REGION TRACKING ALGORITHMS
ON LASER SCANNING DEVICES APPLIED TO CELL TRAFFIC ANALYSIS

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Abstract

In vivo and *in situ* confocal images are often distorted by motion artifacts and soft tissue deformations. To measure small amplitude phenomena on this type of images, we have to compensate for those artifacts. We present in this paper a Region Of Interest (ROI) tracking algorithm specialized for confocal imaging using a scanning device. Two different algorithms are presented: one based on the motion artifacts, and one based on affine registration. One typical application of this tool is developed: the blood velocity estimation inside a capillary on a moving organ. These first results show that the method permits accurate estimations of blood cell velocities even in presence of motion artifacts.

In vivo Imaging and Motion Artifacts

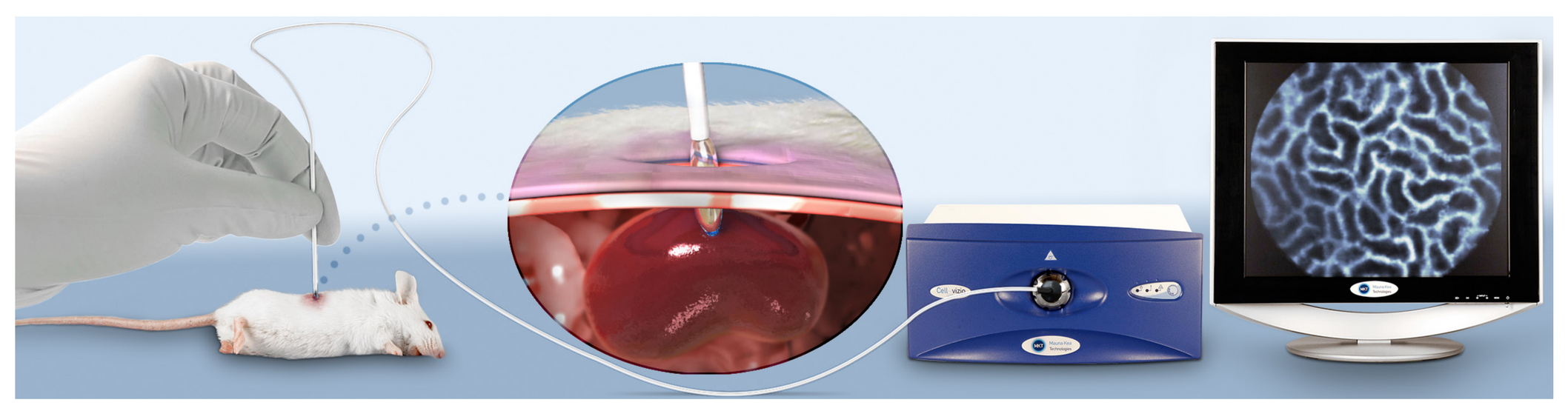


Fig. 1. Typical minimally invasive experimental setup with Cellvizio®. The kidney is accessed through a buttonhole.

Cellvizio® is a complete imaging system distributed by Leica in North America, Europe and Japan under the name Leica FCM-1000. It is based on a fibered technology for fluorescence confocal imaging of the living animal. It acquires microscopic resolution sequences, displays them in real-time and enables live measurements.

In vivo confocal microscopy
- Create motion artifacts due to tissue or objective motion
- Classical image stabilization and registration technique are not directly applicable

Still, there is a growing need for quantification on specific moving organs: liver, bladder, heart...
- Pharmaco-kinetics parameters of molecules, Changing morphology of micro-structures, Bio distribution parameters...

