Revolution in Oncology: Artificial Intelligence and Precision Medicine

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Artificial Intelligence (AI)

- **Definition**
- Simulation of human intelligence using algorithms and systems
- Capable of learning, reasoning, and decision-making

- **History**
- 1950s: Early algorithms and concept introduction
- 1980s-1990s: Neural networks & deep learning emergence
- 2000s onwards: Medical applications

- **AI in Medicine**
- Disease diagnosis
- Treatment prediction and optimization
- Clinical data management

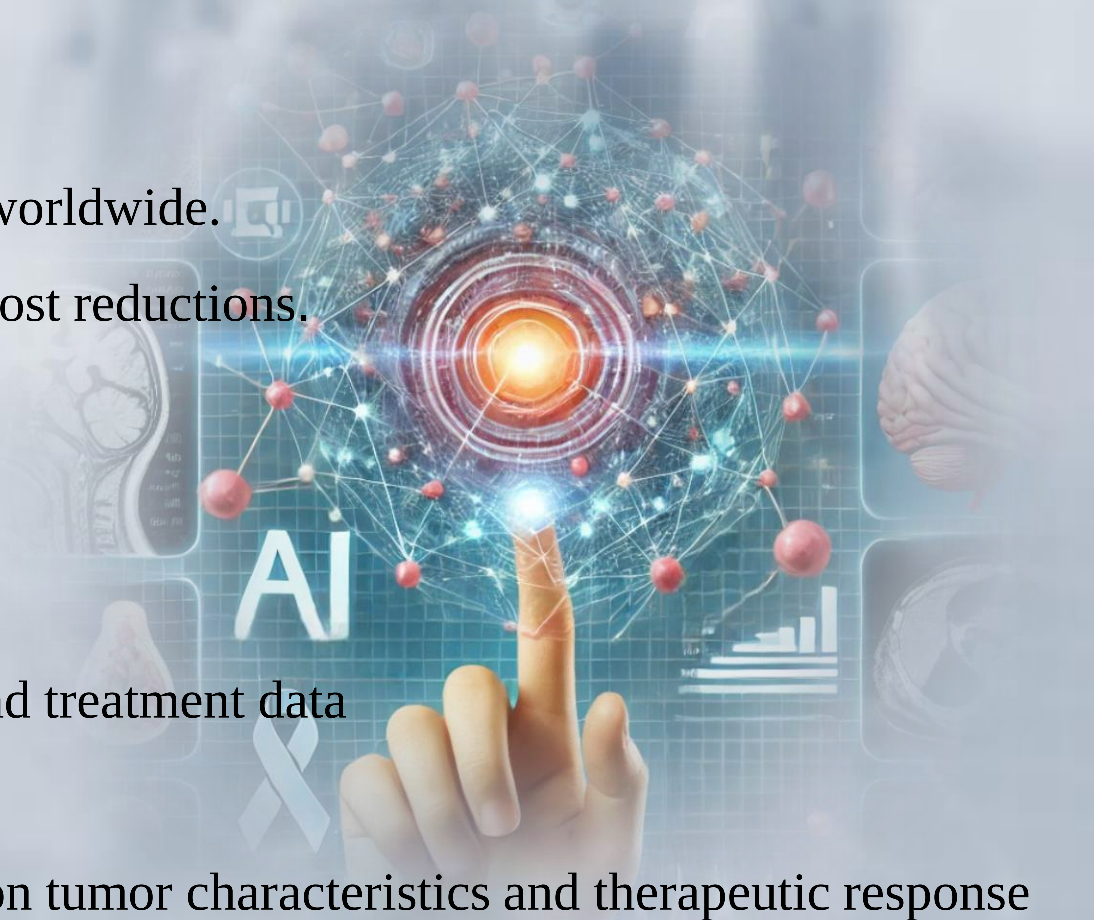
AI in Oncology

➢ Why AI is Crucial in Oncology ?

- **Global Impact :** Cancer is the second leading cause of death worldwide.
- **Clinical Challenges :** Faster diagnoses, effective treatments, cost reductions.

➢ Contributions of AI in Oncology

- **Application in Diagnosis :** Tumor detection in MRI, CT, PET
- **Complex Data Management :** Integrating genetic, clinical, and treatment data
- **Outcome Prediction :** Forecast patient survival
- **Personalized Treatment :** Optimizing treatment plans based on tumor characteristics and therapeutic response



Machine Learning (ML)

- **Machine learning is a branch of AI focused on building computer systems that learn from data to identify patterns and make predictions.**

- **Stages of Machine Learning in Oncology:**

1.Data Collection:
Gathering large datasets (images, clinical reports, genomic data).
2.Data Preprocessing:
Cleaning, normalizing, and labeling data for better accuracy.
3.Model Training:
Using algorithms (SVM, DT, ANN) to learn from data.
4.Model Testing:
Validating the model with unseen data.
5.Deployment & Monitoring:
Applying the trained model in clinical practice and monitoring its performance.

