CBEB 2024

XXIX CONGRESSO BRASILEIRO DE ENGENHARIA BIOMÉDICA

Realização

SBEB

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CBEB 2024
XXIX CONGRESSO BRASILEIRO DE ENGENHARIA BIOMÉDICA

IA na saúde

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Medical Image Computing Lab. (MICLab)
Faculdade de Engenharia Elétrica e de Computação - Unicamp

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WHY DEEP LEARNING IS SUDDENLY CHANGING YOUR LIFE

Decades-old discoveries are now electrifying the computing industry and will soon transform corporate America.

TC News Video Events Crunchbase

CRUNCH NETWORK

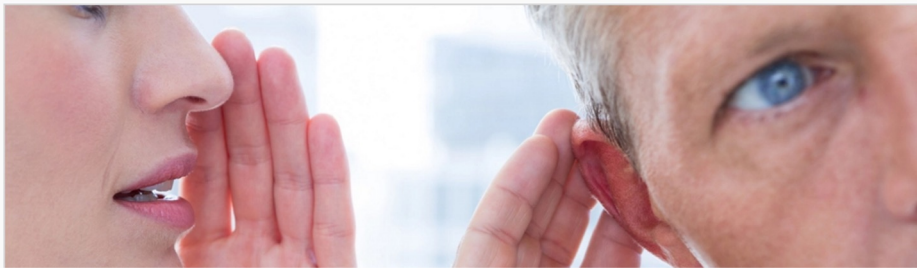
Advances in AI and ML are reshaping healthcare

Posted Mar 16, 2017 by Megh Gupta (@guptamegh), Qasim Mohammad (@QasimAMohammad)

TC News Video Events Crunchbase

Microsoft hits a speech recognition milestone with a system just as good as human ears

Posted Oct 18, 2016 by Devin Coldewey



Google's New Chip May Be the Future of AI Systems

Google's latest revelation may be the biggest advancement yet in chips that power artificial intelligence systems, but other companies are releasing innovations of their own.

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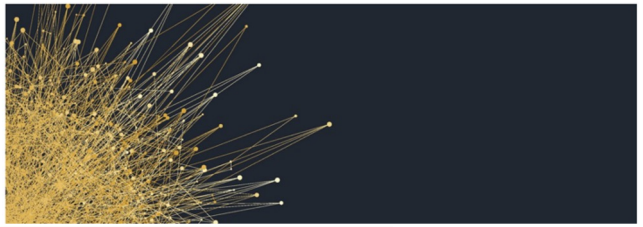
CADE METZ BUSINESS 12.25.16 7:00 AM

2016: THE YEAR THAT DEEP LEARNING TOOK OVER THE INTERNET



Entrepreneur TOP 50 HOW TO MAGAZINE FRANCHISE 500 EVENTS

Can Artificial Intelligence Identify Pictures Better than Humans?

Image credit: Shutterstock.com

DIGITALD • UGHNUT

ARTICLE

Eren Kocyigit
12 January 2017

CATEGORIES

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How Deep Learning is Transforming the Future of Technology?

There is no doubt that Big Data has been one of the most popular topics among marketers and tech enthusiasts for several years.

nature International weekly journal of science

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Archive > Volume 521 > Issue 7553 > Insights > Reviews > Article

ARTICLE PREVIEW

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NATURE | INSIGHT | REVIEW

Deep learning

Yann LeCun, Yoshua Bengio & Geoffrey Hinton

Affiliations | Corresponding author

Nature **521**, 436–444 (28 May 2015) | doi:10.1038/nature14539
Received 25 February 2015 | Accepted 01 May 2015 | Published online 27 I

ForbesCommunityVoice™ Connecting expert cor

Tech / #NewTech

APR 17, 2017 @ 07:00 AM 1,643

It's Time To Embrace AI's Superior Prediction Powers

Porque levou tanto tempo?

1958 Perceptron

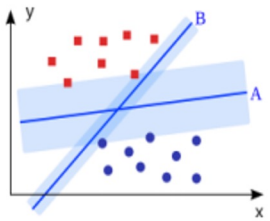
1969
Perceptron criticized

1986 Backpropagation

awkward silence (AI Winter)

Convolution Neural Networks for Handwritten Recognition
1998

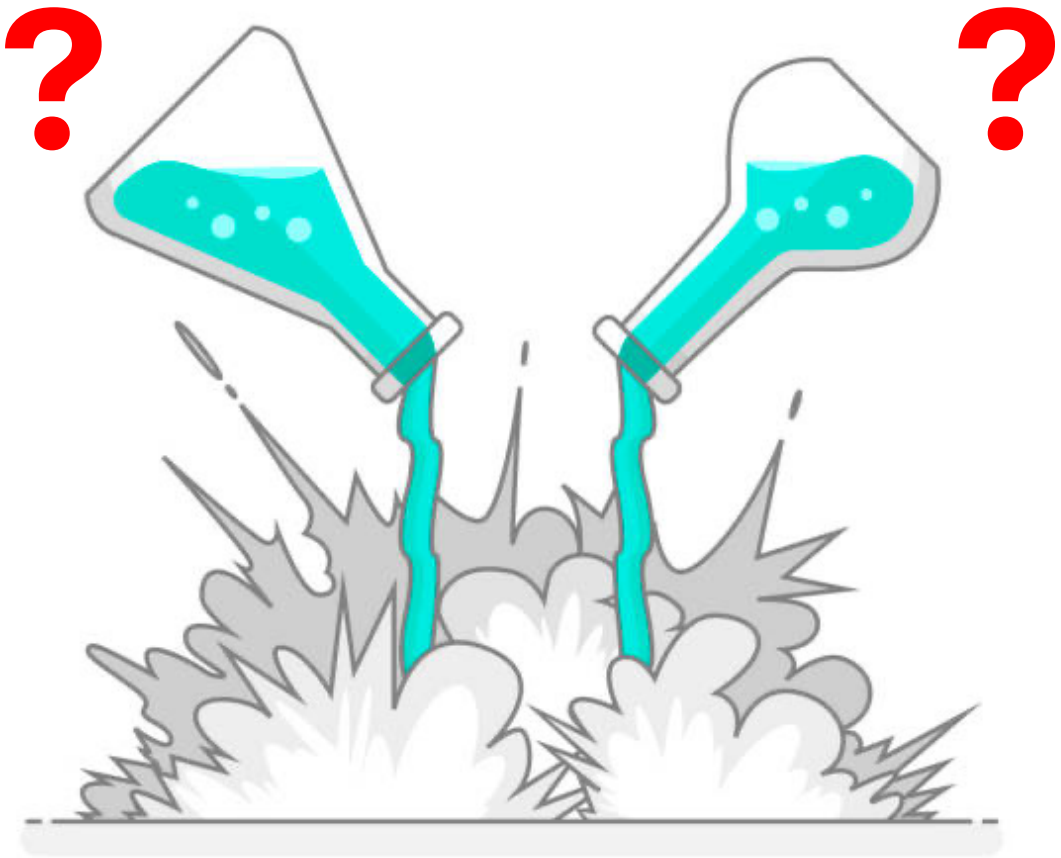
1995
SVM reigns



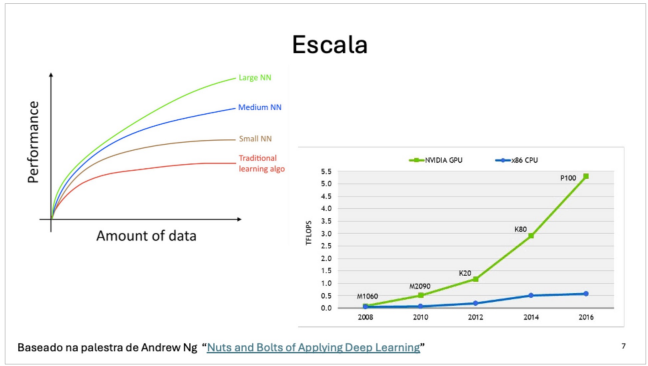
2006
Restricted Boltzmann Machine

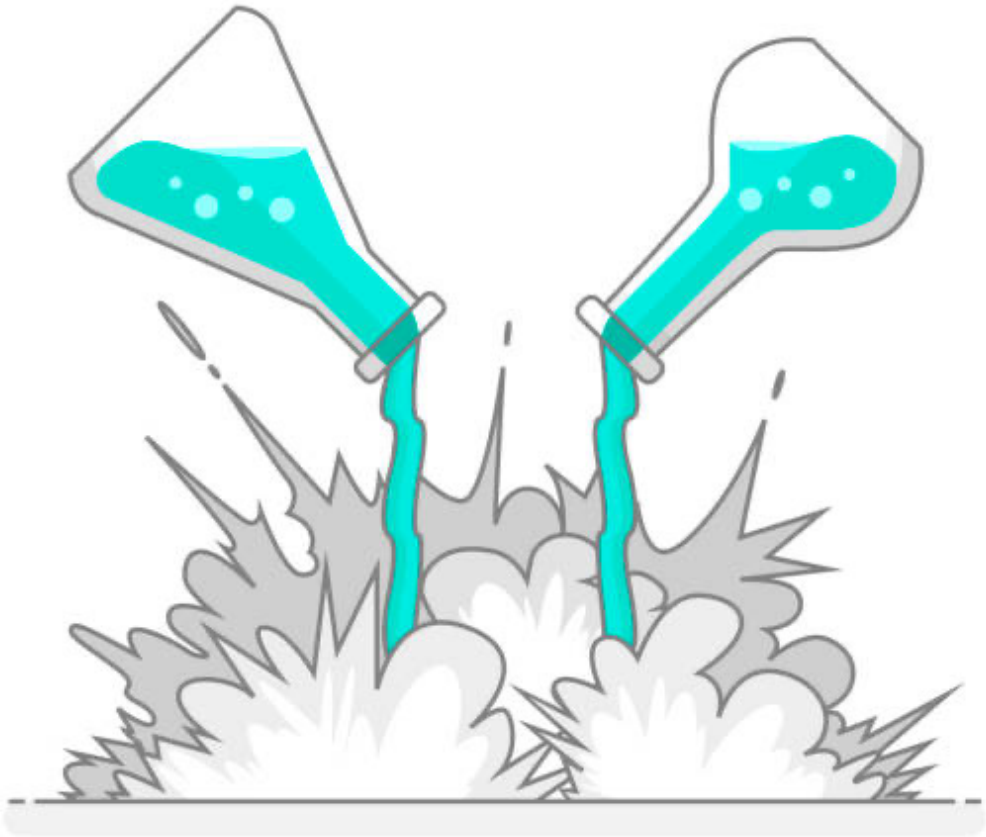
Google Brain Project on 16k Cores
2012

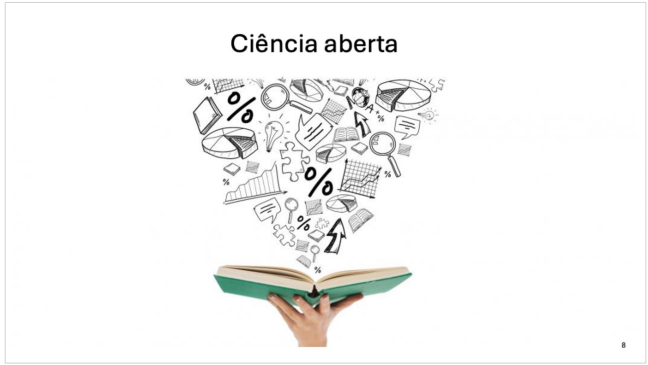
2012
AlexNet wins ImageNet
IMAGENET



Aprendizado profundo

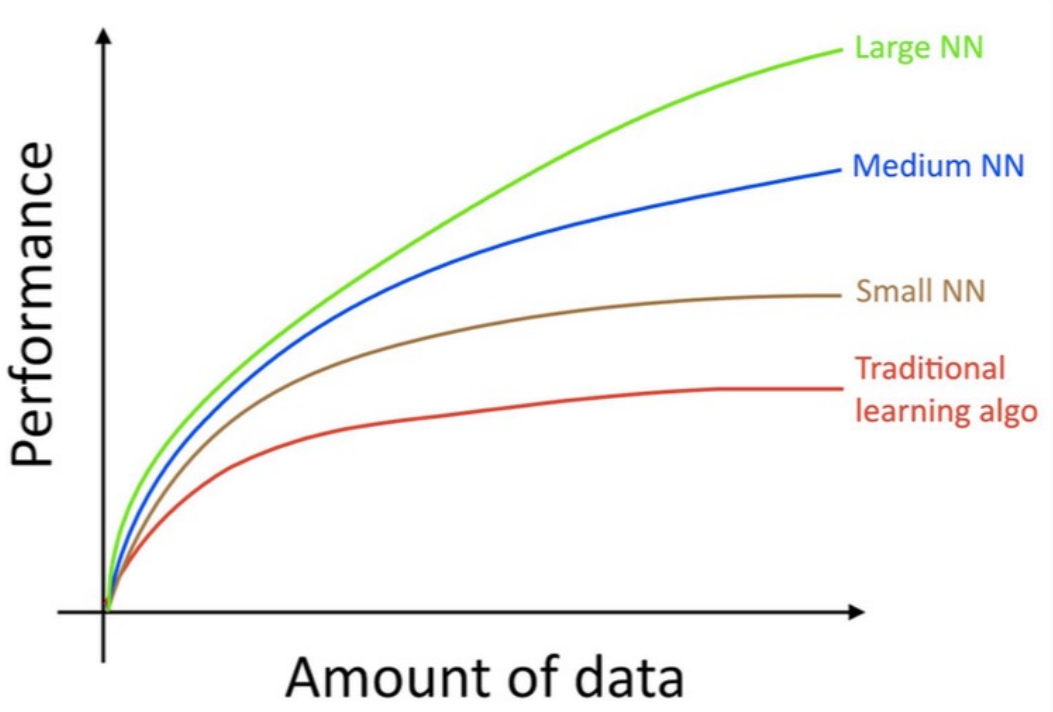


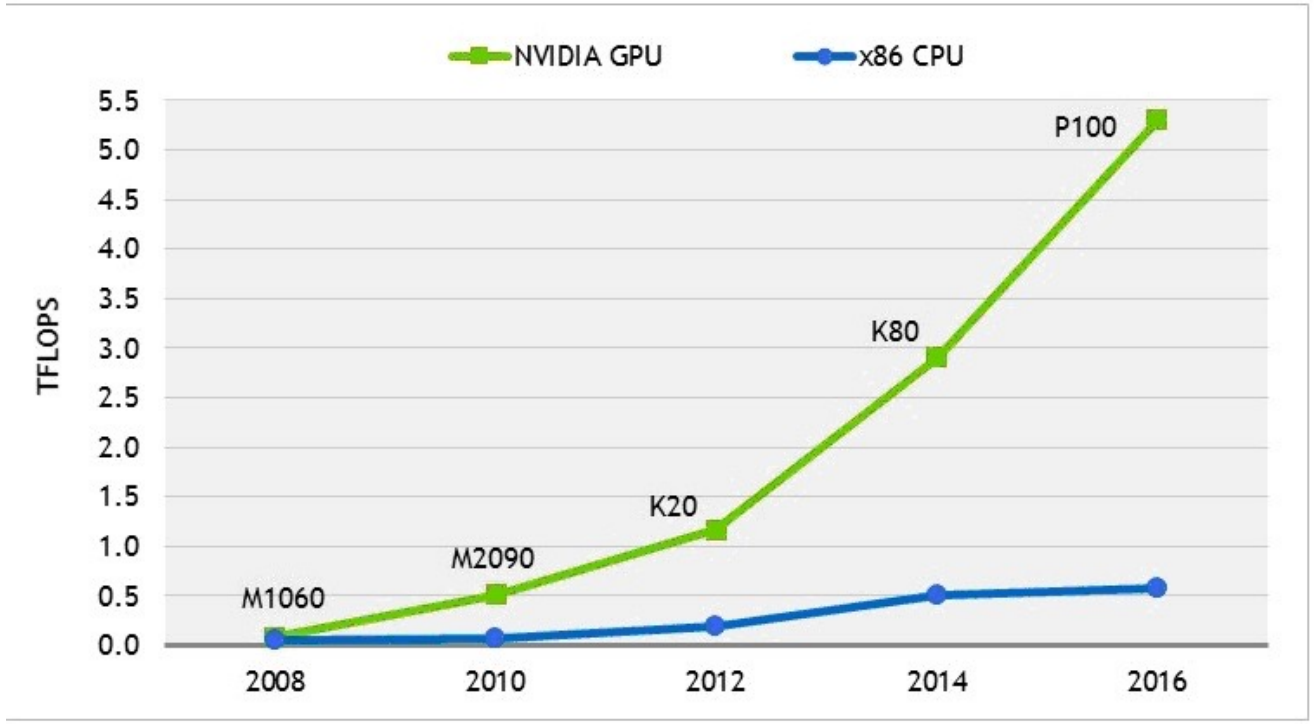




Aprendizado profundo

Escala





Baseado na palestra de Andrew Ng "Nuts and Bolts of Applying Deep Learning"

Ciência aberta

Ciência aberta

IP[y]: Notebook spectrogram Last Checkpoint: a few seconds ago (autosaved)

IPython (Python 3)

File Edit View Insert Cell Kernel Help

Code Cell Toolbar: None

Simple spectral analysis

An illustration of the Discrete Fourier Transform using windowing, to reveal the frequency content of a sound signal.

