

# Ryuji Hirayama

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## Research Interests

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Volumetric display, Holography, High-performance computing, Acoustic levitation, Multimodal system, Haptics, Parametric audio, Human-computer interaction

## Education

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2014.03–2017.04	<b>PhD in Engineering</b> Graduate School of Engineering, Chiba University, Japan Theme: Volumetric display containing multiple 2D images
2012.03–2014.04	<b>Master of Engineering</b> Graduate School of Engineering, Chiba University, Japan
2008.03–2012.04	<b>Bachelor of Engineering</b> Faculty of Engineering, Chiba University, Japan

## Experience

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2020.07–present	<b>Postdoctoral Research Fellow</b> Department of Computer Science, University College London, UK
2019.04–2020.06	<b>Postdoctoral Research Fellow</b> Interact Lab, School of Engineering and Informatics, University of Sussex, UK
2019.01–2019.03	<b>Rutherford Research Fellow</b> Interact Lab, School of Engineering and Informatics, University of Sussex, UK
2018.04–2018.12	<b>Research Fellow of the Japan Society for the Promotion of Science (PD)</b> Masuda Lab, Faculty of Industrial Science and Technology, Tokyo University of Science, Japan
2018.04–2018.09	<b>Visiting Research Fellow</b> Interact Lab, School of Engineering and Informatics, University of Sussex, UK
2017.04–2018.03	<b>Research Fellow of the Japan Society for the Promotion of Science (PD)</b> Itot Lab, Graduate School of Engineering, Chiba University, Japan
2015.04–2017.03	<b>Research Fellow of the Japan Society for the Promotion of Science (DC2)</b> Itot Lab, Graduate School of Engineering, Chiba University, Japan
2014.11–2015.03	<b>Research Assistant of the IMPACT Program</b> Graduate School of Engineering, Chiba University, Japan
2014.10–2015.03	<b>Teaching Assistant (Experiment of electrical and electronics engineering III)</b> Faculty of Engineering, Chiba University
2013.07–2014.10	<b>Student Assistant (Leaning support for undergraduates)</b> Academic Link Center, Chiba University

## Journal Papers

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1. **R. Hirayama**, D. M. Plasencia, N. Masuda, and S. Subramanian, “A volumetric display for visual, tactile and audio presentation using acoustic trapping,” *Nature* **575**, 320–323 (2019), highlighted in Nature Asia and Featured in Nature.
2. **R. Hirayama**, H. Nakayama, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, “Projection of multiple directional images on a volume structure with refractive surfaces,” *Optics Express* **27**(20), 27637–27648 (2019).

