A workflow to process 3D+time microscopy images of developing organisms and reconstruct their cell lineage

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Statistical and biomathematical Models for imaging in cancer
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Issues
Data Treatment

Membranes

Nuclei

Rawdata

Filtering

Filterdata
Centers Detection
Filtering
Points Detection
Filter Data
Segmentation
Polydata
Data Treatment
Rawdata

Diagram showing the process of data treatment with steps including raw data, filtering, centers detection, points detection, filter data, segmentation, and polydata.
Centers Detection
Segmentation
Vector Fields
Filtering
Rawdata
Filterdata
Pointdata
Mitosis Detection
List Pointdata
Polydata
Pointdata
Vextordata
Data
Treatment
Tracking by nearest neighbors

~ 90% of good links
False Negative
Data treatment artefacts

False Positive
Coherence arguments

Cell division

Tracking
100% good links?

No cell history fully reconstruct

Data:
- 3 millions of centers
- 12 hours of acquisition
- 500 time steps

Evaluation: % valid temporal links
Results: ~2% of errors
**MorphoTrack**: a probabilistic cell tracking algorithm without any parameters by data assimilation

**Spread certainties by iteration** (EM Algorithm)

- **Cell lineage probability Maximization**
- **Cell dynamics Estimation**
- **Cell behavior Prediction**
- **Data Assimilation**

**Results:**
- **Test**: several organisms
- **Evaluation**: % errors ≤ other methods
- **Method without parameters**
- **Easily correctable cell lineage**

Digital embryo with a probability associated to each link
Reconstruction of multiscale dynamics of animal morphogenesis

**Issue**: Understanding cellular dynamics

**Objective**: Comparison of digital embryos

**Method**: Automated Reconstruction using a web-service

Results:
- Cells confined to their layer during gastrulation
- Correlation between cell movement and orientation of the division

**Objective**: Construction of prototypes

**Methods**:
- 3D Registration (images and objects)
- Temporal rescale (Dynamics)
- Local averaging

Abstraction
- Correlation between cell movement and orientation of the division
- Orthoslice view
  - Cells confined to their layer during gastrulation

Digitizing
- zoep lacks a part of the hypoblast

Wildtype embryo
Mutant embryo
Organisms Reconstruction

Sea Urchin

Zebrafish

Ascidian
MovIT: Interactive Visualisation Interface

Zebrafish

Observation

Digitizing

Sea Urchin

Abstraction

[Faure & al Nature Communication 2016]
Division Prototype for zebrafish early embryo cell lineage

[ Olivier & al Science 2010]
Ground truth: create annotated databases

- data analysis
- improve reconstruction algorithms
- evaluate methods

Images Annotation Plateform

- detection
- classification
- segmentation
- tracking
Serious Game

Citizen Science

Varieties of world

Education

Levels

Diffusion
Thanks!