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1 Bio

Chenfanfu Jiang is an Associate Professor of Mathematics at the University of California, Los Angeles. He is the director of UCLA's Artificial Intelligence and Visual Computing (AIVC) Lab. His expertise lies in the creation, representation, comprehension, and enhancement of digital 2D/3D content, neural radiance fields, physics-based dynamics, and embodied AI systems, propelling advancements in computer graphics, computer vision, computational mechanics, artificial intelligence, and robotics. He has authored over 100 papers in these disciplines, including more than 40 in prestigious ACM SIGGRAPH/Transactions on Graphics. Jiang has developed computational algorithms that have been widely implemented in computer graphics, robotics, and computational mechanics. His notable contributions include the Affine Particle-In-Cell (APIC) method for fluid dynamics, the Moving Least Squares Material Point Method (MLS-MPM) for continuum materials, and the Incremental Potential Contact (IPC) method for solid dynamics. His research has received funding from the NSF, DOE, and industrial partners such as Toyota, Amazon, Sony, and Adobe. His awards include the UCLA Edward K. Rice Outstanding Doctoral Student Award (2015), NSF CRII award (2018), NSF CAREER award (2020), Amazon Science Hub Award (2023), Sony Faculty Innovation Award (2023), and best paper awards at SCA, MIG, and ICRA. Jiang received his Ph.D. in computer science from UCLA in 2015, co-advised by Demetri Terzopoulos and Joseph Teran. Before his tenure at UCLA, he was an Assistant Professor at the University of Pennsylvania in Computer and Information Science (2017-2021).

Jiang's Affine Particle-In-Cell (APIC) method, recognized with the UCLA Edward K. Rice Outstanding Doctoral Student Award in 2015, dramatically enhanced fluid simulation techniques. APIC yields significantly more stable and low-dissipation fluid behaviors compared to prior methods, leading to more realistic and visually captivating effects. The technology is further refined into Polynomial PIC in 2017 and Power Diagram PIC in 2022. APIC has been adopted as a core fluid solver in VFX software such as SideFX Houdini and Autodesk Maya. Its influence is widespread, contributing to the stunning visual effects in numerous movies and animations like Moana, Zootopia, and Avatar2.

Jiang's work in 2018 on the Moving Least Squares Material Point Method (MLS-MPM) marked a major advancement in the field of elastoplastic material simulation. This development has catalyzed extensive subsequent research, including enhancements for GPU, multi-GPU, and distributed MPM systems. Jiang's decade-long investigations in MPM have led to the widespread adoption of the corresponding algorithms and code. They are integral not only in computer graphics engines like Autodesk Bifrost and NVIDIA Omniverse, but also play a significant role in projects such as the US Department of Energy's Exascale Additive Manufacturing project and the Swiss Federal Institute for Forest, Snow and Landscape Research's geomechanics software. Additionally, his work has made a substantial impact on the evolution of embodied AI and

robotics simulation environments, as evidenced by its implementation in platforms like Drake, PlasticineLab and ManiSkill2.

Jiang's research on the Incremental Potential Contact (IPC) method which resulted in the PhD thesis of his student Minchen Li (currently CS faculty at CMU), was recognized with the prestigious ACM SIGGRAPH Outstanding Doctoral Dissertation Award in 2021. The IPC method is a breakthrough solution to a problem that has vexed the fields of computational mechanics, robotics, and computer graphics for decades — the robust simulation of frictional contact in nonlinear solid dynamics. The IPC method ensures unconditional feasibility and differentiability, maintaining intersection-free and inversion-free trajectories regardless of input. IPC along with its extensions outperform competing methods in robustness and is enabling new applications in machine learning, fabrication design, and robotics, which depend on reliable and differentiable simulation outputs.

2 Education

- Ph.D. Computer Science, University of California, Los Angeles, 2012-2015.
  - Thesis title: The Material Point Method for the Physics-based Simulation of Solids and Fluids.
  - Thesis advisors: Demetri Terzopoulos (Computer Science) and Joseph Teran (Applied Math).
  - Thesis committee: Stanley Osher (Applied Math) and Song-Chun Zhu (Statistics).
  - Winner, UCLA HSSEAS Edward K. Rice Outstanding Doctoral Student Award.
- M.S. Computer Science, University of California, Los Angeles, 2010-2012.
  - Thesis title: Simulation of Elastic Solids with Efficient Self-Collision Handling.
- B.S. Plasma Physics, University of Science and Technology of China, 2006-2010.
  - The *Special Class for the Gifted Young* Program
  - Thesis title: Relativistic Correction of $(v/c)^2$ to the Collective Thomson Scattering for High-Temperature High-Density Plasma.

3 Academic Positions

- Associate Professor, Department of Mathematics, University of California, Los Angeles, July 2022 - Present
- Assistant Professor, Department of Mathematics, University of California, Los Angeles, July 2021 - June 2022
- Assistant Professor, Department of Computer and Information Science (CIS), University of Pennsylvania, June 2017 - June 2021
  - Core faculty at the SIG Center for Computer Graphics
  - Faculty Affiliate at the General Robotics, Automation, Sensing and Perception (GRASP) Lab
  - Affiliated to the Penn Institute for Computational Science (PICS), as Workshop Chair 2017-2021
  - Affiliated to the Graduate Group in Applied Mathematics and Computational Science (AMCS)
- Postdoctoral Scholar,(Jointly) Department of Mathematics and Department of Computer Science, University of California, Los Angeles, 2015–2017

4 Awards and Honors

4.1 Personal/Research Awards and Honors

Awards

1. Amazon Science Hub Award, 2023
2. Sony Faculty Innovation Award, 2023
3. NSF CAREER Award, 2020
4. NSF CISE CRII Award, 2018
5. Edward K. Rice Outstanding Doctoral Student Award, Henry Samueli School of Engineering and Applied Science, University of California, Los Angeles, 2015
6. Honor Graduate Certificate, University of Science and Technology of China, 2010
7. Distinguished Undergraduate Student Researcher, Chinese Academy of Science, 2009
8. Excellent Student Scholarship, University of Science and Technology of China, 2006–2009

Notable Nominations

1. Sole Nomination from UCLA Computer Science Department, Chancellor's Award for Postdoctoral Research, 2017
2. Sole Nomination from UCLA, CGS/ProQuest Distinguished Dissertation Award in Mathematics, Physical Sciences, and Engineering, 2016

