Artificial Intelligence and Machine Learning in Medical Sciences

نسیبه رادی راز

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بسم الله الرحمن الرحیم

دانشگاه علوم پزشکی و خدمات بهداشتی درمانی ایران

عنوان دوره آنلاین:

هوش مصنوعی در پزشکی با رویکرد بالینی

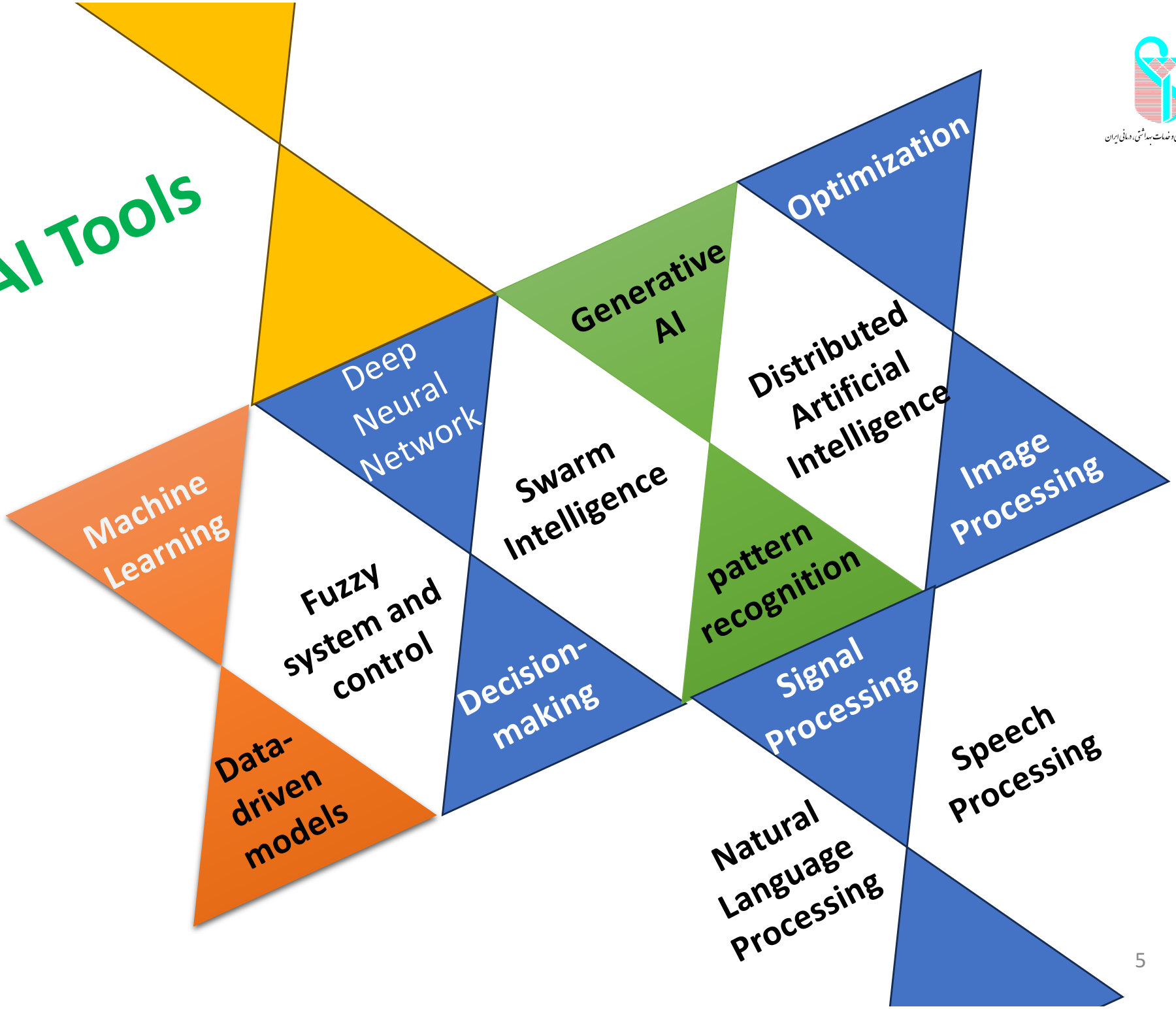
Online Course: Artificial Intelligence in Medicine with Clinical Approach

Course Topics	عناوین بیست و چهار جلسه	تاریخ جلسات
Artificial Intelligence (AI) in medicine	معرفی هوش مصنوعی در پزشکی	۲۸بهمن ۱۴۰۲
AI and Fuzzy systems and its applications in medicine	هوش مصنوعی و سیستم های فازی در پزشکی	۵ اسفند ۱۴۰۲
Machine Learning and its applications in medicine	یادگیری ماشین و کاربردهای آن در پزشکی	۱۲اسفند۱۴۰۲
Evolutionary systems and its applications in medicine	الگوریتم های بهینه سازی تکاملی و کاربردهای آن در پزشکی	۱۹اسفند ۱۴۰۲
Neural networks and deep neural networks in medicine	شبکه های عصبی و شبکه های عصبی عمیق در پزشکی	۲۵فروردین ۱۴۰۳
Application of AI in Early Detection of Disease	کاربرد هوش مصنوعی در تشخیص زودهنگام بیماری ها	۱ اردیبهشت ۱۴۰۳
Swarm Intelligence and multi-agent/swarm in medicine	هوش ازدحامی، سیستم های چند عامله/ازدحامی در پزشکی	۸اردیبهشت ۱۴۰۳
Application of AI in Cancer	کاربردهای هوش مصنوعی در سرطان	۲۲اردیبهشت ۱۴۰۳
Application of AI in surgery	کاربردهای هوش مصنوعی در جراحی	۲۹ اردیبهشت ۱۴۰۳
Applications of AI in Neurology	کاربردهای هوش مصنوعی در مغز و اعصاب	۵ خرداد ۱۴۰۳
Application of AI in Internal Medicine	کاربردهای هوش مصنوعی در پزشکی داخلی	۱۲ خرداد ۱۴۰۳
Applications of AI in cardiovascular	کاربردهای هوش مصنوعی در قلب و عروق	۱۹ خرداد ۱۴۰۳
Applications of AI in Breast Disease	کاربردهای هوش مصنوعی در بیماری های پستان	۲۶ خرداد ۱۴۰۳
Application of AI in Ophthalmology	کاربردهای هوش مصنوعی در چشم پزشکی	۲ تیر ۱۴۰۳
Application of AI in Nephrology	کاربردهای هوش مصنوعی در نفرولوژی	۹ تیر ۱۴۰۳
Application of AI in Otorhinolaryngology	کاربردهای هوش مصنوعی در گوش و حلق و بینی	۱۶ تیر ۱۴۰۳
Application of AI in Gynecology and obstetrics	کاربردهای هوش مصنوعی در زنان و مامایی	۲۳ تیر ۱۴۰۳
Application of AI in pediatric medicine	کاربردهای هوش مصنوعی در پزشکی اطفال	۳۰ تیر ۱۴۰۳
Application of AI in anesthesia	کاربردهای هوش مصنوعی در بیهوشی	۶ مرداد ۱۴۰۳
Application of AI in emergency medicine	کاربردهای هوش مصنوعی در پزشکی اورژانس	۱۳ مرداد ۱۴۰۳
Applications of artificial intelligence in orthopedics	کاربردهای هوش مصنوعی در ارتوپدی	۲۰ مرداد ۱۴۰۳
Application of AI in pain management	کاربردهای هوش مصنوعی در مدیریت درد	۲۷ مرداد ۱۴۰۳
Application of AI in pharmacology	کاربردهای هوش مصنوعی در داروسازی	۳ شهریور ۱۴۰۳
Application of AI in dentistry	کاربردهای هوش مصنوعی در دندان پزشکی	۱۰ شهریور ۱۴۰۳

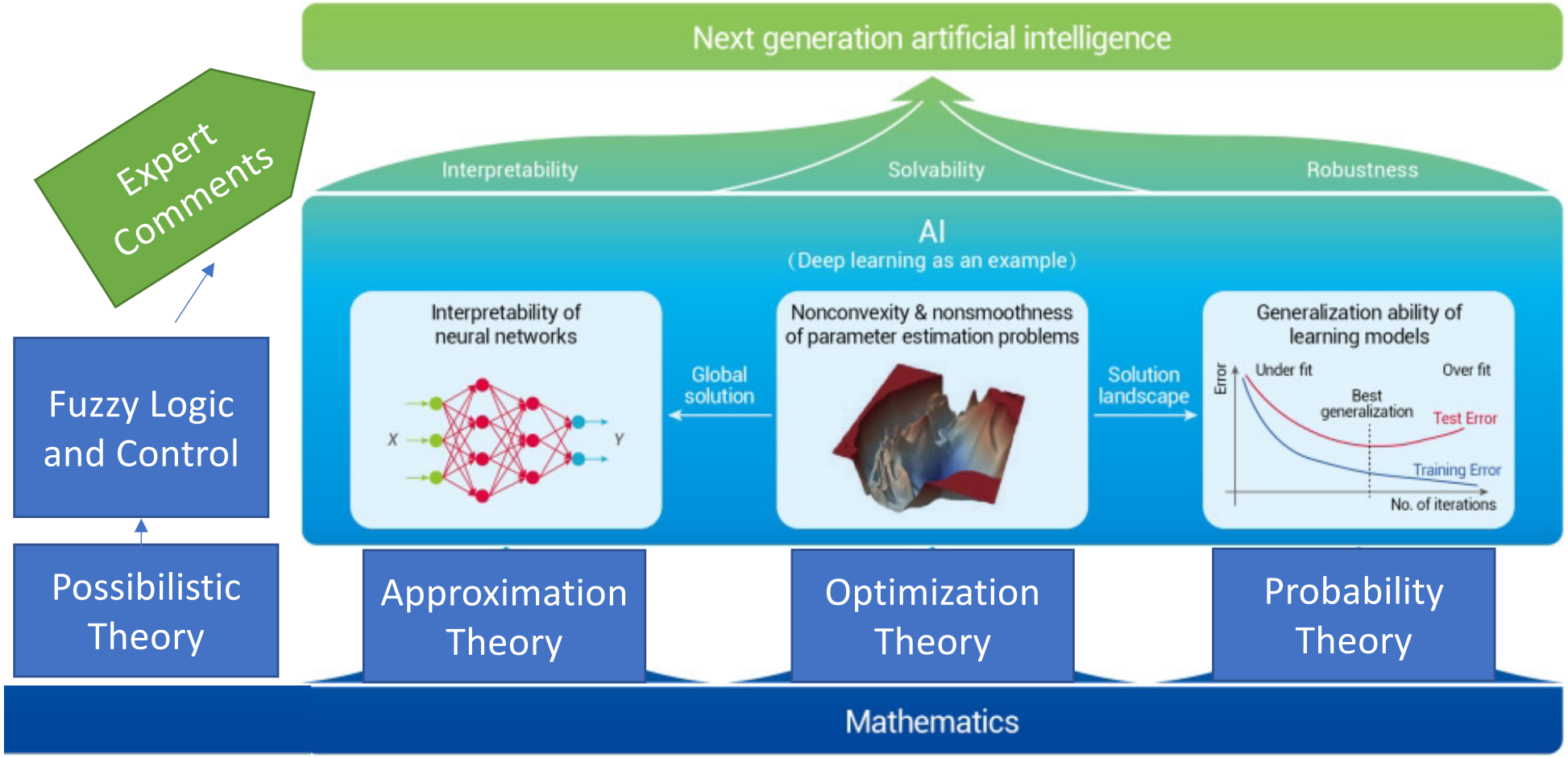
Artificial Intelligence

AI is a multidisciplinary field of study dealing with intelligence, perceiving, and inferring information by machines.

Narrow AI: is used to solve a specific problem.
General AI: is used for solving general problems.
Super AI: Nobody knows what will happen.


AI Tools
Optimization
Generative AI
Deep Neural Network
Distributed Artificial Intelligence
Machine Learning
Swarm Intelligence
Image Processing
pattern recognition
Fuzzy system and control
Decision-making
Signal Processing
Data-driven models
Speech Processing
Natural Language Processing

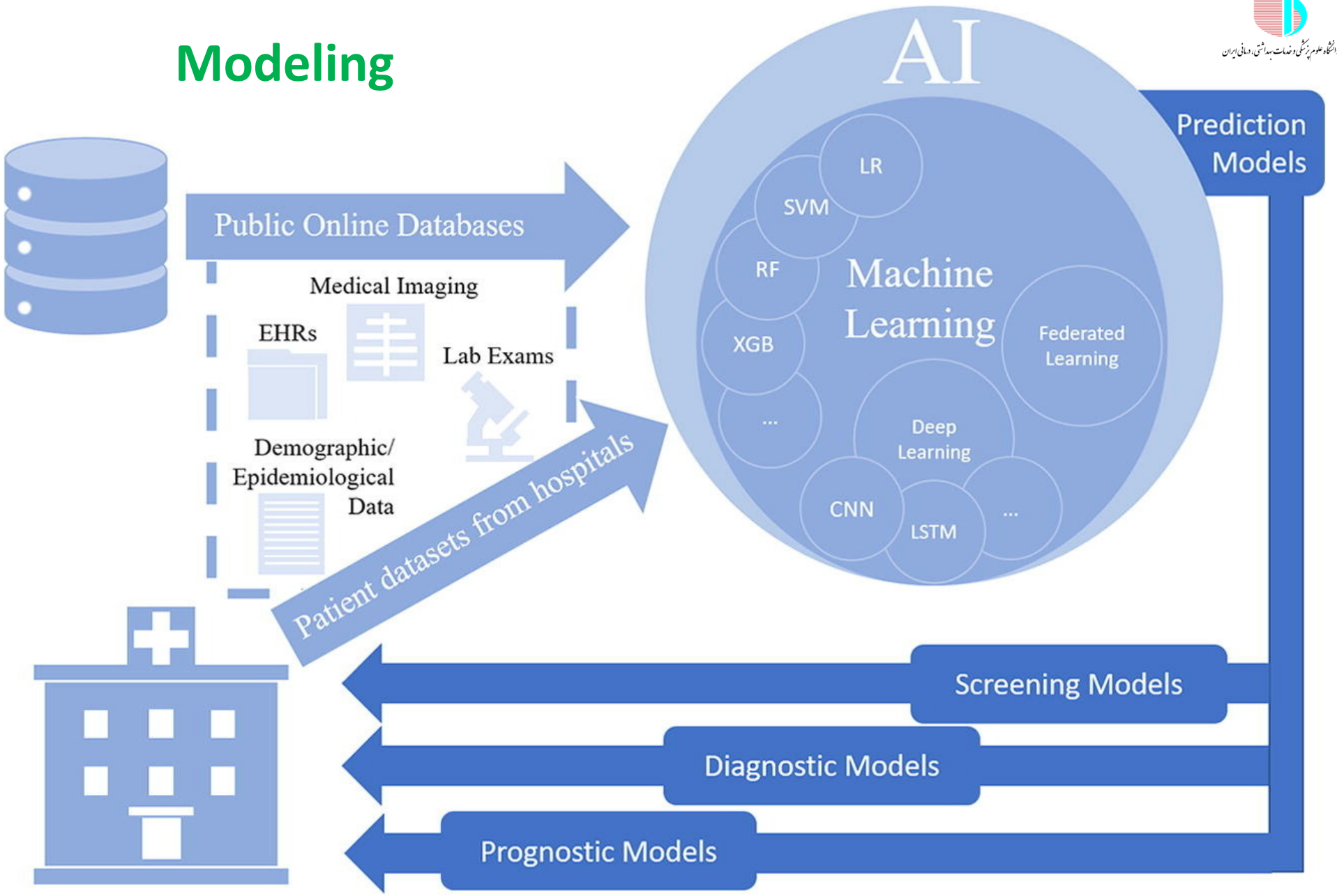
Artificial Intelligence

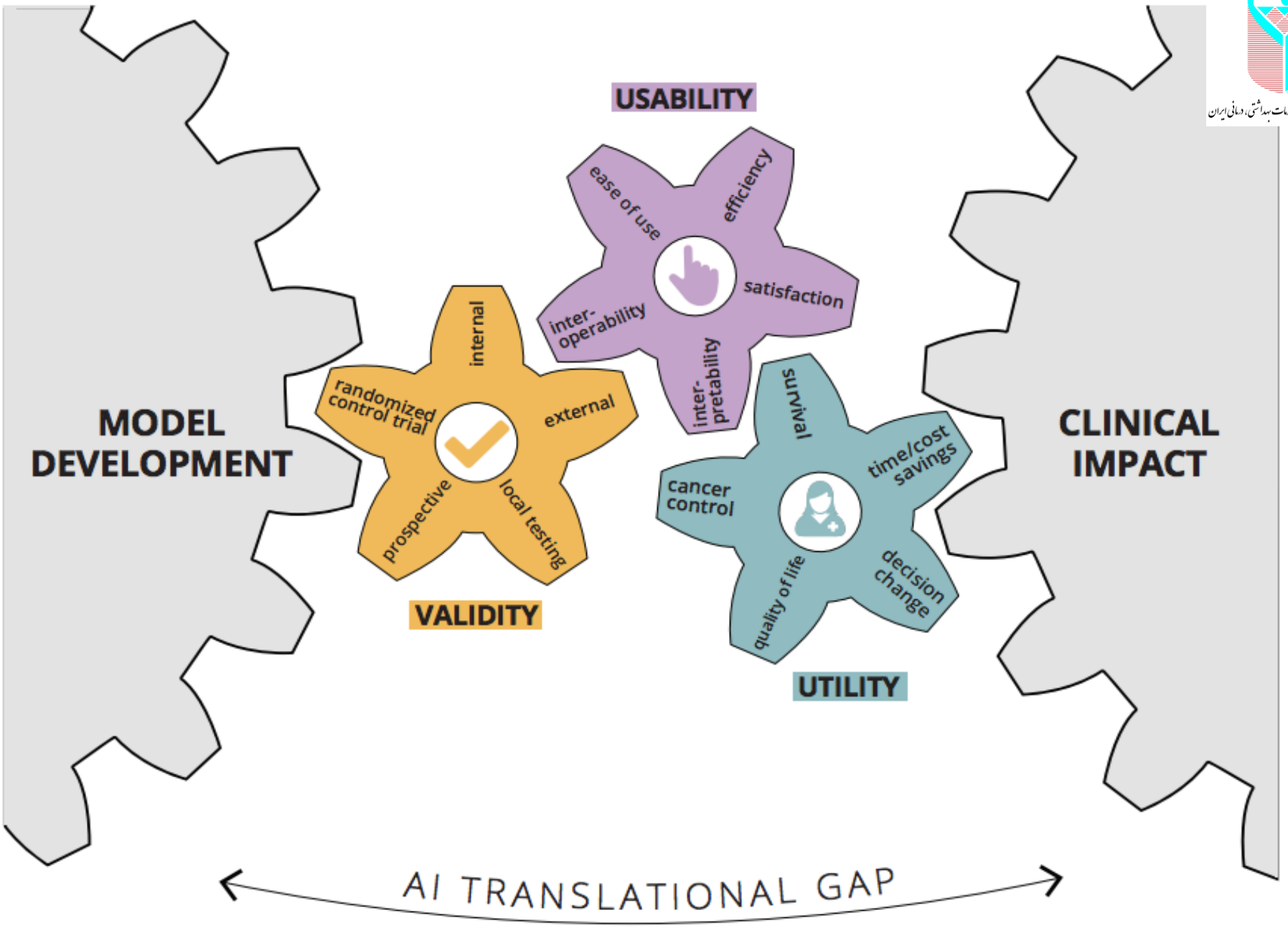


Aspect of Intelligence

- Generalization
- learning/adapting
- Optimization
- Social Interaction
- Cognition

Modeling


AI
Prediction Models
LR
SVM
RF
XGB
...
Machine Learning
Federated Learning
Deep Learning
CNN
LSTM
...
Public Online Databases
Medical Imaging
EHRs
Lab Exams
Demographic/ Epidemiological Data
Patient datasets from hospitals
Screening Models
Diagnostic Models
Prognostic Models


MODEL DEVELOPMENT
CLINICAL IMPACT
USABILITY
ease of use
efficiency
satisfaction
inter-operability
inter-pretability
VALIDITY
internal
external
randomized control trial
prospective
local testing
UTILITY
survival
time/cost savings
decision change
quality of life
cancer control
AI TRANSLATIONAL GAP

Machine Learning

In ML machine learn from data without being explicitly programmed.

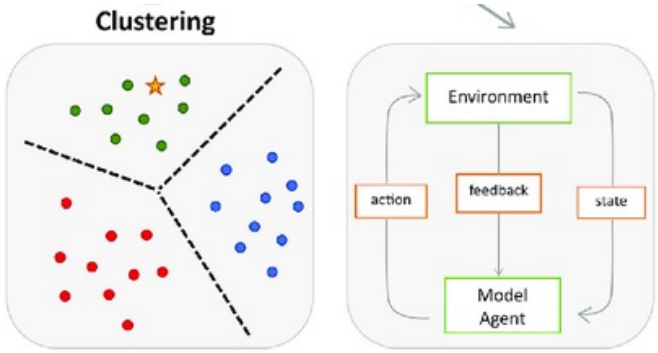
ML claims to save time, money, and effort

