# Artificial Intelligence in Radiation Oncology

ICRO - PRODVANCE, Thiruvananthapuram

## Artificial Intelligence, Machine learning and Deep Learning - Technical POV

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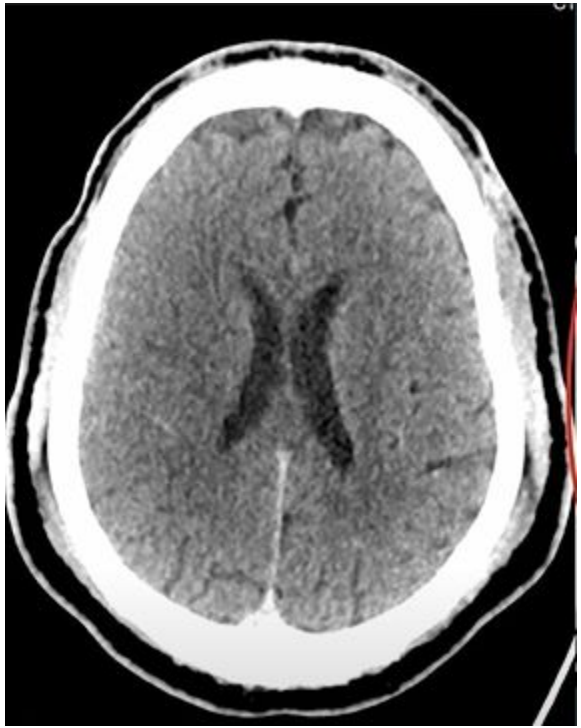
KARKINOS

# Objectives

- Introduction to AI, ML, DL
- Data Pre-Processing in Radiation Oncology
- Feature Engineering in Radiation Oncology
- Deep Learning in Radiation Oncology - Introduction to use cases

# Can you diagnose?



# How did you do?

Knowledge of - Type of Image + Normal Anatomy + Abnormal Anatomy + Clinical Condition

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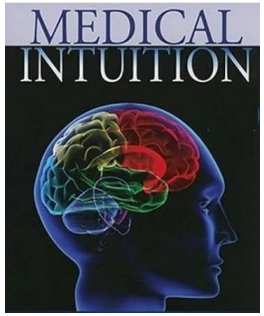


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# Introduction to AI, ML and DL

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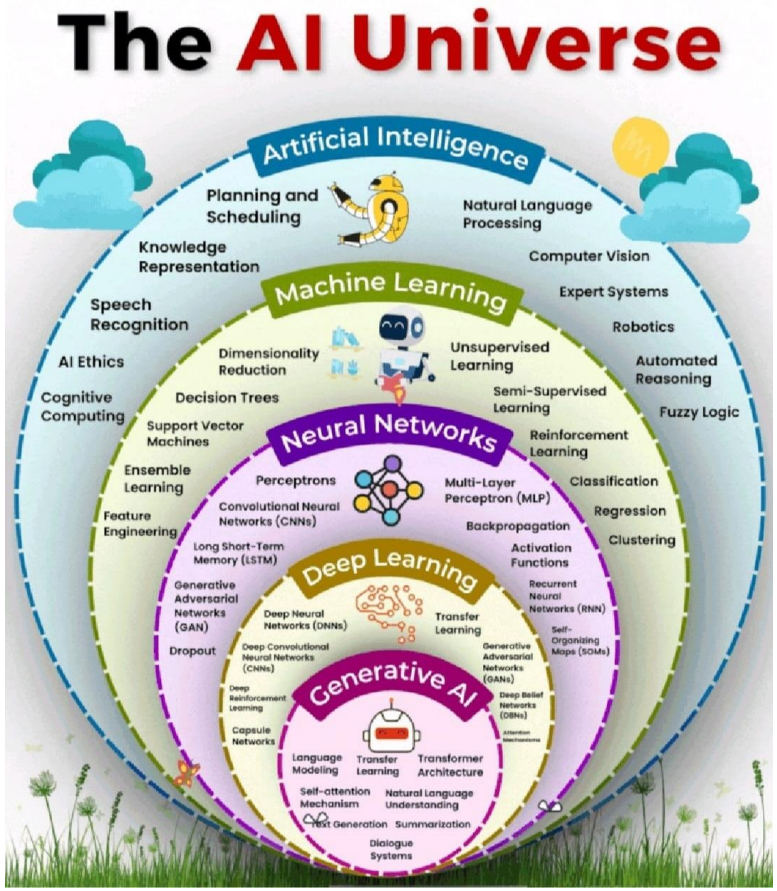
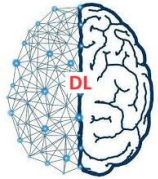



