

Tracking

Thierry Pécot

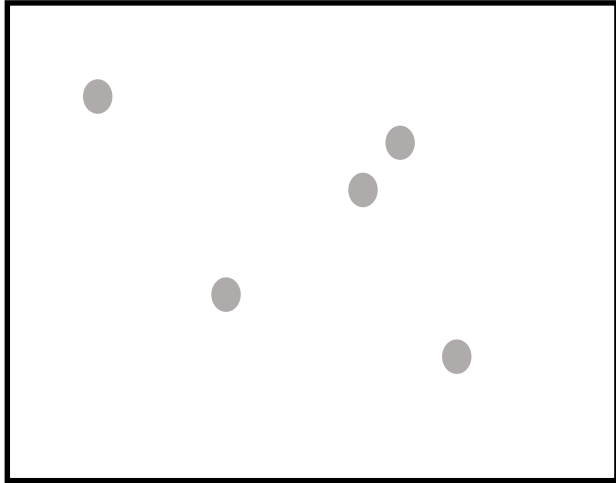
Research Engineer

Biosit SFR UMS CNRS 3480 – Inserm 018

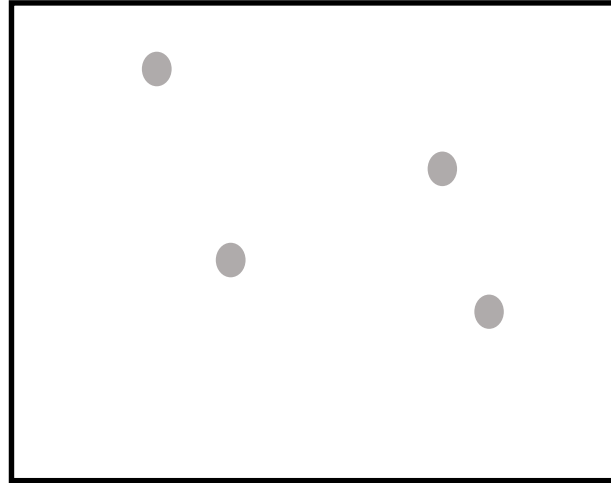
CZI Imaging Scientist



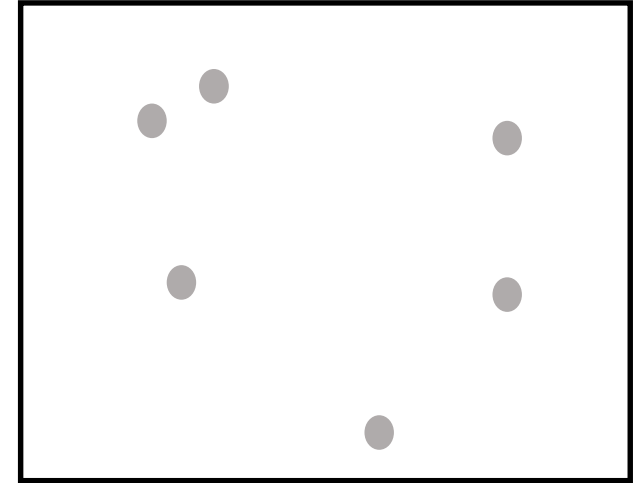
TRACKING MAIN STEPS



Frame #1



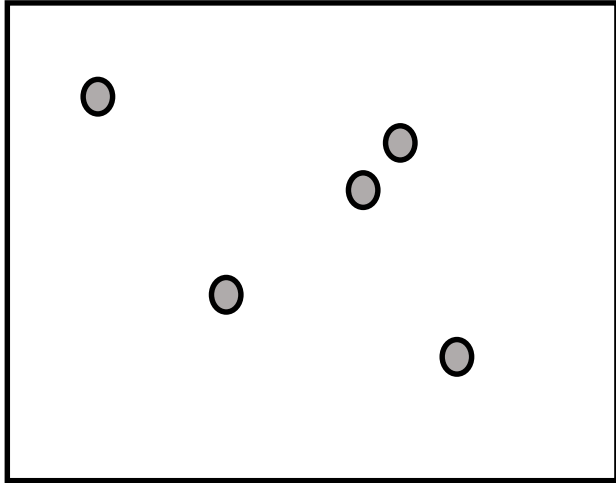
Frame #2



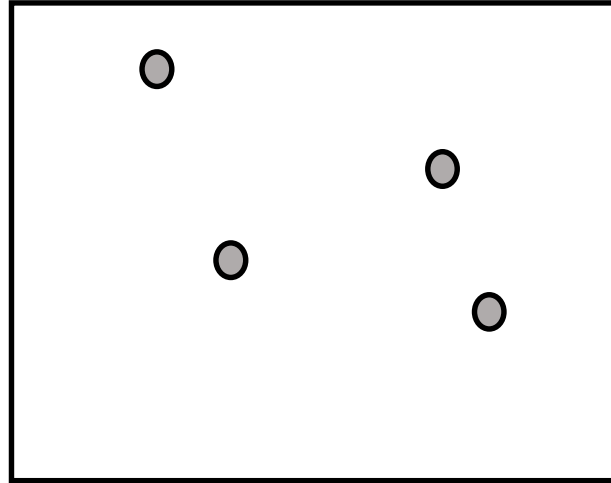
Frame #3

TRACKING MAIN STEPS

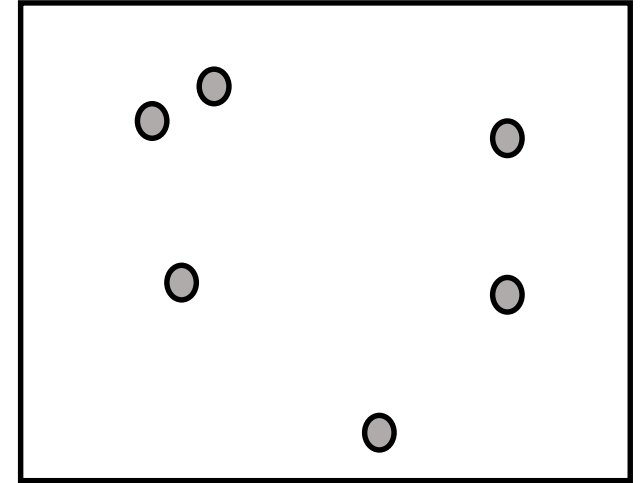
Segmentation



Frame #1



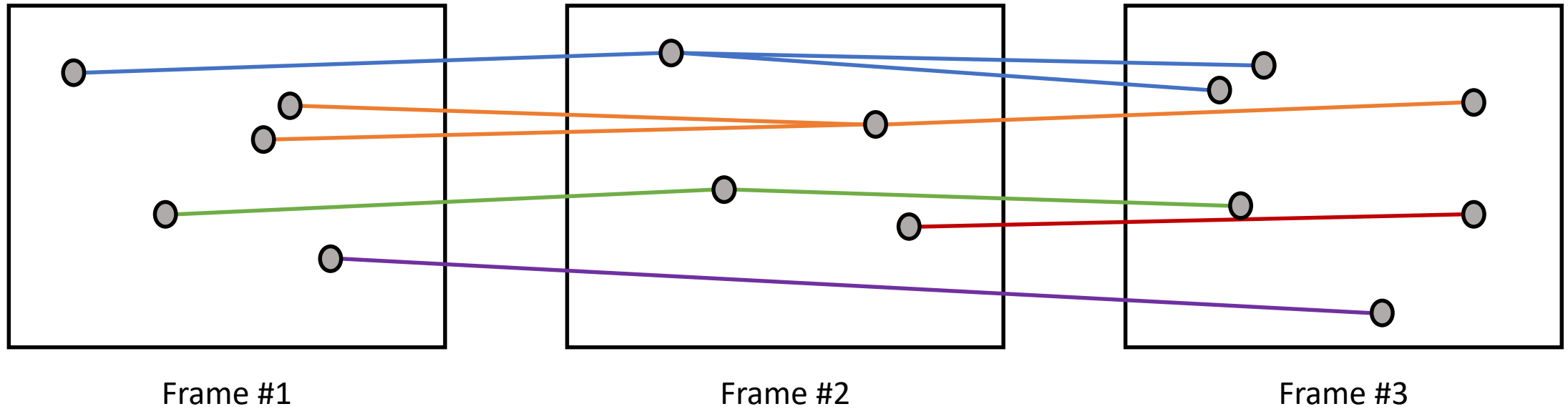
Frame #2



Frame #3

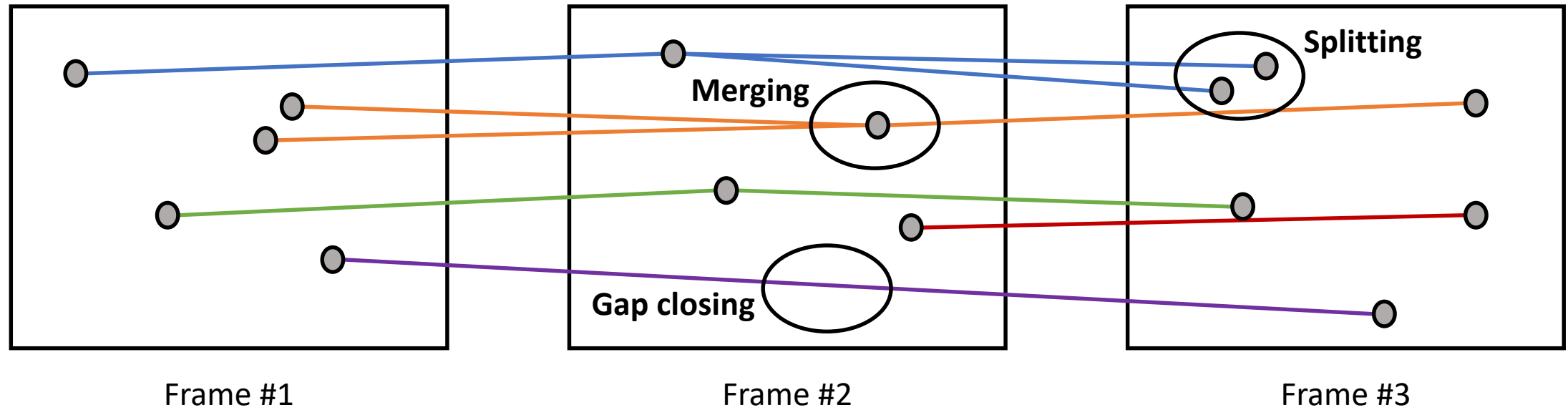
TRACKING MAIN STEPS

Data association, particle linking,...



TRACKING MAIN STEPS

Special events





Methods












Volume 115, 15 February 2017, Pages 80-90



TrackMate: An open and extensible platform for single-particle tracking