4.2 Paper Awards

1. Best Paper Award in Mechanisms and Design, IEEE International Conference on Robotics and Automation (ICRA), 2021
2. Third place winner in the Computer Graphics Forum Cover Image Contest (CD-MPM), 2020
3. Best Paper Award, ACM SIGGRAPH/EG Symposium on Computer Animation (SCA), 2019
4. Best Paper Award, Motion In Games (MIG), 2017
5. Best Paper Award, ACM SIGGRAPH/EG Symposium on Computer Animation (SCA), 2013

5 Funding

1. Toyota Research Institute (TRI) University Research Program, 2024-2026
2. Sony Faculty Innovation Award: Topologically Flexible Material Point Methods for Scalable Multiphysics, 2023-2024
3. Amazon Science Hub for Humanity and Artificial Intelligence Award: Differentiable Physics Augmented Neural Radiance Fields for Real-to-Sim & Manufacture-Ready 3D Garment Reconstruction, 2023-2024
4. UC Multicampus Research Programs and Initiatives (MRPI) RFA: MRPI 2023 Planning/Pilot Award: High-Performance numerical solvers for scalable and flexible simulation on modern hardware, 2023-2025
5. NSF CAREER: Simulation of Geometrically Flexible Materials with Applications to Computer Graphics and Computational Science, 2020-2025
6. Contract on Exascale Computing Project from US Department of Energy (DOE): High-performance computing model of powder-scale melting and solidification simulations, 2019-2022

7. NSF CCF-1813624 (AF: Small: Collaborative Research): Large-scale adaptive Material Point Methods for complex materials in multiphysics simulation, Co-PI(s): Eftychios Sifakis (UW-Madison), 2018-2022
8. NSF ASCENT: Programmable Photonic Computation Accelerators (PPCA), PI: Liang Feng (Penn), Co-PI(s): Shays Fainman (UCSD), 2020-2024
9. NSF CISE CRII Research Grant Award IIS-1755544 (CRII: CHS): Robust algorithms modeling frictional contact with industrial, medical and computer graphics applications, 2018-2020
10. Team Grants for Interdisciplinary Activities (TGIA) , University of Pennsylvania: Collaboration between departments of Mechanical Engineering and Applied Mechanics (MEAM) and the Computer and Information Sciences (CIS) on Numerical Modeling of Soft Interactions for Robots, with Cynthia Sung (Penn), Summer 2020
11. Team Grants for Interdisciplinary Activities (TGIA) , University of Pennsylvania: Collaboration between departments of surgery and the computer information sciences to create a software model of hiatal hernias, with Kristoffel Dumon (Penn), Summer 2019
12. Penn Provost's Undergraduate Research Mentoring (PURM) Award, 2018
13. Equipment and software donations from NVidia and SideFX, 2017-2019
14. Gift from Adobe, 2018-2023
15. Gift from Awowd, 2017

6 Invited Talks

1. What You See is What You Simulate, UIUC vision seminar, April 4, 2024
2. Physics-Based Animation of Solids and Fluids, Invited talk at Demetri Terzopoulos's CS 174C, February 5, 2024
3. Scientific Visual Computing in Computer Graphics, UCLA Computer Science Department Faculty Meeting, January 23, 2024
4. Differentiable Material Point Method's Recent Connections to Real World, University of Maryland Computer Science Department Seminar, October 12, 2023
5. Mathematical Principles behind Snow, International Symposium on Computer Engineering and Intelligent Communications, Aug 18, 2023
6. Variational Contact, USTC mathematics summer school, July 10, 2023
7. Energetically Consistent Inelasticity, UCLA Mathematics Colloquium, November 10, 2022
8. Scientific Visual Computing, UCLA Bruin Family Weekend Faculty Presentation, October 28, 2022
9. Incremental Potential Elastodynamics with Contact, UC Riverside Computer Science and Engineering Department Colloquilum, October 7, 2022
10. Simulating Granular Media as Continuum Solids, Invited talk at Demetri Terzopoulos's CS 174C, May 16, 2022
11. Incremental Potential Elastodynamics with Contact: Robust Optimization-based Solvers and Smooth Reformulations, Colorado State University Applied Math/Inverse Problems Seminar, Mar 10, 2022
12. Frictional Contact with Guarantees and Smoothness, The first workshop on SEAI: Simulation Technology for Embodied AI, ICCV, October 16, 2021
13. Incremental Potential Elastodynamics with Contact: Robust Optimization-based Solvers and Smooth Reformulations, UCSD Pixel Cafe, October 8, 2021
14. Robust Optimization-based Solvers and Smooth Reformulations, Siemens Next Generation Simulation Talks, September 13, 2021

15. Developments in Smooth Optimization Contact, MIT Summer Geometry Institute (SGI), August 19, 2021
16. Incremental Potential Elastodynamics with Contact, School of Informatics at Xiamen University, June 27, 2021
17. Simulating Granular Media as Continuum Solids, Invited talk at Marcus Roper's Math 272B, May 26, 2021
18. Continuum Rupture Discrete Particles, Toronto Geometry Colloquium, April 14, 2021
19. Incremental Potential Elastodynamics with Contact: Robust Optimization-based Solvers and Smooth Reformulations, UCLA Applied Math Seminar, December 18, 2020
20. Smooth Reformulations for Physics-Based Simulation: with Case Studies on Frictional Contact and Fracture, New Jersey Institute of Technology Computer Graphics, November 8, 2020
21. Smooth Reformulations for Physics-Based Simulation: with Case Studies on Frictional Contact and Fracture, Advanced Innovation Center for Future Visual Entertainment in Beijing Film Academy, October 29, 2020
22. Smooth Reformulations for Physics-Based Simulation: with Case Studies on Frictional Contact and Fracture, MIT Graphics Seminar, October 7, 2020
23. Photorealistic and efficient simulation of natural phenomena, RealTime Conference (RTC 2020), June 8, 2020
24. Recreating Nature with High-fidelity Physics-based Visual Computing, USC Information Sciences Institute (ISI) AI Seminar, February 14, 2020
25. MPM simulation for viscoplastic flows: pluridisciplinary modeling of snow avalanches, Workshop Graphyz on physics and graphics, Inria, October 24, 2019
26. The power of constitutive modeling in physics-based animation: elasticity, inelasticity, and damage mechanics, ACM SIGGRAPH / Eurographics Symposium on Computer Animation, July 27, 2019
27. Elastoplasticity simulation in computer graphics, The Tristate Workshop on Imaging and Graphics (TWIG) April 7, 2018
28. Elastoplasticity simulation in computer graphics, Rutgers University CS department colloquium, March 9, 2018
29. Scientific computing for animation, visual effects, virutal injury and surgery, Penn Presbyterian Medical Center, November 1, 2017
30. Elastoplasticity simulation in computer graphics, 2017 PICS Conference Emergent Phenomena: Patterns, Function and Beyond, October 5, 2017
31. Scientific computing for animation and visual effects, Cisco Research, September 20, 2017
32. Advances in Material Point Method for computer graphics, GAMES: Graphics And Mixed Environment Seminar, August 17, 2017
33. Creating realistic simulations for animations and VFX, University of Pennsylvania Computer and Information Science Department Summer Session, July 6, 2017
34. Hybrid methods for computer graphics simulation of snow, sand, water, foam, lava and beyond, University of Pennsylvania Computer and Information Science Department, December 13, 2016
35. Physics-based simulation of deformable solids and fluids, UCLA Human Perception Lab, October 21, 2015.

