The Role of Artificial Intelligence in Medical Imaging Research

Who am I?

Hey, I’m Komal!

I’m an intern on the Motion Platform Team!

I’m a second year Computer Engineering student @ The University of Waterloo

Recently started a URA at the Vision and Image Processing Lab @ The University of Waterloo

01

Introduction

Let’s learn a little about medical imaging before we get into anything

What is Medical Imaging?

"Medical imaging refers to several different technologies that are used to view the human body in order to diagnose, monitor, or treat medical conditions. Each type of technology gives different information about the area of the body being studied or treated, related to possible disease, injury, or the effectiveness of medical treatment."

Center for Devices and Radiological Health. (n.d.). Medical Imaging. U.S. Food and Drug Administration. Retrieved January 31, 2023, from https://www.fda.gov/radiation-emitting-products/radiation-emitting-products-and-procedures/medical-imaging

Why AI?

(hey that rhymes!)

Quicker identification of diseases (also leading to quicker decision making in terms of treatment)

SAFER identification of diseases

02

Research

Let’s take a look at this paper by
Xiaoli Tang, Ph.D

Abstract

Without doubt, artificial intelligence (AI) is the most discussed topic today in medical imaging research, both in diagnostic and therapeutic. For diagnostic imaging alone, the number of publications on AI has increased from about 100–150 per year in 2007–2008 to 1000–1100 per year in 2017–2018. Researchers have applied AI to automatically recognizing complex patterns in imaging data and providing quantitative assessments of radiographic characteristics. In radiation oncology, AI has been applied on different image modalities that are used at different stages of the treatment. i.e. tumor delineation and treatment assessment. Radiomics, the extraction of a large number of image features from radiation images with a high-throughput approach, is one of the most popular research topics today in medical imaging research. AI is the essential boosting power of processing massive number of medical images and therefore uncovers disease characteristics that fail to be appreciated by the naked eyes. The objectives of this paper are to review the history of AI in medical imaging research, the current role, the challenges need to be resolved before AI can be adopted widely in the clinic, and the potential future.

Brief Overview of History

Summer 1956!

JEOPARDY!

Brief Overview of History (cntd)

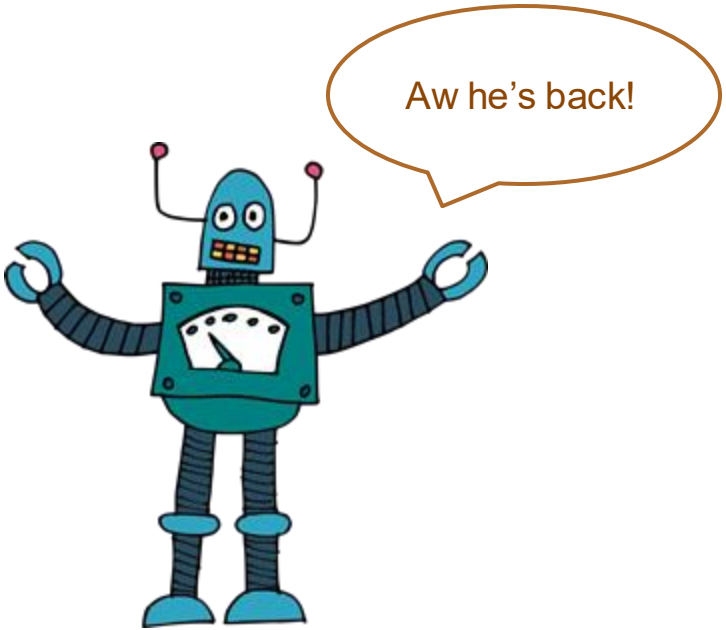
Radiomics? 

The extraction of a large number of image features from radiation images with a high-throughput approach

Bedankt voor dit woord Lambin P.!*

* “Thank you for this term Lambin P.” in Dutch

Brief Overview of History (cntd)



The Current Role of AI in Radiology

Machine Learning and its Limitations

- Applied to diagnostic imaging in the 1980s
- Examples of algorithms used:
  - Principal Component Analysis (PCA)
  - Support Vector Machines (SVM)
  - Convolutional Neural Networks (CNN)
- Limitations
  - Having to defined the class of the image that it belongs to
- So what is the solution?
  - Deep learning - efficient BUT requires a looooooot more data
  - TPU - Tensor Processing Unit

Is Deep Learning REALLY that much more effective?

YES

Imagine a DL algo that predicts lung cancer without the patient being exposed to radiation, false positives, and overdiagnosis.

