Dan Zeng

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Research Interests

My research centers around computer graphics, vision, computational geometry, imaging, and topology. I develop geometric algorithms for reconstructing shapes from sensor data such as image volumes and point clouds. I also research methods for analyzing shapes in ways that are useful for downstream applications. My methods often entail designing efficient graph algorithms. I enjoy working across interdisciplinary teams.

Education

Ph.D. Candidate in Computer Science (Advisor: Dr. Tao Ju) — August 2017-May 2022 (expected)
Washington University in St. Louis — Saint Louis, MO

Bachelor of Science in Computer Science — August 2013-May 2017
Washington University in St. Louis — Saint Louis, MO

Research Experience

Graph-based optimization for topological simplification of 3D shapes 2019-present
Collaboration: Wash U. and St. Louis University

- Developed a novel global optimization algorithm for maximally simplifying topological noise within a 3D shape with minimal changes to its geometry. The algorithm optimally selects cuts and fills via reduction to a Node-Weighted Steiner Tree problem.
- The algorithm shows vastly improved topological and geometric results compared to prior methods, achieving the optimal topological result in nearly all cases and achieving >99.9% simplification for very complex examples (e.g. corn roots from CT scans) with thousands of noisy topological features.
- Paper "To cut or to fill: A global optimization approach to topological simplification" was accepted and presented at SIGGRAPH Asia 2020. Project page: https://danzeng8.github.io/topo-simplifier/

Geometric algorithms for computing root system architecture from X-ray CT imaging 2020-present
Collaboration: Wash U., Donald Danforth Plant Science Center, and St. Louis University

- Developed TopoRoot, a method for computing hierarchy and fine-grained traits of maize roots from CT images. The method repairs topological errors, creates a geometric graph to represent branching structure, and infers the hierarchy using an algorithm which minimizes the maximum hierarchy level.
- TopoRoot computes fine-grained traits with significantly improved accuracy (up to 380% improvement depending on trait) compared to prior methods, and also computes novel traits.
- TopoRoot runs within 7 minutes for 400^3 images, enabling high-throughput computation.
- Demonstrated usefulness to biological studies through the ability to differentiate between a mutant variety of Maize and a wild-type across 12 of 23 fine-grainedtraits which are computed by TopoRoot.
- Paper under review by Plant Methods journal. Preprint: https://doi.org/10.1101/2021.08.24.457522, Github: https://github.com/danzeng8/TopoRoot
- Lead the project forward through clear communication with plant biologists and computer scientists.

Facebook Reality Labs Research Internship: A robust domestic UV mapping tool May-Sept. 2020
Mentors: Yajie Yan, Phillipe Bouttefroy (worked with: Thomas Whelan, Simon Green, and Alan Oursland)

- Developed a tool which uses Variational Shape Approximation to compute charts and Least Squares Conformal Maps to flatten them in order to produce UV maps free of non-manifold artifacts.
- Integrated the tool into the existing mesh reconstruction pipeline. The tool showed an ability to simplify the pipeline, which previously required external tools with specialized knowledge to operate.
- On a dataset of highly complex indoor reconstructions, the tool demonstrated 50% lower parameterization error and >20x speed-up compared to open-source implementations.

Computing Sorghum Panicle Architecture from X-ray CT imaging 2018-2019

Collaboration: Wash U., Donald Danforth Plant Science Center, and St. Louis University

- Developed a method to trace the primary branches of sorghum panicles as part of a study which revealed continuous morphological variation across genetically diverse sorghum panicles. The method first computes a geometric skeleton, identifies the stem using thickness criteria, then traces primary branches using a longest-path algorithm. Github: https://bit.ly/37DxkWQ
- The traits derived from each computed branch showed high correlation with hand measurements.
- Published in and on the cover of New Phytologist journal, May 2020 (cover: https://bit.ly/2UitFL6)
- Wash U news article highlighting my contributions: https://bit.ly/2VQ0rDR

Geometric Algorithms for Modeling Protein Structures 2016-2017

- Implemented a C++ interface for pathwalking (algorithm for determining protein backbones in Cryo-EM density maps) in Gorgon, a molecular modeling software suite (https://bit.ly/2VZVbNG)
- Developed a method that uses local maxima to identify α-helices and β-sheets in density maps.
- Presented at Wash. U.'s Undergraduate Research Symposium (poster: https://bit.ly/3jQxiAE)

Publications

- **Dan Zeng**, Yiwen Ju, Mao Li, Ni Jiang, Hannah Schreiber, Erin Chambers, David Letscher, Tao Ju, Christopher N. Topp. TopoRoot: A method for computing hierarchy and fine-grained traits of maize roots from X-ray CT images. Plant Methods (under review). doi: https://doi.org/10.1101/2021.08.24.457522
- David Letscher, Erin W. Chambers, Tao Ju, Hannah Schreiber, **Dan Zeng**. VHS: a package for homological simplification of voxelized plant root data for skeletonization. Currently under review by Computational Geometry: Theory and Applications.
- **Dan Zeng**, Erin Chambers, David Letscher, Tao Ju. 2020. To cut or to fill: A global optimization approach to topological simplification. ACM Transactions on Graphics (Proc. ACM Siggraph Asia 2020), 39(6): No. 201
- Mao Li, Mon-Ray Shao, **Dan Zeng**, Tao Ju, Elizabeth A. Kellogg, Christopher N. Topp. 2020. Comprehensive 3D Phenotyping reveals Continuous Morphological Variation across Genetically Diverse Sorghum Inflorescences. New Phytologist Journal.

Honors / Awards

- Imaging Sciences Pathway Fellowship (2019-2021), awarded by the Division of Biology and Biomedical Sciences at Washington University
- Dean's Select PhD Fellowship at Washington University (2017)
- Thomas H. Eliot Scholarship Award at Washington University (2013)

Teaching

Teaching Assistant: CSE 554 Geometric Computing for Biomedicine (2 lectures given, office hours), CSE 530 Database Management Systems (office hours) , CSE 132 Introduction to Computer Science II (office hours)

Technical Skills

- Programming Languages and Libraries: C/C++(Expert), Python(Expert), Mathematica(Expert), Java(Proficient), Matlab(Proficient), SQL(Proficient), OpenGL, CGAL, Eigen, Boost, TBB, NumPy
- Other Professional Skills / Tools: Visual Studio, Visual Studio Code, Git, Vim, Adobe Photoshop & Premiere, HTML/CSS, Javascript, R, SPSS, UCSF Chimera
- Languages: English (native), Chinese (fluent)