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RPPR Final Report
as of 04-Apr-2022

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Proposal Number: 78345MACF **Agreement Number: W911NF-21-1-0095**
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Final Report for Period Beginning 10-Feb-2021 and Ending 09-Feb-2022
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STEM Degrees: 0 **STEM Participants:** 53

Major Goals: Support from this grant was used to run the first ever Summer Geometry Institute (SGI; formerly Geometry Processing Summer Institute) in 2021. SGI was a six-week summer program for undergraduate and early master's students, providing training and early research experiences in applied geometry.

SGI set out to accomplish the following objectives:
* spark collaboration among students and researchers in geometry processing,
* launch inter-university research projects in geometry processing involving team members across broad levels of seniority (undergraduate, graduate, faculty, industrial researcher),
* introduce students to geometry processing research and development, and
* diversify the “pipeline” of students entering geometry processing research, in terms of gender, race, socioeconomic background, and home institution.

In its first offering, the major goal of SGI was to develop a model for online research-based education that would bring a diverse cohort of students into the field.

The role of this particular funding was to provide financial support to SGI Fellows to cover the cost of participating full-time in the program for 6 weeks. This aspect was critical to the success of SGI in accomplishing its mission targeting participants from underrepresented and underserved groups, many of whom would not have been able to participate without this support.

Accomplishments: SGI 2021 was overwhelmingly successful in achieving its technical and community-oriented goals. The program is on a path toward becoming a mainstay of the geometry processing community, and already has affected the size and composition of the incoming graduate student body in geometry processing research. Moreover, MIT has embraced SGI as a model program for efforts aiming to improve aspects of diversity, equity, and inclusion (DEI) in computing research and graduate recruiting.

Overall, a cohort of 34 SGI Fellows participated in the full six-week program; an additional ~20 students participated (without stipend) in the initial week of tutorials. The SGI applicant pool easily could have filled a program that was 2-3 times as large without affecting the quality of the participants. 76.5% self-identified as members of an underrepresented group in computing or mathematical sciences, and 17 countries were represented among the Fellows.

The first week of SGI centered around a crash course in geometry processing, intended to introduce Fellows to key

ideas in geometry processing research. A different volunteer organized each day; the theme of the day matched the volunteer's expertise. SGI 2021 featured the following tutorial days:

* Day 1: Basic techniques in geometry processing (Dr. Oded Stein, MIT)
* Day 2: Shape deformation (Hsueh-Ti Derek Liu, University of Toronto, and Jiayi Eris Zhang, University of Toronto and Stanford)
* Day 3: Shape representations (Silvia Sellán, University of Toronto)
* Day 4: Shape correspondence (Michal Edelstein, Technion, and Abhishek Sharma, École Polytechnique)
* Day 5: Directional fields (Prof. Amir Vaxman, Utrecht University)

Roughly 2-3 hours of each tutorial day were devoted to lecture/discussion, with an emphasis on interactivity; instructors were encouraged to design their materials with as little necessary background knowledge as possible.

Beyond lectures, each day featured exercises wherein students implemented geometry processing algorithms. Each lecture dovetailed with the exercises, so the students would see the broader landscape relating to each exercise. A team of volunteer teaching assistants (TAs), composed of graduate students, helped the SGI Fellows over live chat and Slack. The TAs provided an approachable means of getting help with the challenging exercises and also troubleshooted technical issues.

The remaining weeks of SGI were dedicated to research experiences for the 34 SGI Fellows. SGI research projects introduced students to multiple faculty mentors while reducing the span of time during which mentors interacted with the program. Mentors volunteered to host research projects that each lasted 1-2 weeks. Each week, the SGI Fellows were presented with a list of projects and short abstracts from the mentors and were asked to rank the projects based on interest. Then, a behind-the-scenes matchmaking algorithm matched 2-3 students to each project. If students were on two-week projects, they could choose to stay on the same team or switch, e.g. if their current project was not successful or if there was a new project abstract in the coming week that was particularly attractive, with the caveat that they should discuss the decision with their current mentor.

