Object Flow

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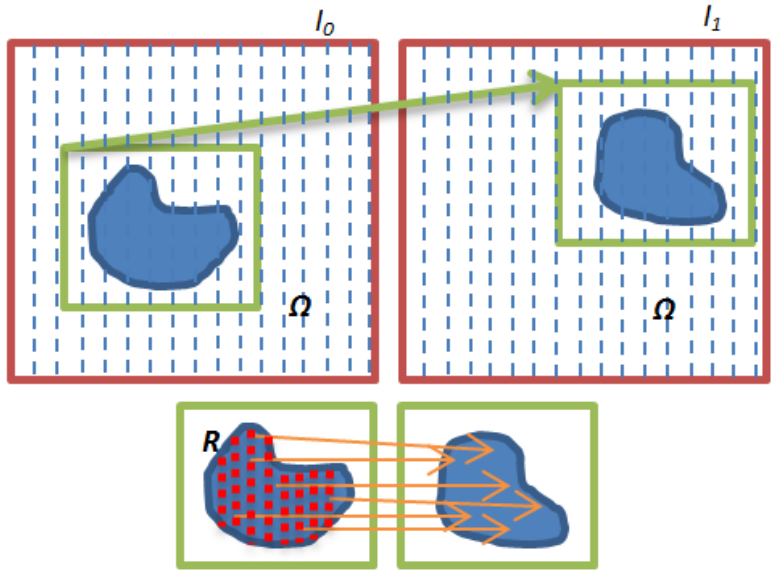
technicolor

Introduction

Problem definition

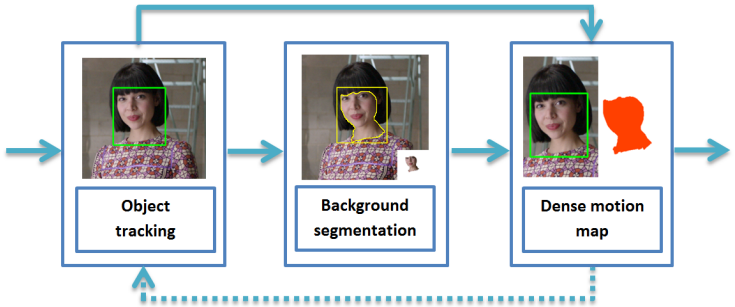
Given an image sequence, say $I_t, t : 0..N-1$, and an initial position of the interest object in the first frame of this sequence. Let $\mathcal{R} \in \Omega$ be the region corresponding to the support of the object in the bi-dimensional grid Ω. Then, the object flow, $\mathcal{O}(x)$, is defined as $\mathcal{O}(x) = d_{0,t}(x), \forall x \in \mathcal{R}$.



Pipeline

Object flow pipeline

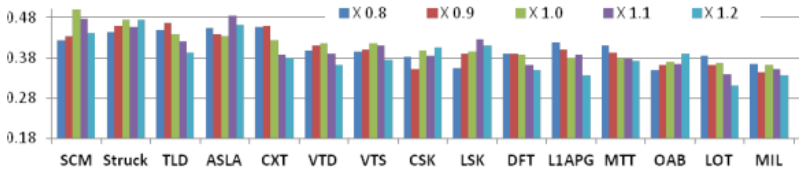
3 main steps: Tracking, Segmentation and Flow estimation. What information to use to refine the object motion?



Tracking

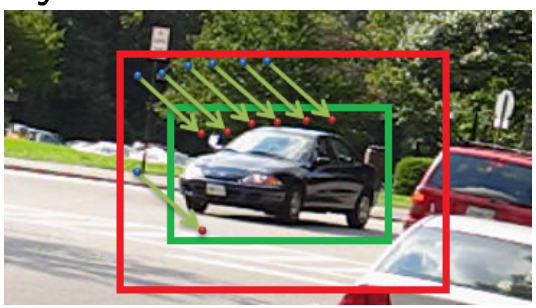
Tracking

Tracking by detection methods have shown very good performance in modern benchmarks.