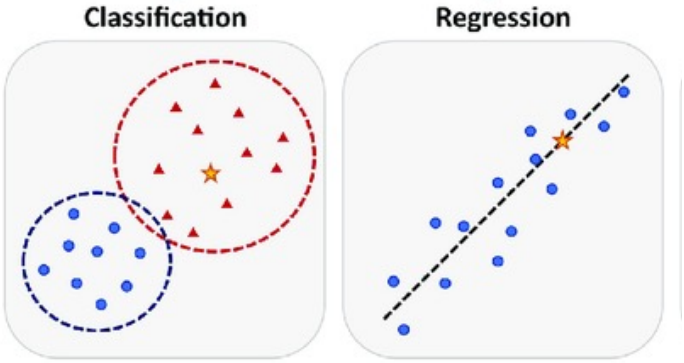
Unsupervised learning

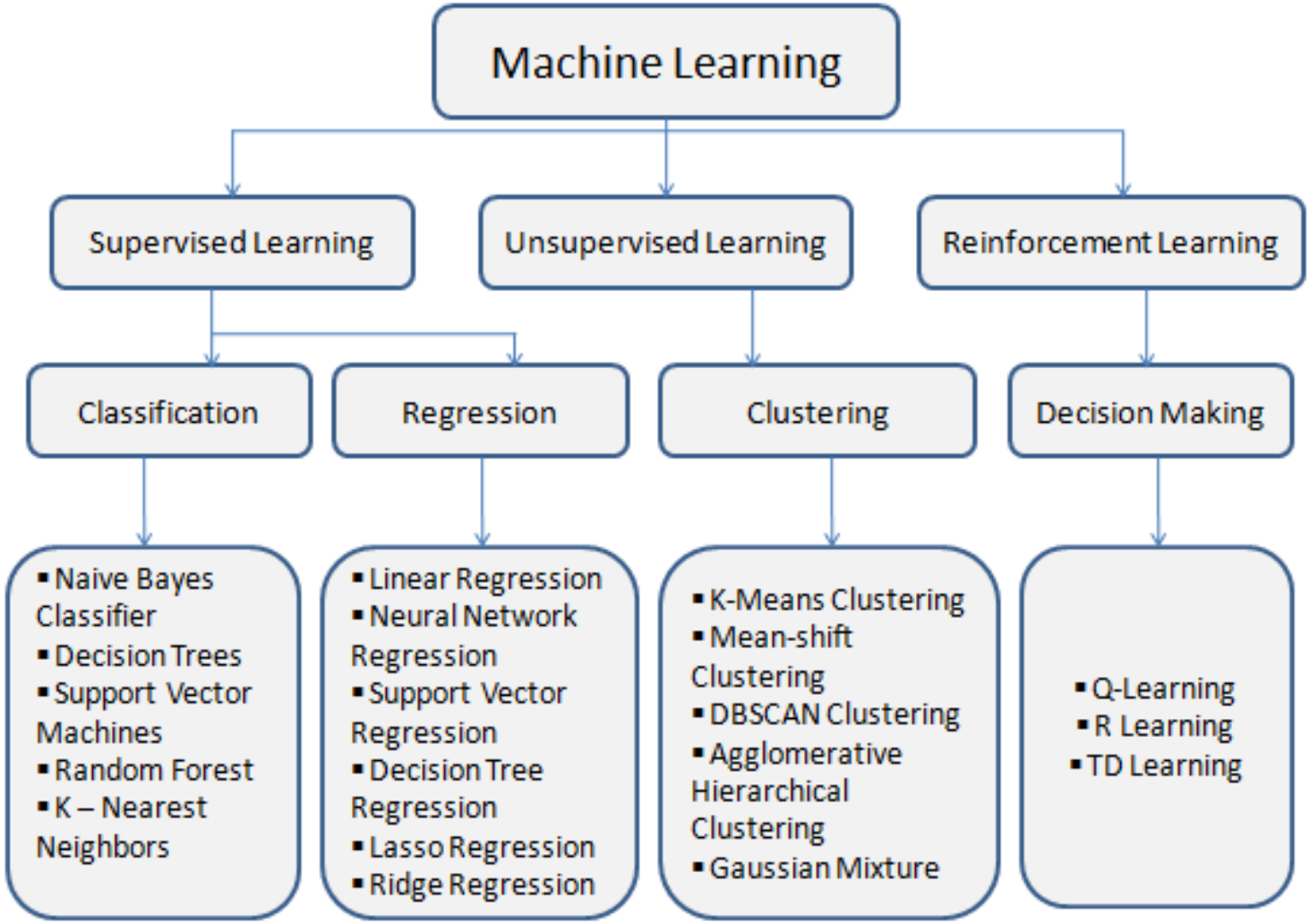
supervised learning

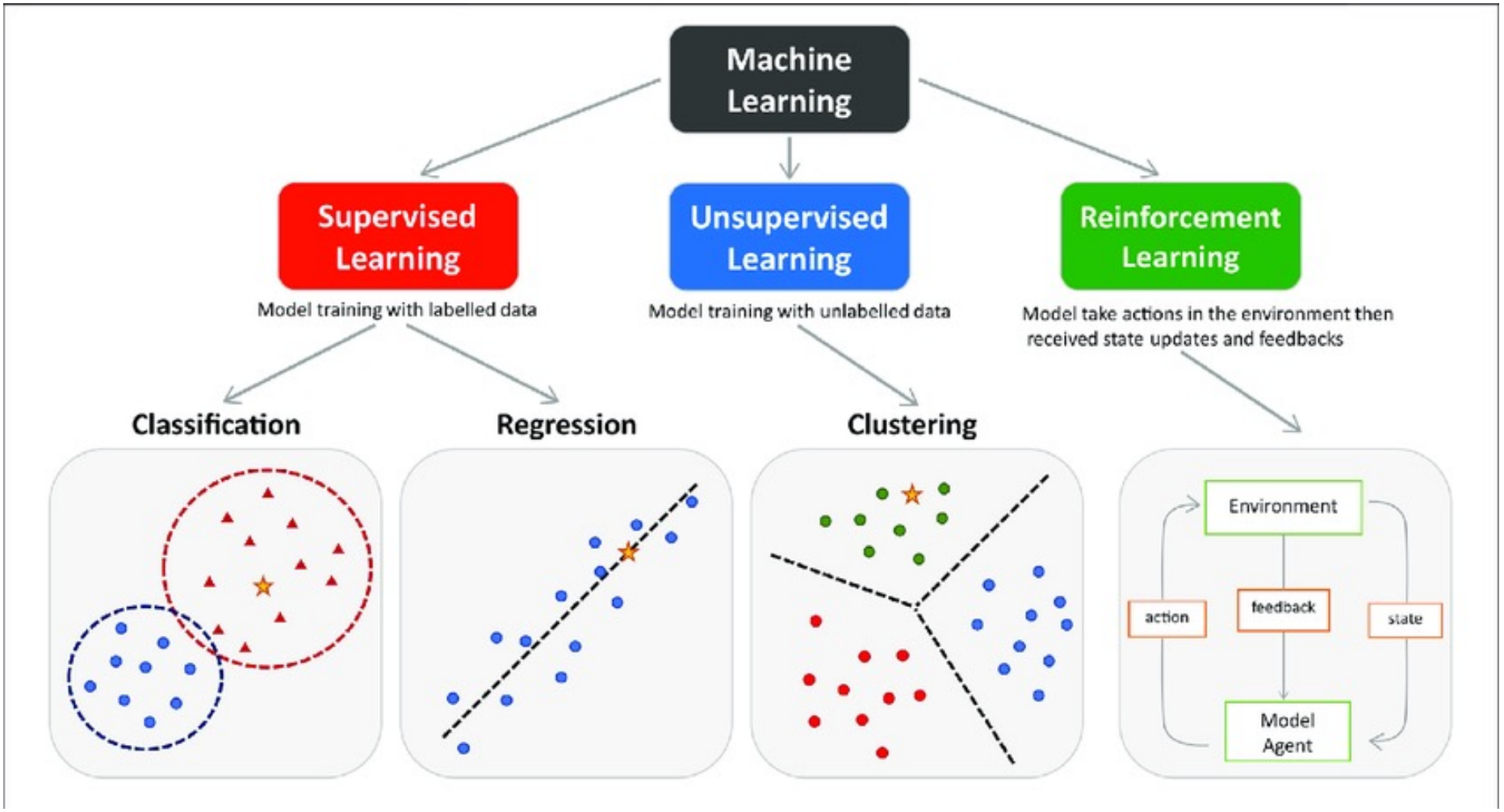
Reinforcement Learning

ML

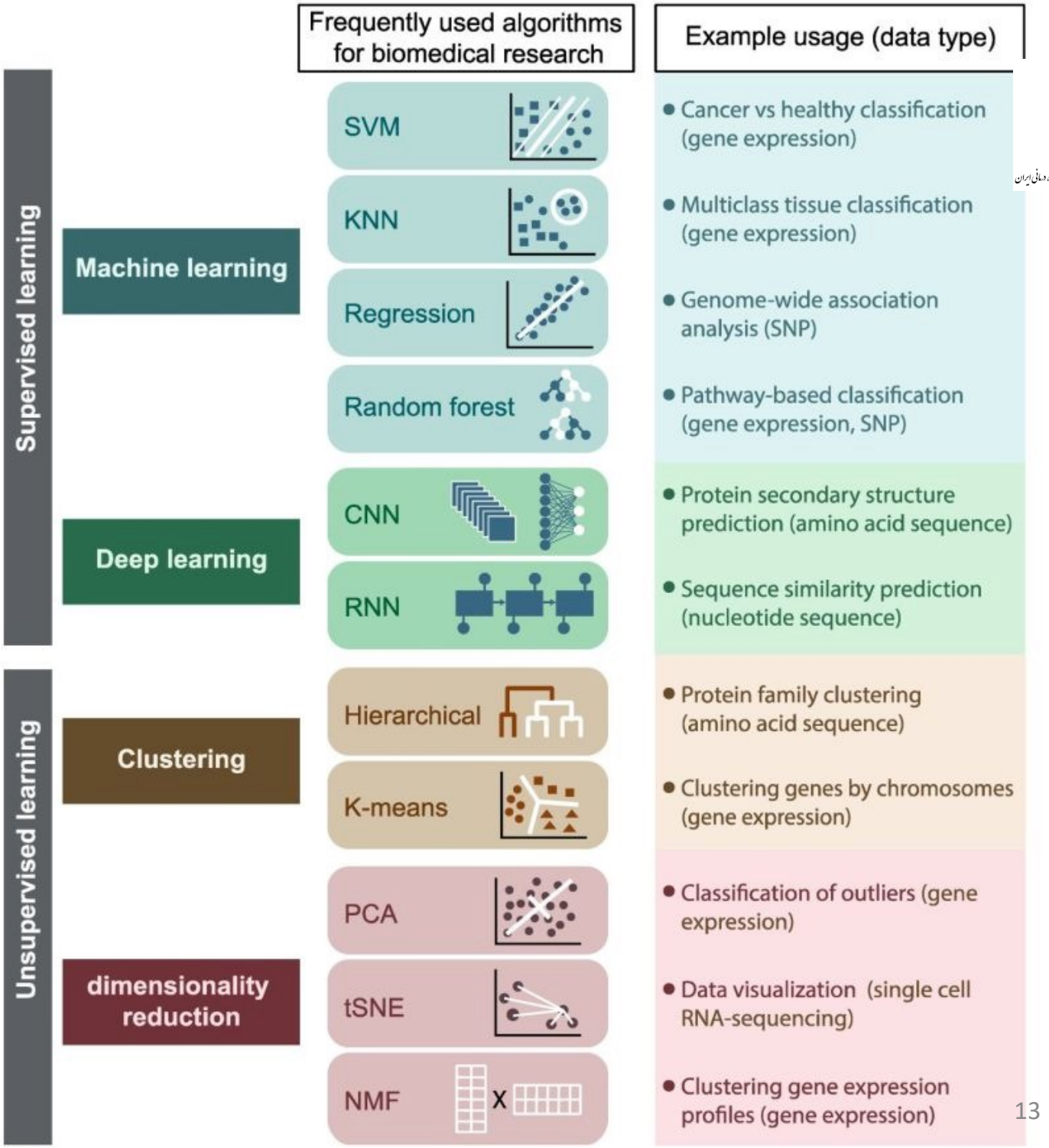

Clustering
Environment
action
feedback
state
Model
Agent


Classification
Regression

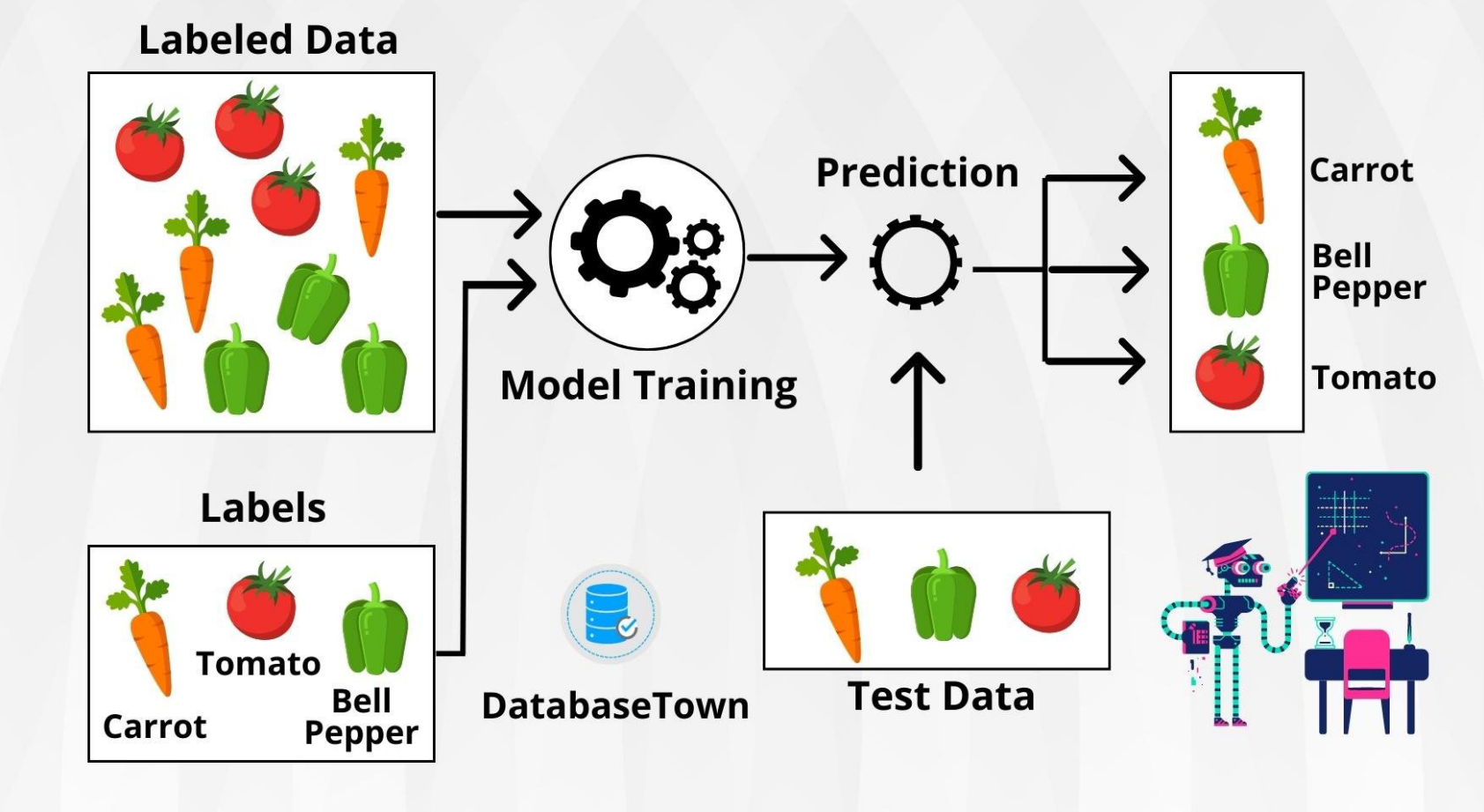

Machine Learning
Supervised Learning
Unsupervised Learning
Reinforcement Learning
Classification
Regression
Clustering
Decision Making
▪ Naive Bayes Classifier
▪ Decision Trees
▪ Support Vector Machines
▪ Random Forest
▪ K – Nearest Neighbors
▪ Linear Regression
▪ Neural Network Regression
▪ Support Vector Regression
▪ Decision Tree Regression
▪ Lasso Regression
▪ Ridge Regression
▪ K-Means Clustering
▪ Mean-shift Clustering
▪ DBSCAN Clustering
▪ Agglomerative Hierarchical Clustering
▪ Gaussian Mixture
▪ Q-Learning
▪ R Learning
▪ TD Learning


Machine Learning
Supervised Learning
Model training with labelled data
Unsupervised Learning
Model training with unlabelled data
Reinforcement Learning
Model take actions in the environment then received state updates and feedbacks
Classification
Regression
Clustering
Environment
action
feedback
state
Model Agent

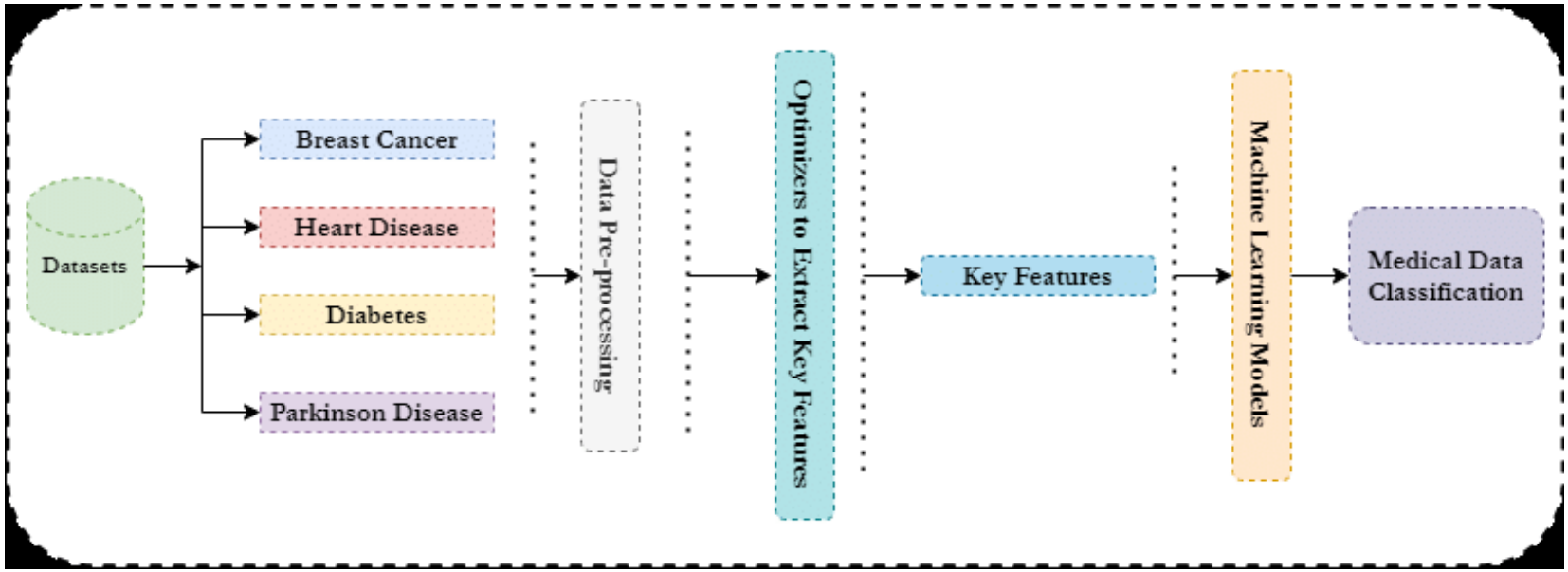
Example


Frequently used algorithms for biomedical research
Example usage (data type)
Supervised learning
Machine learning
SVM
KNN
Regression
Random forest
Cancer vs healthy classification (gene expression)
Multiclass tissue classification (gene expression)
Genome-wide association analysis (SNP)
Pathway-based classification (gene expression, SNP)
Deep learning
CNN
RNN
Protein secondary structure prediction (amino acid sequence)
Sequence similarity prediction (nucleotide sequence)
Unsupervised learning
Clustering
Hierarchical
K-means
Protein family clustering (amino acid sequence)
Clustering genes by chromosomes (gene expression)
dimensionality reduction
PCA
tSNE
NMF
X
Classification of outliers (gene expression)
Data visualization (single cell RNA-sequencing)
Clustering gene expression profiles (gene expression)

Supervised Learning

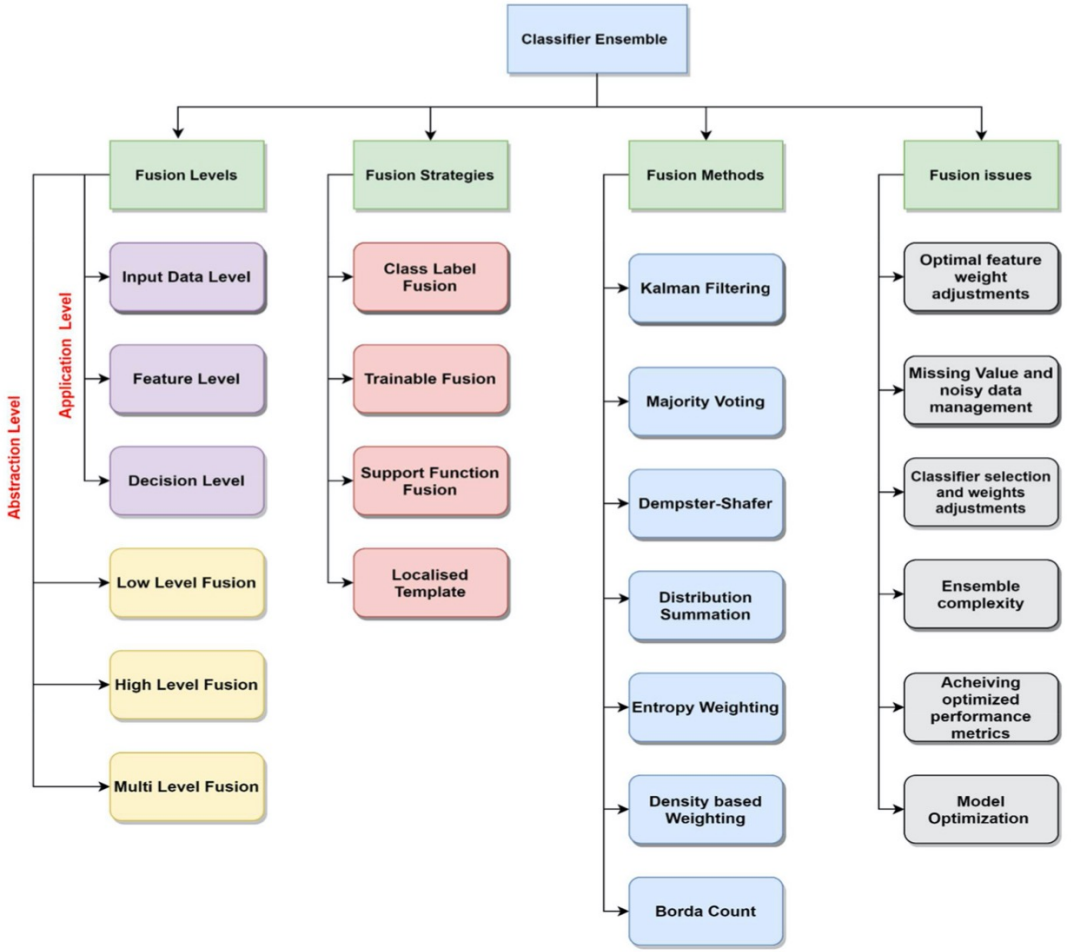


Supervised Learning and discrete data: Classification

- Classifier accuracy depends on dimension and type of data set.
- Single classification techniques are not capable enough to handle huge data. Sometimes the accuracy level changes according to the number of classifiers employed.
- To overcome this problem, fusion algorithms have been introduced.
- 

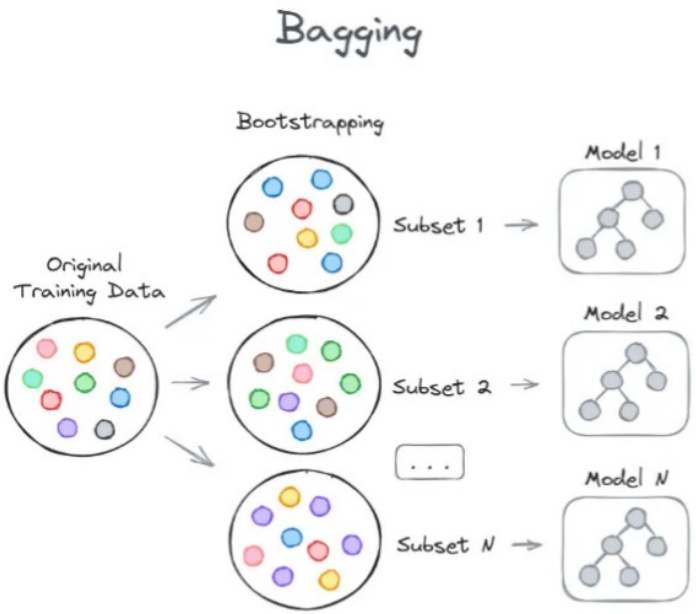
classifier ensemble

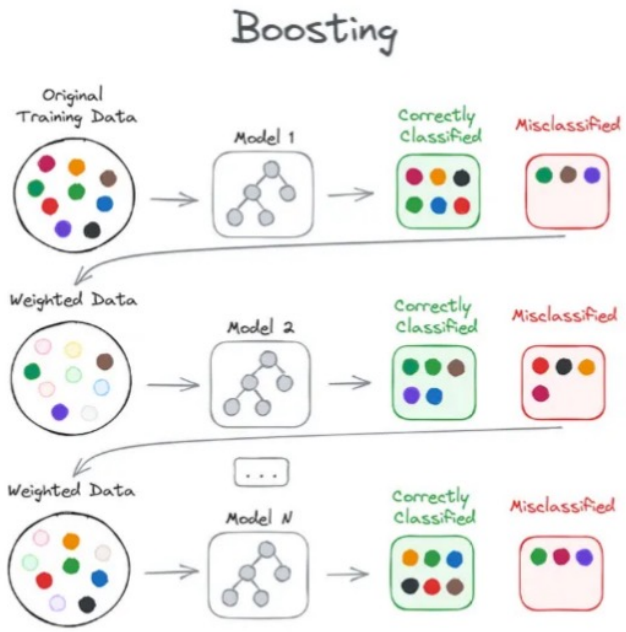
- Machine learning-based classification models have improved accuracy by combining the results of multiple ML algorithms. Such an ensemble approach
- Ensemble or fusion methods consider the output of each classifier as input. It considers the class level accuracy collected from all classifiers rather than the whole dataset. The model has to run all classification algorithms. It takes more time but efficacy increases.

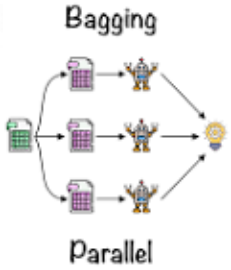


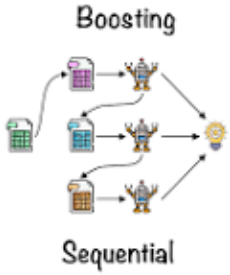
Ensembles

collection of machine learning models or learners. For grouping weak learning models to create a more accurate learner







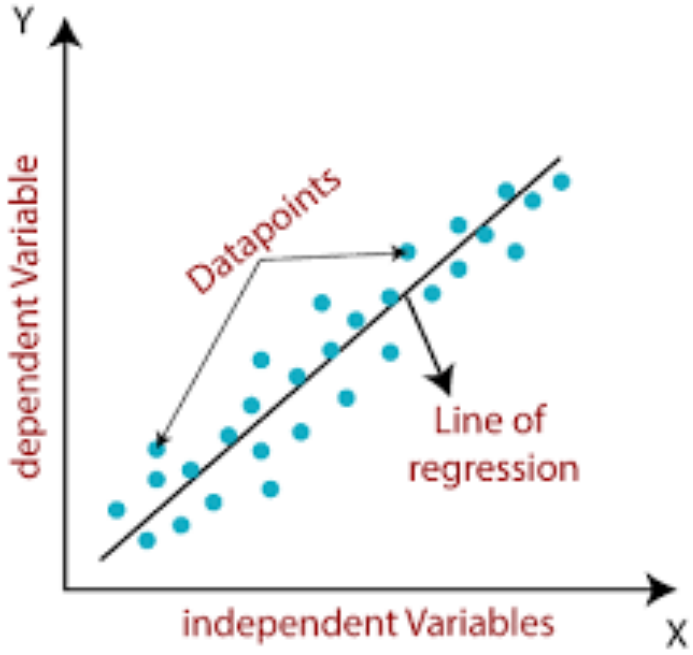


creating multiple independent models with datasets using the bootstrap sampling technique for reducing error within a noisy dataset by reducing variance.

produces a collection of predictive models iteratively. Each new model learn s from the errors of previous models.

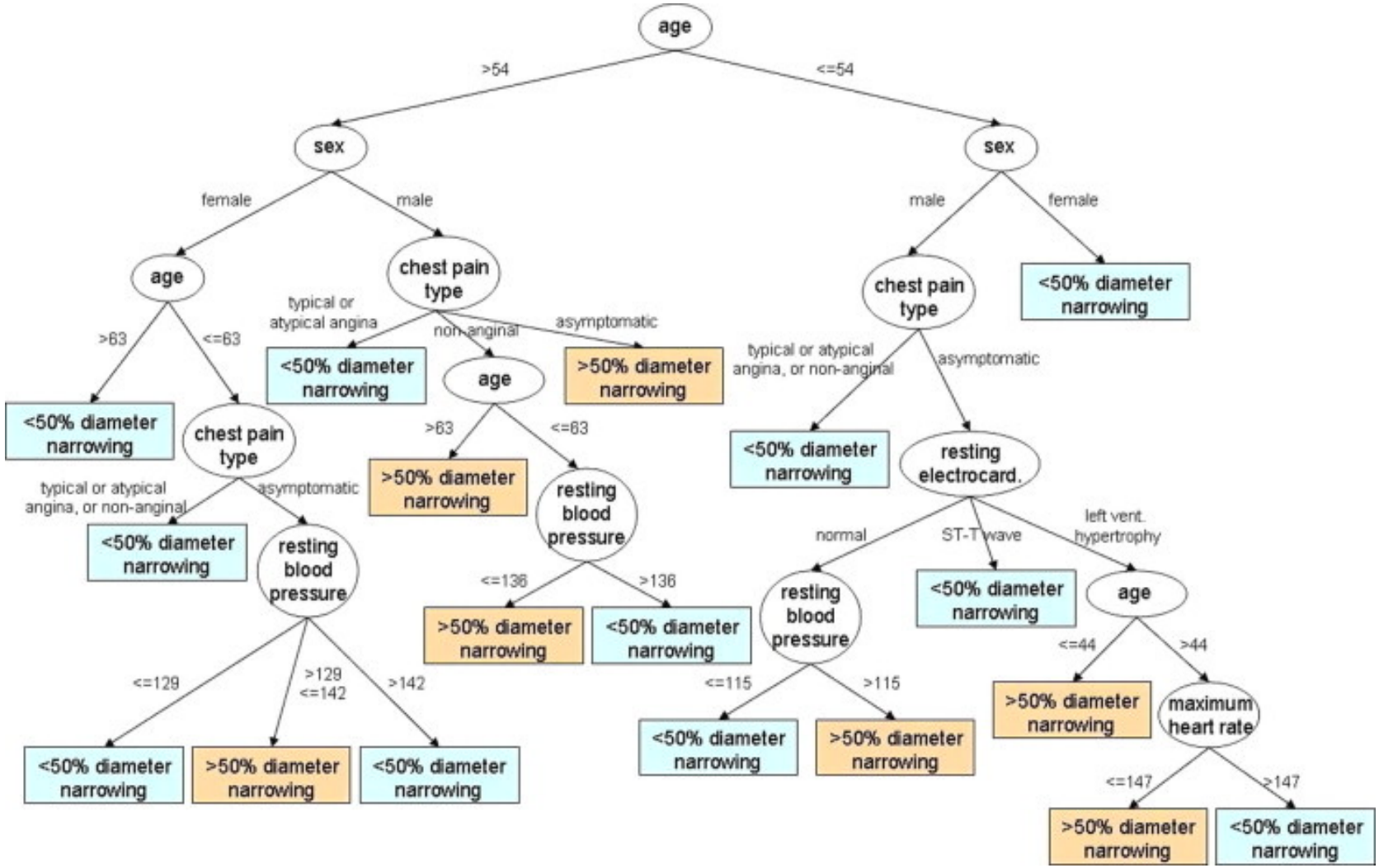
Regression

- Regression involves predicting an output that is a continuous variable.
- As a regression-based system predicts a value, performance is measured by assessing the number of prediction errors.

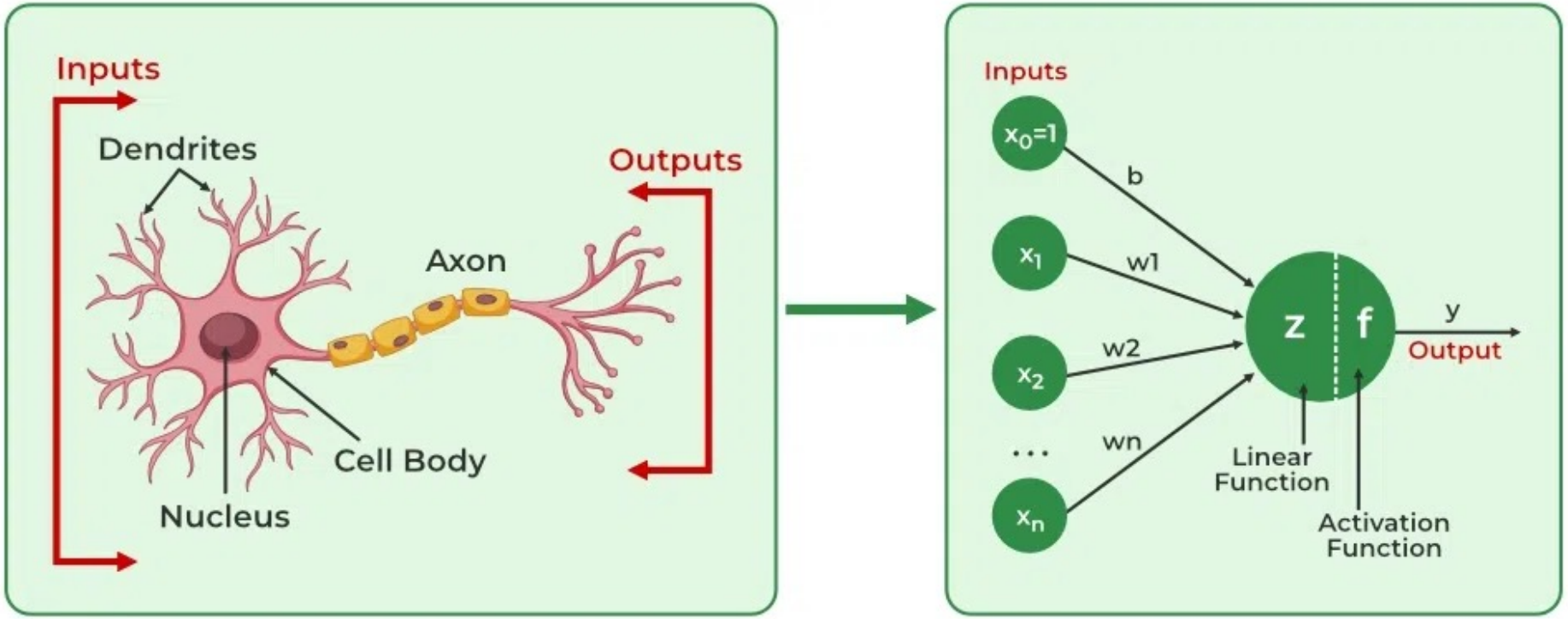


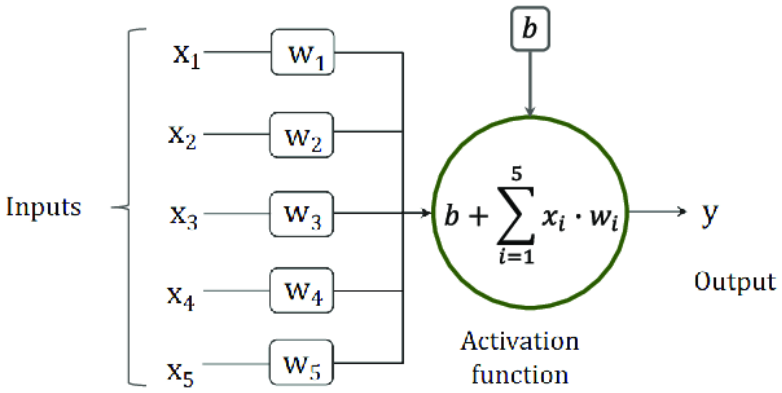
Decision trees

a non-parametric supervised learning algorithm, which is utilized for both classification and regression tasks.

