AI-Powered Auxiliary Medical Diagnostic Systems

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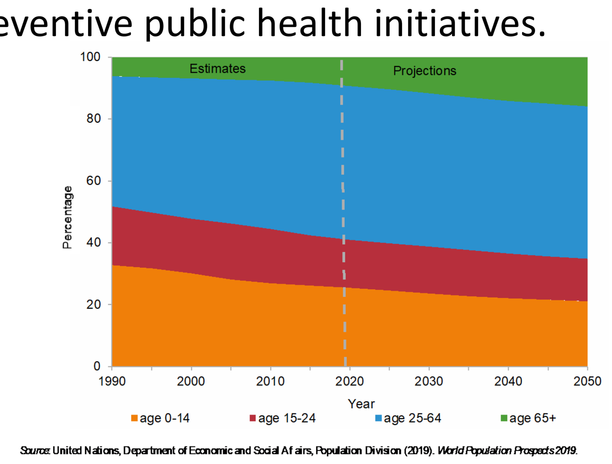
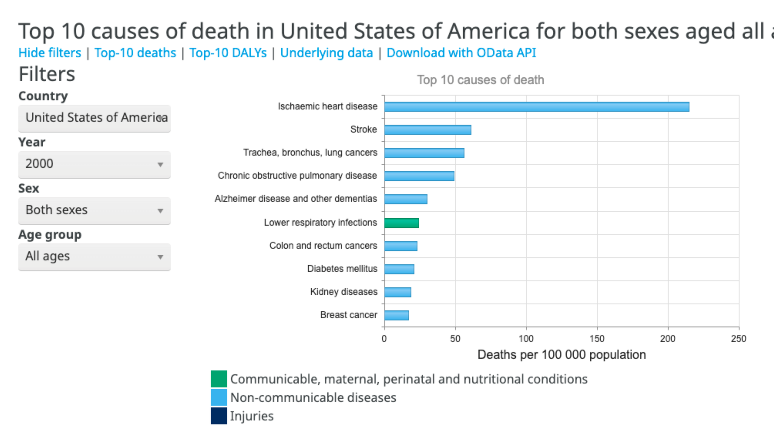
Motivation

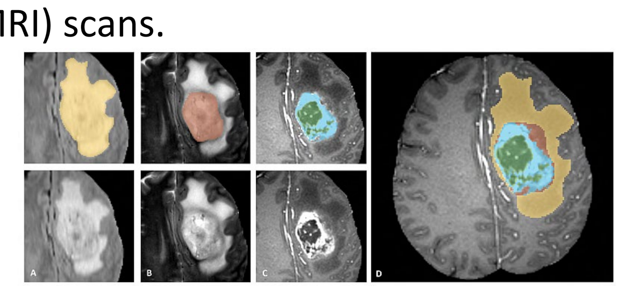
As the global population grows and ages, the prevalence of chronic and systemic diseases in adulthood increases, requiring strategies to better care for the elderly and, at the same time, to develop preventive public health initiatives.

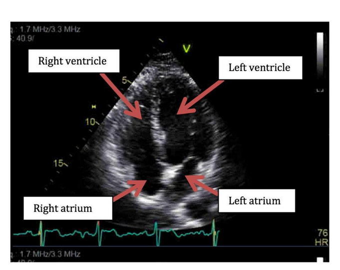




Source WHO - www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death

The diagnosis of chronic and systemic diseases is generally based on medical imaging exams, such as X-rays, computational tomography (CT), ultrasounds and magnetic resonance imaging (MRI) scans.





Source: BRATS –brain MRIs (https://www.med.upenn.edu/cbica/brats/) and MSMC-echocardiogram (https://www.msmc.com/cardiac-imaging-looking-inside-the-heart/)

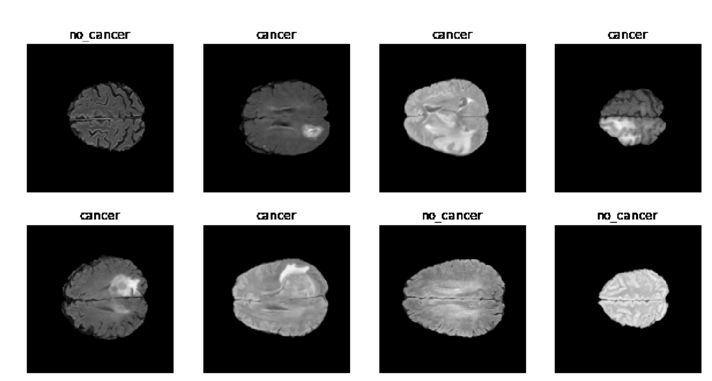
Average diagnostic error rates ranging from 3% to 5%. There are approximately 40 million diagnostic errors involving imaging annually worldwide. [Itri, Jason N., et al. "Fundamentals of diagnostic error in imaging." Radiographics 38.6 (2018)]

