Human-on-the-loop segmentation optimization using 3D visualization and interaction

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Advances in segmentation algorithms now enable researchers, with all levels of expertise in segmentation to produce high-dimensional data at scale. Traditional inspection methods fall short, failing to capture spatio-temporal relationships. We present a system for interactive, comparative bulk segmentation analysis and validation up to 5D, leveraging the Meta Quest 3 for an intuitive, immersive experience.

Problem statement(s)

Scenario: Increased (abstract) data flow

Lab automation allows for 24/7 data generation

Automated segmentation creating non-stop organoid masks

Problem

Large amount of unsupervised data stream stored

Need

Need for quick, high-volume data validation to keep up with constant data stream

Proposed solution

Scalable spatiotemporal and multi-channel segementation validation for large datasets in VR

Scenario: Wider target audience

More high-level, accessible segmentation methods:

Researchers generate their own segmentations

Problem

Growing disconnect between faults in segmentation and understanding

Need

Need for data to be tangible and intuitive for non-expert users

Proposed solution

3D modeled intuitive & interactive segmentations

A human-on-the-loop approach to reduce throughput strain and enable intuitive interaction and validation of complex segmentations

napari-blender

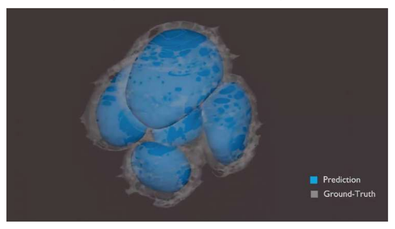
pypi

- computation
- orchestration

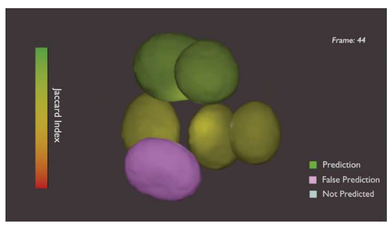
- scene building
- rendering

- display
- interact

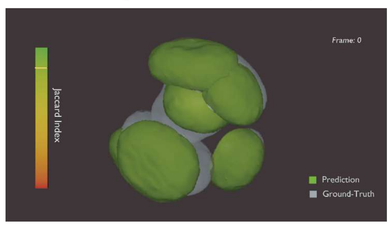
Input volume analysis



Nuclei based segmentation analysis



Full organoid based analysis

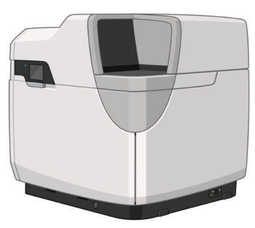


Comparitive segmentation analysis

Track nuclei development over time

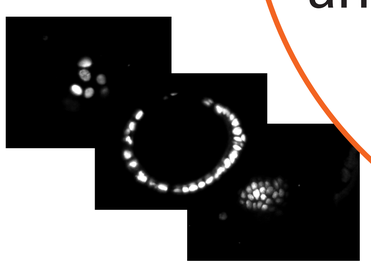
Check it out!

Workflow



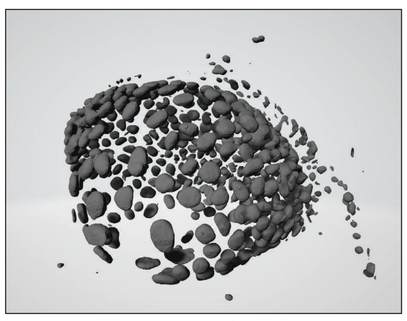
Light microscopy

- Imaging
- Start-off segmentation



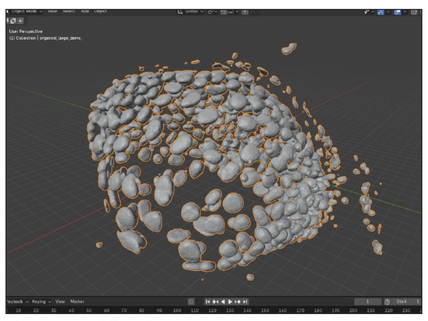
Mouse intestinal organoid

- Data processing
- Segmentation
- 3D creation



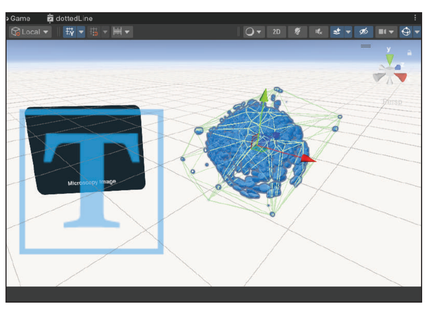
marching cube generated 3D object in 3D viewer

