Master Thesis Presentation

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Eye Movement Tracking with OCT Imaging

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Introduction

Optical Coherence Tomography (OCT) is a widely used non-invasive medical imaging modality, to acquire high-resolution volumetric data from the retina. Recently, its use has rapidly increased in the field of ophthalmic applications. By using the principle of optical interferometry, it provides cross-sectional data for the analysis of retinal pathologies and treatment planning of ocular disorders. The quality of volumetric OCT data is correlated to the scanning speed of the instrument (A-scans) and the processed B- and C-scans. Considerable motion occurs during OCT data acquisition through involuntary eye movements, respiratory movements, heartbeat or head posture changes during the procedure. Therefore, we propose methods to track eye movement and to co-align the fundus images after image acquisition.

Today, two broad categories of motion artifact correction are known: hardware-based solutions and software-based solutions. Deep Learning methods based on Convolutional Neural Networks (CNN) are well known for their success in image segmentation, and matching tasks.

Due to their flexibility in handling legacy data and their adaptability to system requirements we proposed two software-based methods (with CNN approach). We explored suitable CNN architectures to correct motion artifacts by co-aligning images and evaluate their reconstruction performance on non-synthetical medical imaging data.

Materials and Methods

The first software-based method is estimating the overlapping area between image pairs. It is trained on learning feature representations and feature matching from randomly transformed natural images with synthetical created ground truth labels. We tested and verified a fully supervised CNN architecture (U-Net) on image tracking of synthetical imaging data. The second software-based method is estimating the pixelwise motion (optical flow) between image pairs. The optical flow information is used to reconstruct the misaligned image pairs by creating image mosaics. There we used a supervised CNN architecture, called FlowNet as a baseline and fine-tuned the architecture to estimate motion fields with various sizes. The generalization on unseen data was established by strong data augmentation. For this method, we used synthetical and non-synthetical data sets, namely: Pascal VOC2012 natural images, Retinal OCT Fluid B-scans, Kaggle Retinopathy fundus images and FIRE fundus images.

Results

134 Fundus image pairs from the FIRE data set, categorized in three groups (A, P, S), were evaluated. For each category, the mean endpoint error (EPE) was measured and analyzed. For category A, we obtained an average EPE of 5.08, for category P 24.01 and for category S 4.11.

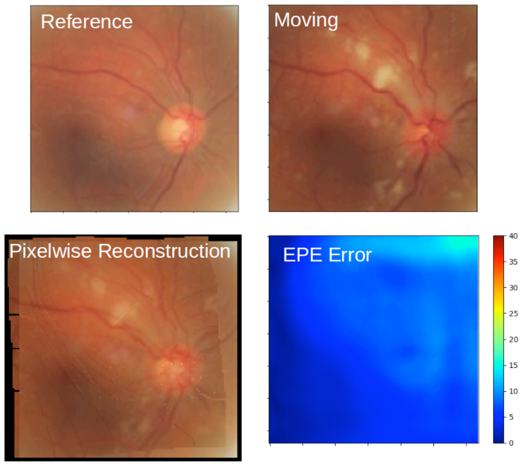

Fig. 1 Automated pixelwise reconstruction of two FIRE fundus images and the corresponding EPE map.

Discussion

The results showed promising performance on image reconstruction of medical data based on CNN architectures.

This thesis provides further important research results for the deep learning methods and also the pixelwise reconstruction. We developed a weighted custom loss function, which helped the network to learn small and large motions simultaneously.

Additionally, the results showed, that traditional matching methods based on hand-crafted feature descriptors can be more and more replaced by deep learning encoder-decoder methods.

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References

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