# Simultaneous Contouring and Tracking

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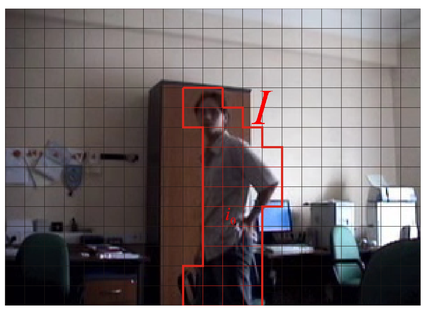
## Abstract

Here we propose the method for tracking of the selected object in video sequence in the absence of a-prior information about background evolution, as well as size and a form of an object. Under such conditions a contouring of an object has to be performed prior to a tracking. Maximum likelihood method is employed for efficient contouring. Estimation of likelihood function, based on residual functions of all parts of frame, is proposed. We implemented an iterative algorithm for maximizing the estimated likelihood function. Developed algorithm showed high performance and stability in a wide spectrum of videos.

## Likelihood function estimation

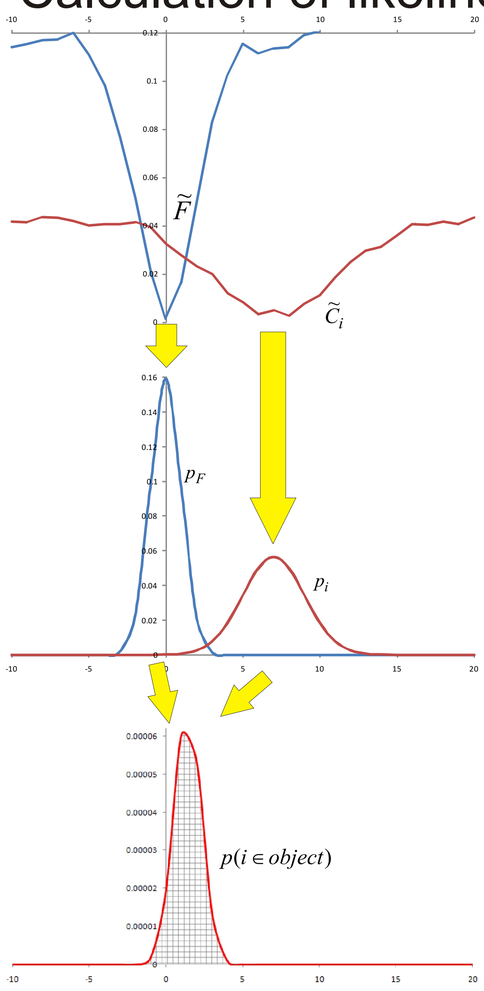
Operator sets $i_0$, algorithm estimates contour $I$ and tracks.




Likelihood function:

$$J(I) = \prod_{i \in I} p(i \in object) \prod_{i \notin I} p(i \notin object)$$

Calculation of likelihood function is based on residual functions:




for single part:

$$\widetilde{C}_i(\delta x, \delta y) = \sum_{l,k \in P_i} \left(f_t(l,k) - f_{t-1}(l-\delta x, k-\delta y)\right)^2$$

for whole object:

$$\widetilde{F}(\delta x, \delta y) = \sum_{i \in I} \widetilde{C}_i(\delta x, \delta y)$$

Distribution of true shift of part:

$$p_i(\delta x, \delta y) = \frac{1}{2\pi\sqrt{\det(\Gamma_i)}} e^{-\frac{1}{2}(\vec{x}-\vec{x}_i)^T \Gamma_i^{-1} (\vec{x}-\vec{x}_i)}$$

Probability that part belongs to object is probability that they have the same shift:

$$p(i \in object) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} p_i(\delta x, \delta y)\, p_F(\delta x, \delta y)\, d\delta x\, d\delta y$$