AI-based diagnostic system

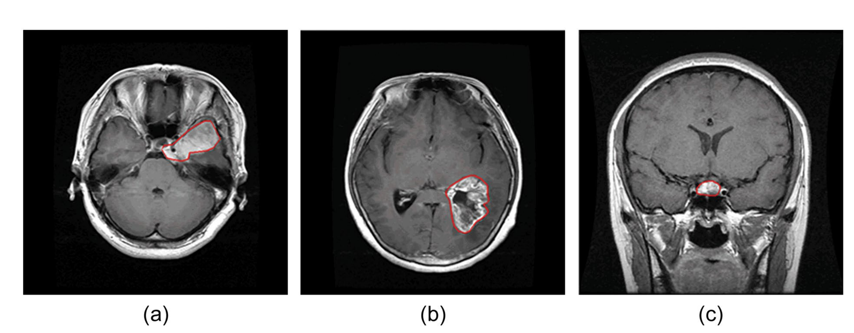
- Deep Learning models are being used to analyze medical data and, most specifically, medical images, and to identify patterns and abnormalities that may not be (YET) visible to radiologists and physicians in general.
- These auxiliary diagnostic systems allow for an early detection of chronic diseases, such as heart conditions and cancer.
- AI models can process large amounts of data quickly and accurately. They can also be used to track health data over time and identify suspicious changes. Finally, AI models can be used to identify rare diseases and conditions that are difficult for humans to diagnose.
- But the area still faces several challenges:
  - Availability of balanced datasets;
  - Assurance of accuracy and reliability;
  - Explainability;
  - Privacy and security;
  - Robustness to diversity in formats, degradations, etc.

Brain Cancer Detection in MRIs

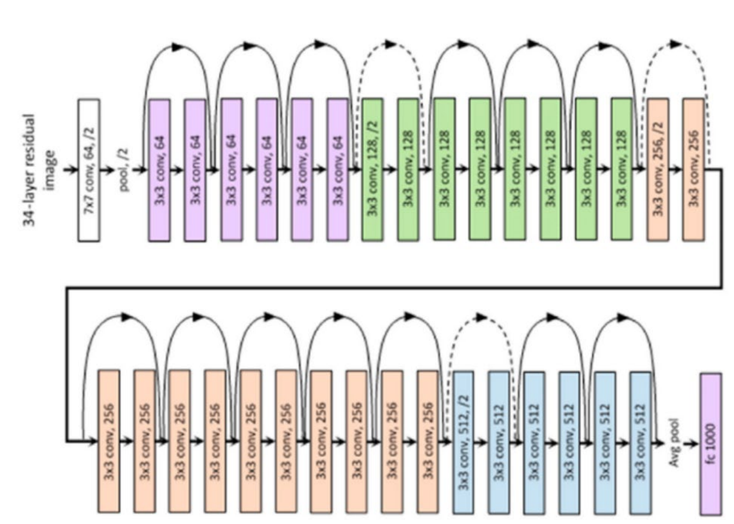
- Cancer incidence and mortality are increasing around the world. In 2018, there were around 18.1 million new cancer cases and 9.6 million brain cancer deaths.
- Although brain tumors correspond to less than 2% of all cancers, they have a high mortality rate. Brain cancers rank as the 3rd cause of cancer-related death in men aged 15-54 years and the 4th cause in women aged 15-34 years. For children and people up to 40 years of age, brain cancers are the most common cause of cancer-related deaths.
- Early detection of cancer tumors significantly increases the chances of recovery and generally results in a better quality of life and a longer life expectancy.
- Magnetic resonance imaging (MRI) constitutes one of the most useful imaging methods for the diagnosis of brain tumors, given that they do not depend on x-rays.
- We aim to design deep learning algorithms that can identify and segment brain tumors.