Credit : Brij Kishore Pandey @brijpandeyji

# What is AI, ML, DL?

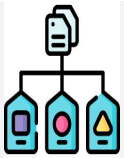

**François Chollet, creator of Keras:** “the effort to automate intellectual tasks normally performed by humans”.


**Arthur Samuel**: “field of study that gives computers the ability to learn without being explicitly programmed”.



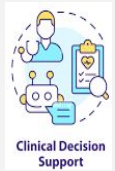

“computers to process data in a way that is inspired by the human brain by recognizing complex patterns in pictures, text, sounds, and other data to produce accurate insights and predictions”

# ML and DL Terminologies



01 Classification

02 Segmentation




03 Detection

04 Image Enhancement

05 Data Augmentation

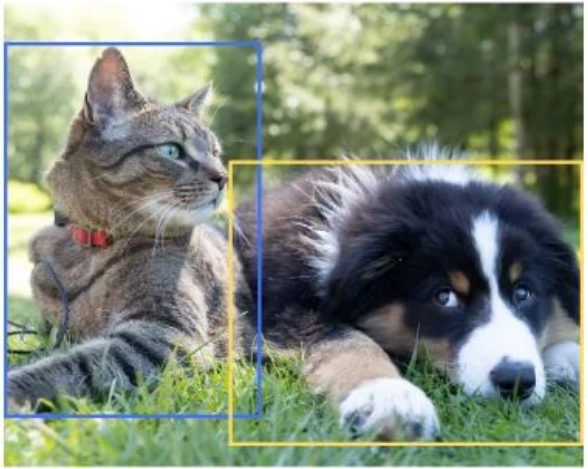
06 Pattern Recognition

# Classification, Detection and Segmentation

Is this a cat?

Image Classification

What is there in the image and where?