Types of Machine Learning

1. Supervised Learning

•**Definition:** Models learn from labeled data.

•**How it works:** Identifies relationships between inputs and outputs to make predictions.

•**Examples in Oncology:** Classifying tumors as benign or malignant using MRI data.

2. Unsupervised Learning

•**Definition:** Models work with unlabeled data to discover hidden patterns or structures.

•**How it works:** Groups similar data points or uncovers correlations.

•**Examples in Oncology:** Clustering cancer patients based on genetic profiles.

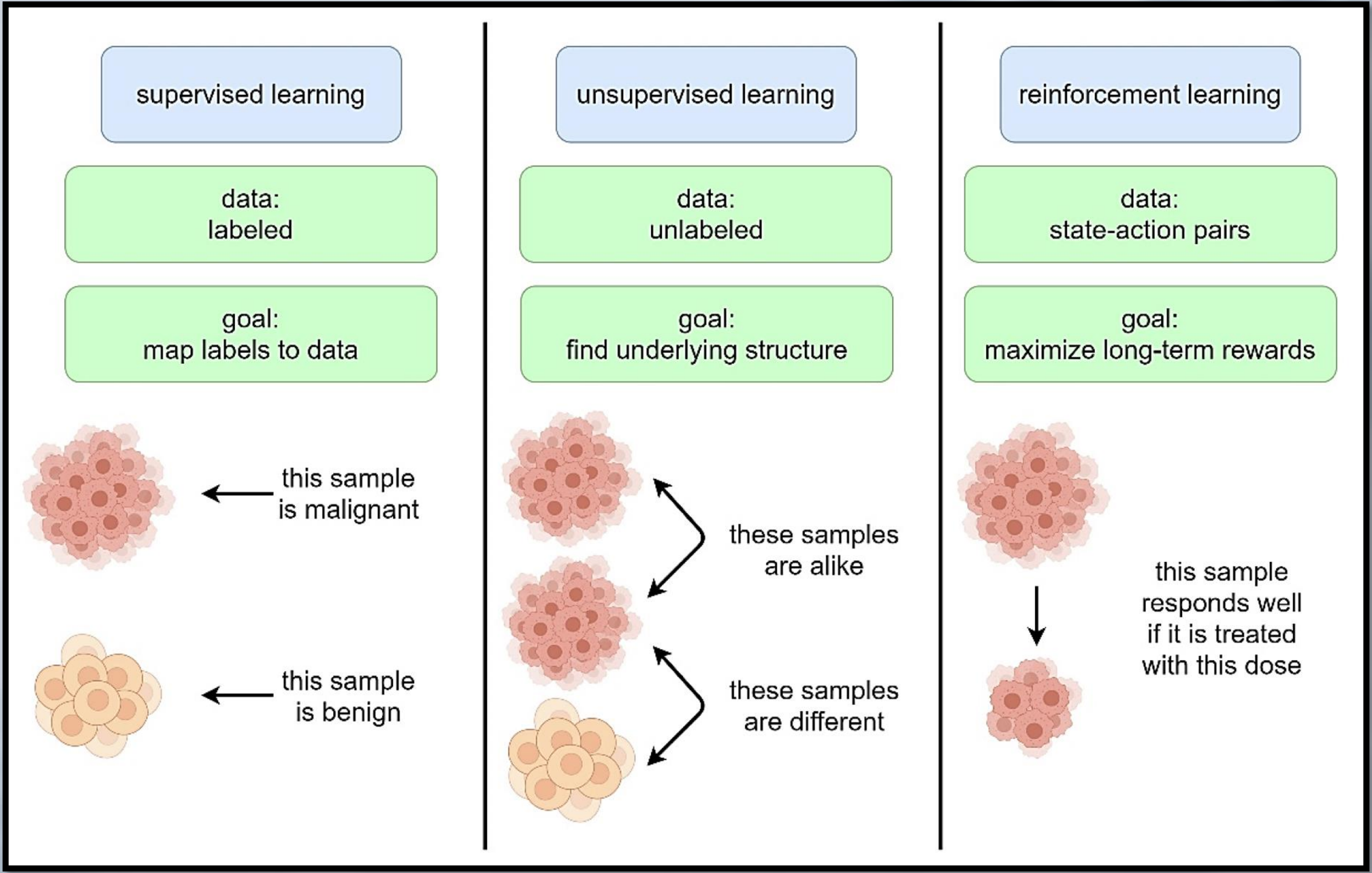
3. Reinforcement Learning

•**Definition:** Models learn through interaction with the environment.

