^r p(\mathbf{y}_n|\mathbf{x}_n^{(i)}) \cdot \delta(\mathbf{x}_n - \mathbf{x}_n^{(i)})$$

with the **candidates** $\{\mathbf{x}_n^{(i)}\}$ carefully selected depending on the application.

Candidate selection using colour



Detection of players. Selection of the candidates $\{x_n^{(i)}\}$ (center of the blobs) using Meanshift for the blue team (top) and orange (bottom).



Candidate updated using specific rules

Example of the soccer videos:

- **Object Apparition and Disappearance:** addition of abstract states x_a (not yet visible), and x_b (not anymore visible).
- **Occlusion by teammate:** Instead of removing a candidate from the pool, its likelihood is reduced.
- **Occlusion by opponents:** positions of the other team are added to the candidate set.

Modelling the prior $p(\mathbf{x}_n)$

- First Order Markov Chain

$$p(\mathbf{x}_n | \mathbf{x}_{1:n-1}) = p(\mathbf{x}_n | \mathbf{x}_{n-1})$$

- Feasible moves defined by $p(\mathbf{x}_n | \mathbf{x}_{n-1})$
- Uniform priors $p(\mathbf{x}_n)$

Overview of the Multitracking scheme

- 1 Candidate selection $x_n^{(i)}$ for each frame n
- 2 Define the transition probabilities $p(x_n|x_{n-1})$
- 3 Find the optimal path $\hat{x}_{1:N}$ using Viterbi
- 4 Decrease artificially the likelihood of estimated state $\hat{x}_{1:N}$
- 5 Repeat steps 3 and 4 to search for another object

Multi-tracking in soccer videos

Multi-tracking for Human observation

Analysis of psychological exercise for young children:

- **Objective**: detection of both hands of the child in the video
- **Candidates**: projection of the segmented skin binary mask
- Transition probabilities limited to prevent a large displacement

$$p(x_n|x_{n-1}) \sim \mathcal{N}(0, 3)$$

Multi-tracking for Human observation

Conclusion

- Viterbi uses all temporal information (offline)
- Random generation of candidates replaced by a deterministic selection
- Extension to deterministic Multi-tracking

Thanks

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- Any Question ?
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