Seeing Far in the Dark with Patterned Flash

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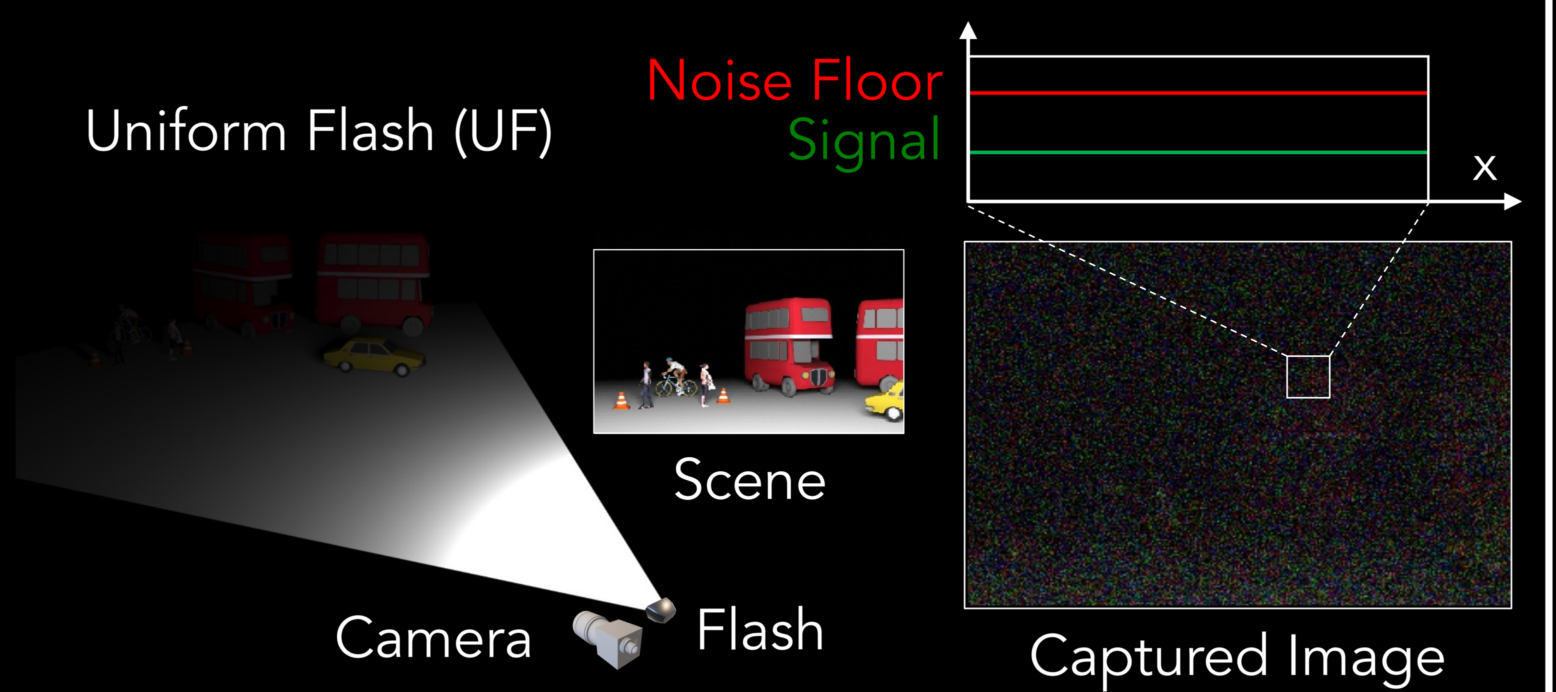
