

Research Interests

I am interested in computer graphics and its applications. My graphics research focuses on topology optimization, surface reconstruction, and shape analysis. I actively pursue applications of graphics techniques in plant phenotyping, augmented / virtual reality, gaming, biomedicine, and related fields.

Education (all at Washington University in St. Louis)

Ph.D. Candidate in Computer Science (Advisor: Dr. Tao Ju)

August 2017-May 2022 (expected)

Bachelor of Science in Computer Science

August 2013-May 2017

Research Experience

Topological optimization for 3D shape reconstruction

2019-present

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

- 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 (primary author) “To cut or to fill: A global optimization approach to topological simplification” was accepted and presented at SIGGRAPH Asia 2020. Project page: bit.ly/3l8HTZa

Geometric algorithms for computing root system architecture from X-ray CT imaging

2020-present

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

- 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 vastly improved accuracy (up to 380% improvement depending on trait, see paper for details) compared to prior methods, and also computes novel traits.
- TopoRoot runs within 7 minutes for 400^3 images, enabling high-throughput computation.
- Paper (primary author) accepted to Plant Methods journal. Preprint: <https://doi.org/10.1101/2021.08.24.457522>, Github: <https://github.com/danzeng8/TopoRoot>
- Lead interdisciplinary research team with plant biologists and computer scientists.
- Mentored five students on the project (one PhD, two masters, and two undergraduates)

Facebook Reality Labs Research Internship: A robust UV mapping tool

May-Sept. 2020

- 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 (boosting developer velocity), which previously required external tools with specialized knowledge to operate.
- On a dataset of highly complex indoor reconstructions, the tool showed 50% lower parameterization error (reducing the visual distortion) and >20x speed-up compared to open-source implementations.

Computing Sorghum Panicle Architecture from X-ray CT imaging

2018-2019

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

- 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 graph from the X-ray CT image, then traverses the graph to identify primary branches. 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>

Danforth Plant Science Center Research Internship: Christopher Topp's Lab May-August 2018

- Researched geometric methods for phenotyping plant roots and panicles. My observations and discussions with biologists formed the foundation for some of the above works.
- Prototyped a semi-automatic software pipeline for analyzing X-ray CT imaging of plants and mentored lab members on its usage on lab machines.
- Generated surface reconstructions of plant structures from point clouds and voxelized image volumes for educational virtual reality exhibits.

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. 2021. TopoRoot: A method for computing hierarchy and fine-grained traits of maize roots from 3D imaging. Plant Methods (accepted). <https://doi.org/10.1101/2021.08.24.457522>
- David Letscher, Erin W. Chambers, Tao Ju, Hannah Schreiber, **Dan Zeng**. 2021. VHS: a package for homological simplification of voxelized plant root data for skeletonization. Computational Geometry: Theory and Applications (under review).
- **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. <https://doi.org/10.1145/3414685.3417854>
- 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. <https://doi.org/10.1111/nph.16533>

Talks

- "To cut or to fill: A global optimization approach to topological simplification" the 14th SIGGRAPH Asia Conference and Exhibition (SIGGRAPH Asia 2020). Virtual Conference.
- "TopoRoot: An Automatic Pipeline for Plant Architectural Analysis from 3D Imaging" the 1st North American Plant Phenotyping Network Conference (2021). Lightning Talk. Virtual Conference.

Honors / Awards

- Imaging Sciences Pathway Fellowship (2019-2021), awarded by the Division of Biology and Biomedical Sciences at Washington University in St. Louis. Took courses covering the principles, mathematics, and applications of imaging.
- Dean's Select PhD Fellowship at Washington University in St. Louis (2017)
- Thomas H. Eliot Scholarship Award at Washington University in St. Louis (2013)

Teaching Assistant Experience

- CSE 554 Geometric Computing for Biomedicine (graduate level): Gave two lectures, conducted recitation sections, and tutored students during office hours. Brought experiential learning experiences from my research to the classroom
- CSE 530 Database Management Systems (graduate level): As head teaching assistant, I coordinated group projects, held office hours, and provided individual tutoring
- CSE 132 Introduction to Computer Science II (undergraduate level): Held office hours and provided individual tutoring
- Proficient with using Canvas, Blackboard, Piazza, and Git for assignments, grading and discussion

Extracurricular Activities

Career Development Officer, Association of Graduate Engineering Students 2018-2019

- Organized networking events to connect graduate students with industry. The AGES Spring Networking events of 2018 and 2019 were attended by over 100 students and representatives. Over 120 students and 34 representatives from 24 companies went to our September 26, 2019 event.

Volunteer Experience

Organizer and volunteer, St. Louis Modern Chinese School Childhood-present

- Started and organized a dragon dance team composed of volunteers from diverse backgrounds throughout St. Louis, which performed at local events such as the downtown Thanksgiving/July 4 parades and cultural festivals such as the Chinese Culture Days at the MO Botanical Gardens.
- Organized seminars where experts introduced topics such as education, personal finance, retirement, and healthcare to St. Louis immigrants.

Technical Skills

- Programming Languages and Libraries: C/C++(Expert), Python(Expert), Mathematica(Expert), Java(Proficient), Matlab(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, UCSF Chimera, 3D Vision, Machine learning model building
- Languages: English (native), Chinese (fluent)

References

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