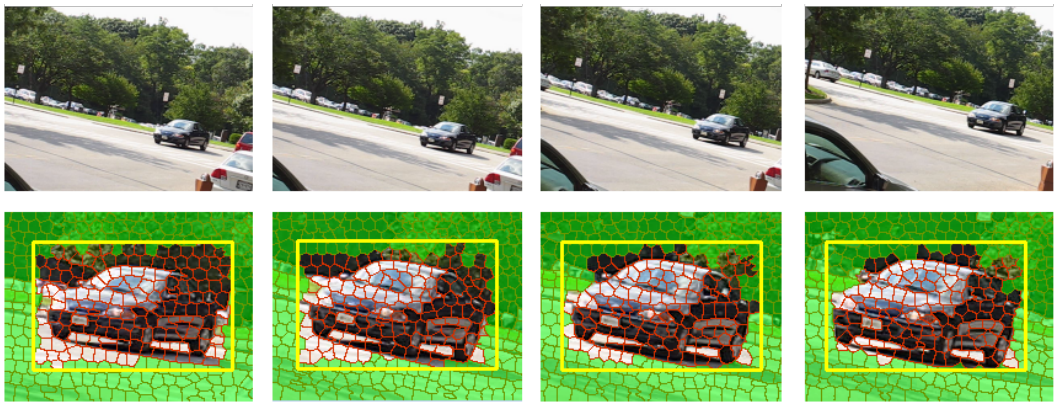
Segmentation

Tracker window offers valuable information for object segmentation. Can it be completed naturally by video dynamics?



Background tracking

Regions outside window can be labelled as background...



Segmentation

Superpixel flow

A superpixel matching method is used to track background regions. This matching can be modelled with a pairwise Markov Random Field.

$$E(l) = \sum_{p \in \Gamma} D_p(l_p; I_0, I_1) + \sum_{(p,q):q \in \mathcal{N}_r} S_{p,q}(l_p, l_q)$$