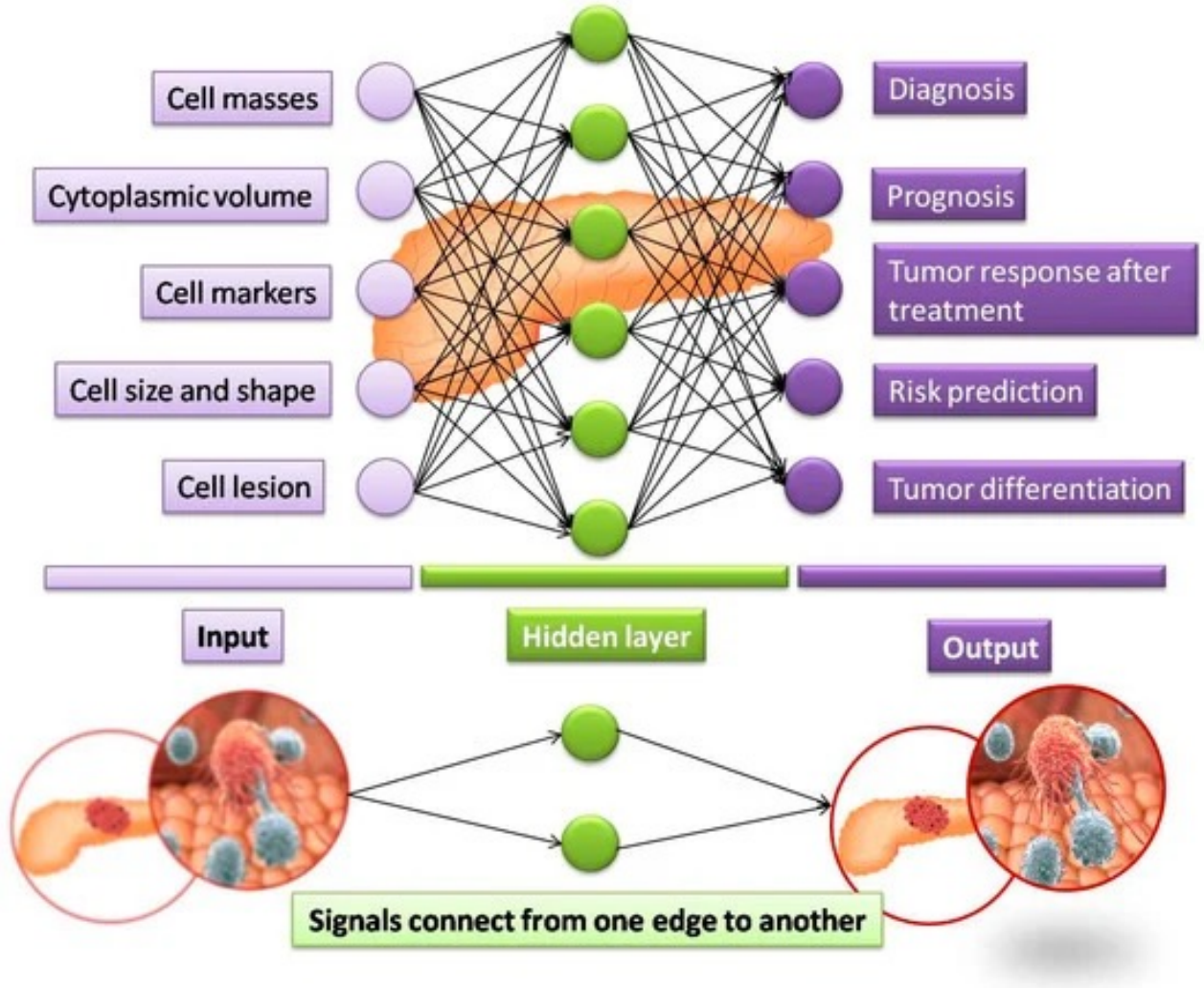


Artificial Neural Network

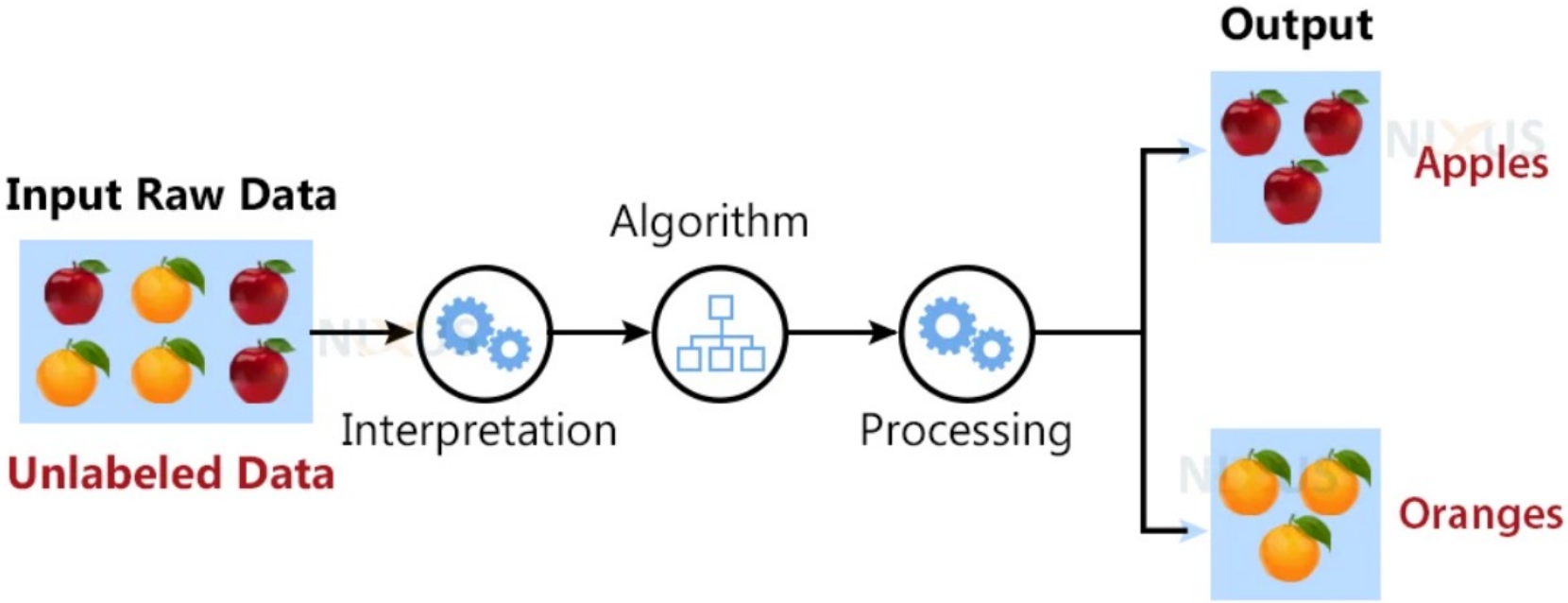




Sample Artificial Neural Network (ANN) model for the diagnosis of cancer

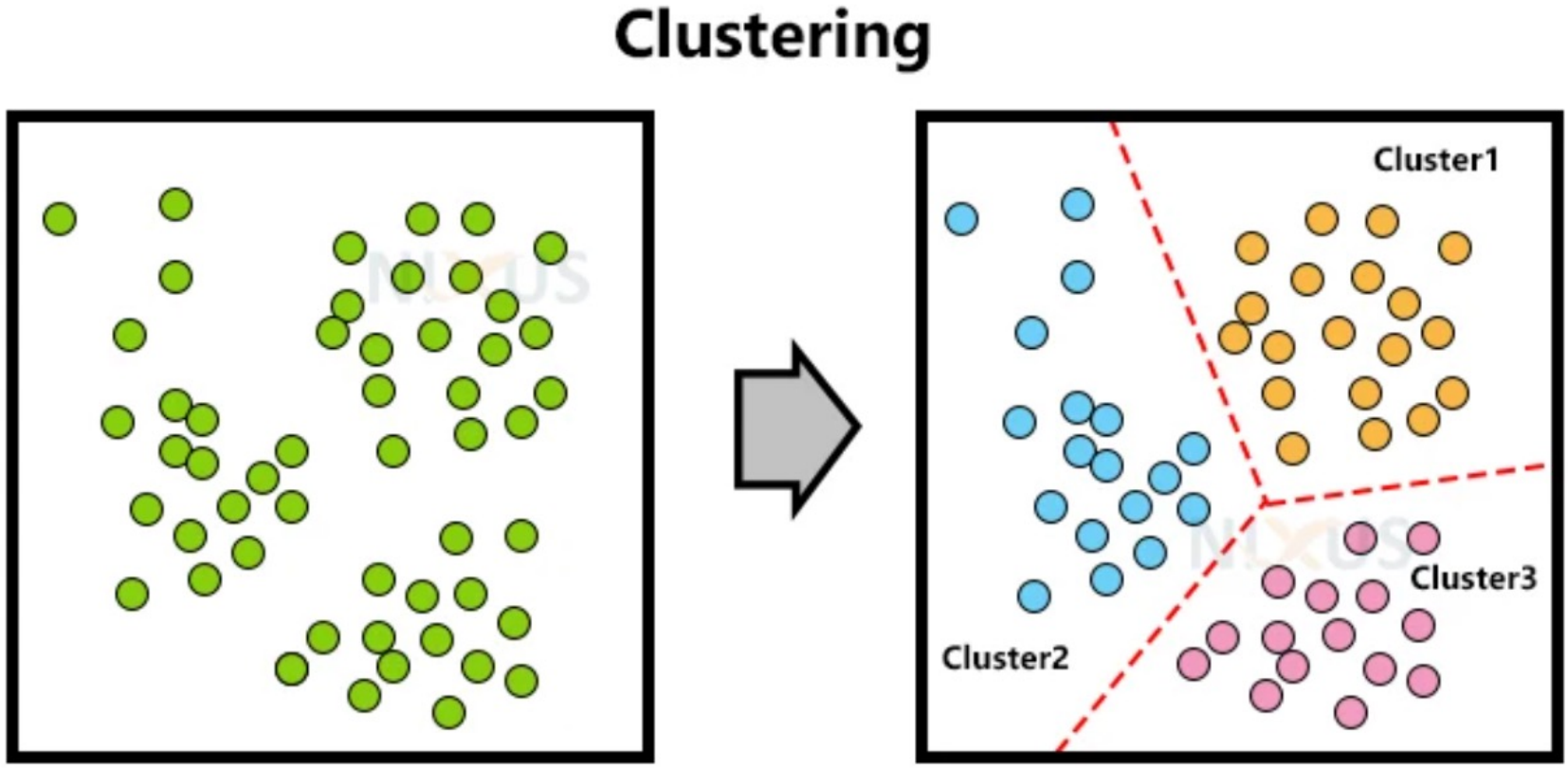


Unsupervised Learning

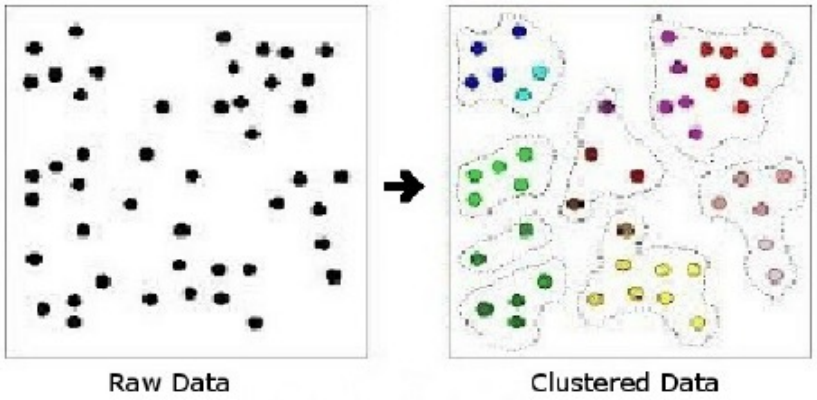


Clustering

These models work by identifying similarities among data items and classifying them according to the presence or absence of such commonalities.

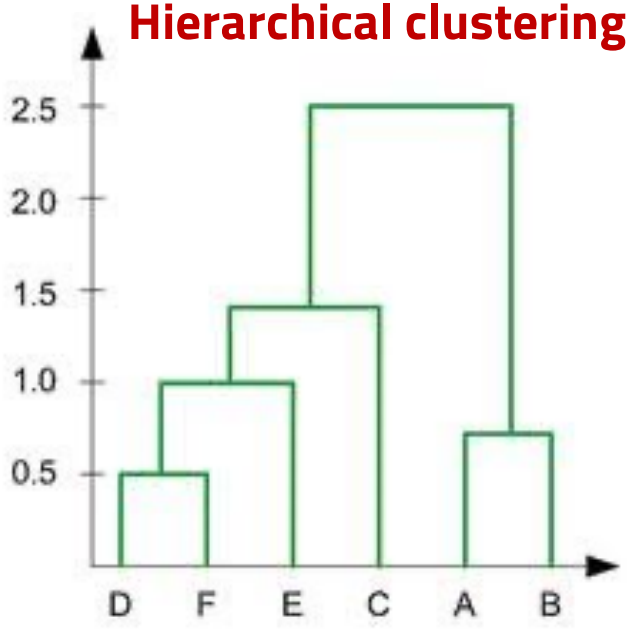


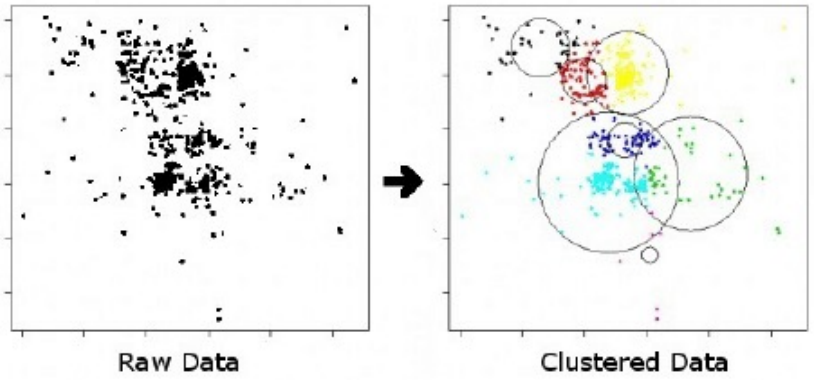
Types of Clustering in Machine Learning



Exclusive Clusters

Hierarchical clustering





Nonexclusive Clusters

Probabilistic clustering

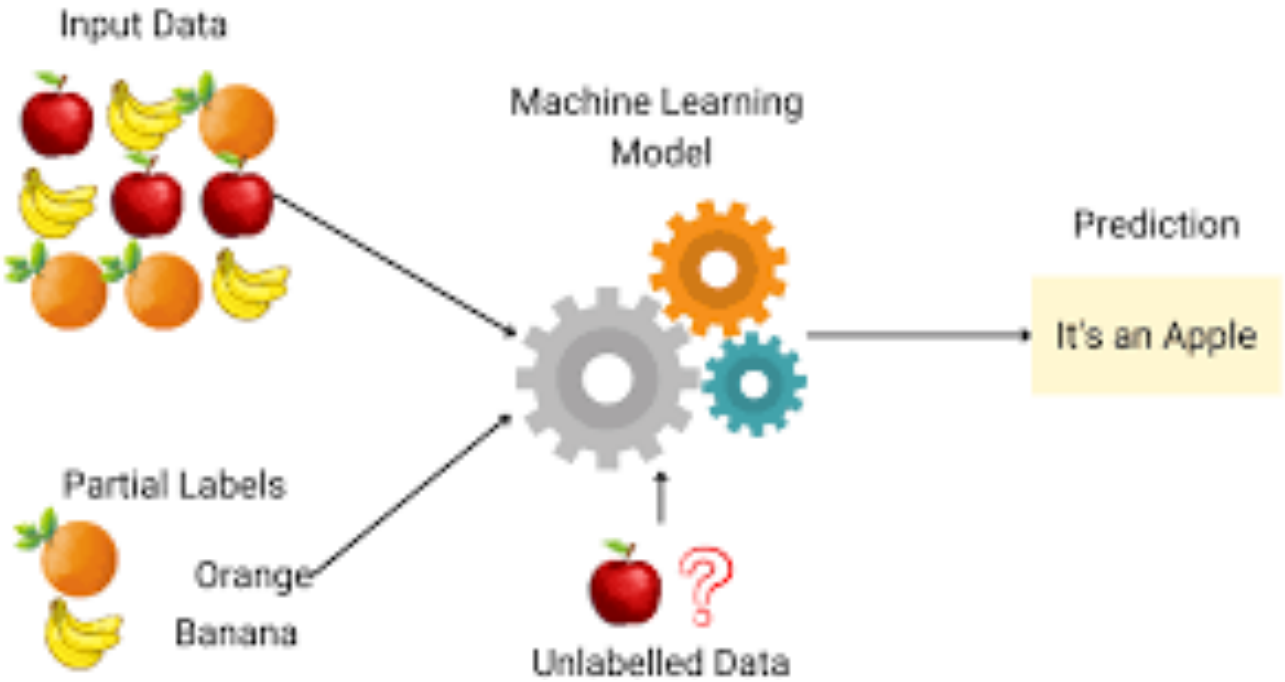
Fuzzy clustering

Reinforcement learning

learning the optimal behavior in an environment to obtain maximum reward. This optimal behavior is learned through interactions with the environment and observations of how it responds, similar to children exploring the world around them and learning the actions that help them achieve a goal.

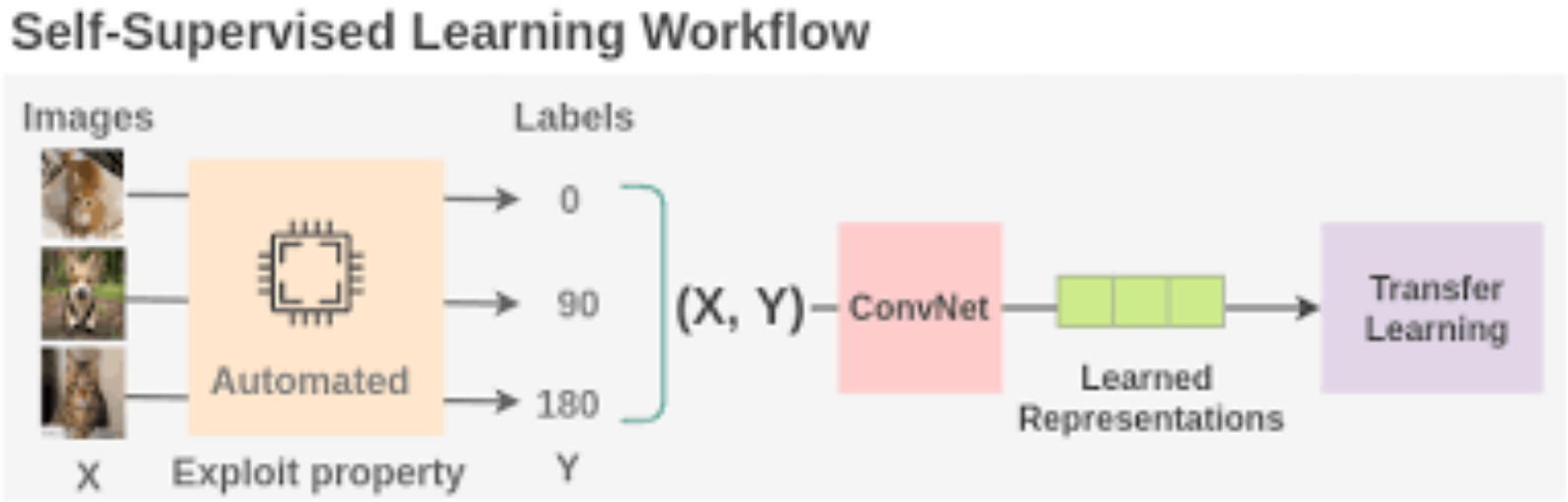
Semi-supervised Learning

Semi-supervised learning is the type of machine learning that uses a combination of a small amount of labeled data and a large amount of unlabeled data to train models.



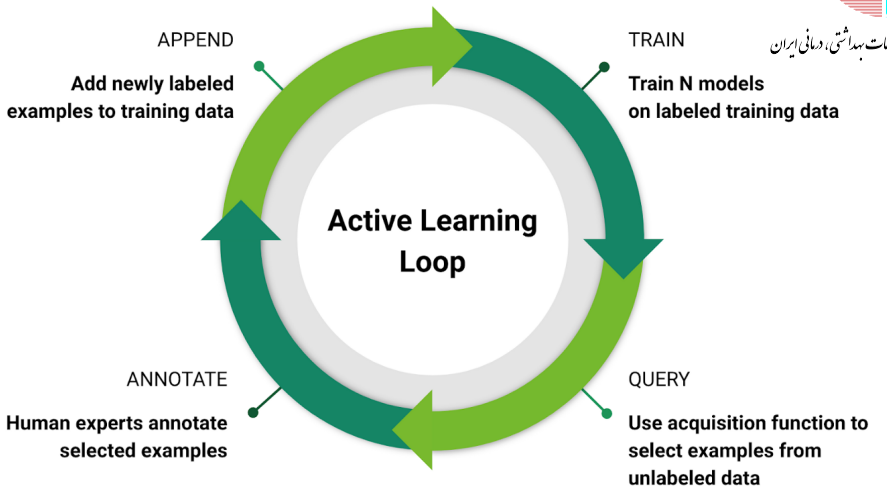
Self-Supervised Learning

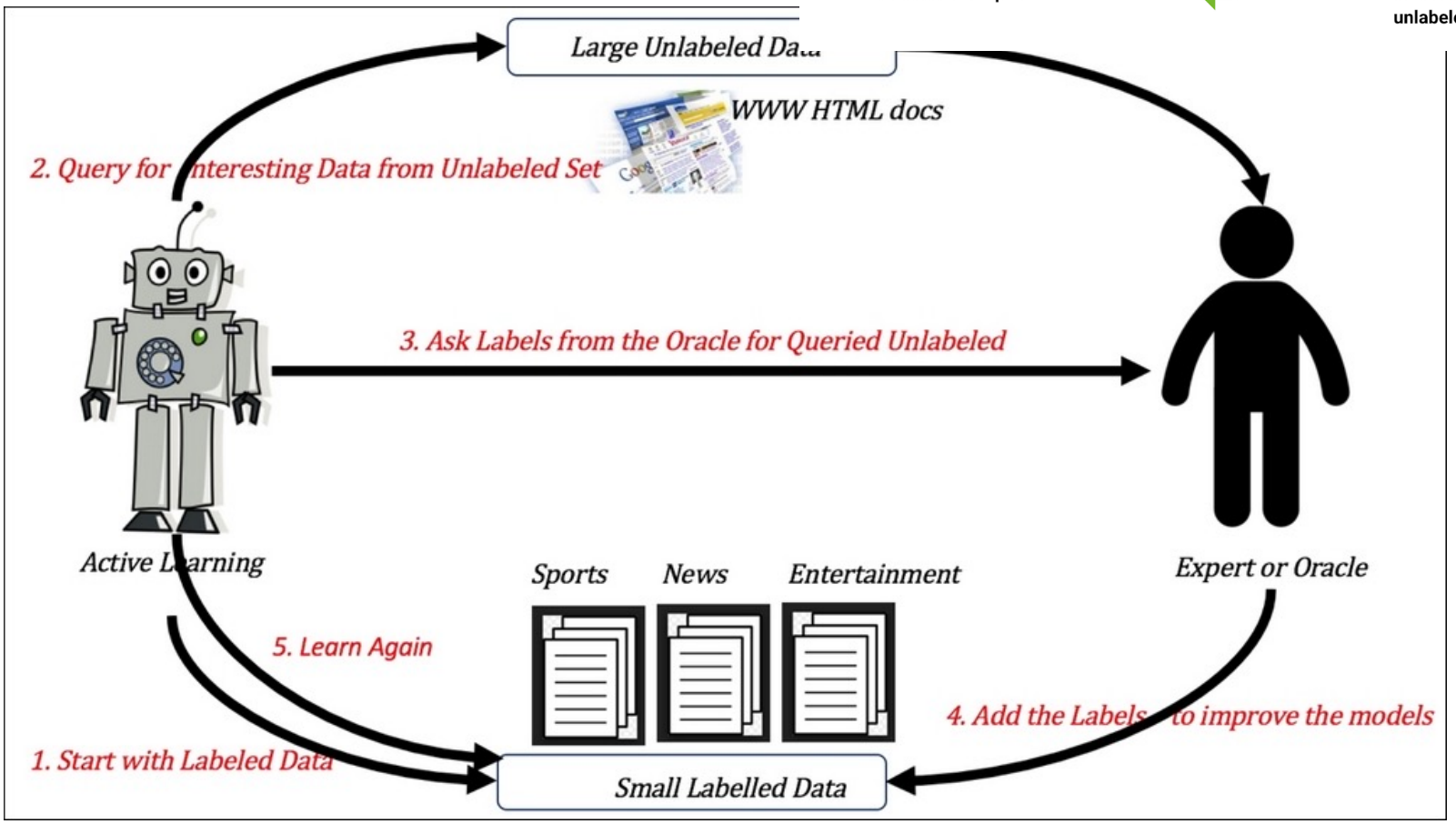
a machine learning process where the model trains itself to learn one part of the input from another part of the input.



Active Learning

a learning algorithm can interactively query a human user (or some other information source), to label new data points with the desired outputs.

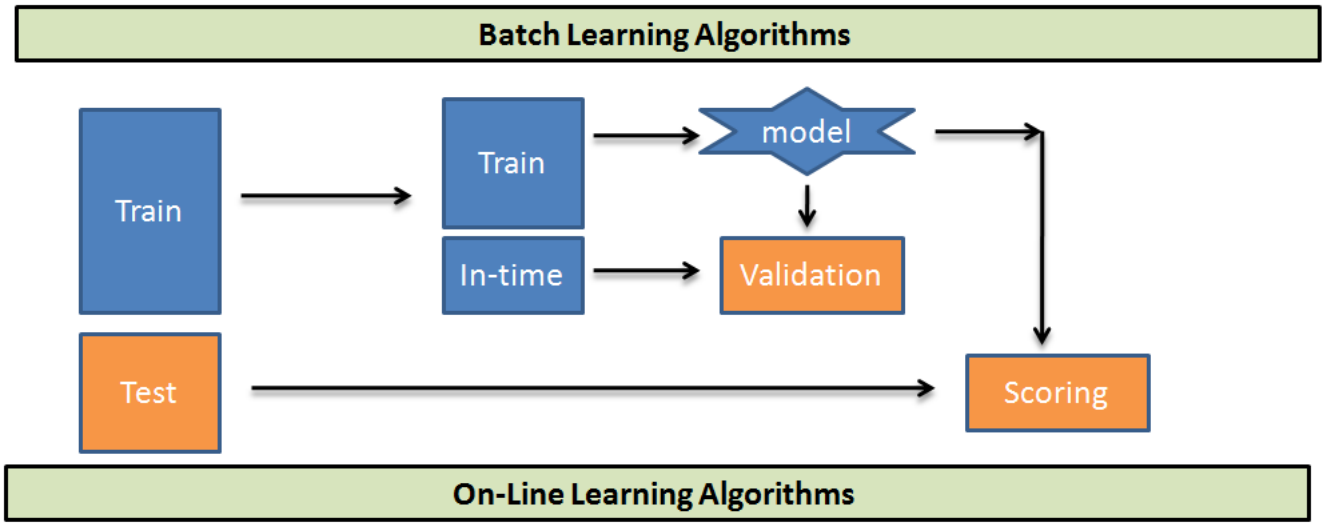


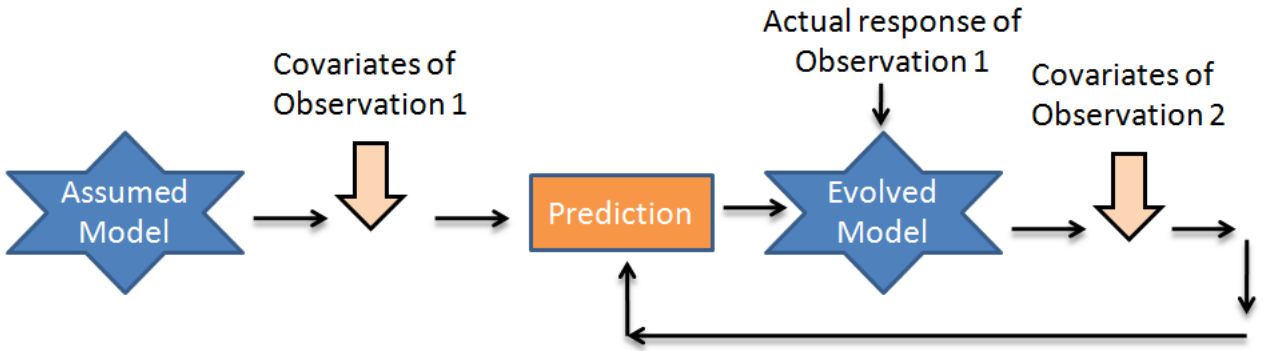


Online Learning

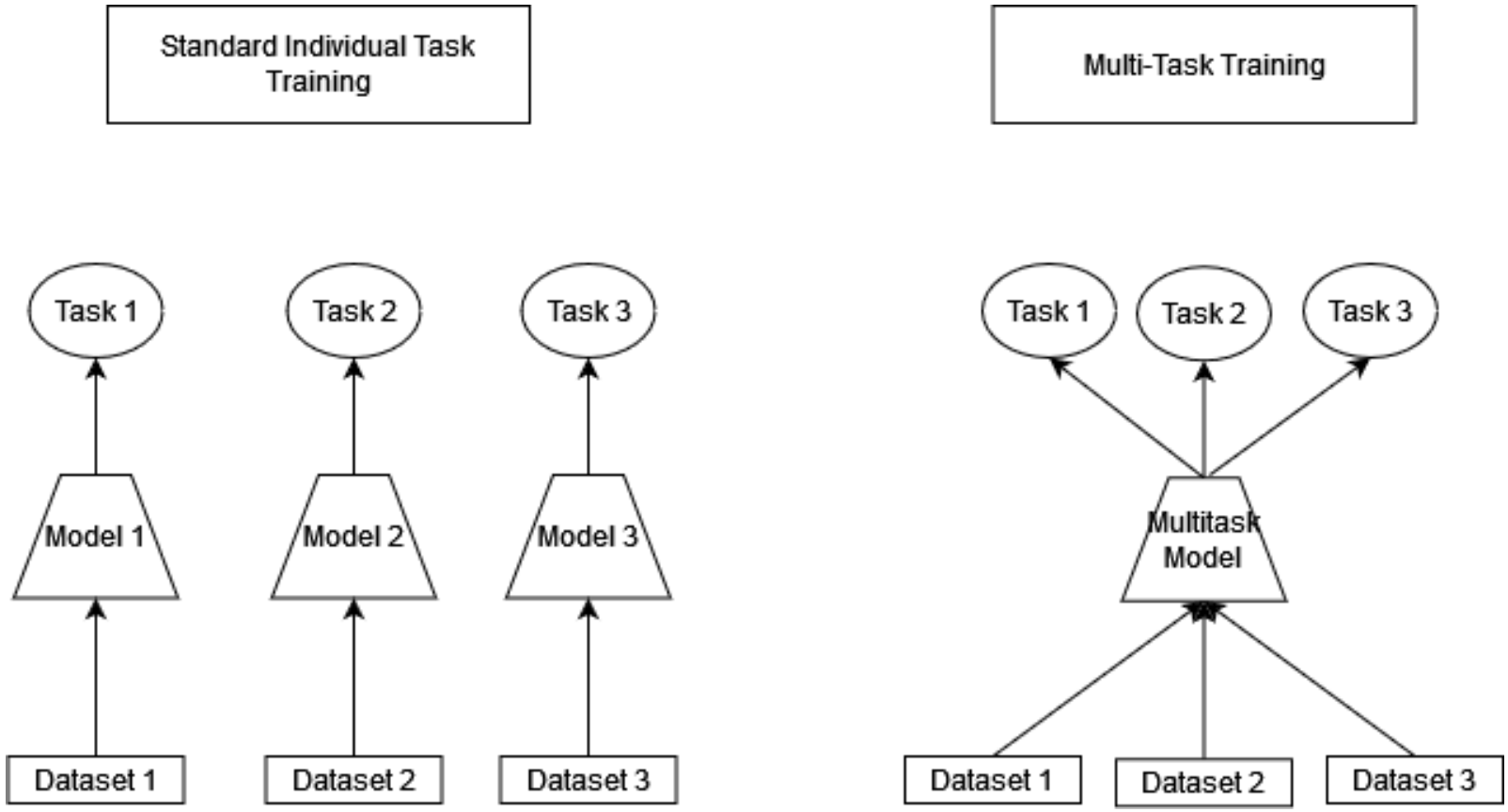
computationally infeasible to train over the entire dataset, Or dynamically adapt to new patterns in the data.

data becomes available in sequential order and is used to update the best predictor for future data at each step,





Multi-task Learning

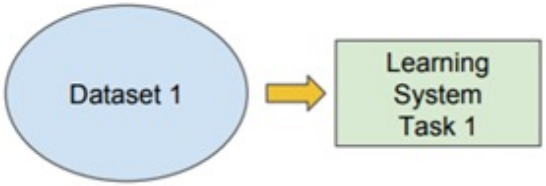


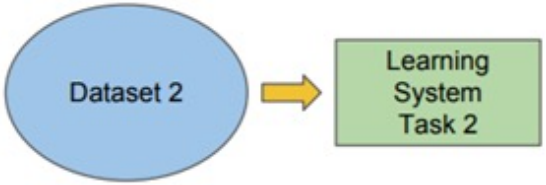
multiple learning tasks are solved at the same time, while exploiting commonalities and differences across tasks. This can result in improved learning efficiency and prediction accuracy for the task-specific models, when compared to training the models separately

Transfer learning

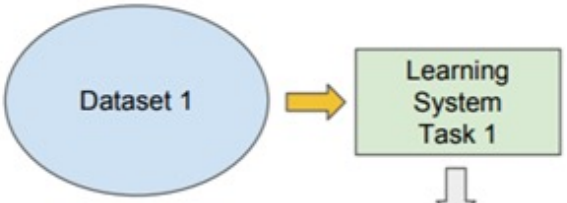
Traditional ML vs Transfer Learning

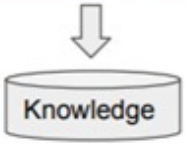
- Isolated, single task learning:
  - Knowledge is not retained or accumulated. Learning is performed w.o. considering past learned knowledge in other tasks

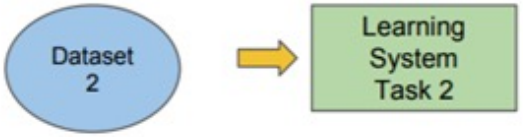




- Learning of a new tasks relies on the previous learned tasks:
  - Learning process can be faster, more accurate and/or need less training data

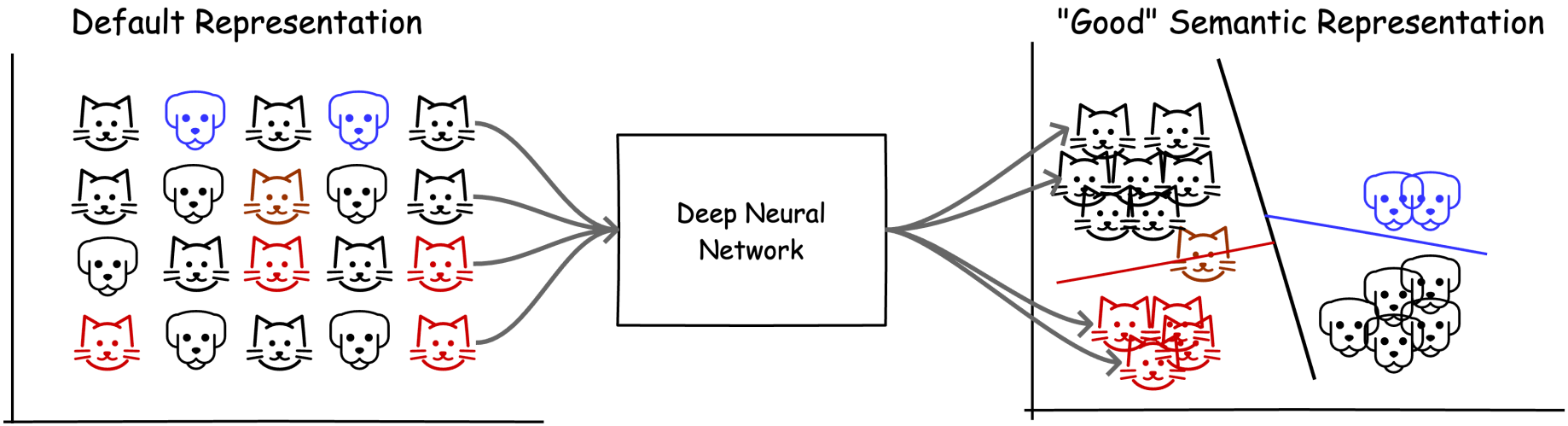




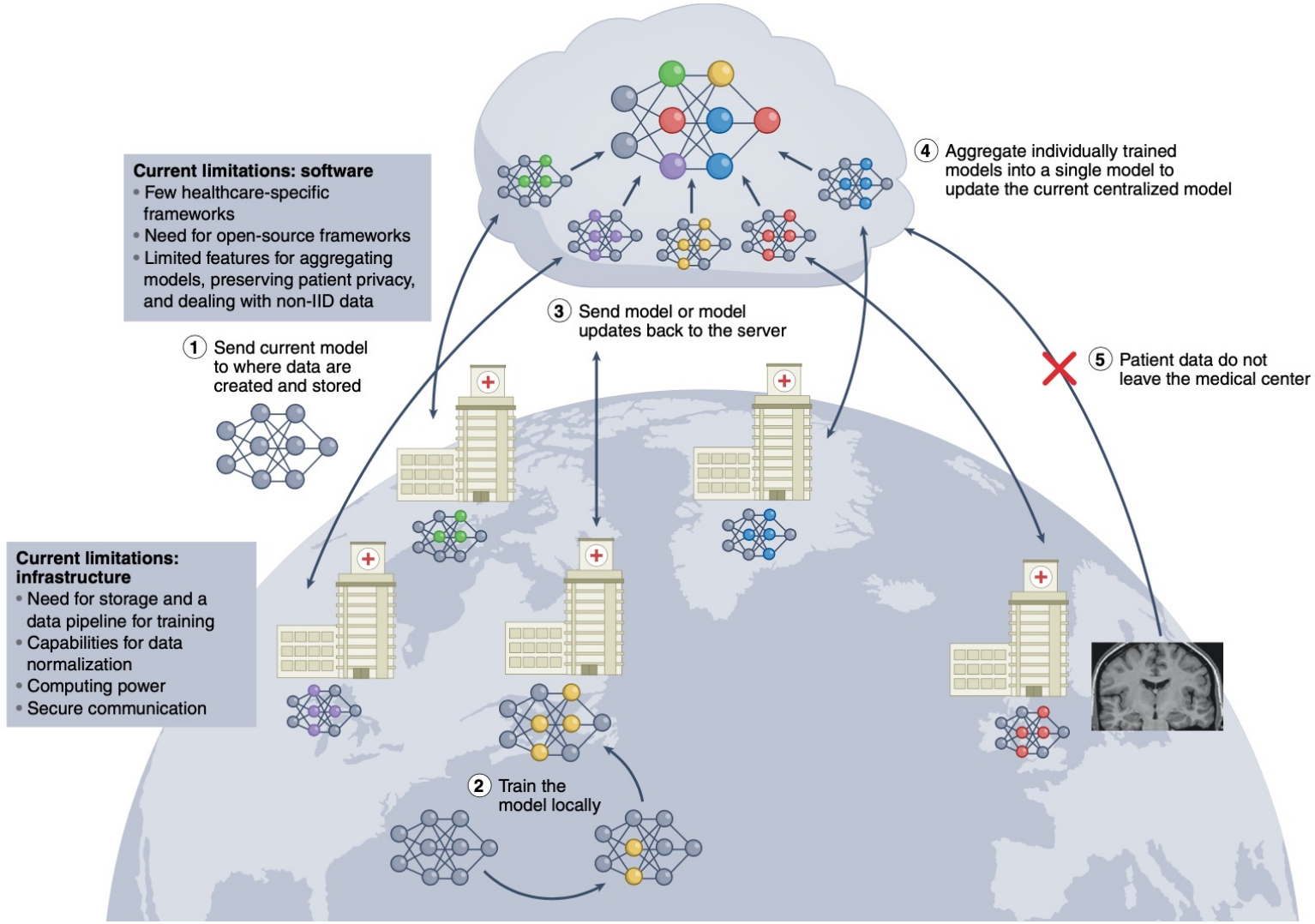


Representation learning or **feature learning**

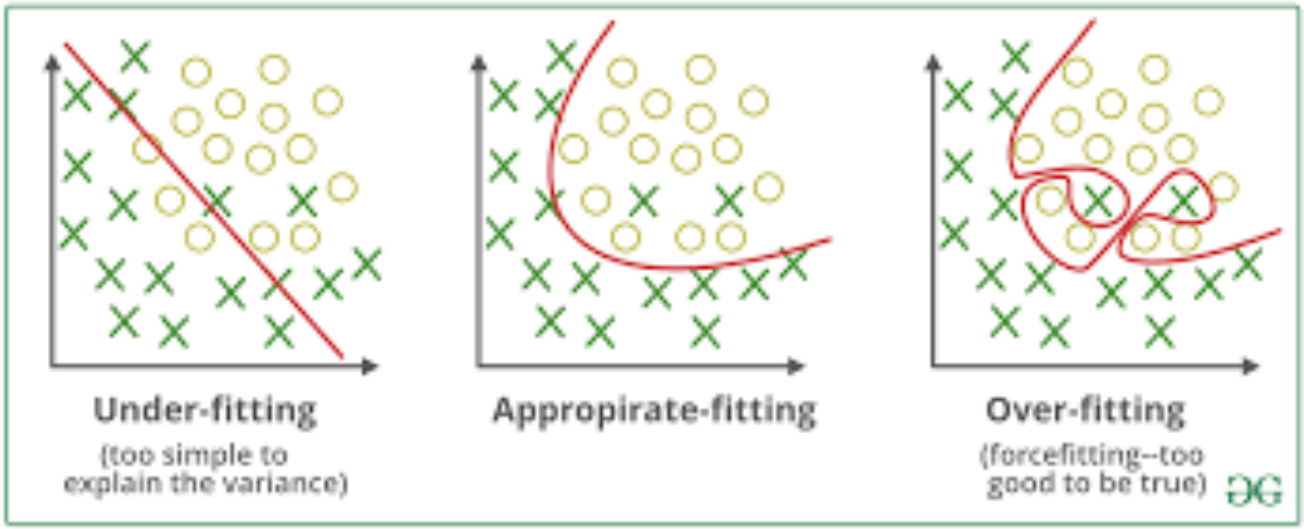
a class of machine learning approaches that allow a system to discover the representations required for feature detection or classification from raw data.