7 Teaching

1. Course instructor and organizer, On Hybrid Lagrangian-Eulerian Simulation Methods: Practical Notes and High-Performance Aspects, SIGGRAPH 2019
2. Course instructor and organizer, The Material Point Method for Physics Based Simulation: Modeling and Discretization, SIGGRAPH 2016
3. Instructor, Math 269B, UCLA, Winter 2023
4. Instructor, Math 269A, UCLA, Fall 2022, Fall 2023
5. Instructor, Math 285J, UCLA, Winter 2022, Spring 2024
6. Instructor, Math 151A: Applied Numerical Methods, UCLA, Fall 2021, Winter 2024
7. Instructor, CIS 563: Physically Based Animation, UPenn, Spring 2018, Fall 2018, Fall 2019, Fall 2020
8. Instructor, EAS 205: Applications of Scientific Computing, UPenn, Spring 2019, Spring 2020
9. Instructor, CIS 700/006: Special Topics in Computer Graphics, UPenn, Fall 2020
10. Instructor, CIS 700/004: Physics-Based Material Simulation, UPenn, Fall 2017
11. Teaching Assistant, Introduction to C++ Programming (PIC 10A), UCLA, Spring 2012
12. Teaching Assistant, Introduction to C++ Programming (PIC 10A), UCLA, Winter 2012
13. Assistant Lecturer, University of Science and Technology of China, 2009–2010

8 Service

University (date in terms of academic year)

1. Computing Committee, Department of Mathematics, UCLA, 2023-2024
2. Undergraduate Advising, Department of Mathematics, UCLA, 2023-2024
3. Graduate Advisor, Department of Mathematics, UCLA, 2023-2024
4. Faculty Advisor for the Math of Computation Major, Department of Mathematics, UCLA, 2023-2024
5. PhD Qual Committee (ONLA), Department of Mathematics, UCLA, 2023-2024
6. Computing Committee, Department of Mathematics, UCLA, 2022-2023
7. PIC Committee, Department of Mathematics, UCLA, 2022-2023
8. Graduate Advisor, Department of Mathematics, UCLA, 2022-2023
9. Graduate Admission Committee, Department of Mathematics, UCLA, 2022-2023
10. Faculty Advisor for the Math of Computation Major, Department of Mathematics, UCLA, 2022-2023
11. PhD Qual Committee (ONLA), Department of Mathematics, UCLA, 2022-2023
12. Computing Committee, Department of Mathematics, UCLA, 2021-2022
13. PIC Committee, Department of Mathematics, UCLA, 2021-2022
14. Graduate Advisor, Department of Mathematics, UCLA, 2021-2022
15. PhD Qual Committee (ONLA), Department of Mathematics, UCLA, 2021-2022
16. ABET coordinator, Department of CIS, University of Pennsylvania, 2020-2021
17. Chair, Penn Institute for Computational Science (PICS) workshop series, 2020-2021
18. Chair, Penn Institute for Computational Science (PICS) workshop series, 2019-2020
19. Chair, Penn Institute for Computational Science (PICS) workshop series, 2018-2019
20. Chair, Penn Institute for Computational Science (PICS) workshop series, 2017-2018

Professional Roles

1. Scientific committee, International Experts Summit on AI and ML, 2024
2. Technical Papers Committee, ACM SIGGRAPH Asia 2023
3. Co-chair, ACM SIGGRAPH Symposium on Computer Animation (SCA) Conference, 2023
4. Technical Papers Committee, ACM SIGGRAPH Asia 2022
5. Co-chair, 1st Workshop on Simulation Technology for Embodied AI, ICCV 2021
6. Chair, Symposium on Computer Animation (SCA) Showcase Program, 2021
7. Technical Papers Committee, ACM SIGGRAPH 2020
8. Technical Papers Committee, rographics 2020
9. Chair, Penn SIG Computer Graphics Colloquium Series, 2020
10. Co-chair, 5th Workshop on Vision Meets Cognition, CVPR 2019
11. Technical Papers Committee, ymposium on Computer Animation (SCA), 2019
12. Session Chair, Symposium on Computer Animation (SCA), 2019
13. Co-chair, 2018 PICS Conference on Modern Computational Science, 2018
14. Co-chair, 4th Workshop on Vision Meets Cognition, CVPR 2018
15. Organizer, The Tristate Workshop on Imaging and Graphics (TWIG) 2018
16. Co-chair, 3rd Workshop on Vision Meets Cognition, CVPR 2017
17. Technical Papers Committee, Symposium on Computer Animation (SCA), 2017
18. Co-chair, 1st Workshop on Virtual Reality meets Physical Reality, SIGGRAPH Asia 2016
19. Co-chair, 2nd Workshop on Physical and Social Scene Understanding, CogSci 2016

Reviewer

1. ACM SIGGRAPH 2016,2017,2018,2019,2020,2021,2022,2023,2024
2. ACM SIGGRAPH Asia 2016,2017,2018,2019,2020,2021,2022,2023
3. ACM Transaction on Graphics (TOG) 2017,2018,2019,2020,2021,2022,2023,2024
4. IEEE Transactions on Visualization and Computer Graphics (TVCG) 2017,2018,2019,2020,2021,2022,2023,2024
5. Computer Methods in Applied Mechanics and Engineering (CMAME) 2021,2022,2023,2024
6. Eurographics 2014,2017,2018,2019,2020,2021,2022,2023
7. Computer Graphics Forum 2017,2018,2019,2020,2021,2022,2023,2024
8. Computational Particle Mechanics (CPM) 2021,2022,2023
9. Pacific Graphics 2016,2017,2018,2019,2020,2021,2022,2023
10. Additive Manufacturing 2022
11. International Conference on Machine Learning (ICML) 2022
12. Association for the Advancement of Artificial Intelligence (AAAI) 2020
13. Haptics Symposium 2020
14. IEEE Access 2019
15. Computer & Graphics 2017
16. Computer Animation and Virtual Worlds 2017
17. CAAI Transactions on Intelligent Technology 2016
18. AIMS Inverse Problems and Imaging 2016
19. IEEE Transactions on Biomedical Engineering 2016