Jean-Yves Tinevez ^a , Nick Perry ^{a, 1}, Johannes Schindelin ^{b, 2}, Genevieve M. Hoopes ^c, Gregory D. Reynolds ^c, Emmanuel Laplantine ^d, Sebastian Y. Bednarek ^c, Spencer L. Shorte ^a, Kevin W. Eliceiri ^{b, e}

Bringing TrackMate into the era of machine-learning and deep-learning

 Dmitry Ershov, Minh-Son Phan,  Joanna W. Pylvänäinen,  Stéphane U. Rigaud, Laure Le Blanc,  Arthur Charles-Orszag,  James R. W. Conway,  Romain F. Laine,  Nathan H. Roy,  Daria Bonazzi,  Guillaume Duménil,  Guillaume Jacquemet,  Jean-Yves Tinevez

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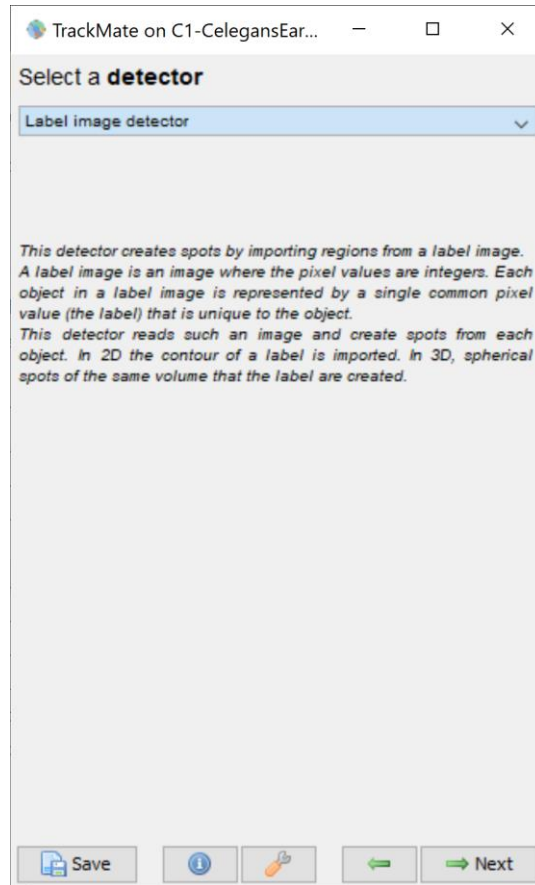
Robust single-particle tracking in live-cell time-lapse sequences

[Khuloud Jaqaman](#) , [Dinah Loerke](#), [Marcel Mettlen](#), [Hirotaka Kuwata](#), [Sergio Grinstein](#), [Sandra L Schmid](#) & [Gaudenz Danuser](#)