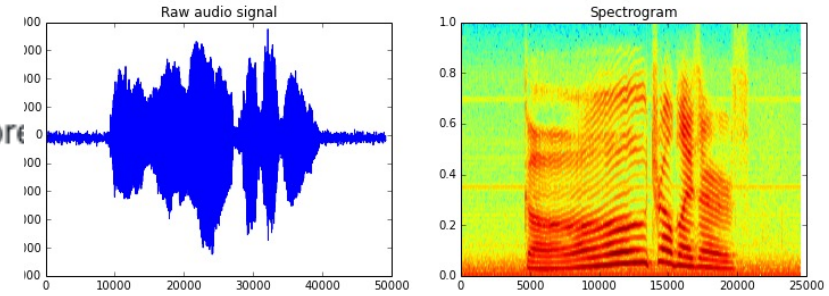
$$X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i}{N} kn} \qquad k = 0, \ldots, N-1$$

We begin by loading a datafile using SciPy's audio file support:

```
scipy.io import wavfile
, x = wavfile.read('test_mono.wav')
```

we can easily view its spectral structure using matplotlib's builtin specgram routine:

```
plotlib inline
matplotlib import pyplot as plt
(ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
plot(x); ax1.set_title('Raw audio signal')
specgram(x); ax2.set_title('Spectrogram');
```



Why GitHub? Team Enterprise Explore Marketplace Pricing

Repositories 320K

Code ?

Commits 301K

Issues 156K

Discussions Beta 707

Packages 43

Machine learning

Machine learning is a way of modeling and interpre
to respond intelligently.

See topic

320,049 repository results

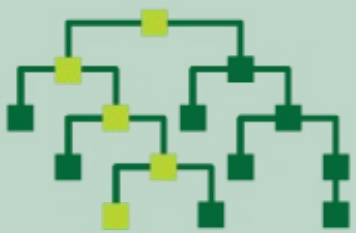
AI

Artificial Intelligence

Any technique that enables computers to mimic human behavior.

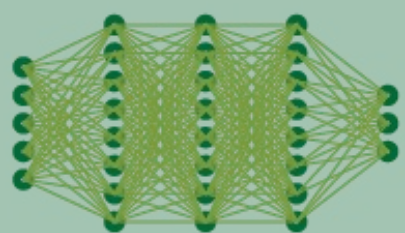
Machine Learning

The ability to learn without directly being programmed.



Deep Learning

The learning of underlying features in data using deep neural networks.



https://www.visiopharm.com/ai-deeplearning

Como as máquinas aprendem?

Learn From Experience

Follow Instructions

Will doctors be re

Inteligência artificial eleva em 20% detecção de câncer de mama e 'reduz' trabalho de radiologistas

Estudo publicado na revista The Lancet Oncology apontou que a inteligência artificial pode tornar a triagem de mamografia mais precisa e eficiente. Os pesquisadores ressaltam, no entanto, que a inteligência artificial não está pronta para ser implementada no 'mundo real'.

https://g1.globo.com/saude/noticia/2023/08/02/inteligencia-artificial-eleva-em-20percent-deteccao-de-cancer-de-mama-e-reduz-trabalho-de-radiologistas.ghtml

Modelo de aprendizado de máquina prevê AVC no momento da triagem

24/04/2023 às 14:00 • **1 min** de leitura

> Desenvolvido por pesquisadores das universidades Carnegie Mellon, Florida International e Santa Clara, nos EUA, um novo modelo de máquina consegue prever, com alto grau de precisão, a ocorrência de derrames cerebrais **ainda no momento da triagem dos pacientes.**

A pesquisa considerou o modelo de previsão "com alta sensibilidade e especificidade razoável". Seu grande diferencial é que as variáveis usadas já são coletadas no dia a dia por provedores e pagadores. Se não pode ser considerado um "padrão-ouro" para diagnosticar AVC, o modelo é um complemento útil para sistemas de pontuação existentes, **especialmente em hospitais com pouca disponibilidade de recursos e ferramentas diagnósticas**.

Sonho possível? Ministério da Saúde quer adotar inteligência artificial no SUS, mas enfrenta desafios

— Para pensar no uso da IA, precisamos primeiro completar o processo de digitalização do SUS. Ainda usamos prontuários médicos físicos, por exemplo. Precisamos desses materiais em formato digital, e isso demanda trabalho e investimento, mas como retorno temos otimização dos diagnósticos, dos equipamentos médicos e do próprio sistema de dados do SUS — diz Maranhão.

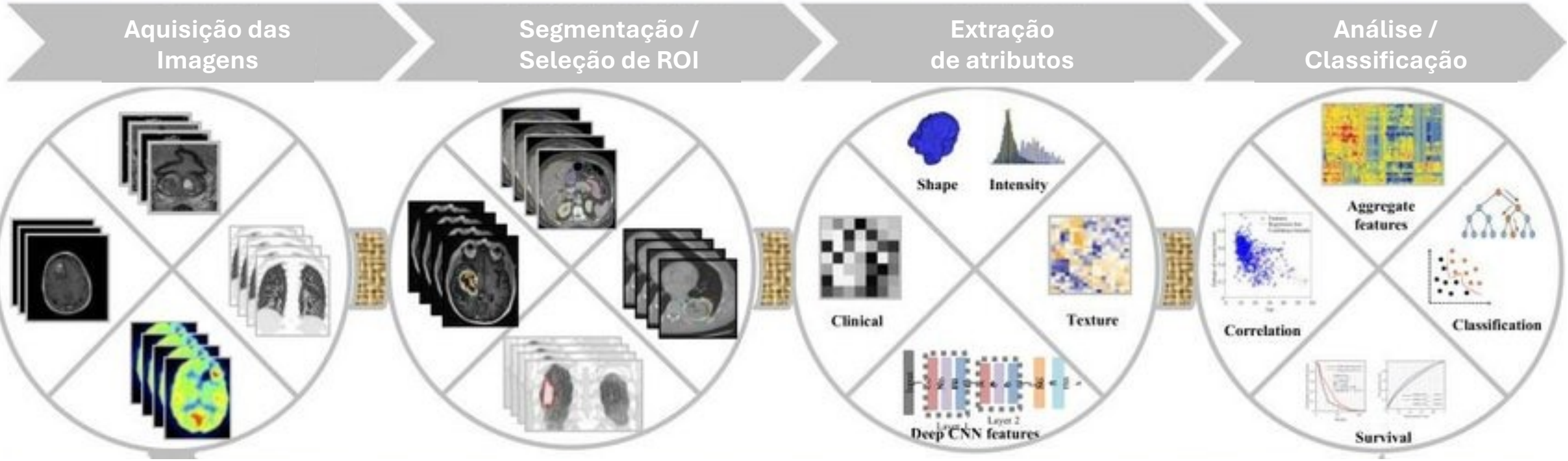
Em nota, o Ministério da Saúde afirma que o uso da IA tem o potencial de aprimorar os diagnósticos e tratamentos de doenças, o desenvolvimento de novos medicamentos e a realização de cirurgias mais precisas. Essa também é uma realidade em expansão na vigilância epidemiológica, no telecuidado e na utilização de boas evidências traduzidas em algoritmos clínicos", complementa.

TECNOLOGIA DA INFORMAÇÃO

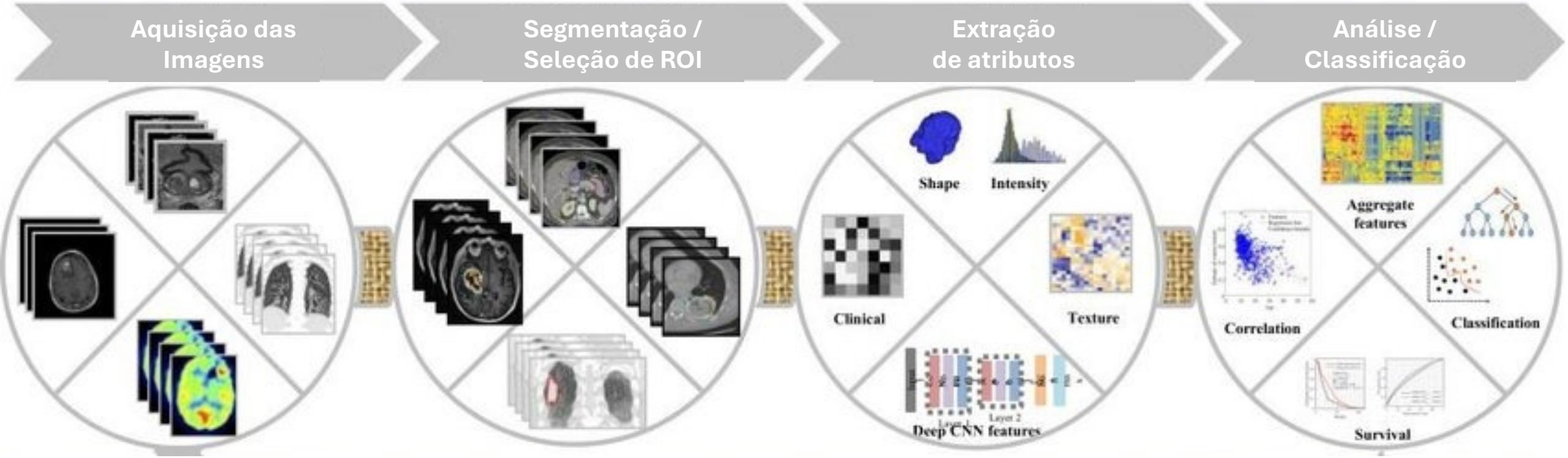
A inteligência artificial chega à saúde

Tecnologias dotadas desses recursos já são usadas na área médica, mas desafios precisam ser superados para sua incorporação em maior escala no país

De acordo com o relatório “Artificial intelligence index report 2022”, da Universidade Stanford, foram investidos pelo setor privado em todo o mundo US$ 11,3 bilhões em pesquisa e inovação com IA para medicina e saúde em 2021, um aumento de 40% em relação ao ano anterior. Nos últimos cinco anos, os recursos somaram US$ 28,9 bilhões, o que posicionou o segmento como o maior receptor de investimentos privados em IA, superando atividades tradicionais no uso de tecnologias da informação, como o setor financeiro e o varejo. A visão computacional, segmentando imagens de órgãos, lesões ou tumores, foi uma das aplicações que despertaram mais interesse na comunidade médica.

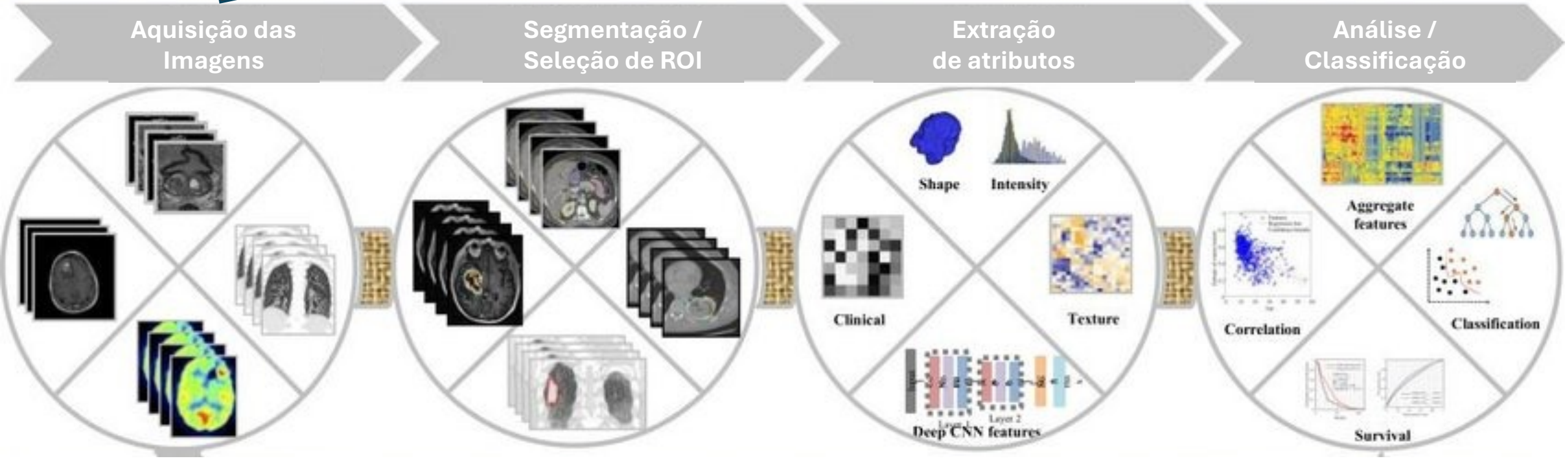

Aquisição das Imagens
Segmentação / Seleção de ROI
Extração de atributos
Análise / Classificação
Shape
Intensity
Clinical
Texture
Deep CNN features
Aggregate features
Correlation
Classification
Survival

Posso usar DL para classificar sujeitos em grupo A e B olhando suas imagens?



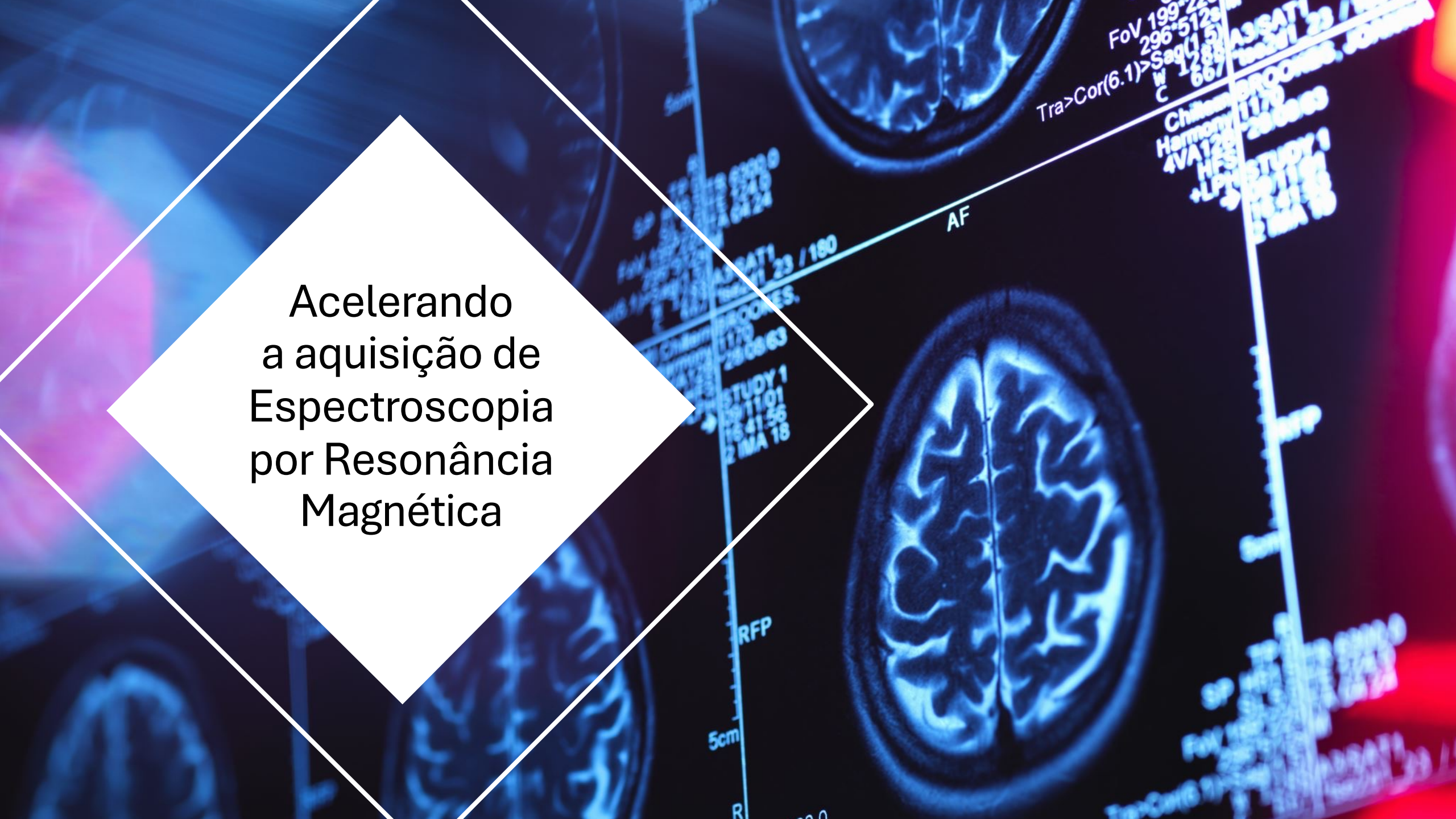
Diagnóstico

Posso reduzir o tempo (e custo) de aquisição usando DL?



