3D Visualization and Morphometrics with SlicerMorph

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SlicerMorph Team:

Co-PI: **Dr. Adam Summers** (UW FHL)
Co-PI: **Dr**. **Doug Boyer** (Duke Evol. Anthropology & Director of MorphoSource)
Lead Developer: **Dr. Sara Rolfe** (UW FHL & SCRI)
Consultant: **Dr. Steve Pieper** (Isomics Co., Chief Software Architect of 3D Slicer
Post-Docs: **Dr. Kelly Diamond** & **Dr. Arthur Porto**

A typical workflow in 3D Morphometrics:

1. Find your data (e.g., MorphoSource, DigiMorph, your lab etc).
2. Find a software that will enable 3D visualization, segmentation and conversion to mesh, then landmark digitization (commercial software like Aviso, Mimics, Geomagics, Analyze, or free ImageJ, 3D Slicer, ITK-Snap)
3. Export landmark/measurements data into a format that can be understood by the analysis software.
4. Analyze using R (or MorphoJ)

Survey of 3D morphometrics

Conducted on morphometrics online discussion group.

Primary challenges were:

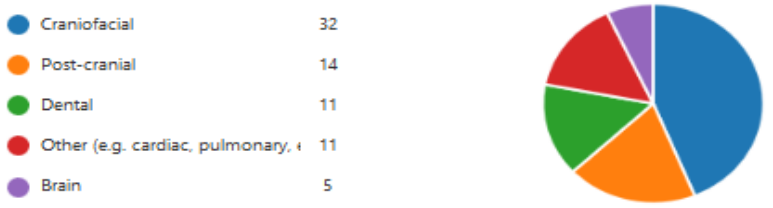
1. Data wrangling (converting formats)
2. Annotation (landmarking, measurements, segmentation)
3. Analysis and visualization

An Integrated Platform for Retrieval, Visualization and Analysis of 3D Morphology. 08/01/2018 – 07/31/2021
Murat Maga (Seattle Children's): NSF Award #1759883
Adam Summer (University of Washington): NSF Award #1759637
Doug Boyer (Duke University): NSF Award #1759839

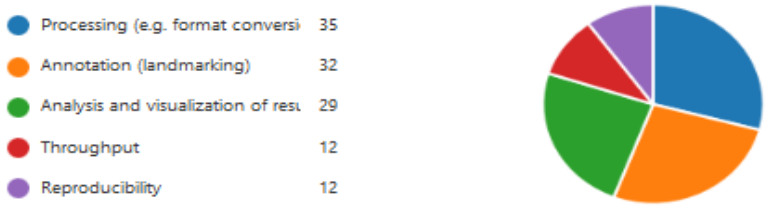
2. What organism are you working on? (choose multiple if need)

3. What is your main research focus ? (choose multiple if need)

4. What anatomical system are you working on? (choose multiple if need)



5. What are your challenges working with these data? (choose multiple if need)



Goals of SlicerMorph

1. Provide the tools to download, visualize, segment, animate, measure, annotate your data. Basically all steps of any 3D geometric morphometrics research (and others), **except for domain-specific** analysis (symmetry decomposition, phylogenetic PCA, linear models, covariation)
2. Train and Support the community.