1 - SEGMENTATION

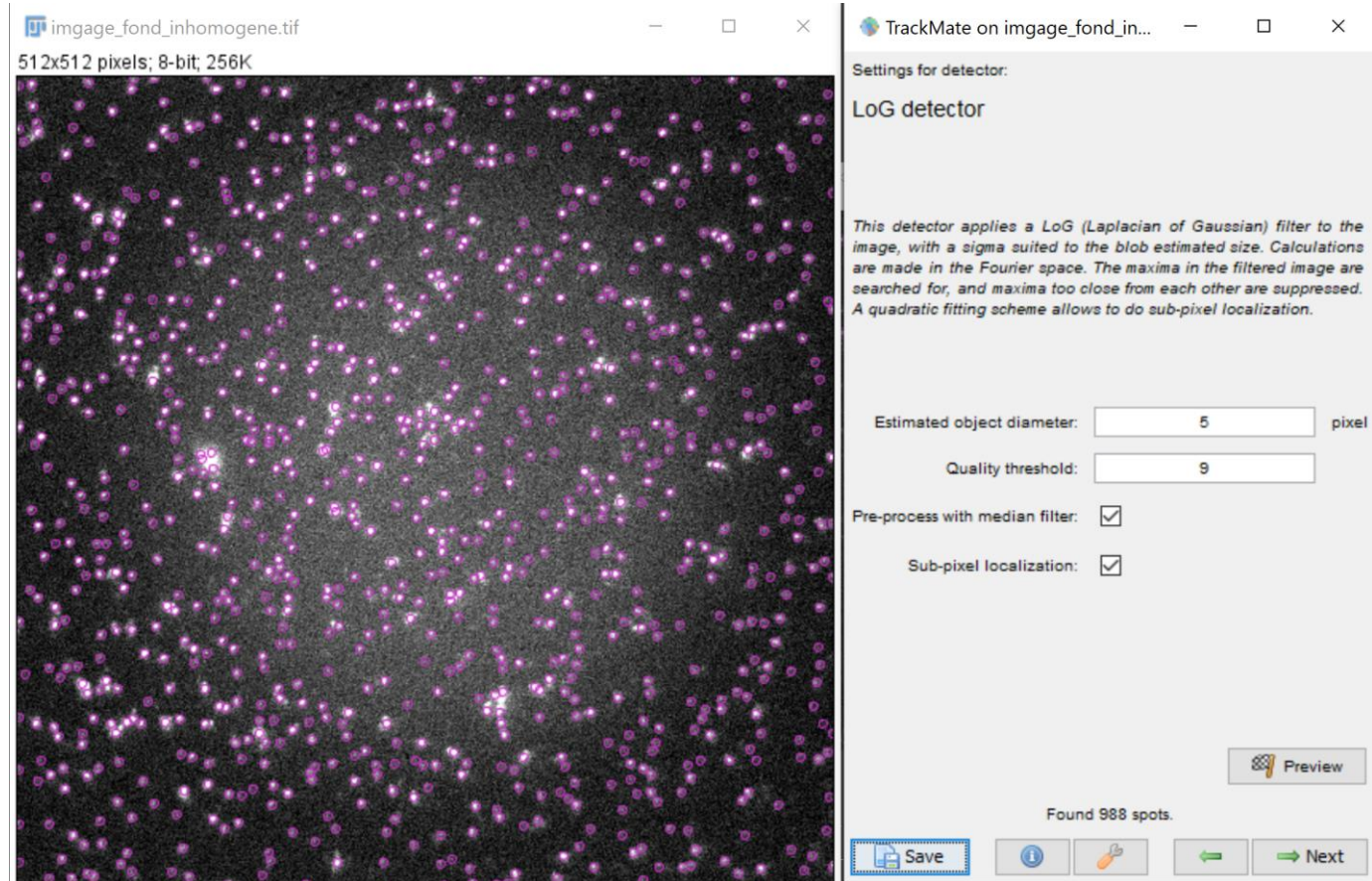
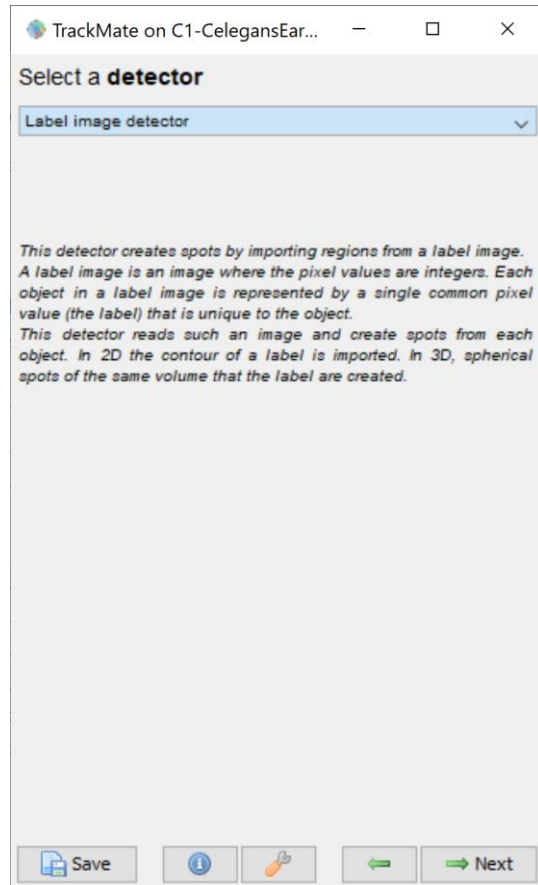
Classic detectors:

