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Synthetic Fundus Fluorescein Angiography using Deep Neural Networks

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Angiographic Fundus Imaging

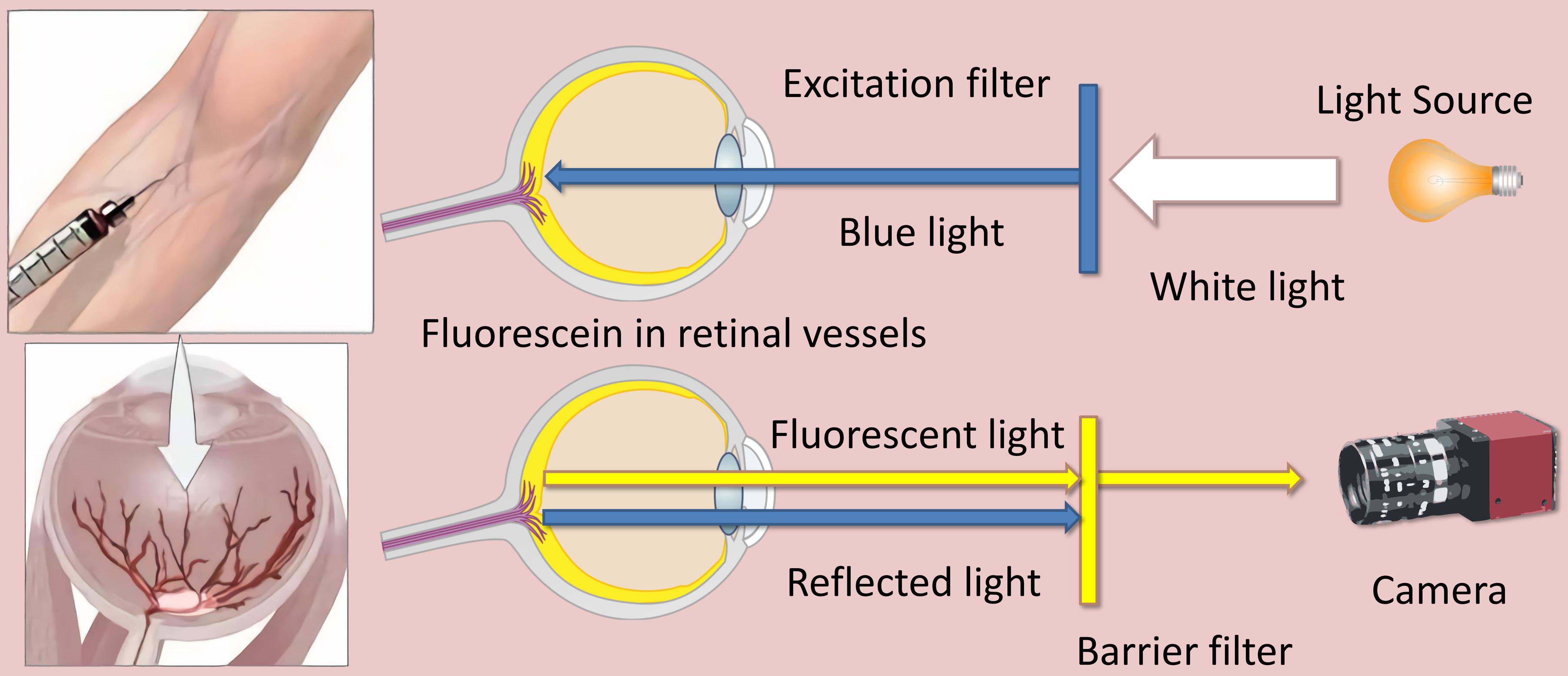

Figure 1: An intravenous, fluorescent dye bounds to leukocytes, which excites the molecules when exposed to blue light. This, in turn, produces a narrow yellow-green light. The enhanced image highlights different features of the fundus.

Introduction

- **Physicians** are increasingly **reluctant** to use angiographic imaging [1]
- Angiographic imaging may **pose risks** of harm to the patient
  - E.g. allergic reactions, nausea, thrombophlebitis, seizures
- Image **synthetization** to possibly
  - **Reduce** the **need** for angiographic imaging
  - Create **large**, synthetic **databases** for machine learning application

Materials and Methods

- **Generative** adversarial networks (GAN) use an additional **discriminator** which discerns real and synthesized images.
- **CycleGAN** (Fig. 2.) translates between two image domains A and B, **without** the need for **tightly-coupled** pairs [2]
- Dataset provided by [3] and People's Hospital of Jiangmen City, China
  - Training data: 365 color and 265 angiographic images
  - Test data: 14 color and 14 angiographic images
- All images downsampled to resolution of 256 x 256
- Data **augmentation**:
  - Rotated by 90, 180, and 270 degrees
  - Resized to 286 x 286 and cropped randomly