Fig. 2. Slit-scan photo by J.H. Lartigue

Region Tracking

Motion Compensation Algorithm

- Estimation of translation using 2D cross-correlation
- Estimation of the velocity: $\tilde{\eta} = [\tilde{\eta}^x, \tilde{\eta}^y]$
- Computation of the distortion tranformation: v_k

$$\begin{cases} x_d = x + (t(x) - t(0))\tilde{\eta}^x = x + (y/v_y)\tilde{\eta}^x = x + \eta^x y, \\ y_d = y + (t(y) - t(0))\tilde{\eta}^y = y + (y/v_y)\tilde{\eta}^y = (1 + \eta^y)y. \end{cases}$$

- Optimization of the rigid transformation: r_k

The resulting transformation between frames j and k is:

$$f_{j,k}(p) = v_j^{-1} \circ r_j^{-1} \circ r_k \circ v_k = v_j^{-1} \circ r_{j,k} \circ v_k$$

Affine Registration Algorithm

- Initialize translation using 2D cross-correlation
- Optimize Affine Transformation T_k^a using SSD criterion

$$\sum_p \|I(p) - I_k(T_k^a(p))\|^2$$

Performance Comparison

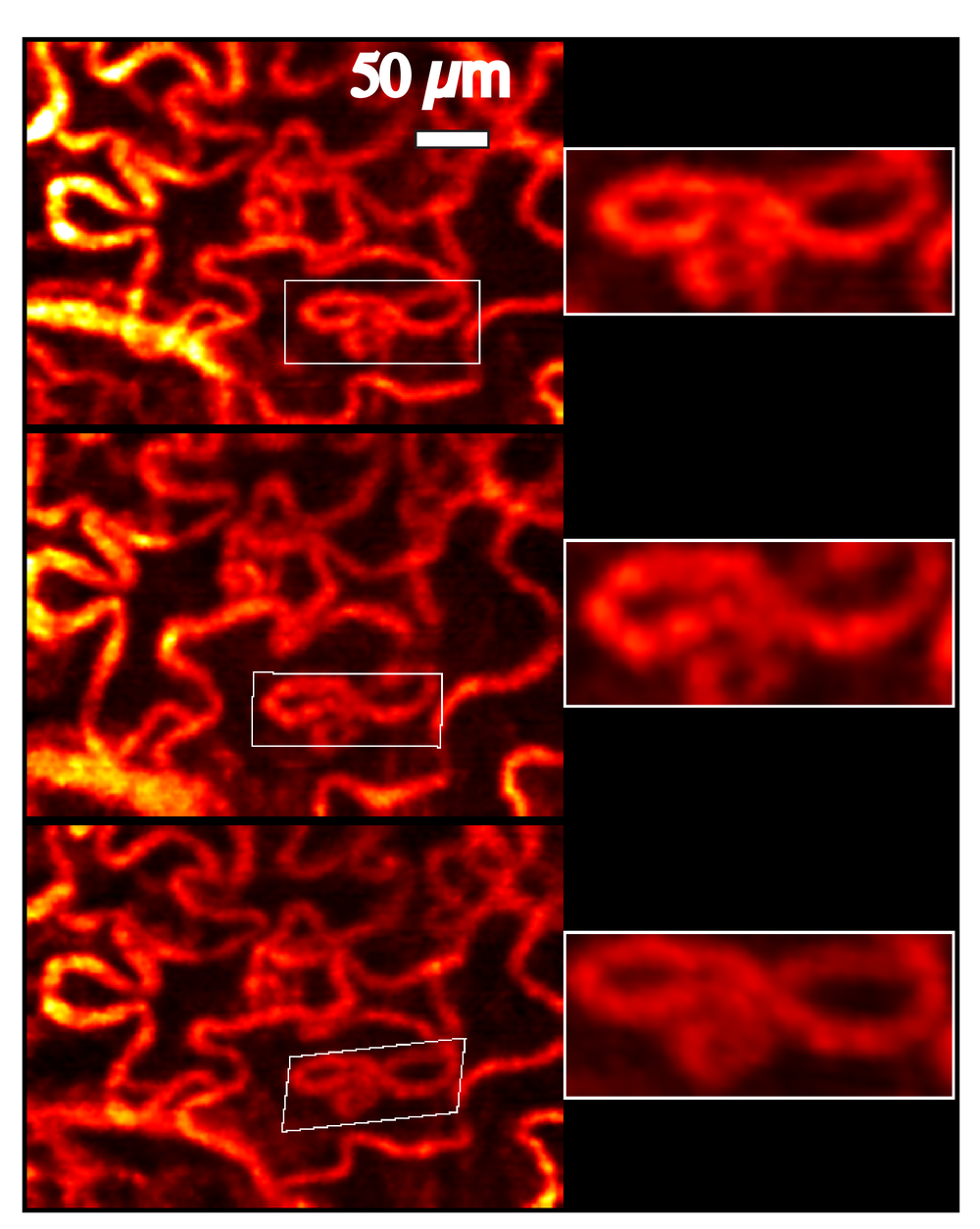


Fig. 3. Motion Compensation Algorithm

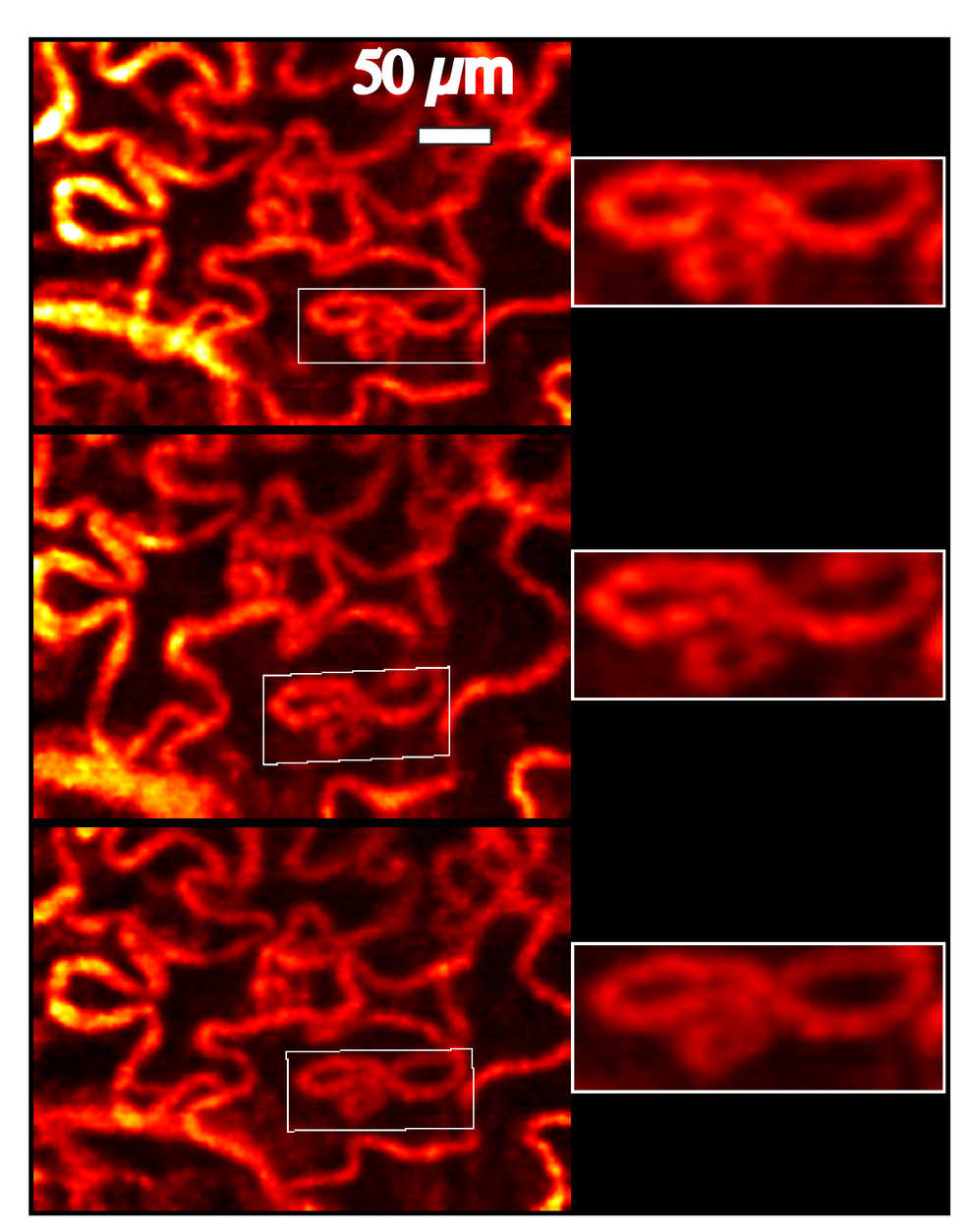


Fig. 4. Affine Registration Algorithm

Images Fig 3 and 4 are courtesy of Anne-Carole Duconseille and Olivier Clément, Descartes Image, Small Animal Imaging Facility, Université Paris V, Paris, France