- **Manual annotation**
- **Threshold detector**
- **DoG/LoG detector**



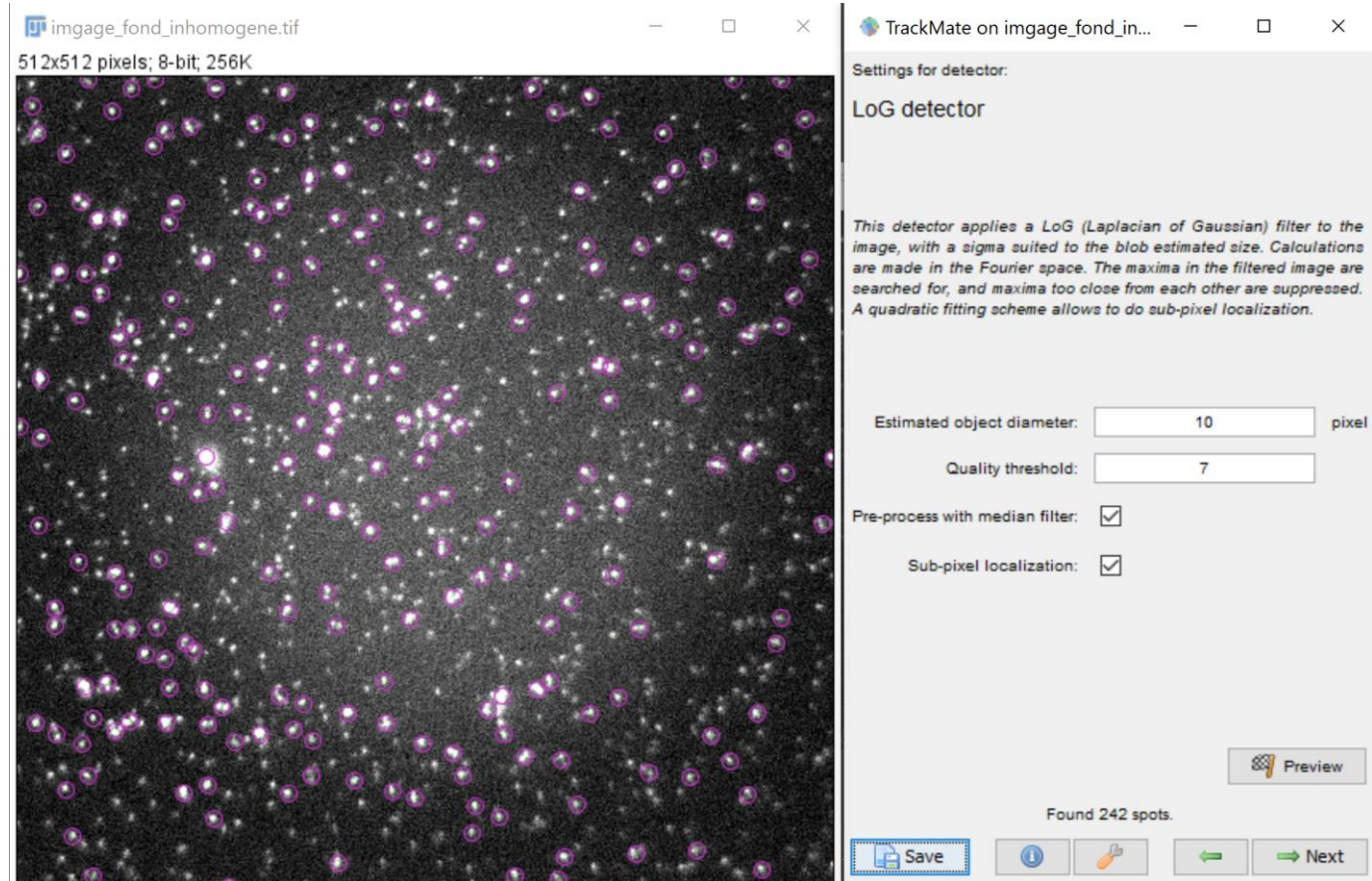
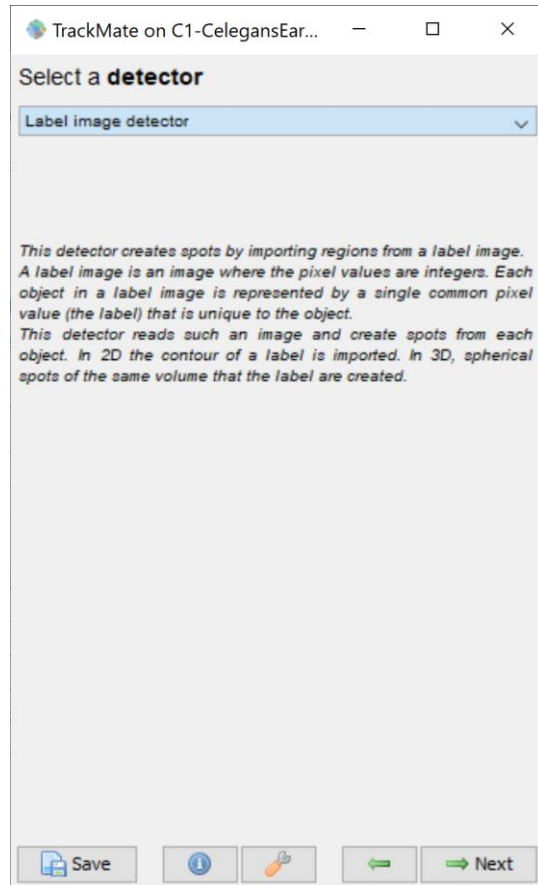
1 - SEGMENTATION

LoG detector: scale-based detector, powerful with **objects of the same size** such as intracellular particles



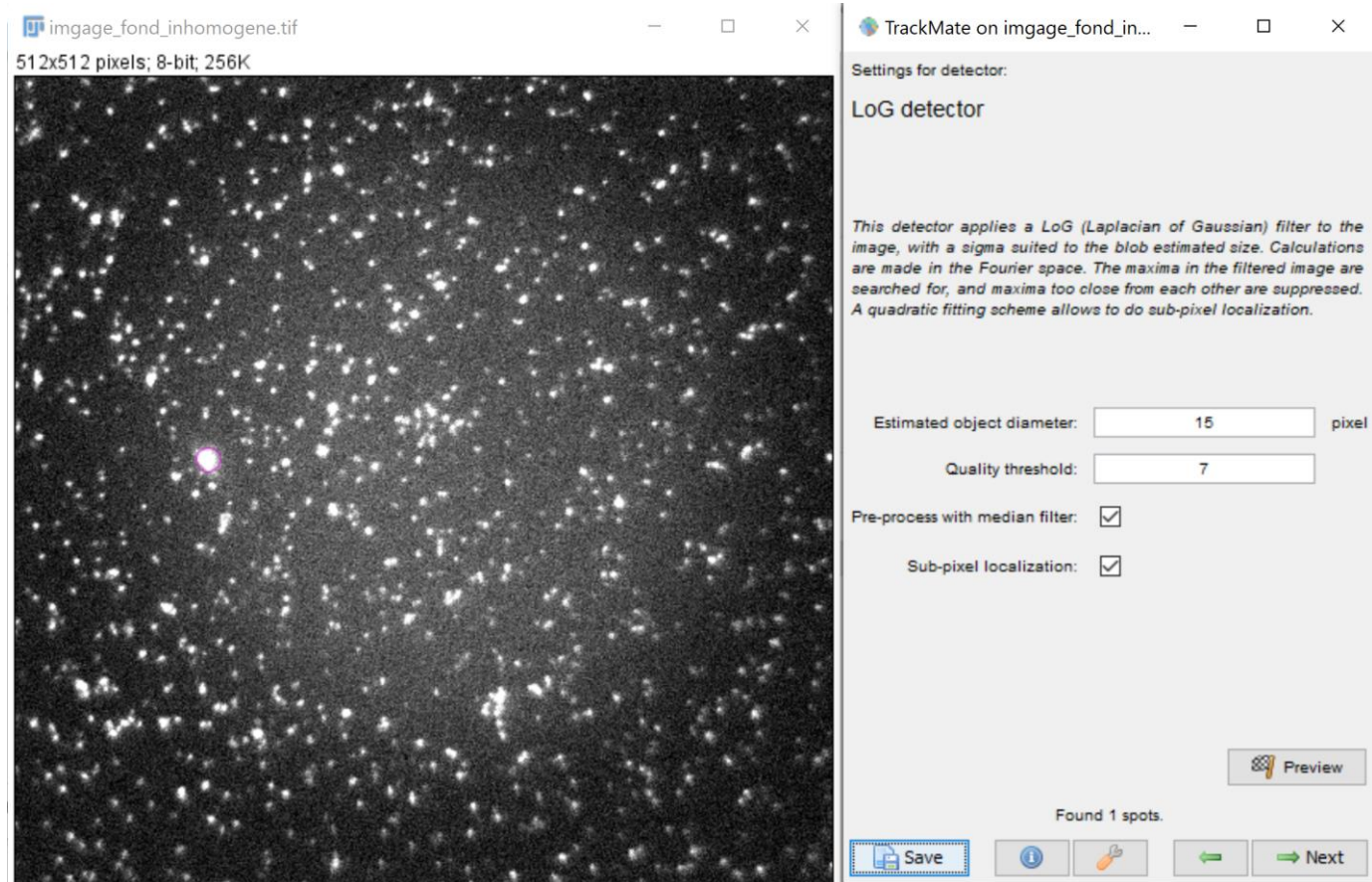
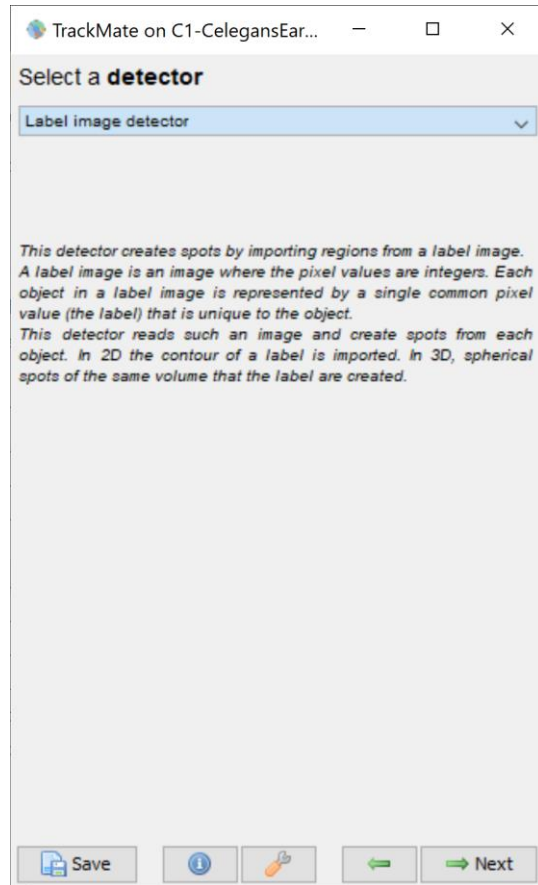
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LoG detector: scale-based detector, powerful with **objects of the same size** such as intracellular particles

