cg@penn

UNIVERSITY OF PENNSYLVANIA

December 2017

Deformable dragon by Ziyin Qu (SCMP '18), Yaoyi Bai (CGGT '18) and Joshuah Wolper (PhD)

Letter from Norm Badler, SIG Center Director

Greetings from CG@Penn!

Much has happened since our last Newsletter, and we hope this one fills the gap. Our faculty has grown by two: Assistant Professor Chenfanfu ("Fanfu") Jiang joined us in summer 2017, and DMD/CGGT alum Adam Mally is now a full-time Lecturer. These additions translate into immediate research and teaching opportunities. Fanfu is well known for physics-based modeling of materials, and has contributed to material effects for water, snow, sand, and cloth in movies such as Frozen and Moana. Fanfu offered a Seminar course in these techniques this Fall. Adam (with co-instructor Rachel Hwang) inaugurated a new course in "Procedural Graphics" (profiled inside). Adam also modernized our first computer graphics course and expanded it to include our first semester CGGT students as well as our DMD undergraduates.

We celebrated Fanfu's move to Penn with a nice party at SIGGRAPH 2017 co-hosted with his alma mater, UCLA. We had an excellent time mingling with Penn alumni, other computer graphics folks, as well as present students and faculty from UCLA and Penn. We also applaud Fanfu's four SIGGRAPH papers, the SIGGRAPH paper by alumni Peter Kutz and Karl Li, and our Transactions on Graphics paper presented there by former lab PostDoc Funda Durupinar.

We had an amazing summer research program in 2017, hosting 24 students across projects supervised by Fanfu, Steve, Adam, and Norm. We attracted applicants from other Universities and hosted international visitors as well. We look forward to an even larger 2018 program. If you have considered making a donation to Penn Engineering, please consider designating your gift to the SIG Center. All gifts that we receive are channeled into student support activities such as summer stipends and conference travel. Your support will be greatly appreciated by those given such extracurricular opportunities.

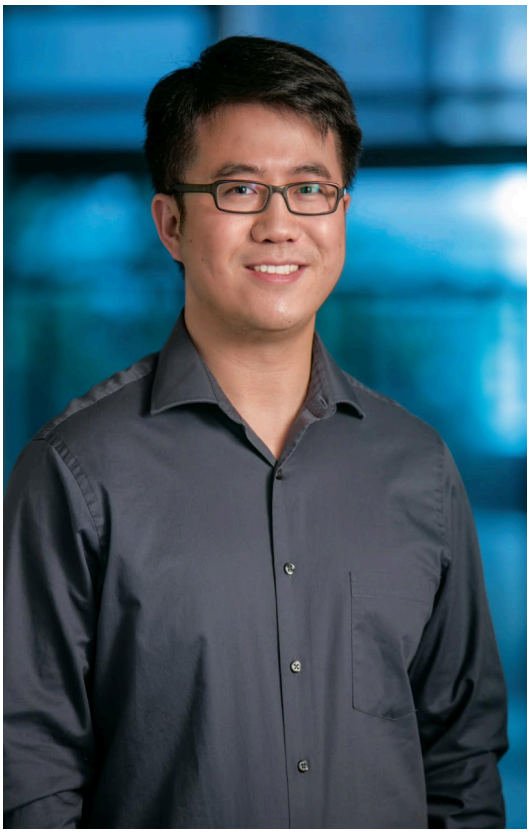
This issue also includes notes on an VR Showcase entry at the Cannes Film Festival, "Pippa's Pan", that Penn students participated in, articles from "Faces of SIGGRAPH Profiles" for Patrick Cozzi and Rachel Hwang, graduates and empoyers for the 2017 class, and a University-wide effort by Sacha Best on "Turning Virtual Reality into a Real Community." Special thanks to Chloe Snyder (DMD '17) for designing this Newsletter.

The image that graces the inside cover and our annual Holiday card was produced by CGGT '17 student Mariano Merchante. Yes, it is a 3D model of part of Penn's College Hall, not a photograph (the real trees aren't nearly that tall!).

Recently we calculated that there are around 500 alumni from our computer graphics programs. That's a significant impact and many of your are part of that. We hope you enjoy this Newsletter. Please let us know if there is news we should hear!

Norm

Introducing Chenfanfu ("Fanfu") Jiang



Assistant Professor of Computer and Information Science (CIS), and newest member of the CG@Penn family.

Even if you have never met Dr. Jiang, you are probably familiar with the products of his state-of-the-art research on the Affine Particle-in-Cell Method (APIC). APIC was one of the key components of the fluid simulation in the Disney movie *Moana*.

Chenfanfu Jiang received his Ph.D in CS from UCLA in 2015, co-advised by Prof. Demetri Terzopoulos and Prof. Joseph Teran. He was awarded the UCLA Edward K. Rice Outstanding Doctoral Student Award in 2015. He received his B.S. in Physics from Class for the Gifted Young (SCGY) of University of Science and Technology of China (USTC) in 2010. His primary research focus is physics-based simulation for animation and visual effects and cross-field collaborative research with computer vision, scene understanding, robotics, cognitive science, and medical training.

Among his many awards for his work, Dr. Jiang has received the Best Paper Award at the ACM SIGGRAPH/EG Symposium on Computer Animation -SCA (2013). His paper "Position-Based Multi-Agent Dynamics for Real-Time Crowd Simulation" received the Best Paper Award in Motion in Games 2017! Dr. Jiang and his team also had two SIGGRAPH papers and two SIGGRAPH Asia in 2017. His SIGGRAPH 2017 paper on porous water-sand mixture is featured in Gizmodo.

Dr. Jiang's current research team at Penn includes: Andre Pradhana Tampubolon, Penn Computer and Information Science Postdoc, Chi Zhang, Penn Robotics master student, Ziyin Qu, Penn Scientific Computing master student, and Hannah Bollar, Penn Digital Media Design undergraduate student. Dr. Jiang's research on virtual injury and medical training has been featured in New Scientist, Gizmodo, Popular Science and Science Net.