Results and Discussion

- Structures such as vessels are **enhanced** compared to the color image
- **Fine vessel** structures are **unclear** or **not present** within the synthesized, but visible in the ground truth
- Some local structures are located at **different** positions or even **made up** by the generating network
- **Contrast differences** between ground truth and synthesized images

➡ **Synthetic images appear realistic, but medical use case is questionable**

Conclusions and Outlook

- **Image translation** between color fundus and angiographic images
- Cycle consistency GAN allows training with **unpaired** image data
- Planned: **Clinical study** to investigate medical use case
- Technical outlook: **quantitative** analysis and increasing image resolution

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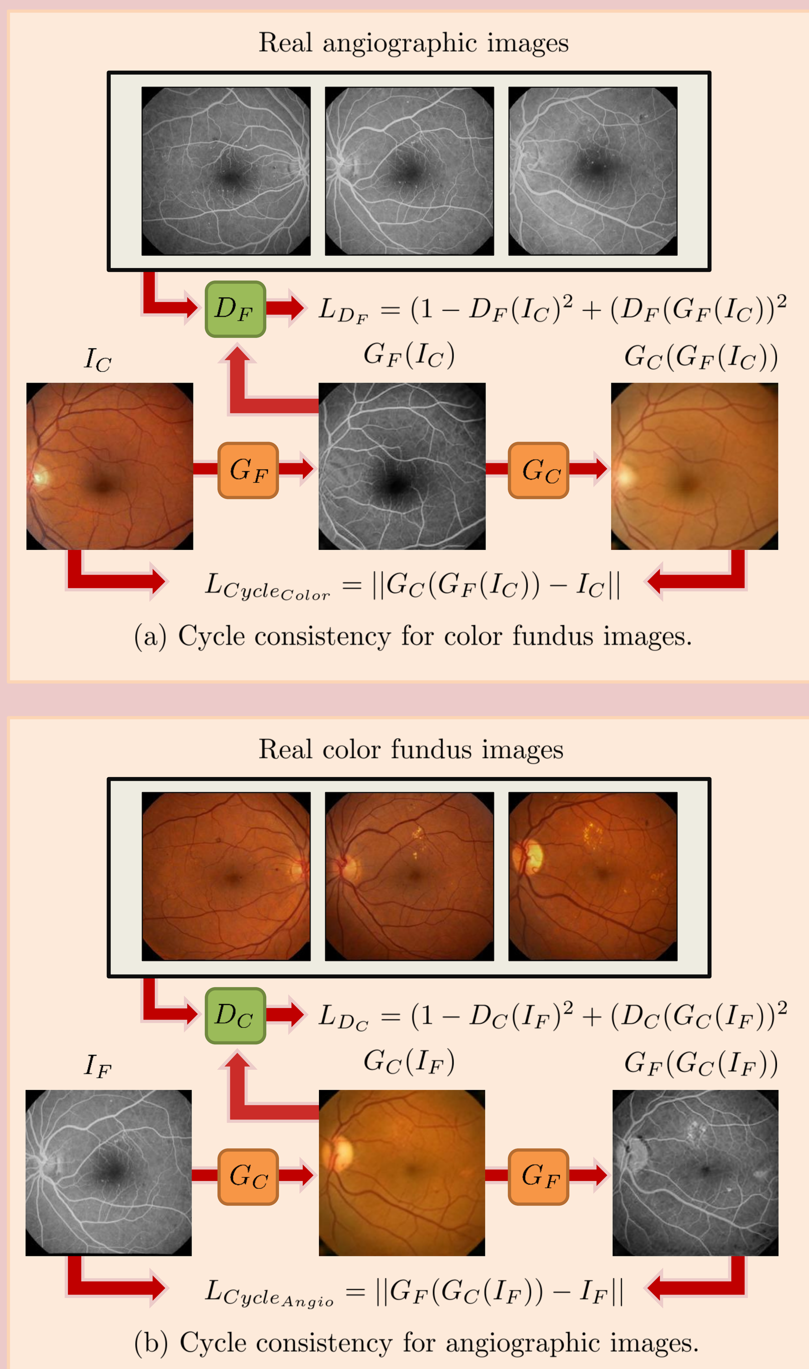

Figure 2: The two figures visualize the composition of the loss term used for the training process of the cycleGAN architecture.

Color fundus image generator G_C and fluorescence angiographic image generator G_F. Similarly, D_C and D_F denote the respective discriminator networks. The input images are denoted as I_F and I_C.

Cycle consistency is enforced so that the backwards translation resembles the input image for both ways, see $L_{Cycle,Angio}$ and $L_{Cycle,Angio}$.