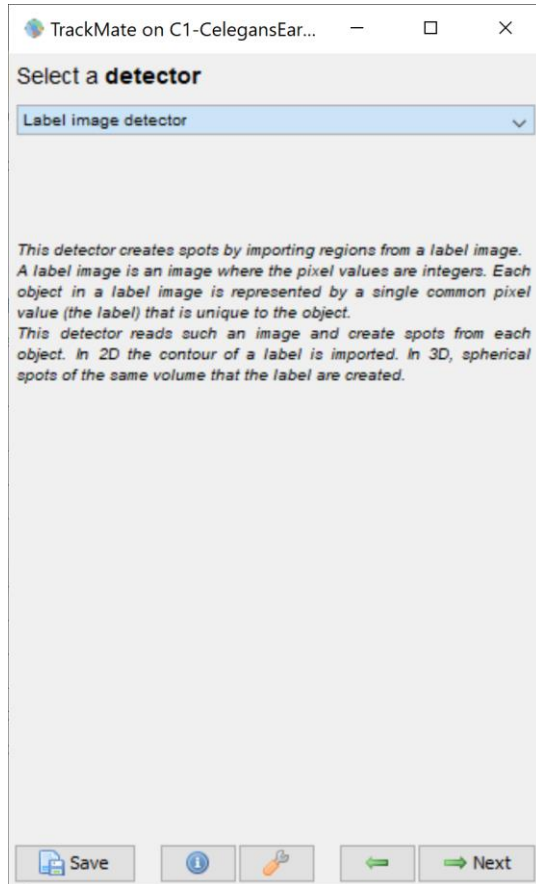


1 - SEGMENTATION

LoG detector: scale-based detector, powerful with **objects of the same size** such as intracellular particles



1 - SEGMENTATION



Classic detectors:

- **Manual annotation**
- **Threshold detector**
- **DoG/LoG detector**

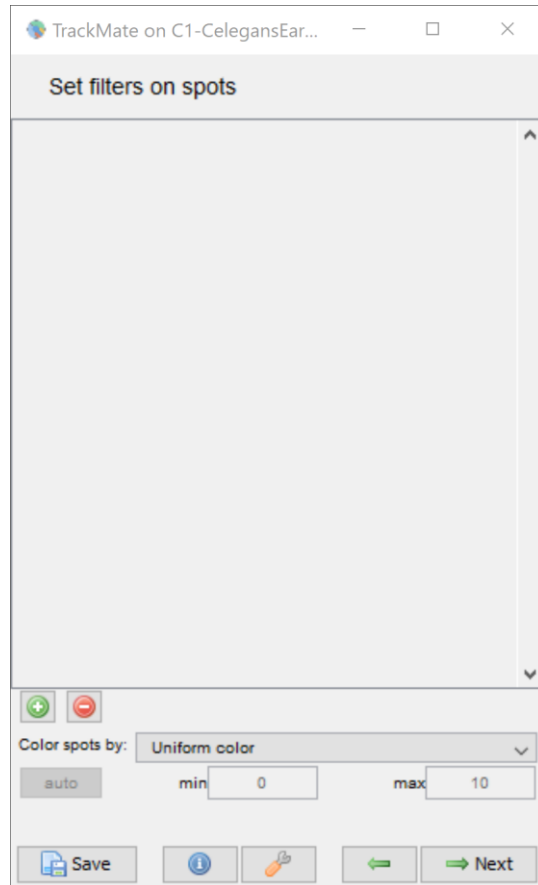
New generation detectors:

- **Stardist**
- **Cellpose**
- **Weka**
- **Ilastik**
- **MorpholibJ**
- **Custom segmentation via label images**

2 - SPOT FILTERING

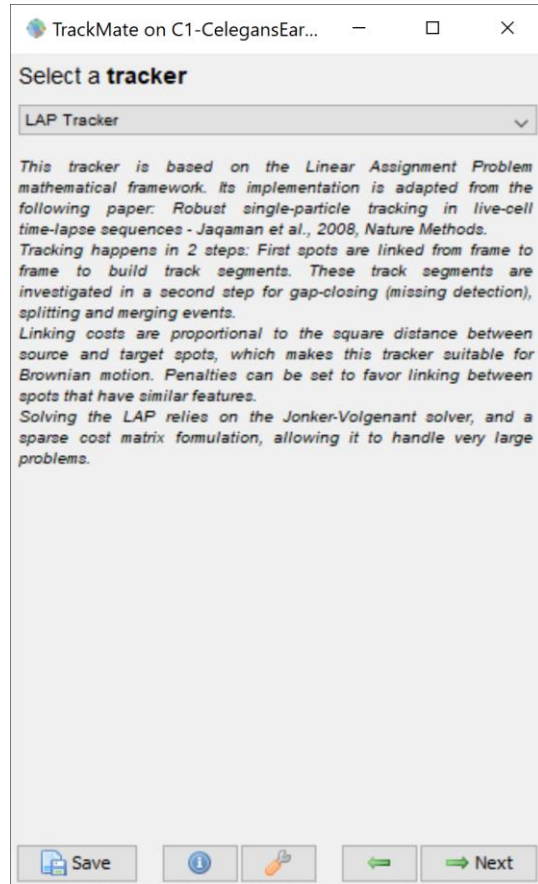
Filter out spots based on **spot features** such as size, average intensity, ...

Possibility to **visualize spot features** with heat maps.



