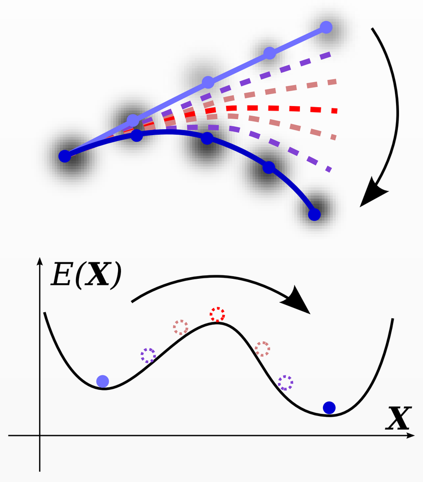

MULTI-TARGET TRACKING BY CONTINUOUS ENERGY MINIMIZATION

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Abstract

We propose to formulate multi-target tracking as minimization of a continuous energy function. Other than a number of recent approaches we focus on designing an energy function that represents the problem as faithfully as possible, rather than one that is amenable to elegant optimization. To find strong local minima of the proposed energy we extend the conjugate gradient method with periodic trans-dimensional jumps. Experiments on public datasets validate our approach.

Objectives

- Form an energy function which represents the actual situation (more) faithfully
- Find strong local minima

Setting

- **Tracking-by-Detection** approach. A sliding window detector (HOG, HOF) extracts a set of hypotheses.
- Data Association (tracking) is performed in 3D world coordinates (On the ground plane).
- Global Tracking formulation: all trajectories within a time window are **optimized jointly**.
- The energy function (1) is minimized by a combination of **conjugate gradient** descent and trans-dimensional **jump moves**.

References

[1] A. Andriyenko and K. Schindler, Multi-Target Tracking by Continuous Energy Minimization, in *CVPR*, 2011

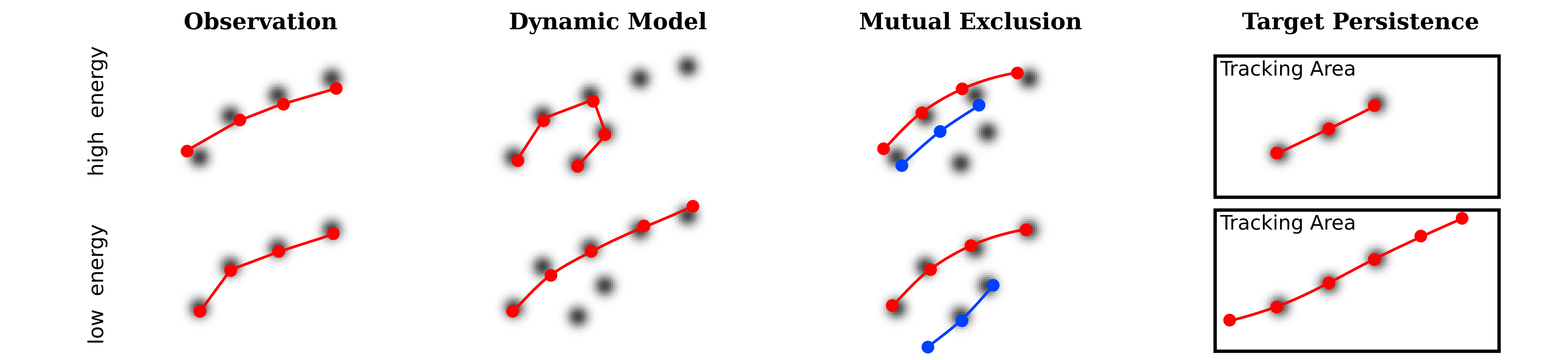
[2] J. M. Ferryman and A. Shahrokni PETS '09: dataset and challenge. In *Winter-PETS*, 2009. www.cvg.rdg.ac.uk/PETS2009/

[3] M. Andriluka, S. Roth, and B. Schiele. Monocular 3d pose estimation and tracking by detection. In *CVPR*, 2010.

Energy

The energy E is defined in continuous space over *all* targets in *all* frames [1]:

