A Deep Learning Approach for Image Reconstruction from Smartphone Under Display Camera Technology

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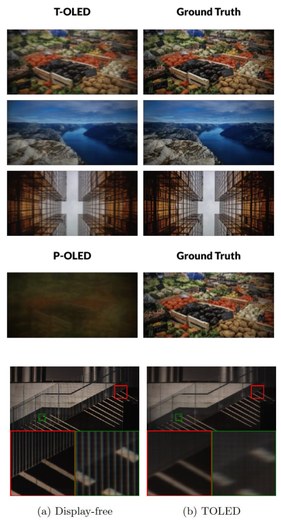
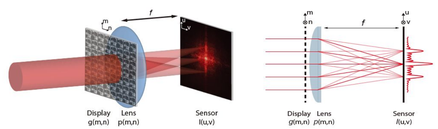
Motivation



(a) Display-free (b) TOLED

Example T-OLED images from the dataset.

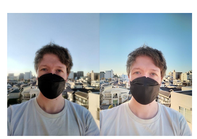
- Current approaches to reconstructing images from under display cameras lead to poor output quality
- Novel dataset for T-OLED images available for testing UDC computer vision algorithms
- Deep learning successful at deblurring and blind convolution [1]



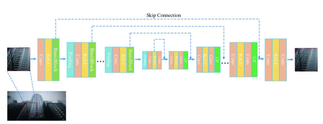
(a) 3D schematics (b) 2D schematics

The optical system for an under display camera

Related Work



A selfie from ZTE's Axon 20 on the left, and from the Axon 30 on the right (with UDC).
https://www.theverge.com/22776271/under-display-selfie-cameras-zte-microsoft-xiaomi



One patch-based large-scale U-Net approach presented in [2]

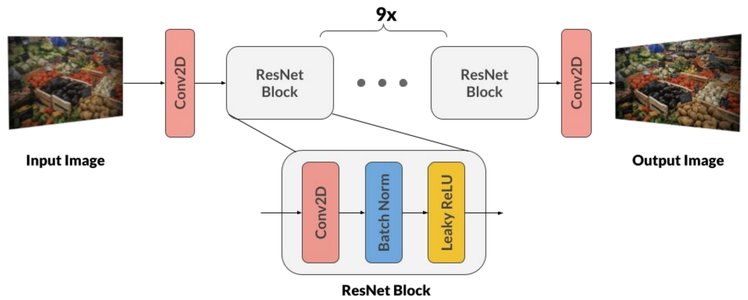
- Current industry approaches look overprocessed and unnatural (ZTE Axon 20, Galaxy Z Fold 3)
- First large-scale academia initiative: workshop at CVPR 2021 [2]
  - Successful approaches: large U-Net, ADMM + PyNet → Fusion U-Net, spatial patch restoration with deep ResNet
  - Unreasonably long inference time and large model size

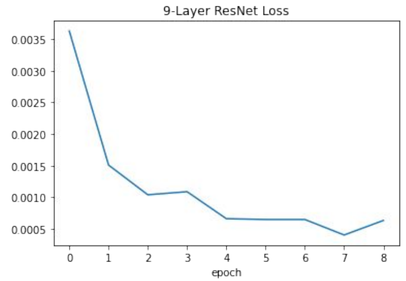
References

[1] S. Nah. "Deep multi-scale convolutional neural network for dynamic scene deblurring", CVPR 2017
[2] Y. Zhou, et al., "Udc 2020 challenge on image restoration of under-display camera: Methods and results," in Computer Vision – ECCV 2020 Workshops.

New Technique

- **Dataset:** 80:10:10 train/test/validation split
  - 240 1024 x 2048 images total
- **Preprocessing:** randomized horizontal flips for data augmentation, resize images to 650 x 325 to meet Google Colab data constraints
- **Shallow ResNet approach**
  - Faster inference and better training at a PSNR cost
  - l1 loss function with Adam optimizer and 0.01 learning rate, convergence within 8 epochs





Experimental Results

- **Qualitative Results:**
  - Less blur in output
  - Sharper output images
- **Quantatitive Results:**
  - Average PSNR improvement of 2.39
    - Average Input Image PSNR: 30.7
    - Average Output Image PSNR: 33.09
- **Things the Model Struggles with:**
  - Color Correction
  - Vertical Fringes
  - Extreme Lighting Situations