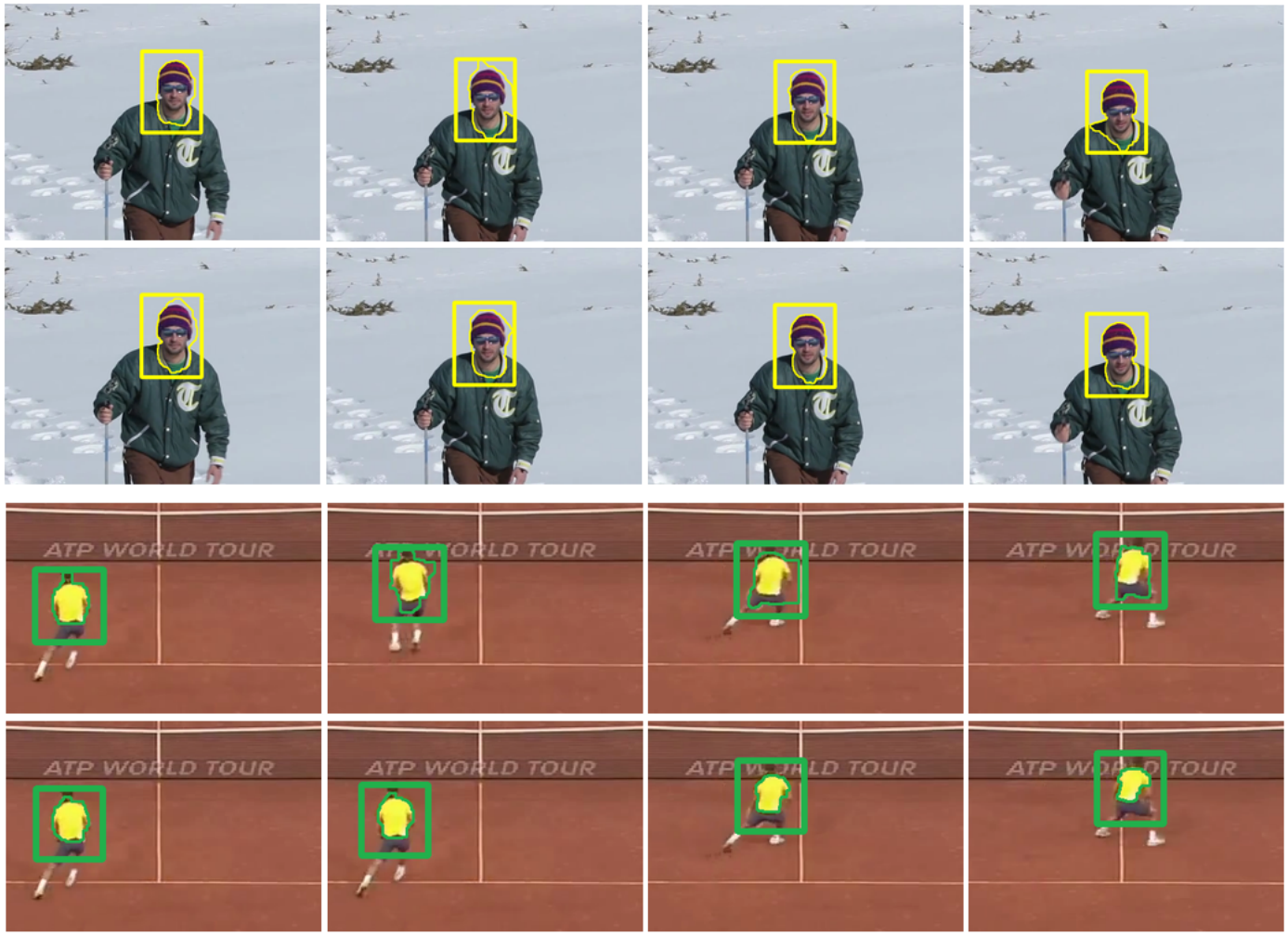
With l the set of labels of the superpixels in I_0, that match with those in I_1. $\mathcal{N}_r$ is a neighbourhood of radius r of the superpixel p. Γ is the set of superpixels in an image.