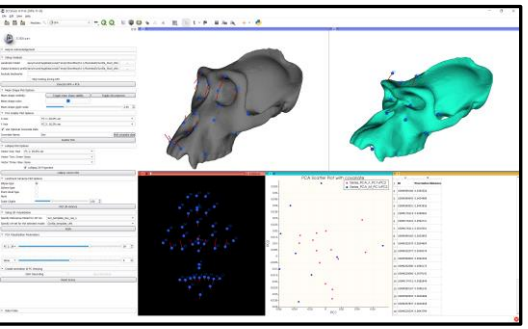
SLICERMORPH

Software Development

3D Geometric Morphometrics and Shape Analysis

Auto3Dgm

Landmark-free shape correspondence



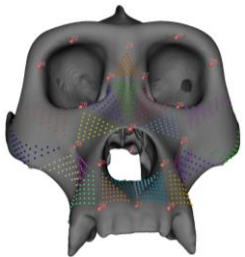
Generalized Procrustes Analysis

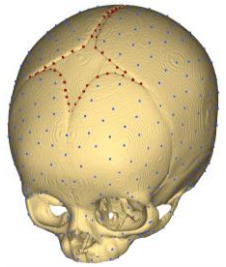
- Landmark variances
- 3D PCA visualization
- Patch-based semi-Landmarks
- Curve-based semi-landmarks
- Spherical templates
- Plotting
- Export to R

Tools and Utilities

Extra Modules

- SlicerAnimator
- ImageStack
- Skyscan µCT import
- SplitVolumes
- MorphoSource integration



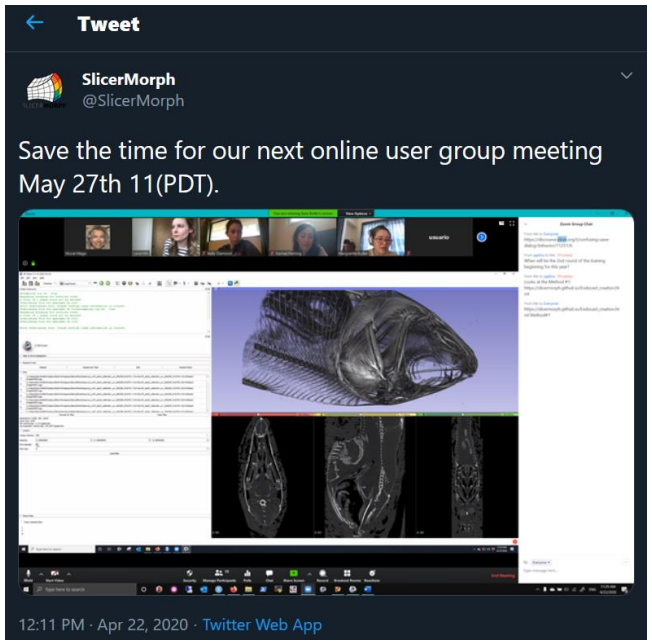


Community Support

- Virtual Office Hours
- 3D Slicer Forum
- Documentation
- Video Tutorials

Training

- Intense Workshops
- Short Tutorials
- Invited Lectures



SlicerMorph Short Courses at Friday Harbor Labs

	2/16	2/17	2/18	2/19	2/20	2/21	2/22	2/23
7:45-8:15		Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	
8:30-10:15		**Introduction** Maga **3D imaging** Summers	**Applied Imaging Concepts** Rolfe	**Introduction to Statistical Shape Analysis II: Semi-Landmarks and beyond** Rolfe	**Auto3Dgm and landmark-free correspondence of biological form** Boyer	**Applications of SSA: Phylogenetics** Shan	**Work on your on data / TBD**	Brunch / Checkout
10:15-10:30		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
10:30-12:15		Attendee project Presentations - Initial	**Slicer #3: Segmentation, mesh conversion** Maga	**SlicerMorph # 1: Statistical Shape Analysis: Work with sample data** Maga	**Auto3Dgm: Establishing Landmark-free correspondence** Shan	**Repetitive tasks, Scripting in Slicer** Rolfe	**Work on your on data / TBD**	
12:15-12:45		Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	
1:00-3:00	Course check-in & Self-Paced Pre Course Lab (Dining Hall)	**Slicer #1: UI, overview of functionality, extensions, finding help** Mercan	**Introduction to Statistical Shape Analysis I: Landmark-based methods** Maga	**Template-based analysis and computational anatomy** Maga	**Application of SSA: Modeling growth** Mercan	**Building Statistical Shape Models in R** Schlager	**Setting your own lab / Concluding remarks** SlicerMorph team	
3:00-3:15		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
3:15-5.15		**Slicer #2: Data formats, getting data from M/S, saving** Maga	**Slicer #4: Measurements and Visualization** Rolfe	**SlicerMorph # 2: Statistical Shape Analysis: Work on your data**	**Integrating SlicerMorph with R** Mercan	**Data processing in R: Plotting, modeling** Schlager	Visualization Competition and Social	
6:00-6:30	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	
7:00-8:00		Smores on beach	Study Hall @Dining Hall -	Study Hall @Dining Hall -	Study Hall @Dining Hall -	Study Hall @Dining Hall -		