In Spring of 2018, Dr. Jiang will be teaching CIS 563, Physically Based Animation. We are thrilled to have Dr. Jiang at Penn!

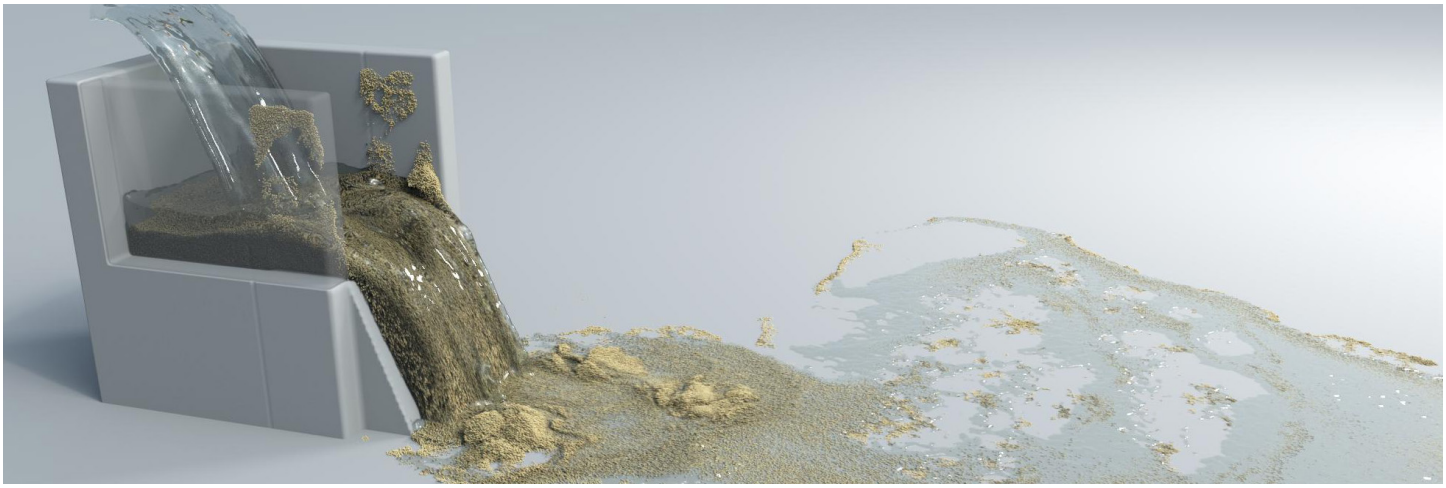
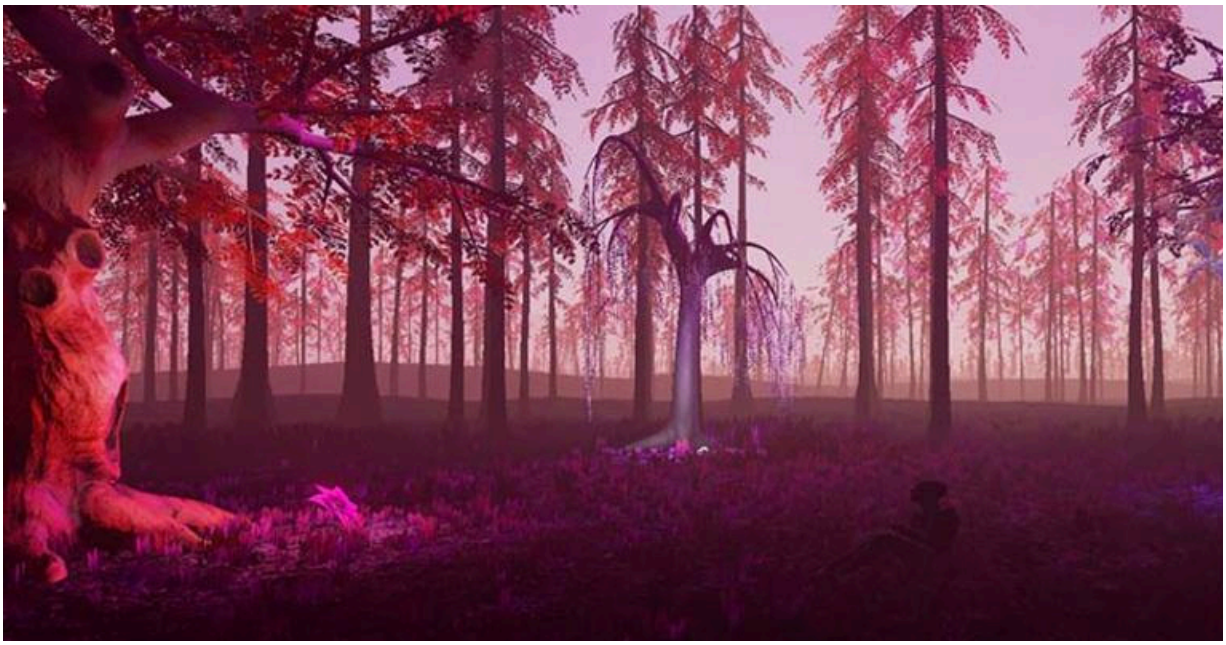


Image from "Multi-Species Simulation of Porous Sand and Water Mixtures"

VR Film *Pippa's Pan* scores in the VR showcase at Cannes Film Festival 2017

by Richard Lee (DMD '17)

Our team consisted of 20 students spread across the US from schools such as Yale, School of Visual Arts, Brown, and CalArts. We had a mix of artists and engineers, each lending their strengths to the different aspects of the film, from animation and 3D modeling to sound engineering and programming. The team was mainly assembled by the director, Yale student Celine Tien, by spreading word about the project at various schools and through mutual connections and referrals.



