

# Topic 1: Conventional Cameras & their Limits

## Lecture 1: Course roadmap & introduction to camera optics

[1] M. S. Levoy, "Lectures on Digital Photography: Optics I," 2016, pp. 1–81. ([pdf](#)).

[2] M. S. Levoy, "Lectures on Digital Photography: Optics II," 2016, pp. 1–48. ([pdf](#)).

## Lecture 2: Noise & optical blur

[3] A. Abdelhamed, M. A. Brubaker, and M. S. Brown, "Noise Flow: Noise Modeling With Conditional Normalizing Flows," in Proc. IEEE ICCV, 2019, pp. 3165–3173. ([pdf](#)).

[4] A. Lohmann, "Scaling laws for lens systems," *Appl Optics*, 1989. ([pdf](#)).

[5] (optional reading) N. Joshi, R. Szeliski, and D. J. Kriegman, "PSF estimation using sharp edge prediction," Proc. IEEE CVPR, 2008. ([pdf](#)).

[6] (optional reading) M. S. Levoy, "Lectures on Digital Photography: Noise and ISO," 2016, pp. 1–50. ([pdf](#)).

# Topic 2: Multi-Perspective Imaging

## Lecture 3: Imaging with camera arrays

[7] B. Wilburn, N. Joshi, V. Vaish, E.-V. Talvala, E. Antunez, A. Barth, A. Adams, M. Horowitz, and M. S. Levoy, "High performance imaging using large camera arrays," in Proc. ACM SIGGRAPH, 2005. ([pdf](#)).

[8] K. Venkataraman, D. Lelescu, J. Duparré, A. McMahon, G. Molina, P. Chatterjee, R. Mullis, and S. Nayar, "PiCam: an ultra-thin high performance monolithic camera array," *ACM TOC (SIGGRAPH Asia)*, vol. 32, no. 6, 2013. ([pdf](#)).

[9] (optional reading) R. C. Bolles, H. H. Baker, and D. H. Marimont, "Epipolar-plane image analysis: An approach to determining structure from motion," *Int. J. Computer Vision*, vol. 1, no. 1, pp. 7–55, 1987. ([pdf](#)).

## Lecture 4: Multi-perspective imaging with a single lens

[10] T. E. Bishop and P. Favaro, "The Light Field Camera: Extended Depth of Field, Aliasing, and Superresolution," *IEEE T-PAMI*, 2012. ([pdf](#)).

[11] N. Wadhwa, R. Garg, D. E. Jacobs, B. E. Feldman, N. Kanazawa, R. Carroll, Y. Movshovitz-Attias, J. T. Barron, Y. Pritch, and M. S. Levoy, "Synthetic depth-of-field with a single-camera mobile phone," *ACM TOG (SIGGRAPH)*, vol. 37, no. 4, pp. 64–13, Jul. 2018. ([pdf](#)).

[12] (optional reading) E. H. Adelson and J. Wang, "Single lens stereo with a plenoptic camera," *IEEE T-PAMI*, 1992. ([pdf](#)).

[13] (optional reading) R. Ng, M. Levoy, M. Brédif, G. Duval, M. Horowitz, and P. Hanrahan, "Light field photography with a hand-held plenoptic camera," CSTR 2005-02, 2005. ([pdf](#)).

# Topic 3: High-Speed Imaging & Lensless Imaging

## Lecture 5: Optical coding for imaging dynamic scenes

[14] D. Liu, J. Gu, Y. Hitomi, M. Gupta, and S. K. Nayar, "Efficient space-time sampling with pixel-wise coded exposure for high-speed imaging," *IEEE T-PAMI*, vol. 36, no. 2, pp. 248–260, 2014. ([pdf](#)).

[15] O. Cossairt, M. Gupta, and S. K. Nayar, "When Does Computational Imaging Improve Performance?," *IEEE-TIP*, no. 99, p. 1, 2012. ([pdf](#)).