•**How it works:** Optimizes decision-making strategies by trial and error.

•**Examples in Oncology:** Developing optimal radiotherapy treatment plans.

Types of Machine Learning

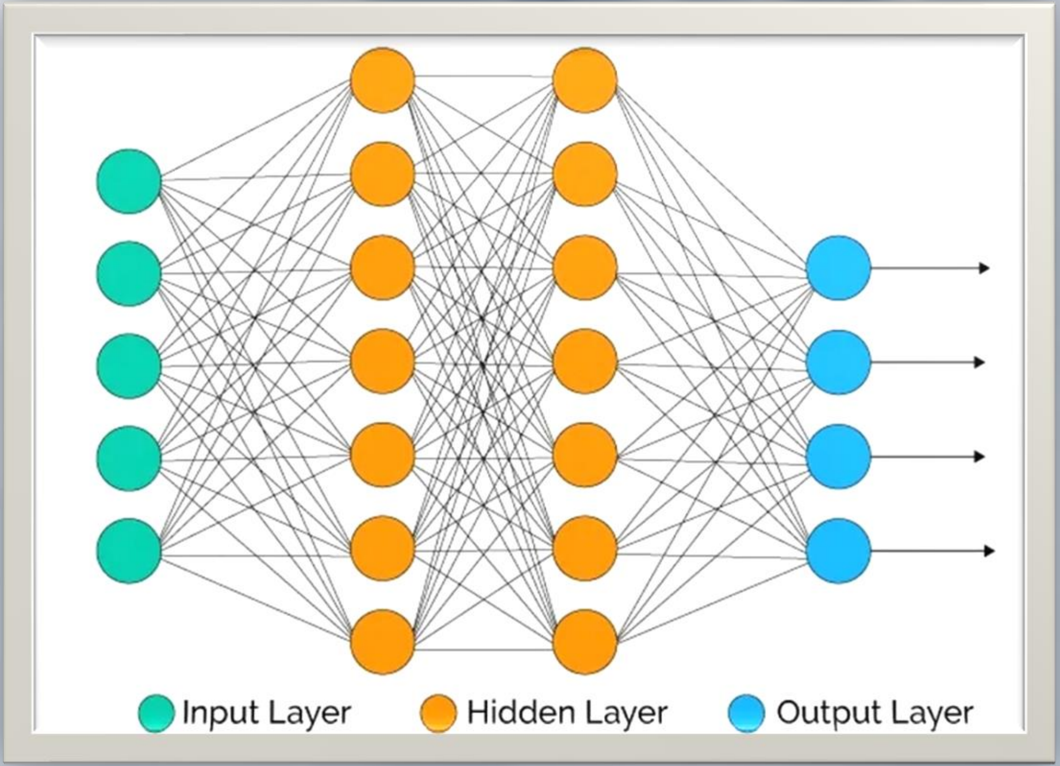


Deep Learning (DL)

