UCLouvain

3D Tumor vascularization reconstruction from MicroCT imaging

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Preface

This is a preface

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Contents

Abstract

Elevator pitch: I am working on reconstructing the vascularization network of tumors imaged using microct, a method of ct or xray scanning that is of particularly high resolution. The raw images are generally not directly usable as the vascularization is discontinuous, and the way it appears in images varies based on the size of the vasculature, due to more contrast agent being present in larger vessels, and smaller vessels not getting any agent, but contrast in this case being due to the red blood cells.

Abstract:

Soft tissue analysis presents multiple challenges relating to the required techniques to obtain structural information. One such technique is MicroCT, an Ex-vivo method of 3D reconstruction. However, this process, as with all imaging processes, does not produce semantic information in and of itself. The step of semantic extraction generally makes use of expert knowledge, computer algorithms, or more recently machine and deep learning. In this document, we aim to develop an adaptable and re-usable method for the semantic extraction of blood vessels from MicroCT scans, characterized by one practical application: that of extracting vascularization of tumors, in order to compare tumors treated with a vasculature modifying treatment with control tumors.

List of Figures

Chapter 1

Introduction

Blurb: what is vascularization and why is it important What is MicroCT, what other imaging modalities exist, and what are the variants of CT what is the process of reconstruction, what are methods, why is it important, what does it allow

1.1 Context - biology

- Define tumor vascularization (blood vessel networks in tumors induced by the tumor to continue growing -> see wlodarski).
- Role of vascularization: nutrient/oxygen supply to tumor, metastasis/spreading but can also allow treatment delivery
- Why reconstruction of vascularization matters -> allows us to estimate state of tumor, better evaluate treatments

1.2 Imaging general overview

- Main imaging modalities: 2D histology, MRI, conventional CT, ultrasound
- Pros and cons for each wrt to vascular analysis (resolution, invasiveness/ex or in vivo, 3D vs 2D, contrast/colour)

1.3 Focus on MicroCT and CECT

What is MicroCT <> CT (resolution, ex-vivo nature, sample preparation).

- Why are CEST agents used
- Explain contrast mechanisms for soft tissue and vessels (contrast agent vs native contrast like RBCs).
- Explain issue with dynamic nature of the images: big vessels vs small vessels

Conclude with why we're using MicroCT for this situation and more generally why MicroCT can be attractive for vascularization (3D, high resolution) and why it is challenging (noise, artifacts, variation with vessel size).

1.4 Exploring the reconstruction problem

Most current imaging techniques produce non semantic data
- Example of imaging that does extract (near) semantic data: xray of bones
- Widen to most other imaging and other xray based techniques: most don't differentiate so well

Return to CECT:
- It outputs data that needs processing, explain why, discuss voxel sizes, discuss the use of staining agents

Present semantic extraction / segmentation / reconstruction of structures.
- Situations and examples where it is good
- Contrast with specific issues in your setting:

– Dynamic nature of the target based on size – 3D problematic

1.5 Existing approaches to semantic extraction

1.5.1 traditional image processing (thresholding, filtering, morphological ops).

- Show it working for CECT
- Show it failing for some examples, motivate need for going deeper

1.5.2 model-based and graph-based reconstruction

- Discuss what it is
- Discuss its downsides (tuning, expert knowledge, fragile to context changes)

1.5.3 machine learning / deep learning methods.

- Discuss its use for semantic extraction
- Discuss its downsides

– need for lots of data – poor generalization – poor re-usability by other researchers – poor failure characterization: can fail in unexpected ways, or silently – poor wider scientific community understanding of how to validate and pipeline ML

1.6 Problem statement and objective

HMW (HOW MIGHT WE) reconstruct vasculature from MicroCT robustly across variable vessel size scales, starting with tumors then widening to other vascularized tissue, while ensuring extraction of research relevant metrics, compatibility with methods used by existing researchers, and portability to other data

Chapter 2

State of the art

Blurb:
methods for reconstruction of structures from imaging data in 2d in 3d methods for microct analysis specifically, methods for 3d reconstruction methods for vascularization reconstruction for different body parts for different purposes for different imaging modalities

2.1 Overview

We will begin with generic semantic information extraction in 2D, expand to 3D TODO: Clarify terminology reconstruction vs segmentation vs skeletonization/nodes and branches vs registration (?) then we will move on to MicroCT specific segmentation and reconstruction and then move on to reconstruction of vascularization specifically

2.2 Semantic information extraction

2.2.1 2D

2.2.2 3D

2.3 MicroCT semantic information extraction

2.3.1 Pre-processing/filtering/area of interest

2.3.2 classical techniques (thresholding)

limitations

2.3.3 Machine learning techniques

2.3.4 Tools used in the real world (Avizo, Dragonfly)

2.4 Vascularization reconstruction

Vascularization in different body parts and tissues -> explain it varies and if anyone has done a review

2.4.1 2D

Echography 2D histo etc

2.4.2 3D

Chapter 3

To be defined better:

3.1 Portable machine learning / Opensource / Freely available software

Discuss limitations of current softwares wrt portability

3.1.1 Opensource

SOTA of Opensource methods

3.1.2 Closed source / Paid

SOTA of closed source methods

General histo

MicroCT/3D

3.1.3

Searches used:

Bibliography