9 Supervision

Postdocs Supervised

1. Minchen Li, Penn Computer and Information Science Postdoc, 2021.1 - 2021.6, UCLA Mathematics, 2021.7 - 2023., next stop: assistant professor at CMU
2. Ming Gao, Penn Computer and Information Science Postdoc, 2018.8 - 2019.6, next stop: research scientist at Tencent America
3. Andre Pradhana Tampubolon, Penn Computer and Information Science Postdoc, 2017.6 - 2018.7, next stop: software engineer at Dreamworks

PhD Students Supervised

1. Chang Yu (co-advised with Demetri Terzopoulos), UCLA CS, 2023 - Present
2. Tianyi Xie (co-advised with Demetri Terzopoulos), UCLA CS, 2023 - Present
3. Yadi Cao (co-advised with Demetri Terzopoulos), UCLA CS, 2021 - Present
4. Zeshun Zong, UCLA Mathematics, 2021 - Present
5. Xuan Li, UCLA Mathematics, 2021 - Present
6. Yunuo Chen, UCLA Mathematics, 2021 - Present
7. Ziyin Qu, Penn Computer and Information Science, 2019 - Present
8. Yuxing Qiu (co-advised with Demetri Terzopoulos), UCLA Computer Science, 2021 - 2024
    - *Dissertation: Scalable and Efficient Material Point Method on Modern Platforms (Defended 2024/1/29).*
9. Yu Fang, Penn Computer and Information Science, 2018 - 2023
    - *Dissertation: Contact Modeling for Optimization Time Integration (Defended 2023/8/23).*
10. Joshuah Wolper, Penn Computer and Information Science, 2017 - 2021
    - *Dissertation: Material Point Methods for Simulating Material Fracture (Defended 2021/4/22).*
11. Minchen Li, Penn Computer and Information Science, 2018 - 2020
    - *Adobe Fellowship winner 2020*
    - *ACM SIGGRAPH Outstanding Doctoral Dissertation Award winner 2021*
    - *Symposium of Computer Animation (SCA) Doctoral Dissertation Award winner 2021*
    - *Dissertation: Robust and Accurate Simulation of Elastodynamics and Contact (Defended 2020/11/16).*

Master Students Supervised

1. Tianyi Xie, UCLA CS, 2022 - 2023
    - *Dissertation: A Contact Proxy Splitting Method for Langrangian Solid-Fluid Coupling*
2. Jin Wu, Penn AMCS, 2021
    - *Dissertation: Deep Learning Based Two-grid Preconditioner for Conjugate Gradient Solver*
3. Jiarui Yan, Penn Computer and Information Science, CGGT, 2020 - 2021
    - *Dissertation: A Method Of Applying Graph Neural Network Into Nonlinear Deformation Simulation*
4. Yan Dong, Penn Computer and Information Science, CGGT, 2020 - 2021, next stop: PhD student at Clemson

- *Dissertation: Neural Projective Dynamics*

5. Yue Li, Penn Computer and Information Science, CGGT, 2018 - 2020, next stop: PhD student at ETHZ
   - *Dissertation: Hybrid Eulerian-Lagrangian Topology Optimization*
6. Bowen Yang, Penn Computer and Information Science, CGGT, 2018 - 2019, next stop: software engineer at Apple
   - *Dissertation: Efficient Staggered Grid Fluid Simulation Bounded on Sphere Surfaces*
7. Ziyin Qu, Penn Scientific Computing Master's, 2017 - 2019, next step: PhD student at UPenn

Undergraduate Students Supervised through Research Projects

1. Boqian Li, HUST visiting undergraduate student, 2023.11-Present
2. Joy Liu, UCLA Math, 2023.10-Present
3. Jianping Ye, UCLA Math summer REU program, 2021.6-2022
4. Sian Wen, UCLA Math summer REU program, 2021.6-2022
5. Mingxin Li, UCLA Math summer REU program, 2021.6-2021.8
6. Yuchuan Yang, UCLA Math summer REU program, 2021.6-2021.8
7. Zeshun Zong, UCLA Math summer REU program (*exception: as a PhD student researcher), 2021.6-2021.8
8. Haorong Wang, Penn CIS undergraduate student, through TGIA grant, 2020.7-2020.9.
9. Beini Gu, Penn CIS undergraduate student, through TGIA grant, 2020.7-2020.9
10. Enoch Solano-Sanchez, Penn CIS undergraduate student, through TGIA grant, 2019.7-2019.9
11. Saranya Sampath, Penn CIS undergraduate student, through TGIA grant, 2019.7-2019.9
12. Nicholas Magarino, Penn CIS undergraduate student, through TGIA grant, 2019.7-2019.9
13. Sang Lee, Penn CIS undergraduate student, through TGIA grant, 2019.7-2019.9
14. Shenqi Hu, Penn CIS undergraduate student, through TGIA grant, 2019.7-2019.9
15. Thy Tran, Penn CIS undergraduate student, through TGIA grant, 2019.7-2019.9
16. Jiecong Lu, Penn CIS (DMD) undergraduate student, 2018.9-2020.6
17. Meggie Cheng, Penn CIS (DMD) undergraduate student, 2019.9-2020.6
18. Yunuo Chen, University of Science and Technology of China visiting student, 2019.7 - 2019.9
19. Yi Gu, University of Michigan visiting student, 2018.7 - 2018.9
20. Chen Li, University of Science and Technology of China visiting student, 2018.7 - 2018.9
21. Liangzhen Fei, University of Science and Technology of China visiting student, 2018.7 - 2018.9
22. Mark Choi, Penn CIS undergraduate student, 2018.7 - 2018.9
23. Xinyang Zhang, University of California, Los Angeles visiting student, 2018.7 - 2018.9
24. Yuanming Hu, MIT EECS / Tsinghua University visiting student, 2017.7 - 2017.9
25. Hannah Bollar, Penn CIS undergraduate student, 2017.6-2017.12
26. Yu Fang, Tsinghua University visiting undergraduate student, 2017.6-2017.1
27. Ziheng Ge, University of Science and Technology of China visiting student, 2017.6-2017.12
28. Duotun Wang, Beijing Institute of Technology undergraduate student, 2017.7-2017.9
29. Wenting Sun, Penn CIS undergraduate student, 2017.6-2017.9
30. Jason Wang, Penn CIS undergraduate student, 2017.6-2017.9