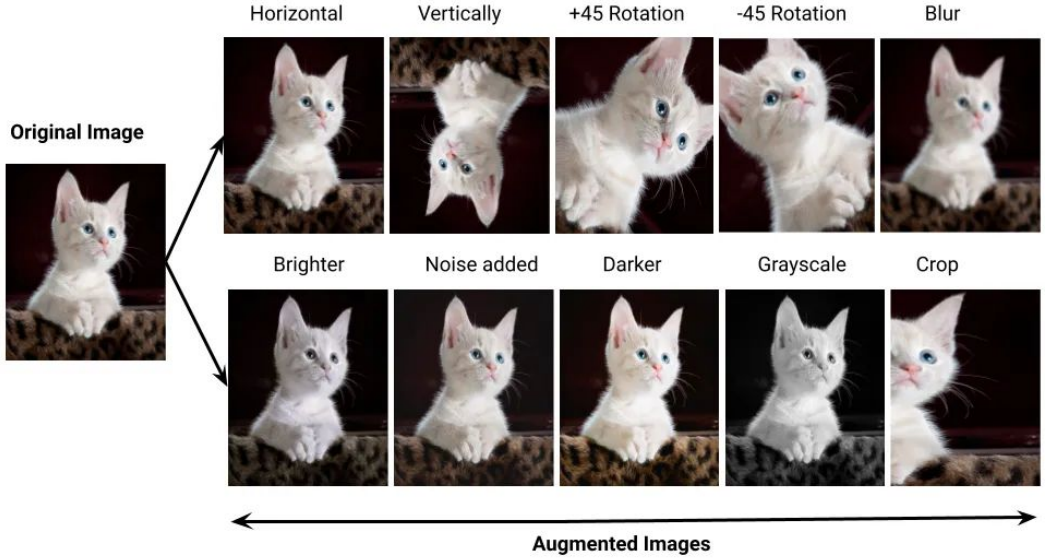


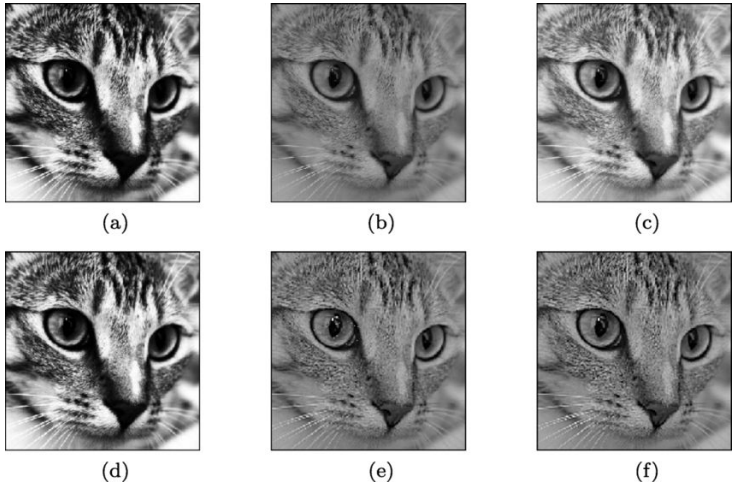
Object Detection

Which pixels belong to which object

Image Segmentation

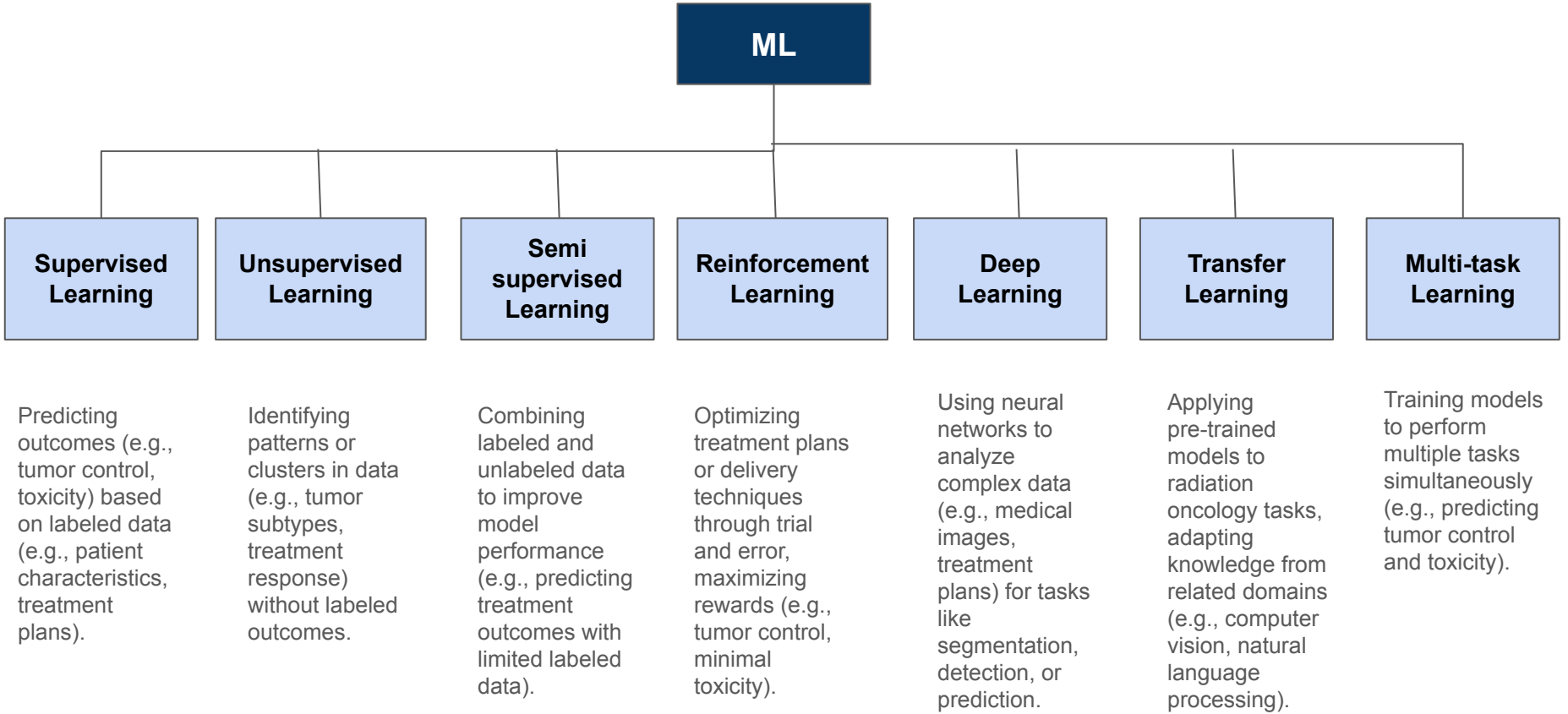
# Augmentation and Enhancement



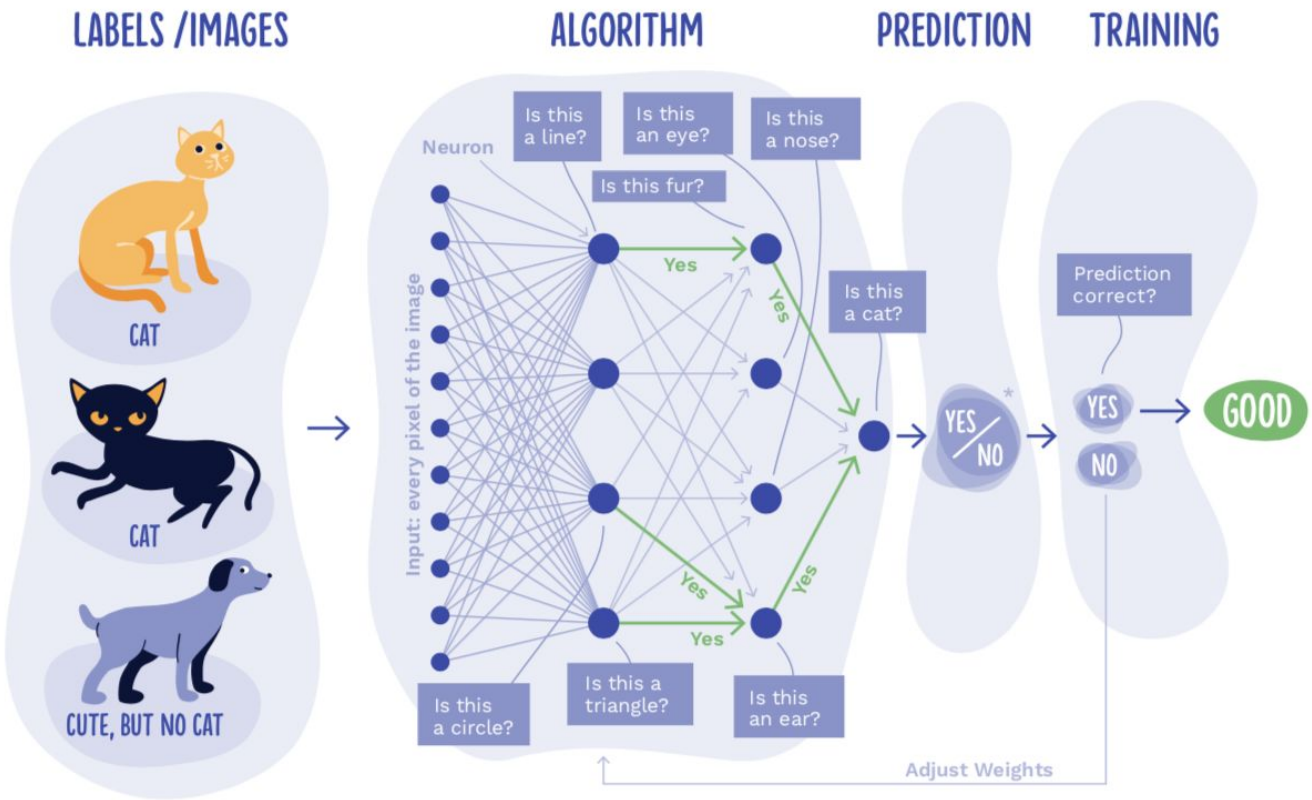



# Pattern Recognition

# Types of ML


ML
Supervised Learning
Unsupervised Learning
Semi supervised Learning
Reinforcement Learning
Deep Learning
Transfer Learning
Multi-task Learning
Predicting outcomes (e.g., tumor control, toxicity) based on labeled data (e.g., patient characteristics, treatment plans).
Identifying patterns or clusters in data (e.g., tumor subtypes, treatment response) without labeled outcomes.
Combining labeled and unlabeled data to improve model performance (e.g., predicting treatment outcomes with limited labeled data).
Optimizing treatment plans or delivery techniques through trial and error, maximizing rewards (e.g., tumor control, minimal toxicity).
Using neural networks to analyze complex data (e.g., medical images, treatment plans) for tasks like segmentation, detection, or prediction.
Applying pre-trained models to radiation oncology tasks, adapting knowledge from related domains (e.g., computer vision, natural language processing).
Training models to perform multiple tasks simultaneously (e.g., predicting tumor control and toxicity).