Reconstrução ou Denoising

Acelerando a aquisição de Espectroscopia por Resonância Magnética



Ressonância Magnética: Imagem vs. Espectroscopia

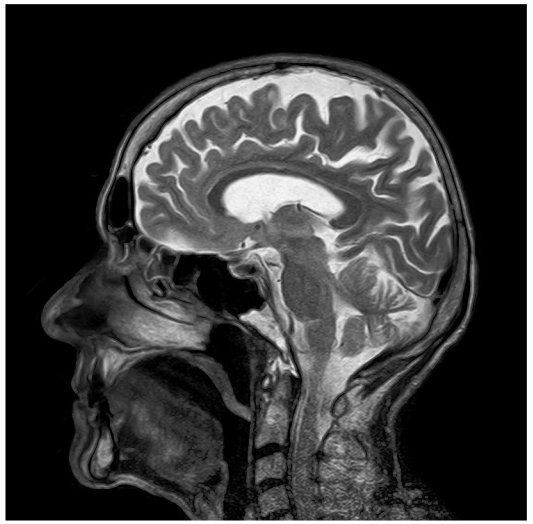
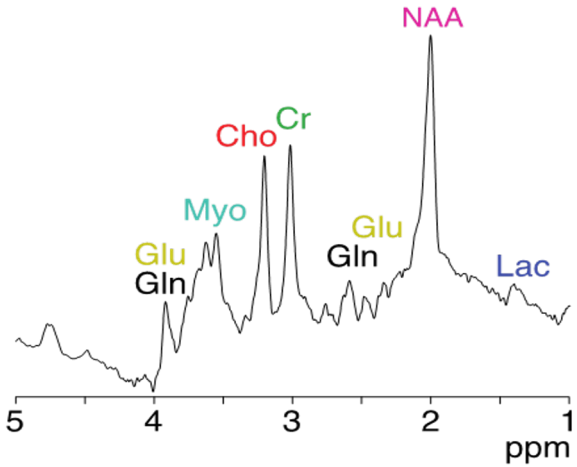


Imagem de RM

Resonância das moléculas de água



Espectroscopia por RM

Resonância dos metabólitos

MRI: Imagem 2D ou 3D

MRS: espectro químico

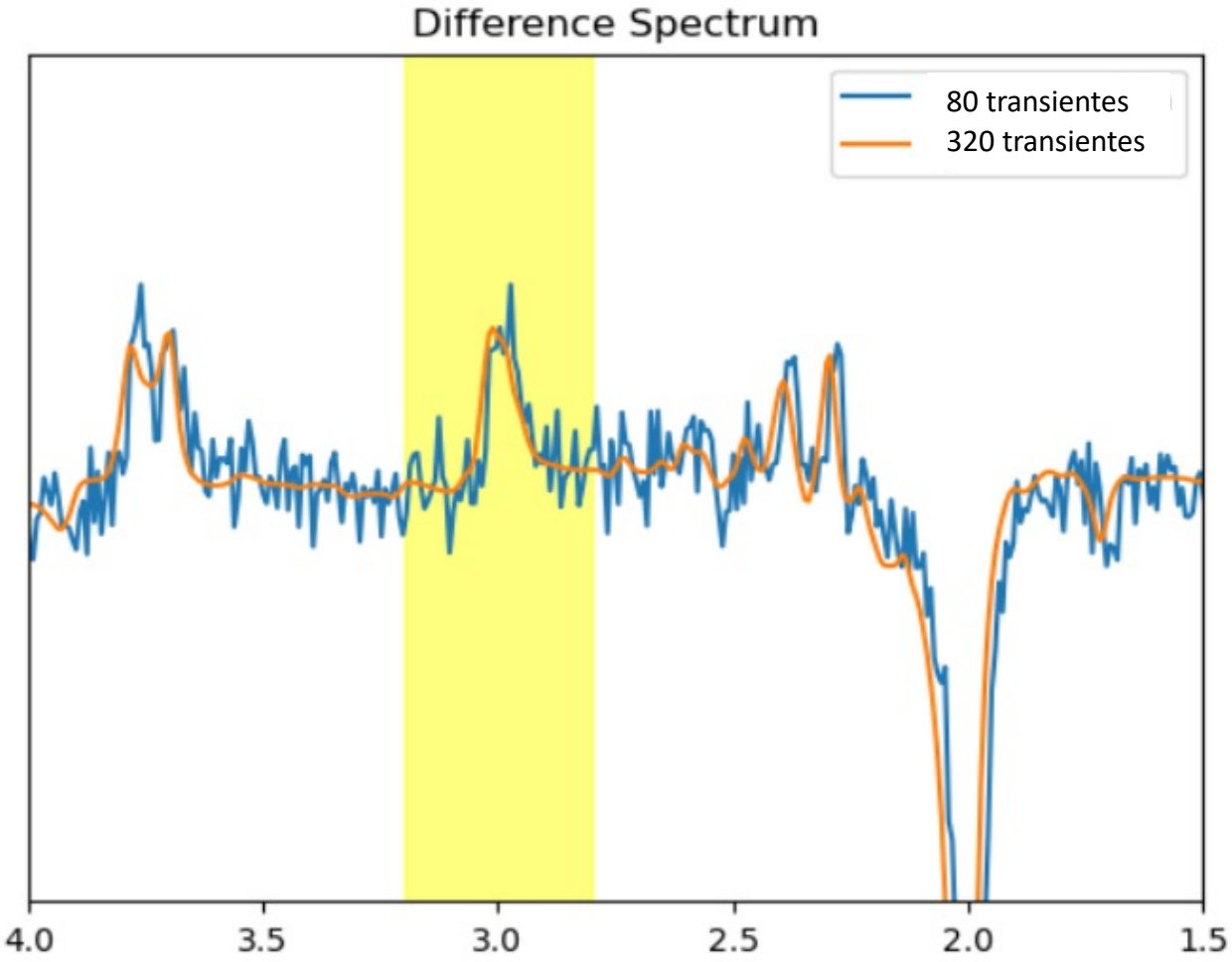
Vantagens: MRS is a non-invase method for metabolites analysis of healthy and pathological brain.

Challenges: acquisition time is at least 10-12 minutes (too long, sucepttible to motion artifacts).

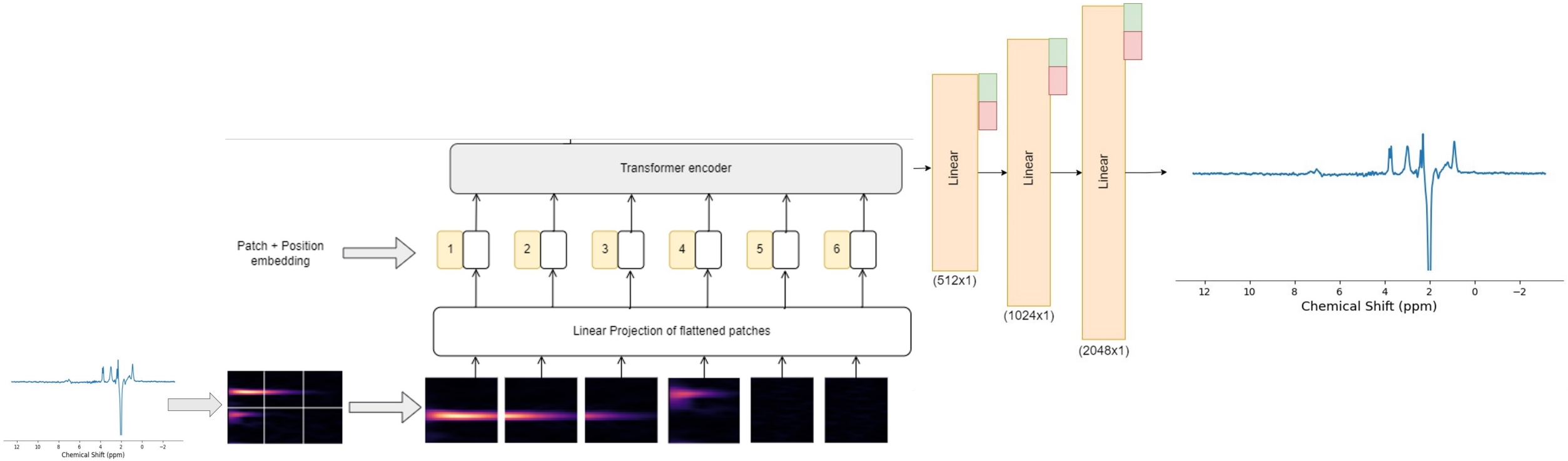
Harris, A. D.. (2021). Introduction to MR Spectroscopy - ISMRM (PowerPoint)

Reconstruindo dados de MRS

É possível melhorar a qualidade do espectro final, adquirindo 4 vezes menos dados (transientes)?

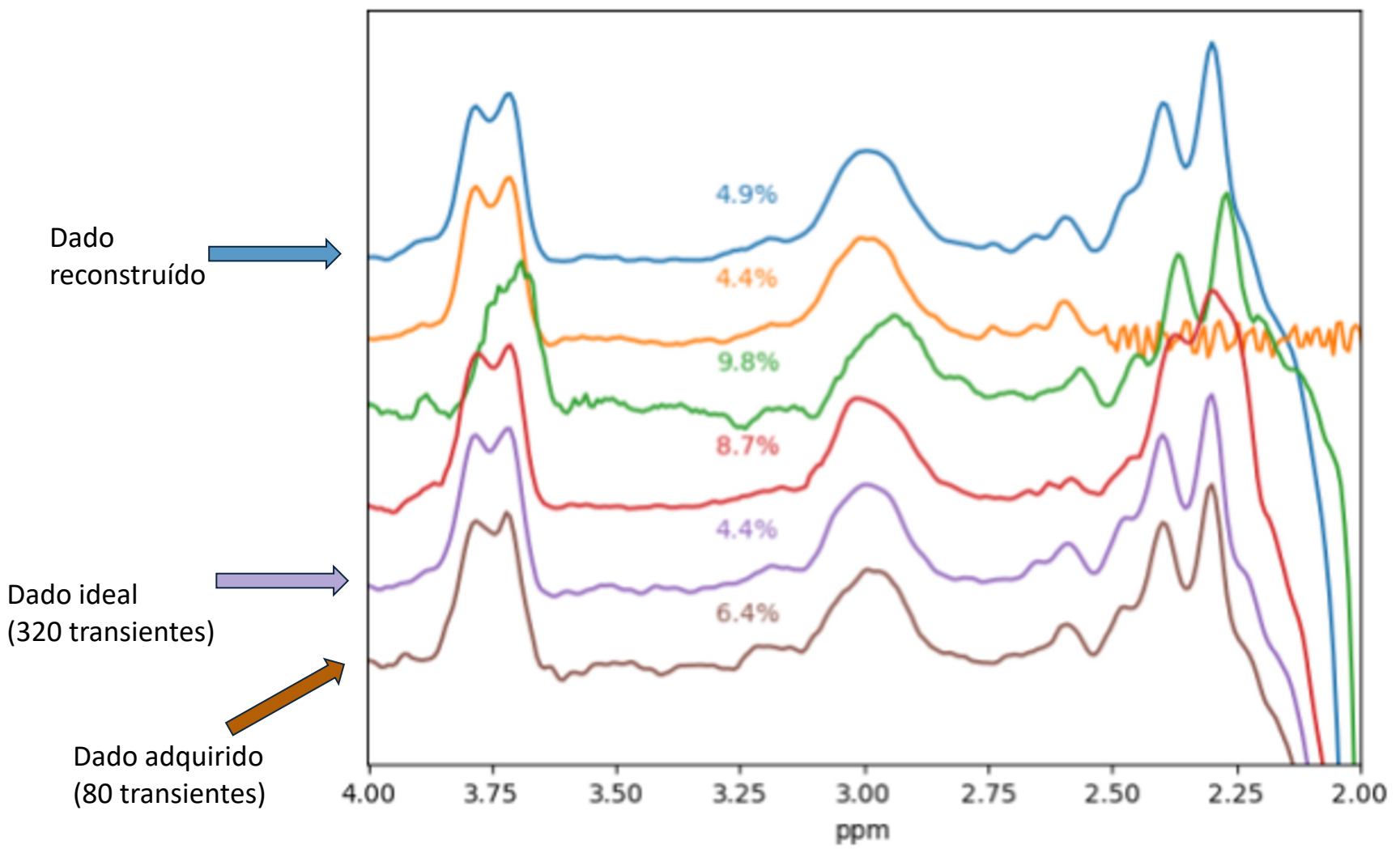


Arquitetura - Spectro-ViT



https://github.com/MICLab-Unicamp/Spectro-ViT

Dias et al., *Magnetic Resonance imaging, p. 110219 (2024)*



Resultado da reconstrução

permite uma aceleração de 4 vezes

Acelerando a aquisição de Imagens de RM ponderadas em difusão

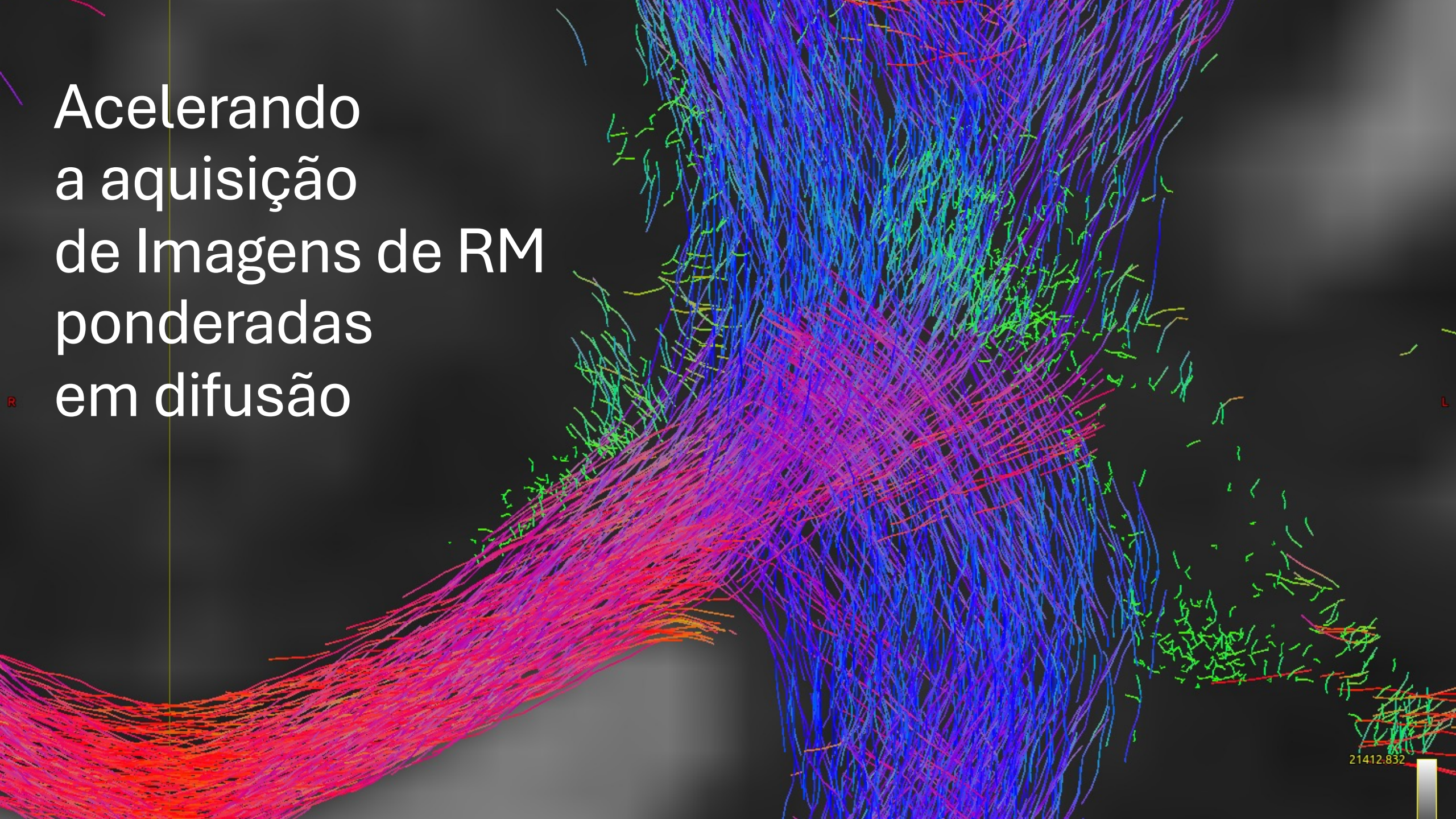
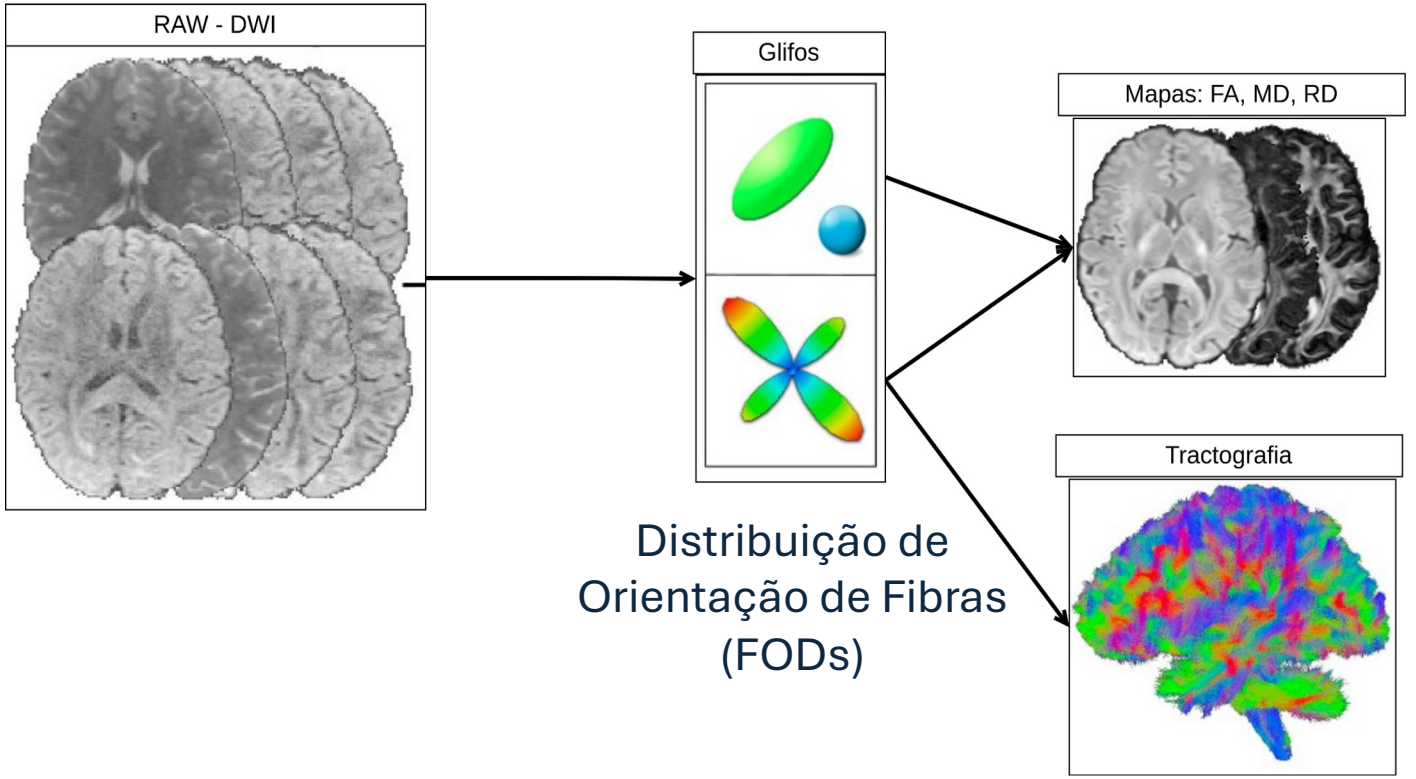