Visiting Scholars/Professors/Graduate Students Hosted

1. Siyu Ma, UCSD visiting graduate student, 2024.1-Present
2. Ying Jiang, HKU visiting PhD student, 2023.1 - Present
3. Yidong Zhao, KAIST visiting PhD student, 2023.10 - 2024.2
4. Johan Gaume, EPFL visiting professor, 2022.5
5. Lars Blatny, EPFL visiting PhD student, 2022.5
6. Xuan Li, State University of New York at Stony Brook, 2019.9 - 2020.8
7. Xinlei Wang, Zhejiang University, 2018.10 - 2020.1
8. Yuxing Qiu, University of California, Los Angeles, 2019.7 - 2020.1
9. Kang Li, Hubei University visiting Professor, 2018.9 - 2019.9
10. Johan Gaume, EPFL visiting professor, 2018.10 - 2018.11
11. Yupeng Jiang, University of Sydney, 2018.10 - 2019.2

PhD Student Dissertation Committee Served NOT as the Advisor

1. Alexander Mayer, UCLA Math, 2023
2. Benjamin Jarman, UCLA Math, 2023
3. Xiao Zeng, UCLA CS, 2022
4. Feng Gao, UCLA CS, 2022
5. Nghia Truong, Utah CS, 2019
6. Tiantian Liu, Penn CIS, 2018
7. Ming Gao, UW-Madison CS, 2018

Master Student Thesis Committee Served NOT as the Advisor

1. Tomoyori Iwao, UCLA CS, 2022
2. Xinling Yu, Penn AMCS, 2021
3. Yaoyi Bai, Penn CGGT, 2018

10 Publications

Papers

1. Jessica Weakly*, Xuan Li*, Tejas Agarwal, Minchen Li, Spencer Folk, Chenfanfu Jiang, and Cynthia Sung, Bistable Aerial Transformer (BAT): A Quadrotor Fixed-Wing Hybrid that Morphs Dynamically via Passive Soft Mechanism, Journal of Mechanisms and Robotics (JMR). 2024.
2. Tianyi Xie, Zeshun Zong, Yuxing Qiu, Xuan Li, Yutao Feng, Yin Yang, Chenfanfu Jiang, PhysGaussian: Physics-Integrated 3D Gaussians for Generative Dynamics, Computer Vision and Pattern Recognition (CVPR), 2024
3. Yutao Feng, Yintong Shang, Xuan Li, Tianjia Shao, Chenfanfu Jiang, Yin Yang, PIE-NeRF: Physics-based Interactive Elastodynamics with NeRF, Computer Vision and Pattern Recognition (CVPR), 2024

4. Ying Jiang*, Chang Yu*, Tianyi Xie*, Xuan Li* (equal contributions), Yutao Feng, Huamin Wang, Minchen Li, Henry Lau, Feng Gao, Yin Yang, Chenfanfu Jiang, VR-GS: A Physical Dynamics-Aware Interactive Gaussian Splatting System in Virtual Reality, Arxiv, 2024
5. Yutao Feng*, Xiang Feng* (equal contributions), Yintong Shang, Ying Jiang, Chang Yu, Zeshun Zong, Tianjia Shao, Hongzhi Wu, Kun Zhou, Chenfanfu Jiang, Yin Yang, Gaussian Splashing: Dynamic Fluid Synthesis with Gaussian Splatting, Arxiv, 2024
6. Yadi Cao, Yidong Zhao, Minchen Li, Yin Yang, Jinhyun Choo, Demetri Terzopoulos, Chenfanfu Jiang, Material Point Methods on Unstructured Tessellations: A Stable Kernel Approach With Continuous Gradient Reconstruction, Arxiv, 2023
7. Xuan Li, Yu Fang, Lei Lan, Huamin Wang, Yin Yang, Minchen Li, Chenfanfu Jiang, Subspace-Preconditioned GPU Projective Dynamics with Contact for Cloth Simulation, ACM SIGGRAPH Asia 2023
8. Zeshun Zong, Xuan Li, Minchen Li, Maurizio M. Chiaramonte, Wojciech Matusik, Eitan Grinspun, Kevin Carlberg, Chenfanfu Jiang, Peter Yichen Chen, Neural Stress Fields for Reduced-order Elastoplasticity and Fracture, ACM SIGGRAPH Asia 2023
9. Ziyin Qu, Minchen Li, Yin Yang, Chenfanfu Jiang, Fernando de Goes, Power Plastics: A Hybrid Lagrangian/Eulerian Solver for Mesoscale Inelastic Flows, ACM SIGGRAPH Asia 2023
10. Minchen Li, Zachary Ferguson, Teseo Schneider, Timothy Langlois, Denis Zorin, Daniele Panozzo, Chenfanfu Jiang, Danny M. Kaufman, Convergent Incremental Potential Contact, Arxiv, 2023
11. Haozhe Su, Xuan Li, Tao Xue, Chenfanfu Jiang, Mridul Aanjaneya, A Generalized Constitutive Model for Versatile MPM Simulation and Inverse Learning with Differentiable Physics, Symposium on Computer Animation (SCA), 2023
12. Yu Fang, Minchen Li, Yadi Cao, Xuan Li, Joshuah Wolper, Yin Yang, Chenfanfu Jiang, Augmented Incremental Potential Contact for Sticky Interactions, IEEE TVCG, 2023
13. Yunuo Chen, Tianyi Xie, Cem Yuksel, Danny Kaufman, Yin Yang, Chenfanfu Jiang, Minchen Li, Multi-Layer Thick Shells, ACM SIGGRAPH, 2023
14. Tianyi Xie, Minchen Li, Yin Yang, Chenfanfu Jiang, A Contact Proxy Splitting Method for Lagrangian Solid-Fluid Coupling, ACM Transactions On Graphics (SIGGRAPH), 2023
15. Lei Lan, Minchen Li, Chenfanfu Jiang, Huamin Wang, Yin Yang, Second-order Stencil Descent for Interior-point Hyperelasticity, ACM Transactions On Graphics (SIGGRAPH), 2023
16. Yuxing Qiu, Samuel T. Reeve, Minchen Li, Yin Yang, Stuart R. Slattery, Chenfanfu Jiang, A Sparse Distributed Gigascale Resolution Material Point Method, ACM Transactions On Graphics (SIGGRAPH), 2023
17. Yadi Cao, Menglei Chai, Minchen Li, Chenfanfu Jiang, Efficient Learning of Mesh-Based Physical Simulation with BiStride-Multi-Scale(BSMS)-GNN, International Conference on Machine Learning (ICML), 2023
18. Xuan Li, Yi-Ling Qiao, Peter Yichen Chen, Krishna Murthy Jatavallabhula, Ming Lin, Chenfanfu Jiang, Chuang Gan, PAC-NeRF: Physics Augmented Continuum Neural Radiance Fields for Geometry-Agnostic System Identification, International Conference on Learning Representations (ICLR), 2023
19. Yidong Zhao, Chenfanfu Jiang, Jinhyun Choo, Circumventing Volumetric Locking in Explicit Material Point Methods: A Simple, Efficient, and General Approach, Arxiv, International Journal for Numerical Methods in Engineering (IJNME), 2023
20. Hangxin Liu, Zeyu Zhang, Ziyuan Jiao, Zhenliang Zhang, Minchen Li, Chenfanfu Jiang, Yixin Zhu, Song-Chun Zhu, Reconfigurable Data Glove for Reconstructing Physical and Virtual Grasps, Engineering, 2023