[16] (optional reading) R. Raskar, A. Agrawal, and J. Tumblin, "Coded exposure photography: motion deblurring using fluttered shutter," in Proc. ACM SIGGRAPH, 2006. ([pdf](#)).

## Lecture 6: Optical coding for lensless imaging

[17] M. S. Asif, A. Ayremilou, A. Sankaranarayanan, A. Veeraraghavan, and R. G. Baraniuk, "FlatCam: Thin, Lensless Cameras Using Coded Aperture and Computation," *IEEE TCI*, vol. 3, no. 3, pp. 384–397, Jul. 2017. ([pdf](#)).

[18] N. Antipa, G. Kuo, R. Heckel, B. Mildenhall, E. Bostan, R. Ng, and L. Waller, "DiffuserCam: lensless single-exposure 3D imaging," *Optica*, vol. 5, no. 1, 2018. ([pdf](#)).

[19] (optional reading) N. Antipa, P. Oare, E. Bostan, R. Ng, and L. Waller, "Video from stills: Lensless imaging with rolling shutter," in Proc. IEEE ICCP, 2019. ([pdf](#)).

# Topic 4: Computational Optics for High-Performance Imaging

## Lecture 7: Optical coding with diffractive optical elements

[20] Y. Peng, Q. Fu, F. Heide, and W. Heidrich, "The Diffractive Achromat Full Spectrum Computational Imaging with Diffractive Optics," *ACM TOG (SIGGRAPH)*, vol. 35, no. 4, pp. –11, Jul. 2016. ([pdf](#)).

[21] Y. Peng, Q. Sun, X. Dun, G. Wetzstein, W. Heidrich, and F. Heide, "Learned large field-of-view imaging with thin-plate optics," *ACM TOG (SIGGRAPH Asia)*, vol. 38, no. 6, pp. 219–14, Nov. 2019. ([pdf](#)).

## Lecture 8: Other forms of optical coding

[22] O. S. Cossairt, D. Miao, and S. K. Nayar, "Scaling law for computational imaging using spherical optics," *J Opt Soc Am A*, vol. 28, no. 12, pp. 2540–2553, 2011. ([pdf](#)).

[23] Q. Guo, Z. Shi, Y.-W. Huang, E. Alexander, C.-W. Qiu, F. Capasso, and T. Zickler, "Compact single-shot metalens depth sensors inspired by eyes of jumping spiders," *Proceedings of the National Academy of Sciences*, vol. 116, no. 46, pp. 22959–22965, Nov. 2019. ([pdf](#)).

[24] (optional reading) R. J. Lin, V.-C. Su, S. Wang, M. K. Chen, T. L. Chung, Y. H. Chen, H. Y. Kuo, J.-W. Chen, J. Chen, Y.-T. Huang, J.-H. Wang, C. H. Chu, P. C. Wu, T. Li, Z. Wang, S. Zhu, and D. P. Tsai, "Achromatic metalens array for full-colour light-field imaging," *Nat. Nanotechnol.*, vol. 14, no. 3, pp. 227–231, Mar. 2019. ([pdf](#)) ([supp](#)).

## Lecture 9: High-performance imaging with coherent light

[25] J. Holloway, Y. Wu, M. K. Sharma, O. Cossairt, and A. Veeraraghavan, "SAVI: Synthetic apertures for long-range, subdiffraction-limited visible imaging using Fourier ptychography," *Science Advances*, vol. 3, no. 4, Apr. 2017. ([pdf](#)).

[26] Y. Wu, M. K. Sharma, and A. Veeraraghavan, "WISH: wavefront imaging sensor with high resolution," *Light: Science & Applications 2019 8:1*, vol. 8, no. 1, p. 44, May 2019. ([pdf](#)) ([supp](#)).