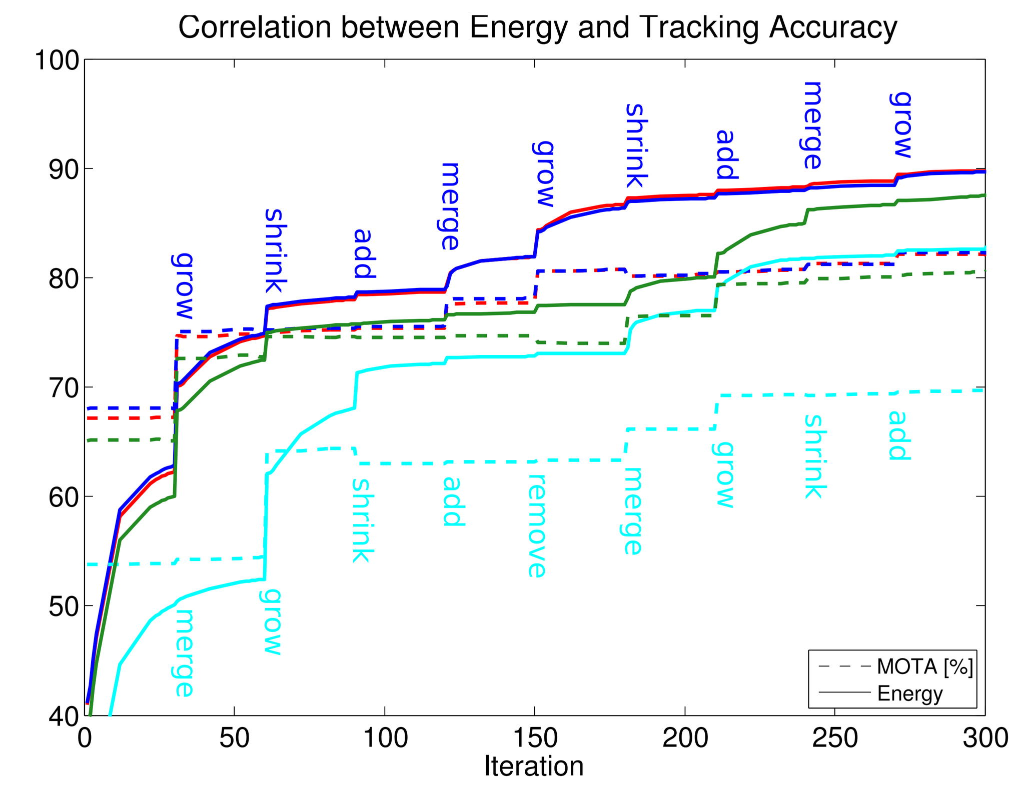
$$E = E_{\text{obs}} + \alpha E_{\text{dyn}} + \beta E_{\text{exc}} + \gamma E_{\text{per}} + \delta E_{\text{reg}} \quad (1)$$

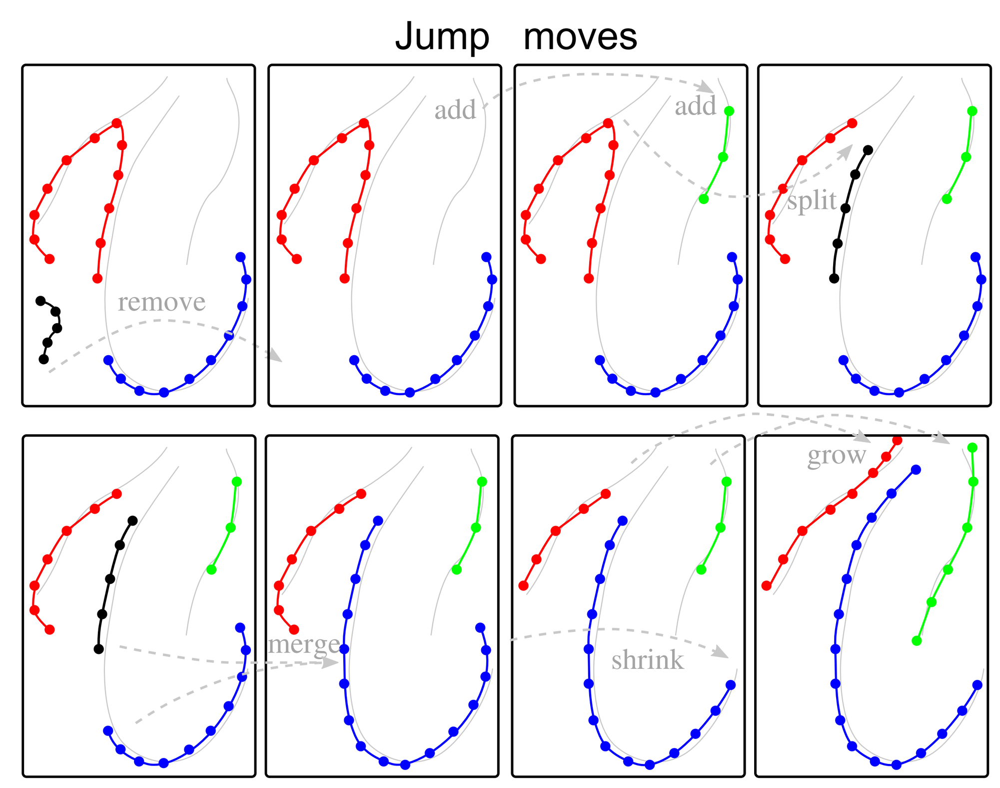


$$\sum_{t,i}\left(\lambda - \sum_{g}\frac{c}{\|\mathbf{X}_i^t - \mathbf{D}_g^t\|^2 + c}\right) \qquad \sum_{t,i}\|\mathbf{v}_i^t - \mathbf{v}_i^{t-1}\|^2 \qquad \sum_{t,i\neq j}\frac{1}{\|\mathbf{X}_i^t - \mathbf{X}_j^t\|^2} \qquad \sum_{i,t=1,F}\frac{1}{1+\exp(1-b(\mathbf{X}_i^t))}$$

Optimization

1. Initialize with an arbitrary tracker, *e.g.* Extended Kalman Filter (EKF), ILP, etc...
2. Minimize E locally using conjugate gradient descent.
3. Execute a jump move to find a better configuration (see figure below).
4. Iterate steps 2 and 3 until convergence or max. number of iterations.





Results

Quantitative results of an EKF-tracker (initial) and our method (final).

Sequence	MOTA [%]			MOTP [%]			MT		
	initial	final	**diff**	initial	final	**diff**	initial	final	**diff**
TUD [3]	53.3	60.9	**+7.6**	57.4	65.9	**+8.4**	5	6	**+1**
PETS [2]	64.7	78.7	**+14.0**	75.4	76.7	**+1.4**	9	16	**+7**