Pippa's Pan is a story about a woman suffering from Alzheimer's disease who is trying to recapture memories of her husband. The film is experienced through a VR headset, which allows the participant (the person experiencing the film) to become immersed in its environment - in this case the computer-generated "forest" of Pippa's mind. Celine wrote the original script for the story, and once **Irem Öz** (also DMD '17) and I started on the project, we were able to use our previous experience working in VR to help develop the script to suit the needs of the medium. This included aspects like utilizing non-linear storytelling and designing the user experience around a space that would be viewed from all angles.

We collaborated remotely through a variety of channels and tools – we used Google Hangouts for meetings and Slack to organize our communications, and a mix of Google Drive and Box to store our content and work on the project simultaneously.

Pippa's Pan is one of the world's first live-action VR films, merging traditional animation and world building with motion capture and lightfield technology. We were able to use the unique aspects of VR technology to enhance the participant's immersion in the story and world. The participant becomes an actor "agent". The agent can walk around, "transport" to a different location in the forest, and engage with objects in the film – by picking up a flower, for example. These actions also influence the memories viewed by the agent, allowing for a non-linear storyline in which the agent affects the experience as he or she engages in it. This helped convey a story of love and loss — of entering into and holding on to memories.

Pippa's Pan won third prize in the AT&T VR/AR Challenge, selected from 67 submissions in the virtual and augmented reality platforms in three rounds of judging. As third-place winners, the creative team for *Pippa's Pan* won a $5,000 cash prize. You can read more about the film and the team at https://developer.att.com/blog/vr-ar-challenge-pippas-pan, and on their Facebook page https://www.facebook.com/pippaspanvr/

Faces of SIGGRAPH: Patrick Cozzi

This Q&A was originally published in the ACM SIGGRAPH Member Profiles.

1. What do you do, and how long have you been doing it?
At Analytical Graphics, Inc., I help the Cesium team and user community create software and standards for 3D geospatial visualization. I also teach computer graphics at the University of Pennsylvania, occasionally write, edit, or review graphics books, and help out with conferences, journals, etc. I'm an engineering practitioner with a bit of academic activity. I've worked in graphics for 13 years and also a few years tinkering in high school in the days of 320×200 256 color displays when everyone was writing their own software rasterizers just before commodity GPUs.

2. What was your first job?
When I was a senior in high school, I developed in-house project management and recruiting software for a local magazine company using the in-style tools of the time – don't laugh – Visual Basic 6, SQL Server 2000, and Visual SourceSafe. I actually started as a typist in the ads department, and moved to the IS department thanks to my brother who was a web developer there.

3. Where did you complete your formal education?
I went to Penn State for undergrad. Most of my graphics education comes from the University of Pennsylvania where I earned a master's in computer science. It is a fantastic place that I basically never left; I now teach the GPU Programming and Architecture course there as well as advise student projects with a focus on creating industry impact, often in collaboration with Khronos.

4. How did you first get involved with ACM SIGGRAPH?
My first SIGGRAPH conference was 2008. I've been every year since. Everyone in graphics at Penn was always talking about SIGGRAPH so I knew I just had to start attending.

5. What is your favorite memory of a SIGGRAPH conference?
At SIGGRAPH 2011, we did a book signing for my first book – on a niche topic of virtual globe rendering – and people actually showed up!
Also, at SIGGRAPH 2016, I was in an Educators Panel with Ed Angel, Dave Shreiner, and Eric Haines. I learned so much from their books and courses over the years, it was a bit surreal to be on a panel with them.

6. Describe a project that you would like to share with the ACM SIGGRAPH community.
Much of my current work is focused on 3D Tiles, an open format for visualizing massive heterogeneous 3D geospatial datasets. Given the incredible data acquisition trends from satellite imagery, LIDAR, drones, and photogrammetry, there is a big need to bring massive model techniques from the graphics industry into geospatial. 3D Tiles does exactly this.

7. If you could have dinner with one living or non-living person, who would it be and why?
Definitely my dad. I still remember when he bought our first computer – "you better use it for school!" – and took me to buy my first graphics book, "Power Graphics using Turbo Pascal."

8. What is something most people don't know about you?
I failed spelling in fifth grade. No one usually fails spelling; they didn't even have summer school for it. Things didn't turnaround academically for me until I was in high school.

9. From which single individual have you learned the most in your life? What did they teach you?
I couldn't possibly name just one. At Penn, Norm Badler and Steve Lane made graphics approachable and alm seem easy. At AGI, Jimmy Tucholski and Deron Ohlarik took a chance on me to work on graphics when I knew very little about the topic. Through working on our book, OpenGL Insights, I learned a lot about community and dedication from Christophe Riccio. Through Khronos, I continue to learn a lot about technology adoption and leadership from Neil Trevett. I also learn a lot from my students; their self-chosen final projects usually set the direction for the course the following year.

10. Is there someone in particular who has influenced your decision to work with ACM SIGGRAPH?
As a student at Penn, there was so much excitement around SIGGRAPH. Norm Badler and Steve Lane have created a great culture.

11. What can you point to in your career as your proudest moment?
After I defended my master's thesis, Norm Badler said to me "congratulations, you earned a master's degree the hard way" because the thesis was an optional replacement for two courses. This was a notable milestone at the start of a long journey.

Faces of SIGGRAPH: Rachel Hwang (CGGT '17)

This Q&A was originally published in the ACM SIGGRAPH Member Profiles

1. What do you do, and how long have you been doing it?
I work as a game developer at an indie game studio.

2. What was your first job?
My first job was working on Cesium, an open source globe rendering project featuring a lot of interesting graphics research.

3. Where did you complete your formal education?
My graphics education was at the University of Pennsylvania, where I received a masters in Computer Graphics and Game Technology.