3 - DATA ASSOCIATION

Trackers:

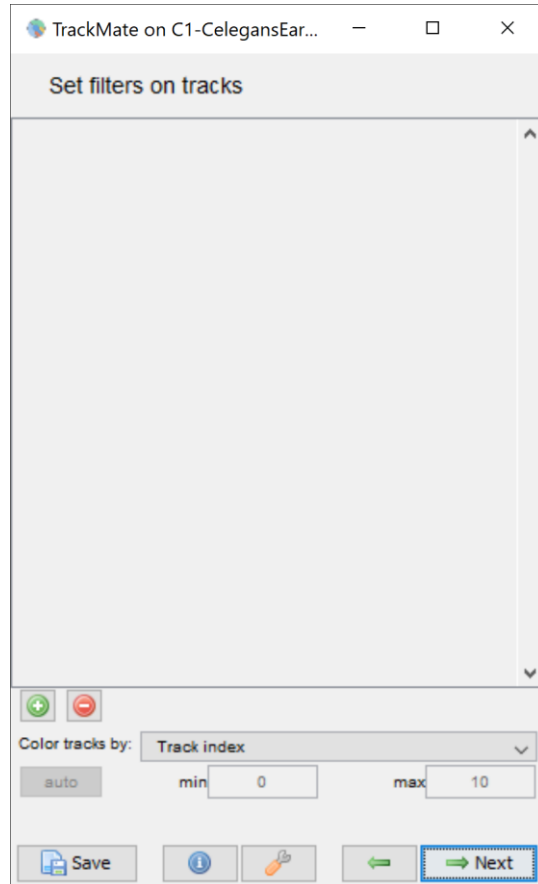


- **Manual tracking**
- **Overlap tracker:** based on intersection over union between two consecutive frames – only 2D
- **Nearest-neighbor tracker:** associate closest particles between two consecutive frames
- **Kalman tracker:** based on Kalman filtering, suited for objects with directed and constant motion, allows gap closing
- **Lap tracker:** implementation of utrack (Jaqaman *et al.*), based on the Minear Assignment Problem mathematical framework, allows to change linking cost between particles by penalizing features and to perform splitting, merging and gap closing
- **Simple LAP tracker:** same as LAP tracker, without cost penalties, splitting and merging

4 - TRACK FILTERING

Filter out tracks based on **track features** such as number of spots, duration, ...

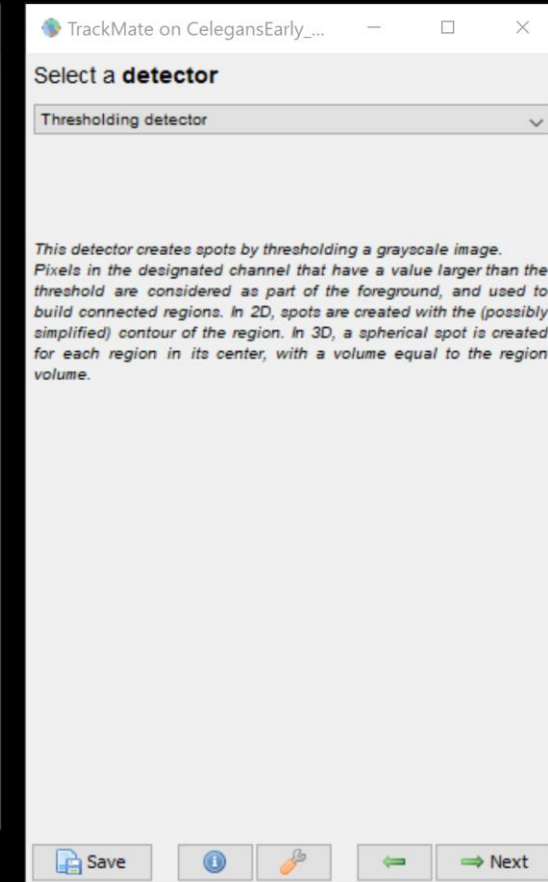
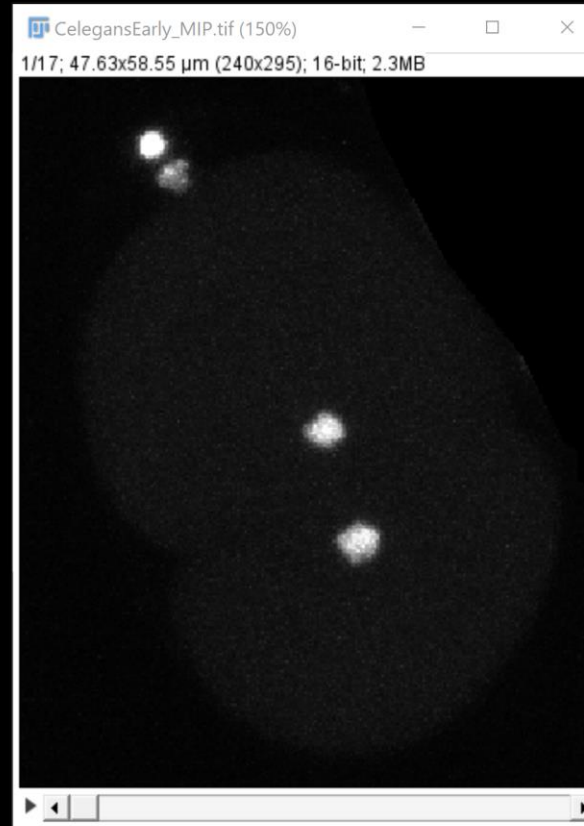
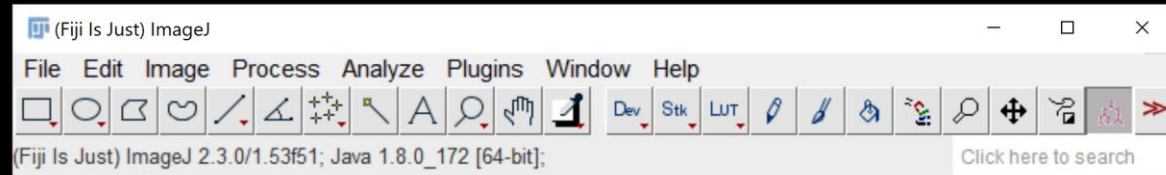
Possibility to **visualize track features** with heat maps.