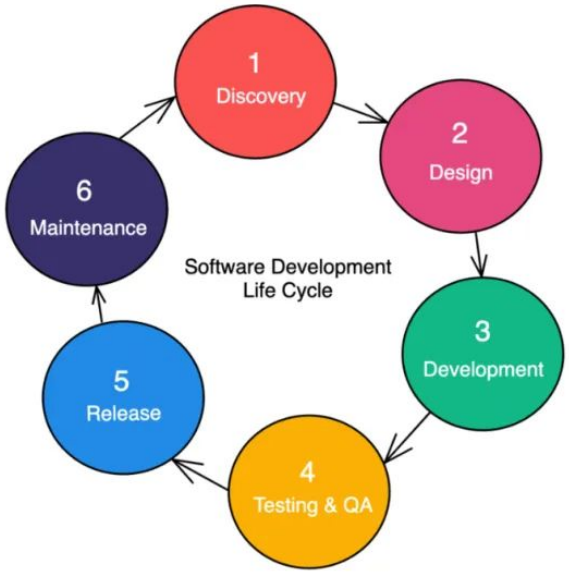
# Deep Learning Basics



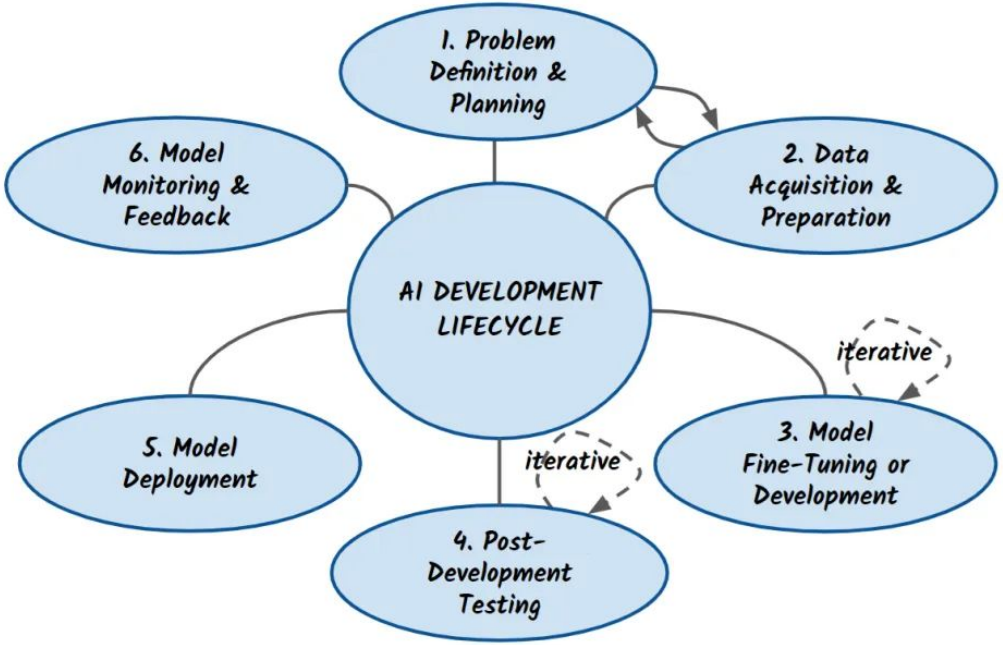
# Introduction to AI Development Process

Data Preprocessing
Feature Extraction

# SDLC Vs AI Development

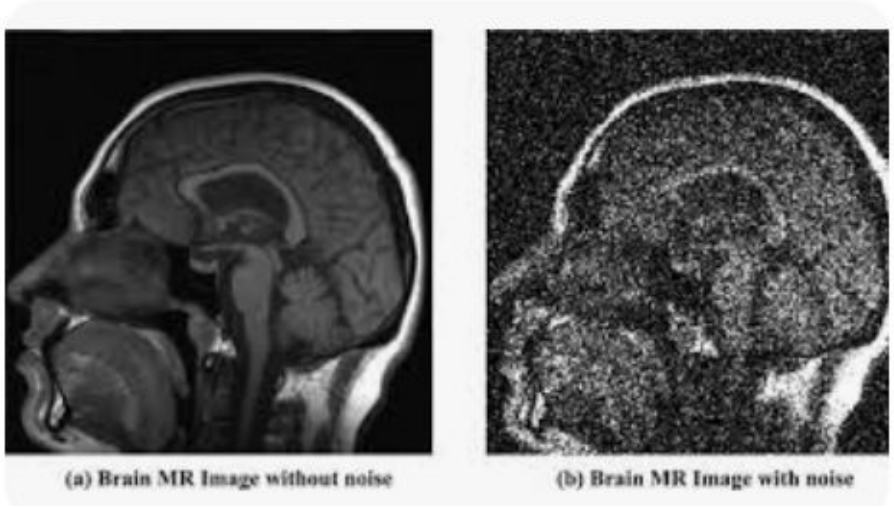



Traditional software development lifecycle. Source: https://www.couchbase.com/




The AI Development Lifecycle, Source: The Business Case for AI.