Data and Spatial terms

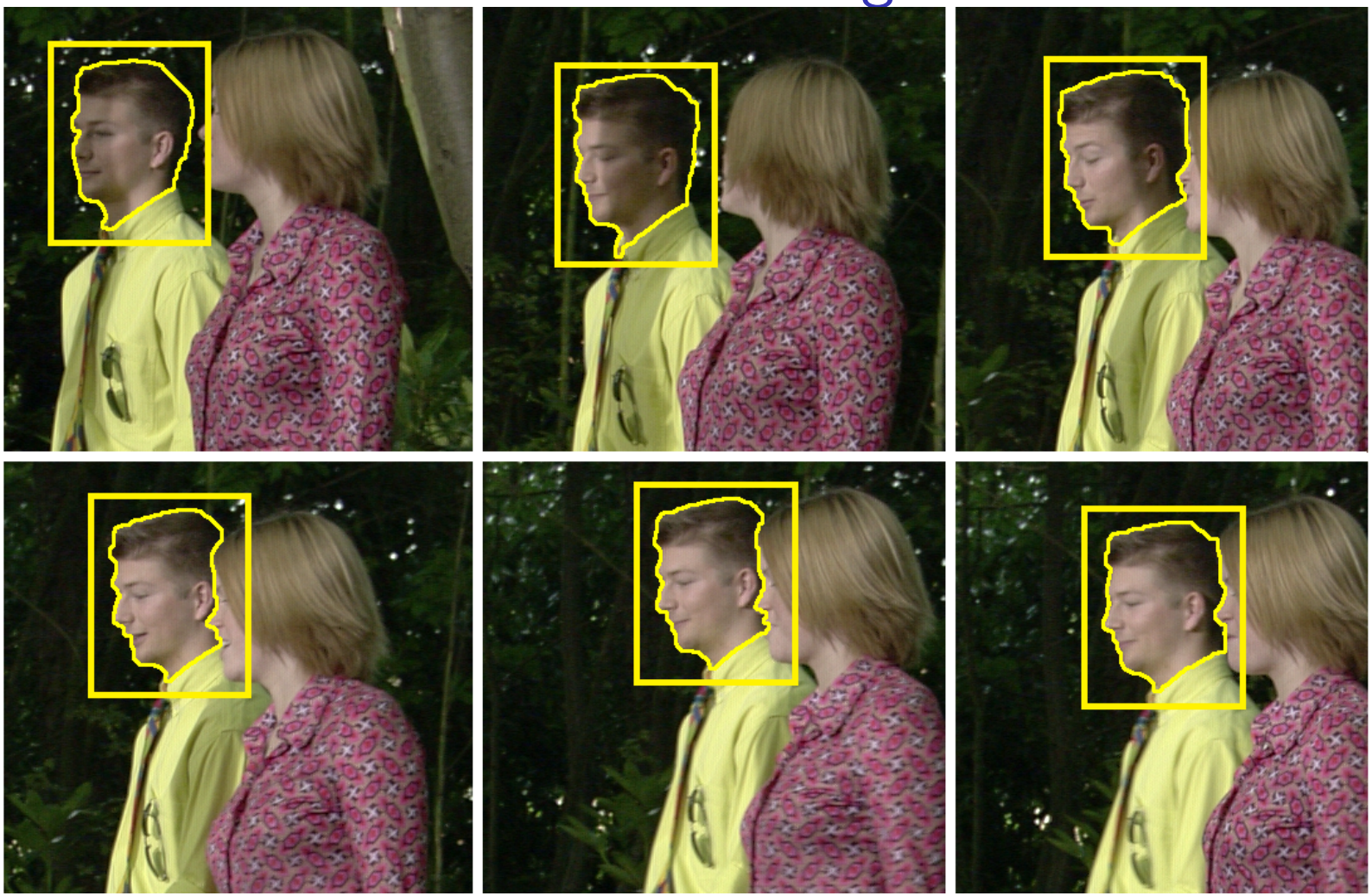
The correspondent superpixels are similar. $D_p(l_p; I_0, I_1) = \sqrt{1 - \frac{1}{\sqrt{\bar{\mathbf{h}}(p)\bar{\mathbf{h}}(p')N^2}} \sum_i \sqrt{\mathbf{h}_i(p)\mathbf{h}_i(p')}}$.

Similar superpixels in one frame have similar motion vector. $S_{p,q}(l_p, l_q) = \lambda(p)\sqrt{\frac{|u_{p_c} - u_{q_c}|}{\|p_c - q_c\|} + \frac{|v_{p_c} - v_{q_c}|}{\|p_c - q_c\|}}$