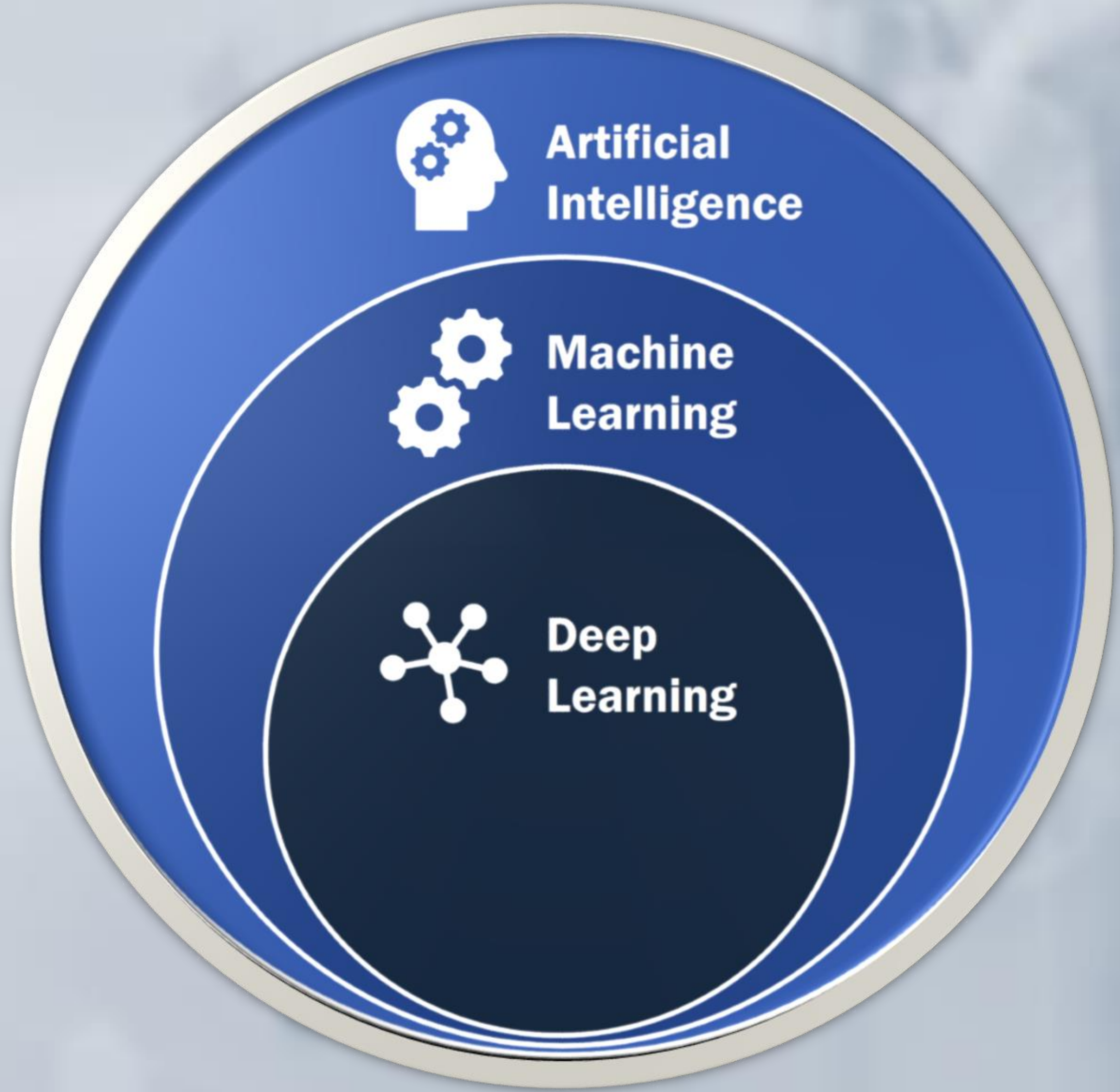
- **Deep Learning is a subset of ML using layered neural networks to handle complex data.**

- **Key Components of Deep Learning :**
  - **Input Layer:** Receives raw data
  - **Hidden Layers:** Processes data through multiple layers of neurons.
  - **Output Layer:** Provides predictions or classifications.

- **Key Features of Deep Learning :**
  - **Automated Feature Extraction**
  - **Handles Complex Data**
  - **High Prediction Accuracy**



The Evolution of AI



Radiomics

- **Radiomics** is an emerging machine learning method that can extract numerical data reflecting biologically important tissue characteristics from medical imaging information.

- **Quantitative features** describe the intensity, texture and geometrical characteristics attributed to the tumor radiographic data.

- These features have been used to build **predictive models** for diagnosis, prognosis, and therapeutic response.

The Importance of Radiomics

1) **Non-invasive :** Provides critical information without the need for biopsy or surgery

2) **Comprehensive :** Allows for a deeper understanding of tumor heterogeneity by analyzing vast amounts of data from medical images.

3) **Cost-Effectiveness :** Radiomics leverages existing medical imaging data, reducing additional testing costs.

4) **Personalized Treatment :** Facilitates the development of personalized treatment plans based on the specific characteristics of a patient's tumor.

Clinical Applications of AI in Oncology

Early Cancer Detection

Radiation Therapy Planning

Predicting Treatment Response

Predicting Survival Outcomes

Tumor Grading Classification

AI in Early Detection of Prostate Cancer

Definition: Early detection of cancer involves identifying malignancies at an initial stage when treatment is more likely to be successful.

Application: In prostate cancer, AI algorithms increase the accuracy and efficiency of early cancer detection by analyzing image data from MRI scans.

Importance: Early detection significantly improves patient outcomes and survival rates.

Findings:

1) AUC: 0.96 for cancer vs. benign.
2) AUC: 0.85 for high-risk vs. low-risk cases.