HANDS ON TRACKMATE

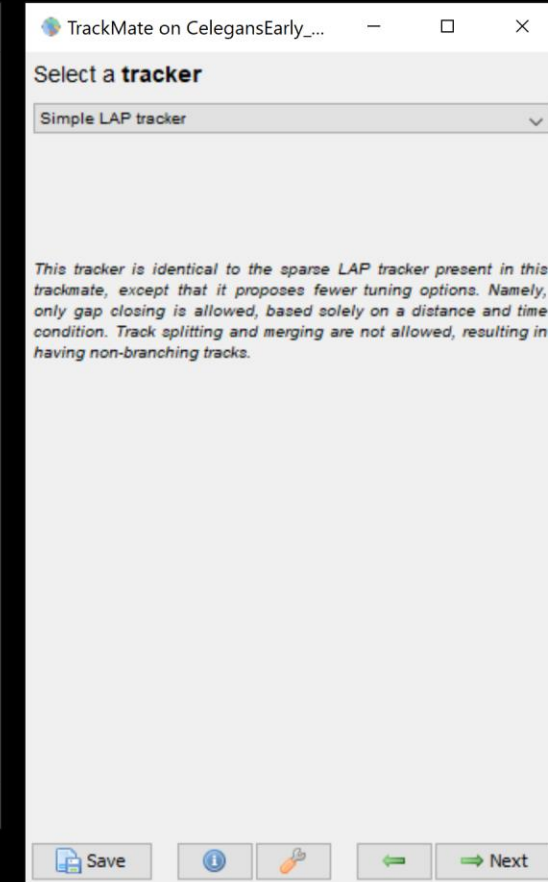
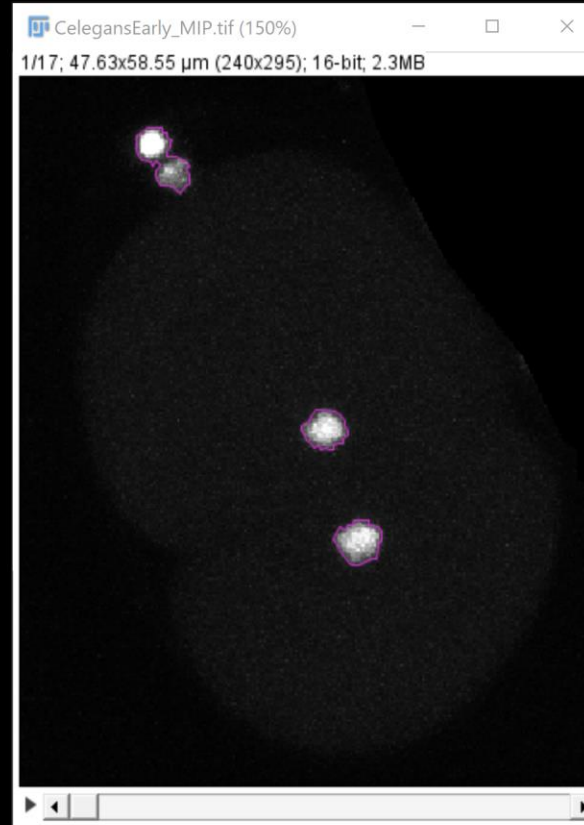
Open CelegansEarly_MIP with **TrackMate**
and segment cells with **Thresholding**
detector

Filter out as many as possible **non-cell**
objects but keep **all cells** detected

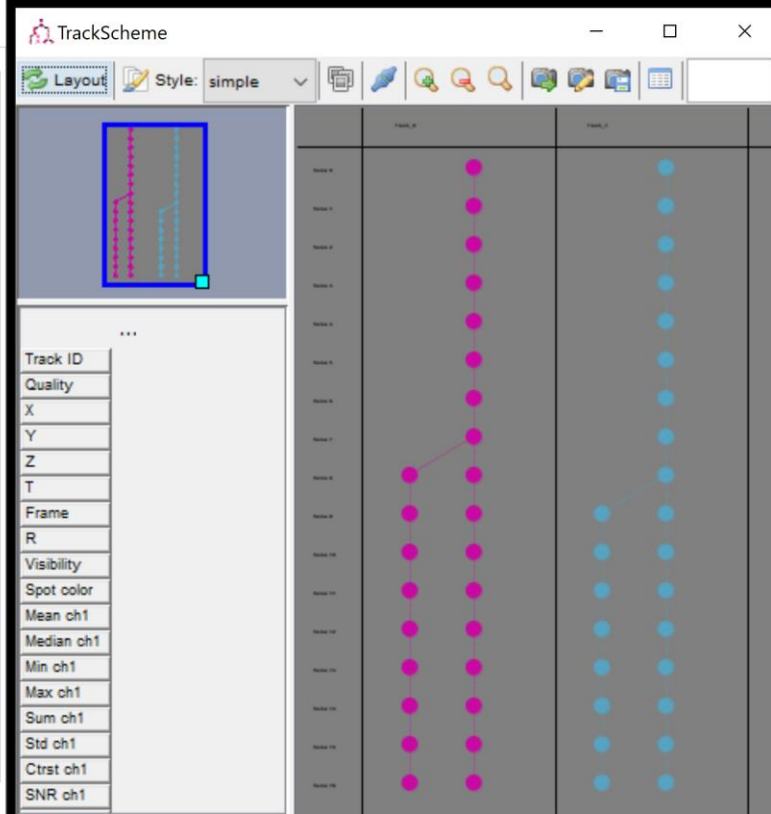
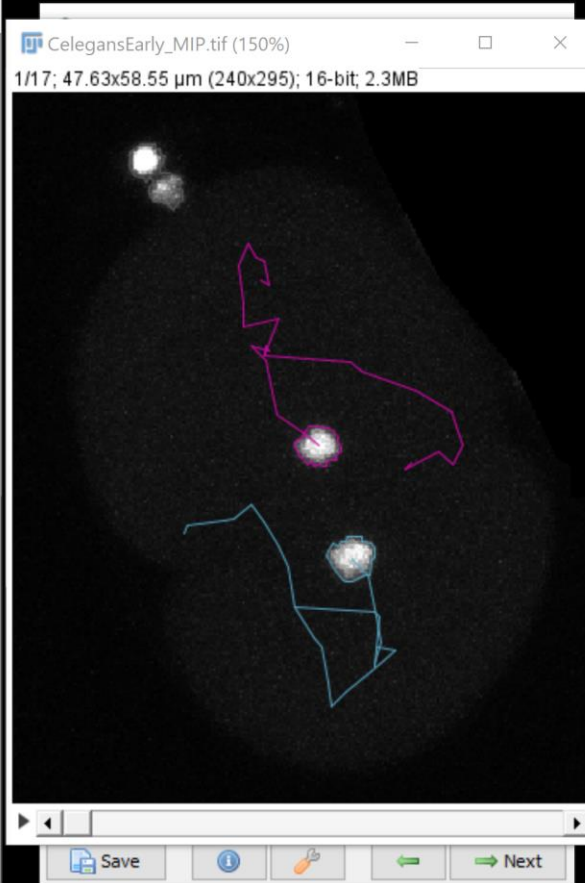
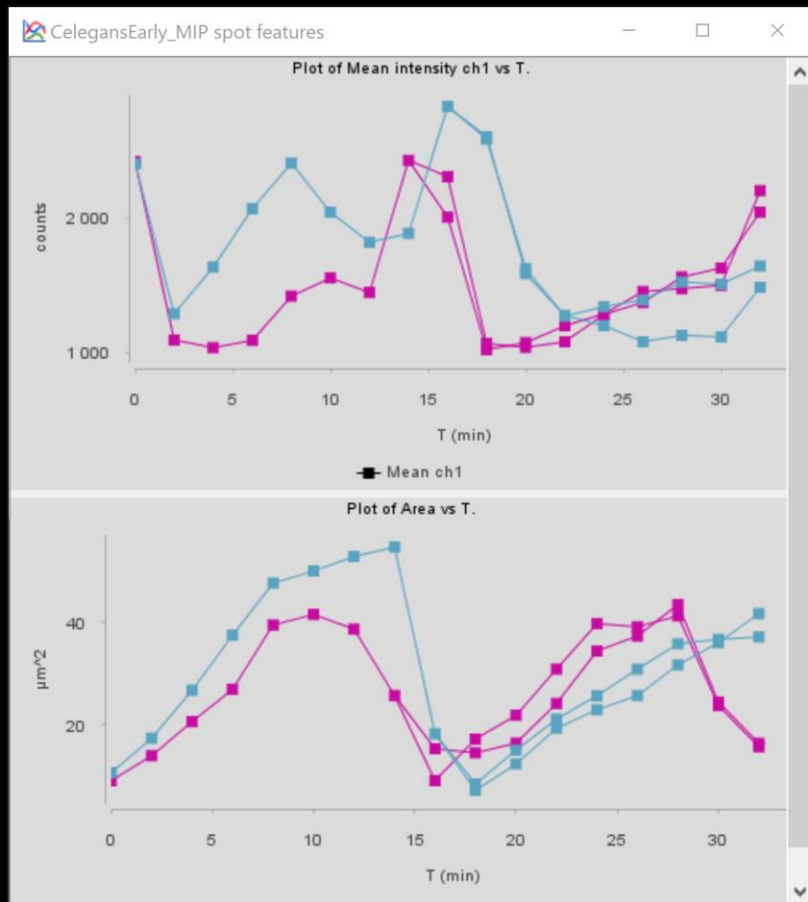
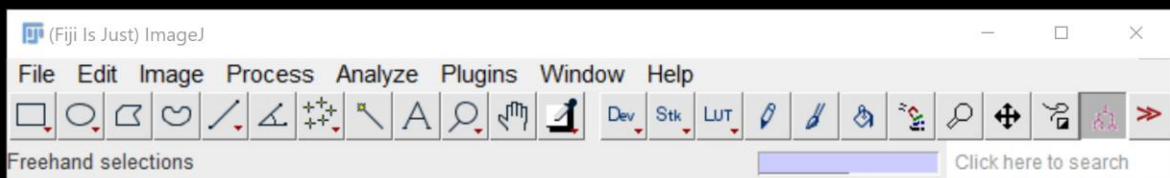