4. How did you first get involved with ACM SIGGRAPH?
I first joined though the student chapter at my university.

5. What is your favorite memory of a SIGGRAPH conference?
I can't pinpoint a single moment as being my favorite. My favorite aspect of SIGGRAPH is the magic of being surrounded by thousands of people sharing a common passion, and striking up interesting conversations and friendships constantly throughout the week.

6. Describe a project that you would like to share with the ACMSIGGRAPH community.
My favorite project has been a graphics class I designed and taught at the University of Pennsylvania on procedural graphics techniques. The entire course, lecture materials and assignments are open source and available online here if you're interested: https://cis700-procedural-graphics.github.io/

7. If you could have dinner with one living or non-living person, who would it be and why?
Many, many good candidates! One of my picks would be Ada Lovelace -- I would love to hear about her thought processes in helping to found the discipline of computer science, and her struggles with doing technical work as a women in her time and social context.

8. What is something most people don't know about you?
I dream very vividly, and enjoy keeping detailed accounts of the often very narratively complex dreams I have. These accounts often inspire me in my creative graphics work.

9. From which single individual have you learned the most in your life? What did they teach you?
I owe so much to my favorite high school English teacher, who taught me to write and speak clearly. No matter what your field, solid communication skills are invaluable.

10. Is there someone in particular who has influenced your decision to work with ACM SIGGRAPH?
Patrick Cozzi has been an inspiration to me in my graphics career, not just as an engineer, but also as a mentor and community leader. He always, always makes time to help out new and up-and-coming members of the graphics community despite juggling many responsibilities. He's an excellent example of how individuals can help grow collaborative intellectual communities.

11. What can you point to in your career as your proudest moment?
My proudest accomplishment has definitely been the creation of my procedural graphics class. It was an experimental topic and format, but I'm very happy with the community it created, and the blend of technical and artistic perspective that students seemed to get from it. I'm also pleased to say that the curriculum will live on, and the course continues to be offered.

SIGGRAPH Round Up

CG@Penn was well represented both the 2017 SIGGRAPH and SIGGRAPH Asia Conferences with several papers and talks:

- **Anisotropic Elastoplasticity for Cloth, Knit, and Hair Frictional Contact** *Chenfanfu Jiang, Theodore Gast, and Joseph Teran:* In this anisotropic constitutive model for simulating cloth, knit, and hair frictional contact, the model is discretized with the Material Point Method and a novel update of the deformation gradient. Collision-intensive scenarios with up to one million degrees of freedom run in less than 30 seconds per frame. Collaboration with UCLA, JixeFX.
- **Multi-Species Simulation of Porous Sand and Water Mixtures** *Andre Pradhana Tampubolon, Theodore Gast, Gergely Klár, Chuyuan Fu, Joseph Teran, Chenfanfu Jiang, and Ken Museth:* This multi-species model for simulation of gravity-driven landslides and debris flows with porous sand and water interactions uses the material point method and mixture theory to describe individual phases coupled through a momentum exchange term. Collaboration with UCLA and DreamWorks Animation.
- **An Adaptive Generalized Interpolation Material Point Method for Simulating Elastoplastic Materials** *Ming Gao, Andre Pradhana, Chenfanfu Jiang, Eftychios Sifakis:* Through a novel discretization model and the adaptation of sparse paged grid data structure, the approach allows adaptive refining and coarsening of different regions of simulated elastoplastic materials, leading to a highly efficient Material Point Method solver that concentrates most of the computation resources in specific regions of interest. Collaboration with Univeristy of Wisconsin.
- **A Polynomial Particle-In-Cell Method** *Chuyuan Fu, Qi Guo, Theodore Gast, Chenfanfu Jiang, Joseph Teran:* By viewing the grid-to-particle transfer as a linear and angular momentum conserving projection of the particle-wise local grid velocities onto a reduced basis, the new method (PolyPIC) greatly improves energy and vorticity conservation in hybrid particle-grid solid and fluid simulations, revealing unprecedented details in a wide range of physical simulations. Collaboration with UCLA.

Fifth year PhD student **Tiantian Liu** also presented at SIGGRAPH 2017:

- **Quasi-Newton Methods for Real-time Simulation of Hyperelastic Materials** *Tiantian Liu, Sofien Bouaziz Ladislav Kavan*: We present a new method for real-time physics-based simulation supporting many different types of hyperelastic materials. Previous methods such as Position Based or Projective Dynamics are fast, but support only limited selection of materials; even classical materials such as the Neo-Hookean elasticity are not supported. Recently, Xu et al. [2015] introduced new "spline-based materials" which can be easily controlled by artists to achieve desired animation effects. Simulation of these types of materials currently relies on Newton's method, which is slow, even with only one iteration per timestep. In this paper, we show that Projective Dynamics can be interpreted as a quasi-Newton method. This insight enables very efficient simulation of a large class of hyperelastic materials, including the Neo-Hookean, spline-based materials, and others. Our final method is typically more than 10 times faster than one iteration of Newton's method without compromising quality. Collaboration with University of Utah and EPFL.

Norm Badler's work was also represented with oral presentation of his *Transactions on Graphics* paper led by former HMS Center Post Doc **Funda Durupinar**.

