Ultrasound Image Synthesis from Inaccurate Poses with Bundle-Adjusted Neural Radiance Fields

Project Management and Software Development
for Medical Applications

General Info

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Project Abstract

This project aims to develop a framework for synthesizing ultrasound images from inaccurate poses using the NeRF. The core objective of this method is to enhance the synthesis process by simultaneously learning a 3D scene representation from ultrasound images while optimizing camera poses to mitigate pose estimation errors.

Background and Motivation

NeRF is a technique for achieving photorealistic image synthesis. It accomplishes this by learning 3D representations from pose-annotated images. One critical prerequisite of NeRF involves accurately computing position vectors from camera poses. However, acquiring precise camera poses can be challenging, even when using tracking techniques. As a result, recent research has concentrated on the concurrent optimization of 3D reconstruction and pose correction [1].

The ultrasound image formation model differs from the conventional model used in natural images. Consequently, we have developed a NeRF framework designed explicitly for ultrasound imaging [2]. Like the original NeRF, this approach relies on precise poses, but this dependency on ideal poses introduces rendering quality issues stemming from pose estimation errors. Additionally, it necessitates the challenging task of co-registering ultrasound sweeps.

Student's Tasks Description

First, the student will get familiar with both Ultra-NeRF and BARF. They will understand the differences between the modalities (ultrasound vs. RGB) and gain insight into how errors in pose estimation impact the learning of 3D scene representations. Then, they will implement ultrasound rendering within the BARF framework. Finally, they will train the model and evaluate the results. Through this, they will acquire knowledge in 3D reconstruction from ultrasound images, training neural networks on remote servers, and proficiency in utilizing essential image evaluation tools, including ImFusion and popular software packages like open3D or scikit-image.

Technical Prerequisites

The student should have a basic understanding of deep learning and basic familiarity with deep learning frameworks. Proficiency in Python is essential.

Please send the completed proposal to ardit.ramadani@tum.de, lennart.bastian@tum.de and tianyu.song@tum.de. Please note that this proposal will be evaluated by the BMC coordinators and will be assigned to a student only in case of acceptance.

References

1. *Lin, Chen-Hsuan, Wei-Chiu Ma, Antonio Torralba, and Simon Lucey. "Barf: Bundle-adjusting neural radiance fields." In Proceedings of the IEEE/CVF International Conference on Computer Vision 2021*

2. Wysocki, Magdalena, Mohammad Farid Azampour, Christine Eilers, Benjamin Busam, Mehrdad Salehi, and Nassir Navab. "Ultra-NeRF: Neural Radiance Fields for Ultrasound Imaging." In Medical Imaging with Deep Learning. 2023