Self-support resources

- **SlicerMorph Project website**: http://SlicerMorph.org (links to tutorials, data etc)
- **Get 3D Slicer and SlicerMorph:** https://download.slicer.org (use preview version)
- **Get packaged SlicerMorph:** http://download.SlicerMorph.org
- **Sign up for SlicerMorph listserve**: http://bit.ly/SM-listserv
- **Video tutorials for SlicerMorph specific functions:** http://bit.ly/SM_youtube
- **Engage with Slicer(Morph) community:** https://discourse.slicer.org
- **Signup for a semi-annual short-course at FHL** http://workshop.slicermorph.org
- **Review previous short courses**: https://github.com/SlicerMorph/W_2020

Take Home Message

SLICER**MORPH** is not a traditional research project, but a chance to build a digital community of organismal biologists and quantitative morphologists around 3D Slicer that value open science and collaboration.

We are looking forward to your engagement.

Acknowledgements

Extended SlicerMorph Team

Sara Rolfe (UW/SCRI, Lead Developer)
Doug Boyer (Duke, SlicerMorph Co-PI)
Adam Summers (UW, SlicerMorph Co-PI)
Julie Winchester (Duke, MorphoSource)
Steve Pieper (Chief Software Architect of 3D Slicer)
Kelly Diamond (SCRI, Post-doc)
Arthur Porto (SCRI, Post-doc)
3D Slicer Developer Community

SlicerMorph Advisory Board

James Rohlf (Stony Brook University)
Dean Adams (Iowa State University)
David Polly (Indiana University)
Anjali Goswami (Natural History Museum, London)

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NSF-Advances in Biological Informatics
Murat Maga (Seattle Children's): Award #1759883
Adam Summer (UW): Award #1759637
Doug Boyer (Duke University): Award #1759839

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Plan for the rest of the session

- Today's powerpoints, slides and tutorial content at https://github.com/SlicerMorph/VMM
- 10 minute demo of 3D Slicer from images to morphometrics
- Breakout sessions for specific topics (table in the next slide)
- **Signup for your break session choice at google sheet link so that we can assign you to the right session.**
- Some back to the joint session at 12.45pm

Breakout groups:

3D Slicer Overview: (Kelly) Useful for people who never used 3D Slicer before, or for those who are knowledgeable with other 3D biomedical software but want to learn more about 3D Slicer. **Introduces:** UI, concepts, importing image stacks, 3D rendering, measurements, landmarking, animation, MorphoSource query and retrieval (3D models only).	**SlicerMorph and 3D GMM specific functionality (Sara)** Assumes having collected 3D landmarks and showcases morphometrics specific functionality in SlicerMorph: **Introduces:** Sample Data module (for SlicerMorph data), GPA + PCA, plotting, finding outliers (landmarks and samples), visualizing PC shape deformations, exporting results, patch-based LMs. Interacting with Python
Segmentation and 3D Models: (Arthur) Show cases Segment Editor and Segmentations modules of 3D Slicer to generate segmentations from volumetric data (CT/MR), masking and splitting segmentations, exporting 3D models. Making casts of endocranium. **Introduces:** Importing Image stacks, Segment Editor, Segmentation Modules.	**Specific questions on Slicer / SlicerMorph (Murat)** Anything that you don't feel covered in one of those sessions.

Signup up at link to the google sheet.