3. A. Shiraki, D. Matsumoto, **R. Hirayama**, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "Improvement of an algorithm for displaying multiple images in one space," *Applied Optics* **58**(5), A1–A6 (2019).
4. T. Nishitsuji, Y. Yamamoto, T. Sugie, T. Akamatsu, **R. Hirayama**, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "Special-purpose computer HORN-8 for phase-type electro-holography," *Optical Express* **26**(20), 26722 (2018).
5. T. Kakue, Y. Wagatsuma, S. Yamada, Y. Endo, Y. Nagahama, **R. Hirayama**, T. Shimobaba, and T. Ito, "Review of real-time reconstruction techniques for aerial-projection holographic displays," *Optical Engineering* **57**(6), 061621 (2018).
6. T. Sugie, T. Akamatsu, T. Nishitsuji, **R. Hirayama**, N. Masuda, H. Nakayama, Y. Ichihashi, A. Shiraki, M. Oikawa, N. Takada, Y. Endo, T. Kakue, T. Shimobaba, and T. Ito, "High-performance parallel computing for next-generation holographic imaging," *Nature Electronics* **1**, 254–259 (2018).
7. T. Shimobaba, Y. Endo, T. Nishitsuji, T. Takahashi, Y. Nagahama, S. Hasegawa, M. Sano, **R. Hirayama**, T. Kakue, A. Shiraki, and T. Ito, "Computational ghost imaging using deep learning," *Optics Communications* **413**, 147–151 (2018).
8. T. Shimobaba, K. Matsushima, T. Takahashi, Y. Nagahama, S. Hasegawa, M. Sano, **R. Hirayama**, T. Kakue, and T. Ito, "Fast, large-scale hologram calculation in wavelet domain," *Optics Communications* **412**, 80–84 (2018).
9. A. Shiraki, M. Ikeda, H. Nakayama, **R. Hirayama**, T. Kakue, T. Shimobaba, and T. Ito, "Efficient method for fabricating a directional volumetric display using strings displaying multiple images," *Applied Optics* **57**(1), A33–A38 (2018).
10. T. Shimobaba, N. Kuwata, M. Honma, T. Takahashi, Y. Nagahama, M. Sano, S. Hasegawa, **R. Hirayama**, T. Kakue, A. Shiraki, N. Takada, and T. Ito, "Convolutional neural network-based data page classification for holographic memory," *Applied Optics* **56**(26), 7327–7330 (2017).
11. **R. Hirayama**, A. Shiraki, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "Operating scheme of a light-emitting diode array for a volumetric display exhibiting multiple full-color dynamic images," *Optical Engineering* **56**(7), 073108 (2017).
12. **R. Hirayama**, T. Suzuki, T. Shimobaba, A. Shiraki, M. Naruse, H. Nakayama, T. Kakue, and T. Ito, "Inkjet printing-based volumetric display projecting multiple full-colour 2D patterns," *Scientific Reports* **7**, 46511 (2017).
13. T. Shimobaba, Y. Endo, **R. Hirayama**, Y. Nagahama, T. Takahashi, T. Nishitsuji, T. Kakue, A. Shiraki, N. Takada, N. Masuda, and T. Ito, "Autoencoder-based holographic image restoration," *Applied Optics* **56**(13), F27–F30 (2017).
14. T. Shimobaba, Y. Endo, **R. Hirayama**, D. Hiyama, Y. Nagahama, S. Hasegawa, M. Sano, T. Takahashi, T. Kakue, M. Oikawa, and T. Ito, "Holographic micro-information hiding," *Applied Optics* **56**(4), 833–837 (2017).
15. **R. Hirayama**, A. Shiraki, M. Naruse, S. Nakamura, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "Optical Addressing of Multi-Colour Photochromic Material Mixture for Volumetric Display," *Scientific Reports* **6**, 31543 (2016).
16. T. Shimobaba, M. Makowski, Y. Nagahama, Y. Endo, **R. Hirayama**, D. Hiyama, S. Hasegawa, M. Sano, T. Kakue, M. Oikawa, T. Sugie, N. Takada, and T. Ito, "Color computer-generated hologram generation using the random phase-free method and color space conversion," *Applied Optics* **55**(15), 4159–4165 (2016).
17. **R. Hirayama**, H. Nakayama, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, "Image quality improvement for a 3D structure exhibiting multiple 2D patterns and its implementation," *Optics Express* **24**(7), 7319–7327 (2016).
18. T. Sanpei, T. Shimobaba, T. Kakue, Y. Endo, **R. Hirayama**, D. Hiyama, S. Hasegawa, Y. Nagahama, M. Sano, M. Oikawa, T. Sugie, and T. Ito, "Optical encryption for large-sized images," *Optics Communications* **361**, 138–142 (2016).
19. T. Shimobaba, T. Kakue, Y. Endo, **R. Hirayama**, D. Hiyama, S. Hasegawa, Y. Nagahama, M. Sano, M. Oikawa, T. Sugie, and T. Ito, "Improvement of the image quality of random phase-free holography using an iterative method," *Optics Communications* **355**, 596–601 (2015).
20. T. Shimobaba, T. Kakue, Y. Endo, **R. Hirayama**, D. Hiyama, S. Hasegawa, Y. Nagahama, M. Sano, M. Oikawa, T. Sugie, and T. Ito, "Random phase-free kinoform for large objects," *Optics Express* **23**(13), 17269–17274 (2015).
21. **R. Hirayama**, M. Naruse, H. Nakayama, N. Tate, A. Shiraki, T. Kakue, T. Shimobaba, M. Ohtsu, and T. Ito, "Design, implementation and characterization of a quantum-dot-based volumetric display," *Scientific Reports* **5**, 8472 (2015), *highlighted in Nature Japan*
22. D. Arai, T. Shimobaba, K. Murano, Y. Endo, **R. Hirayama**, D. Hiyama, T. Kakue, and T. Ito, "Acceleration of computer-generated hologram using tilted wavefront recording plane method," *Optics Express* **23**(2), 1740–1747 (2015).
23. T. Shimobaba, M. Makowski, T. Kakue, N. Okada, Y. Endo, **R. Hirayama**, D. Hiyama, S. Hasegawa, Y. Nagahama, and T. Ito, "Numerical investigation of lensless zoomable holographic projection to multiple tilted planes," *Optics Communications* **333**, 274–280 (2014).
24. T. Shimobaba, T. Kakue, N. Okada, Y. Endo, **R. Hirayama**, D. Hiyama, and T. Ito, "Ptychography by changing the area of probe light and scaled ptychography," *Optics Communications* **331**, 189–193 (2014).

