Artificial Intelligence in Computed Tomography

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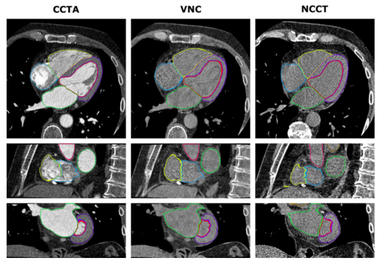
Introduction

- Computed Tomography (CT) is "the process of creating a cross-sectional tomographic plane of any part of the body" (Rollins et al., 2019, p. 206).
- Advancements in the field of computed tomography have allowed the introduction of procedures such as computed tomography angiography (CTA) as well as oncological applications and assistance in COVID-19 diagnosis.
- The objective of Artificial Intelligence (AI) applied in CT is to enhance the efficiency of radiologists' and physicians' tasks, enabling them to perform procedural steps more swiftly and with greater effectiveness.



Automated segmentation of cardiac structures using deep learning using coronary computed tomography angiography (CCTA), virtual non-contrast (VNC), and true non-contrast (NCCT) (Lin et al., 2021).

Artificial Intelligence (AI)

- Artificial intelligence (AI) refers to the use of computational techniques to mimic human thought processes and learning capacity (Lin et al., 2021, p. 1).
- Alan Turing first discovered the possibility of artificial intelligence in 1950 when designing the "Turing Test".
- AI can be narrowed down into subcategories of ML and DL:

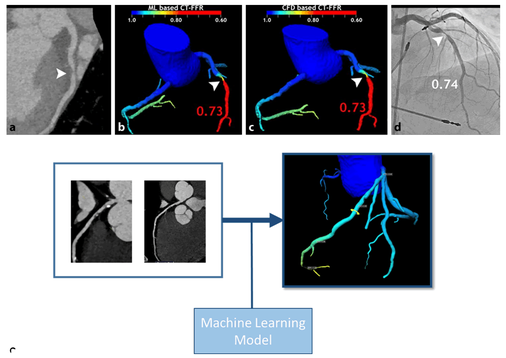
-Machine Learning (ML)- a subset of AI that employs statistical methods which inherently improve the algorithms performance with experience gained by training on additional data (Cau et al., 2021, p. 2).

-Deep Learning (DL)- a subtype of ML, which may automatically learn from raw data and it is particularly applicable to pixel-based data (Cau et al., 2021, p. 2).

- Other components of AI to ensure user-friendly accessibility are cognitive computing and natural language processing.
- Cognitive computing- analyze text and speech to imitate the interaction between human and machine
- Natural Language Processing (NLP)- allows for the computer to recognize linguistics and interpret human nature.
- In diagnostic imaging, image reconstruction, structure segmentation, noise reduction, prediction outcome, and efficiency increase are capabilities of AI that accelerate the diagnostic process.

Heart

- In CT, CTA, is a common procedure used to diagnose cardiovascular disease (CVD), the leading cause of death worldwide (Cau et al., 2021, p.1).
- CTA procedures assess vessels in the body via the injection of contrast media.
- Visualization of stenosis in the coronary tree, plaque characteristics, coronary calcification and scoring, and modeling of flow are prospects of cardiac CT in which AI can be applied (Siegersma et al., 2019, p. 4).
- A study applying AI in CT coronary angiograms using 163 patients resulted in a 0.77 accuracy for coronary plaque detection and characterization and accuracy of 0.80 for stenosis detection (Siegersma et al., 2019, p. 5).



Stenosis displayed in different imaging methods (Siegersma et al., 2019, p. 5).

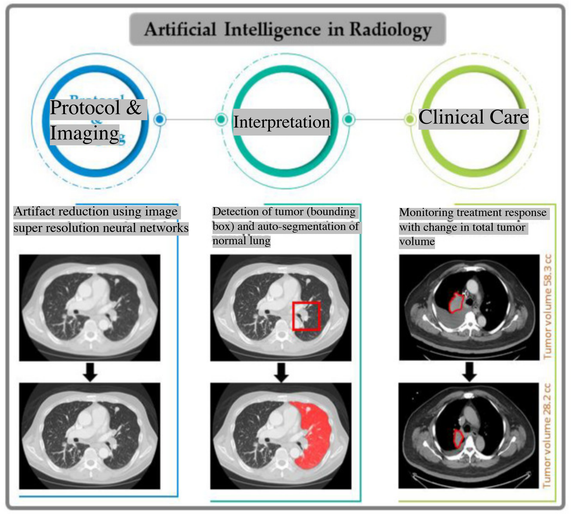
- Non-invasive fractional flow reserve (FFR) was achieved by AI estimation of the lumen area, therefore decreasing the number of invasive coronary angiography's (ICA) ultimately reducing patient dose and duration of procedure.
- AI approaches have demonstrated a high intra—class correlation coefficient of 0.95 for automated detection of coronary artery calcium in electrocardiogram-gated (ECG) non-contrast enhanced CT imaging (Siegersma et al., 2019, p. 5).