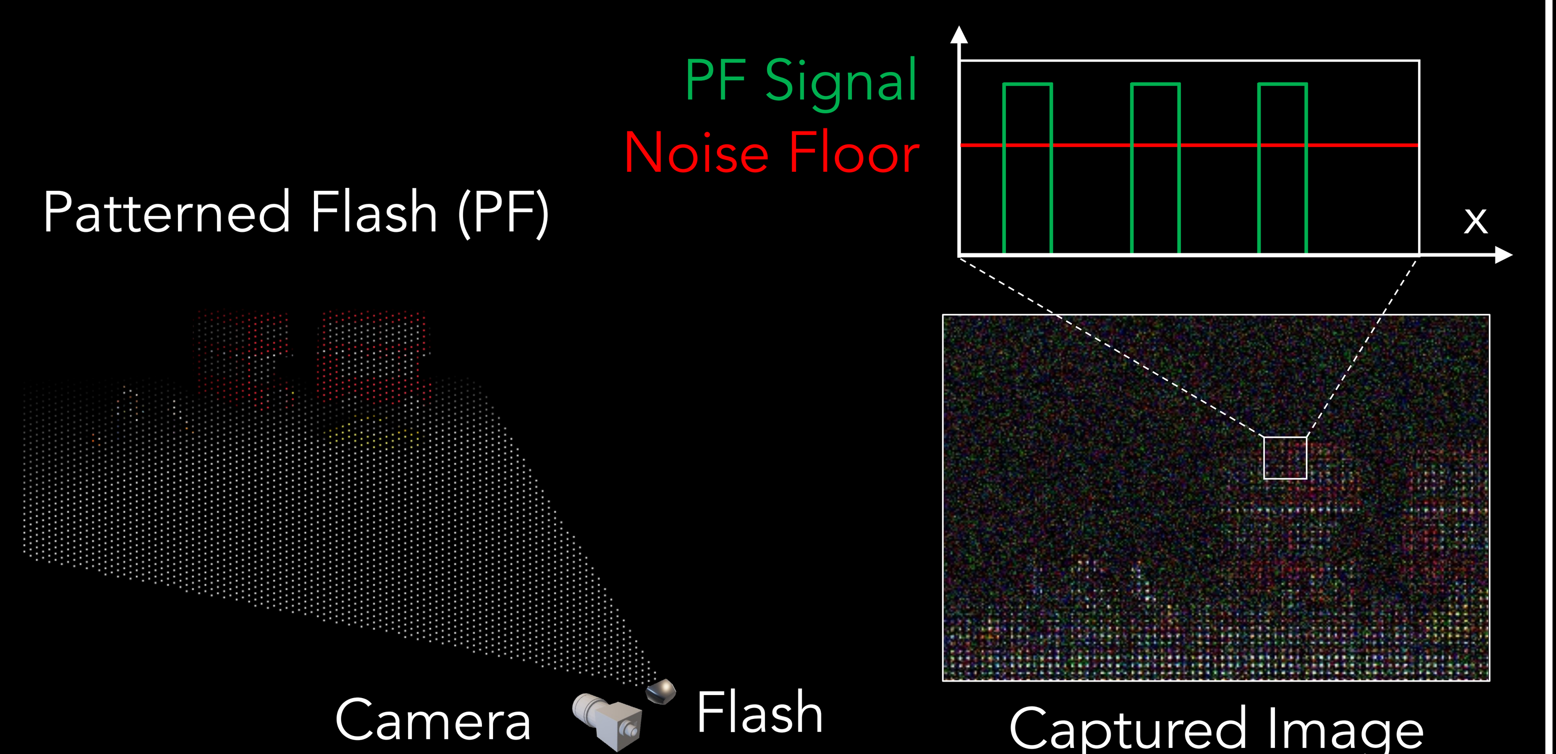
Code and data: https://github.com/zhsun0357/Seeing-Far-in-the-Dark-with-Patterned-Flash