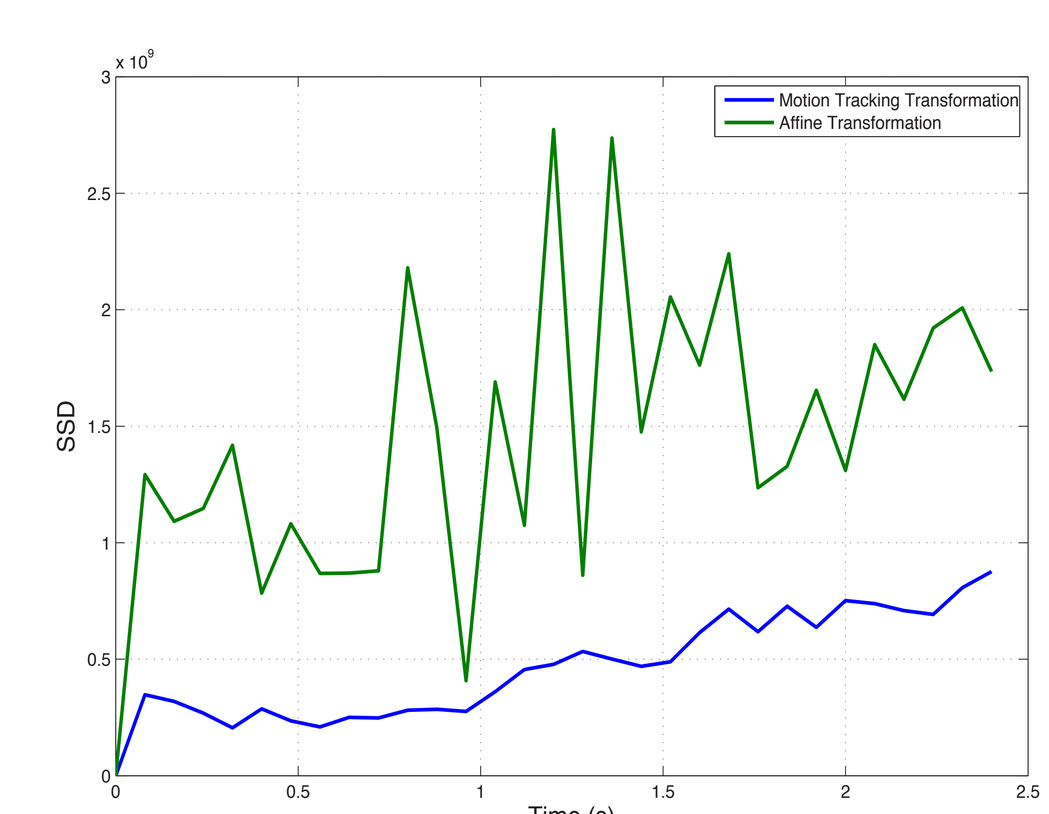