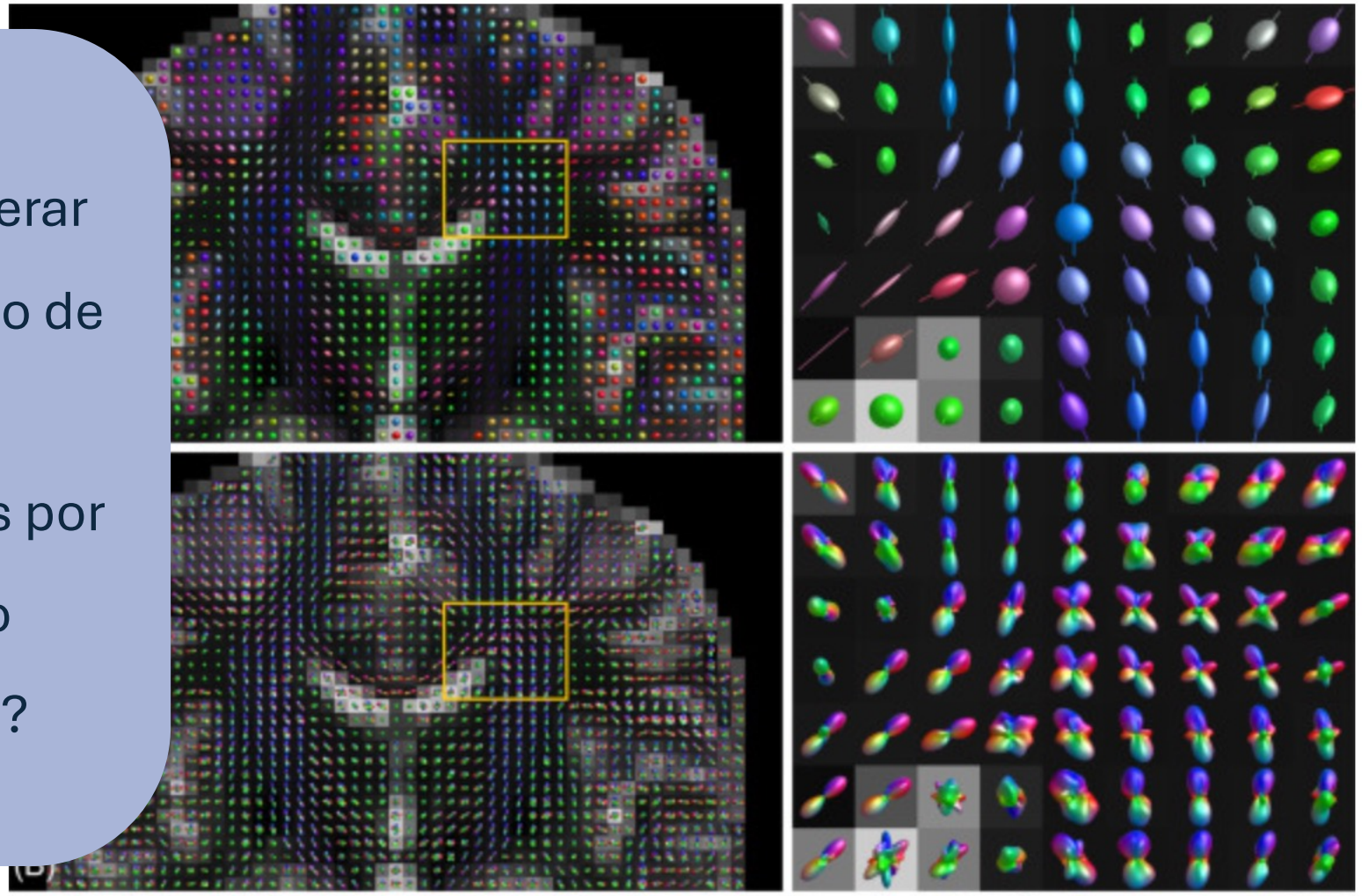
Imagem de Difusão por Ressonância Magnética (dMRI)

- Mede o movimento das molécules de água nos tecidos
- Usada para investigator a microstructura do tecido cerebral
- Exemplos:
  - Planejamento cirúrgico
  - Monitoramento da integridade das fibras neuronais



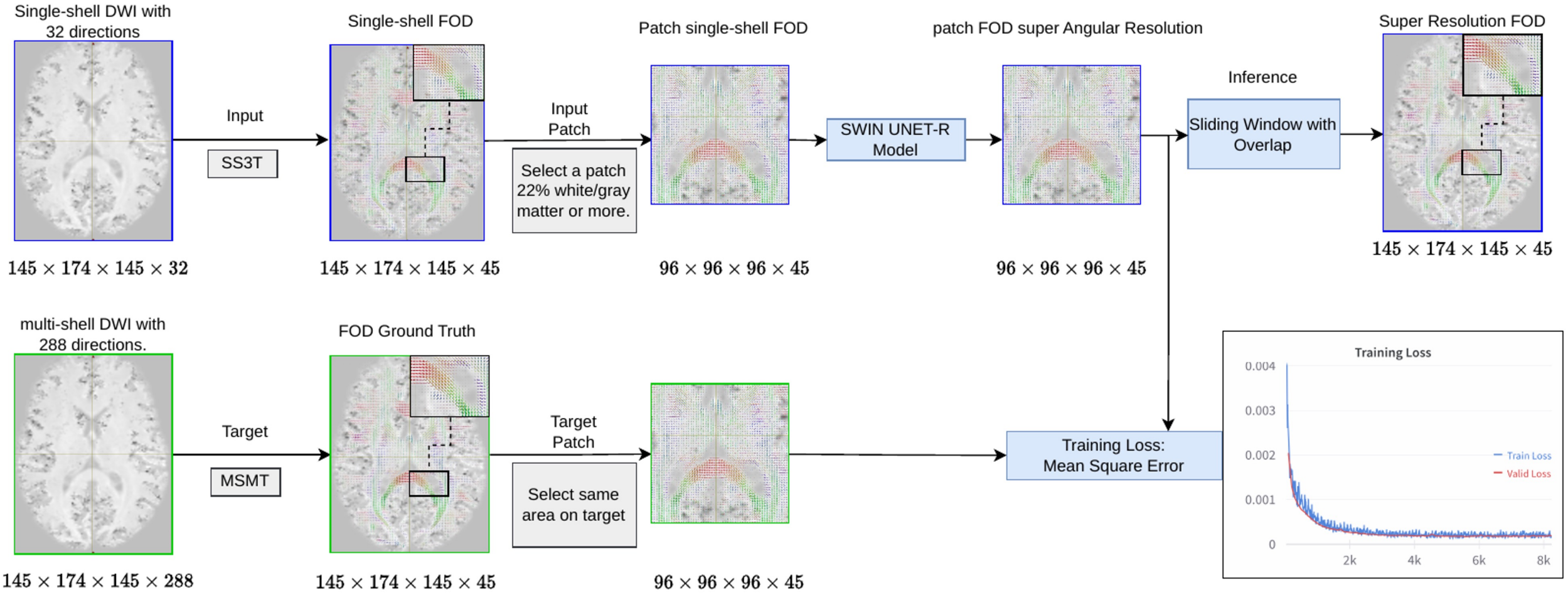
É possível usar DL para gerar Distribuição de Orientação de Fibras (FODs) equivalente às produzidas por dados **HARDI**, usando somente dados **LARDI**?

LARDI
Aquisição de 6 minutos



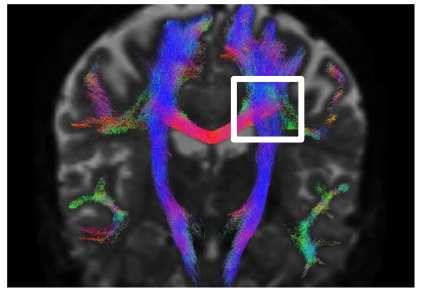
HARDI
Aquisição de 38 minutos

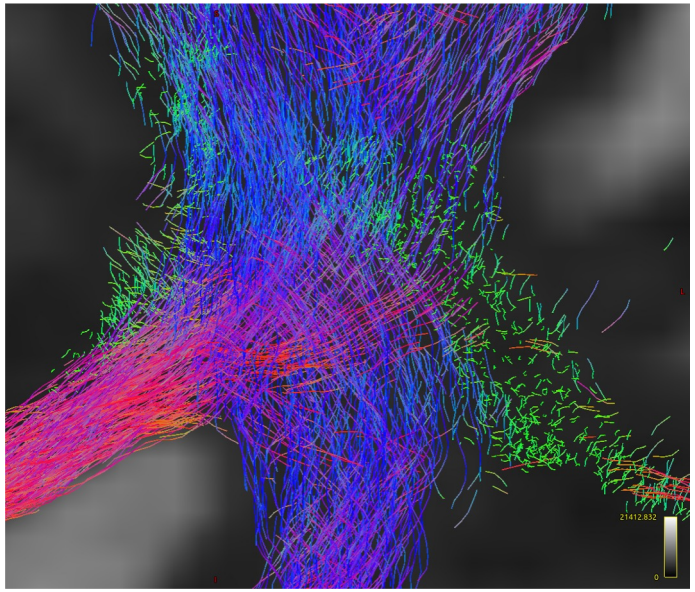
FOD-Swin-Net: o modelo proposto



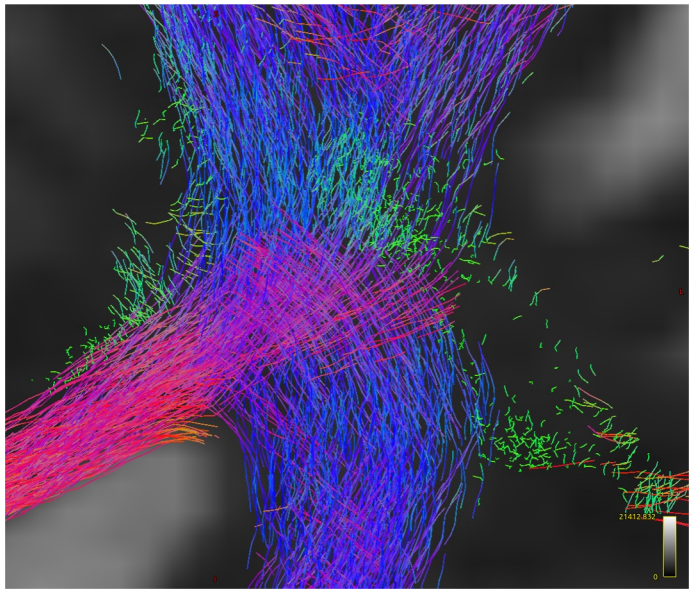
Oliveira M et al. ”FOD-Swin-Net: angular super resolution of fiber orientation distribution using a transformer-based deep model", *ISBI 2024*.

Impacto na tractografia

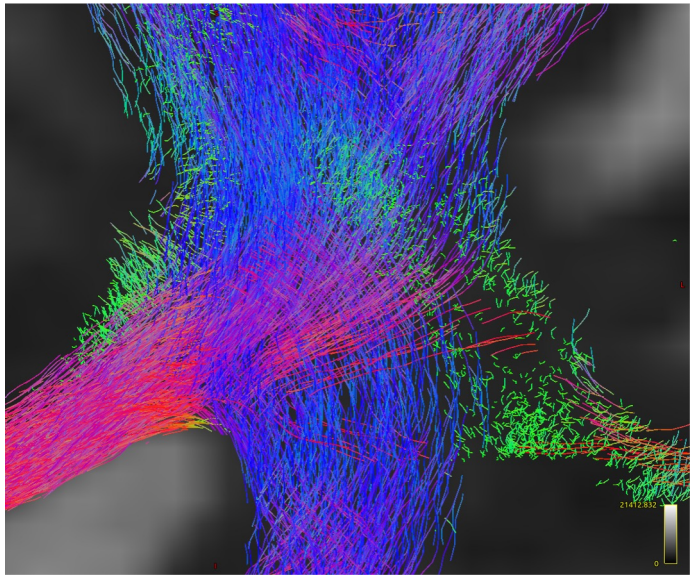




LARDI (6 min.)



RECONSTRUÍDO

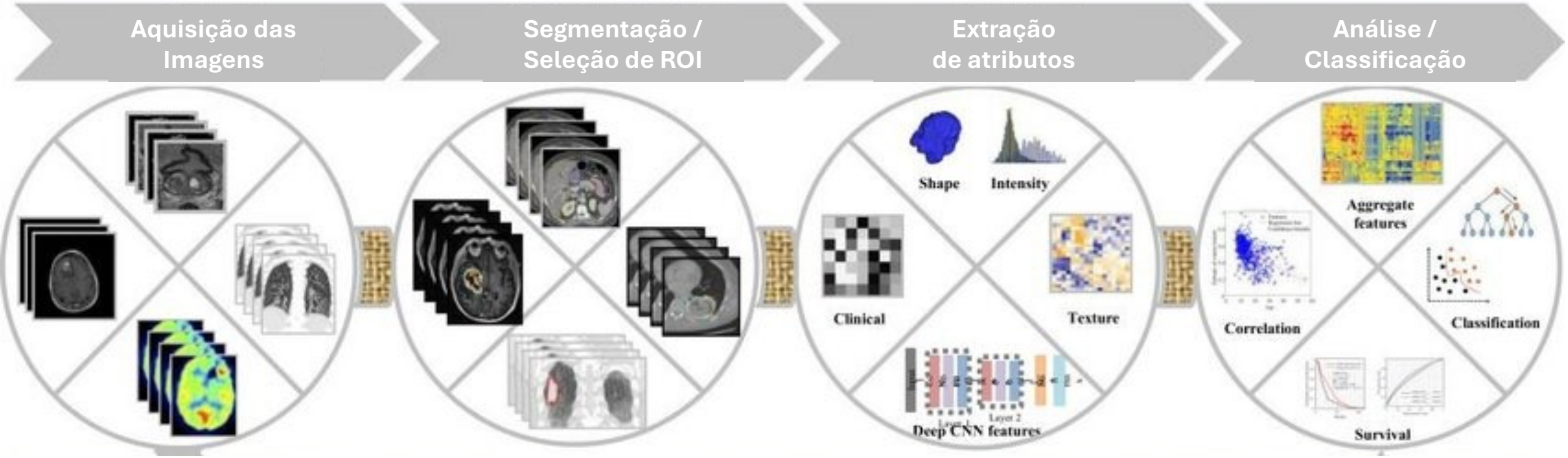


HARDI (38 min.)