25. T. Shimobaba, T. Kakue, M. Oikawa, N. Takada, N. Okada, Y. Endo, **R. Hirayama**, and T. Ito, "Calculation reduction method for color computer-generated hologram using color space conversion", *Optical Engineering*, **53**(2), 024108 (2014).
26. T. Shimobaba, T. Kakue, M. Oikawa, N. Okada, Y. Endo, **R. Hirayama**, N. Masuda, and T. Ito, "Non-uniform sampled scalar diffraction calculation using non-uniform fast Fourier transform," *Optics Letters* **38**(23), 5130–5133 (2013).
27. T. Shimobaba, M. Makowski, T. Kakue, M. Oikawa, N. Okada, Y. Endo, **R. Hirayama**, N. Masuda, and T. Ito, "Lensless zoomable holographic projection using scaled Fresnel diffraction," *Optics Express* **21**(21), 25285–25290 (2013).
28. T. Shimobaba, H. Yamanashi, T. Kakue, M. Oikawa, N. Okada, Y. Endo, **R. Hirayama**, and T. Ito, "Inline digital holographic microscopy using a consumer scanner," *Scientific Reports* **3**, 2664 (2013).
29. H. Nakayama, A. Shiraki, **R. Hirayama**, N. Masuda, T. Shimobaba, and T. Ito, "Three-dimensional volume containing multiple two-dimensional information patterns," *Scientific Reports* **3**, 1931 (2013).