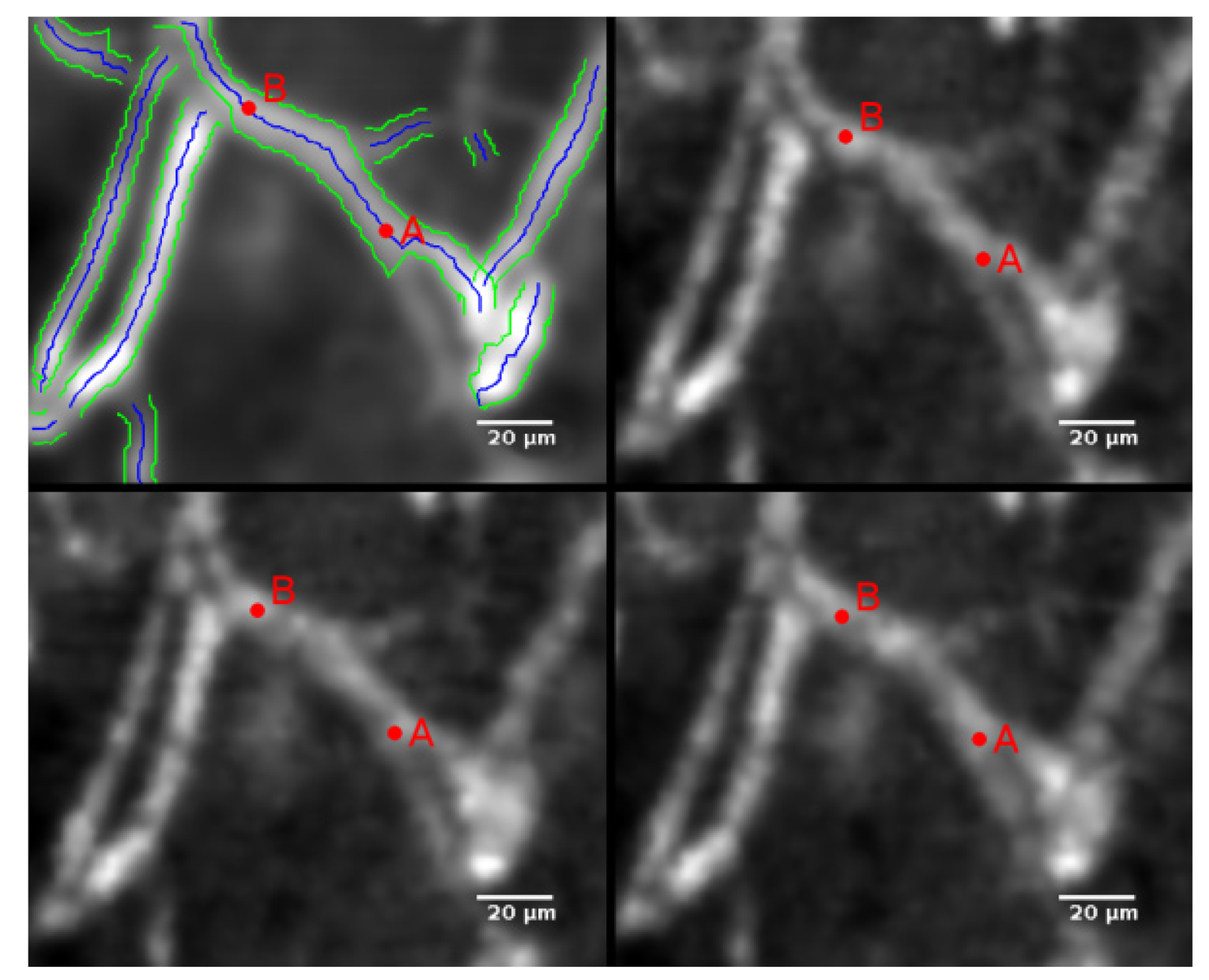