# What are the issues with raw imaging data?



(a) Brain MR Image without noise (b) Brain MR Image with noise

## Noise

- Quantum Noise
- Electronic Noise
- Thermal Noise
- Patient Factors
- Image Acquisition


## Artifacts

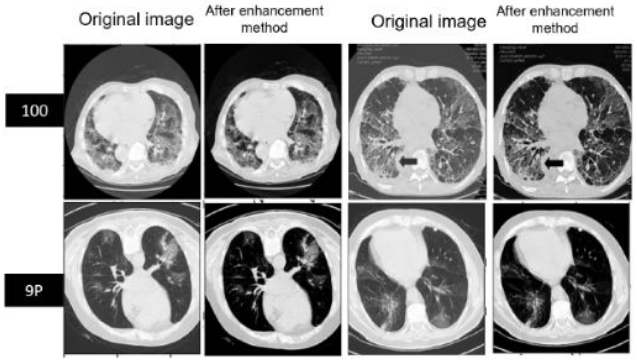
- Metal Artifacts
- Motion artifacts
- Beam hardening artifacts
- Ring artifacts
- Magnetic field
- Image noise or grain
- Reconstruction artifacts

# What happens without data pre-processing?

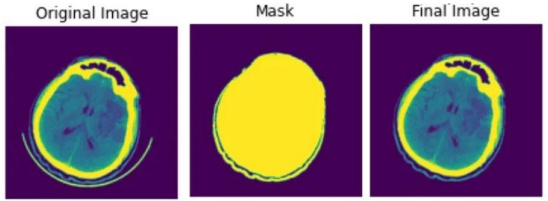
1. Inaccurate results due to noise and artifacts
2. Higher incidence of false positives/negatives
3. Inefficient analysis leading to wasted computational cost
4. Outliers leading to over or under fitting
5. Lack of standardization
6. Regulatory non-compliance

# How to do imaging data pre-processing?

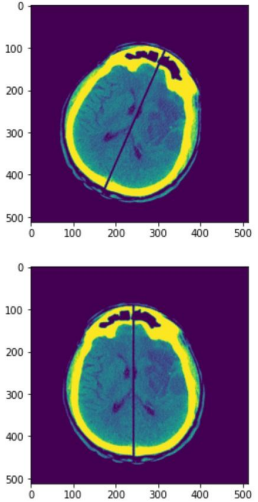
**Transforming to Hounsfield-unit - HU**



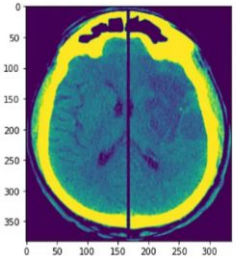

**Removing Noise**




**Tilt Correction**



**Cropping and Padding**



**Source** - https://www.researchgate.net/figure/Hounsfield-unit-HU-before-enhancing-the-contrast-and-normalized-A-HU-of-MedSeg_fig4_370650442