## Conference Proceedings

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1. D. M. Plasencia, **R. Hirayama**, R. Montano, and S. Subramanian, "GS-PAT: High-Speed Multi-point Sound-Fields for Phased Arrays of Transducers," *SIGGRAPH 2020*, Online conference (2020.08, accepted)
2. D. Matsumoto, **R. Hirayama**, N. Hoshikawa, H. Nakayama, T. Shimobaba, T. Ito, and A. Shiraki, "GPU Acceleration of Algorithm to Design Directional Volumetric Display for Real-time," *IDW 2019 / 3DSA 2019*, Sapporo, Japan (2019.11).
3. T. Murase, **R. Hirayama**, N. Hoshikawa, H. Nakayama, T. Shimobaba, T. Ito, and A. Shiraki, "Development of Volumetric Display Capable of Transmitting Information in Different Languages Using Language Identification," *IDW 2019 / 3DSA 2019*, Sapporo, Japan (2019.11).
4. M. Baba, **R. Hirayama**, N. Hoshikawa, H. Nakayama, T. Shimobaba, T. Ito, and A. Shiraki, "Implemented of Images and Sounds Person Tracking System using Directional Volumetric Display," *IDW 2019 / 3DSA 2019*, Sapporo, Japan (2019.11).
5. D. Matsumoto, T. Murase, **R. Hirayama**, H. Nakayama, T. Shimobaba, T. Ito, and A. Shiraki, "Subjective Image Quality Evaluation to Compare Algorithms for Designing a Directional Volumetric Display," *IDW 2018*, Nagoya, Japan (2018.12).
6. T. Murase, D. Matsumoto, **R. Hirayama**, H. Nakayama, T. Shimobaba, T. Ito, and A. Shiraki, "Image Quality Improvement for 3D Structure Exhibiting Multiple 2D Patterns Using Convolutional Neural Networks," *IDW 2018*, Nagoya, Japan (2018.12).
7. D. Matsumoto, A. Shiraki, **R. Hirayama**, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "Improvement of the Algorithm for Designing a 3D Object Exhibiting Multiple 2D Images," *3DSA 2018*, Taipei, Taiwan (2018.08).
8. M. Ikeda, A. Shiraki, **R. Hirayama**, T. Kakue, T. Shimobaba, and T. Ito, "Simulation of the Projection Mapping to a Directional Volumetric Display," *IDW 2017*, Sendai, Japan (2017.12).
9. **R. Hirayama**, H. Nakayama, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, "Controllable color particles in a 3D crystal projecting multiple dynamic full-color images," *ACM SIGGRAPH 2017 Posters*, 73, Los Angeles, USA (2017.07).
10. **R. Hirayama**, T. Suzuki, T. Shimobaba, A. Shiraki, M. Naruse, H. Nakayama, T. Kakue, and T. Ito, "Inkjet-printed 3D structure projecting multiple full-color images," *OPIC IP2017*, IP-20AM-1-5, Yokohama, Japan (2017.04).
11. F. Kawashima, **R. Hirayama**, A. Shiraki, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito "Gradation expression by overlap of voxels in volumetric display composed of photochromic materials," *IDW / AD 2016*, 3DSAp2/3Dp2-1, Fukuoka, Japan (2016.12).
12. **R. Hirayama**, A. Shiraki, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "3-D crystal with a curved surface projecting multiple 2-D images," *ACM SIGGRAPH Asia 2016 Posters*, 41, Macao, China (2016.12).
13. **R. Hirayama**, A. Shiraki, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "Refraction-compensating algorithm for a 3D glass structure exhibiting multiple 2D images," *FiO / LS 2016*, JTh2A-68, Rochester, USA (2016.10).
14. M. Oikawa, D. Hiyama, **R. Hirayama**, S. Hasegawa, Y. Endo, T. Sugie, N. Tsumura, M. Kuroshima, M. Maki, G. Okada, C. Lei, Y. Ozeki, K. Goda, and T. Shimobaba, "A computational approach to real-time image processing for serial time-encoded amplified microscopy," *SPIE Photonics West BIOS 2016 (Proc. SPIE 9720)*, 97200E, San Francisco USA (2016.03).
15. (invited) A. Shiraki, H. Nakayama, **R. Hirayama**, T. Kakue, T. Shimobaba, and T. Ito, "Volumetric display containing multiple two dimensional information patterns," *IDW 2015*, PRJ1-1, Otsu, Japan (2015.12).
16. **R. Hirayama**, A. Shiraki, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, "3-D crystal exhibiting multiple 2-D images with directivity," *ACM SIGGRAPH Asia 2015 Posters*, 1, Kobe, Japan (2015.11).