Fig. 5. SSD measurement on final result

Motion Compensation
+ physic (model) based
+ more stable
+ faster

Affine Registration
+ more generic
+ if good stability, can be more accurate

Application To Cell Traffic Analysis



Images Fig 6 and right strip of this poster are courtesy of Raphaël Boisgard, Frédéric Ducongé and Bertrand Tavitian, CEA SHFJ, Inserm, U 803 Orsay France

Fig. 6. Vessel Detection on mean image, and spatio-temporal analysis of blood flow along medial axis AB.

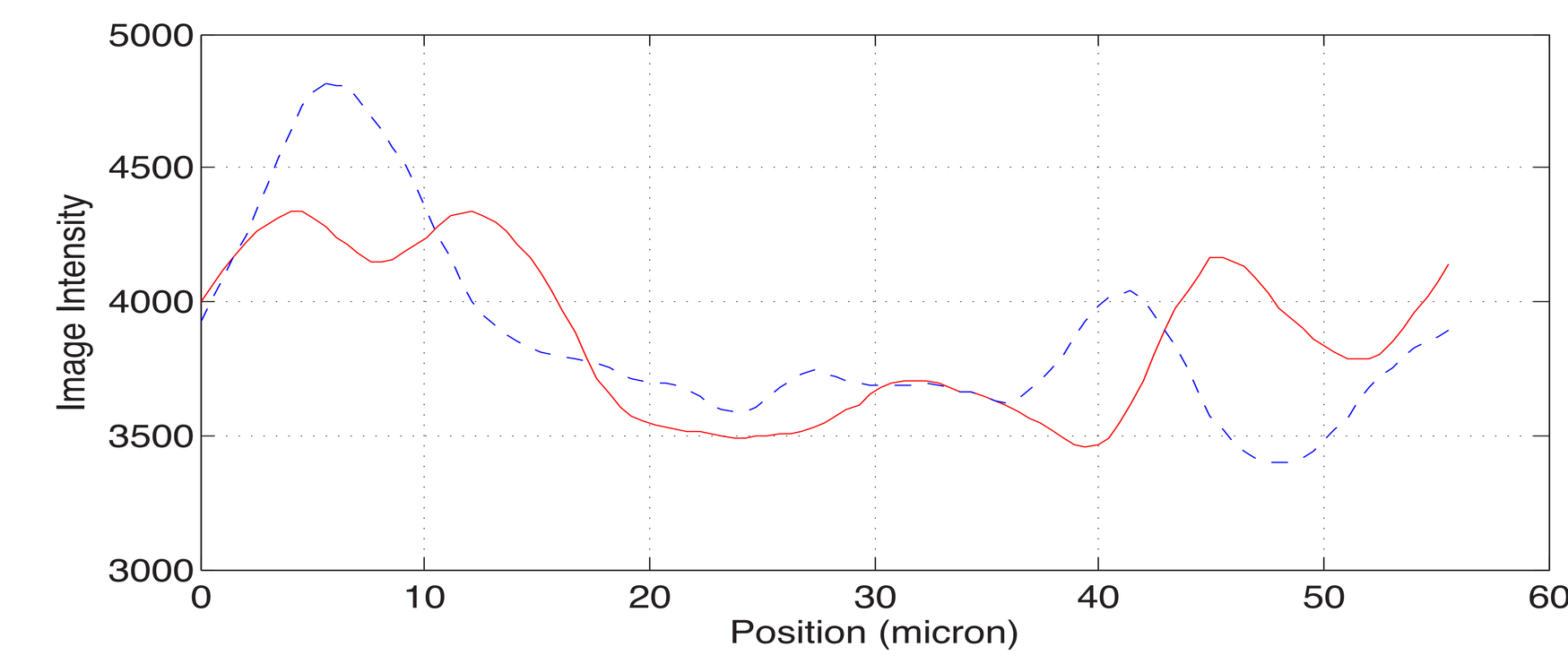


Fig. 7. A-B lines from medial axis detection on two contiguous frames.

- In vivo imaging of a tumoral skin Xenograft on a mouse
- Manual selection of a Region Of Interest
- Automatic tracking of the ROI
- Vessel Detection on the temporal mean ROI (Krissian et. al., 2000)
- Spatio-temporal analysis by cross correlation