# Topic 5: Imaging with Unconventional CMOS Sensors

## Lecture 10: Coded-imaging sensors & event cameras

[27] M. Wei, N. Sarhangnejad, Z. Xia, N. Gusev, N. Katic, R. Genov, and K. N. Kutulakos, "Coded Two-Bucket Cameras for Computer Vision," in Proc. ECCV, 2018, pp. 54–71. ([pdf](#)).

[28] N. Matsuda, O. Cossairt, and M. Gupta, "MC3D: Motion Contrast 3D Scanning," in Proc. IEEE ICCP, 2015, pp. 1–10. ([pdf](#)).

[29] (optional reading) D. Joubert, M. Hébert, H. Konik, and C. Lavergne, "Characterization setup for event-based imagers applied to modulated light signal detection," *Appl Optics*, vol. 58, no. 6, pp. 1305–13, 2019. ([pdf](#)).

## Lecture 11: SPAD imaging basics

[30] A. Kirmani, D. Venkatraman, D. Shin, A. Colaco, F. N. C. Wong, J. H. Shapiro, and V. K. Goyal, "First-Photon Imaging," *Science*, vol. 343, no. 6166, pp. 58–61, Jan. 2014. ([pdf](#)) ([supp](#)).

[31] A. K. Pediredla, A. C. Sankaranarayanan, M. Buttafava, A. Tosi, and A. Veeraraghavan, "Signal processing based pile-up compensation for gated single-photon avalanche diodes," *arXiv.org*. 2018. ([pdf](#)).

[32] (optional reading) P. Chandramouli, S. Burri, C. Bruschini, E. Charbon, and A. Kolb, "A Bit Too Much? High Speed Imaging from Sparse Photon Counts," in Proc. IEEE ICCP, pp. 1–9, 2019. ([pdf](#)).

## Lecture 12: Advanced methods for SPAD imaging

[33] A. Ingle, A. Velten, and M. Gupta, "High Flux Passive Imaging with Single-Photon Sensors," in Proc. IEEE CVPR, 2019. ([pdf](#)).

[34] Q. Sun, J. Zhang, X. Dun, G. BERNARD, Y. Peng, and W. Heidrich, "End-to-End Learned, Optically Coded Super-resolution SPAD Camera," *ACM TOG (SIGGRAPH Asia)*, 2019. ([pdf](#)).

# Topic 6: Time-of-Flight 3D Imaging

## Lecture 13: Continuous-wave time of flight

[35] M. Gupta, A. Velten, S. K. Nayar, and E. Breitbach, "What are optimal coding functions for time-of-flight imaging?," *ACM TOG*, vol. 37, no. 2, 2018. ([pdf](#)).

[36] A. Kadambi and R. Raskar, "Rethinking Machine Vision Time of Flight With GHz Heterodyning," *IEEE Access*, vol. 5, pp. 26211–26223, 2017. ([pdf](#)).

[37] (optional reading) R. Lange and P. Seitz, "Solid-state time-of-flight range camera," *IEEE J. Quantum Electron.*, vol. 37, no. 3, pp. 390–397, 2001. ([pdf](#)).

## Lecture 14: High-performance 3D sensing with SPADs

[38] A. Gupta, A. Ingle, and M. Gupta, "Asynchronous Single-Photon 3D Imaging," in Proc. IEEE ICCV, 2019, pp. 7909–7918. ([pdf](#)).

[39] F. Heide, S. Diamond, D. B. Lindell, and G. Wetzstein, "Sub-picosecond photon-efficient 3D imaging using single-photon sensors," *Sci. Rep.*, vol. 8, no. 1, pp. 1–8, Dec. 2018. ([pdf](#)).

## Topic 7: Non-Transient Computational Light Transport (CLT)

### Lecture 15: The Light Transport Matrix & early CLT approaches

[40] P. Sen, B. Chen, G. Garg, S. Marschner, M. Horowitz, M. S. Levoy, and H. P. A. Lensch, "Dual photography," in ACM SIGGRAPH, 2005, pp. 745–755. ([pdf](#)).