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11 Projects (Papers by Topic)

My research goal includes bridging the gap between virtual and physical reality. This corresponds to advancing both Metaverse and Embodied AI through developing simulation generative modeling and machine learning technologies that work together.

11.1 Simulation and Modeling

11.1.1 Elastic and Inelastic Deformable Models

1. Material Point Methods on Unstructured Tessellations: A Stable Kernel Approach With Continuous Gradient Reconstruction, 2024
2. Power Plastics: A Hybrid Lagrangian/Eulerian Solver for Mesoscale Inelastic Flows, 2023
3. Neural Stress Fields for Reduced-order Elastoplasticity and Fracture, 2023
4. Circumventing Volumetric Locking in Explicit Material Point Methods: A Simple Efficient and General Approach, 2023
5. Convergent Incremental Potential Contact, 2023
6. Augmented Incremental Potential Contact for Sticky Interactions, 2023
7. Multi-Layer Thick Shells, 2023
8. Second-order Stencil Descent for Interior-point Hyperelasticity, 2023
9. Affine Body Dynamics: Fast, Stable & Intersection-free Simulation of Stiff Materials, 2022
10. A Unified Newton Barrier Method for Multibody Dynamics, 2022
11. Energetically Consistent Inelasticity for Optimization Time Integration, 2022
12. Codimensional Incremental Potential Contact, 2021
13. Intersection-free Rigid Body Dynamics, 2021
14. Medial IPC: Accelerated Incremental Potential Contact with Medial Elastics, 2021
15. High-order Differentiable Autoencoder for Nonlinear Model Reduction, 2021
16. AnisoMPM: Animating Anisotropic Damage Mechanics, 2020
17. Incremental Potential Contact: Intersection- and Inversion-Free, Large-Deformation Dynamics, 2020
18. Hierarchical Optimization Time Integration for CFL-Rate MPM Stepping, 2020
19. CD-MPM: Continuum Damage Material Point Methods for Dynamic Fracture Animation, 2019
20. Silly Rubber: An Implicit Material Point Method for Simulating Non-Equilibrated Viscoelastic and Elastoplastic Solids, 2019
21. Decomposed Optimization Time Integrator for Large-Step Elastodynamics, 2019
22. A Hybrid Material Point Method for Frictional Contact with Diverse Materials, 2019
23. Simulation and Visualization of Ductile Fracture with the Material Point Method, 2019
24. A Temporally Adaptive Material Point Method with Regional Time Stepping, 2018
25. A Moving Least Squares Material Point Method with Displacement Discontinuity and Two-Way Rigid Body Coupling, 2018
26. An Adaptive Generalized Interpolation Material Point Method for Simulating Elastoplastic Materials, 2017
27. Anisotropic Elastoplasticity for Cloth, Knit and Hair Frictional Contact
28. An Angular Momentum Conserving Affine-Particle-In-Cell Method, 2017

29. Drucker-Prager Elastoplasticity for Sand Animation, 2016
30. Optimization Integrator for Large Time Steps, 2015
31. An Adaptive Virtual Node Algorithm with Robust Mesh Cutting, 2014
32. A Level Set Method for Ductile Fracture, 2013

11.1.2 Fluids and Mixture

1. A Contact Proxy Splitting Method for Lagrangian Solid-Fluid Coupling, 2023
2. The Power Particle-In-Cell Method, 2022
3. An Efficient B-Spline Lagrangian/Eulerian Method for Compressible Flow, Shock Waves, and Fracturing Solids, 2022
4. A Large-Scale Benchmark for the Incompressible Navier-Stokes Equations, 2021
5. Ships, Splashes, and Waves on a Vast Ocean, 2021
6. A Unified Second-Order Accurate in Time MPM Formulation for Simulating Viscoelastic Liquids with Phase Change, 2021
7. A Novel Discretization and Numerical Solver for Non-Fourier Diffusion, 2021
8. IQ-MPM: An Interface Quadrature Material Point Method for Non-Sticky Strongly Two-Way Coupled Nonlinear Solids and Fluids, 2020
9. Chemomechanical Simulation of Soap Film Flow on Spherical Bubbles, 2020
10. A Hybrid Lagrangian/Eulerian Collocated Velocity Advection and Projection Method for Fluid Simulation, 2020
11. Efficient and Conservative Fluids using Bidirectional Mapping, 2019
12. Real-Time Fluid Simulation on the Surface of a Sphere, 2019
13. Animating Fluid Sediment Mixture in Particle-Laden Flows, 2018
14. A Polynomial Particle-In-Cell Method, 2017
15. Multi-Species Simulation of Porous Sand and Water Mixtures, 2017
16. The Affine Particle-In-Cell Method, 2015
17. A Material Point Method for Viscoelastic Fluids, Foams and Sponges, 2015
18. Augmented MPM for Phase-Change and Varied Materials, 2014