AI-Optimized Radiation Therapy Planning in Lung Cancer

Definition: Radiation therapy planning designs optimal radiation doses to target lung tumors while sparing healthy tissues, with AI automating tumor identification and dose optimization.

Application: Tumor Segmentation - Dose Optimization

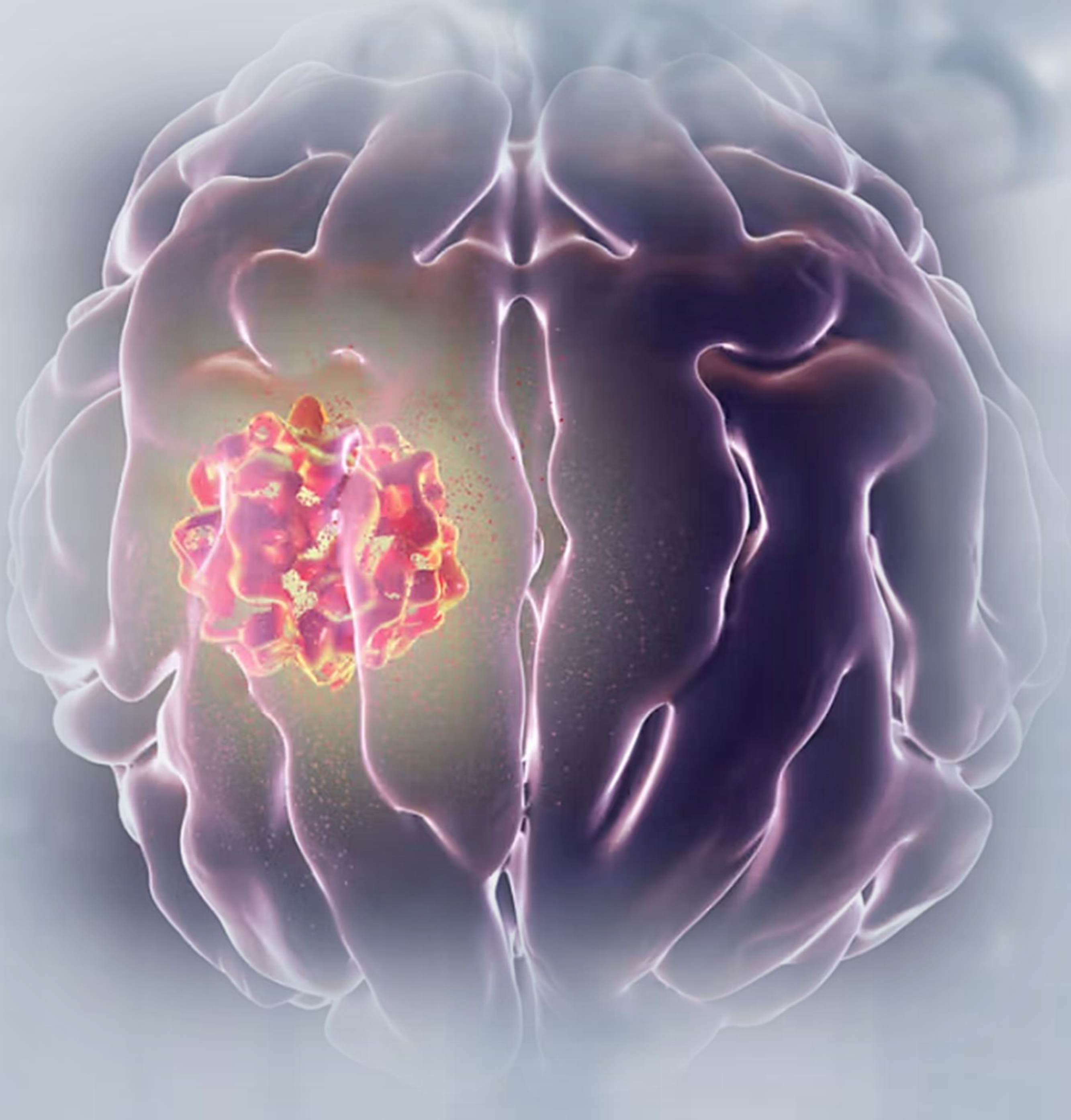
Importance:

- Ensures precise tumor targeting, improving treatment effectiveness.
- Reduces radiation exposure to healthy lung tissues, minimizing side effects.

Findings:

1) AI achieves up to 92% accuracy in segmenting lung tumors from CT scans.
2) AI improves radiation dose coverage by up to 85%, minimizing damage to healthy tissues.