# Feature engineering with imaging data

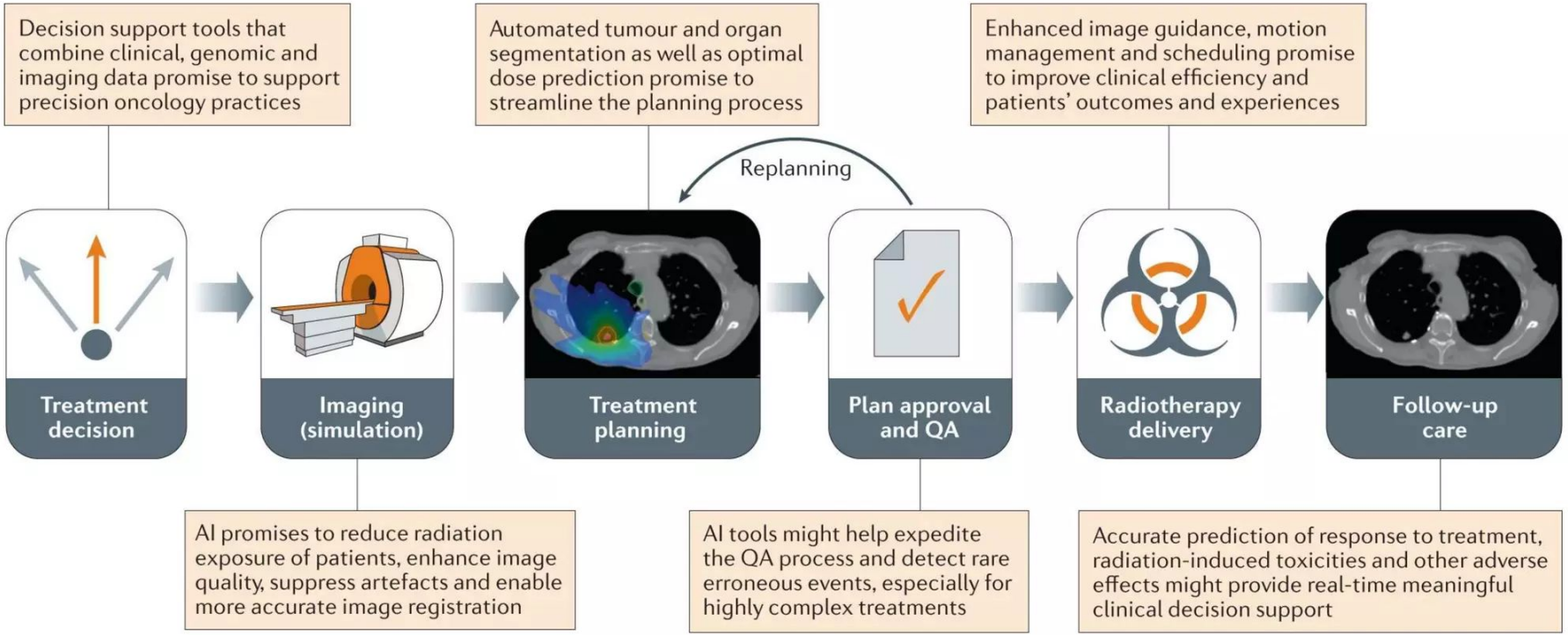
"feature engineering in radiology images involves extracting relevant information from images to create new features that can be used to improve model performance, diagnosis, or analysis"

- **Shape and size features:** Area, perimeter, diameter, and volume.
- **Intensity features:** Mean, median, mode, and standard deviation.
- **Texture features:** Gabor filters or Haralick features.
- **Segmentation features:** Tumor size or shape.
- **Spatial features:** Relationships between different regions or structures.
- **Frequency features:** Fourier transform.
- **Deep learning features:** Use convolutional neural networks (CNNs) to learn features from images.

# Why do we need feature extraction?

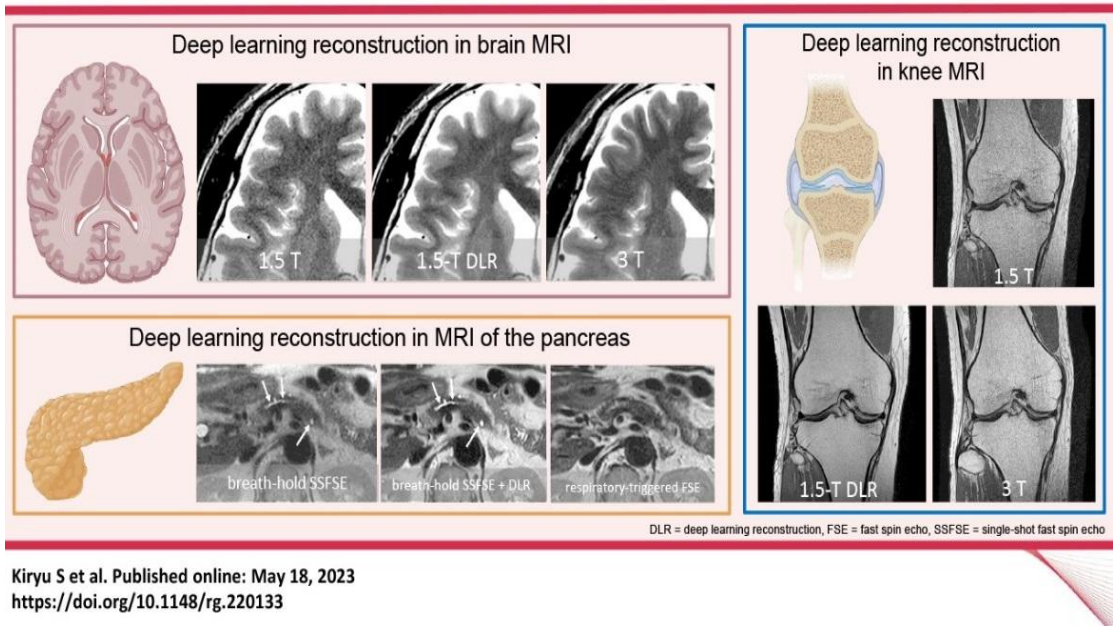
| | |
|---|---|
| 01 | Improve Model Performance |
| 02 | Lessen computation cost |
| 03 | Improve model interpretability |