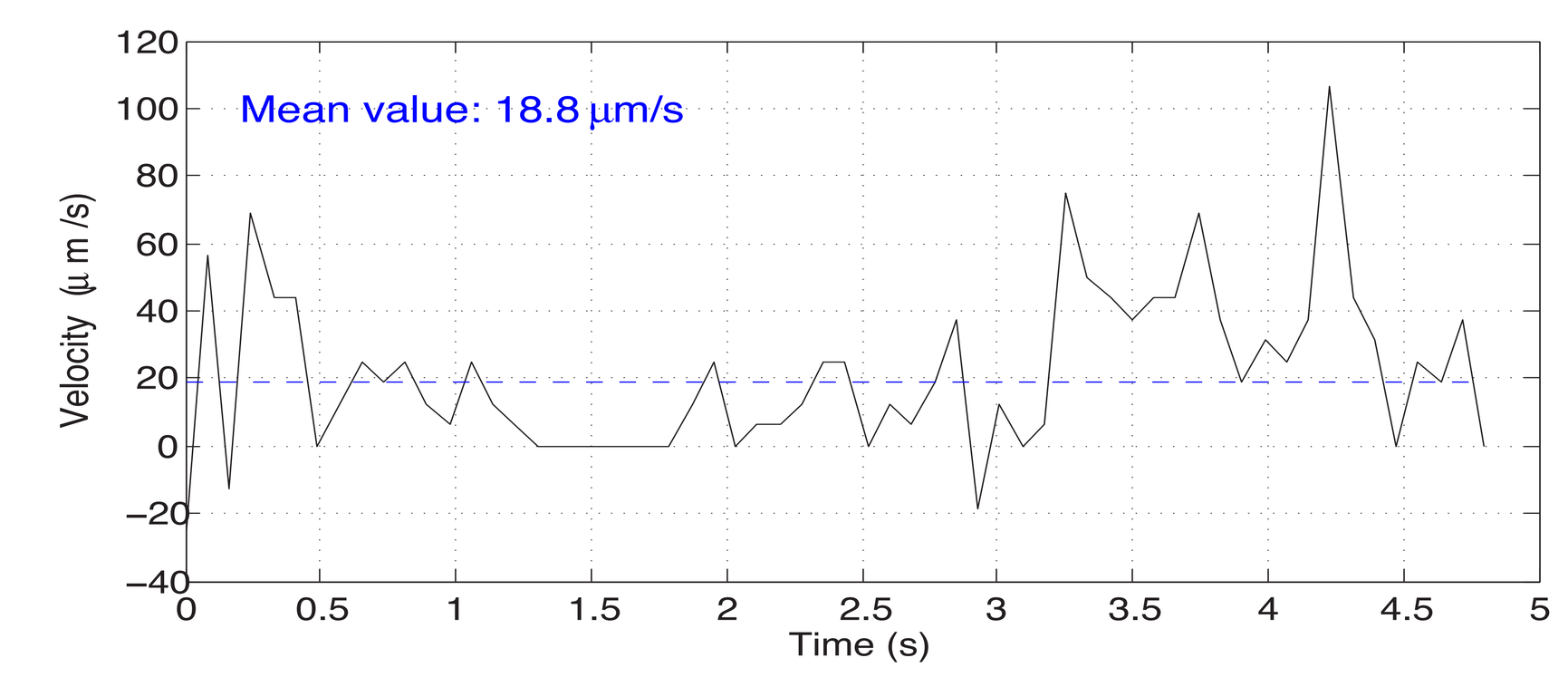


Fig. 8. Velocity estimation at 12Hz frame rate after motion tracking. The blue line is the mean velocity.

Contributions and Conclusion

In vivo and *in situ* microscopic imaging bring new constraints to image quantification: constant motion and large amount of data.

Our contribution is to bridge the gap between *in vivo in situ* confocal microscopy and standard confocal microscopy when dealing with morphological quantification:
- Bring stability as a preprocessing step,
- Motion tracking is based on physical model (motion compensation algorithm), or includes more generic transformation (affine)
- In the near future: stabilization should be real-time

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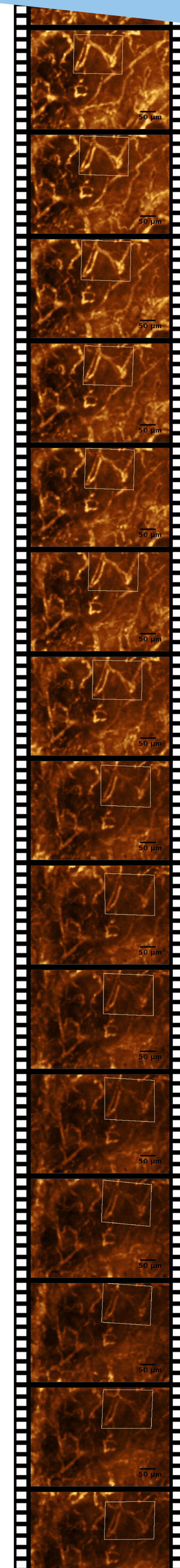

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