https://github.com/MICLab-Unicamp/FOD-Swin-Net

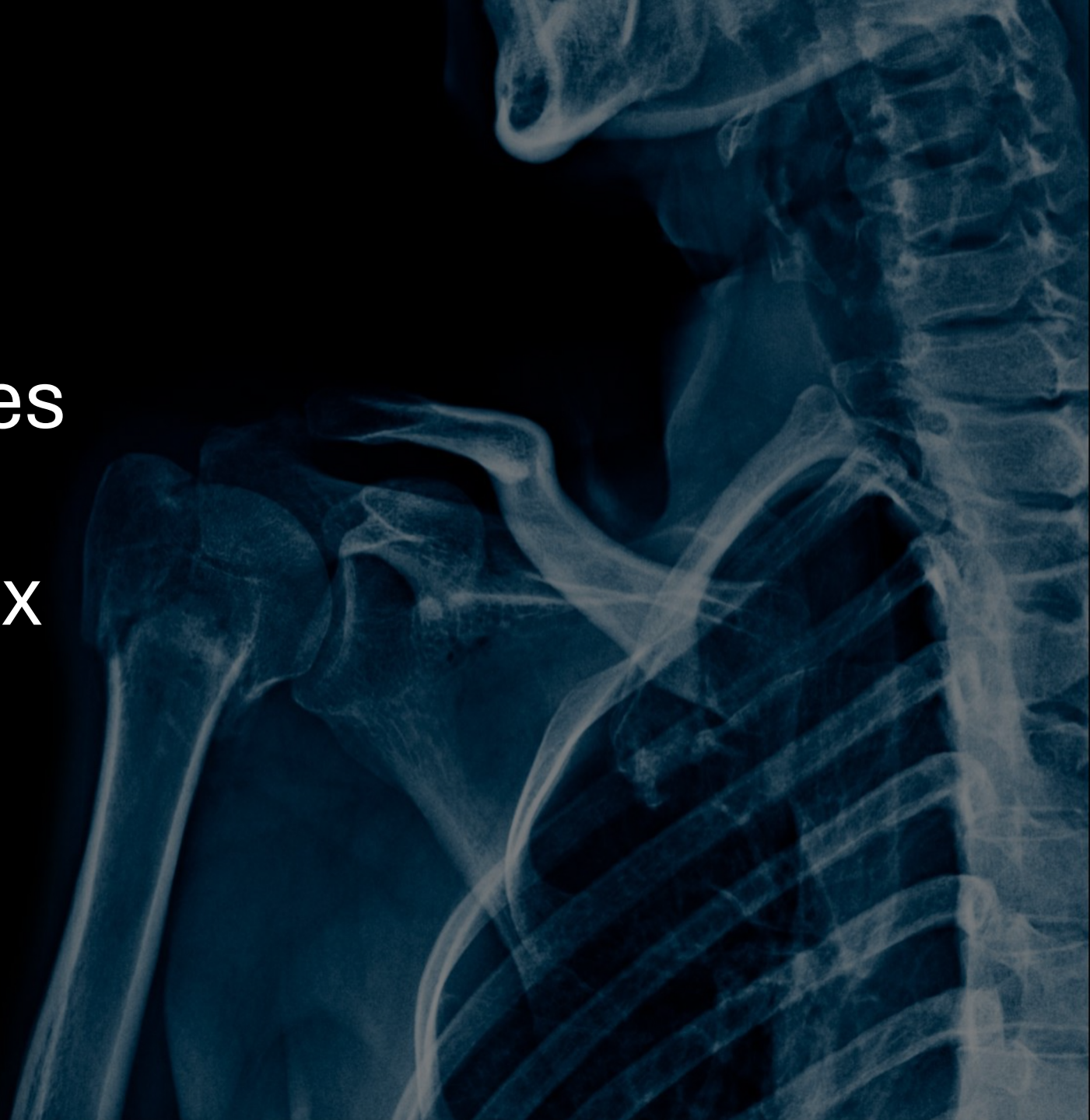
Oliveira M et al., *Proceedings of ISBI* (2024)

Posso pre-processor os dados usando DL?

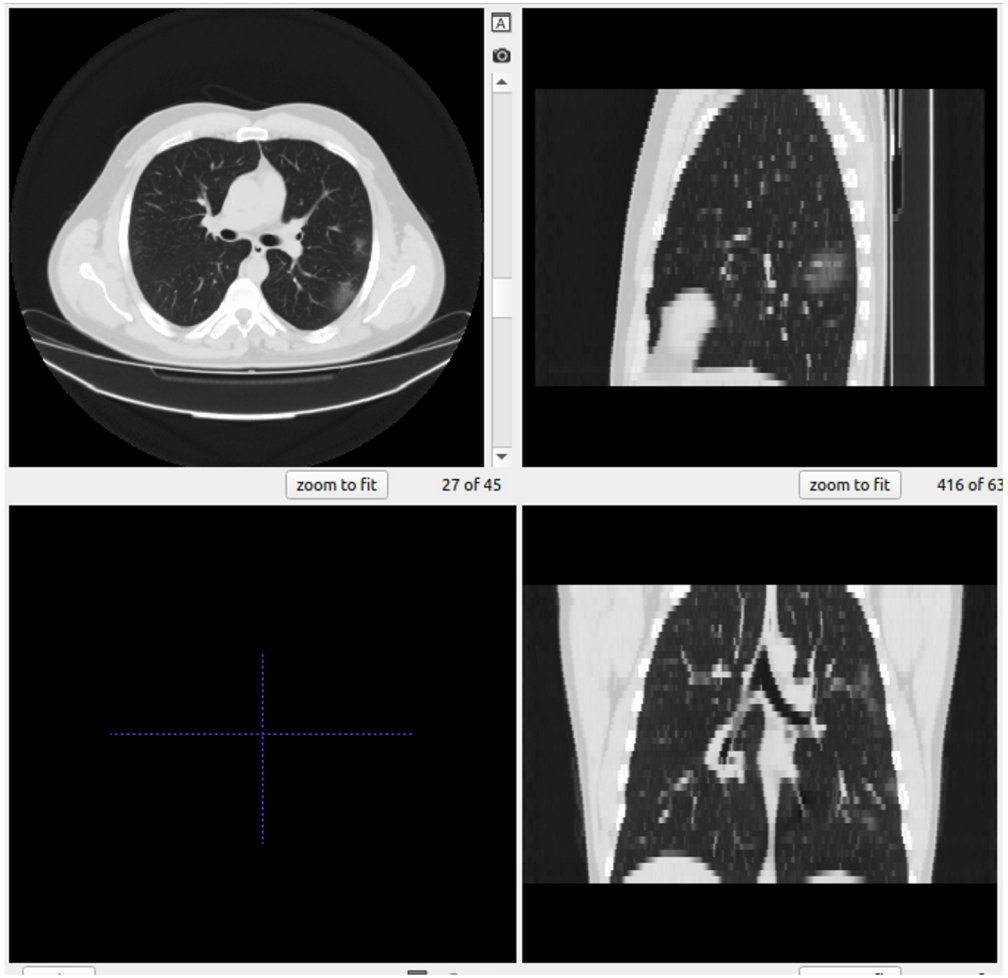


Seleção de Região de Interesse (ROI)

Identificando regiões de interesse em Tomografia de tórax



Estruturas pulmonares em CT



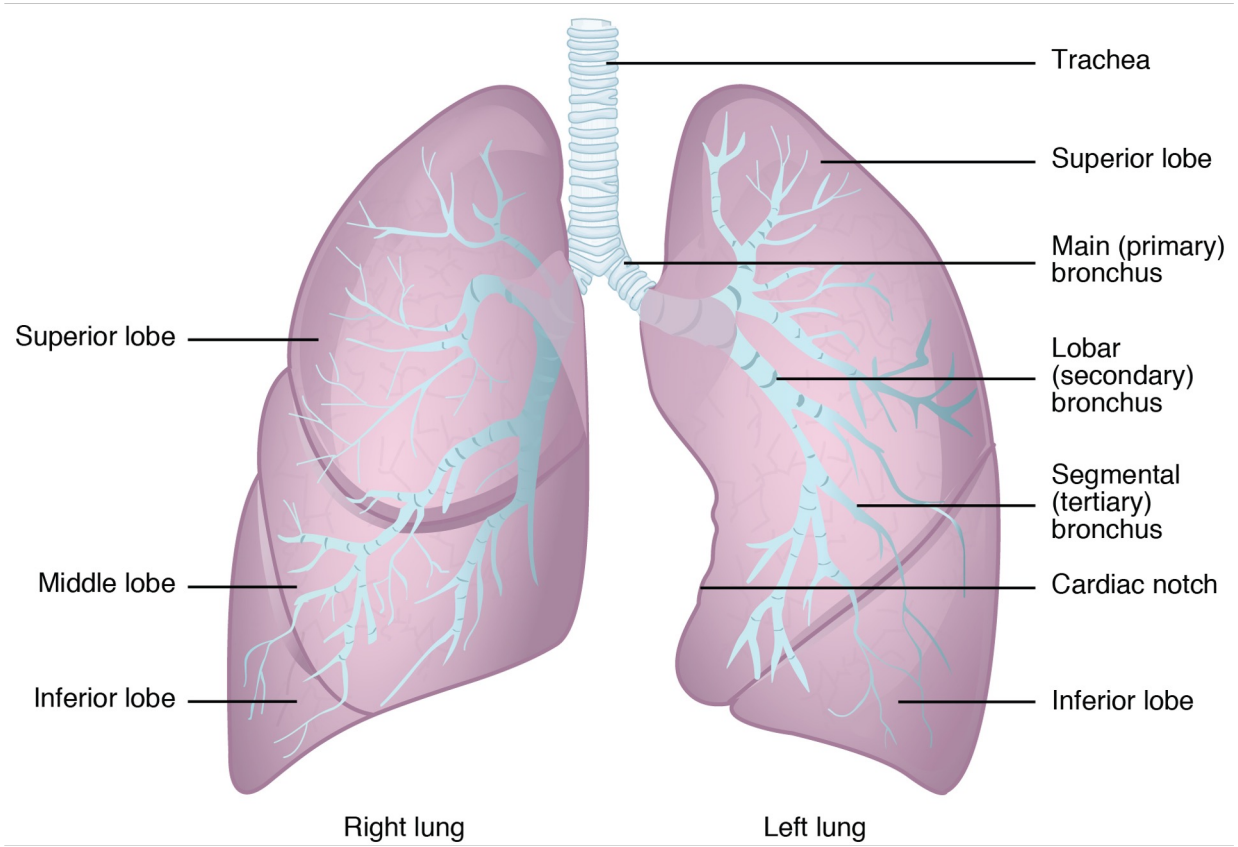
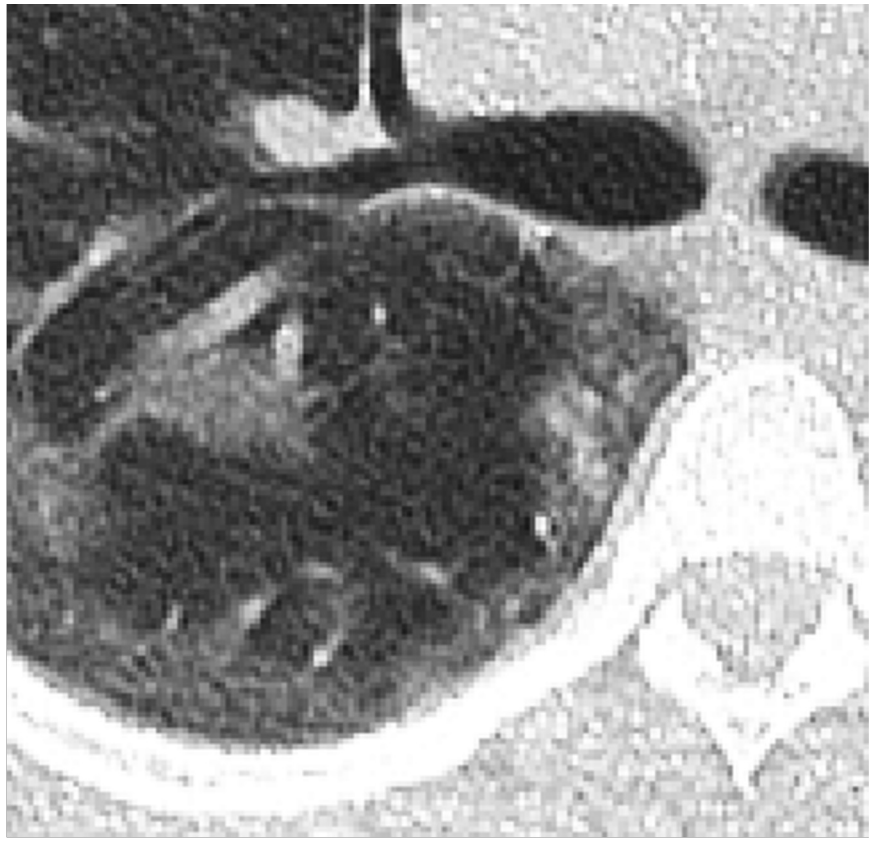


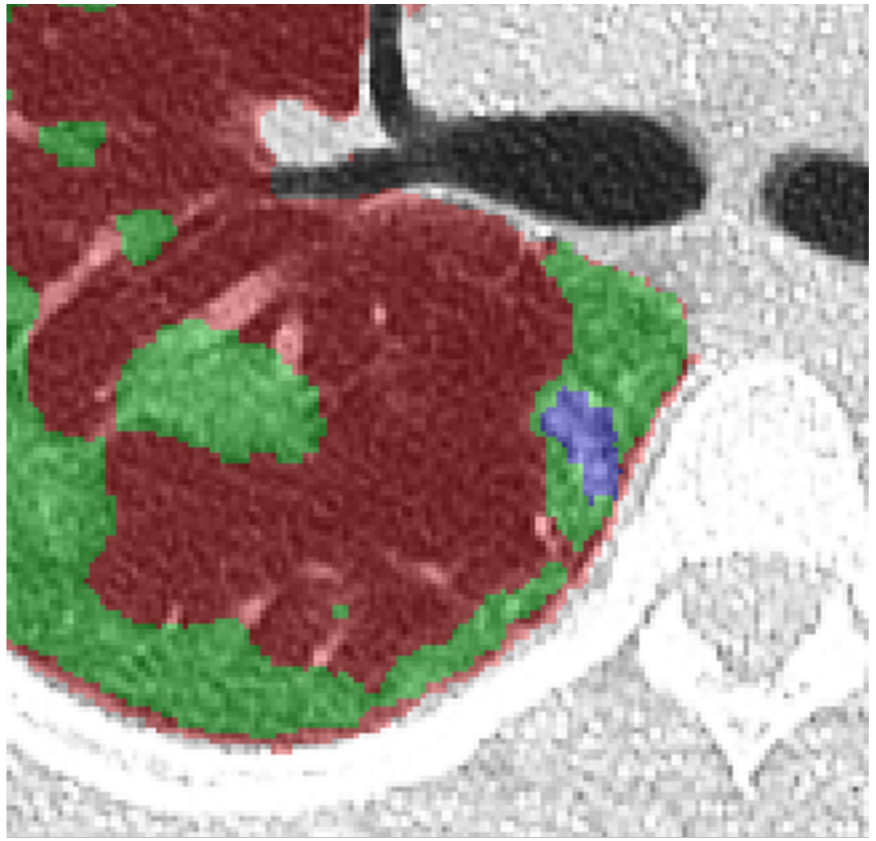
Illustration of the lungs and airways [1].

[1] Betts, J. Gordon, et al. "**Anatomy and Physiology** 2e." (2022).

Achados em pulmão (tecido patológico)

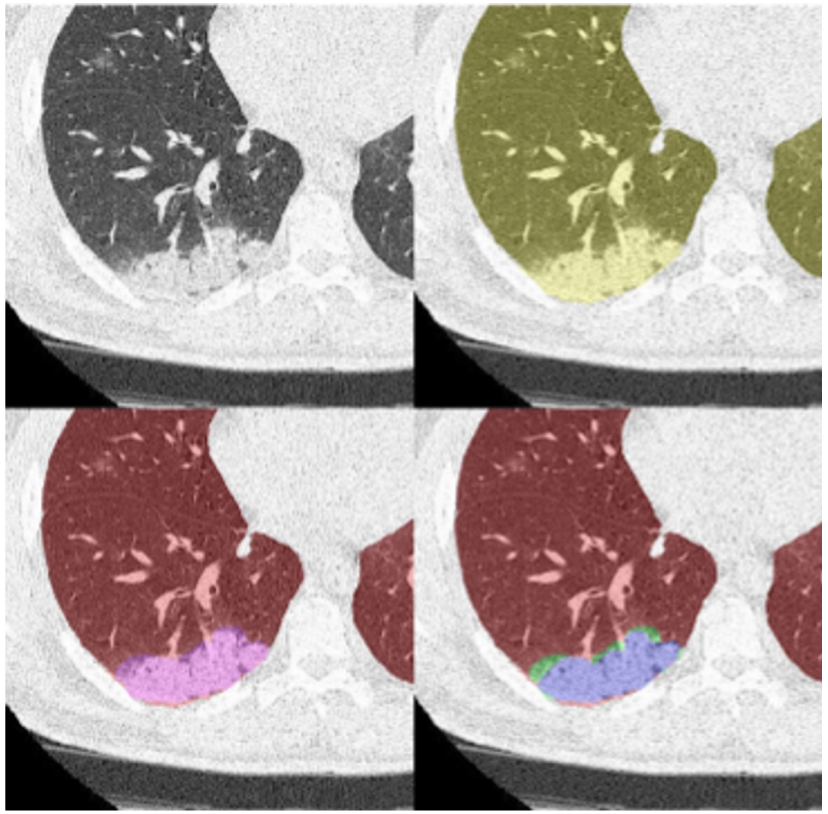
Algumas doenças que afetam o pulmão podem gerar:
efeito de vidro fosco (ground-glass opacity - GGO) e **consolidações (consolidation)**.



