Skin Lesion Super Resolution in Total Body Photography

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Introduction

- **Background:**
  - 5.4M cases of non-melanoma skin cancer each year in US
  - 20% of Americans get some form of skin cancer by age 70
  - 76,000 melanomas diagnosed each year leading to 10,000 deaths
  - Need in Total Body Photography (TBP) for early detection

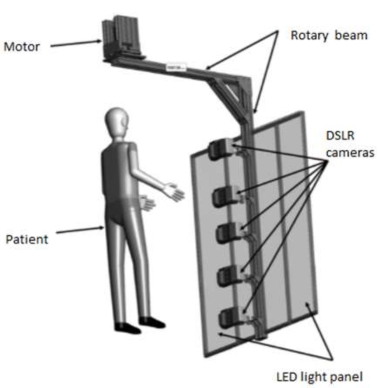
- **Motivations:**

1) Although Total Body Photography (TBP) has been increasingly used in early melanoma screening, the TBP systems fall short in capturing images with sufficient lesion detail.
2) Multi-image super-resolution (MISR) is applicable for TBP but requires a systematic workflow.
3) Lack of publicly available clinical skin lesion dataset limits the model training for MISR.

- **In this work:**

We proposed a workflow to enhance the resolution of images for lesion of interest (LOI) in TBP. First, we captured multi-frames of low-resolution (LR) images for LOI based on the back-projection method. Next, the LR images are used to reconstruct a high-resolution (HR) image through the MISR model, which is trained on our synthetic multi-frame data with the clinical images. In addition to publicly available clinical images, we leveraged CycleGAN[2] to style-transfer dermoscopic images into the clinical image domain that is closer to the data distribution of TBP images. To the best of our knowledge, we are the first group that incorporates super-resolution into TBP.

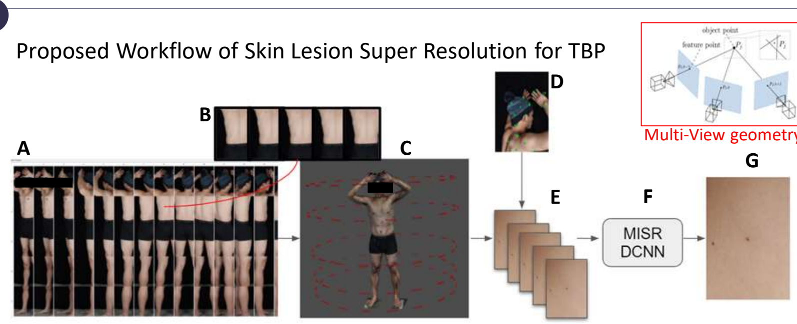
System Design



- 360-degree scan
- Imaging subsystem:
  5 cameras with 33 MP
  focal length 35-55 mm
  ISO 1000
  exposure time 1/250 sec
  aperture f/11
  Auto-focus
- Lighting subsystem:
  white/UV/Violet
- System controlled in PLC
- A flexible Graphical User Interface is designed for operating the system

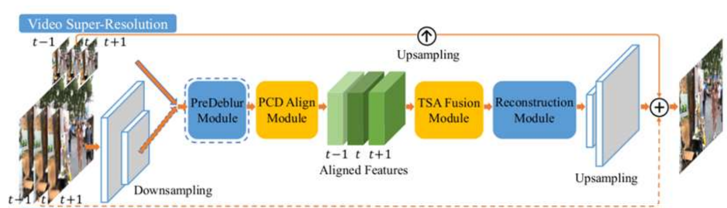
Method

1 Proposed Workflow of Skin Lesion Super Resolution for TBP



A. Image acquisition from TBP system
B. Burst of image sequence
C. Photogrammetry 3D reconstruction by Structure from Motion and Multi-View Stereo
D. Selection of Lesion of Interest (LOI)
E. Derive input of LR images for LOI
F. Apply MISR for LOI
G. Final output of HR image for LOI

2 Multi-Image Super-Resolution (MISR) Framework [1]

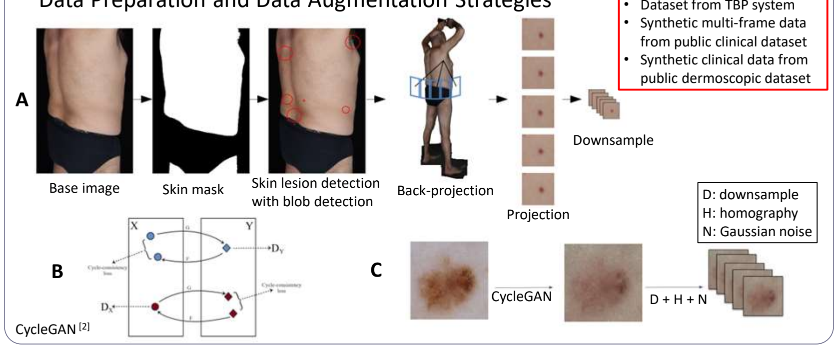


SISR: $I_x = (I_y \otimes k) \downarrow_s + n$ ⟶ MISR can be formulated similarly with additional challenges of aligning multiple frames and fusing information from aligned frames

where I_x and I_y are LR and HR image, k is the blurring kernel, ⊗ is the convolution operation, $\downarrow_s$ is a downsampling operation with a scaling factor s , and n is the additive white Gaussian noise

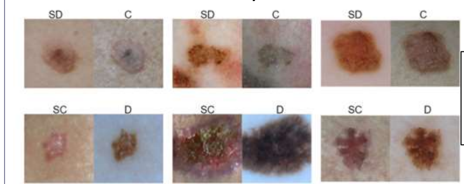
3 Data Preparation and Data Augmentation Strategies

- Dataset from TBP system
- Synthetic multi-frame data from public clinical dataset
- Synthetic clinical data from public dermoscopic dataset



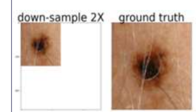
Result

Qualitative Result of Synthetic Data

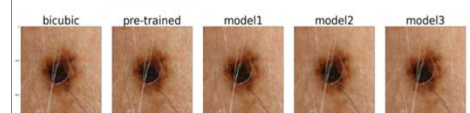


C: Clinical
D: Dermoscopic
SD: Synthetic dermoscopic
SC: Synthetic clinical

Qualitative and Quantitative Result of Super-Resolution



Methods	Bicubic	Pre-trained	Model1	Model2	Model3
PSNR/SSIM	30.21/0.7160	31.71/0.7755	37.97/0.9238	37.15/0.9107	38.30/0.9285



Model1: Fine-tuned on C
Model2: Fine-tuned on C+D
Model3: Fine-tuned on C+SC

* The result shown here is tested on a clinical image.

Conclusion

- A workflow of skin lesion super resolution for TBP is proposed and implemented for proof-of-concept.
- The data augmentation strategy with CycleGAN can effectively help with the insufficiency in training data.
- The designed TBP machine can be further used to collect multi-spectral and multi-angle data for skin lesions.
- The TBP system needs to improve the quality of the base image, especially the out-of-focus problem during the scan.
- The TBP system can be studied to optimize the image-capture pipeline and the super-resolution result in the future.

Reference

[1] Xintao Wang et al., EDVR: Video restoration with enhanced deformable convolutional networks. In CVPRW, 2019

[2] Jun-Yan Zhu et al., Unpaired image-to-image translation using cycle-consistent adversarial networks. In ICCV, 2017

Acknowledgments

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