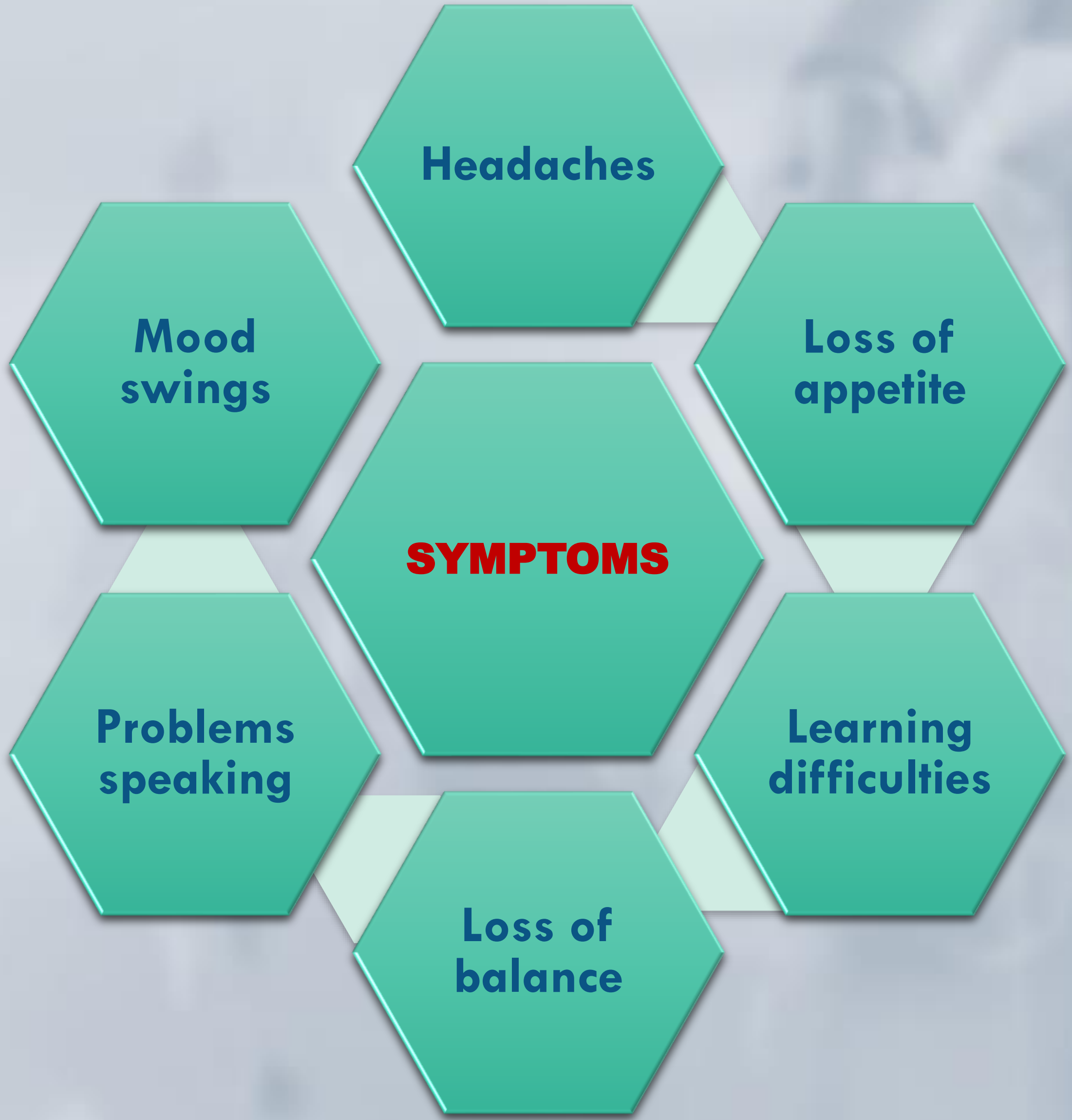
Radiomics Features in Glioblastoma Patients



INTRODUCTION

- Glioblastoma multiforme (GBM) is the most common primary malignant brain tumor in adults and most aggressive tumor.
- Brain tumors are graded on a I to IV scale (slow to fast grow).
- GBM is a grade IV Tumor that develops from star-shaped glial cells (astrocytes)
- Glioblastoma accounts for 20% of all intracranial tumors and 60% of astrocytic tumors.
- Most common in older patients (45-55y) and more common in men than women.