Federated learning



Overfitting and Underfitting



Overfitting: Good performance on the training data, poor generalization to other data.

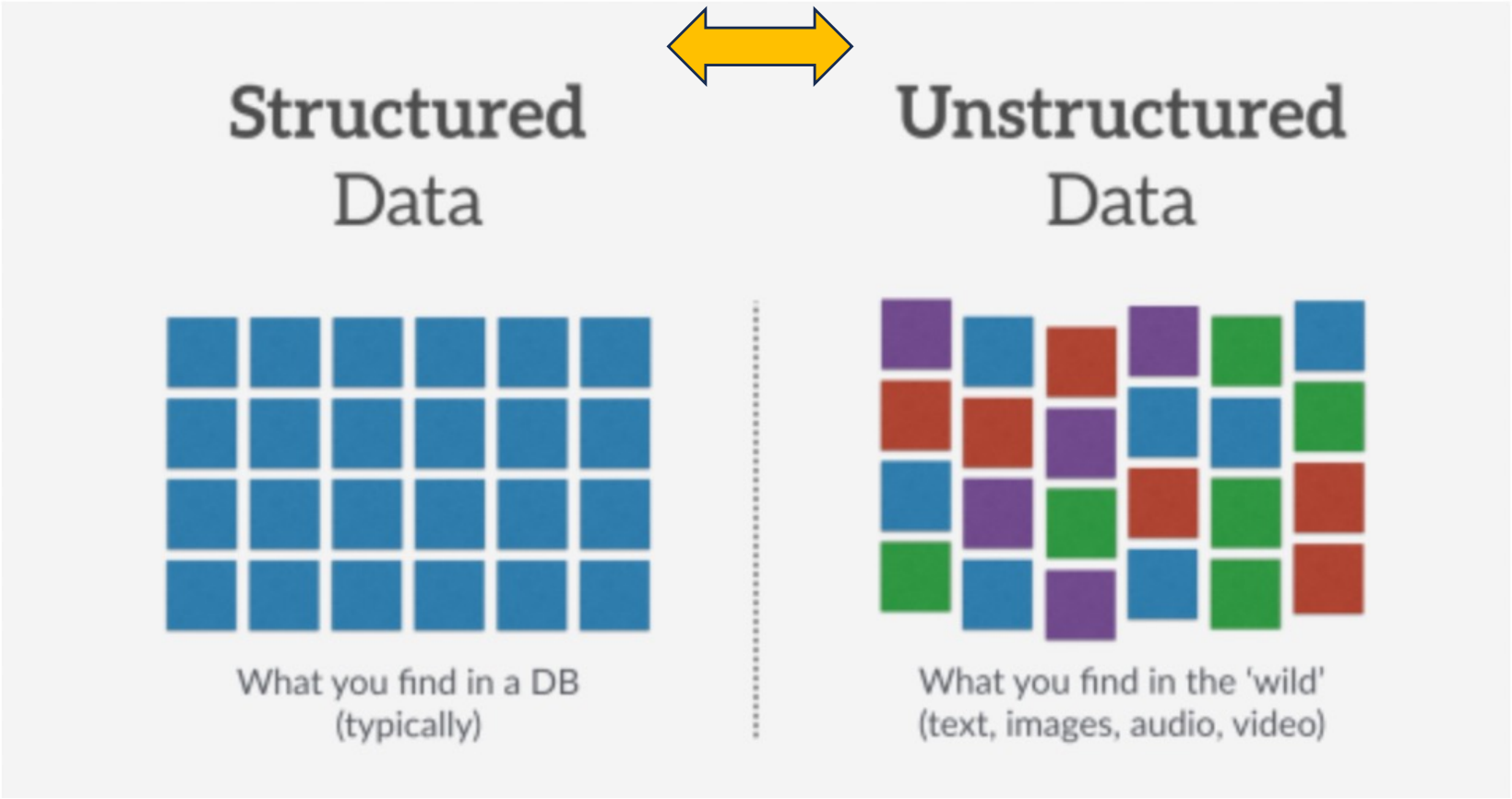
Underfitting: Poor performance on the training data and poor generalization to other data

Data

- Data is everywhere.
- Data itself can take many forms—character, text, words, numbers, pictures, sound, or video.
- data is a set of values of qualitative or quantitative variables.
- Each piece of data falls into two main types: structured and unstructured.
- To become information, data requires interpretation.

Structured data

Semi-structured data



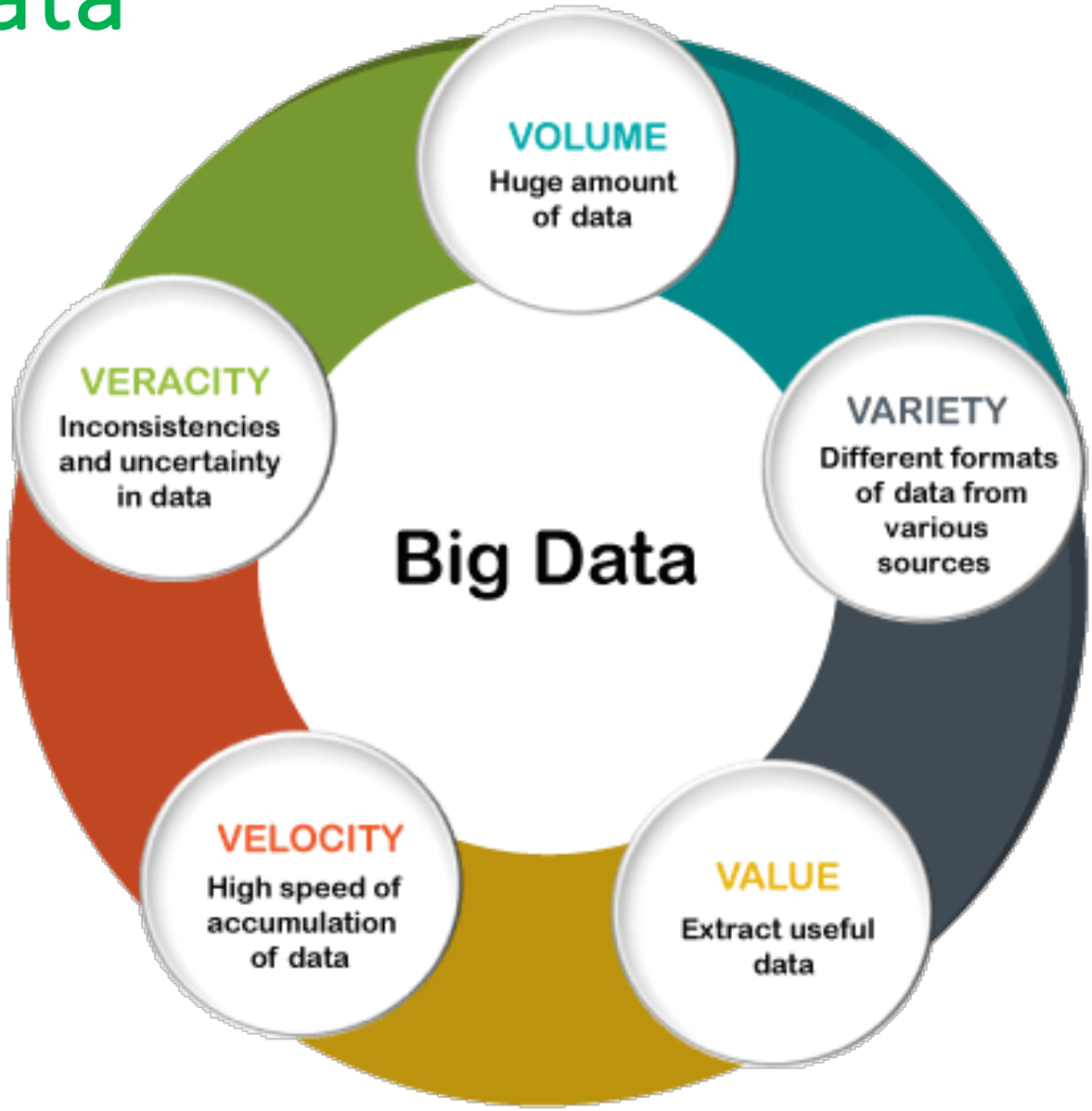
Some Data Source

- Web and social media data—clicks, history, health forums
- Machine-to-machine data—sensors, wearables
- Big transaction data—health claim data, billing data
- Biometric data—fingerprints, genetics, biomarkers
- Human-generated data—e-mail, paper documents, electronic medical records

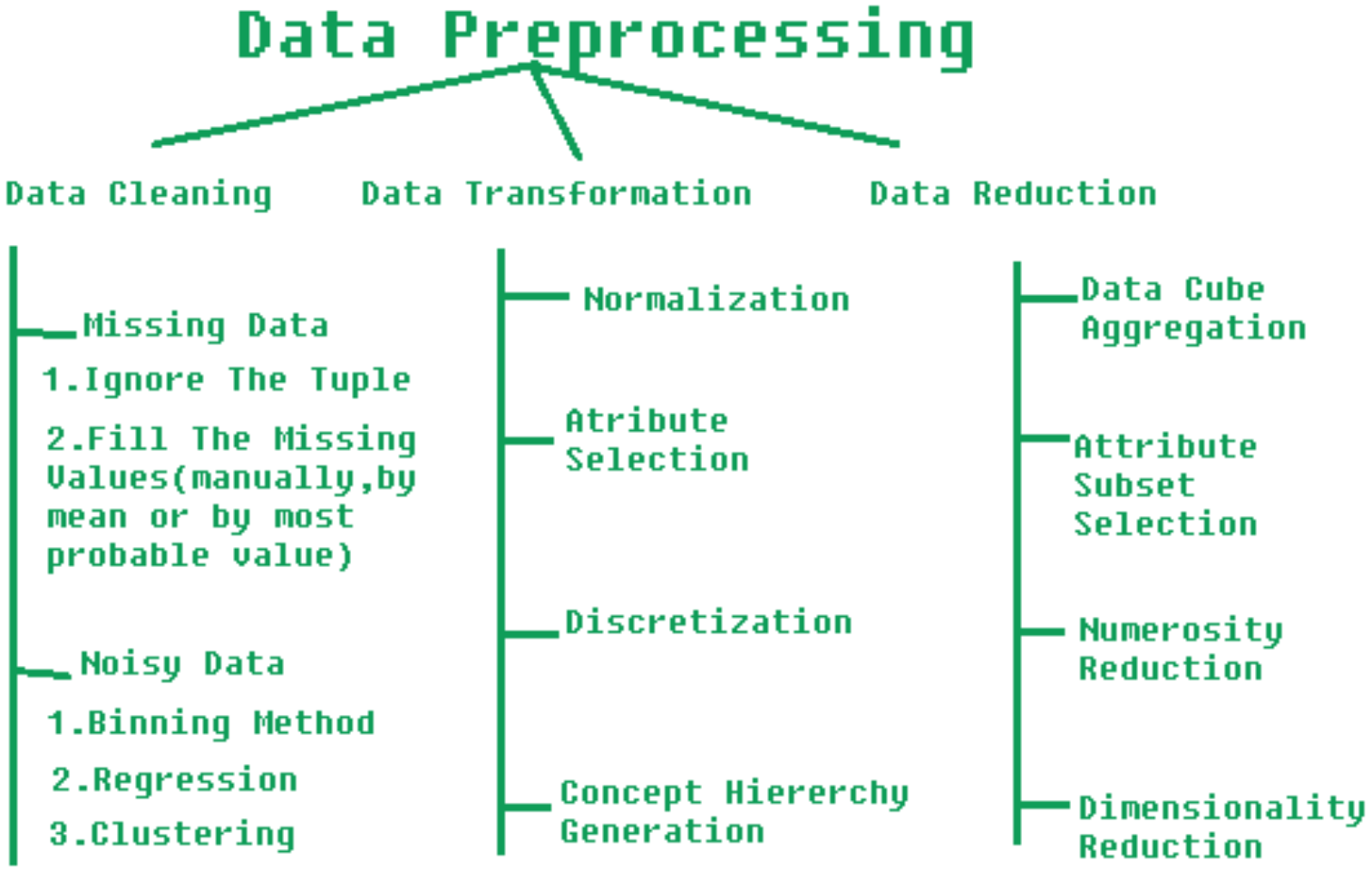
Definition

- Instance: A single row of data or observation.
- Feature: A single column of data. It is a component of the observation.
- Data type: This refers to the kind of data represented by the feature (e.g., Boolean, string, number)
- Dataset: A collection of instances used to train and test machine learning models.
- Training dataset: Dataset used to train the machine learning model
- Testing dataset: Dataset used to determine accuracy/performance of the machine learning model.

Big data


VOLUME
Huge amount of data
VARIETY
Different formats of data from various sources
VALUE
Extract useful data
VELOCITY
High speed of accumulation of data
VERACITY
Inconsistencies and uncertainty in data
Big Data

Pre-Processing



ML Performance Metrics

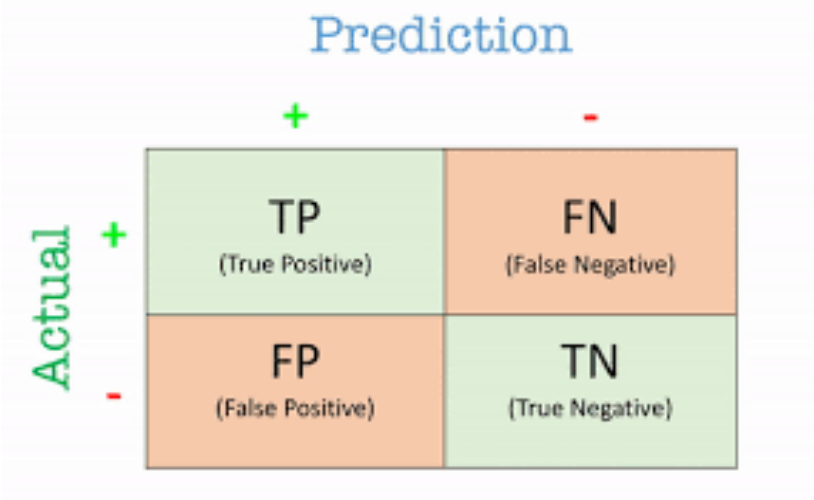
- Accuracy
- Precision
- Recall
- F1-Score

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

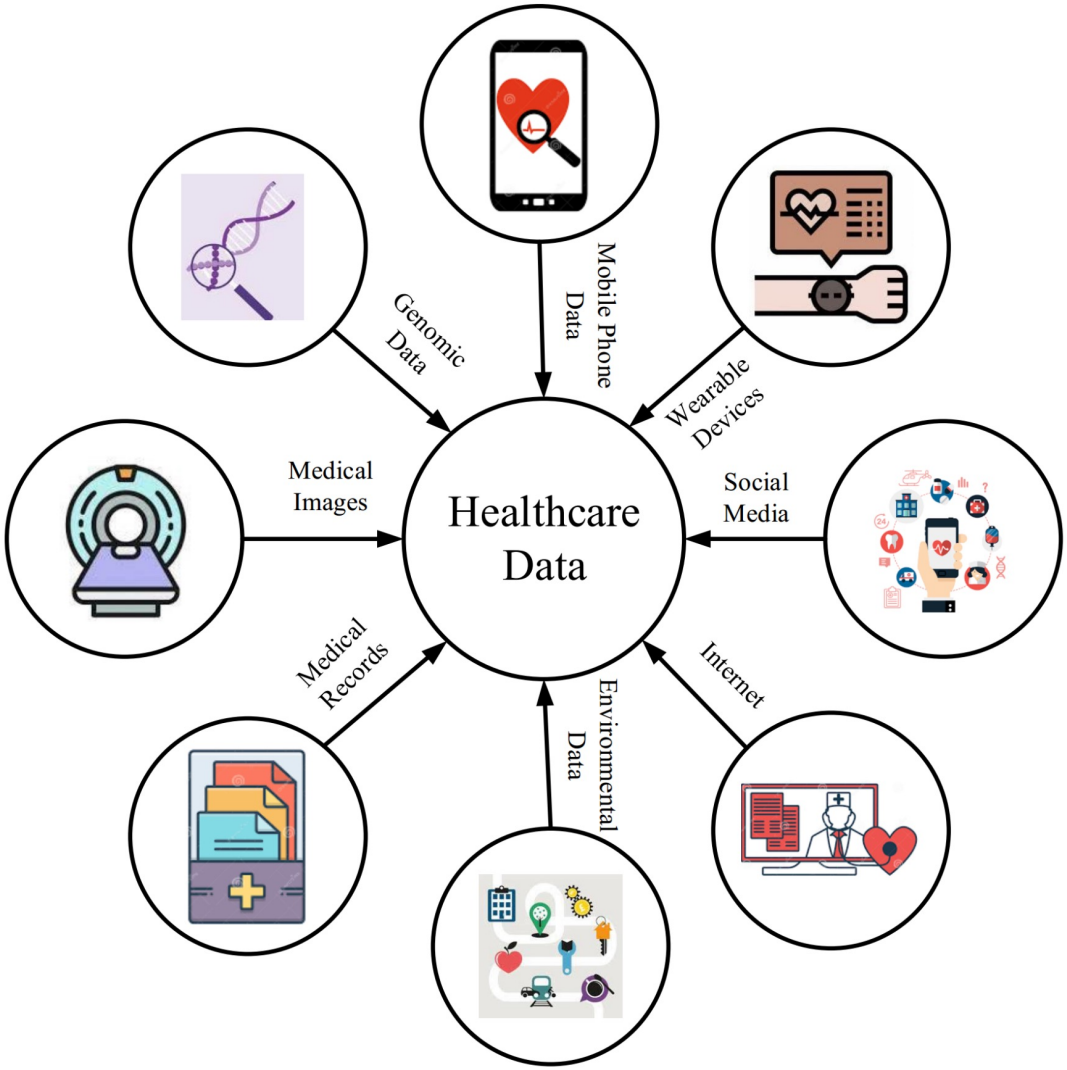
$$F_1 = 2 \cdot \frac{Precision \cdot Recall}{Precision + Recall}$$



MACHINE LEARNING IN HEALTHCARE EXAMPLES

- Microsoft
- Tempus: making precision medicine
- Tebra: Medical Automation Solution
- PathAI: AI-powered pathology
- Ciox Health: Healthcare Data Management
- Solutions:
- Beta Bionics: insulin delivery system
- Subtle Medical: AI-based software solution that enhances up to 60% faster MRI
- Pfizer: drug discovery company
- Insitro: drug discovery company
- BioSymetrics: drug discovery company

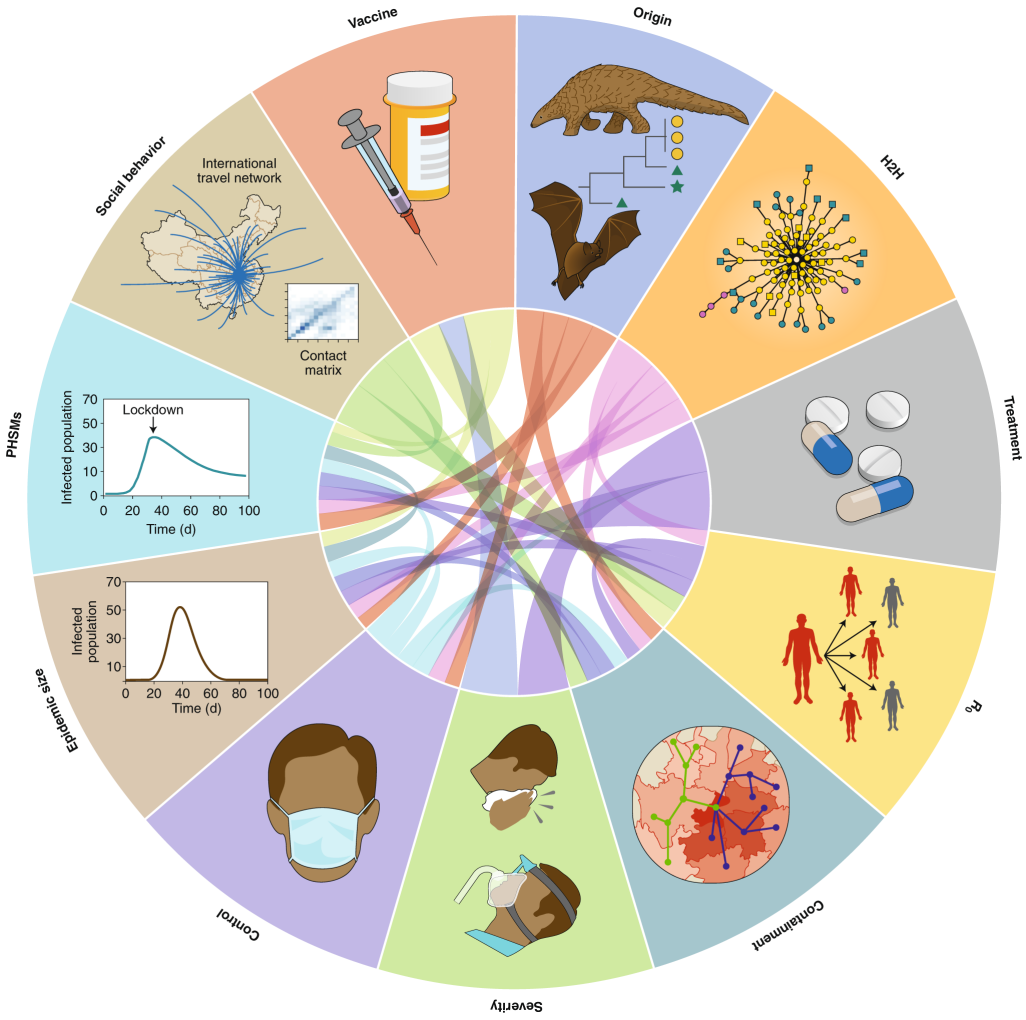
Application of Machine Learning in Medicine



Potential Epidemic Outbreaks

HML systems to monitor and anticipate potential epidemic outbreaks in various parts of the world.

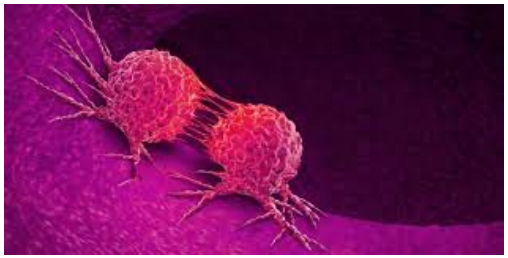
This digital system can forecast disease outbreaks by gathering data from satellites, real-time updates on social media, and other crucial information from the web.



Early Detection of Disease

New Tools
New Biopsy
Non-invasive

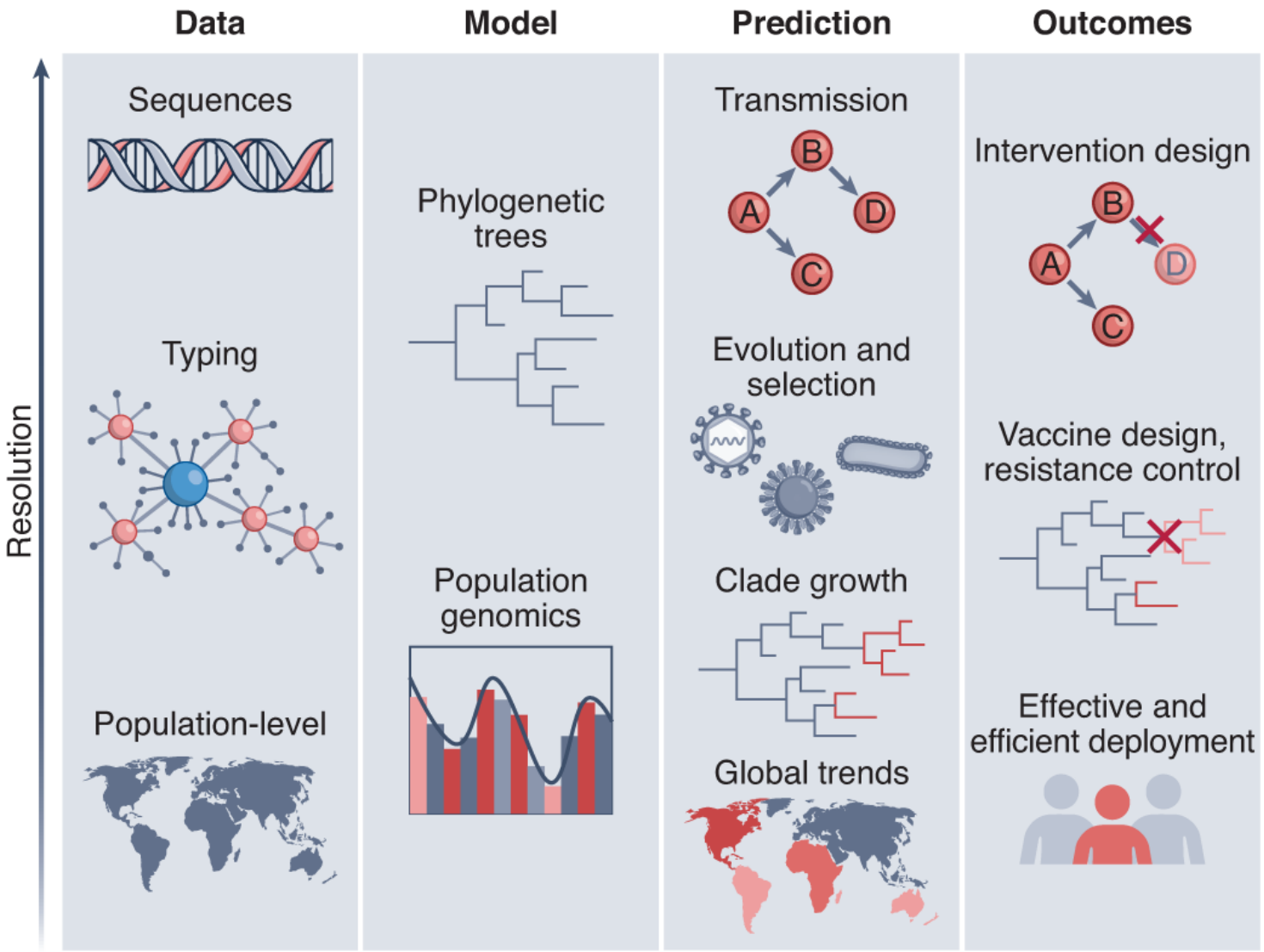
New type of Data in all scale

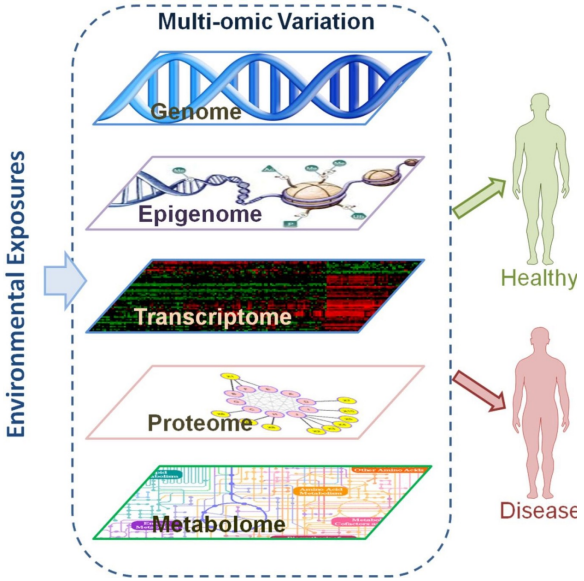


Complex for human understanding proper for AI

Patient data
Patient family and ancestors ' data
Patient environment data
Doctor evaluation