**Contour estimation:**

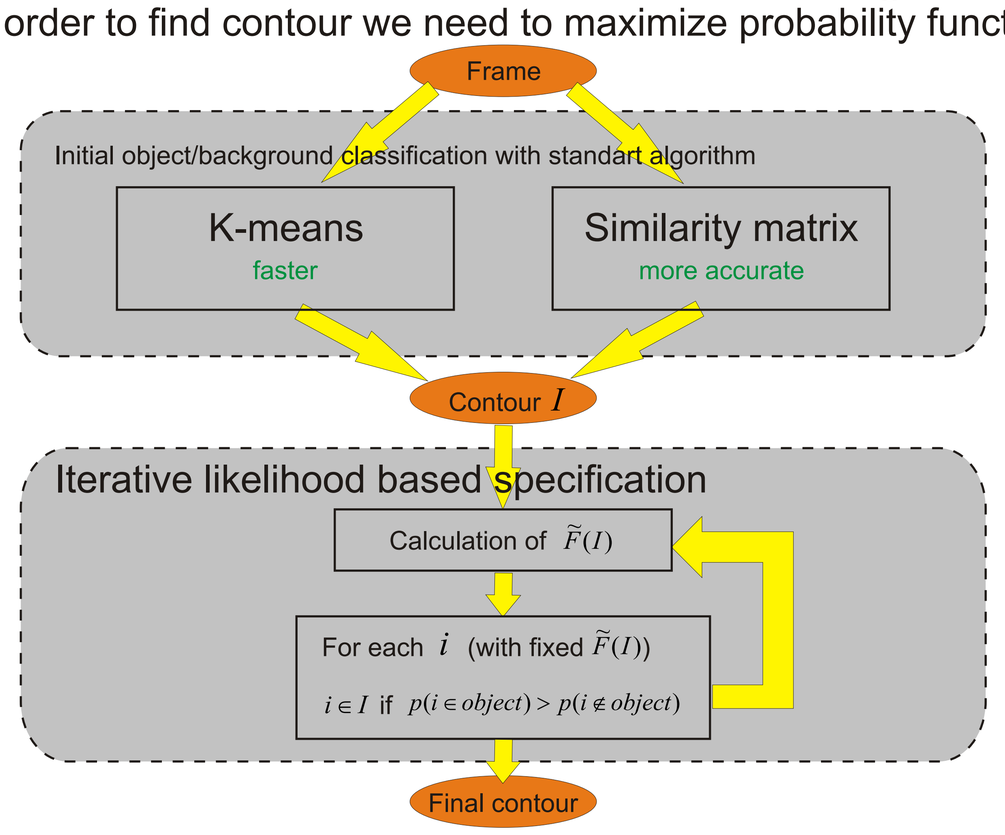
$$I = \arg\max_I J(I)$$

**Shift estimation:**

$$(\delta\hat{x}, \delta\hat{y}) = \arg \min_{(\delta x, \delta y)} \widetilde{F}(I)$$

## Maximum likelihood finding

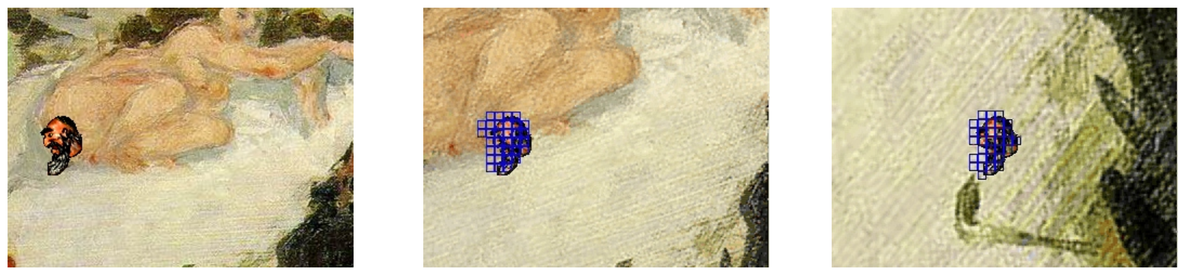
In order to find contour we need to maximize probability function




## Results

### Simulated images

*Moving object on affine tranforming background.*

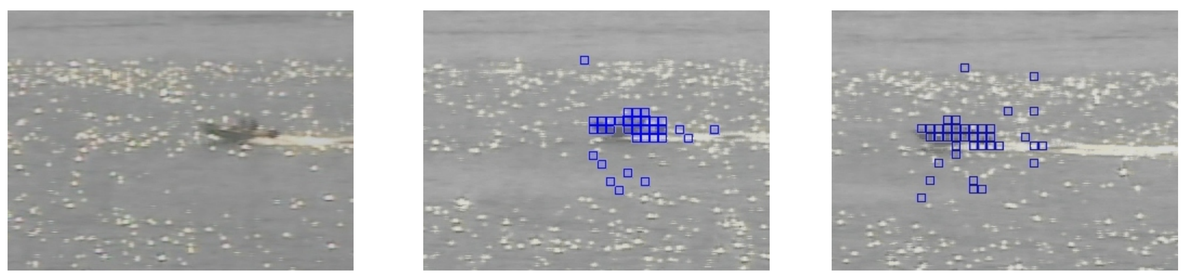


### Person tracking

*Moving object on changing background.*

### Boat tracking

*Moving object on fast changing background with moving camera.*
*Random separated parts can be filtered with morphological algorithms*



## Conclusion

Algorithm of simultaneous contouring and tracking is designed. It showed the following characteristics:

- high performance in case of significant prior uncertainty

- 0.08 rms error of shift estimation

- 30 frames per second on Pentium M 1.7 GHz