[41] S. K. Nayar, G. Krishnan, M. D. Grossberg, and R. Raskar, "Fast separation of direct and global components of a scene using high frequency illumination," in Proc. ACM SIGGRAPH, 2006, pp. 935–944. ([pdf](#)).

[42] (optional reading) M. O'Toole, R. Raskar, and K. N. Kutulakos, "Primal-dual Coding to Probe Light Transport," *ACM TOG (SIGGRAPH)*, vol. 31, no. 4, pp. 39:1–39:11., 2012. ([pdf](#)).

### Lecture 16: Efficient light transport probing

[43] M. O'Toole, J. Mather, and K. N. Kutulakos, "3D Shape and Indirect Appearance by Structured Light Transport," *IEEE T-PAMI*, vol. 38, no. 7, pp. 1298–1312, 2016. ([pdf](#)).

[44] M. O'Toole, S. Achar, S. G. Narasimhan, and K. N. Kutulakos, "Homogeneous codes for energy-efficient illumination and imaging," *ACM TOG (SIGGRAPH)*, vol. 34, no. 4, 2015. ([pdf](#)).

[45] (optional reading) S. Achar, J. R. Bartels, W. L. Whittaker, K. N. Kutulakos, and S. G. Narasimhan, "Epipolar time-of-flight imaging," *ACM TOG (SIGGRAPH)*, vol. 36, no. 4, 2017. ([pdf](#)).

### Lecture 17: Applications of non-transient CLT

[46] M. Sheinin, Y. Y. Schechner, and K. N. Kutulakos, "Computational Imaging on the Electric Grid," in Proc. IEEE CVPR, 2017. ([pdf](#)).

[47] J. Wang, J. Bartels, W. Whittaker, A. C. Sankaranarayanan, and S. G. Narasimhan, "Programmable Triangulation Light Curtains," in Proc. ECCV, 2018, pp. 19–34. ([pdf](#)).

[48] (optional reading) H. Kubo, S. Jayasuriya, T. Iwaguchi, T. Funatomi, Y. Mukaigawa, and S. G. Narasimhan, "Programmable Non-Epipolar Indirect Light Transport: Capture and Analysis," *IEEE TVCG*, vol. PP, no. 99, pp. 1–1, Oct. 2019. ([pdf](#)).

### Lecture 18: Coherent-light CLT & the Transmission Matrix

[49] S. Popoff, G. Leroose, M. Fink, A. C. Boccara, and S. Gigan, "Image transmission through an opaque material," *Nat Commun*, vol. 1, p. 81, 2010. ([pdf](#)).

[50] M. Sharma, C. A. Metzler, S. Nagesh, O. Cossairt, R. G. Baraniuk, and A. Veeraraghavan, "Inverse Scattering via Transmission Matrices: Broadband Illumination and Fast Phase Retrieval Algorithms," *IEEE TCI*, vol. PP, no. 99, pp. 1–1, May 2019. ([pdf](#)).

[51] (optional reading) O. Katz, P. Heidmann, M. Fink, and S. Gigan, "Non-invasive single-shot imaging through scattering layers and around corners via speckle correlations," *Nature Photonics*, vol. 8, no. 10, pp. 784–790, Oct. 2014. ([pdf](#)).

## Topic 8: Transient Imaging

### Lecture 19: Transient imaging with time-of-flight cameras

[52] A. Velten, Di Wu, A. Jarabo, B. Masia, C. Barsi, C. Joshi, E. Lawson, M. Bawendi, D. Gutierrez, and R. Raskar, "Femto-photography: capturing and visualizing the propagation of light," *ACM TOG*, vol. 32, no. 4, 2013. ([pdf](#)).

[53] F. Heide, M. B. Hullin, J. Gregson, and W. Heidrich, "Low-budget Transient Imaging Using Photonic Mixer Devices," *ACM TOG (SIGGRAPH)*, vol. 32, no. 4, 2013. ([pdf](#)).