These sprints of research activity presented unique opportunities and challenges. On the positive side, students got the chance to study multiple topics and to experience different mentoring styles; mentors only were asked to commit to up to two weeks with SGI. On the other hand, two weeks is not enough time to bring a project to fruition---rather, the time period is sufficient for learning the basics of an open problem and implementing proof-of-concept ideas suggesting the feasibility of a possible approach. If a project showed promise for longer-term study, teams were encouraged to document their work and identify a means of collaborating over the longer term. A post-program survey showed that 82.4% of students intended ("likely" or "very likely") to work with an SGI mentor over the longer term.

The program included 19 guest speakers, who were each invited to spend an hour introducing their research and interacting with the students. The program of speakers spanned the applications of and approaches to geometry processing research and development, from Prof. Rana Hanocka's (University of Chicago) work on mesh-based deep learning to Prof. Bruce Fischl's (Harvard/MGH) work on the geometry of the human brain to Prof. Theodore Kim's (Yale University) work promoting anti-racist computer graphics research. The SGI schedule included most guest speakers at either 10am or 4pm ET, to supplement the 11am-4pm official SGI "working hours" for research projects and to balance among time zones; some students chose to watch recordings of the talks at a different time when their time zone made it difficult to attend (and when speakers permitted their talks to be recorded).

Another special session organized by MIT PhD student Leticia Mattos Da Silva went over the graduate admissions process. After introductory slides covering the basics and dispelling common myths about graduate admissions, Ms. Da Silva and some of her colleagues at similar career stages hosted a Q&A session with the Fellows, which garnered so many questions that the discussion continued for weeks on a dedicated Slack channel.

Informal feedback from SGI students, mentors, and other participants reflected the program's many successes as well as aspects to be improved in future iterations. Accompanying this informal signal with more formal feedback mechanisms would bolster confidence in the structure and value of the program.

A number of questions on the final survey asked Fellows to rate on a scale from 1 (strongly disagree) to 5 (strongly agree) their feelings about several statements. The appendix contains average responses to each question. Students generally indicated agreement with the sentiments expressed in these questions, and promisingly the three statements with which they agreed most strongly were:

* SGI has increased my interest in pursuing additional research opportunities. (4.88)
* I would recommend SGI to my student colleagues in the future. (4.82)
* Geometry processing is a welcoming research community. (4.82)

Based on the success of SGI 2021, the community has begun planning a 2022 offering, which has received an overwhelming level of interest and number of applications.

Training Opportunities: The central goals of SGI were to give training opportunities in applied geometry. Please see the other sections for details.

Results Dissemination: A number of research projects launched during SGI are on a path toward submission in a peer-reviewed journal or conference, such as ACM SIGGRAPH, the European Conference on Computer Vision (ECCV), and the International Conference on Machine Learning (ICML).

During the program, SGI Fellows were encouraged to document their research and experiences on an outward-facing blog, available here: http://summergeometry.org/sgi2021/ --- Several SGI Fellows reported that this means of dissemination was valuable as a credential in their subsequent applications for graduate school.

The MIT EECS department featured SGI in a news article describing the program's successes, available here: https://www.eecs.mit.edu/the-shape-of-success-the-summer-geometry-initiative/

Honors and Awards: As of this report, the admissions cycle for the 2021-2022 PhD application season is underway. We have already heard from 5-10 SGI Fellows that they have decided to pursue PhDs in related disciplines, and several have received offers to join laboratories at top universities in the US and abroad.

One project that started as an SGI project already has been accepted to the International Meshing Roundtable (IMR), where it earned the Best Technical Paper award.