HANDS ON TRACKMATE

Use **Simple LAP tracker**, filter out track(s) corresponding to non-cell objects and **manually split** the tracks when **cells divide** with TrackScheme

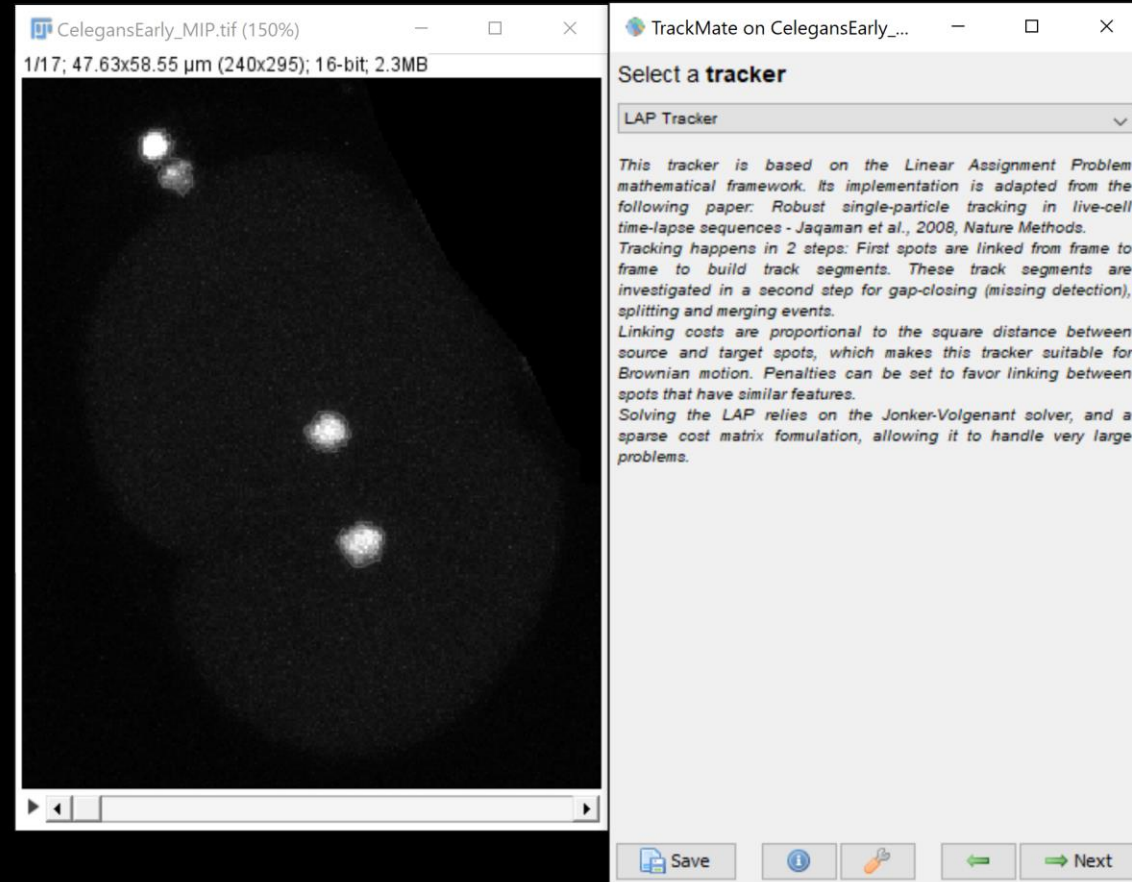
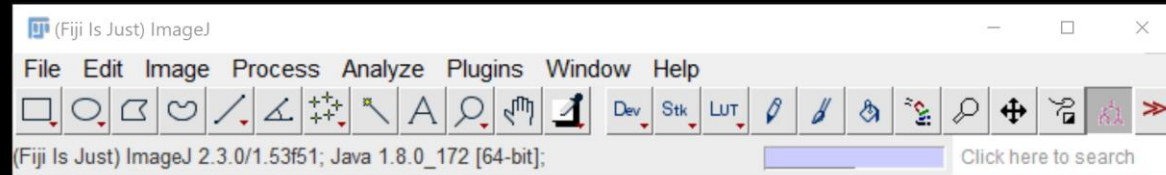


Plot features, save results...



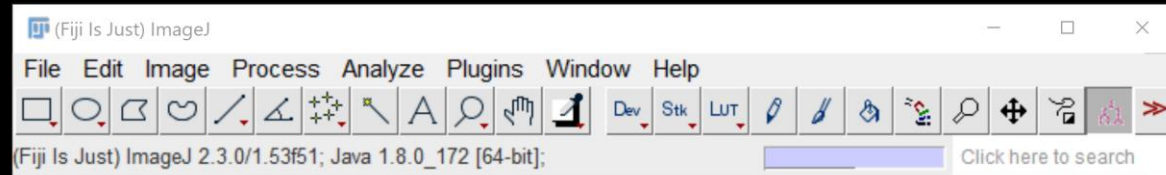
HANDS ON TRACKMATE

Use **LAP tracker** with **splitting** and **filter out track(s)** to directly obtain the **2 tracks** for cells



HANDS ON TRACKMATE

Use **LAP tracker** with **splitting** and **filter out track(s)** to directly obtain the **2 tracks** for cells



Video tutorial: <https://youtu.be/QBSRsv6gxi8>