- 3D refining
- Object manipulation



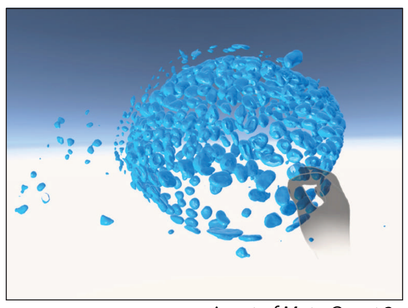
imported 3D object in Blender

- World building
- Interaction logic
- Compiling



Unity scene with 3D object

- Upload/stream data
- Play program
- Interaction



snippet of Meta Quest 3 running interaction scene

Feedback

- Analyze
- Validate
- Process feedbackin model training

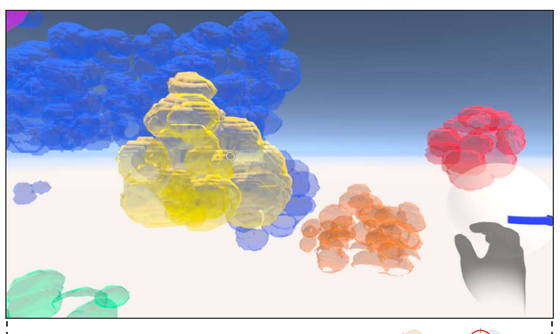
Creating a method where a trusted segmentation system can be validated on a large scale. Allowing for corrections or improvements by human guidance (human-on-the-loop)

Interaction modes

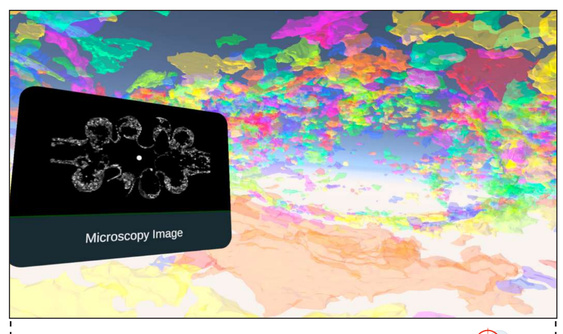
Legend (interaction & visualization type)

Timelapse · Ray interaction · Organoid interaction · Gesture interaction · Tracking · Metrics

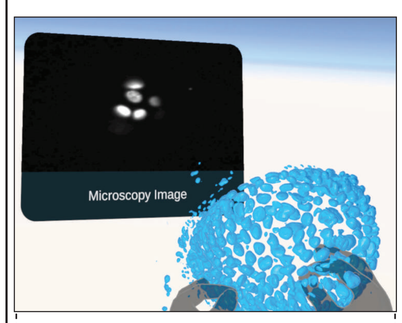
Full well interaction, toggle well properties and grab singular organoid for interaction



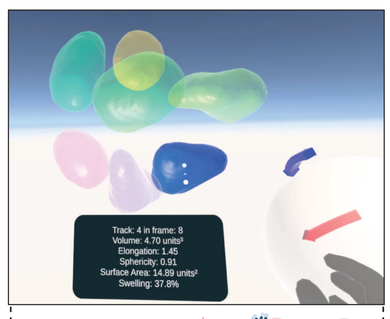
Walk through large organoids and grab individual nuclei, user position tracked on input image



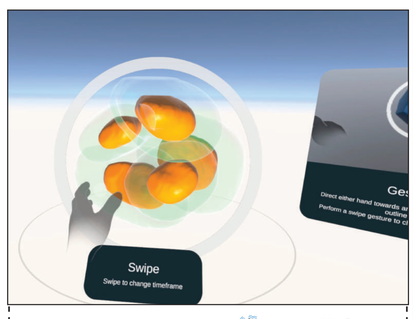
Scale, rotate & grab for analysis against input image



Color tracking & nucleus selection for metrics and motion analysis



Intuitive scrolling through timelapse data



Data generation and segmentation were partly contributed by Jan-Daniël de Leede (Sonnen Lab, Hubrecht Institute) and Sam de Blank (Rios Lab, Prinses Máxima Center).

Connect!

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Browse through our projects on Github

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