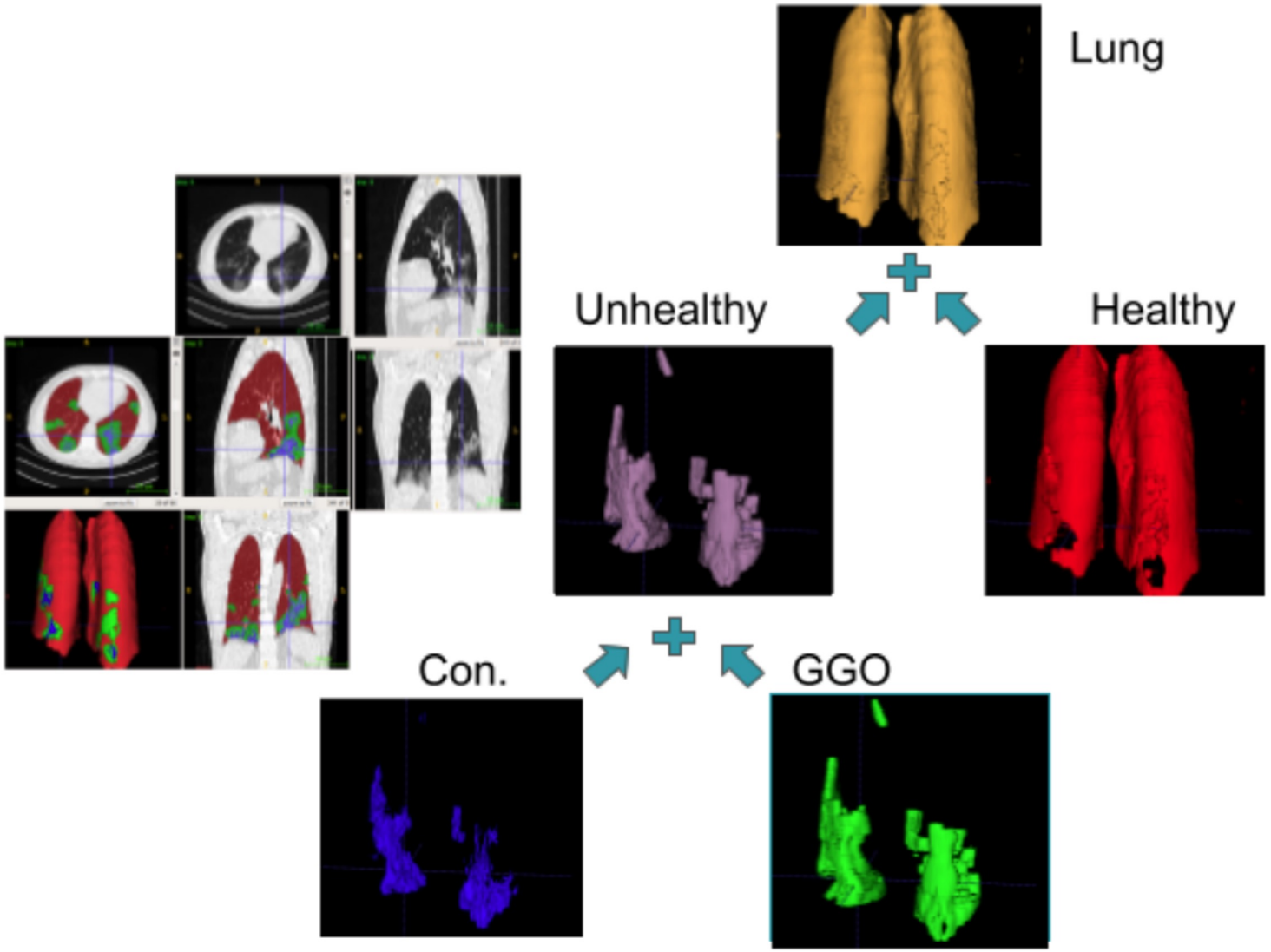


Problema: falta de dados anotados (rótulos)!

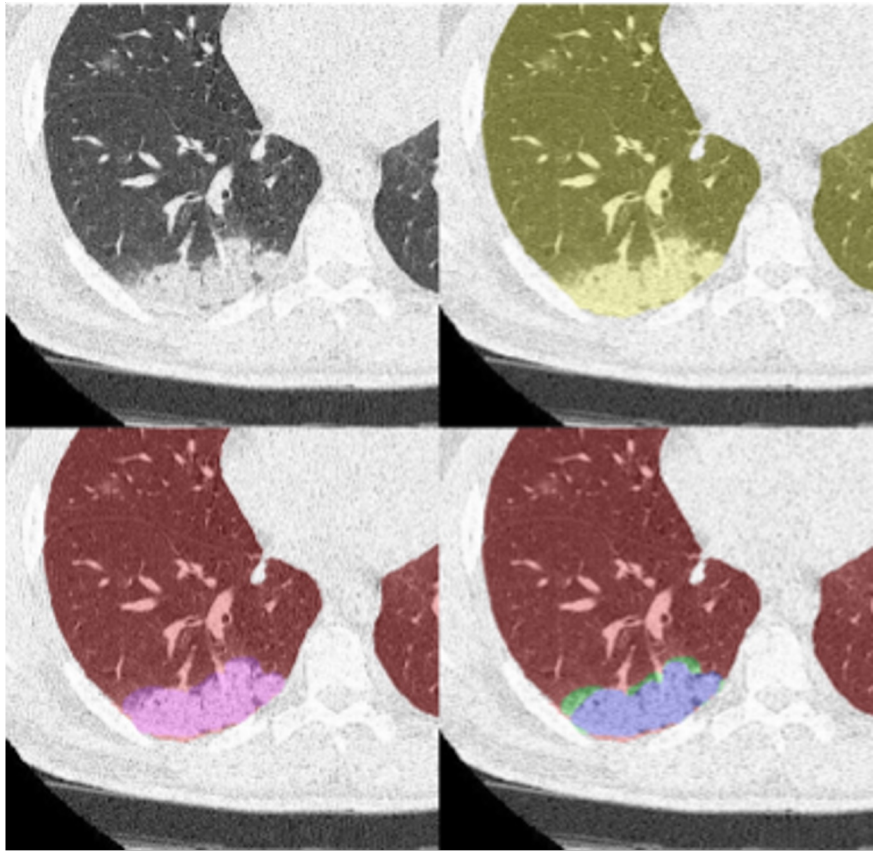
É possível treinar um modelo DL capaz de segmentar diversas regiões de interesse ao mesmo tempo: pulmão, vidro fosco, consolidação, vias aéres, e artérias? Mesmo que meus datasets não contenham todos os rótulos?



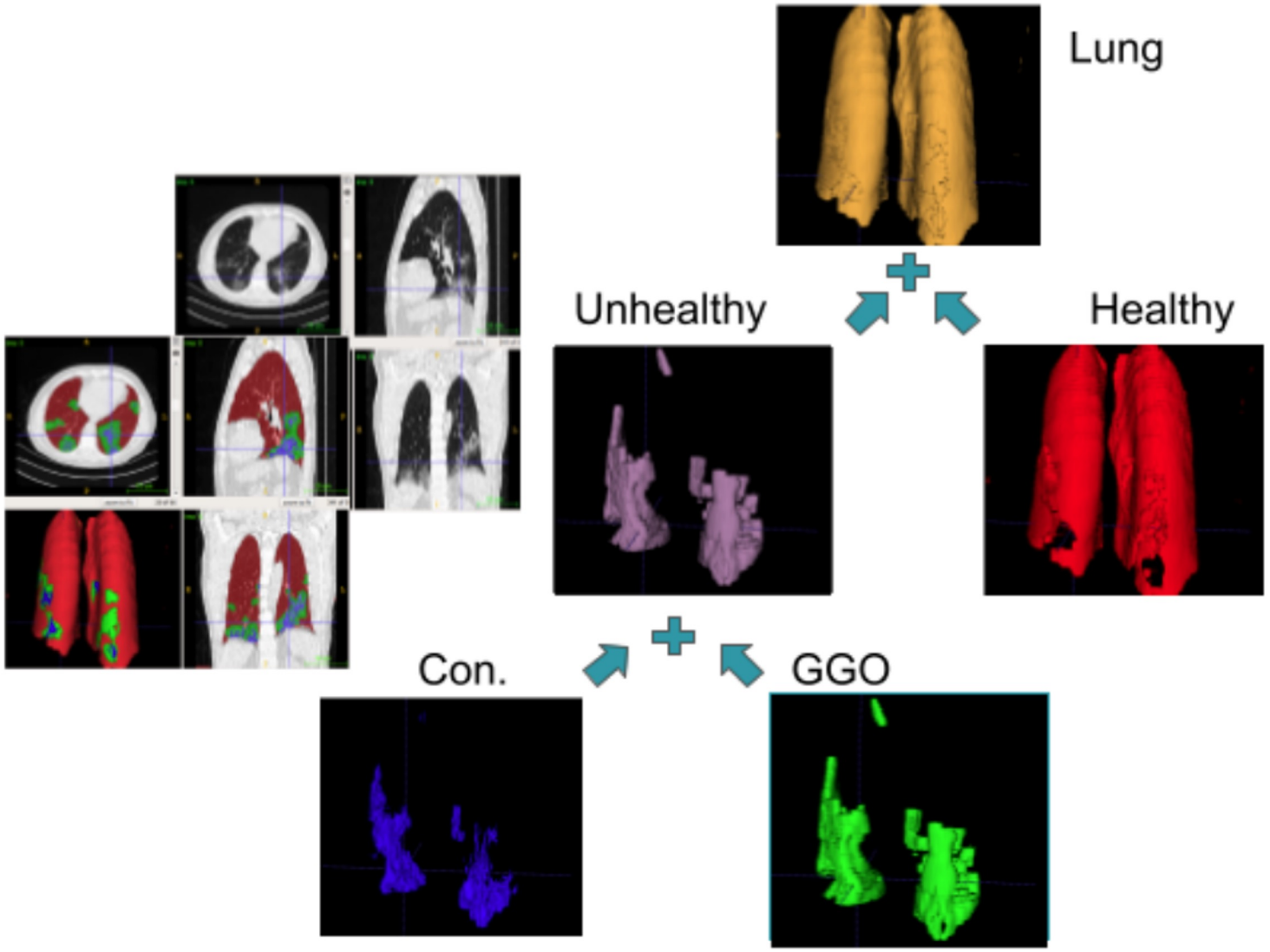
Polymorphic Multitask Learning (PML)



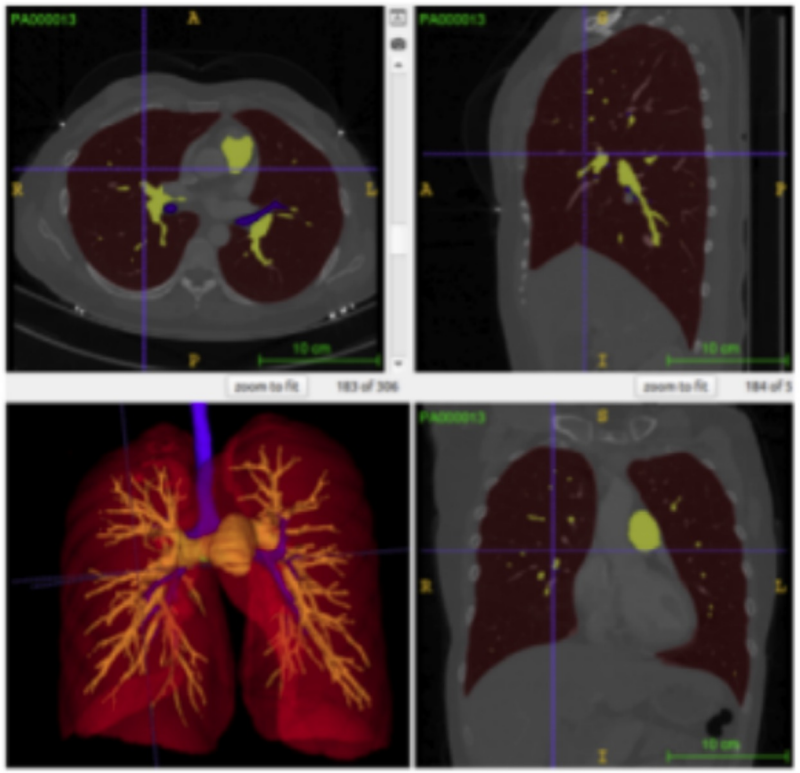
Network output: BG, Healthy, GGO, Consolidations



Polymorphic Multitask Learning (PML)



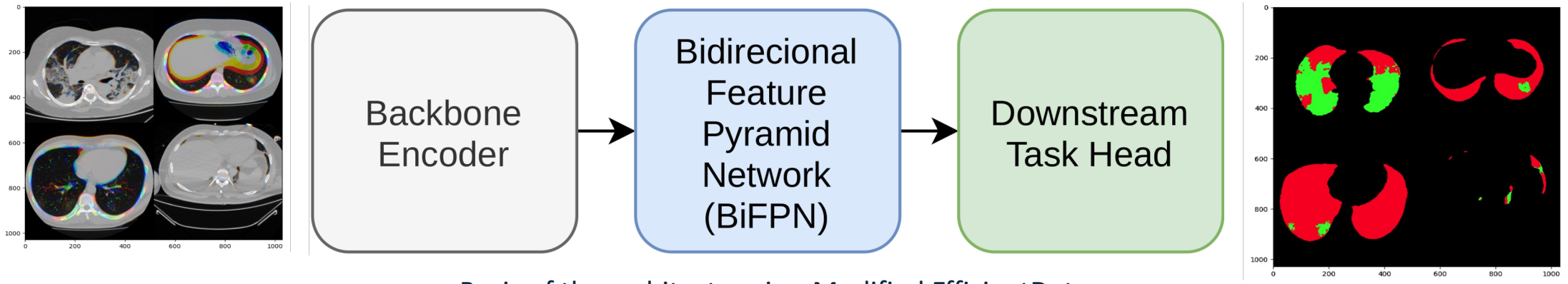
Network output: BG, Healthy, GGO, Consolidations



Auxiliary multitask outputs:
airway, pulmonary artery

MEDPSeg

Modified EfficientDet for Polymorphic Pulmonary Segmentation

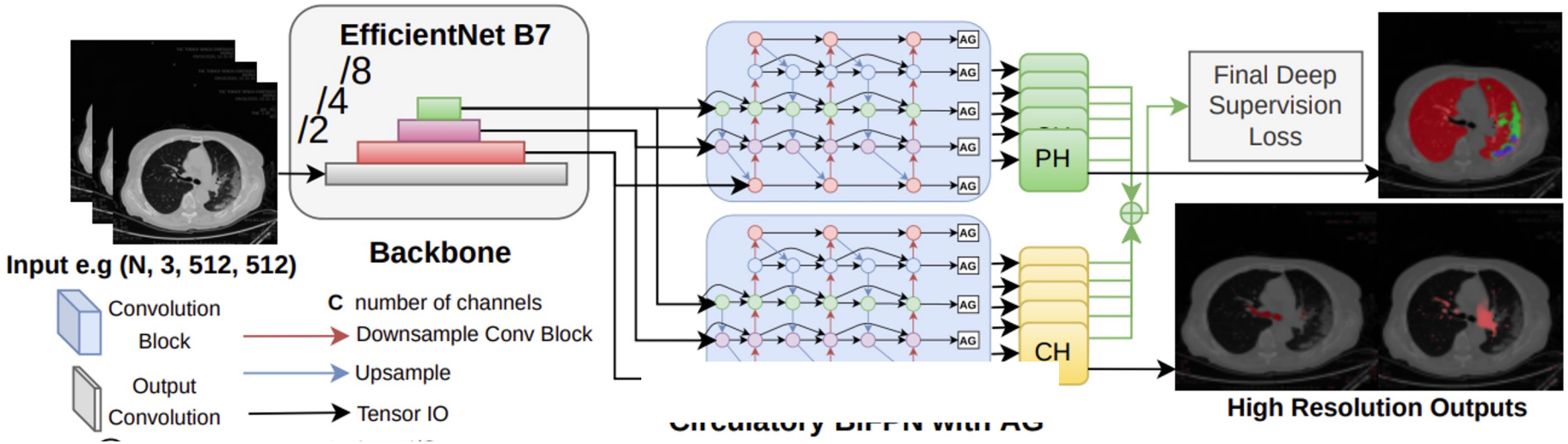


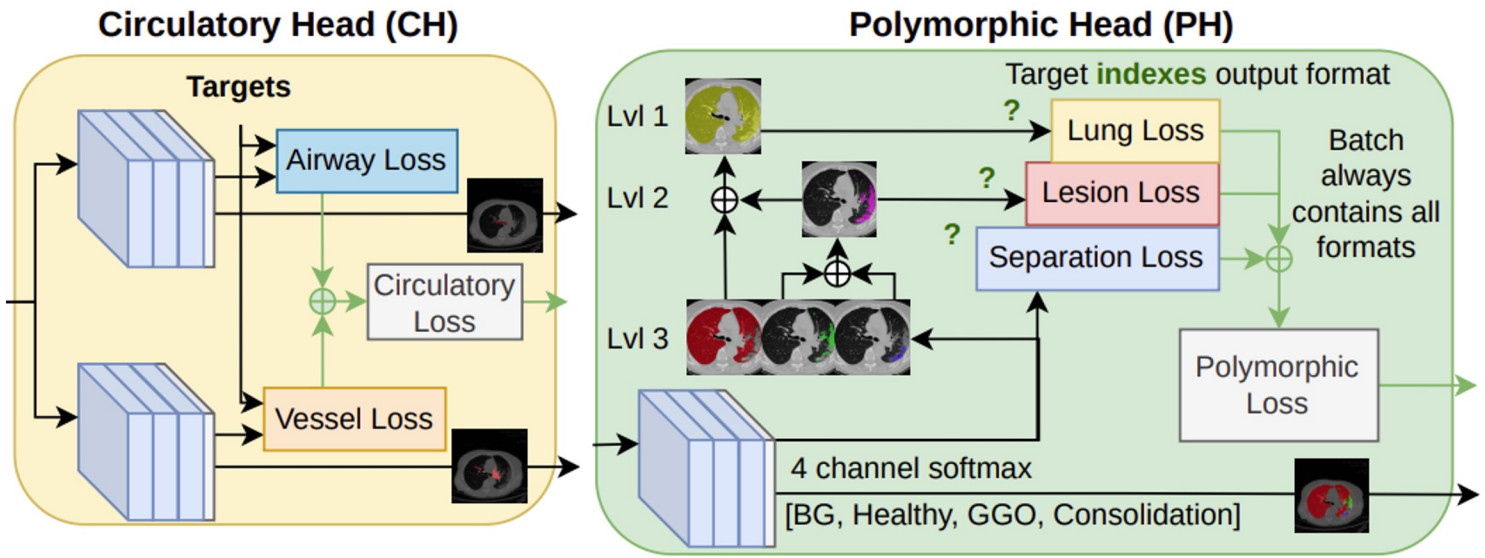
Basis of the architecture is a Modified EfficientDet

Carmo D. et al. Medical Image Analysis (*submitted*).