Problem in the Traditional Flash



- Physical law: light falls off with 1/depth^2
- Flash is limited in distance
  - Flash signal is overwhelmed by sensor noise

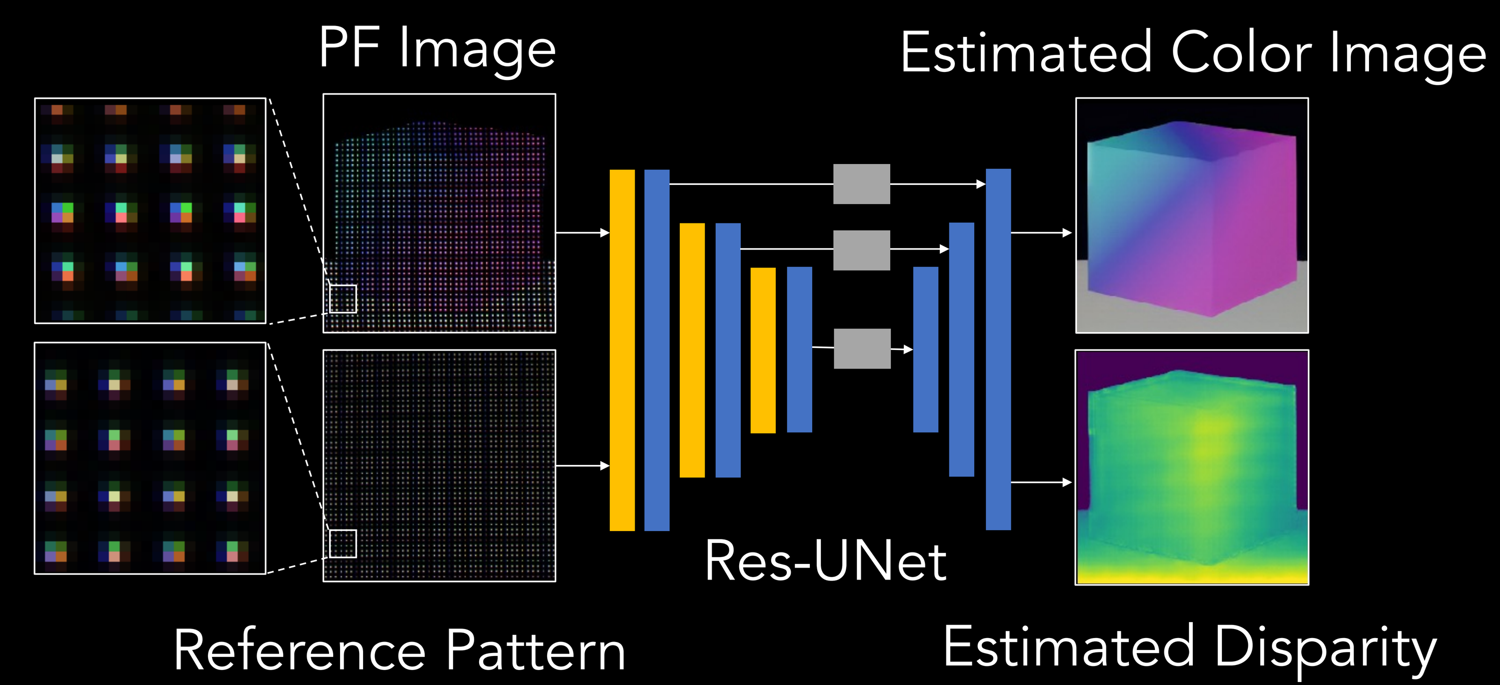
Proposed: Patterned Flash

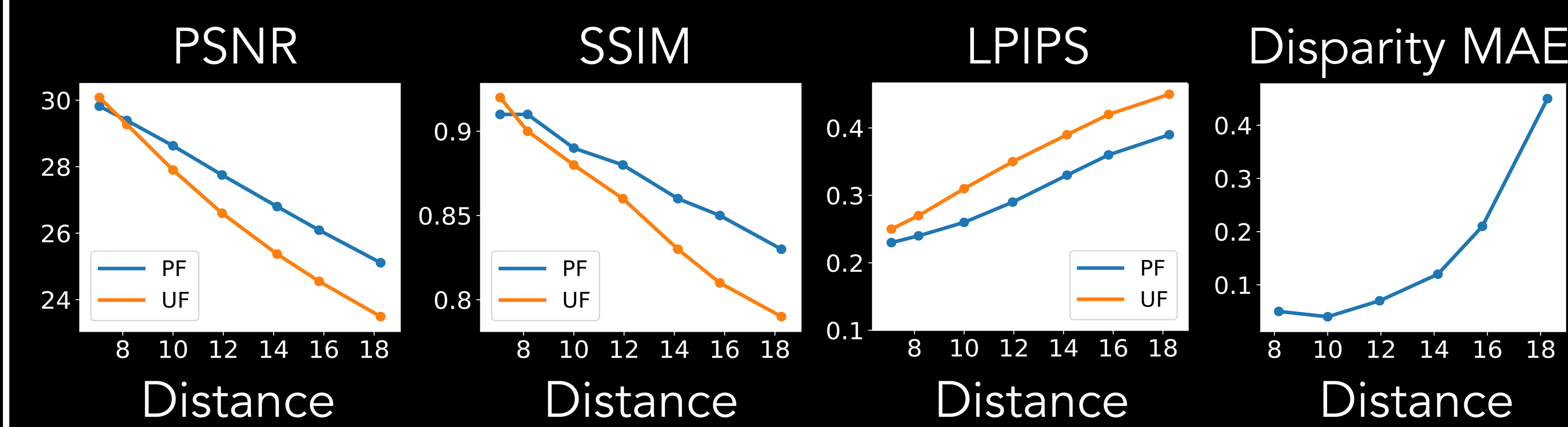


UF Reconstruction | PF Reconstruction | PF Disparity

- PF concentrates light into a dot array for higher signal-noise ratio at dots' location
- PF is also a structured light system that supports depth estimation