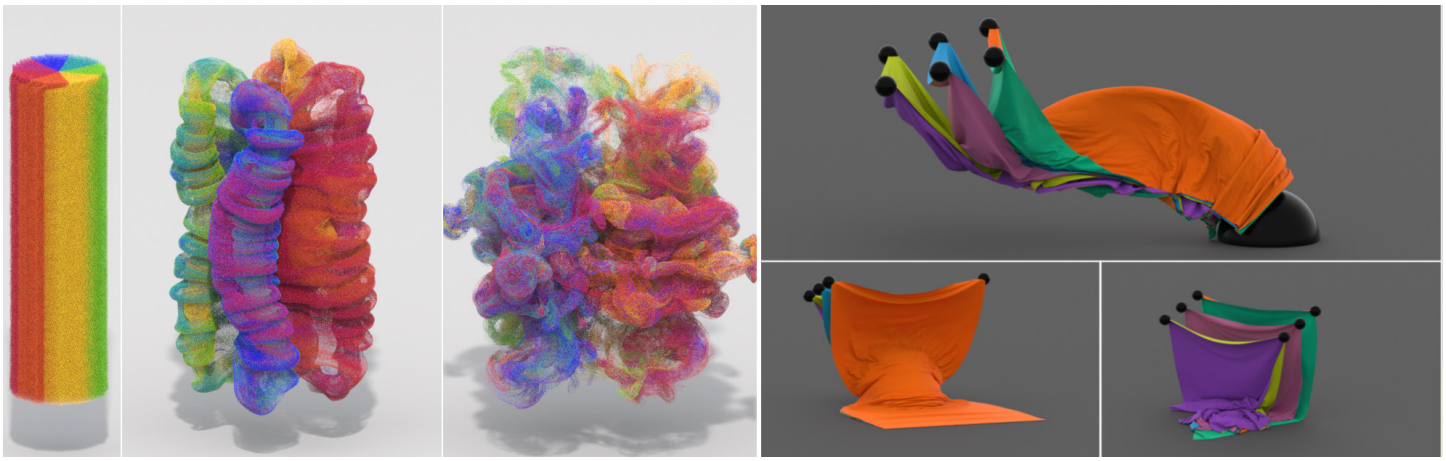
- **PERFORM: Perceptual Approach for Adding OCEAN Personality to Human Motion Using Laban Movement Analysis** *Funda Durupinar, Mubbasir Kapadia, Susan Deutsch, Michael Neff, and Norman Badler:* A major goal of research on virtual humans is the animation of expressive characters that display distinct psychological attributes. The purpose and contribution of this work is to describe a formal, broadly applicable, procedural, and empirically grounded association between personality and body motion and apply this association to modify a given virtual human body animation that can be represented by these formal concepts. Formulating a link from personality to body motion requires an intermediate step; we use Laban Movement Analysis to assist generalization. We have developed an expressive human motion generation system with the help of movement experts and conducted a user study to explore how the psychologically validated OCEAN personality factors were perceived in motions with various Laban parameters. We have then applied our findings to procedurally animate expressive characters with personality, and validated the generalizability of our approach across different models and animations via another perception study. Collaboration with Rutgers University, Drexel University, and the University of California at Davis.

Penn and **UCLA** also hosted a joint reunion and open reception to celebrate the appointment of UCLA PhD Chenfanfu Jiang to the faculty at Penn. The reunion was organized through the SIGGRAPH Birds of a Feather porgram and held at the Millennium Biltmore. The event was well attended and was a great opportunity to re-connect with many Penn alumni attending SIGGRAPH.

James Bartolozzi (DMD '16) and **Matt Kuruc (DMD '08)** of Pixar Animation Studios gave a talk on **"A Hybrid Approach to Procedural Tree Skeletonization"** highlighting a new algorithm for generating tree skeletons which utilizes both volumes and topology to quickly create accurate curve representations of vegetation assets.

Peter Kutz (DMD '13) and **Yining Karl Li (DMD '13, honorary)**, both of Walt Disney Animation Studios, presented a technical paper on **"Spectral and Decomposition Tracking for Rendering Heterogeneous Volumes."** The paper presented two unbiased techniques for sampling free paths in heterogeneous, chromatic participating media. It formulated new techniques in the context of a mathematical framework novel to computer graphics, derived directly from the radiative transfer equation.

Meanwhile, **Patrick Cozzi (MSE '08)** led the Cesium discussion on **"3D Globes on the Web."** Also on the Cesium docket were **Rachel Winetavius Hwang (CGGT '16)** and **Hamoudi Moneimne (CGGT '17)** who joined **Nop Jiarathanakul (DMD, Wharton BSE, CGGT '13)**, a graphics engineer at Autodesk, on the Khronos glTF Birds of a Feather.



Cloth (right) comes from "Anisotropic Elastoplasticity for Cloth, Knit and Hair Frictional Contact", Chenfanfu Jiang, Theodore Gast, Joseph Teran, ACM Trans. Graph. 36, 4 (SIGGRAPH 2017). Smoke (left) comes from "A Polynomial Particle-In-Cell Method", Chuyuan Fu, Qi Guo, Theodore Gast, Chenfanfu Jiang, Joseph Teran, ACM Trans. Graph. 36, 6, Article 222, (SIGGRAPH Asia 2017)

Other Alumni News

Joe Kider (PhD '12) and **Gary Katz (MSE '06)** were one of four winners in the 'Test-Of-Time Category' at the High Performance Graphics conference for their 2008 paper, **"All-pairs Shortest-paths for Large Graphs on the GPU."**

Graham Roberts (DMD '04), of The New York Times, gave a talk, **"A New (Virtual) Reality at the New York Times."** To quote the SIGGRAPH announcement, "When it comes to applying the storytelling power of virtual reality to journalism, The New York Times stands alone as the unparalleled leader. Graham Roberts, Director of Immersive Platforms Storytelling at the Times and leader of the editorial side of their virtual reality initiative, describes how the Times began its immersive adventures and why they are exploring it seriously as part of their larger mission. He also offers insights into recent and ongoing projects, and a vision for the future." The audience was given a peek at the creation of "The Antarctica Series: Under A Cracked Sky,' a short film produced by Roberts and a part of the four films within the Times' Antarctica series. Graham is not only a five-time Emmy-nominated journalist and leader of one of the most innovative approaches to journalism, he also just became a first-time Dad! Congratulations!