# AI in Radiation Oncology




Huynh et al. Nat Rev Clin Oncol 2020

# Deep Learning Reconstruction

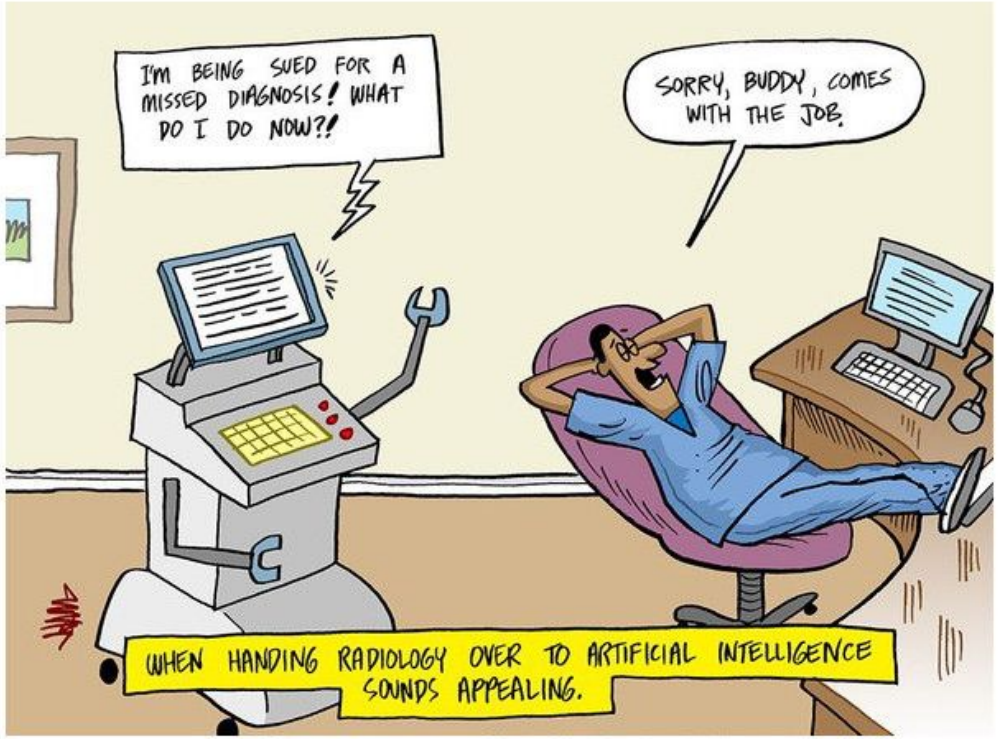



Kiryu S et al. Published online: May 18, 2023
https://doi.org/10.1148/rg.220133

- Cone-beam artifacts
- Motion artifacts
- Truncation artifacts
- Noise

**Filtered back-projection (FBP) / Iterative or Model based reconstruction Vs DLR**

# Thanks!


I'm BEING SUED FOR A MISSED DIAGNOSIS! WHAT DO I DO NOW?!
SORRY, BUDDY, COMES WITH THE JOB.
WHEN HANDING RADIOLOGY OVER TO ARTIFICIAL INTELLIGENCE SOUNDS APPEALING.

# References

Joshi, G., Jain, A., Shalini Reddy Araveeti, Adhikari, S., Garg, H. and Bhandari, M. (2024). FDA-Approved Artificial Intelligence and Machine Learning (AI/ML)-Enabled Medical Devices: An Updated Landscape. *Electronics*, 13(3), pp.498–498. doi:https://doi.org/10.3390/electronics13030498.

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