Multi-omics Data





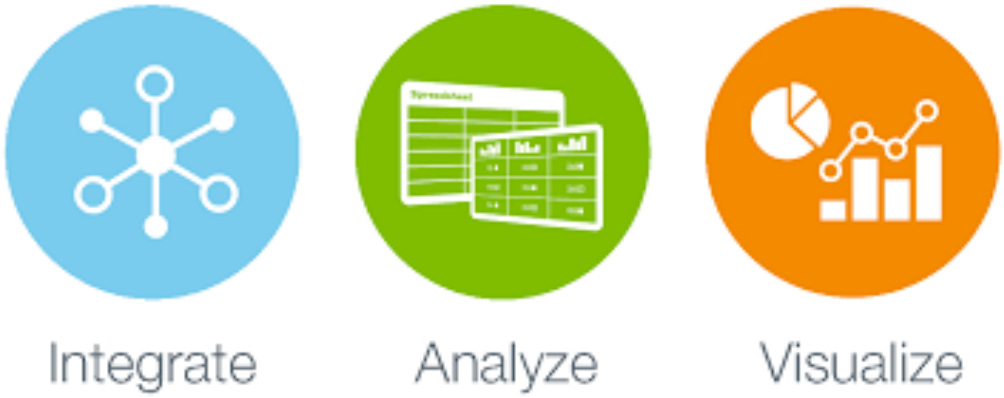
Analyze genetic data

revealing disease prognosis

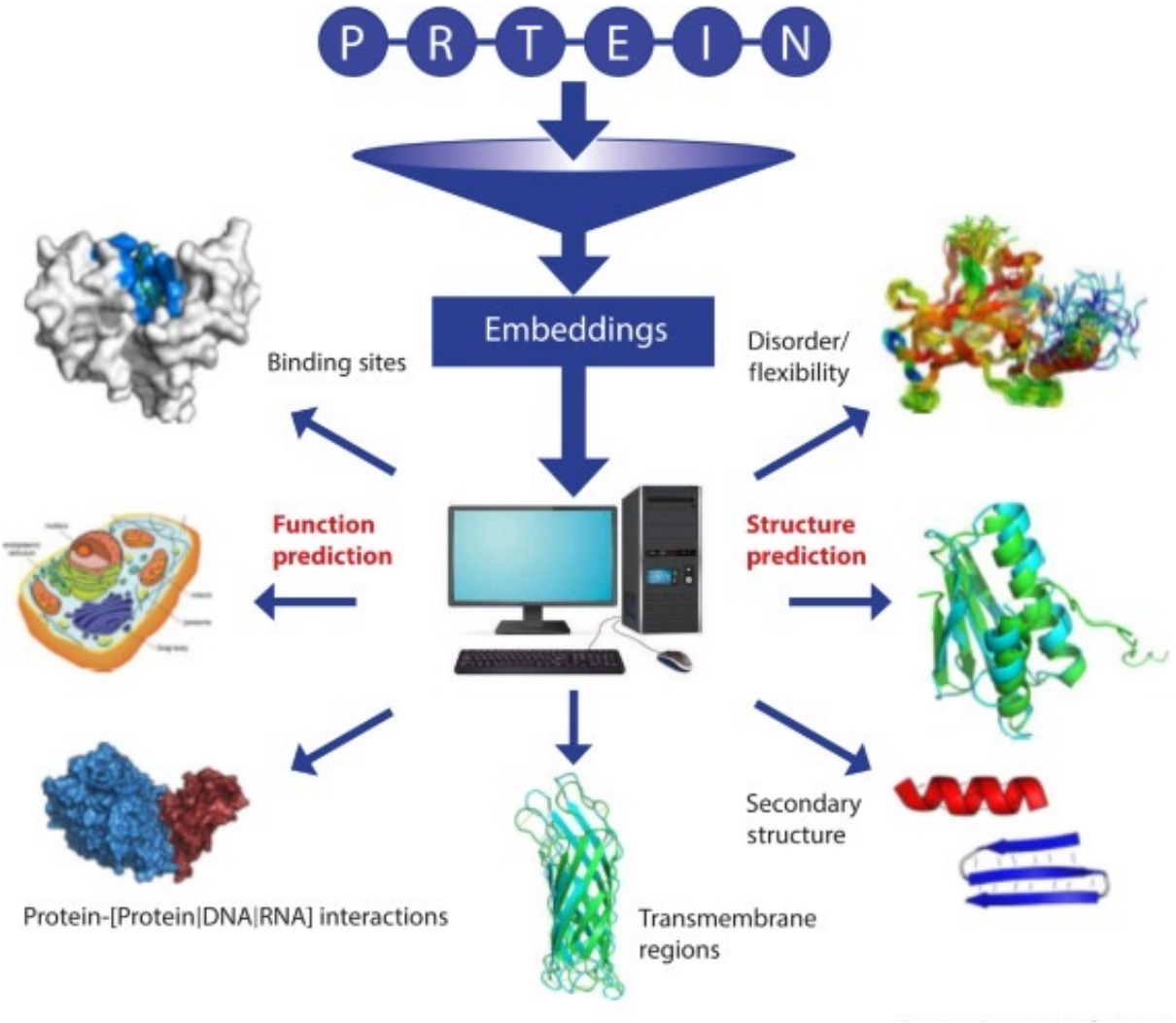
suggesting preventive treatments

best treatment option

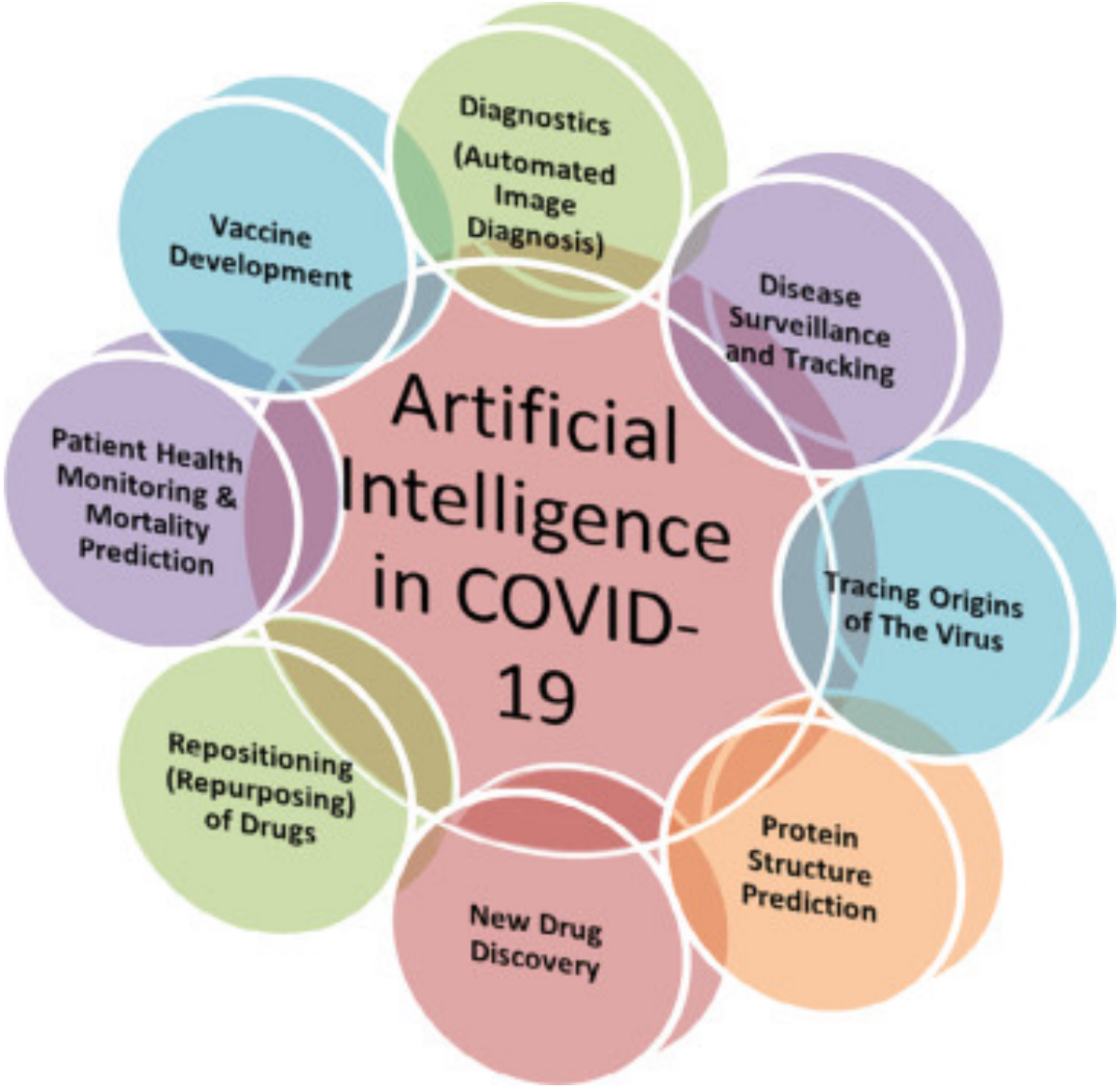
success rates of each treatment



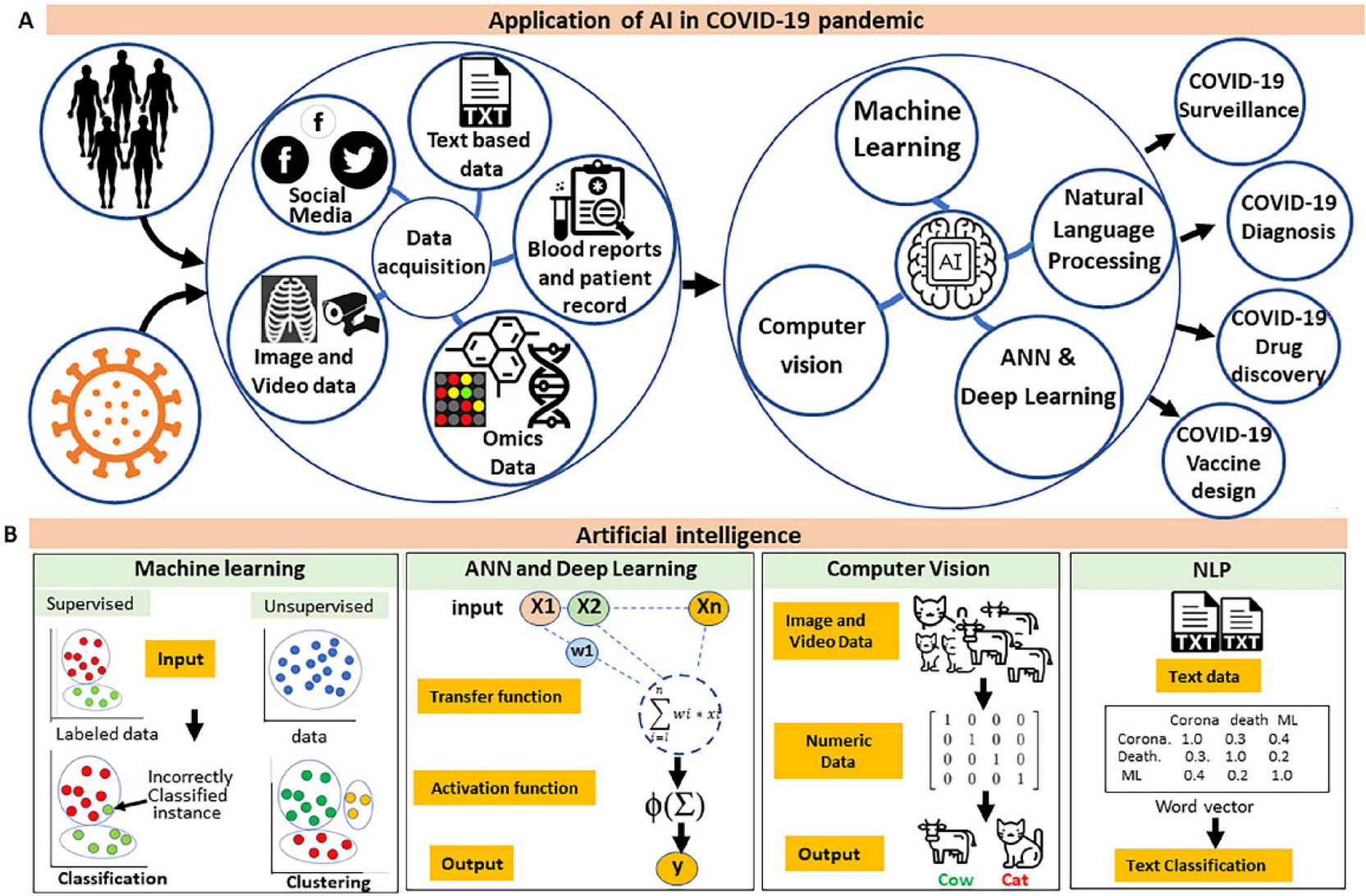
Protein Analyzing



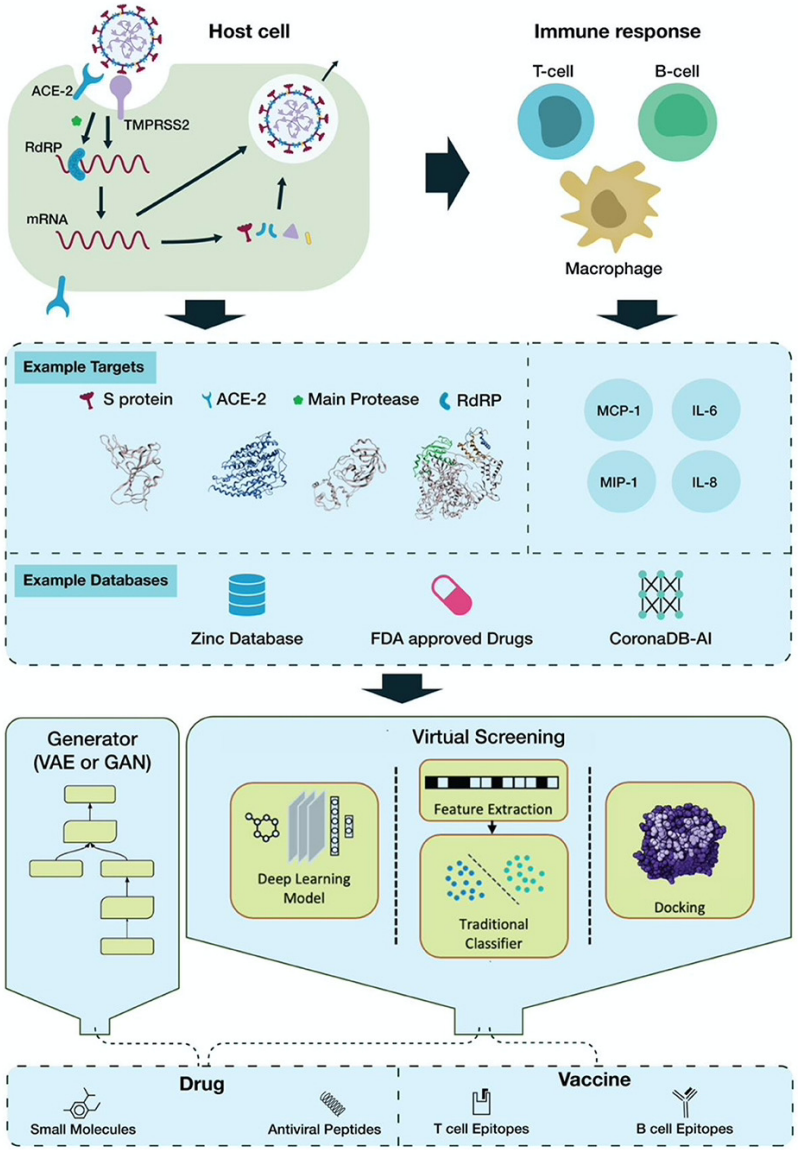
AI and Infectious disease



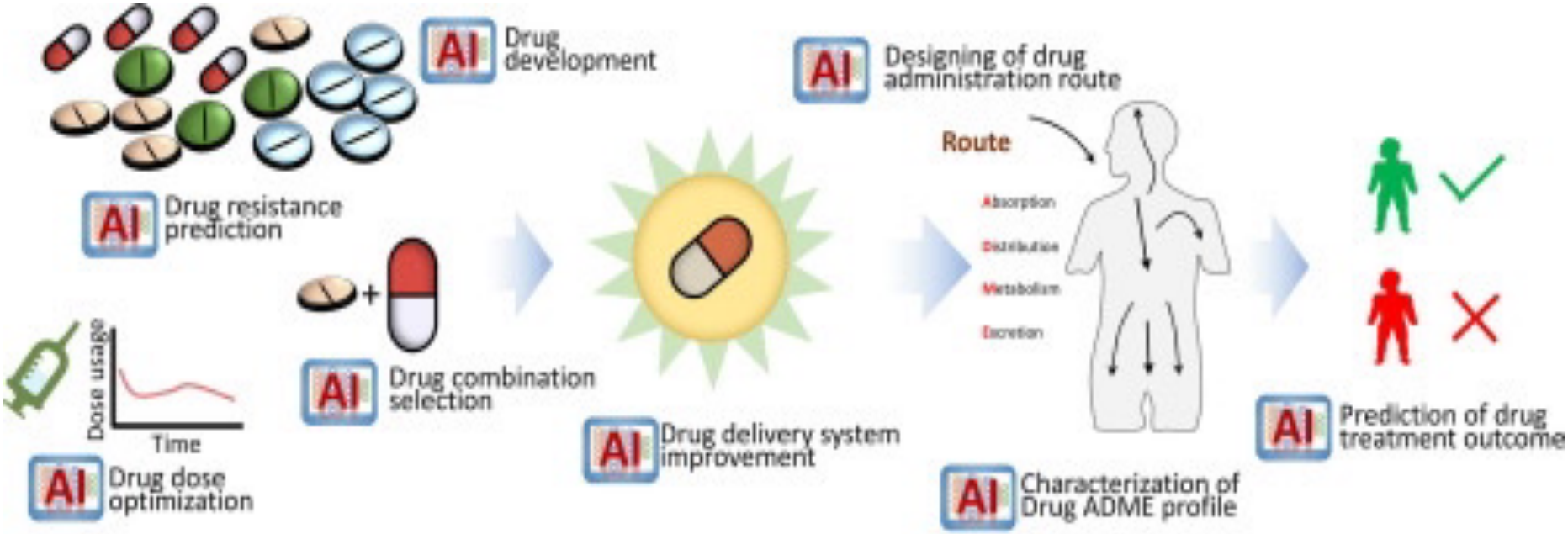
AI and Infectious disease



AI and vaccine development

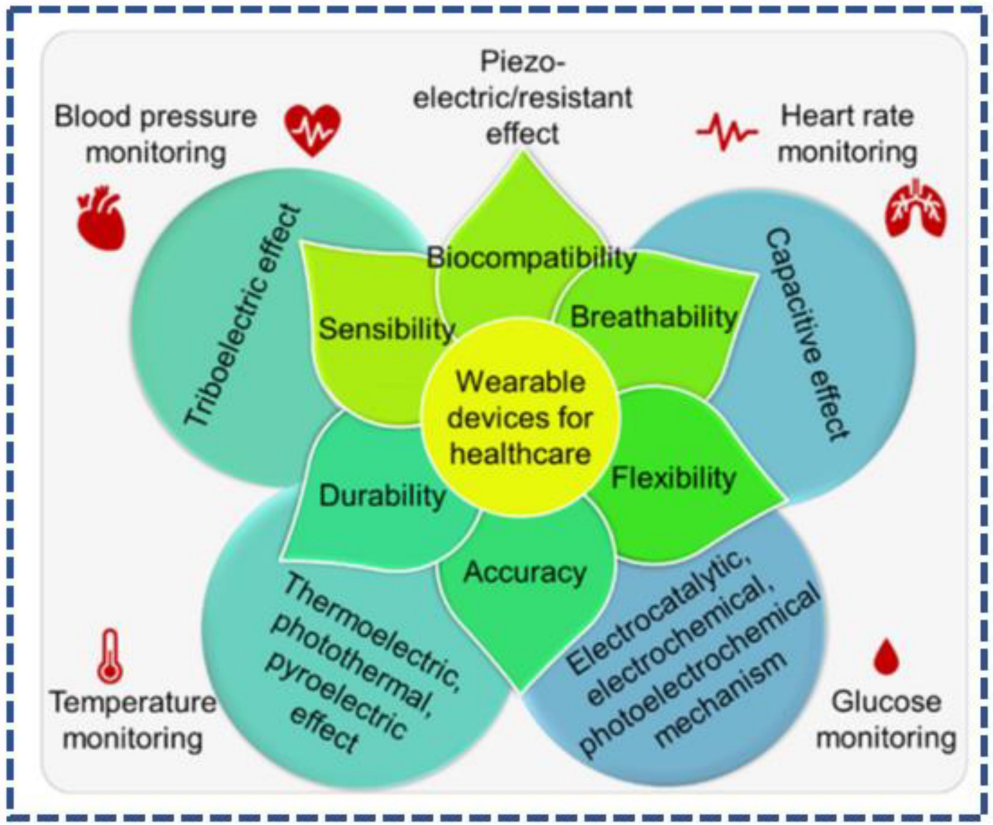


AI in drug delivery

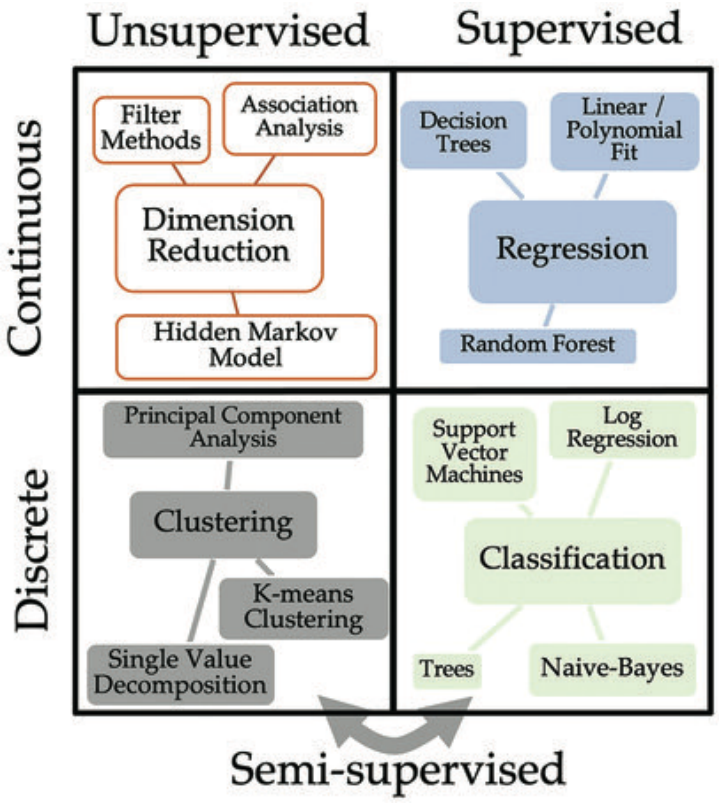


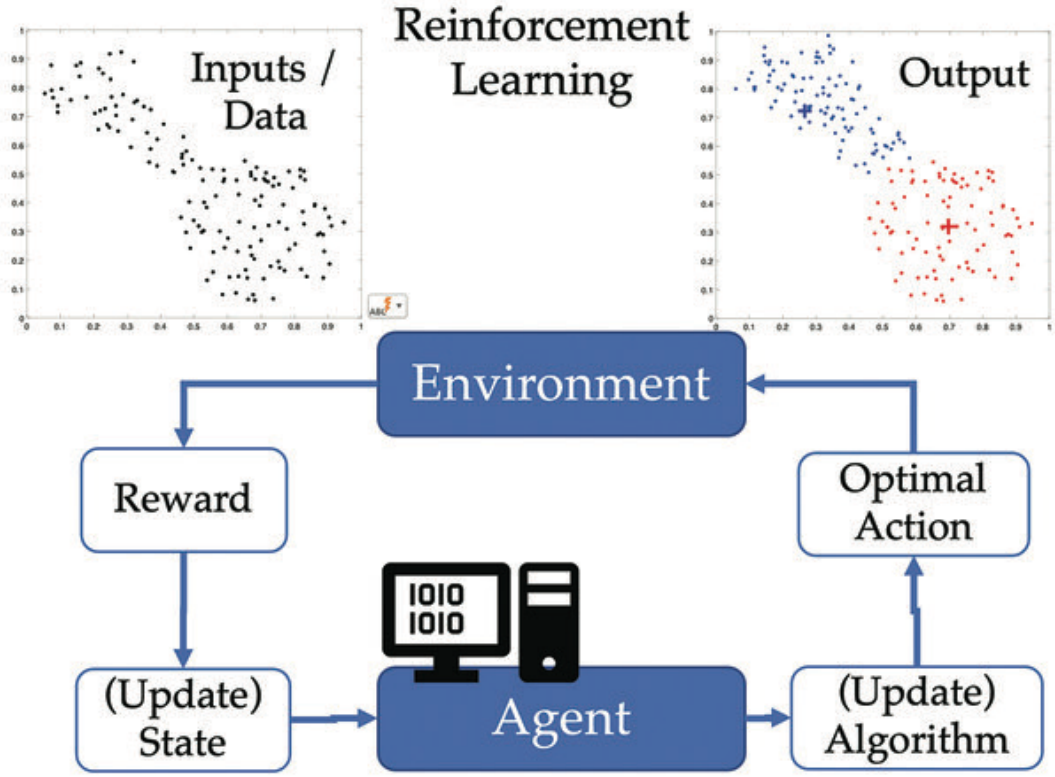
Wearable for wellness monitoring

- ***Support the diagnosis process and predict future issues***



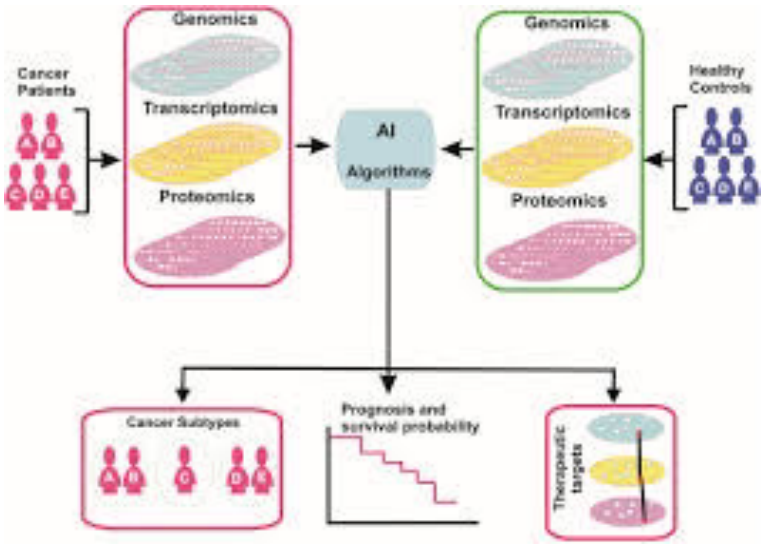
Clinical decision support





Precision Medicine

- Doctors use precision for anticipating a treatment or a disease before its onset which is based on therapies and tests.
- AI precision medicine for disease detection provides useful insights such as type of disease and further course of medications.



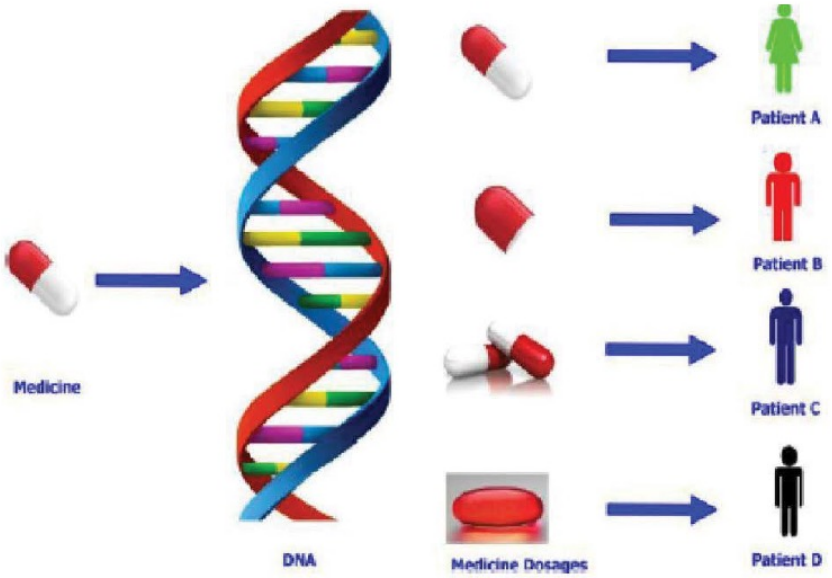
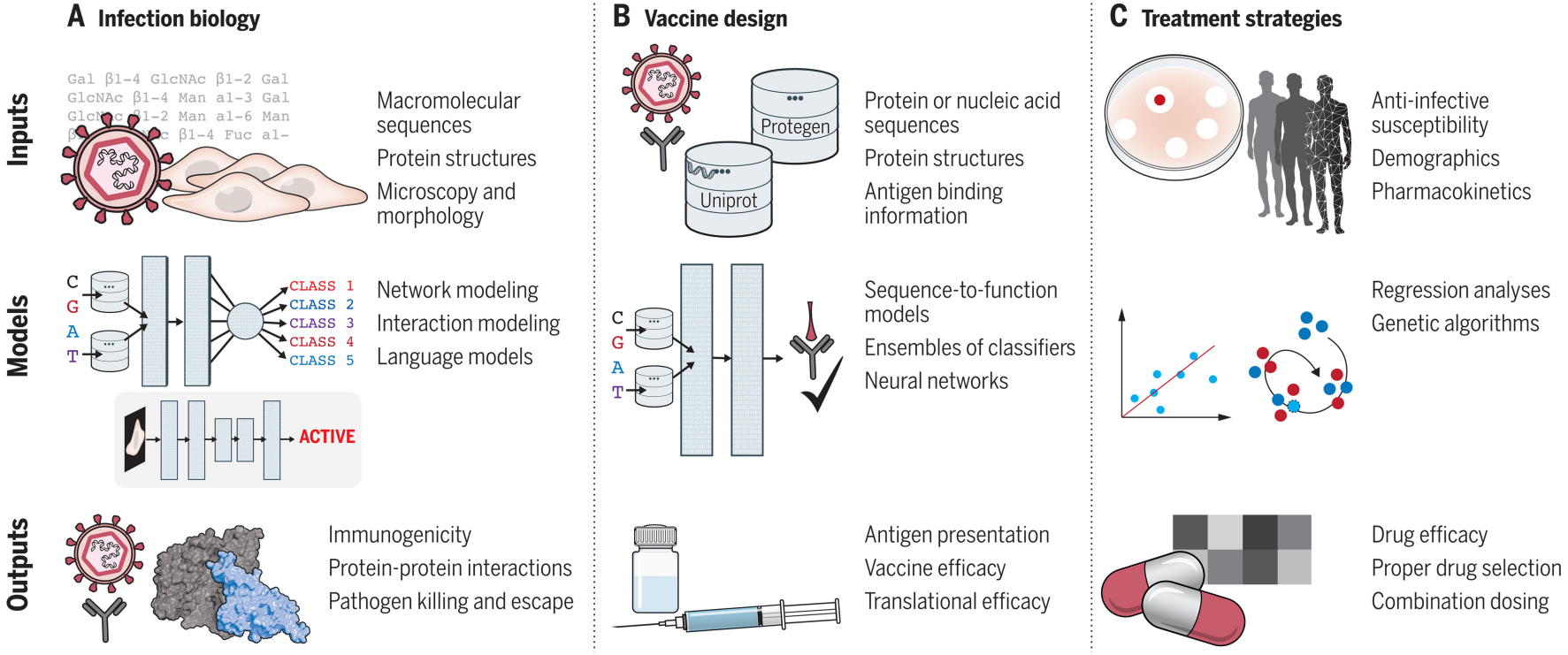


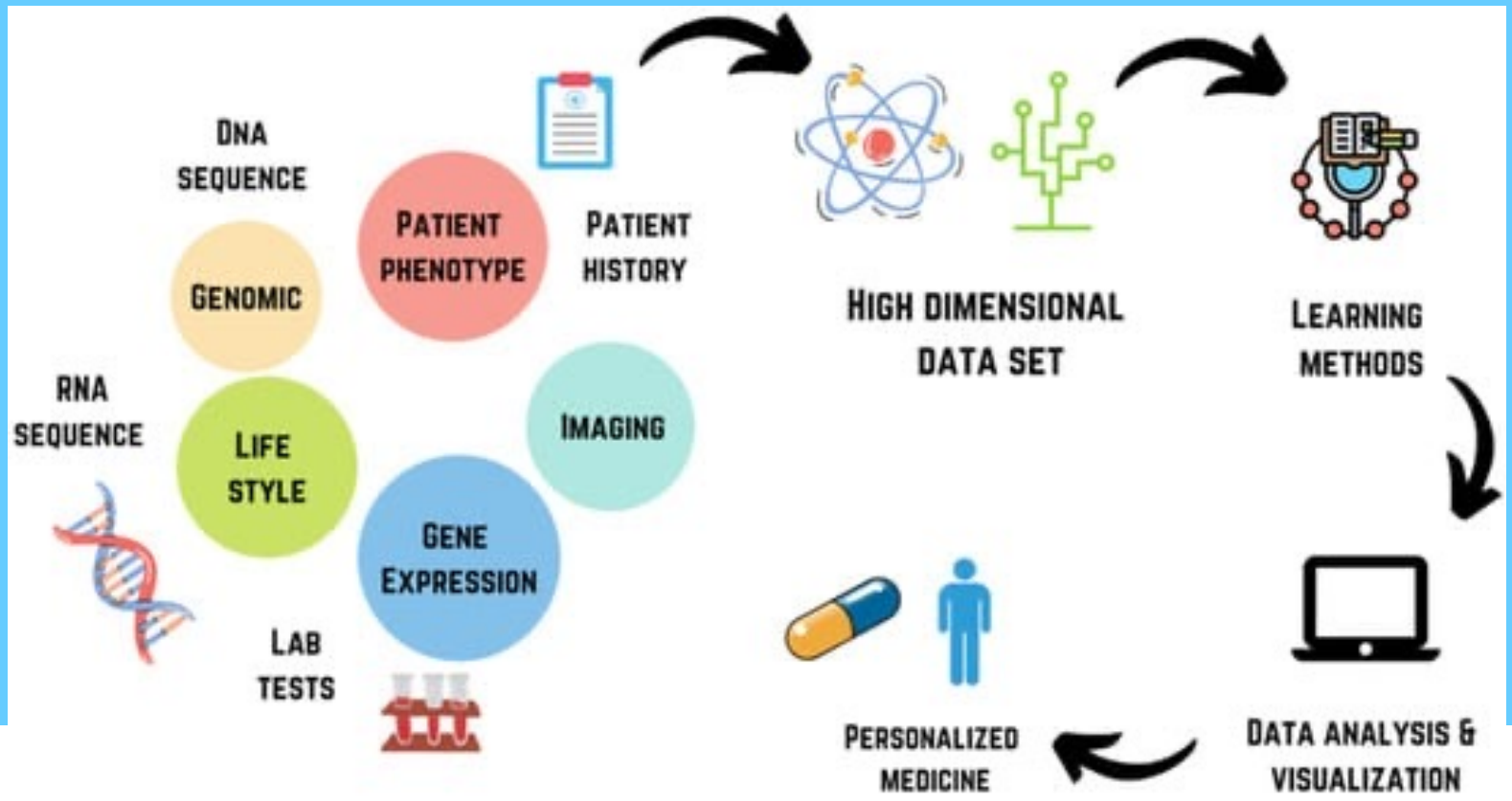
Figure 2: Precision Medicine [3].