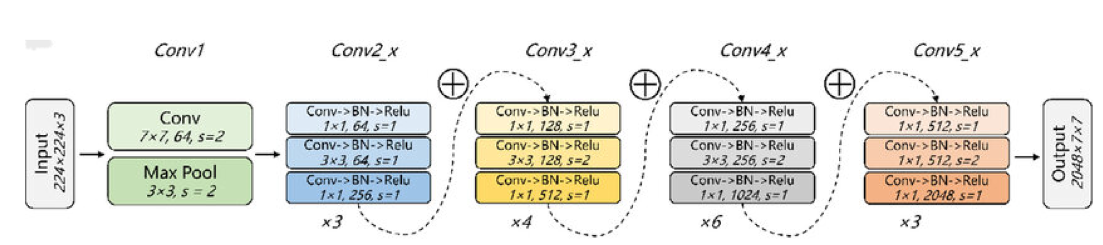
Sample MRI brain images from the Multimodal Brain Tumor Segmentation Challenge 2020 (BRATS2020) dataset



Cheng, Jun, et al. "Enhanced performance of brain tumor classification via tumor region augmentation and partition." PloS one 10.10 (2015): e0140381.



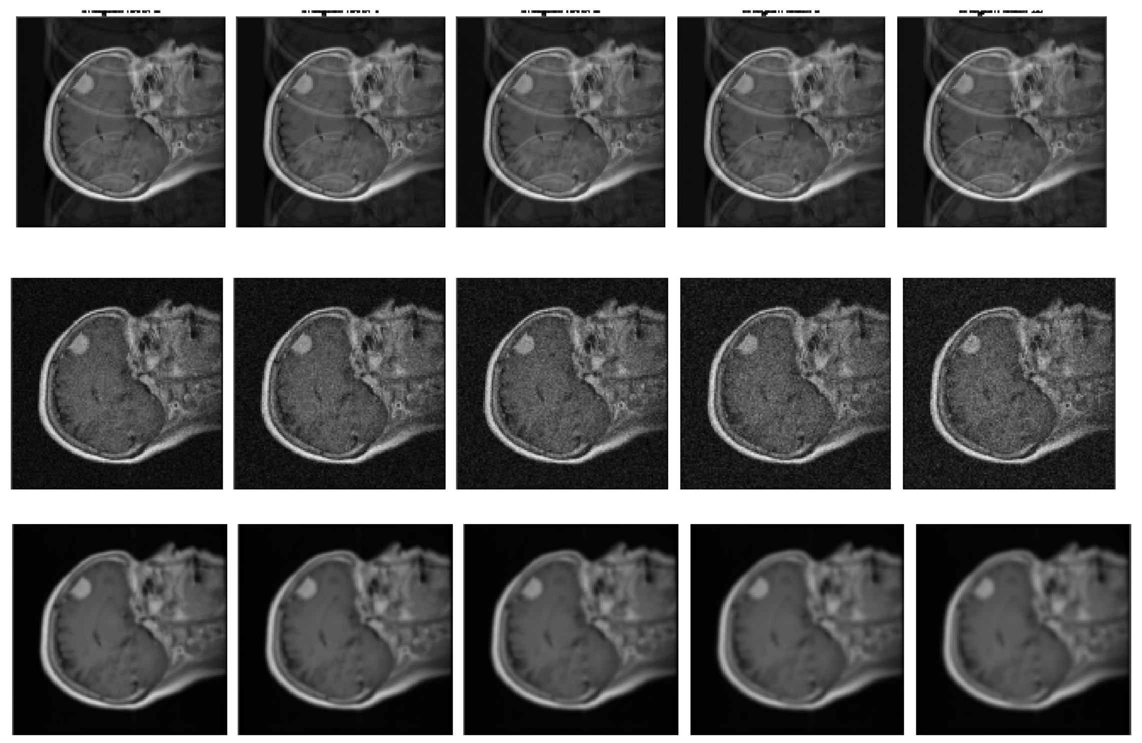
- Several datasets available, but often the specific cases are not available;
- Several architectures are currently available: Resnet and Resnext are displayed here.