Chest

- Thoracic CT scan is the modality of choice for diagnosing COVID-19 and other chest pathologies.
- DenseNet121, Resnet50, and ShuffleNet V2 are pretrained AI networks used to examine Chest CT radiographs.
- These networks are used to segment regions of interest and capture fine structures in chest CT images by extracting features for diagnoses.
- A study using ResNet50 achieved a 94% sensitivity, 98% specificity and area under the curve (AUC), score of 0.9940 when detecting lung segmentation, COVID-19 identification and categorization (Ozsahin, et al., 2020)

Oncological Applications of AI

- Clinical, genomic and histopathological data can be attained from AI models for the purpose of tumor classification through noninvasive imaging.
- Lung cancer and colonic polyps can be diagnosed using a DL model.
- AI methods have shown the potential to stratify patients based on risk factors as well as provide automated measurements of tumor volume via tumor segmentation.
- AI tools developed for specific, narrow tasks, such as case assignment, lesion detection, and segmentation of regions of interest, are critical for oncological imaging. (Paudyal et al., 2023).



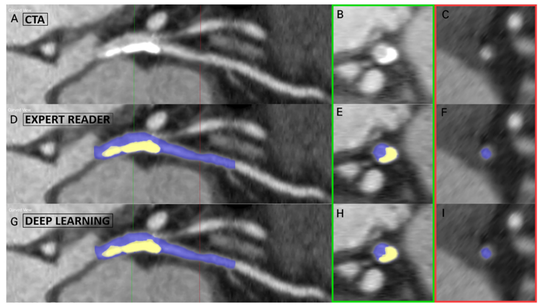
These images show the abilities of AI for tumor detection and monitoring upon a chest CT (Paudyal, 2023, p. 5).

Limitations/Misconceptions

- AI in healthcare has been limited to date.
- No studies have been performed that show that the implementation of AI indeed leads to higher quality of care, lower healthcare costs or improved patient outcomes.
- Repeating studies, inclusion of a large range of diversity and validation designed ML models will be important before routine implementation in clinical practice.
- Current AI technology is considered narrow and only as good as the dataset that trained it
- The data used in the studies might have come from different institutions and different scanners (Ozsahin et al., 2020, p. 8).
- Legal issues regarding safety and morality are put into question when using patient information.

Future Applications

- To deepen the understanding of AI's potential and its capabilities for CT assistance, numerous studies must be conducted as well as negotiate through the ethical concerns that may arise.
- Dose optimization, workflow improvement, image reconstruction and predictive analytics are aspects that are achievable through AI beyond CT.
- "AI shows great promise for patient positioning, image acquisition, and reconstruction pipelines by reducing scan time, suppressing artifacts, and improving overall image quality via optimization of the signal-to-noise ratio (SNR)" (Paudyal et al., 2023, p. 4).
- Virus detection, diagnosis and predictions, prevention, response, recovery, and accelerate research are other applications of AI (Ozsahin et al., 2020).
- A potential leap forward in oncological applications include tailored treatment plans by using metabolic and functional status gained thorough AI databases (Paudyal et al., 2023, p. 3).
- To reach AI full potential in cardiovascular CT, cardiologists and radiologists need to be actively involved in the development and implementation of this technology (Lin et al., 2021).



Case example of lumen and calcified plaque segmentation on coronary CT angiography (CTA) in a lesion extending from the left main into the left anterior descending artery (Lin et al., 2021, p. 18)

Conclusion

- The progress of AI in healthcare is in its initial stages. Predicting when the widespread integration of AI will become present remains challenging.
- Extensive research on the future of AI in the CT field will be exposed in the coming years.
- Improved daily clinical practice, reducing human variability, saving clinicians time, and achieving better performance in a reduced time frame are aspects of the integration of AI in CTA as well as healthcare universally.

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