The adversarial loss, i.e. the capacity of the network to distinguish between real and fake images, is modeled by L_{D_C} and L_{D_F}.

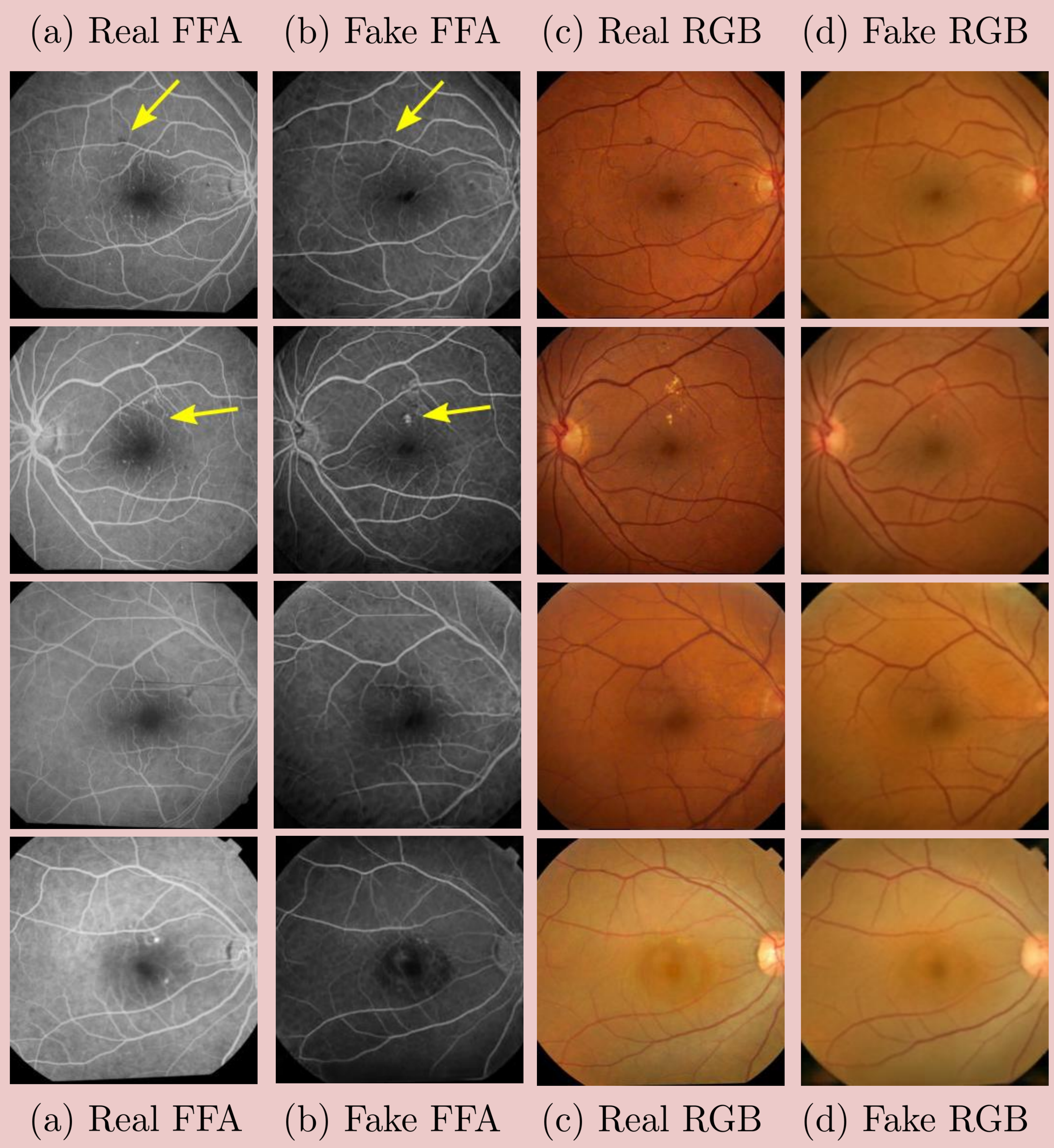

Figure 3: Each row shows from left to right the real and generated angiographic image, the authentic color image and the reconstructed color image to show cycle consistency.

References

[1] Musa, F., et al. "Adverse effects of fluorescein angiography in hypertensive and elderly patients." *Acta Ophthalmologica 84.6 (2006): 740-742.*

[2] Zhu, J. Y., et al. (2017). Unpaired image-to-image translation using cycle-consistent adversarial networks. *arXiv preprint arXiv:1703.10593.*

[3] Hajeb Mohammad Alipour, S et al. "Diabetic retinopathy grading by digital curvelet transform." Computational and mathematical methods in medicine 2012 (2012).