17. (invited) **R. Hirayama**, A. Shiraki, H. Nakayama, T. Kakue, T. Shimobaba, and T. Ito, “3-D crystal exhibiting multiple 2-D images with directivity,” VRCAI 2015, 33, Kobe, Japan (2015.10).
18. **R. Hirayama**, A. Shiraki, M. Naruse, H. Nakayama, N. Tate, T. Kakue, T. Shimobaba, and T. Ito, “Optically controlled quantum-dot-based volumetric display exhibiting multiple patterns,” JSAP-OSA Joint Symposia 2015, 15p-2F-10, Nagoya, Japan (2015.09).
19. (invited) **R. Hirayama**, M. Naruse, H. Nakayama, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, “Optically controlled volumetric display exhibiting multiple two-dimensional patterns,” CC3DMR 2015, 340–341, Busan, South Korea (2015.06).
20. **R. Hirayama**, H. Nakayama, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, “Development of volumetric display based on multi-bit color LED,” APCCAS 2014, 547–550, Okinawa, Japan (2014.11).
21. **R. Hirayama**, H. Nakayama, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, “Volumetric display containing multiple two-dimensional color motion pictures,” SPIE DSS 2014 (Proc. SPIE 9117), 911717, Baltimore, USA (2014.05).
22. (invited) T. Kakue, N. Masuda, Y. Endo, **R. Hirayama**, N. Okada, T. Shimobaba, and T. Ito, “Special-purpose computer for real-time reconstruction of holographic motion picture,” OIT 2013 (Proc. SPIE 9042), 90420B, Beijing, China (2013.11).
23. **R. Hirayama**, R. Omura, Y. Kobayashi, A. Shiraki, H. Nakayama, T. Kakue, N. Masuda, T. Shimobaba, and T. Ito, “Development of a digitized volumetric display containing multiple two-dimensional patterns,” 3DSA 2013, P7-2, Osaka, Japan (2013.06).
24. **R. Hirayama**, H. Ando, A. Shiraki, H. Nakayama, T. Kakue, N. Masuda, T. Shimobaba, and T. Ito, “Image-quality improvement of multiple two-dimensional patterns contained in three-dimensional volume,” 3DSA 2013, S11-1, Osaka, Japan (2013.06).
25. **R. Hirayama**, T. Shimobaba, H. Nakayama, A. Shiraki, T. Kakue, N. Masuda, and T. Ito, “Optical encryption using three-dimensional volume containing multiple two-dimensional information patterns,” DHIP 2012, C015, Tokushima, Japan (2012.09).

## News Articles

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1. **R. Hirayama**, A. Shiraki, T. Kakue, T. Shimobaba, and T. Ito, “Optical addressing method for full-color 3D display,” SPIE Newsroom (2016).

## Media

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1. **El Hormiguero 3.0** (Prime-time Spanish TV show), “LEVITACIÓN ACÚSTICA” (2020.02).
2. **ITV News** (British TV show), “How holograms could be the future of medicine, advertising and entertainment” (2019.11).
3. **BBC Radio** (British radio channel), “Science in Action” (2019.11).
4. **The Guardian** (British Newspaper), “Hologram-like device animates objects using ultrasound waves” (2019.11).
5. **Discover Magazine** (American science magazine), “With a Floating Bead, This Device Makes Truly 3D Holographs” (2019.11).
6. **Scientific American** (American science magazine), “Hearing Is Seeing: Sound Waves Create a 3-D Display” (2019.11).
7. **Science Magazine** (News site of AAAS/Science), “See the new Star Wars-like display that could ‘revolutionize’ virtual reality” (2019.11).
8. **NBC News** (American news site), “With a single bead of plastic, scientists tease interactive 3D” (2019.11).
9. **NewScientist** (British science magazine), “We can now make animated ‘sound holograms’ that you can touch” (2019.11).
10. **日本経済新聞** (Japanese Newspaper), “立体映像とともに音・触感を再現 英大学が技術” (2019.11).
11. **Dagens Nyheter** (Swedish Newspaper), “Ny teknik skapar 3D-bilder som låter och känns” (2019.11).
12. **NRC Handelsblad** (Dutch Newspaper), “3D-beeld gevangen in geluidsgolven” (2019.11).
13. **Neue Zürcher Zeitung** (Swiss Newspaper), “Fast ein richtiges Holodeck” (2019.11).
14. **Cité des sciences et de l'industrie** (French museum website), “Du virtuel au bout des doigts!” (2019.11).
15. **OSA Publishing, Image of the Week**, “Projection of multiple directional images on a volume structure with refractive surfaces” (2019.10).