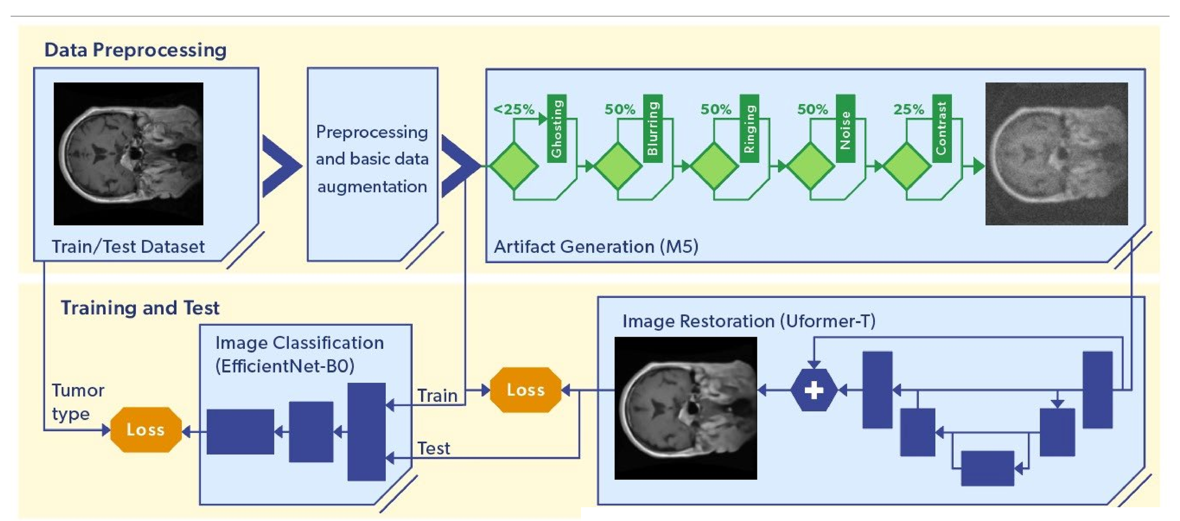
Sample Performance results for ResNet34

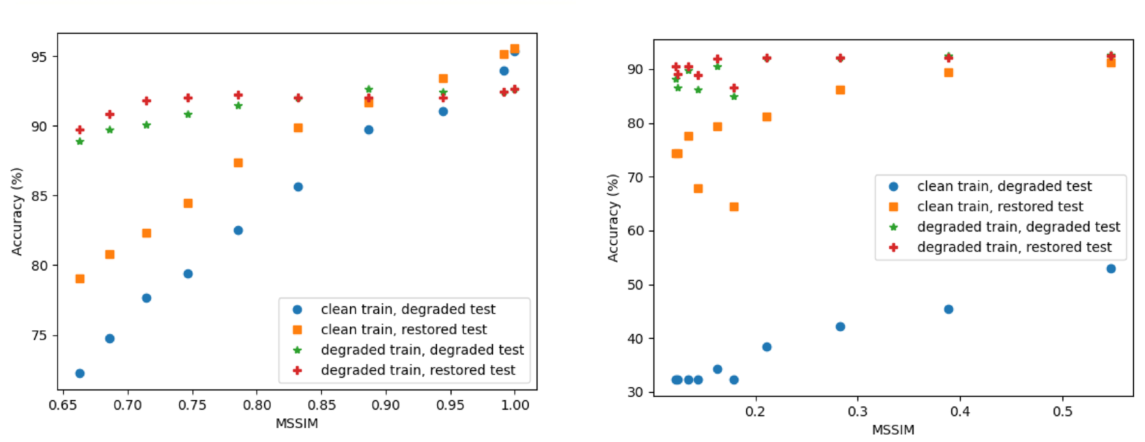
	Accuracy	Precision	F1 scored	Recall
Mean	0.918	0.906	0.920	0.935
Standard Deviation	0.006	0.007	0.006	0.012

Impact of Degradations on Performance



- We have tested several architectures getting overall good results for the most popular datasets; But …
  - How do these results generalize among datasets?
  - How do these models work in real-life scenarios?
  - How degradations present in real-life affect their performance?
- Since there are no datasets with degradations, we created variations of datasets with several intensities and tested how they affected performance metrics.

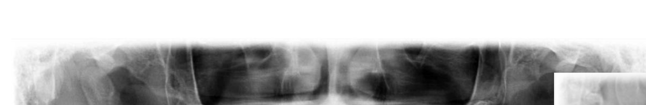




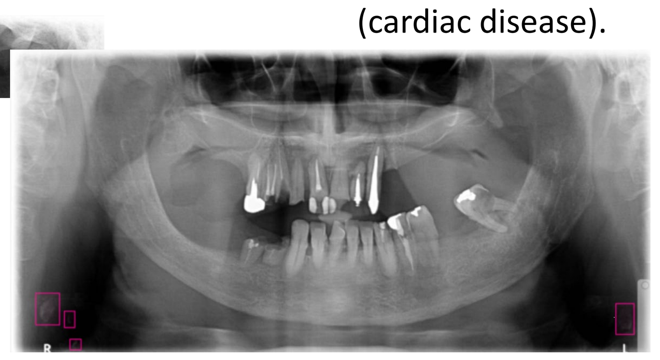
Accuracy versus MSSIM values for tests on MRI scans with (left) blurring and (right) combinations of blurring, contrast, noise, ghosting artifacts.