11.1.3 High Performance and Real-Time Computing

1. A Sparse Distributed Gigascale Resolution Material Point Method, 2023
2. Subspace-Preconditioned GPU Projective Dynamics with Contact for Cloth Simulation, 2023
3. Penetration-free Projective Dynamics on the GPU, 2022
4. A Massively Parallel and Scalable Multi-GPU Material Point Method, 2020
5. GPU Optimization of Material Point Methods, 2018

11.1.4 Geophysics and Mechanics

1. Transition from Sub-Rayleigh Anticrack to Supershear Crack Propagation in Snow Avalanches, 2022
2. Different Erosion and Entrainment Mechanisms in Snow Avalanches, 2022
3. A Barrier Method for Frictional Contact on Embedded Interfaces, 2022
4. BFEMP: Interpenetration-Free MPM-FEM Coupling with Barrier Contact, 2021
5. Three-dimensional and Real-scale Modeling of Flow Regimes in Dense Snow Avalanches, 2021
6. A Glacier–Ocean Interaction Model for Tsunami Genesis due to Iceberg Calving, 2021
7. The Mechanical Origin of Snow Avalanche Dynamics and Flow Regime Transitions, 2020
8. A Hybrid Material-point Spheropolygon-Element Method for Solid and Granular Material Interaction, 2020
9. Investigating the Release and Flow of Snow Avalanches at the Slope-Scale using a Unified Model based on the Material Point Method, 2019
10. Dynamic Anticrack Propagation in Snow, 2018

11.1.5 Others

1. Tailored Approach to Study Legionella Infection Using a Lattice Light Sheet Microscope (LLSM), 2022
2. Guaranteed Globally Injective 3D Deformation Processing, 2021
3. Position-Based Real-Time Simulation of Large Crowds, 2018
4. Position-Based Multi-Agent Dynamics for Real-Time Crowd Simulation, 2017
5. Visualization of Vascular Injuries in Extremity Trauma, 2017
6. Implicit-Shifted Symmetric QR Singular Value Decomposition Of 3x3 Matrices, 2016
7. Fast Automated Liver Delineation from Computational Tomography Angiography, 2016
8. Automated Pericardial Fat Quantification from Coronary Magnetic Resonance Angiography, 2016
9. Modeling and Animating Myriapoda: A Real-Time Kinematic/Dynamic Approach, 2013
10. Relativistic Correction Of $(v/c)^2$ To The Collective Thomson Scattering For High-Temperature High-Density Plasma, 2011

11.2 Generation, learning, and optimization

11.2.1 Radiance Field

1. PhysGaussian: Physics-Integrated 3D Gaussians for Generative Dynamics, 2024
2. PIE-NeRF: Physics-based Interactive Elastodynamics with NeRF, 2024
3. VR-GS: A Physical Dynamics-Aware Interactive Gaussian Splatting System in Virtual Reality, 2024
4. Gaussian Splashing: Dynamic Fluid Synthesis with Gaussian Splatting, 2024
5. PAC-NeRF: Physics Augmented Continuum Neural Radiance Fields for Geometry-Agnostic System Identification, 2023

11.2.2 3D/4D Generation and Vision Understanding

1. TPA-Net: Generate A Dataset for Text to Physics-based Animation, 2022
2. Fast and Scalable Position-Based Layout Synthesis, 2018
3. Configurable 3D Scene Synthesis and 2D Image Rendering with Per-Pixel Ground Truth using Stochastic Grammars, 2018
4. Human-Centric Indoor Scene Synthesis using Stochastic Grammar, 2018
5. Spatially Perturbed Collision Sounds Attenuate Perceived Causality in 3D Launching Events, 2018
6. Consistent Probabilistic Simulation underlying Human Judgment in Substance Dynamics, 2017
7. Inferring Forces and Learning Human Utilities from Videos, 2016
8. Probabilistic Simulation Predicts Human Performance on Viscous Fluid-Pouring Problem, 2016

11.2.3 Learning Physical Dynamics

1. A Generalized Constitutive Model for Versatile MPM Simulation and Inverse Learning with Differentiable Physics, 2023
2. Efficient Learning of Mesh-Based Physical Simulation with BiStride-Multi-Scale(BSMS)-GNN, 2023
3. PlasticityNet: Learning to Simulate Metal, Sand, and Snow for Optimization Time Integration, 2022
4. HoD-Net: High-order Differentiable Deep Neural Networks and its Applications, 2022

11.2.4 Computational Fabrication

1. Topology Optimization with Frictional Self-Contact, 2022
2. Lagrangian-Eulerian Multi-Density Topology Optimization with the Material Point Method, 2021

11.3 Embodiment and Robots

1. Bistable Aerial Transformer (BAT): A Quadrotor Fixed-Wing Hybrid that Morphs Dynamically via Passive Soft Mechanism, 2024
2. Reconfigurable Data Glove for Reconstructing Physical and Virtual Grasps, 2023
3. Midas: A Multi-Joint Robotics Simulator with Intersection-Free Frictional Contact, 2022
4. Complex Locomotion Skill Learning via Differentiable Physics, 2022
5. Soft Hybrid Aerial Vehicle via Bistable Mechanism, 2021
6. Autonomous Precision Pouring from Unknown Containers, 2019
7. Mirroring without Overimitation: Learning Functionally Equivalent Manipulation Actions, 2019
8. A Virtual Reality Platform for Dynamic Human-Scene Interaction, 2016

12 Selected Publicity

1. (UCLA) Professor Chenfanfu Jiang Receives 2023 Amazon Science Hub Award `https://ww3.math.ucla.edu/professor-chenfanfu-jiang-receives-2023-amazon-science-hub-award/`
2. (Amazon) Amazon and UCLA announce 2023 Science Hub awards `https://www.amazon.science/news-and-features/amazon-and-ucla-announce-2023-science-hub-awards`
3. (Radiance Fields) VR-GS: Physics Based Gaussian Splatting in VR `https://radiancefields.com/?p=8497&preview=1&_ppp=5339fb7219`