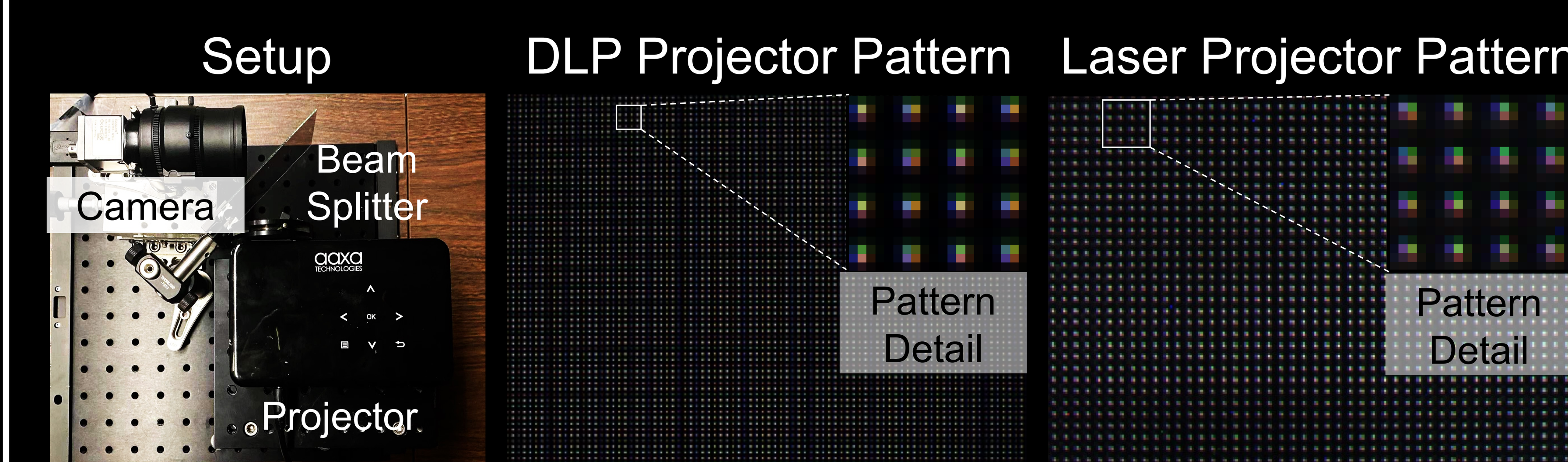
Algorithm





- Joint image reconstruction & depth estimation
- In simulations
  - PF achieves better image restoration quality
  - PF achieves sub-pixel disparity accuracy for depth est.