Another DMD alumnus in the news, **Neil Halloran** was featured in last year's The Best American Infographics. Neil's data-driven documentary, **The Fallen of World War II,** was praised by NPR's Robert Krulwich and won the 2016 Interactive Innovation Award for Visual Media Experience. The award recognizes "content creation and delivery that moves beyond passive viewership by providing a more immersive and engaging entertainment experience." Watch *The Fallen* at https://vimeo.com/128373915.

Post Doc Corner

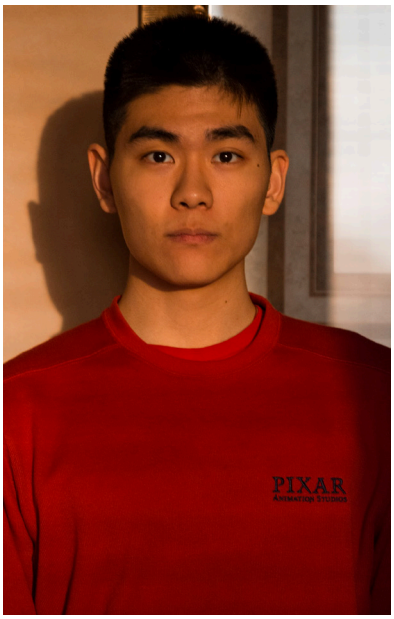
Introducing Andre Pradhana-Tampubolon

Andre Pradhana-Tampubolon is a researcher in computer graphics specializing in physics-based simulation. He obtained his BSc. from California Institute of Technology in 2011 in Applied and Computational Mathematics. He obtained his MASt. from University of Cambridge in 2012 specializing in numerical analysis in the Department of Applied Mathematics and Theoretical Physics (DAMTP). He studied under Prof. Joseph Teran at University of California, Los Angeles from 2012-2017, obtaining a PhD in Mathematics. In 2016, he spent a wonderful summer doing
internship in the R&D department at DreamWorks Animation Studio. He is currently a postdoctoral scholar in the Computer and Information Science Department under the supervision of Dr. Chenfanfu Jiang.

Save the Date!

The **20th Anniversary of DMD** will be celebrated **October 20 or 21, 2018**, as part of the Penn Parents weekend. Breakfast, talks, and reminiscences are planned in Levine Wu & Chen auditorium. Further information will be available via Facebook CG@Penn as plans gel.

Awards



The Dawn and Welton Becket Digital Media Design Award

The 2017 Dawn and Welton Becket Digital Media Design Award is presented to the DMD senior who exemplifies the ideals of the DMD program through outstanding achievement, citizenship, and mentoring.

The award for 2017 went to **Richard C. Lee (DMD '17)** in appreciation for his scholarship, his leadership of the Penn Student SIGGRAPH chapter, his dedication as a TA in the CGGT Game Design Practicum course, his commitment to the Penn Play Games Hackathon, and his significant contributions to the Computer Graphics community at Penn. After internships at Tynker, Pixar and Oculus Story Studio, Richard is now working at Baobab Studios (with fellow DMD alum, **Colin Feo (DMD '15)**).

IFAAMAS Influential Paper Award

The International Foundation for Autonomous Agents and Multiagent Systems Influential Paper Award seeks to recognize publications that have made influential and long-lasting contributions to the field. Candidates for this award are papers that have proved a key result, led to the development of a new subfield, demonstrated a significant new application or system, or simply presented a new way of thinking about a topic that has proved influential.

The 2017 Award went to two papers, one of which was from Penn:

Justine Cassell, Catherine Pelachaud, Norman Badler, Mark Steedman, Brett Achorn, Tripp Becket, Brett Douville, Scott Prevost, and Matthew Stone. **"Animated conversation: Rule-based generation of facial expression, gesture and spoken intonation for multiple conversational agents."** 21st Annual Conference on Computer Graphics and Interactive Techniques (SIGGRAPH), pages 413-420, 1994.

The citation reads: "This paper described for the first time how all multimodal conversational behavior of an agent could be driven by underlying model of face-to-face interaction. It associated cutting-edge computational linguistics with sophisticated computer graphics to result in autonomous agents that were able to engage in a multimodal dialogue with each other. It presents the first fully-functioning system in the area of intelligent virtual agents: a fully embodied, fully autonomous conversing agent that automatically synchronizes facial expressions, head movements, gestures, intonation and speech. Indeed the paper brings together a number of issues that are relevant for agents in virtual environments - and all these aspects have to be structured and balanced. Many papers have built upon this paper and it has made an influential and long-lasting contribution to the field."

CG@Penn Summer Research

Virtual reconstruction and repopulation of the Amazon Baures region of Bolivia, supervised by Norm Badler and Clark Erickson

- Emiliya Al Yafei (DMD '20)
- Youssef Victor (DMD '19)
- Josh Nadel (DMD '20)
- Mabel Ogiriki (Lincoln University '17)

These four students continued the virtual reconstruction of the Bolivian Amazon environment begun during Fall 2016 in the course Professors Clark Erickson and Norm Badler co-teach: CIS106/ANTH258 Visualizing the Past, Peopling the Past. These students had to collaborate to learn the Unreal game engine, add significant terrain, object, and action assets, learn Unreal "Blueprint" programming, virtually clothe the inhabitants, and clean and re-use motion capture human action data. Their main tasks were to build out the human artifacts in this environment, create detailed animations of some of the human activities such as canoeing and fishing, and lay out a village environment.Emiliya and Josh took primary responsibility for building the correctly scaled terrain model from supplied accurate digital elevation datasets, and constructing the human-made features in that terrain such as causeways, canals, and fish weirs. Emiliya and Josh also fixed raw motion capture data for use in Unreal, adjusted and combined animations to create seemingly natural human action and interaction, provided human models with "artificial intelligence" to allow them to roam freely on appropriate areas of the landscape, and scripted their interactions with everyday objects such as carrying baskets, paddling canoes, and fishing as well as interacting with each other. Youssef constructed the entire Baures village, including parametric thatched structures with variable dimensions, rooms, size, and material parameters. Mabel contributed the ethnically correct clothing for the virtual inhabitants. She had to learn and use "Design Suite" software for fashion design to produce animatable clothing for the virtual inhabitants.