Segmentation



Segmentation

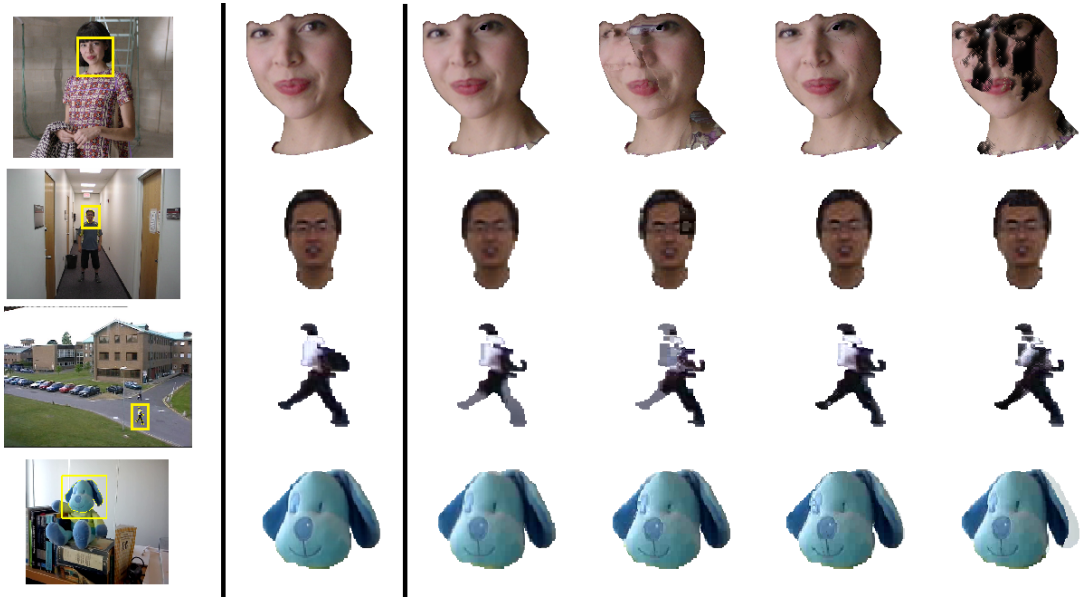


Flow estimation

In which parts of an image is valid the optical flow smoothness prior?