[54] (optional reading) M. O'Toole, F. Heide, L. Xiao, M. B. Hullin, W. Heidrich, and K. N. Kutulakos, "Temporal frequency probing for 5D transient analysis of global light transport," *ACM TOG (SIGGRAPH)*, vol. 33, no. 4, 2014. ([pdf](#)).

### Lecture 20: Transient imaging by interferometry

[55] I. Gkioulekas, A. Levin, F. Durand, and T. Zickler, "Micron-scale light transport decomposition using interferometry," *ACM TOG (SIGGRAPH)*, vol. 34, no. 4, pp. 37–37:14, Jul. 2015. ([pdf](#)).

[56] J. Boger-Lombard and O. Katz, "Passive optical time-of-flight for non line-of-sight localization," *Nat Commun*, vol. 10, no. 1, pp. 1–9, Jul. 2019. ([pdf](#)) ([supp](#)).

## Topic 9: Non-Line-of-Sight 3D Imaging (NLOS)

## Lecture 21: NLOS imaging for diffuse scenes

[57] A. Velten, T. Willwacher, O. Gupta, A. Veeraraghavan, M. G. Bawendi, and R. Raskar, "Recovering three-dimensional shape around a corner using ultrafast time-of-flight imaging," *Nat Commun*, vol. 3, pp. 745–745, Mar. 2012. ([pdf](#)). ([supp](#)).

[58] M. O'Toole, D. B. Lindell, and G. Wetzstein, "Confocal non-line-of-sight imaging based on the light-cone transform," *Nature*, vol. 555, no. 7696, pp. 338–341, Mar. 2018. ([pdf](#)).

## Lecture 22: NLOS imaging for general reflectance

[59] S. Xin, S. Nousias, K. N. Kutulakos, A. C. Sankaranarayanan, S. G. Narasimhan, and I. Gkioulekas, "A Theory of Fermat Paths for Non-Line-of-Sight Shape Reconstruction," in *Proc. IEEE CVPR*, pp. 1–10., 2019. ([pdf](#)).

[60] D. B. Lindell, G. Wetzstein, and M. O'Toole, "Wave-based non-line-of-sight imaging using fast f-k migration," *ACM TOG (SIGGRAPH)*, vol. 38, no. 4, pp. 116–13, Jul. 2019. ([pdf](#)).

# Topic 10: Computational Imaging for Microscopy

## Lecture 23: Illumination coding for high-performance microscopy

[61] S. Abrahamsson, G. Ball, K. Wicker, R. Heintzmann, and L. Schermelleh, "Structured Illumination Microscopy," in *Super-resolution imaging in biomedicine*, A. Diaspro and M. A. M. J. V. Zandvoort, Eds. CRC Press, 2017. ([pdf](#)).

[62] J. Lee, J. V. Chacko, B. Dai, S. A. Reza, A. K. Sagar, K. W. Eliceiri, A. Velten, and M. G. 0001, "Coding Scheme Optimization for Fast Fluorescence Lifetime Imaging," *Proc. ACM SIGGRAPH Asia*, vol. 38, no. 3, pp. 1–16, 2019. ([pdf](#)).

## Lecture 24: Advanced computational microscopy systems

[63] T. Aidukas, R. Eckert, A. R. Harvey, L. Waller, and P. C. Konda, "Low-cost, sub-micron resolution, wide-field computational microscopy using opensource hardware," *Sci. Rep.*, vol. 9, no. 1, pp. 1–12, May 2019. ([pdf](#)).

[64] A. Muthumbi, A. Chaware, K. Kim, K. C. Zhou, P. C. Konda, R. Chen, B. Judkewitz, A. Erdmann, B. Kappes, and R. Horstmeyer, "Learned sensing: jointly optimized microscope hardware for accurate image classification," *Biomedical Optics Express*, vol. 10, no. 12, pp. 1–19, Dec. 2019. ([pdf](#)).