16. **OSA Publishing, Image of the Week**, “Image quality improvement for a 3D structure exhibiting multiple 2D patterns and its implementation” (2016.04).
17. **科学新聞** (Japanese scientific newspaper), “育志賞 - 18人に” (2016.03).
18. **TBS** (Japanese TV show), “未来の起源” (2015.09).
19. **日経産業新聞** (Japanese newspaper), “紫外線当て3D表示—千葉大など装置考案” (2015.04).
20. **日刊工業新聞** (Japanese newspaper), “光を当てると各面に異なる画像を表示—千葉大, 新原理の立体ディスプレイ開発” (2015.02).
21. **テレビ東京** (Japanese TV show), “ワールドビジネスサテライト (トレンドたまご)” (2013.09).
22. **日刊工業新聞** (Japanese newspaper), “見る位置で違う映像に—千葉大ディスプレイ開発” (2013.09).
23. **日刊工業新聞** (Japanese newspaper), “見る方向で違い—千葉大技術開発” (2011.06).

## Grants and Awards

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1. **Grant-in-Aid for JSPS Fellows**, No. 18J01002, Japan Society for the Promotion of Science, 1,300,000 JPY (about £9.2k) + salary (2018.04–2018.12).
2. **Inoue Research Award for Young Scientists**, Inoue Foundation for Science (2018.02).
3. **Young Researcher Award**, Kenjiro Takayanagi Foundation, 2,000,000 JPY (about £1.4k) (2018.01).
4. **President Award for the Excellent Record**, Chiba University (2017.03).
5. **Dean Award for the Excellent Record**, Graduate School of Engineering, Chiba University (2017.03).
6. **GP Program to Support Sending Graduate Students Abroad**, Institute for Global Prominent Research, Chiba University, 136,000 JPY (about £1.0k) (2017.12).
7. **Program to Support Sending Graduate Students Abroad**, Chiba University, 136,000 JPY (about £1.0k) (2017.10).
8. **Grant-in-Aid for JSPS Fellows**, No. 16J30007, Japan Society for the Promotion of Science, 2,300,000 JPY (about £16.2k) + salary (2016.04–2018.03).
9. **JSPS Ikushi Prize**, Japan Society for the Promotion of Science (2016.03).
10. **KONICA MINOLTA Science and Technology Foundation Award**, The Optical Society of Japan, 50,000 JPY (about £0.4k) (2015.06).
11. **Scholarship Loan Forgiveness for Academic Excellence** (Full Amount), Japan Student Services Organization (2015.05).
12. **Best Poster Award (FORUM 8 Award)**, Computer Graphic Arts Society (2015.03).
13. **Outstanding Paper Award for Young C&C Researchers**, NEC C&C Foundation (2015.01).
14. **Grant-in-Aid for JSPS Fellows**, No. 15J07684, Japan Society for the Promotion of Science, 1,200,000 JPY (about £8.5k) + salary (2015.04–Mar. 2016.03)
15. **Scholarship Loan Forgiveness for Academic Excellence** (Full Amount), Japan Student Services Organization (2014.05).
16. **Program to Support Sending Graduate Students Abroad**, Chiba University, 150,000 JPY (about £1.1k) (2014.04).
17. **Grants for Researchers Attending International Conferences**, NEC C&C Foundation, 200,000 JPY (about £1.4k) (2014.04).
18. **President Award for the Excellent Record**, Chiba University (2014.03).
19. **Dean Award for the Excellent Record, Graduate School of Engineering**, Chiba University (2014.03).

## Membership

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| 2016.10–present | <b>Association for Computing Machinery (ACM)</b> |
| 2016.08–present | <b>The Optical Society (OSA)</b>                 |

## Skills

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### Programming

C, C++, C#, Python, CUDA, OpenCL, Matlab, VHDL, Verilog HDL, OpenGL, OpenCV, HTML/CSS

### Others

Electronics (FPGA design and Microcontroller), Real-time system (GPU computing, Multi threads, and FPGA), Fabrication (3D printer, Laser cutter, and Luminescent materials), Projection mapping, 2D/3D design (Illustrator and Maya).