4. (Medium) Revolutionizing 3D Modeling with PIE-NeRF Innovation https://medium.com/@AIWorldBlog/revolutionizing-3d-modeling-with-pie-nerf-innovation-77b812626a0a
5. (Radiance Fields) PIE-NeRF Serves Up a New Slice: Physics-Based NeRFs https://radiancefields.com/pie-nerf-serves-up-a-new-slice-physics-based-nerfs/
6. (Marktechpost) Meet PhysGaussian: An Artificial Intelligence Technique that Produces High-Quality Novel Motion Synthesis by Integrating Physically Grounded Newtonian Dynamics into 3D Gaussians https://www.marktechpost.com/2023/11/26/meet-physgaussian-an-artificial-intelligence-technique-that-produces-high-quality-novel-motion-synthesis-by-integrating-physically-grounded-newtonian-dynamics-into-3d-gaussians/
7. (Medium) PhysGaussian Blends Physics with 3D Rendering Innovation https://medium.com/@AIWorldBlog/physgaussian-blends-physics-with-3d-rendering-innovation-096352baa91a
8. (UCLA) Professor Chenfanfu Jiang awarded Sony Faculty Innovation Award https://ww3.math.ucla.edu/professor-chenfanfu-jiang-awarded-sony-faculty-innovation-award/
9. (Decoder) PAC-NeRF learns physical properties of objects from videos https://the-decoder.com/pac-nerf-learns-physical-properties-of-objects-from-videos/
10. (UCR) UC grant to create computer code library for engineering applications https://insideucr.ucr.edu/awards/2023/01/24/uc-grant-create-computer-code-library-engineering-applications
11. (UCLA) UCLA team receives best paper award at international robotics conference https://newsroom.ucla.edu/dept/faculty/ucla-team-receives-best-paper-award-on-mechanisms-and-design-at-icra-2021
12. (UCLA) Best Paper Award on Mechanisms and Design at ICRA 2021 https://ww3.math.ucla.edu/assistant-professor-jiang-and-ucla-team-receive-best-paper-award-on-mechanisms-and-design-at-icra-2021/
13. (UCLA) Interview with new faculty Chenfanfu Jiang https://physicalsciences.ucla.edu/interview-with-new-faculty-chenfanfu-jiang/
14. (Penn) Simulation of glacial calving and tsunami waves predicts climate change consequences https://penntoday.upenn.edu/news/simulation-glacial-calving-and-tsunami-waves-predicts-climate-change-consequences
15. (Penn) Penn Engineers' New Simulation of Glacial Calving and Tsunami Waves Accurately Predicts these Climate Change Consequences https://blog.seas.upenn.edu/penn-engineers-new-simulation-of-glacial-calving-and-tsunami-waves-accurately-predicts-these-climate-change-consequences/
16. (80 Level) Fracture Studies for Game and Movie Animation https://80.lv/articles/a-new-approach-to-anisotropic-damage-mechanics
17. (Technology) AnisoMPM: Animating Anisotropic Damage Mechanics https://www.technology.org/2020/08/23/anisompm-animating-anisotropic-damage-mechanics/
18. (ECP) ECP-Funded Research Develops Solutions for Additive Manufacturing Simulation Needs https://www.exascaleproject.org/publication/ecp-funded-research-develops-solutions-for-additive-manufacturing-simulation-needs/
19. (ACM SIGGRAPH) New Research From University of Pennsylvania Examines Realistic Damage Mechanics https://blog.siggraph.org/2020/06/new-research-from-university-of-pennsylvania-examines-realistic-damage-mechanics.html/
20. (Gizmodo) Meat-Tearing CG Breakthrough Promises to Make Video Game Injuries Disgustingly Realistic https://www.gizmodo.co.uk/2020/06/meat-tearing-cg-breakthrough-promises-to-make-video-game-injuries-disgustingly-realistic/

21. (ACM Technews) Meat-Tearing CG Breakthrough Promises to Make Video Game Injuries Disgustingly Realistic https://technews.acm.org/archives.cfm?fo=2020-06-jun/jun-12-2020.html
22. (80lv) Fracture Studies for Game and Movie Animation https://80.lv/articles/002sgr-fracture-studies-for-game-and-movie-animation/
23. (The Takeout) Advances in science: We can now tear CGI bread in half https://thetakeout.com/cgi-tearing-bread-upenn-cd-mpm-1834672740
24. (Vice) We Are Not Prepared for the Next Generation of CGI Food https://www.vice.com/en_us/article/gy4yw7/we-are-not-prepared-for-the-next-generation-of-cgi-food
25. (Nature) The 50 most read Nature Communications Earth and planetary sciences articles published in 2018. https://www.nature.com/collections/ebbeeieefe/
26. (ACM Technews) Computer Scientists Create CG Sand That Looks Unbelievably Real https://cacm.acm.org/news/226857-computer-scientists-create-cg-sand-that-looks-nbelievably-real/fulltext
27. (Penn) The snow graphics in Frozen can predict the mechanics of real avalanches https://penntoday.upenn.edu/news/snow-graphics-frozen-can-predict-mechanics-real-avalanches
28. (UCLA) Best Paper Award at ACM SIGGRAPH Conference on Motion in Games 2017 http://www.cs.ucla.edu/best-paper-award-at-acm-siggraph-conference-on-motion-in-games-2017/
29. (Gizmodo) We Finally Figured Out How To Make Realistic CG Mud http://gizmodo.com/we-finally-figured-out-how-to-make-realistic-cg-mud-1795066887
30. (UCLA) UCLA Engineering honors top alumni, teachers, students at 2016 awards dinner http://engineering.ucla.edu/ucla-engineering-honors-top-alumni-teachers-students-at-2016-awards-dinner/
31. (Phys) Mathematicians bring ocean to life for Disney's 'Moana' https://phys.org/news/2017-01-mathematicians-ocean-life-disney-moana.html
32. (UCLA) UCLA mathematicians bring ocean to life for Disney's Moana http://newsroom.ucla.edu/stories/ucla-mathematicians-help-bring-the-ocean-to-life-for-disneys-hit-movie-moana
33. (New Scientist) Blood gushes from virtual leg injury to help train combat medics https://www.newscientist.com/article/dn28557-blood-gushes-from-virtual-leg-injury-to-help-train-combat-medics/
34. (Gizmodo) Simulation of a Leg Gushing Blood Is as Gross as You'd Expect http://gizmodo.com/simulation-of-a-leg-gushing-blood-is-as-gross-as-youd-e-1744946732
35. (Popular Science) Here is A Model Of Exactly How A Leg Bleeds Once It's Been Shot http://www.popsci.com/heres-model-how-leg-bleeds-once-its-been-shot
36. (Science Net) Researchers use virtual blood to train medics. http://news.sciencenet.cn/htmlnews/2015/11/332832.shtm