Development of disease models

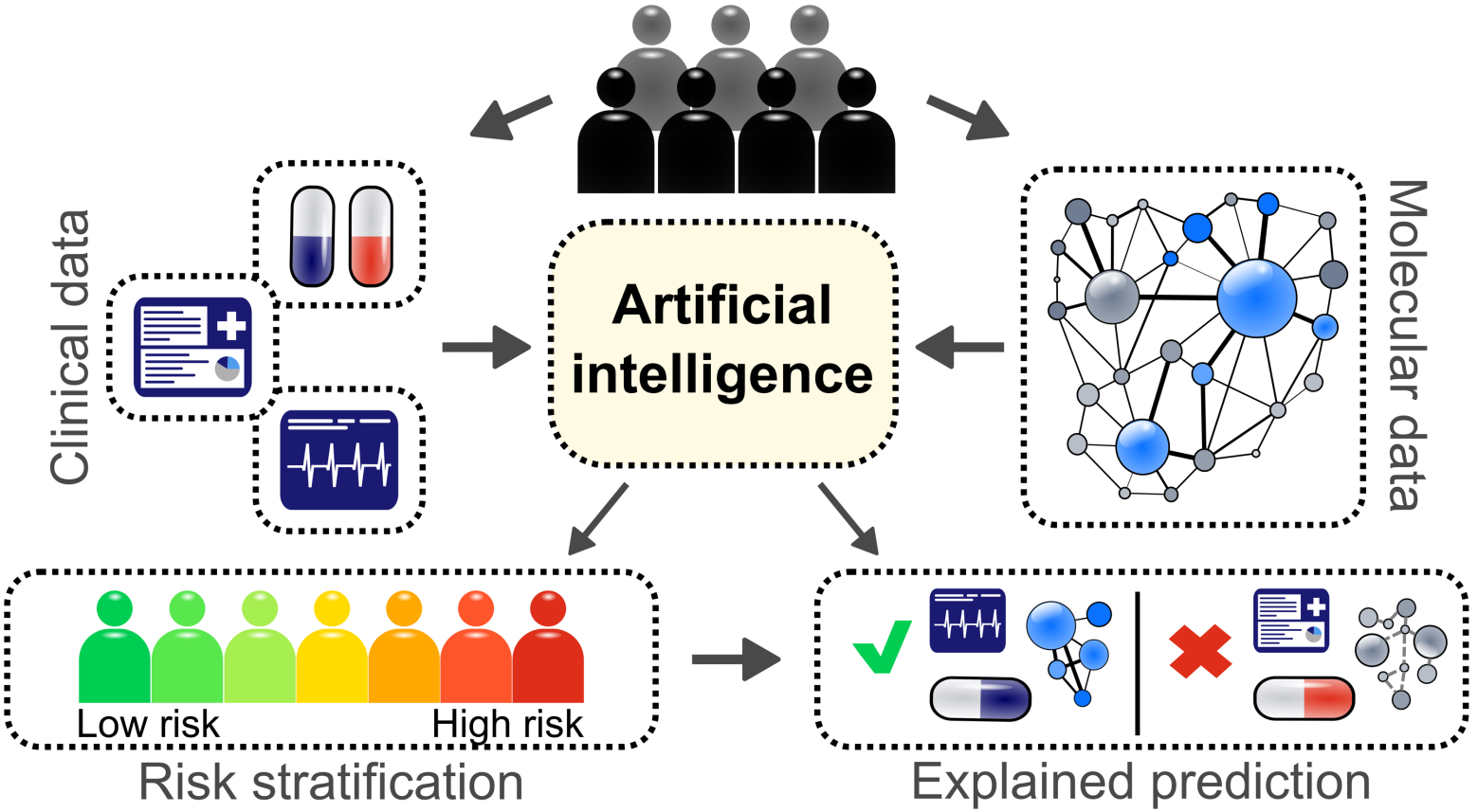


Predictive analytics

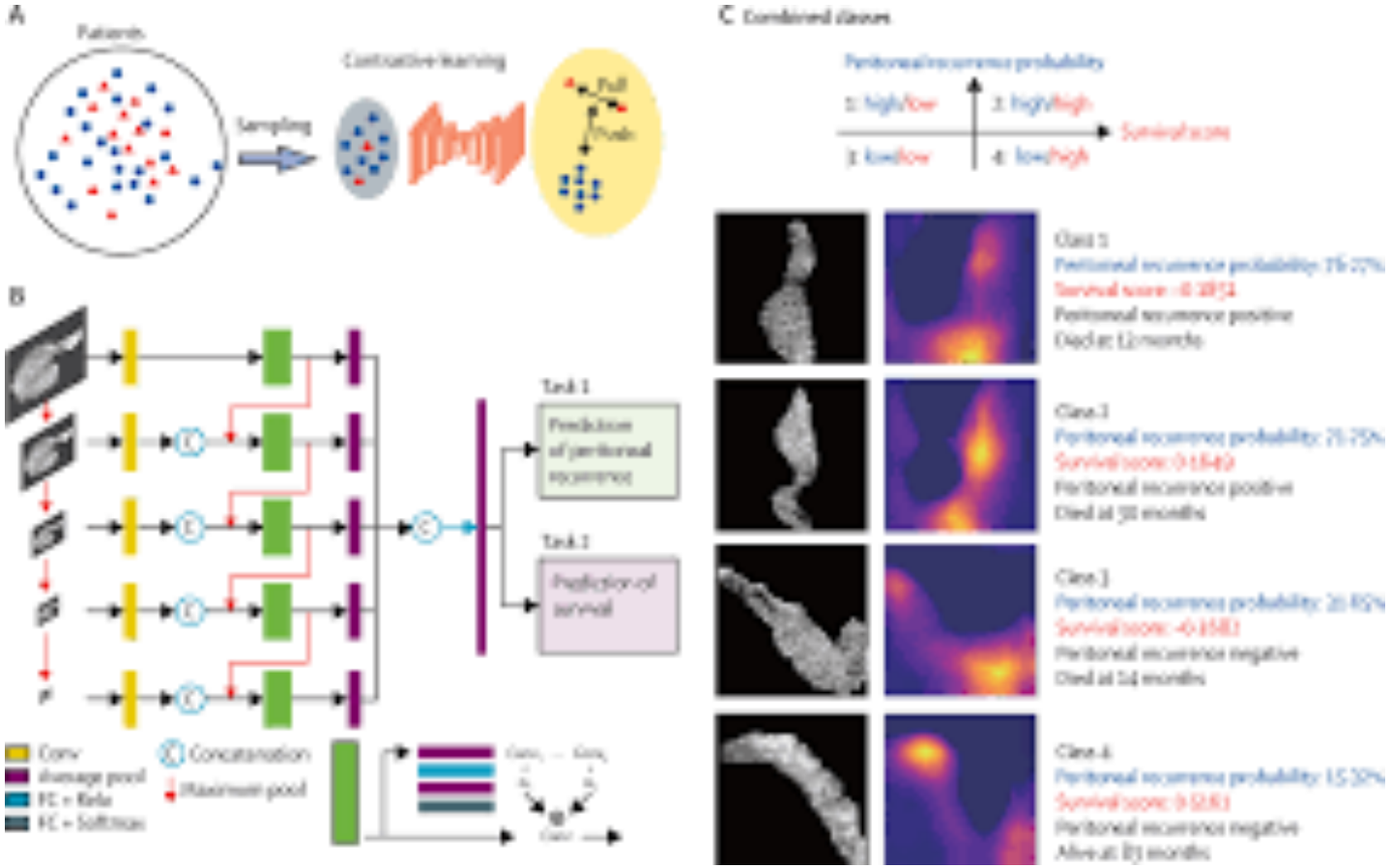
- predict a particular developing a certain disease allowing for earlier intervention and treatment.



Disease Risk Assessment

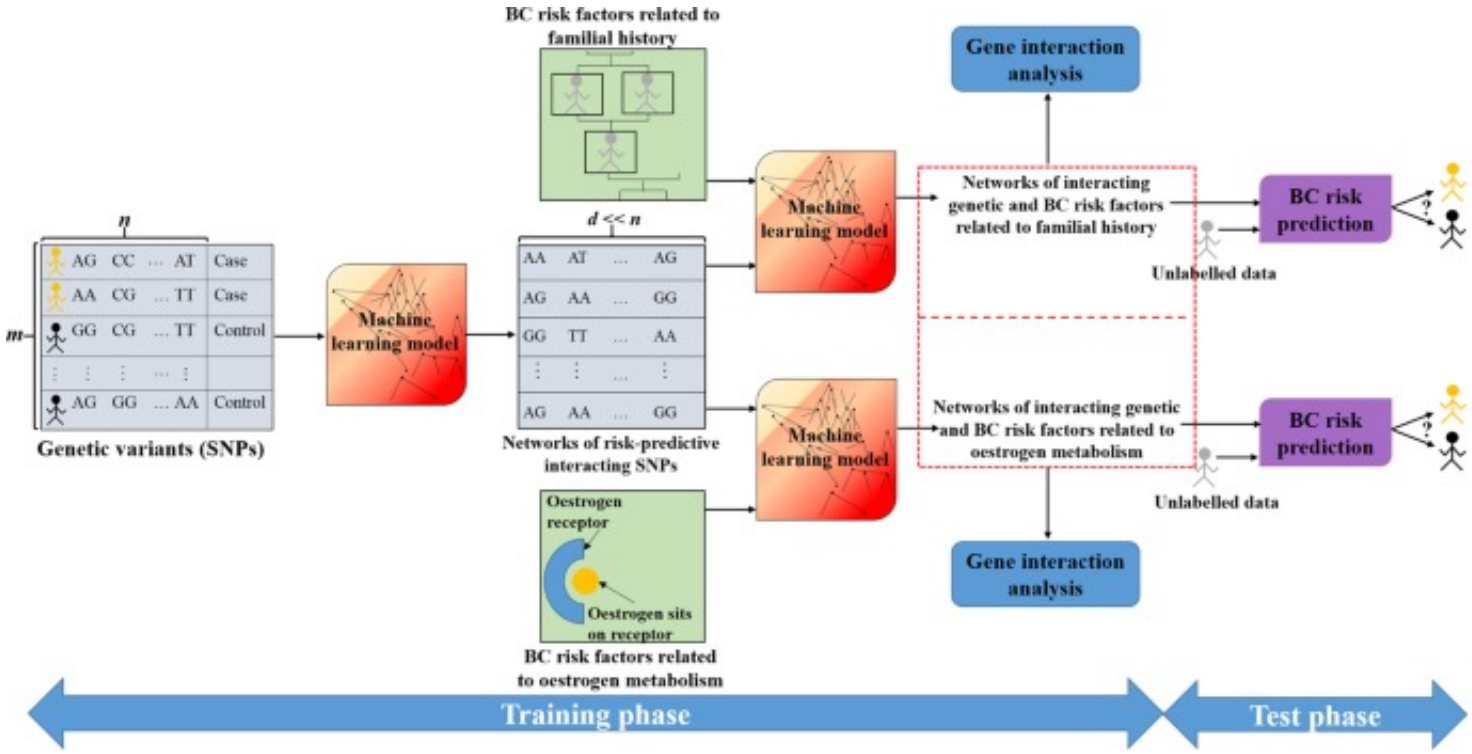


Cancer Recurrence Prediction



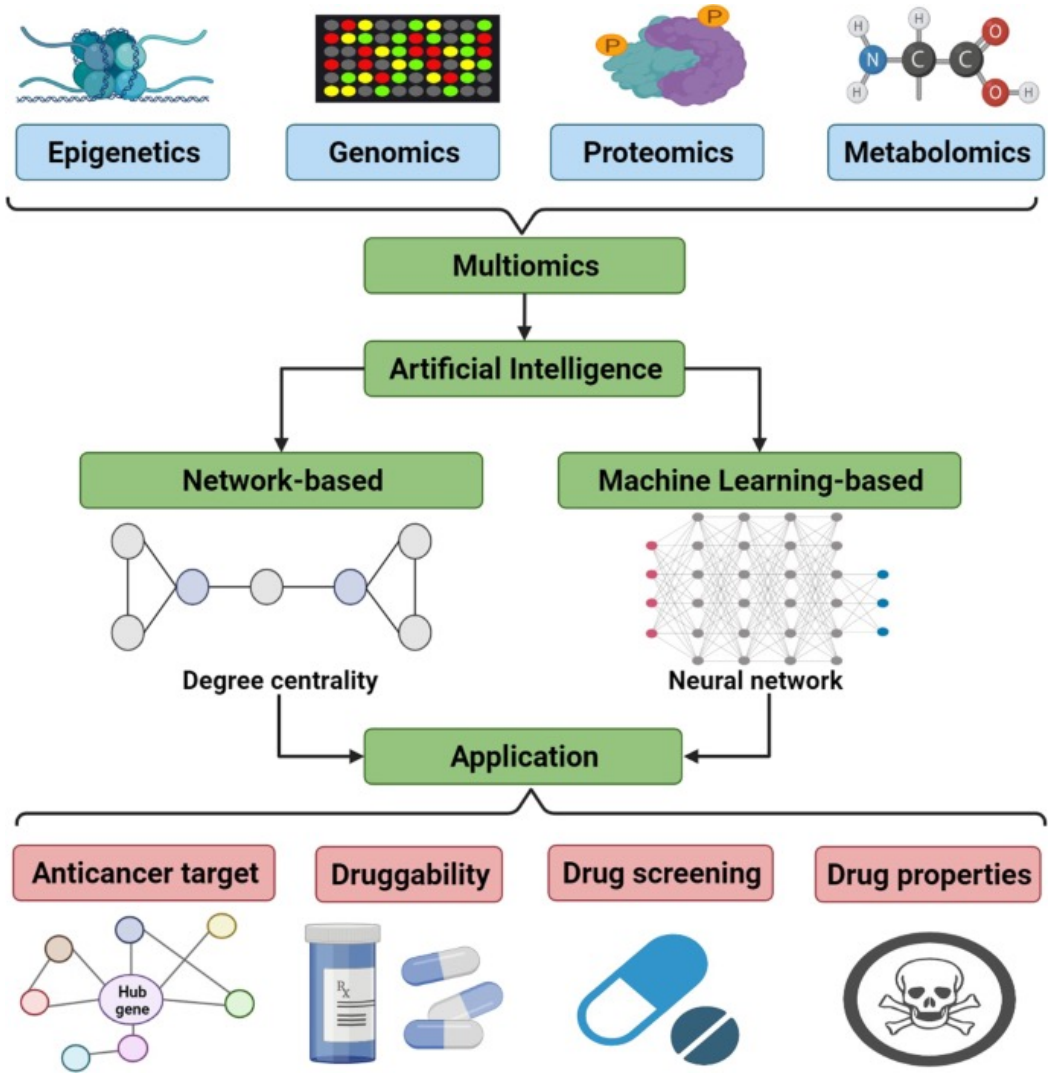
Guihong Wan et al., Prediction of early-stage melanoma recurrence using clinical and histopathologic features," npj Precision Oncology volume 6, Article number: 79 (2022)

Predicting the Risk of Cancer



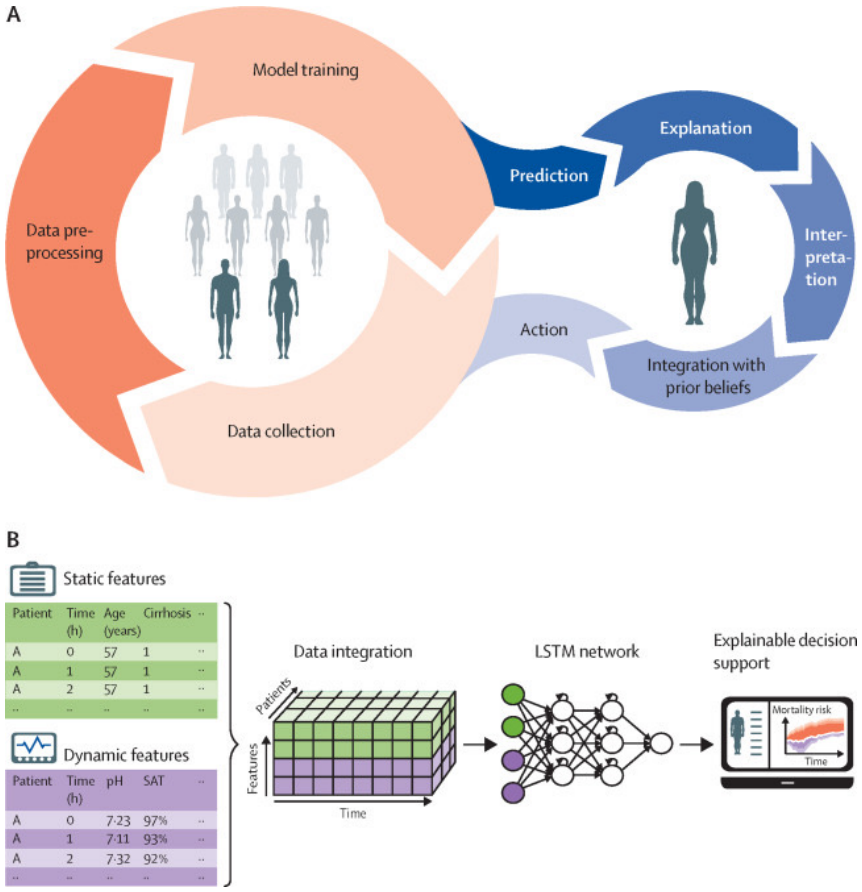
Hamid Behravan, Predicting breast cancer risk using interacting genetic and demographic factors and machine learning, Scientific Reports volume 10, Article number: 11044 (2020)

Analyzing Signaling Pathway



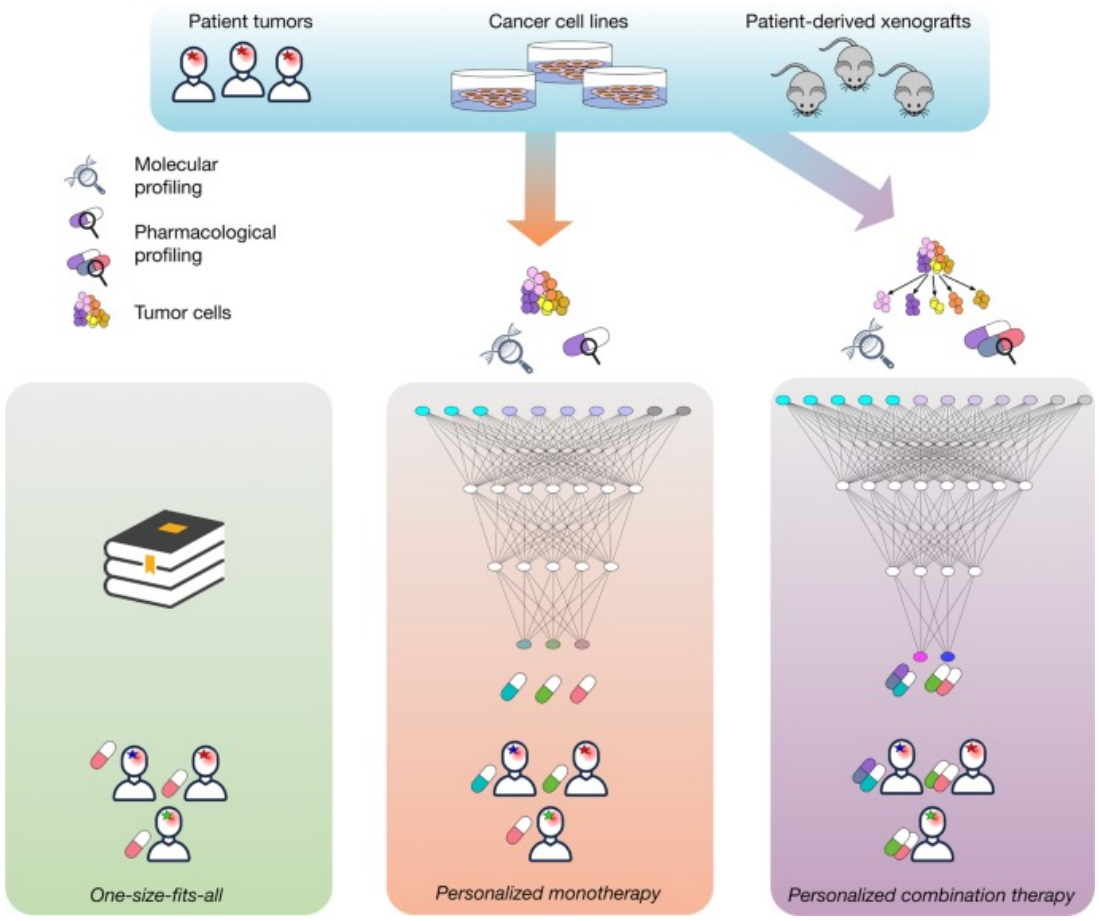
Artificial intelligence in cancer target identification and drug discovery, Signal Transduction and Targeted Therapy volume 7, Article number: 156 (2022)

Predicting Mortality and Morbidity



Predicting 180-day mortality for women with ovarian cancer using machine learning and patient-reported outcome data, Scientific Reports volume 12, Article number: 21269 (2022)

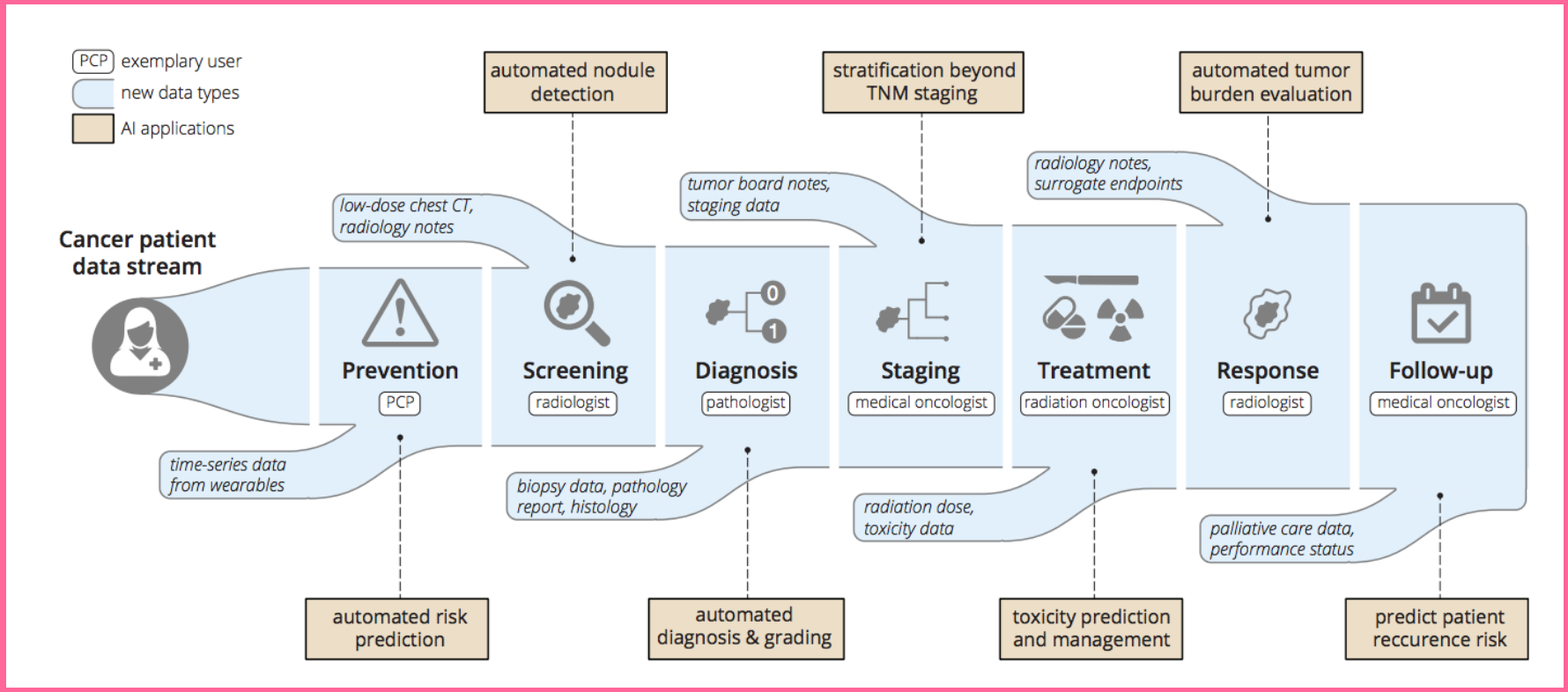
Predicting Treatment Response



Machine learning approaches to drug response prediction: challenges and recent progress, npj Precision Oncology volume 4, Article number: 19 (2020)

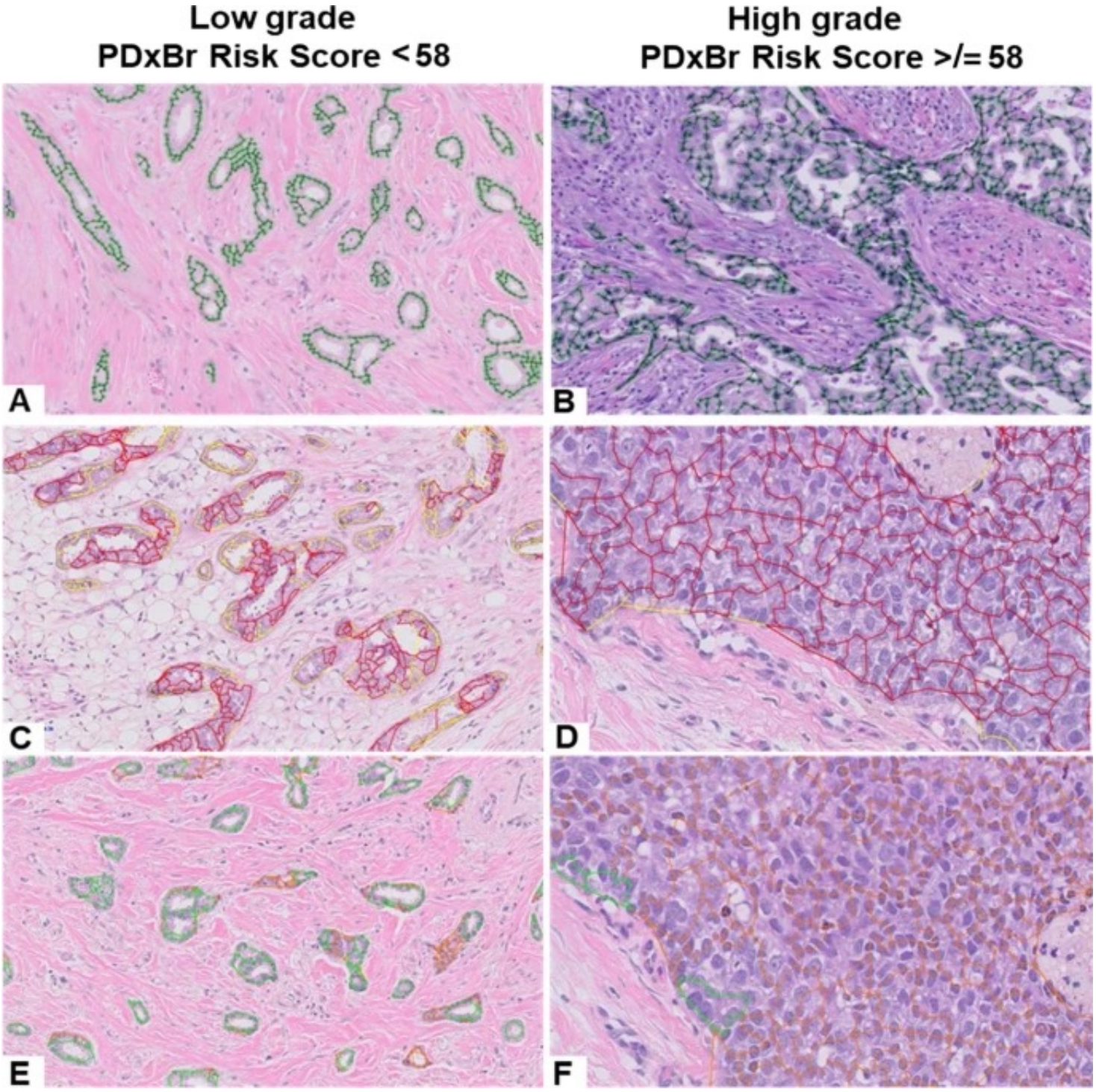
AI-based Patient Monitoring

Intelligent Oncology



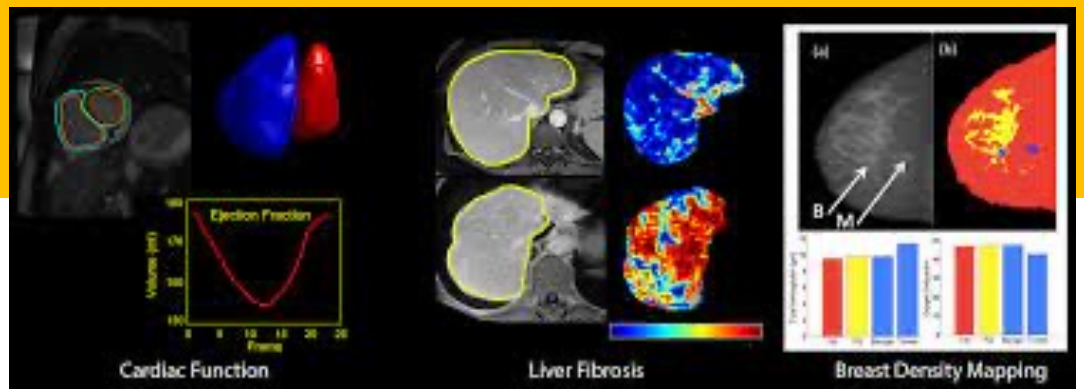
Digital pathology

- Time-consuming, can lead to errors, and is subjective.


Low grade
PDxBr Risk Score < 58
High grade
PDxBr Risk Score >/= 58
A
B
C
D
E
F

Imaging

- The AI software is designed to compare current and previous images, analyze them, and prioritize them too.



Radiology

- Interpretation of Radiology Images
- Virtual Biopsy

Gastroenterology

- April 2021: GI Genius (Cosmo Artificial Intelligence—AI, LTD)

- It is a computer-assisted reading tool designed to aid endoscopists in detecting colonic mucosal lesions (such as polyps and adenomas) in real time during standard white-light endoscopy.

Claudio Luchini Et al, "Artificial intelligence in oncology: current applications and future perspectives" *British Journal of Cancer*, vol. 126, pages4–9, 2022.