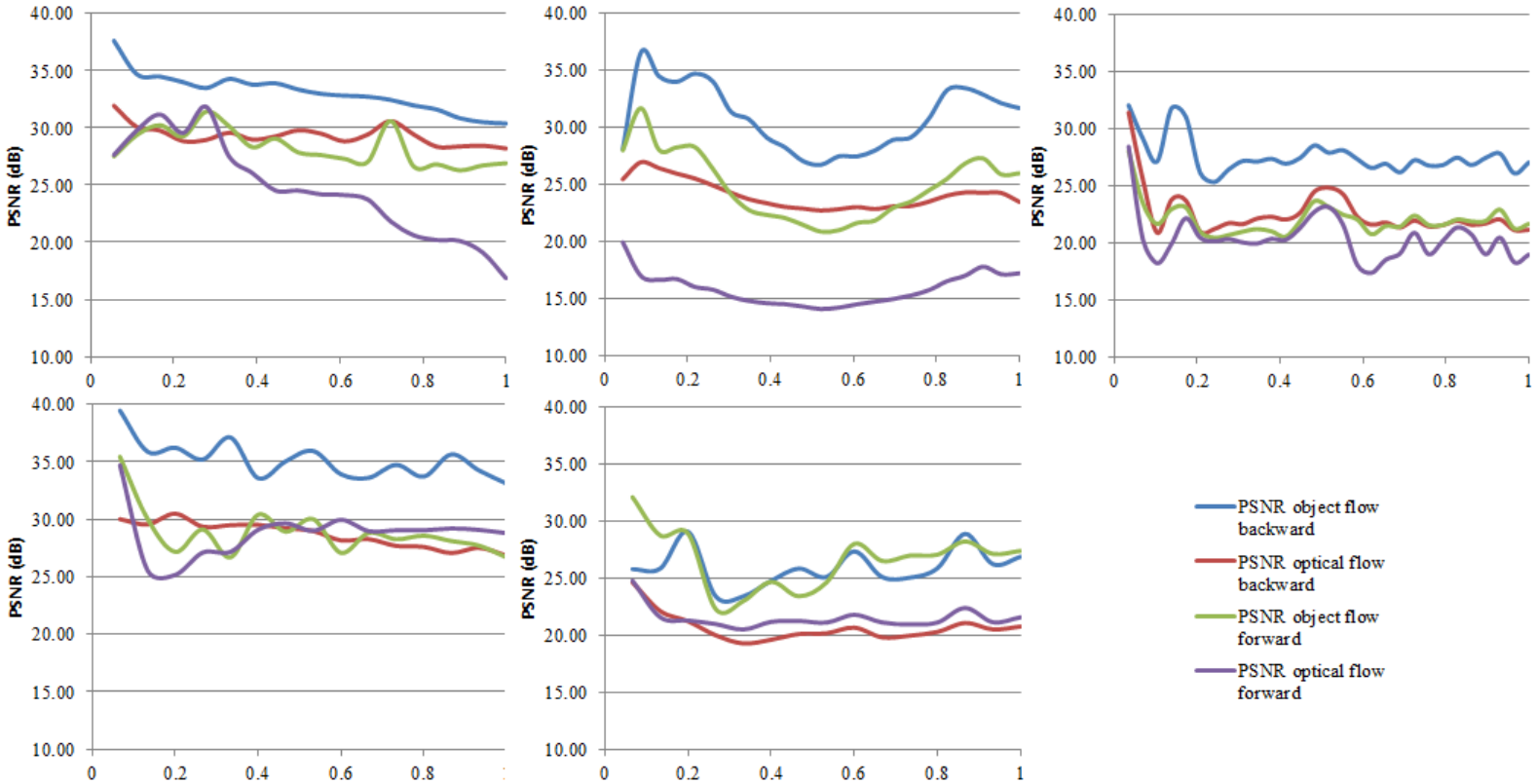
Visual results

Extrapolation results between frame 2 distant frames by using integrated flow. GT Object. Object flow backward, Object flow forward, Optical flow backward, and forward. Simple Flow.