Images from virtual reconstruction and repopulation of the Amazon Baures region of Bolivia. Created in Unreal by Emilya Al Yafei (DMD '20), Youssef Victor (DMD '19), Josh Nadel (DMD '20), Mabel Ogirki (Lincoln U '17)

Augmented Material Point Method for cutting and coupling continuum materials with thin rigid bodies (Fanfu Jiang and Andre Pradhana, supervisors)

- Yuanming Hu (MIT, 1st year Ph.D.)
- Ziyin Qu (University of Pennsylvania, 2nd year M.S.)
- Yu Fang (Tsinghua University, senior)
- Ziheng Ge (University of Science and Technology of China, senior)

This group of four students worked on augmenting the Material Point Method (MPM) to a wider range of physical phenomena - incompressible fluid, surface tension, rigid-deformable coupling, and material cutting. They worked as an effective team and quickly learned the basics of both the mathematical theory and the engineering aspects of the work. With the mentoring of Prof. Chenfanfu Jiang and Postdoc Andre Pradhana, they collaborated to learn both continuum mechanics and numerical analysis techniques for simulation. The tools they used are sophisticated C++ libraries and they needed to make a substantial modification to the existing tools. Yu was in charge of implementing surface tension models and porting a position correction algorithms to MPM, which proves to be helpful to improve particle distribution. He also investigated a rigid-fluid coupling algorithm. Ziheng worked on better incompressible fluid, where imcompresibility is imposed as a computationally inexpensive modification to the MPM simulation loop. Ziyin also worked on incompressible fluid and helped with others' research. At the beginning of the summer, he implemented a weakly compressible fluid model in MPM as a starting point. Yuanming explored the possibility to use asynchronized time integration and implicit explicit schemes to speed up MPM, and developed a cutting algorithm, which also enables weak coupling between particles and rigid bodies, for MPM. The results from this research project will be submitted to a prestigious conference or journal.

Real-time animated face and eyes (Norm Badler, supervisor).

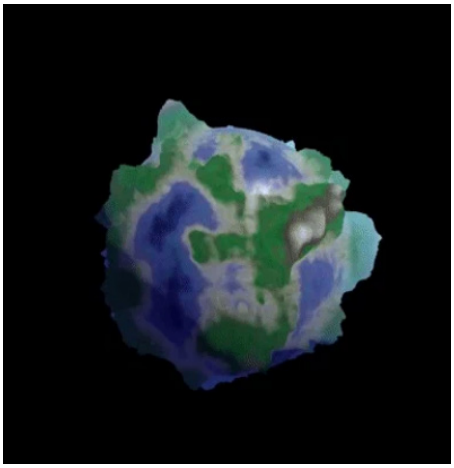
- Grace Gilbert, DMD '20
- Christine Fu, DMD '18
- Xuan Huang, Bryn Mawr '17

This project focused on 3D modeling and animation of detailed human eyes and the skin area surrounding them. We broke this down into three strongly interconnected components: eye motion (gaze and saccade) models, eye blink behaviors, and the wetting and tearing process. Grace Gilbert worked primarily on making the eye model, adding joints to make it move, and simulating tears. Xuan Huang worked on various eye expression and blinking animations, such as a number of blinking-while-crying animations. Christine Fu mainly worked on animating the eyeball, which included rotating the eye to look at given points and implementing eye saccades.
None of these students had any prior experience in 3D face modeling per se, so they started by reading several recent research papers on the topic. We met weekly to discuss the content and import of each of these papers. Then they began implementing geometry and movement models. Their end result was a virtual eye with various parameters for eye expressions and tears controllable by a user-generated script and a probabilistic model to generate eye saccades and gaze directions. Collaboration and software integration were an important component of the learning process for this team.

CIS 700: Procedural Graphics

by Rachel Hwang

Why the separation between art and engineering? I've always found beauty in math and formalism, and science in creative expression. I was delighted to find the graphics program at Penn, a curriculum and community designed around exactly that. The Digital Media Design major (DMD) and the Computer Graphics and Game Technology degree (CGGT) are intended to give students a mixture of engineering and artistic perspective in order to prepare them for work in fields like animation and games that require an understanding of the creative process as well as the technical chops to solve difficult engineering problems. As a CGGT student, I quickly fell in love with programming for visual output, and the wide array of fascinating topics in our curriculum – the rigor of animation math, the satisfaction of 3D modeling. However, I wondered: there were engineering classes and art classes, why were there no courses that combined artistic and engineering challenges more directly?



Procedurally Generated Planet by Daniel McCann, DMD '17

Inspired by my always enterprising classmates, I set out to create the sort of course I wanted to see. The course was designed to be both a visual art and a computer science class, one that gave students a mathematical and algorithmic toolbox in order to create unique generative artwork in the form of software. I filled the curriculum with all my favorite algorithms: noise functions, formal grammars, Voronoi diagrams, everything that I could see being useful in creating complex and beautiful imagery. In the end, the course was approved as CIS 700: Procedural Graphics, which I would teach the semester after I graduated.

I was amazed when 25 students registered, as opposed to the small handful I expected. Thus began the most educational semester of my academic career. Since I was already experimenting with choice of topic, I also decided to experiment with format. Rather than a traditional lecture or seminar, the class met once a week in three hour sessions. The first half of class was lecture in the week's technical topic, and the second half was an in-class lab that asked students to apply the concepts they just learned in a short creative exercise. Since one of the primary goals of my course was to get students thinking creatively with technical concepts, not just implementing them, I also began each class with a short "procedural problem of the day." I would display an image or video and ask the class in a Socratic-style discussion how they would generate the effect they saw algorithmically. Each week, the assignment would ask students to create a procedural art program using the techniques we covered in class, ranging from procedural cities, to bird wings, to plants and crowds.