SYMPTOMS


Headaches
Loss of appetite
Learning difficulties
Loss of balance
Problems speaking
Mood swings
SYMPTOMS

DIAGNOSIS

❖ Neurological exam 

- A patient with any neurological symptoms will first be given a physical exam that includes neurologic function tests.

❖ Removing a sample of tissue for testing (Biopsy) 

- A biopsy can be done with a needle before surgery to remove tissue of tumor .
- The sample of suspicious tissue is analyzed in a laboratory to determine the types of cells and their level of aggressiveness.

❖ Imaging tests 

- MRI and CT scans produce detailed images of the brain (Location & Size,…).

PROGNOSIS

- **Patients have exhibited poor prognosis with a median survival of 12–15 months despite radiation therapy.**
- **Several prognostic factors influence the survival of patients with GBM, including clinical characteristics , molecular characteristics and characteristics of MRI.**
- **Poor prognosis → Due to the spatial and temporal intra-tumor heterogeneity.**
- **Genetic heterogeneity → Reduces the value of invasive biopsy-based genomic analysis**
  → Provides opportunities for non-invasive medical imaging (MRI)

ADVANTAGES OF RADIOMICS

1. **Automatic extraction of radiomics features and offers abundant data relative to qualitative analyses.**

2. **Promising approach for assisting in developing individual treatment strategies in oncology.**