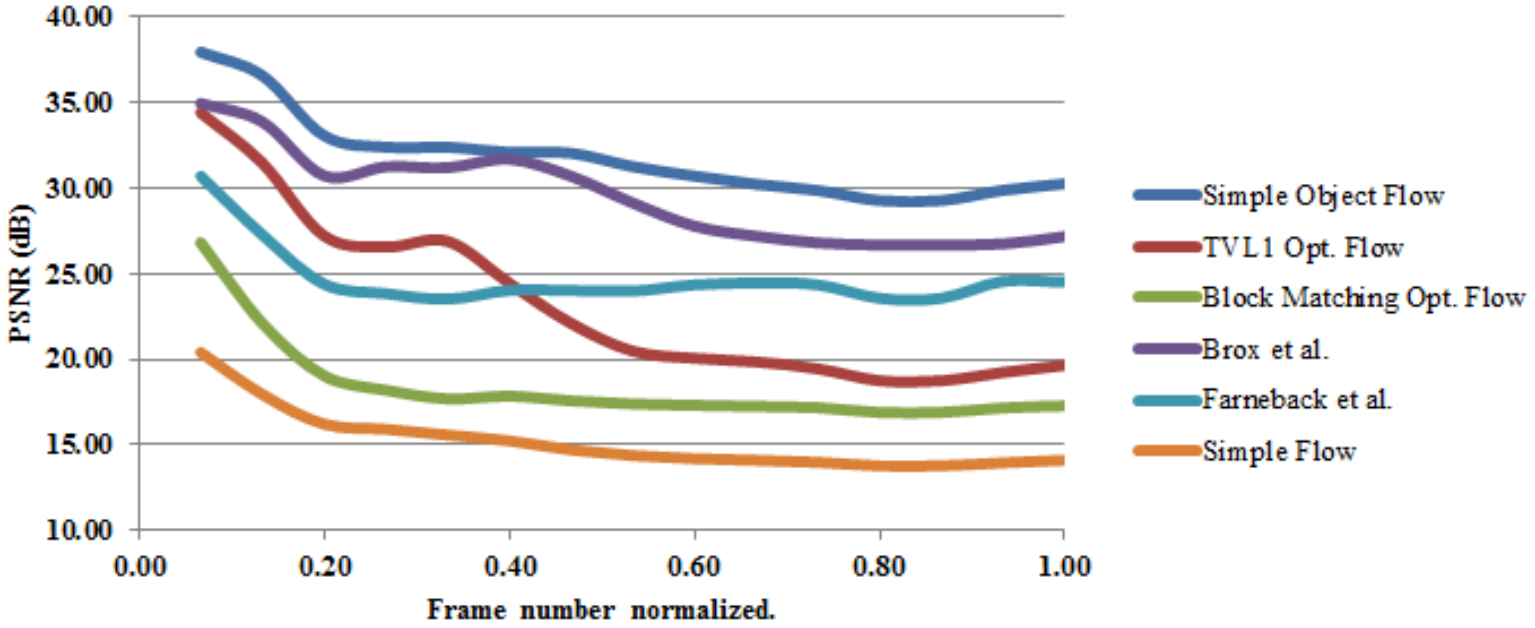
Numerical results

PSNR for every extrapolated frame.



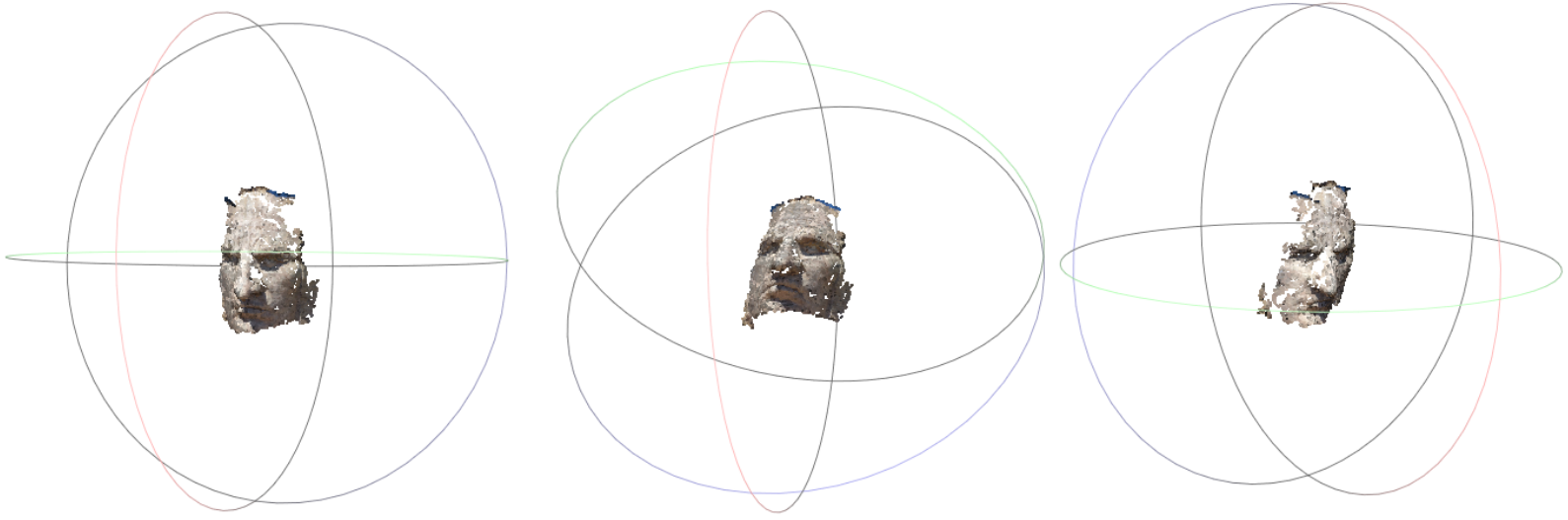
Numerical results

Comparing several optical flow method with the object flow.



Video edition

SfM



Conclusions

1. The object flow problem is presented.
2. A method to match superpixel is explored.
3. An algorithm for object segmentation in video is explained.
4. A system to compute the object flow is proposed.
5. This system has shown to be more precise for dense object motion estimation than regular optical flow methods.
6. Examples of the use of the object flow in real scenarios are presented.