Detecting Chronic Diseases in Dental X-Rays

Identification of atheroma's (cardiac disease).

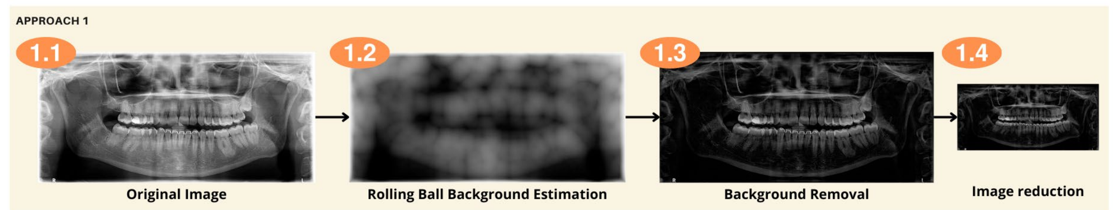


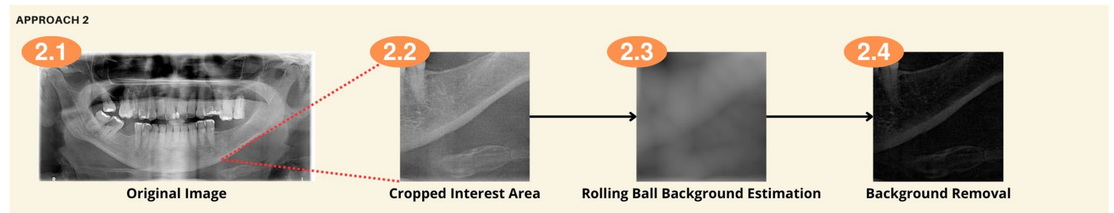
Identification and classification of osteoporosis.



Detecting Osteoporosis

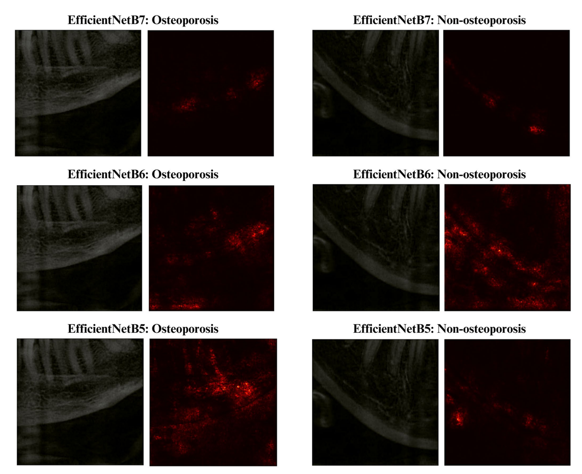
- Osteoporosis (OP) is considered a public health issue and has a high prevalence rate worldwide, with severe clinical and social consequences. Elderly population is at increased risk of developing the disease, especially women in post-menopause who undergo hormonal changes that also contribute to the development of osteoporosis.
- This project is a collaboration with the Odontology Department at University of Brasilia, who has been collecting and annotating dental images at the public University Hospital for several years.





Dataset	Model	Precision	Recall	F1-Score	Accuracy
Full PR	EfficientNet B5	92.98%	92.05%	92.49%	93.37%
	EfficientNet B6	92.65%	91.45%	92.01%	92.97%
	EfficientNet B7	94.68%	94.00%	94.33%	94.98%
Cropped PR	EfficientNet B5	98.53%	98.00%	98.25%	98.35%
	EfficientNet B6	98.28%	97.95%	93.11%	98.11%
	EfficientNet B7	98.32%	98.29%	98.54%	98.62%

- We are currently working on Improving the algorithm for a better classification of intermediate (C2) levels of osteoporosis.
- We are also interested in increasing our dataset and considering other types of images that can be easily acquired.



Bio: Mylene Farias received her B.Sc. degree in Electrical Engineering from Federal University of Pernambuco (UFPE), Brazil, her M.Sc. degree in Electrical Engineering from the State University of Campinas (UNICAMP), Brazil, and her Ph.D. in Electrical and Computer Engineering from the University of California Santa Barbara (UCSB), USA, in 2004 for work in no-reference video quality metrics. Currently, she is an Associate Professor in the Department of Computer Science at Texas State University. Her current interests include biomedical engineering, video quality metrics, multimedia and immersive media (VR/AR).

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