MEDPSeg

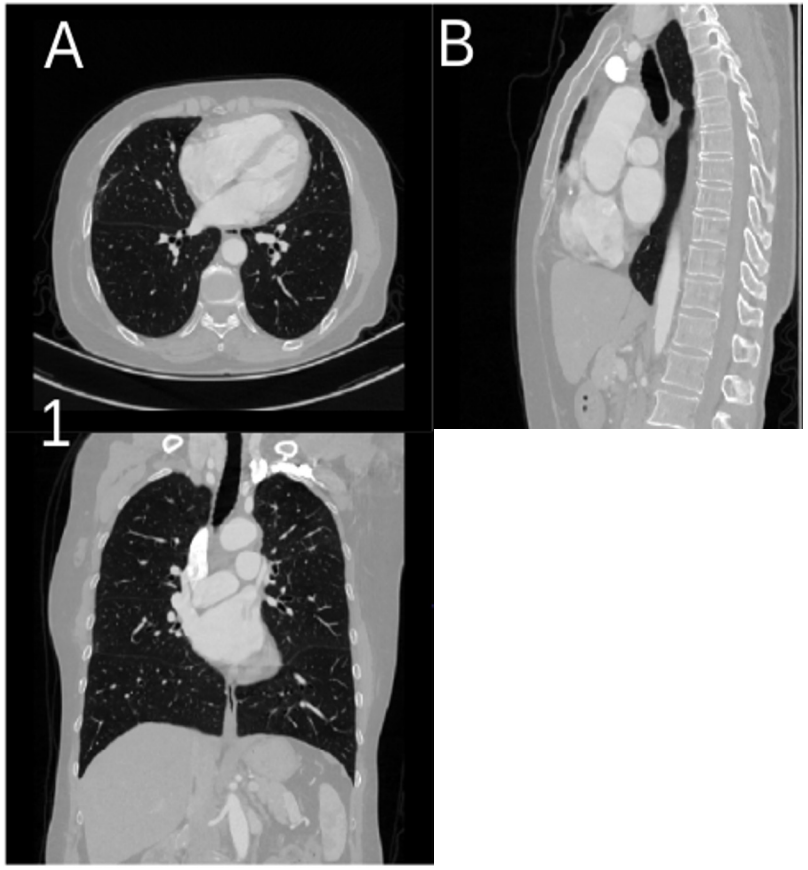
Modified EfficientDet for Polymorphic Pulmonary Segmentation





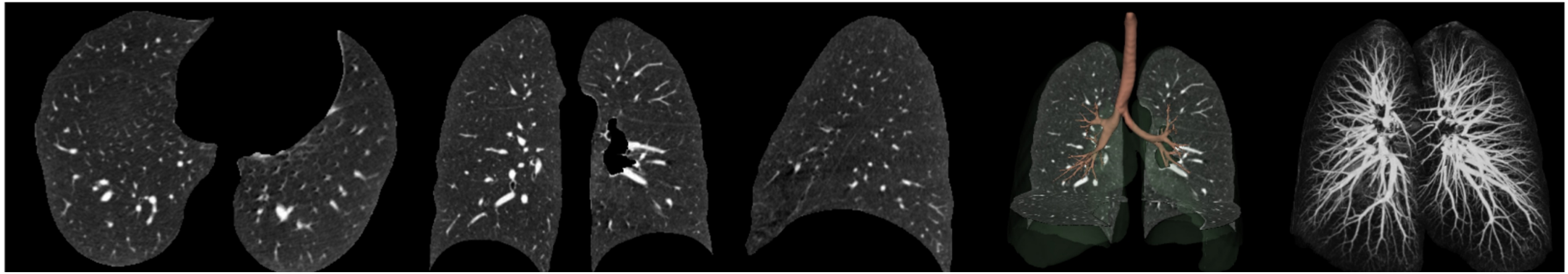
Carmo D. et al. Medical Image Analysis (*submitted*).

Visualizando os resultados



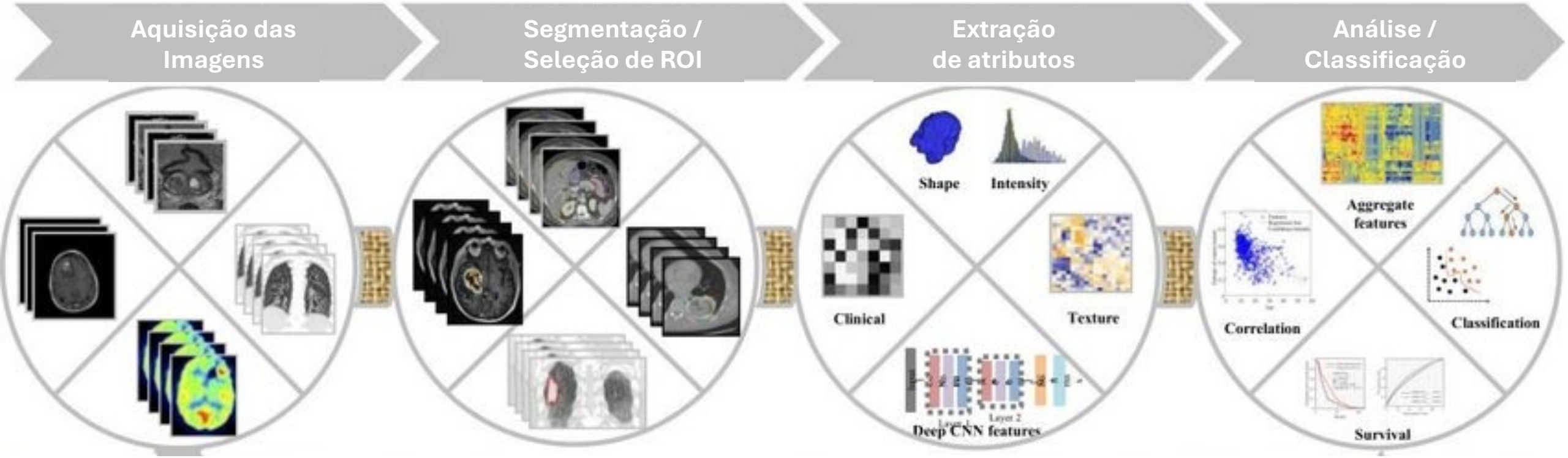
Quantificando os resultados

0% POI



Carmo, D., et al.. In D95. CHALLENGES AND ADVANCES IN COVID-19. American Thoracic Society (2023).

É possível extrair informações/ características usando DL?

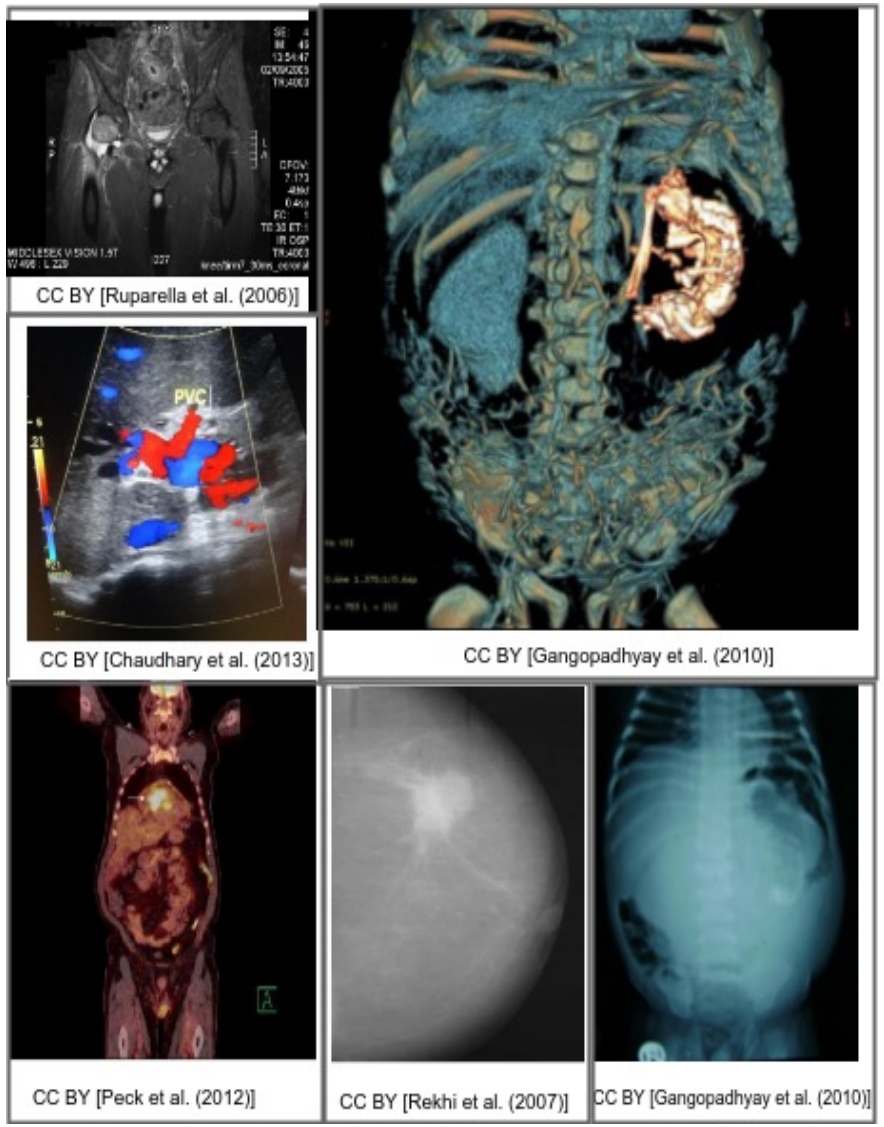


Extração de características

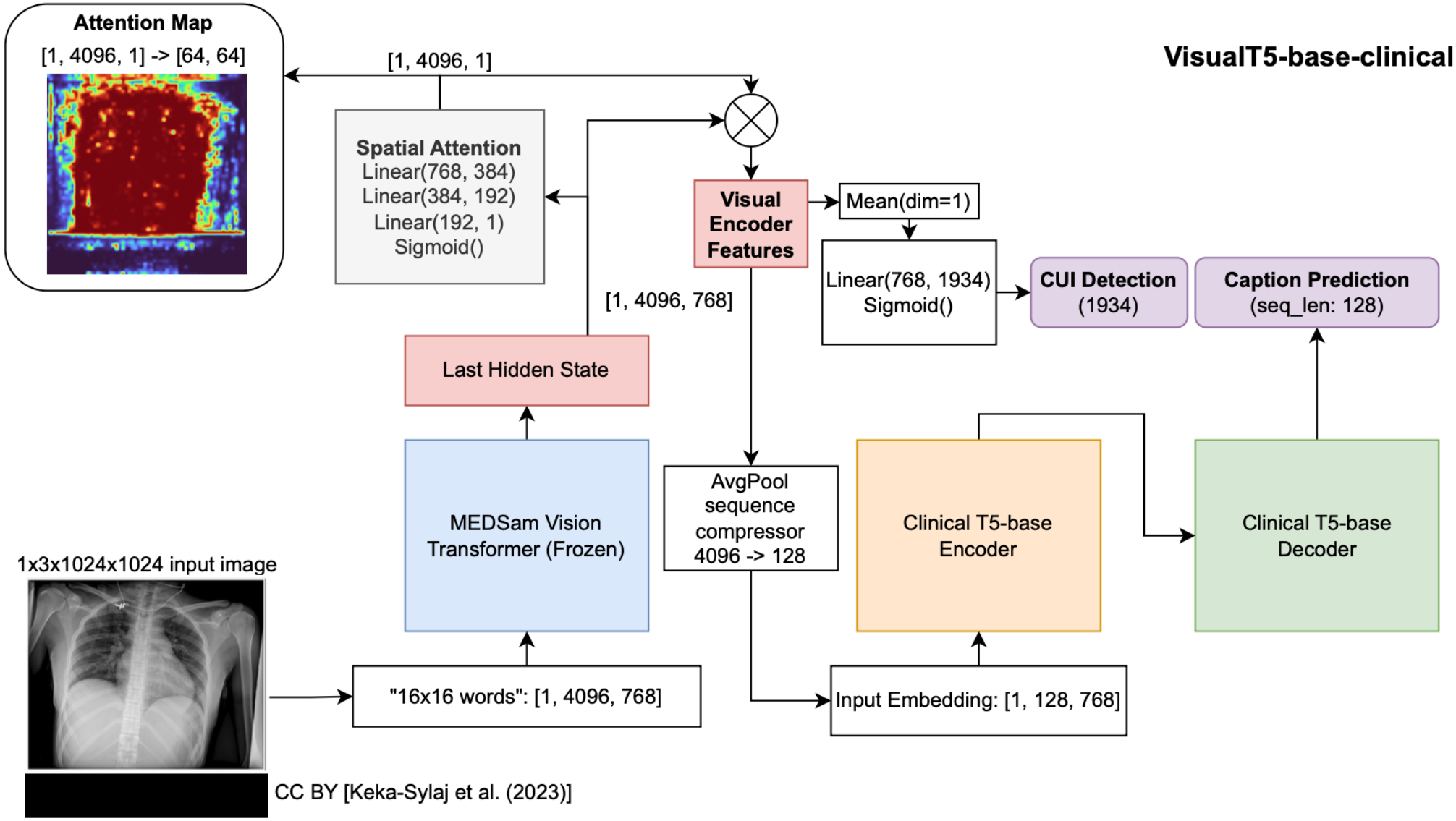
Gerando legendas para imagens médicas

Legenda para imagens (captioning)

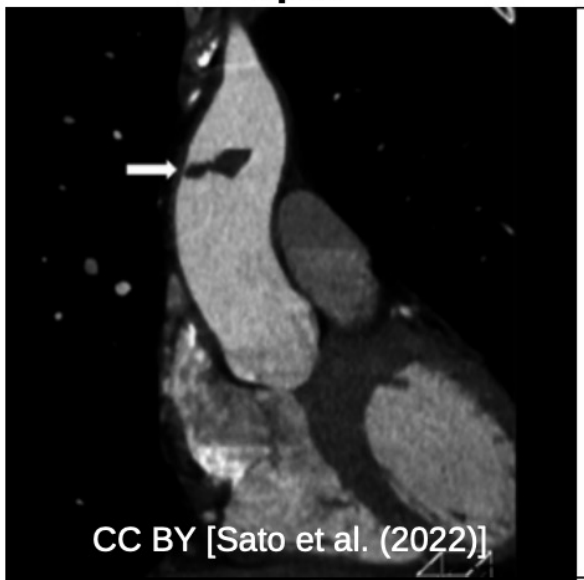
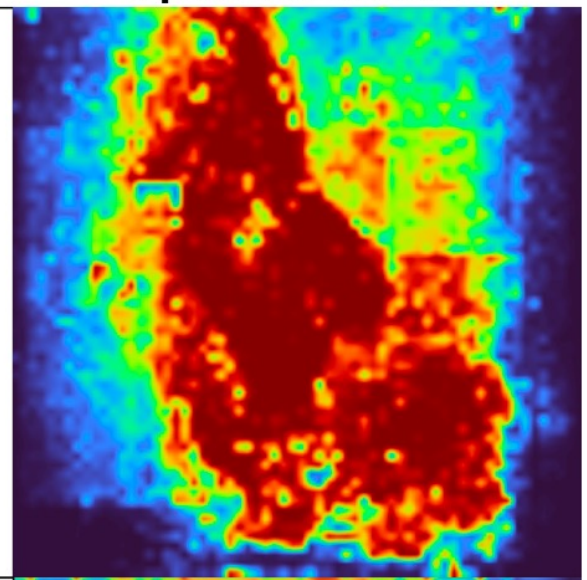
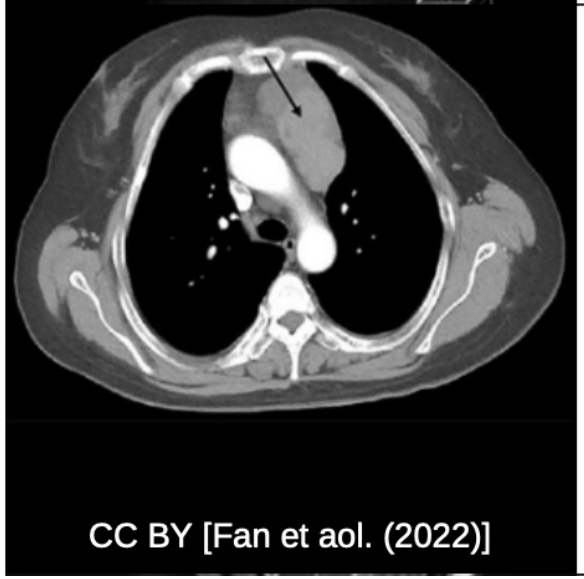
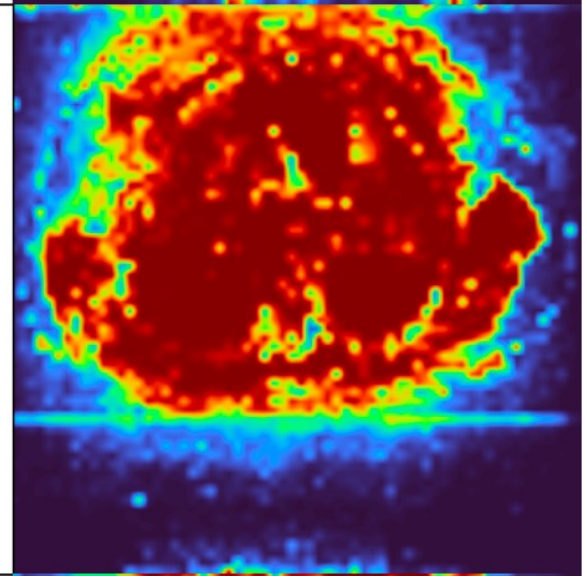
É possível treinar um modelo DL capaz de, ao mesmo tempo, classificar imagens médicas e também gerar uma legenda que as descreva?