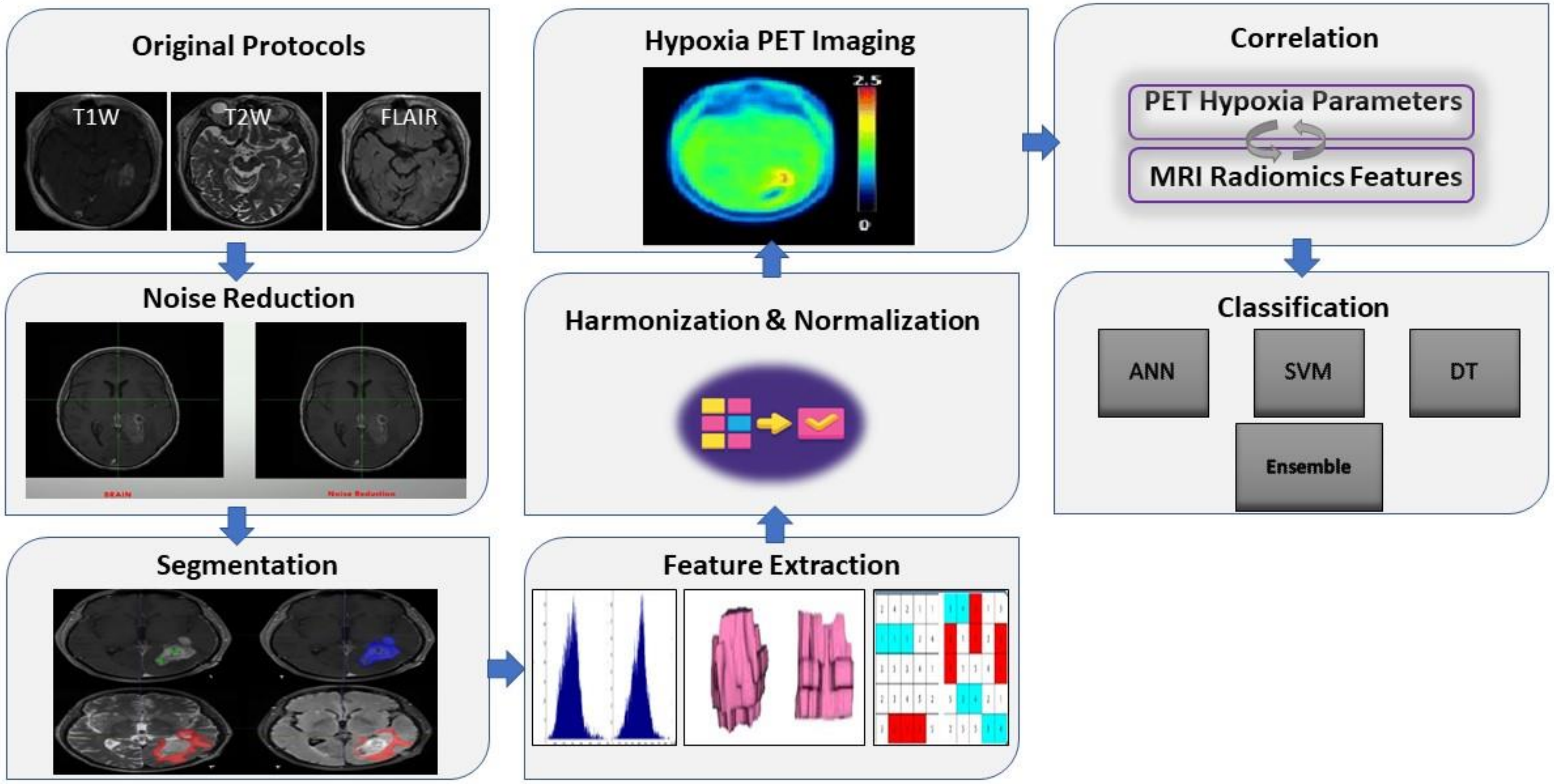
Progress of Radiomics in GBM

1) **Predict the overall survival**

2) **Discrimination between pseudoprogression and progressive disease in GBM patients**

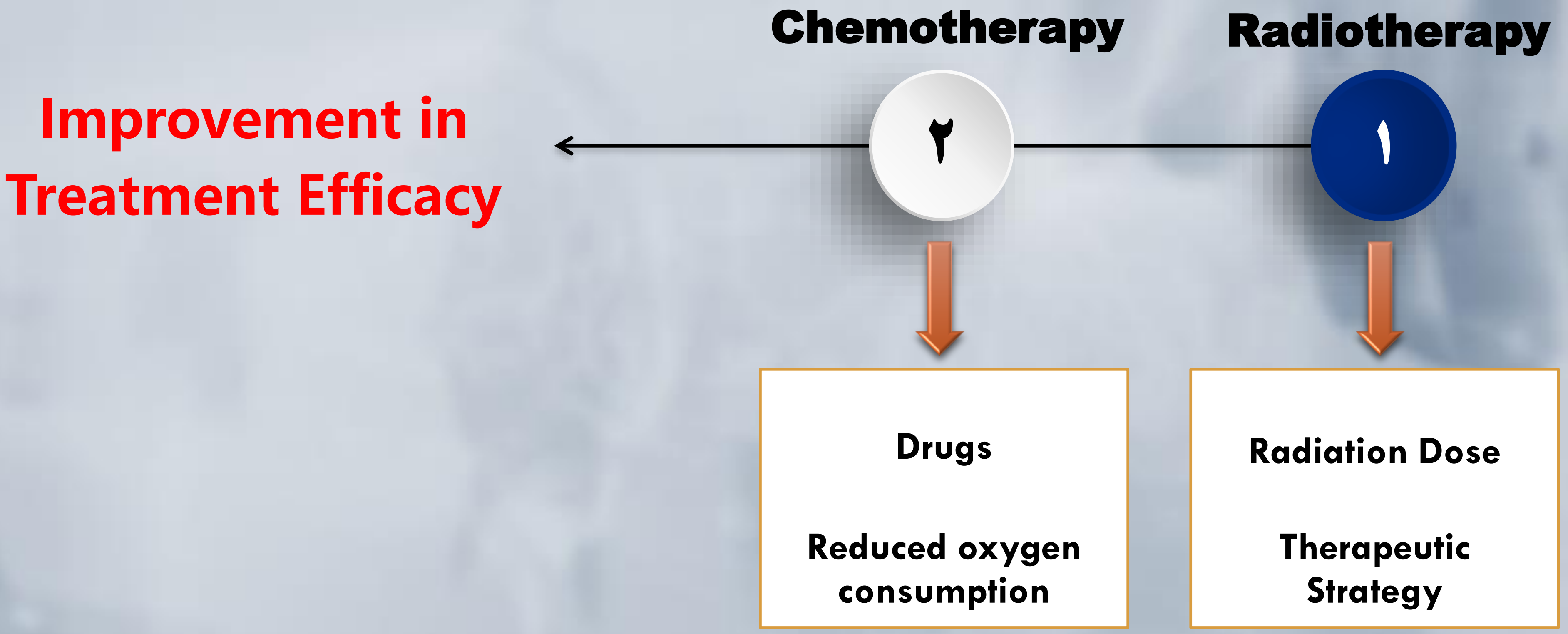
3) **Classification of GBM**

Workflow



Original Protocols
T1W
T2W
FLAIR
Noise Reduction
Segmentation
Hypoxia PET Imaging
2.5
0
Harmonization & Normalization
Feature Extraction
Correlation
PET Hypoxia Parameters
MRI Radiomics Features
Classification
ANN
SVM
DT
Ensemble

Clinical Significance of the Study



CONCLUSION

Radiomics Studies
- Prediction
- Prognostication
- Classification

Future Radiomics
- Radiogenomics

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Thank you
for your attention!