Helping in Medical Decision Making

Predict the risk of major complications after surgery

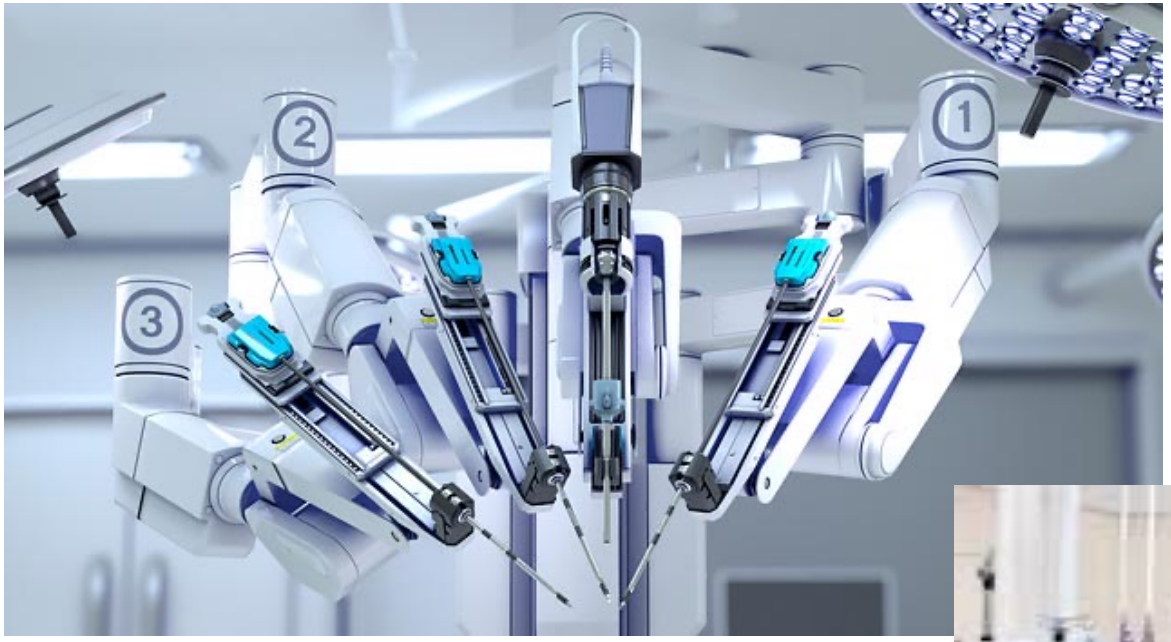
- flap failure
- surgical site infection
- wound dehiscence
- deep vein thrombosis,
- reintubation

Benjamin Shickel Et al., “Dynamic predictions of postoperative complications from explainable, uncertainty-aware, and multi-task deep neural networks,” Scientific Reports volume 13, Article number: 1224 (2023)

Predict the risk of mortality after surgery

Seung Wook Lee Et al., “Multi-center validation of machine learning model for preoperative prediction of postoperative mortality,” npj Digital Medicine volume 5, Article number: 91 (2022)

Medical Robotics



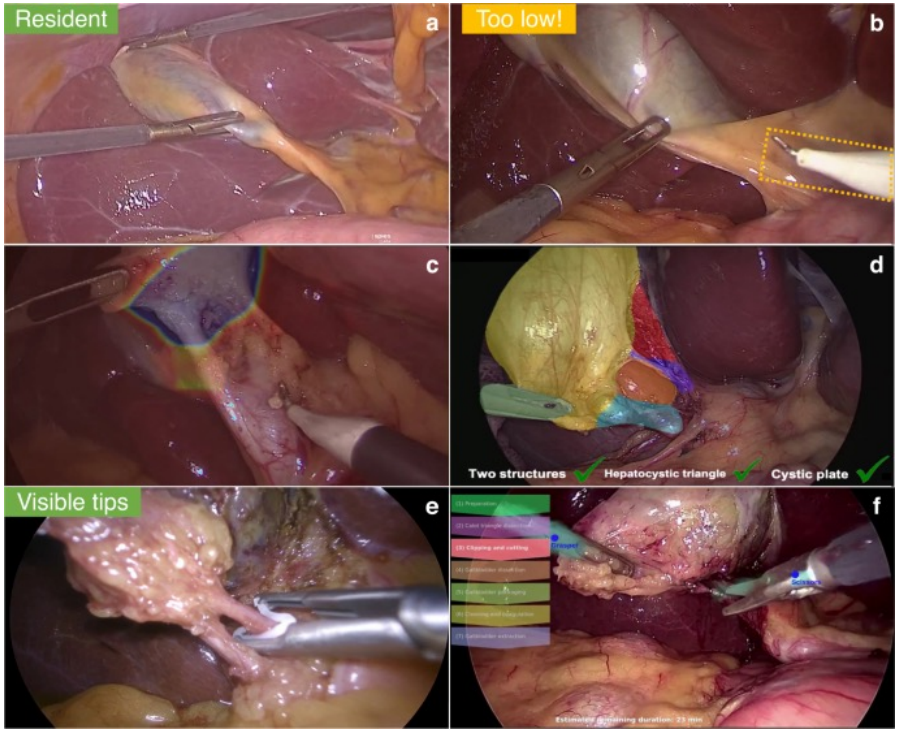
Post-operative Phase

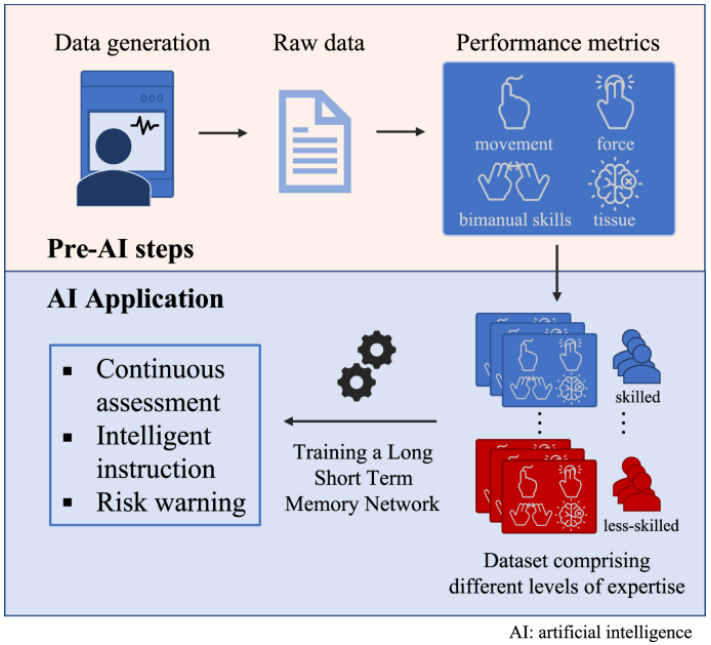
- Surgical room organization
- Estimating remaining surgical time
- Estimating patient’s recovery time
- Estimating blood loss
- Patient Monitoring
- Remote Patient Monitoring
- Modification of medical treatment

Pranav Rajpurkar Et al, “AI in health and medicine,” Nature Medicine volume 28, pages31–38 (2022).
Julián N. Acosta Et al., “Multimodal biomedical AI,” Nature Medicine volume 28, pages1773–1784 (2022)

Enhance surgical training

- Training
- Scoring the performance of surgical trainees.





Omri Bar Et al., "Impact of data on generalization of AI for surgical intelligence applications," Scientific Reports volume 10, Article number: 22208 (2020)

Recai Yilmaz Et al., "Continuous monitoring of surgical bimanual expertise using deep neural networks in virtual reality simulation," npj Digital Medicine volume 5, Article number: 54 (2022).

Pietro Mascagni Et al., "Computer vision in surgery: from potential to clinical value," npj Digital Medicine volume 5, Article number: 163 (2022) .

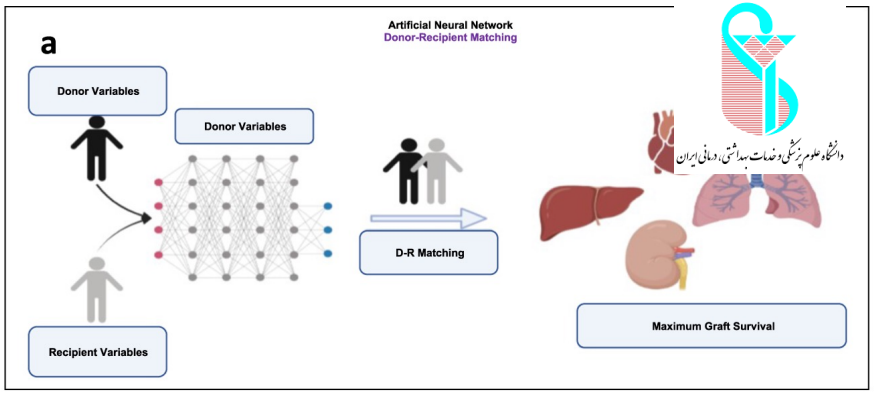
Hospitalization, Triage tools, Operating Room

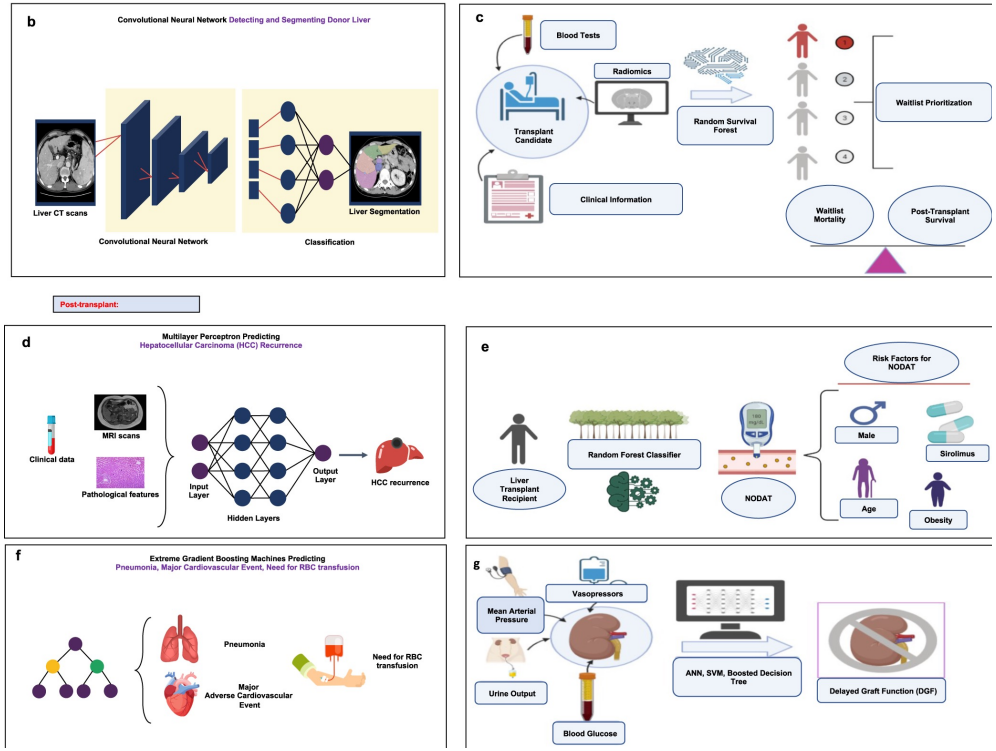
- Predictions of the surgical case duration
- Precise scheduling, limiting waste of resources
- Identifying surgeries with high risks of cancellation

[1] J.-Ting Lee, “Prediction of hospitalization using artificial intelligence for urgent patients in the emergency department,” *Scientific Reports,* vol. 11, No. 19472, 2021.

Organ Transplant

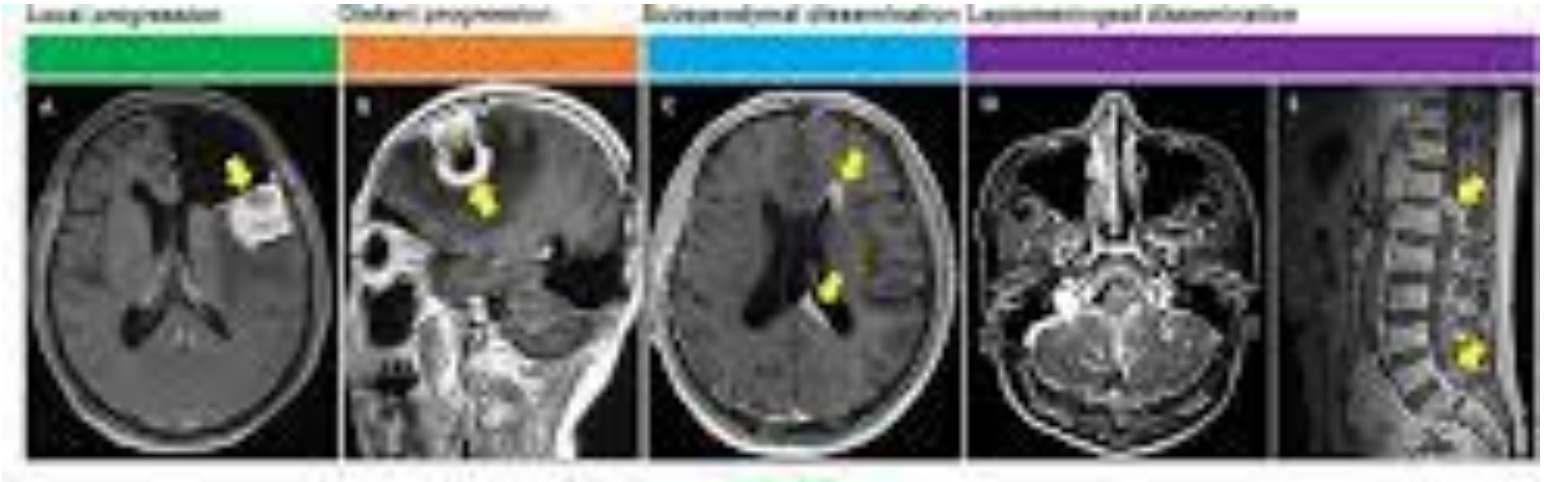
- Optimal transplant donor organ
- organ-allocation



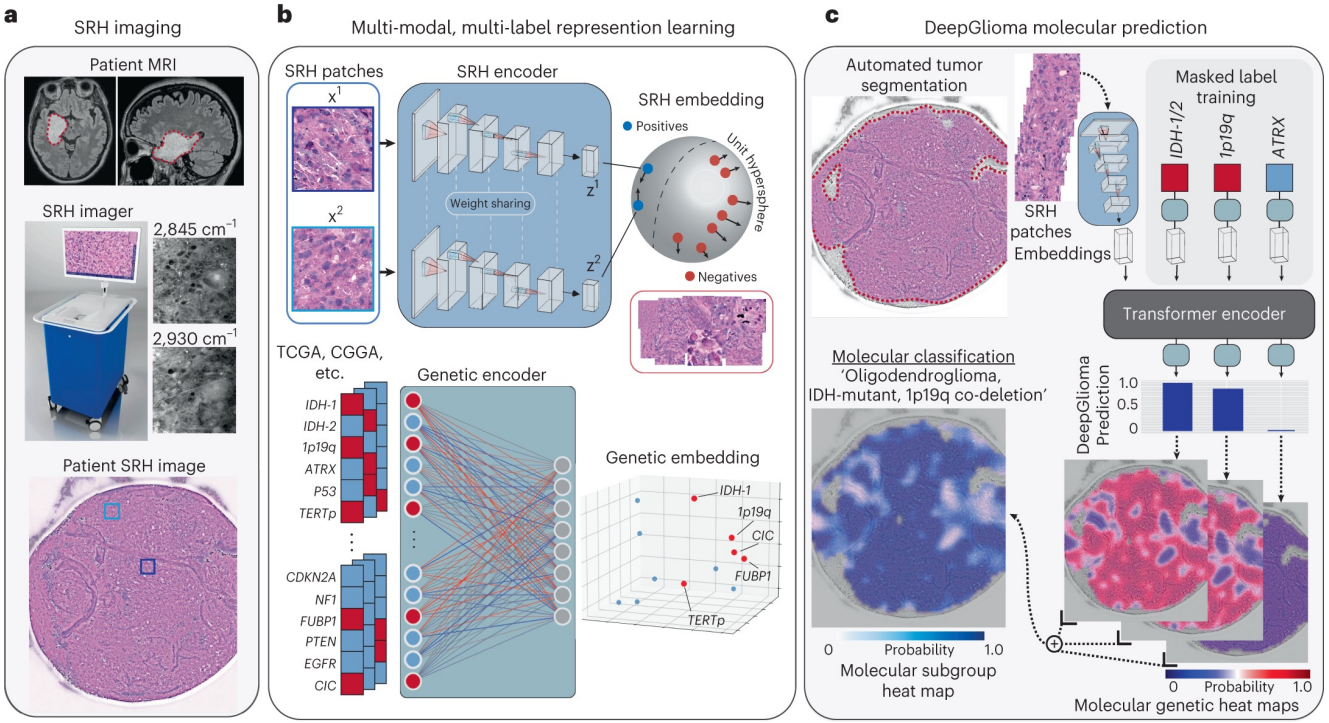


[1] N. Gotlieb Et al., “The promise of machine learning applications in solid organ transplantation,” *npj Digital Medicine,* vol. 5, No. 89, 2022.

AI can predict the progression of a disease



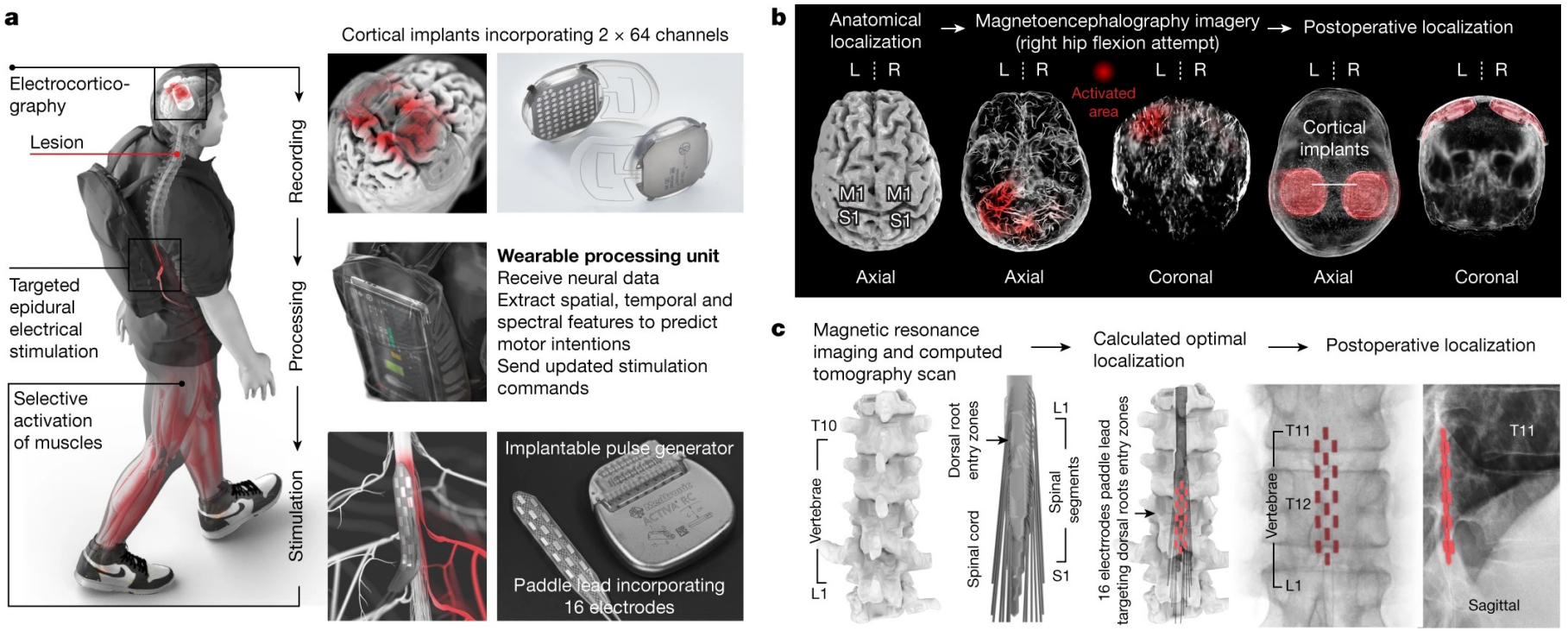
Brain Cancer (AI and optical histology (SRH))



- Molecular classification has transformed the management of brain tumors by enabling more accurate prognostication and personalized treatment.

Artificial-intelligence-based molecular classification of diffuse gliomas using rapid, label-free optical imaging, Nature Medicine volume 29, pages828–832 (2023)

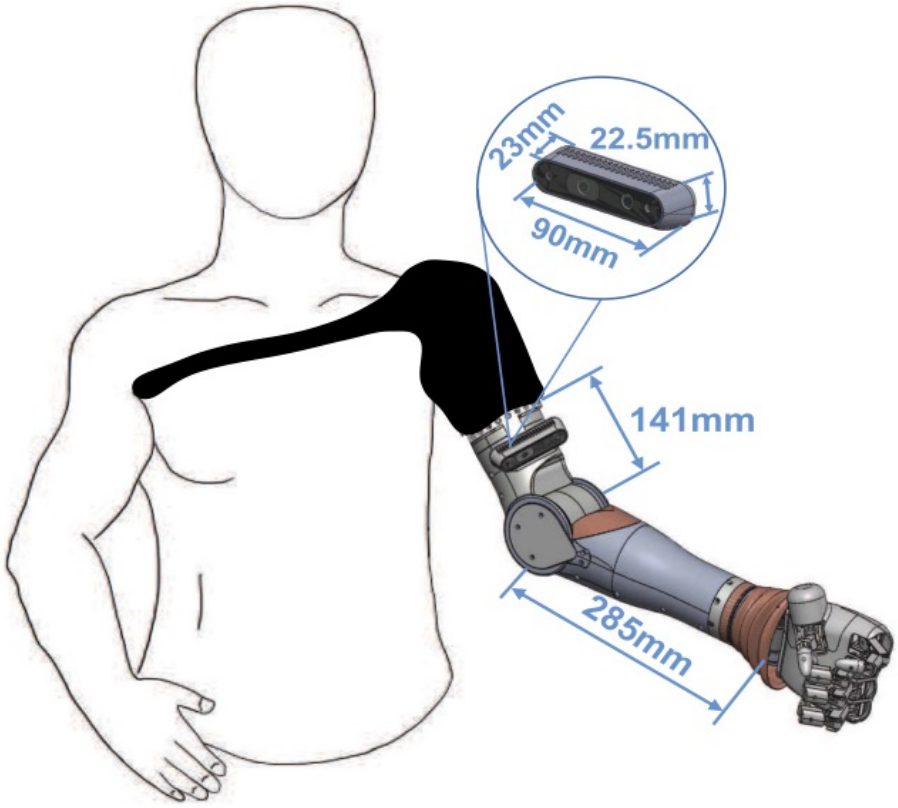
Walking naturally after spinal cord injury using a brain–spine interface

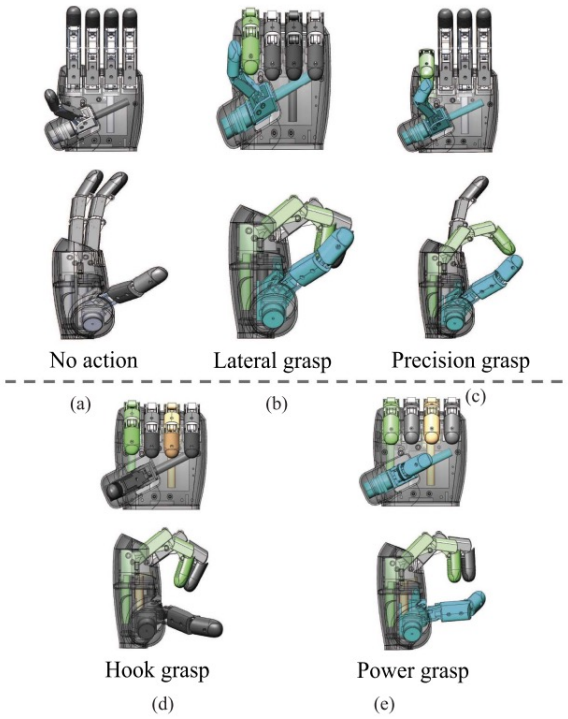


Walking naturally after spinal cord injury using a brain–spine interface, Nature volume 618, pages126–133 (2023)

Cross-Modal Integration and Transfer Learning Using Fuzzy Logic Techniques for Intelligent Upper Limb Prosthesis

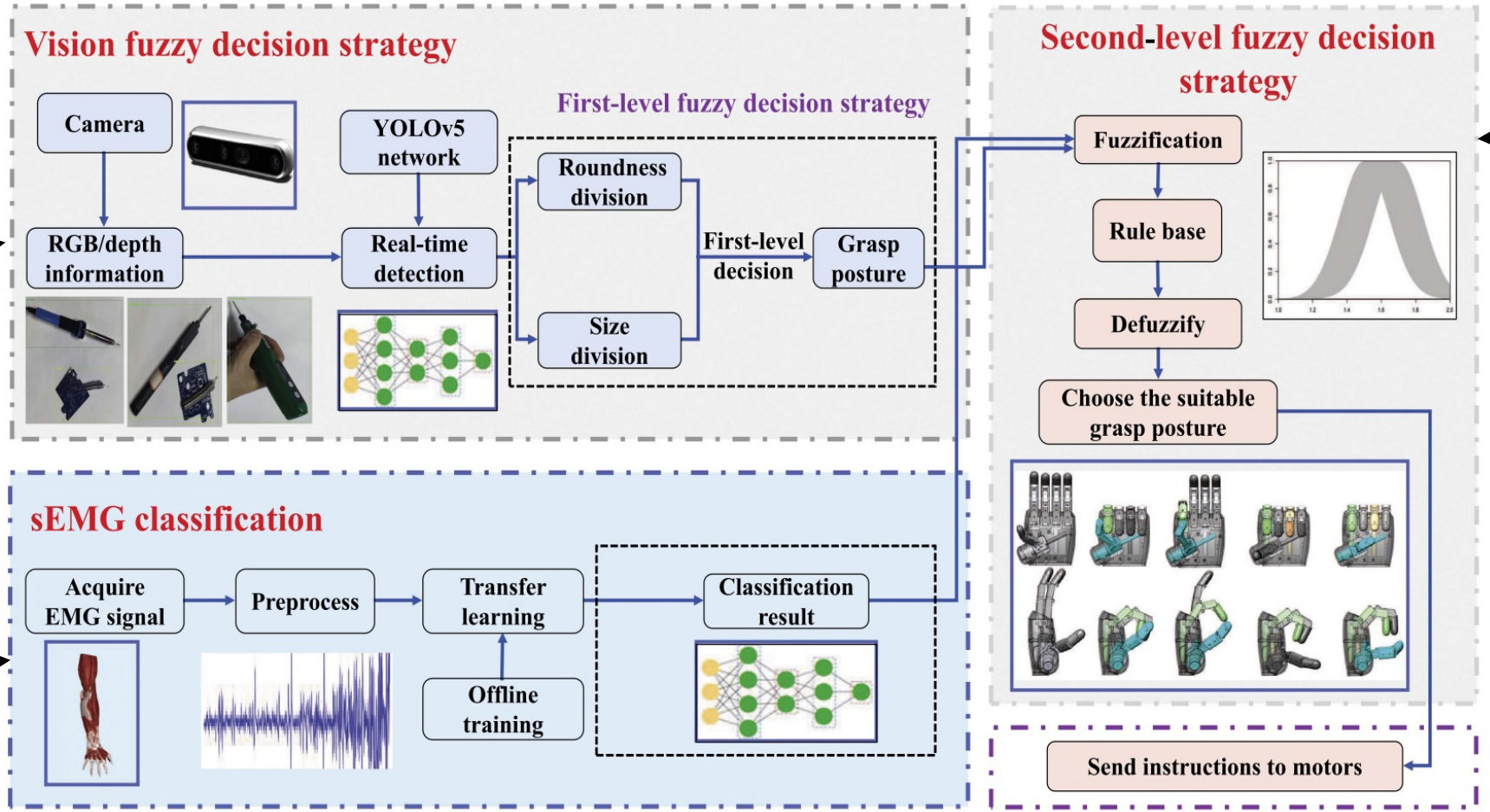
Jin Huang, Zhijun Li, *Fellow, IEEE*, Haisheng Xia, Guang Chen, *Member, IEEE*, and Qingsheng Meng





Then the sEMG signals and image information are integrated to jointly determine the grasping posture of the bionic hand based on fuzzy decision strategy.

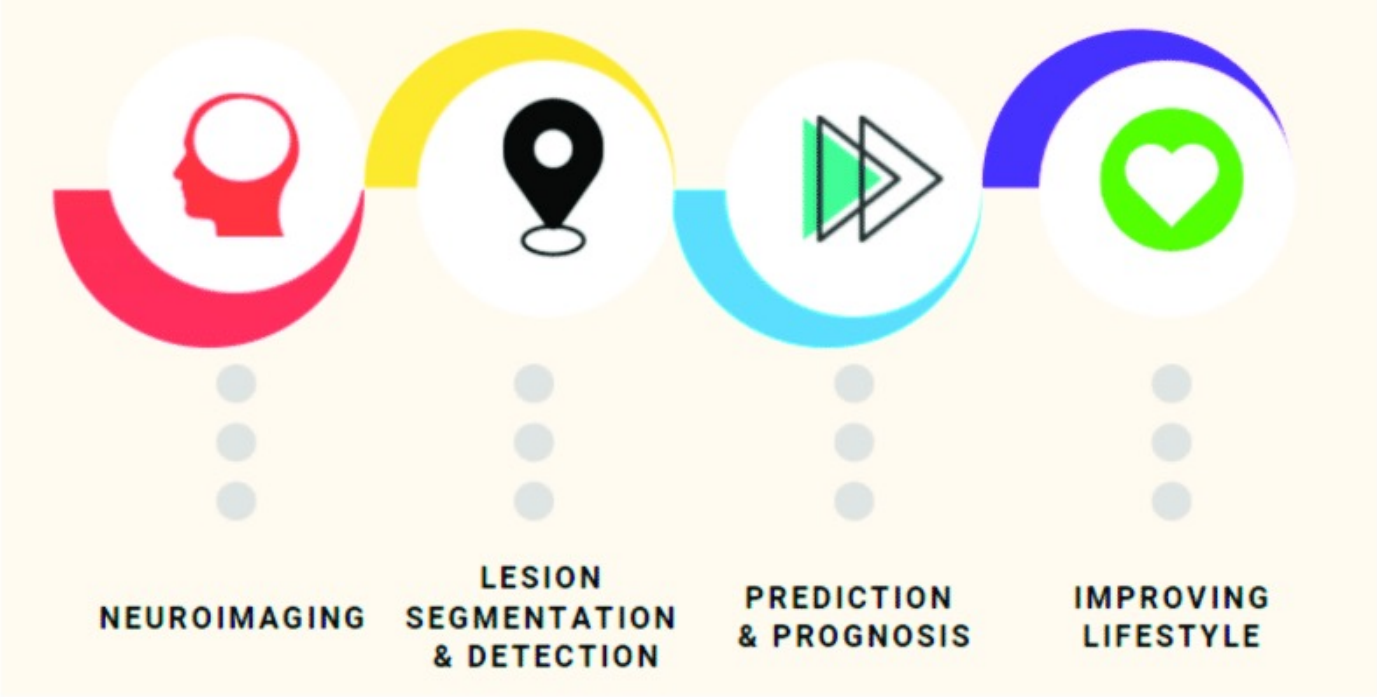
Fusing multisensory data and using cross-modal integration, the system is capable of crossmodally recognizing multimodal information.



First, a transfer learning approach is proposed to improve the decoding of human's intent and enhance the effectiveness of skill transition.

