NEURAL RADIANCE FIELDS FOR VESSEL RECONSTRUCTION FROM 2D X-RAY CORONARY ANGIOGRAPHY PROJECTIONS

PROOF OF CONCEPT

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Introduction

X-ray coronary angiography (CAG) is the standard modality to assess the anatomy of coronary arteries and possible stenoses and to guide coronary interventions. An interventional-cardiologist uses these multiple consecutively acquired two-dimensional (2D) projections from different angles to obtain a mental perception of the complex coronary tree in three-dimensions (3D). A readily available 3D reconstruction of the coronary tree during this procedure facilitates e.g. properly chosen projections for optimal decision making.

A vast amount of traditional and machine learning methods have been proposed for the 3D reconstruction of vessels from CAG, yet the problem remains complex, as key challenges with automation, limited number of projection angles and cardiac and respiratory motion have not been completely solved. Neural Radiance Fields (NeRF) is an emerging deep learning technique for 3D reconstruction and could potentially tackle these challenges [1].

The aim of this work is to show the application of NeRF for vessel reconstruction from CAGs.

Methods

The development of NeRF for vessel reconstruction has been described elsewhere [1]. The feasibility of NeRF for coronary reconstruction will be demonstrated using image data from a single patient and will be assessed in two steps:

1. (more than) two projections from the CAG; and
2. using projections from a synthetic CAG constructed from a Coronary Computed Tomography Angiography (CCTA) using the same projections;

The 3D reconstruction from the CCTA is used as a reference.

X-ray CAG

For each angiogram an end-diastolic frame is selected, resulting in a single frame per projection angle as input for NeRF. The number of projections that is given to the model will be varied from one to the maximum number of selected frames, in order to study if NeRF can deal with limited number of projection angles. In all cases a 3D geometry of the coronary tree is outputted by the model.

Synthetic CAG

Segmentation of the coronary arteries, heart and ribs on CCTA provides a motion free situation, from which arbitrary X-ray projections can be created using volume rendering techniques. Identical angles are chosen for these synthetic angiograms.

Performance of NeRF will be assessed by comparing the centerlines of the coronary tree reconstructed from synthetic and real angiograms to the coronary centerlines from CCTA.

Results

Preliminary (eye-balling) results show that NeRF can reconstruct the coronary tree from a limited number of projections. Quantitative assessment will follow.

Discussion

In this work it will be demonstrated if NeRF can deal with the challenges in reconstructing the coronary tree from (synthetic) coronary angiograms. A CCTA-derived coronary model will serve as ground truth for the reconstructions with NeRF. The minimum requirements needed for NeRF to obtain a proper 3D reconstruction, e.g. the number of clinically used projections, will be one of the results.

The use of synthetic angiograms is explored as a new approach to obtain motion free images from arbitrary projections and to validate CAG reconstruction techniques as the ground truth is already available.

Though it is considered that the general outline of the coronary tree from NeRF, described by centerlines, can be obtained, a validation of the complete 3D reconstruction requires more specific data such as intravascular imaging.

References

1. Maas, K.W.H. et al, [Manuscript in preparation]