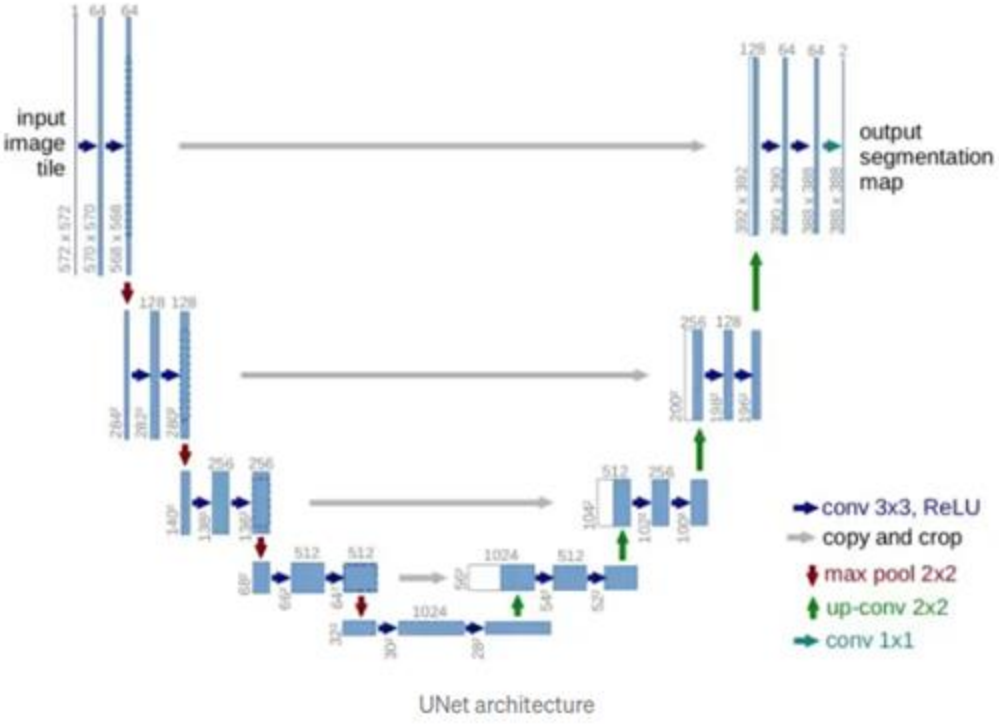
The Current Role of AI in Radiomics

Organ and Lesion Segmentation

BIG IDEA: segment the organs at risk automatically for treatment planning

- Deep learning algorithm have been applied to segment organs:
  - Head and neck organs
  - Brain
  - Lung
  - Prostate
  - And more!
- Lesion segmentations
  - Bladder
  - Breast
  - Bone
  - And more!

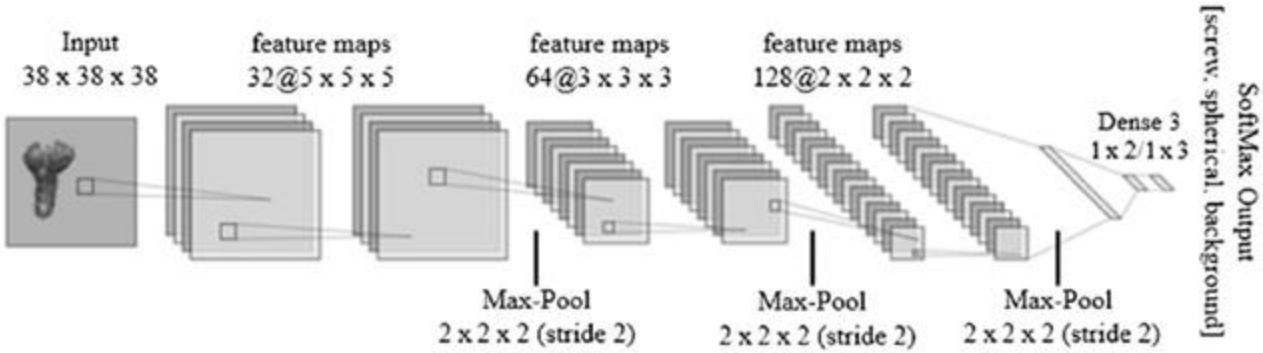
UNet Algorithm



Zhang, J. (2019, October 18). UNet line by line explanation. Medium. Retrieved January 31, 2023, from https://towardsdatascience.com/unet-line-by-line-explanation-9b191c76baf5

Fiducial/Marker Detection

- What even is that?
  - Small metal objects that are placed in or near a tumor in preparation for radiation therapy
- Deep Learning CNN framework
  - Doesn't require previous knowledge of marker properties or any additional learning periods
  - This really seems to work!



Radiomics

Two Steps

1. Feature Extraction
    a. Image segmentation algorithms are applied
    b. Common features are extracted (texture, geometric information, tumor volume, shape, density, pixel intensity, and more
2. DtP (Decode the Phenotype 😉) with Mathematical Models
    a. Use this to find survival rates and viable treatments
    b. Work towards precision (personalized) medicine

Radiomics (and why it's awesome)

It prevents the need for invasive biopsy (and other nasty complications that come hand in hand with it)!

= valid ☑

Challenges That Need to be Resolved Before Clinical Implementation

Quantity of Data (There's A LOT!!!!)

- Time and training of clinicians
- Lack of ability to keep up with labeling
- Some math (theoretical)
  - Different institutions
  - Different implementations for the same procedures
  - Various procedures
  - Different patient cohorts

AKA — a LOT of pre-processing data

Privacy Policies

- Limit in cross-institution image sharing
- Data breaches and security hacks can be very detrimental to progress
- Lack of infrastructure

My thoughts on this...

There are a lot of limitations and challenges that get in the way of this being a seamless process, but it’s life changing (literally).

Thank you!