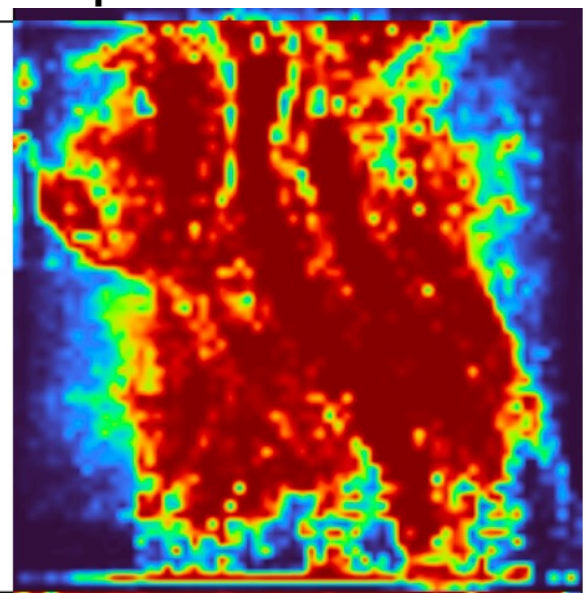
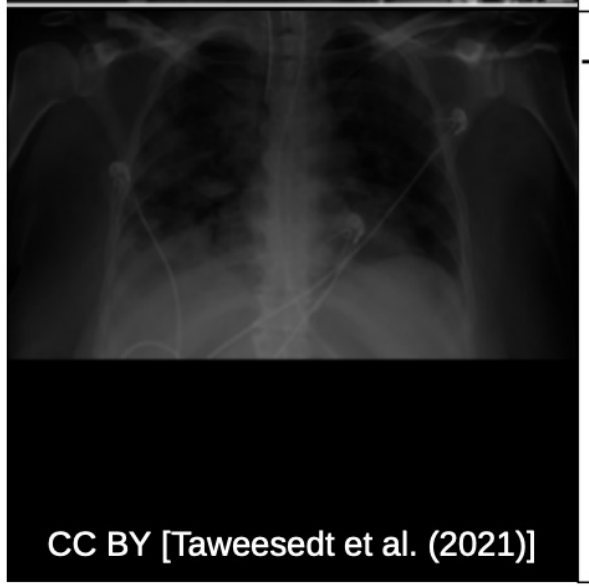
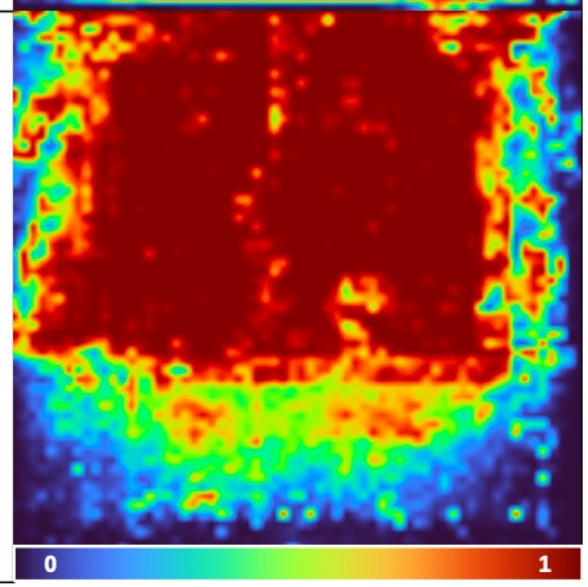


Modelo proposto



Carmo D. et al. In: CLEF (2024).

Input	Target	Prediction	Spatial Attention
 CC BY [Sato et al. (2022)]	Computed tomography (CT) shows floating thrombosis (white arrow) Concept: ['C0040405', 'C0040053'], ['X-Ray Computed Tomography', 'Thrombosis']	Aortic root CT angiogram showing aortic root dilation. Concept: ['C0040405'], ['X-Ray Computed Tomography']	
 CC BY [Fan et aol. (2022)]	Enhanced CT scan of the chest revealed an anterior mediastinal tumor (black arrow). Concept: ['C0025066', 'C0027651', 'C0040405'], ['Mediastinum', 'Neoplasms', 'X-Ray Computed Tomography']	Axial CT scan of the chest showing a large mass in the anterior mediastinum. Concept: ['C0040405'], ['X-Ray Computed Tomography']	

Input	Target	Prediction	Spatial Attention
 CC BY [Trowbridge et al. (2022)]	Early sagittal T2-weighted MRI. Concept: ['C0024485'], ['Magnetic Resonance Imaging']	Sagittal T2-weighted MRI of the cervical spine showing a hyperintense signal in the spinal cord at the C3-C4 level (arrow). Concept: ['C0024485'], ['Magnetic Resonance Imaging']	
 CC BY [Taweesedt et al. (2021)]	The typical chest X-ray finding of a patient with coronavirus disease 2019 infection showing bilateral infiltration. Concept: ['C0332448', 'C1306645', 'C0817096', 'C0009450'], ['Infiltration', 'Plain x-ray', 'Chest', 'Communicable Diseases']	Chest X-ray showing bilateral infiltrates Concept: ['C1306645;C0817096'], ['Plain x-ray;Chest']	

Profa. Leticia Rittner

- Professora Associada – Faculdade de Engenharia Elétrica e de Computação (FEEC)
- Diretora do Medical Image Computing Lab (MICLab)
- Pesquisadora Associada – Brazilian Institute of Neuroscience and Neurotechnology (BRAINN)

Dr. Diedre do Carmo

- Pesquisador - Neuralmind
- Pesquisador Colaborador - Faculdade de Engenharia Elétrica e de Computação (FEEC)

UNICAMP

MICLab

FEEC

neuralmind.ai

Medical Image Computing Lab - MICLab Unicamp

The lab was created under the leadership of Roberto Lotufo and Letícia Rittner to be a focal point for the majority of the students under their supervision

20 followers · University of Campinas · https://miclab.fee.unicamp.br

Overview | Repositories 23 | Projects | Packages | People 9

Popular repositories

e2dhipseg — Public

This contains official implementation for Extended 2D Volumetric Consensus Hippocampus Segmentation

Python ☆ 20 6

CONSNet — Public

CONSNet: Convolutional Neural Networks for Skull-stripping in Brain MR Imaging using Consensus-based Silver Standard Masks

Python ☆ 17 4

ia636 — Public

Python Toolbox for Teaching Image Processing

Python ☆ 14 38

medseg — Public

Official repository for reproducing COVID and Lung segmentation prediction (old version of MEDPSeg)

Python ☆ 10 3

medpseg — Public

MEDPSeg: Official implementation of Modified EfficientDet for Pulmonary Polymorphic Segmentation

Python ☆ 9 4

inCCsight — Public

Python/Dash/Plotly implementation of a data exploration platform for corpus callosum data in DTI

Python ☆ 5 2

People

Top languages

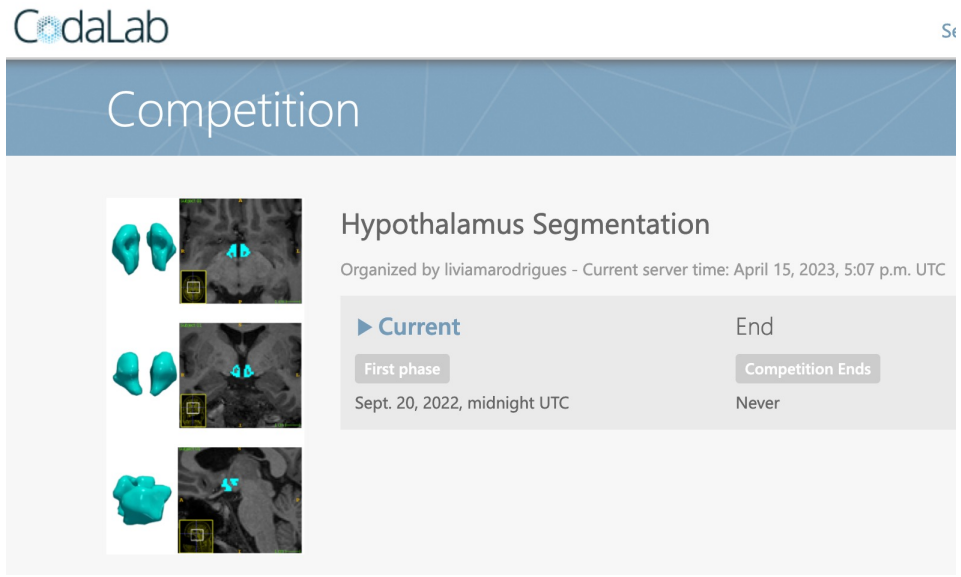
Python · Jupyter Notebook

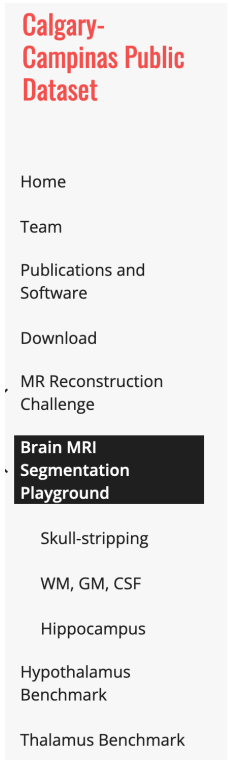
https://github.com/MICLab-Unicamp

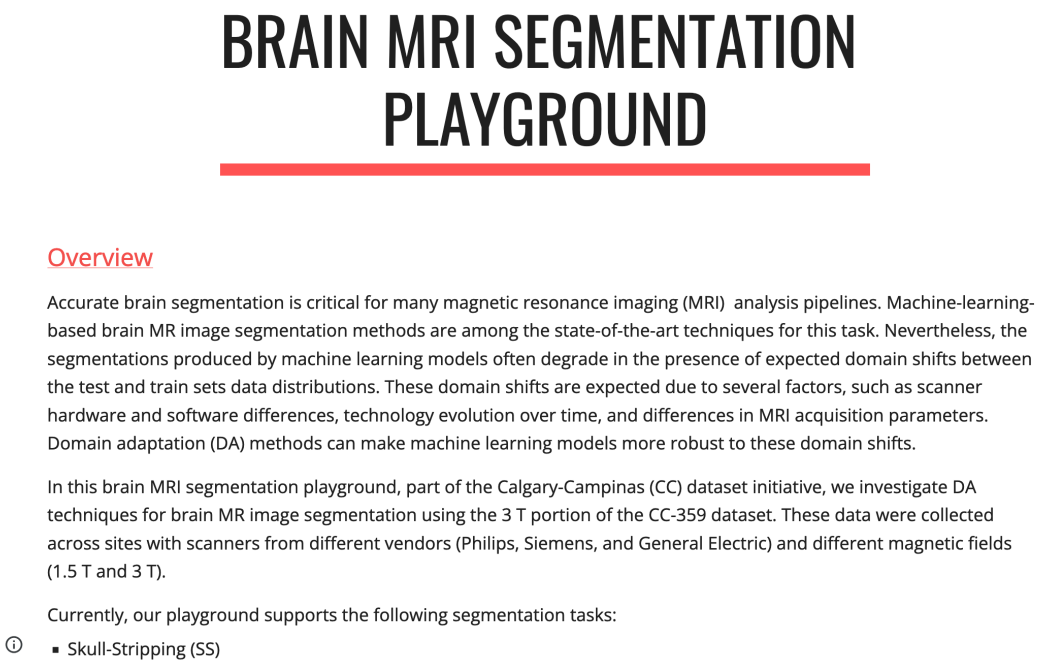
Public datasets

Benchmarks for Medical Image Segmentation

- Hypothalamus segmentation
  - https://codalab.lisn.upsaclay.fr/competitions/7583
- Thalamus segmentation on dMRI
  - https://codalab.lisn.upsaclay.fr/competitions/8329 (preliminary link)
- Calgary-Campinas Dataset
  - Brain MRI segmentation playground
  - Skull-striping
  - Hippocampus







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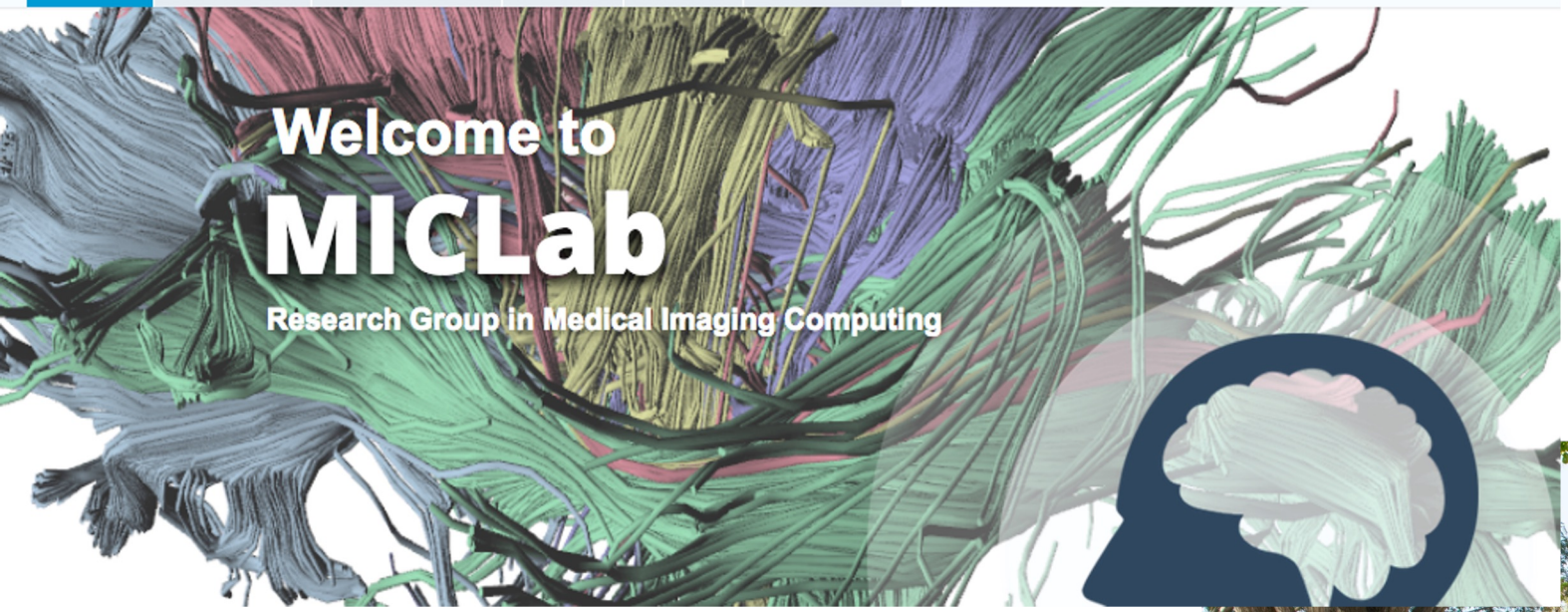


Funding

FAPESP – Fundação de Amparo à Pesquisa do Estado de São Paulo

CNPq – Conselho Nacional de Desenvolvimento Científico e Tecnológico

BRAIM – Brazilian Institute of Neuroscience and Neurotechnology

CAPES

http://miclab.fee.unicamp.br/

https://github.com/MICLab-Unicamp

http://www.lrittner.fee.unicamp.br

lrittner@unicamp.br

Agenda do curso

8h00 – Motivação: o uso de DL na análise de imagens médicas

9h00 – *Garbage in, Garbage out*

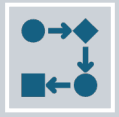
Diretrizes para o tratamento adequado dos dados

Parte prática: pré-processamento e uso dos dados

10h00 – Escolhendo o Modelo: o melhor? Depende...

Como funcionam as CNNs? E os Transformers?

Parte prática: Modelos multimodais envolvendo imagens e texto



11h00 – Avaliando os resultados: do’s and dont’s

Métricas são mais complicadas do que parecem

Parte prática: Dice não é tudo