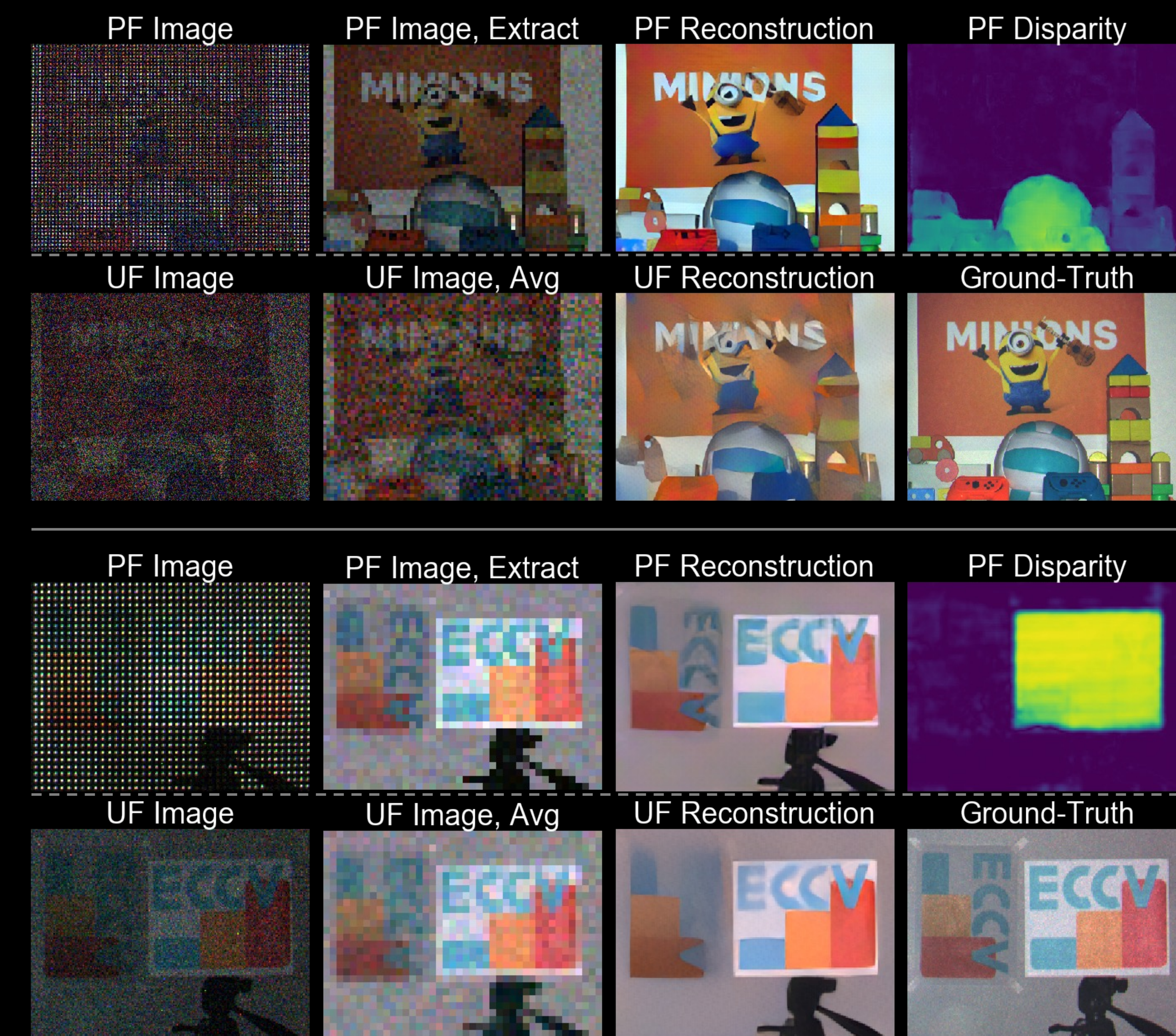
Hardware Prototype



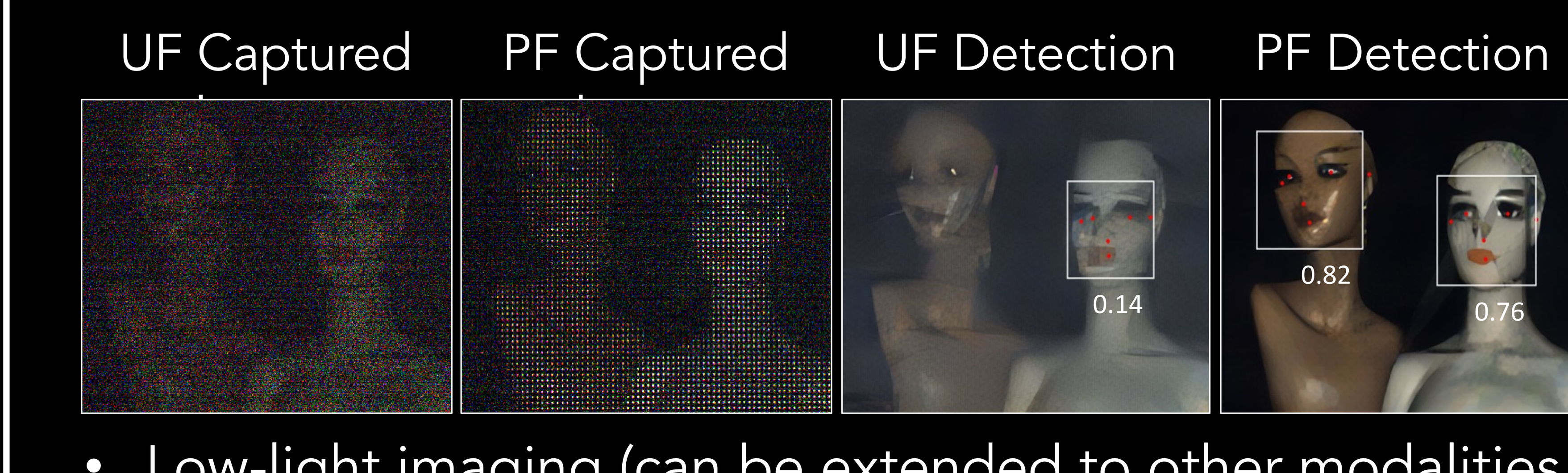
- Setup: camera, projector, beam splitter (for easily adjusting baseline only)
- Regular pattern vs. random pattern
  - The former one has better image restoration quality
- DLP projector is used to emulate the PF and UF
- Laser projector has no light loss, but has low power

Image Restoration

- PF resolves fine details and avoids reconstruction artifacts compared to UF; additionally, PF has depth



Applications



- Low-light imaging (can be extended to other modalities, like IR, UV, hyper-spectral imaging)
- High-level tasks in low-light env., like face/car detection
- Single-shot flash/no-flash imaging; 3D-based background blurring
- PF hardware implementations: MEMS scanner, VCSEL array, diffractive optical element (DOE), …