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PARTICIPANTS:

Participant Type: PD/PI
Participant: Justin Solomon
Person Months Worked: 1.00 **Funding Support:**
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National Academy Member: N

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Article Title: Local Decomposition of Hexahedral Singular Nodes into Singular Curves
Authors: Paul Zhang, Judy Chiang, Xinyi Fan, Klara Mundilova
Keywords: hexahedral meshing
Abstract: Hexahedral (hex) meshing is a long studied topic in geometry processing with many fascinating and challenging associated problems. Hex meshes vary in complexity from structured to unstructured depending on application or domain of interest. Fully structured meshes require that all interior mesh edges are adjacent to exactly four hexes. Edges not satisfying this criteria are considered singular and indicate an unstructured hex mesh. Singular edges join together into singular curves that either form closed cycles, end on the mesh boundary, or end at a singular node, a complex junction of more than two singular curves. While all hex meshes with singularities are unstructured, those with more complex singular nodes tend to have more distorted elements and smaller scaled Jacobian values. In this work, we study the topology of singular nodes. We show that all eight of the most common singular nodes are decomposable into just singular curves. We further show that all singular nodes, regardles
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Partners

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I certify that the information in the report is complete and accurate:
Signature: Justin Solomon
Signature Date: 3/15/22 2:20PM

List of Student Participants in SGI 2021		
First Name	**Last Name**	**Contribution to the Project**
Shreya	Ahirwar	Tutorial week invitee
Juan	Atehortúa	SGI Fellow
Vivian	Auduong	Tutorial week invitee
Judy	Chiang	SGI Fellow
Adrish	Dey	SGI Fellow
Natasha	Diederen	SGI Fellow
Kirby	Dietz	SGI Fellow
Xinyi (Cynthia)	Fan	SGI Fellow
Valerio	Galanti	SGI Fellow
A. Ersagun Guden	Guden	Tutorial week invitee
Olga	Gutan	SGI Fellow
Natalia	Hajlasz	Tutorial week invitee
Shreya	Hegde	SGI Fellow
Caroline	Horsch	Tutorial week invitee
Faith	Hunja	SGI Fellow
Faria	Huq	SGI Fellow
Erick	Jimenez Berumen	SGI Fellow
Berna	Kabadayi	SGI Fellow
Lily	Kimble	SGI Fellow
Jimin	Lee	Tutorial week invitee
Nathan	Lin	Tutorial week invitee
Zihan	Ling	Tutorial week invitee
Saiyue	Lyu	Tutorial week invitee
Bonnie	Magland	SGI Fellow
Asia	Mainenti	Tutorial week invitee
Alice	Mehalek	SGI Fellow
Zeltzyn Guadalupe	Montes Rosales	SGI Fellow
Jonathan	Mousley	SGI Fellow
Dorothy	Najjuma Kamya	SGI Fellow
Lauren	Neudorf	Tutorial week invitee
sidony	o'neal	SGI Fellow
Deniz	Ozbay	SGI Fellow
Kinjal	Parikh	SGI Fellow
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Joana	Portmann	SGI Fellow
Shilpa	Rao	Tutorial week invitee
Tal	Rastopchin	SGI Fellow
Alexander	Rougellis	SGI Fellow
Sneha	Sambandam	SGI Fellow
Foqia	Shahid	SGI Fellow

Maria	Stuebner	Tutorial week invitee
Talant	Talipov	SGI Fellow
Immaculate	Tallam	Tutorial week invitee
Monica	Tang	Tutorial week invitee
Lucas	Valença	SGI Fellow
Sam	van der Poel	Tutorial week invitee
Bryce	Van Ross	SGI Fellow
Marcus	Vidaurri	SGI Fellow
Zhecheng	Wang	SGI Fellow
Wei	Wang	Tutorial week invitee
Helena	Yang	Tutorial week invitee
Sahra	Yusuf	SGI Fellow
Tatiana	Zaitceva	Tutorial week invitee
A full list of program volunteers can be found here:		
http://summergeometry.org/sgi2021/wrapping-up-sgi-2021/		