I'm delighted to say this experiment was a success. Week after week, I was blown away by Penn graphics students' hard work, creativity and enthusiasm for the material. Far from suffering from a lack of rigor, I felt that trying to generate specific output forced students to have a deeper understanding of the algorithms we used. Although this was my first experience designing and teaching a course, students were incredibly receptive to the experimental, sometimes chaotic aspects of the class. I was thrilled to get a sense of community centered around excitement for the material that extended past classroom hours. Students left the class with portfolios of procedural art projects, and I was left with some of the fondest, and most educational memories I have of Penn.

I feel incredibly lucky to have had the opportunity to share my love (or obsession, to be honest) of procedural art with the Penn community. While I'm no longer at Penn, I've delighted to say that Procedural Graphics has been assigned a real course number, CIS 566, and is being taugh by Adam Mally in the Spring Term. Meanwhile, to get inspired, check out the course materials (which are all open source), and consider joining us down the procedural art rabbithole :)

Turning Virtual Reality into a Real Community

by Sacha Best

In Fall 2016 and the beginning of my senior year at Penn. I was faced with a trade-off endemic to many other engineering students: I could either work on a VR passion project outside of class, or continue working as a teaching assistant for various classes in which I'd already invested years of work. This was a hard decision; graduating in May meant that the opportunity to teach and interact with Penn's engaged students would soon disappear, but likewise would the resources Penn offers to student entrepreneurs.

I brought this conundrum to Dr. Swapneel Sheth, a Lecturer in the Department of Computer and Information Science and to Dr. Lane, Professor of Practice and my instructor when I took Game Design, which had a VR component. We spent the next two months collaborating on the syllabus and planning for a full-semester course that eventually made its way onto the roster for Spring 2017 as CIS 568: Virtual Reality Practicum. The goal was to take adept software engineers and give them the tools and background necessary to develop for both VR and AR (augmented reality), where virtual objects are superimposed on the real world.

To manage the class size—interest completely outweighed our capacity—we required students to complete an application, and after careful deliberation, we arrived at our final count of 17 students. However, we decided to record select lectures to broaden our reach to those we could not accept into the classroom. Students completed projects under timelines that would seem insurmountable to a seasoned computer graphics student. They never ceased to amaze me, Dr. Lane, and our TAs.

Students demoing their final projects at Penn VR/AR Day

It was readily apparent at the beginning of our course adventures that interest in VR at Penn extended beyond academics. Therefore, in parallel, I began to foster a community of VR enthusiasts beyond Penn Engineering, and met Tian Pei, an MBA student who had spearheaded the VR/AR effort at Wharton since her arrival at Penn last fall. The two of us began to explore how to showcase VR at Penn. Based on the success of TEDxPenn and PennApps, we concluded that an event showcasing the engineering chops of the industry, but also intended for a non-technical audience, would be the best way to bring together interested students. We were soon joined by Chloe Snyder, a fellow senior in the Digital Media Design program, and together we set out to make Penn the hub for VR/AR on the East Coast. The idea for VR Day was born.

Our work came to fruition when Penn VR Day sold out in just three days! The day began with a set of engaging talks and a panel featuring speakers from Google, HTC, Microsoft, Big Bright Monster, and Variant VR. Attendees were then invited to experience demos from both participating companies and students from CIS 568. In those demos, two amazing things happened. First, our students were able (and elated!) to showcase their work alongside industry moguls, and second, I saw the excitement from my first VR experience reflected on guests trying out the hardware for the first time. Those are two moments I will not soon forget.

This past year has been a whirlwind and filled with truly rewarding work. I cannot thank Professors Lane and Sheth enough for their amazing mentorship throughout the process, nor can I ever hope to repay Chloe and Tian for their tireless work in putting VR Day together. And, of course, if it weren't for Penn, none of this would have been possible. This year's Penn VR Day will be in April. Keep an eye out for VR/AR events around cam-

DMD 2017 Graduates

The DMD and CGGT Classes of 2017 are off to do new and exciting things! Some may be in internship positions or still looking, but there are some great companies interested in our students!

- Paul Batterman
- Alex Mongomery-Daley
- Leesa Fini
- Davin Hazard
- Nancy Huang
- Ji Hyun Sally Kong
- Anais Angela Lee
- Richard Lee
- Dan McCann
- Xhiyu Annie Meng
- Irem Öz
- Conor Ryan
- Chloe Snyder
- Katie Wu
- Robert Zhou

The Penn class of 2017 Ivy Day Stone, designed by DMD 2017 graduate Chloe Snyder

Bloomberg

esri

Disney Movies VR

audible

baobab

Google

Blue Sky STUDIOS

MPC

JPMorganChase

Microsoft

CGGT 2017 Graduates

- Ruoyu Fan
- David Sylvain Simon Grosman
- Rachel Hwang
- Lan Troy Chuang
- Trung Le
- Alexander Miller
- Kangning Gary Li
- Liang Peng
- Jian Ru
- Akshay Shah
- Xueyin Wan
- Kuan Wang
- Menglu Wang
- Zimeng Yang
- Jingyi Zhou

Some DMD and CGGT '17 graduates celebrating at Franklin Field

VELAN STUDIOS

HeavyWater

Microsoft

vmware®

BONFIRE STUDIOS

SYNOPSYS®

havok

Rendered image of College Hall by Mariano Merchante, CGGT 2017. Made using Maya and rendered with Redshift. Every roof tile and wall stone was hand modeled and placed. All materials are procedural, including the snow and its displacement. Specific light bounce cards were added to emphasize atmosphere, along with specular only lights that sculpt the reflection of the windows.

cg@penn

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