Stroke

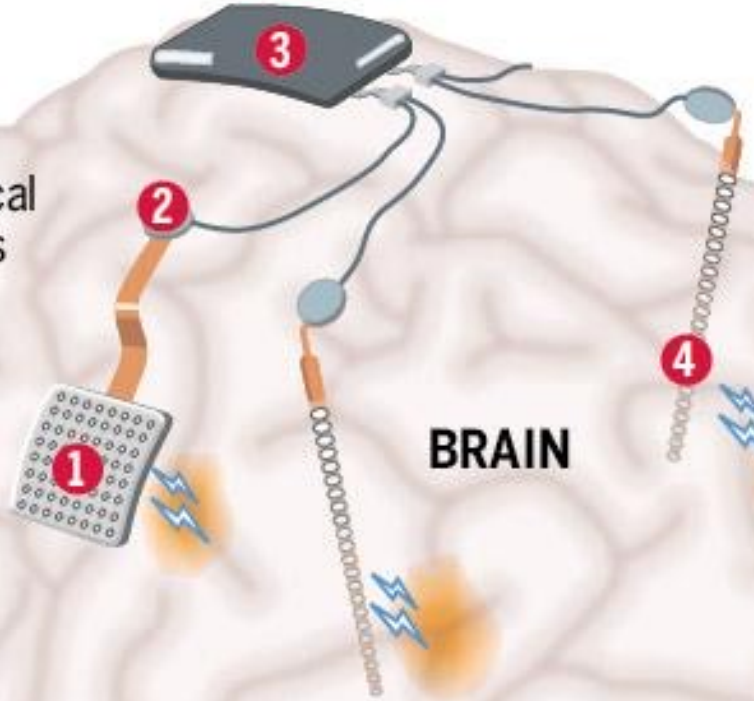
Stroke detection	Type of Stroke detection	Stroke CT Score grading
large vessel occlusion detection	Predict imaging and clinical outcomes	triage, quantification, surveillance



Brain-implanted AI chip

Treating brain disorders using implants

Lawrence Livermore Laboratory scientists are developing a treatment for brain disorders, such as PTSD, using microprocessors to control implanted electrode arrays. Here's how they work:



1. **Electrode arrays** placed over or implanted into the brain record electrical signals from various parts of the brain.

2. **Neuromodulation chips** transmit signals to a control module microprocessor.

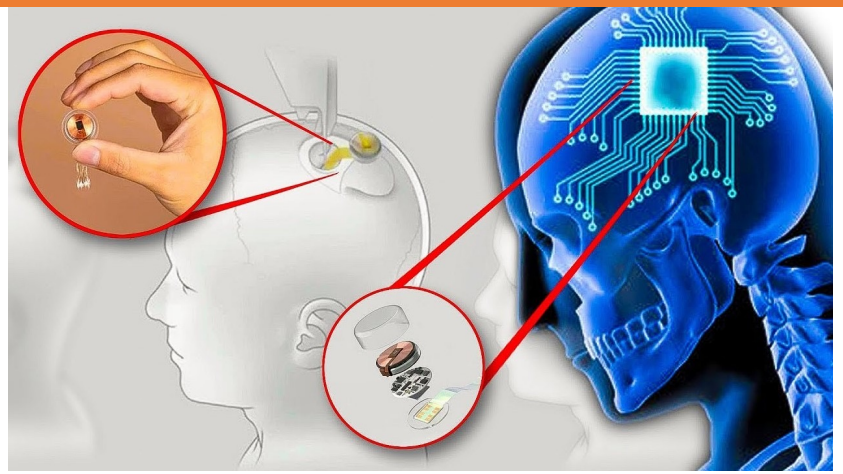
3. **Control module microprocessor** interprets brain signals gathered from neuromodulation chips.

4. The module then directs neuromodulation chips to energize specific electrodes on the arrays, which stimulate affected areas of the brain.

Robotics and Automatior

neural interface

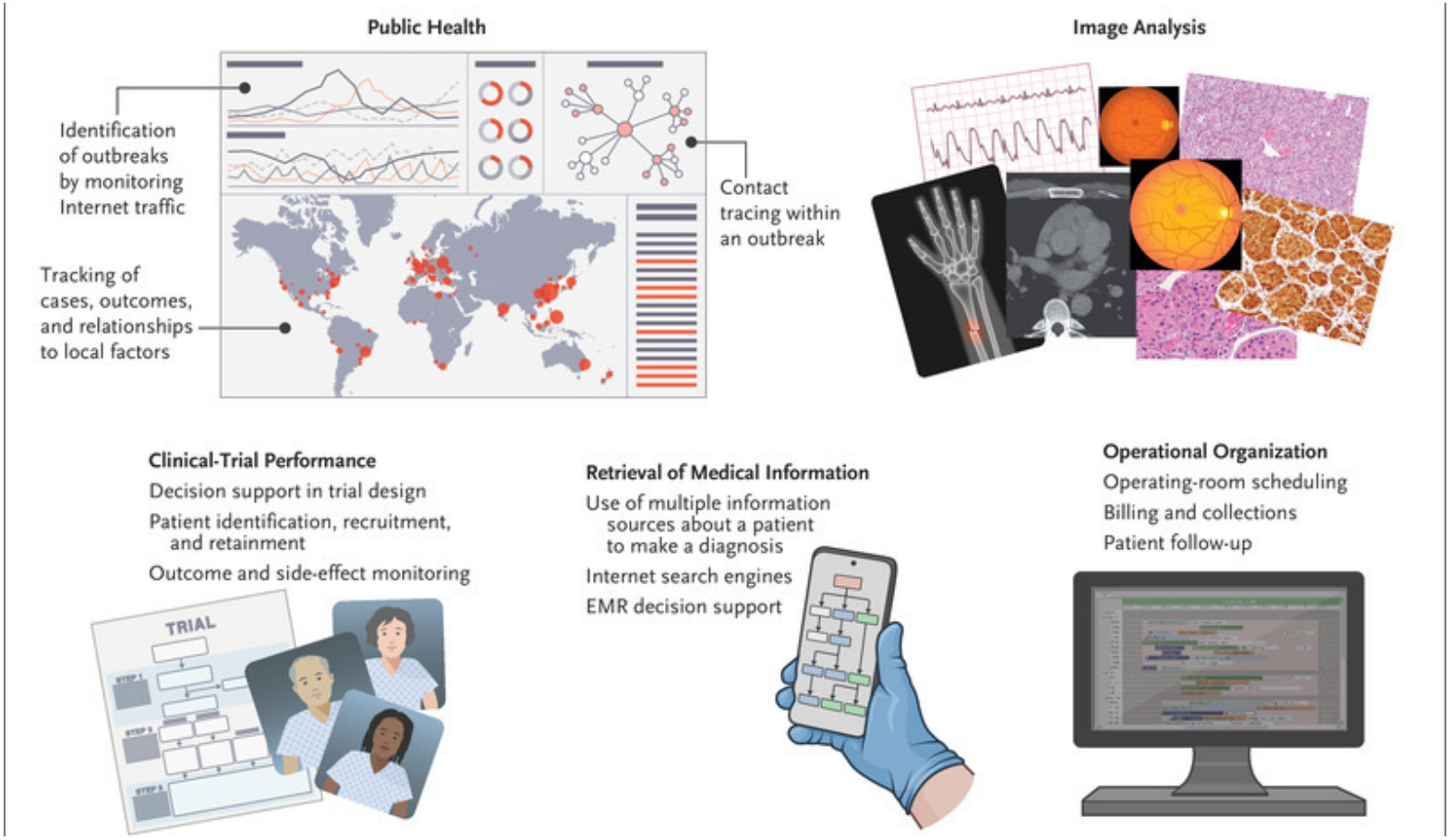
linking the human brain to an external AI system



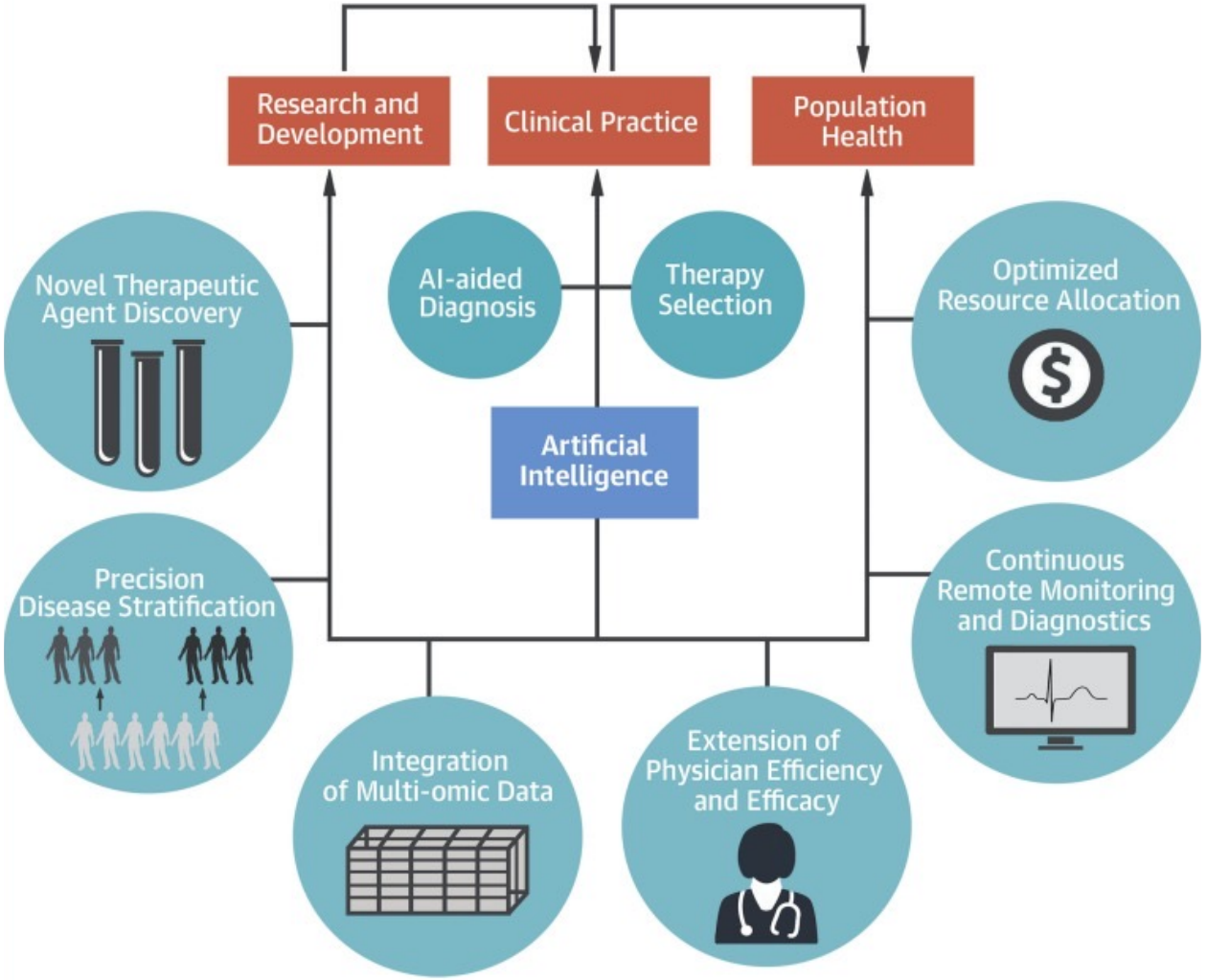
control prosthetic limbs

people with disabilities

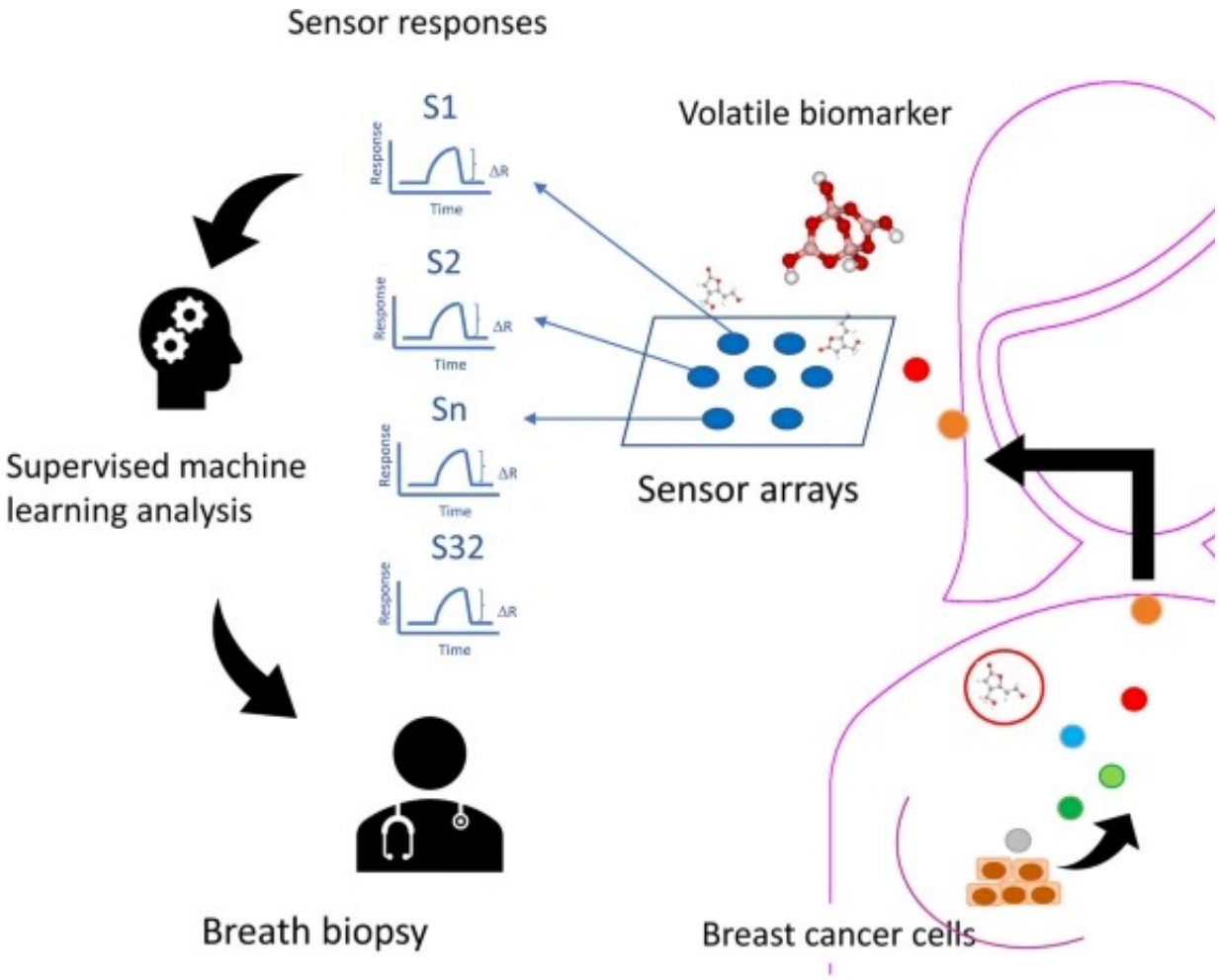
AI in Internal Medicine



Artificial Intelligence in Cardiology

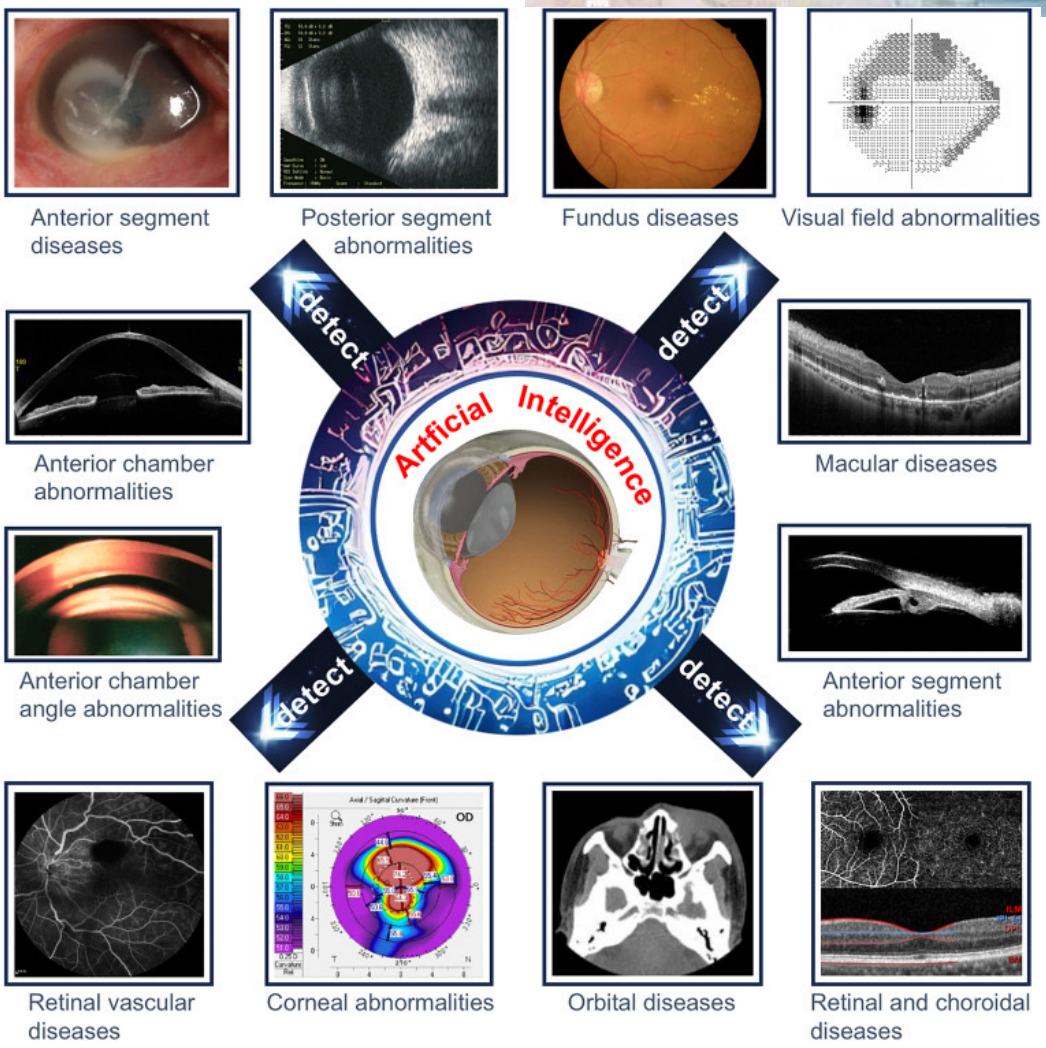


New types of Breast Cancer Biopsy: Breath biopsy



Breath biopsy of breast cancer using sensor array signals and machine learning analysis, Scientific Reports volume 11, Article number: 103 (2021)

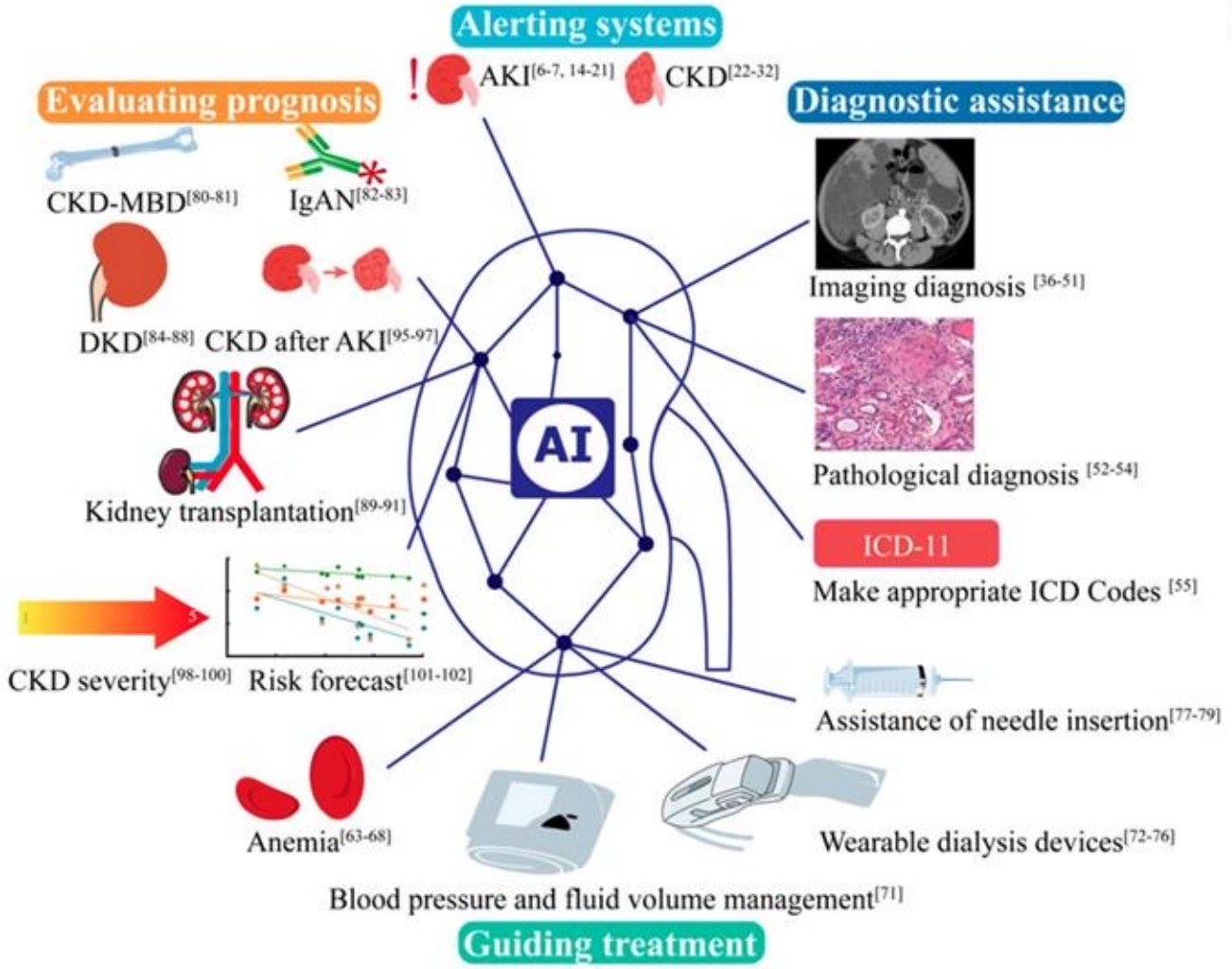
AI in Ophthalmology



[1] A. Rao Et al., "Accessible artificial intelligence for ophthalmologists," *Eye,* vol. 36, pp. 683, 2022.

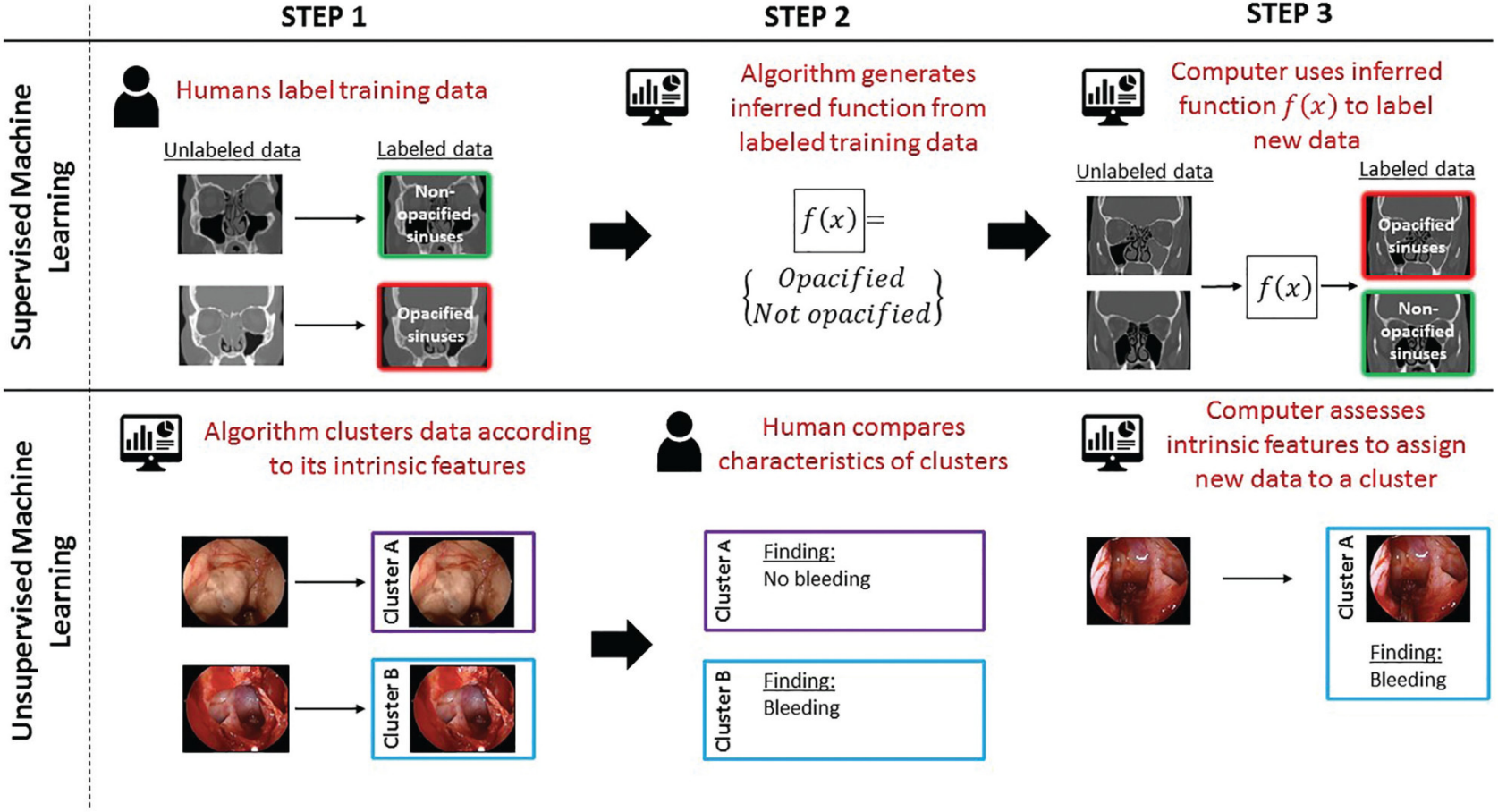
[2] S. Jeon Et al., "AI papers in ophthalmology made simple," *Eye,* vol. 34, pp. 1947–1949, 2020.

AI in Nephrology



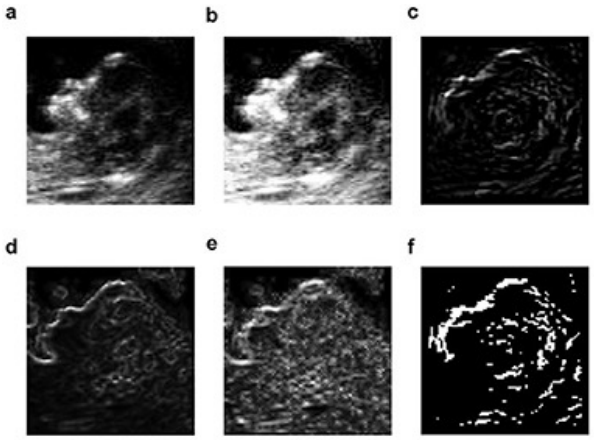
[1] T. J. Loftus Et al., "Artificial intelligence-enabled decision support in nephrology," *Nature Reviews Nephrology*, vol. 18, pp. 452–465, 2022.

AI in Otolaryngology

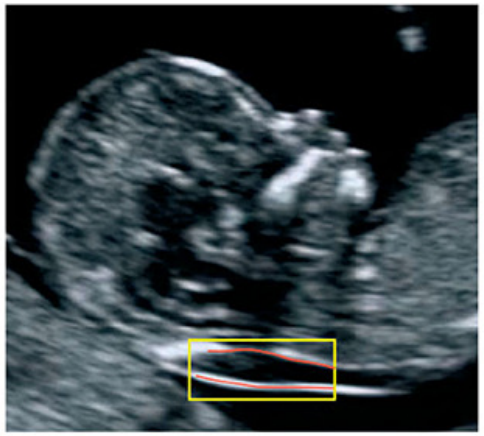


[1] N. A. Lesica Et al., "Harnessing the power of artificial intelligence to transform hearing healthcare and research," *Nature Machine Intelligence,* vol. 3, pp. 840–849, 2021.

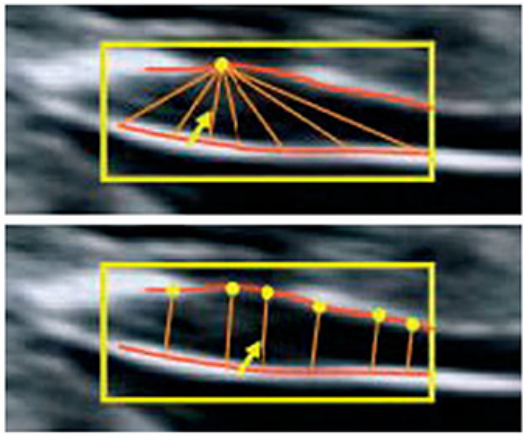
Obstetrics and Gynecology



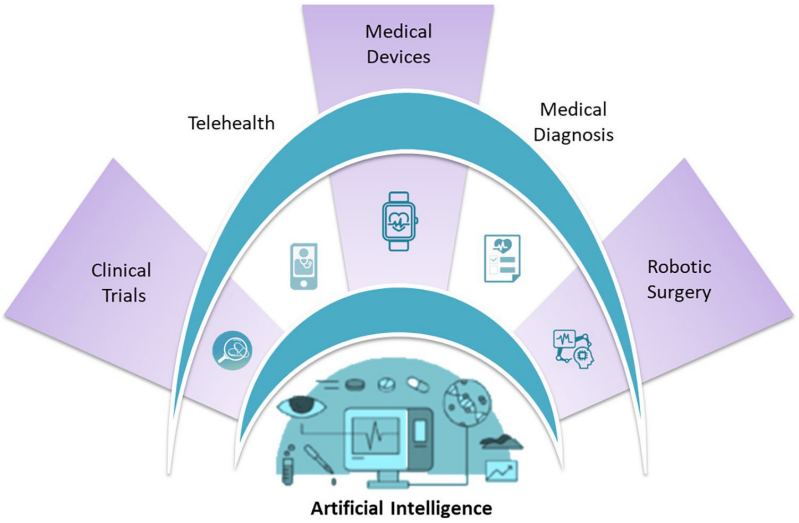
Automatic mid-sagittal plane detection



Automatic segmentation of the nuchal membrane and the edge of the soft tissue overlying the cervical spine

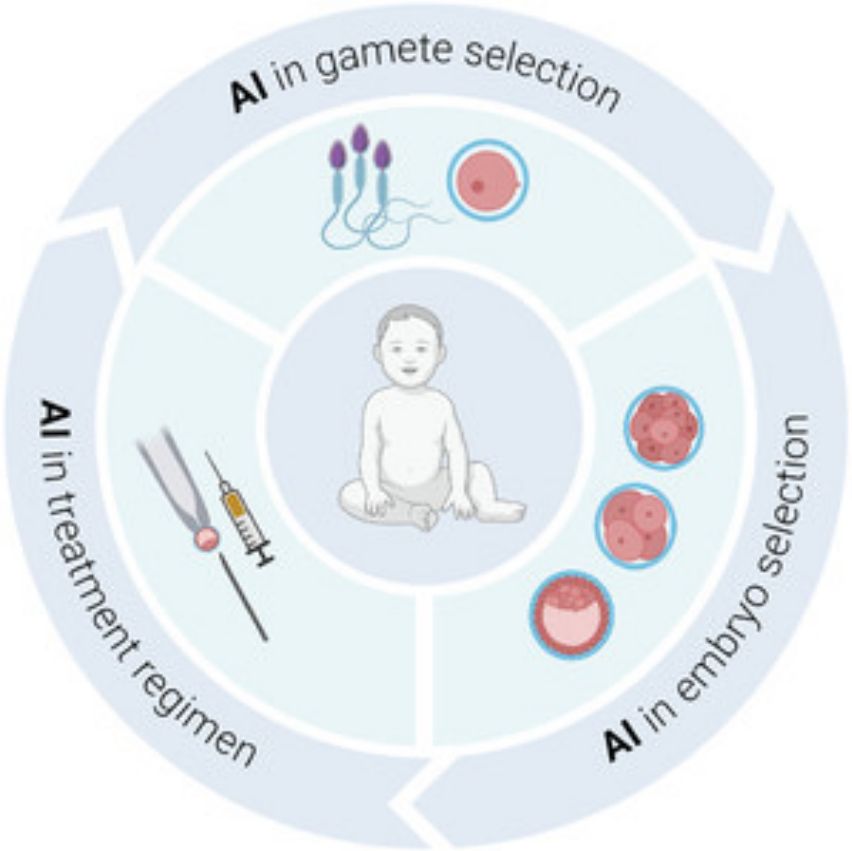


Calculates the minimum vertical distance between the two lines and computes the largest as the NT measurement

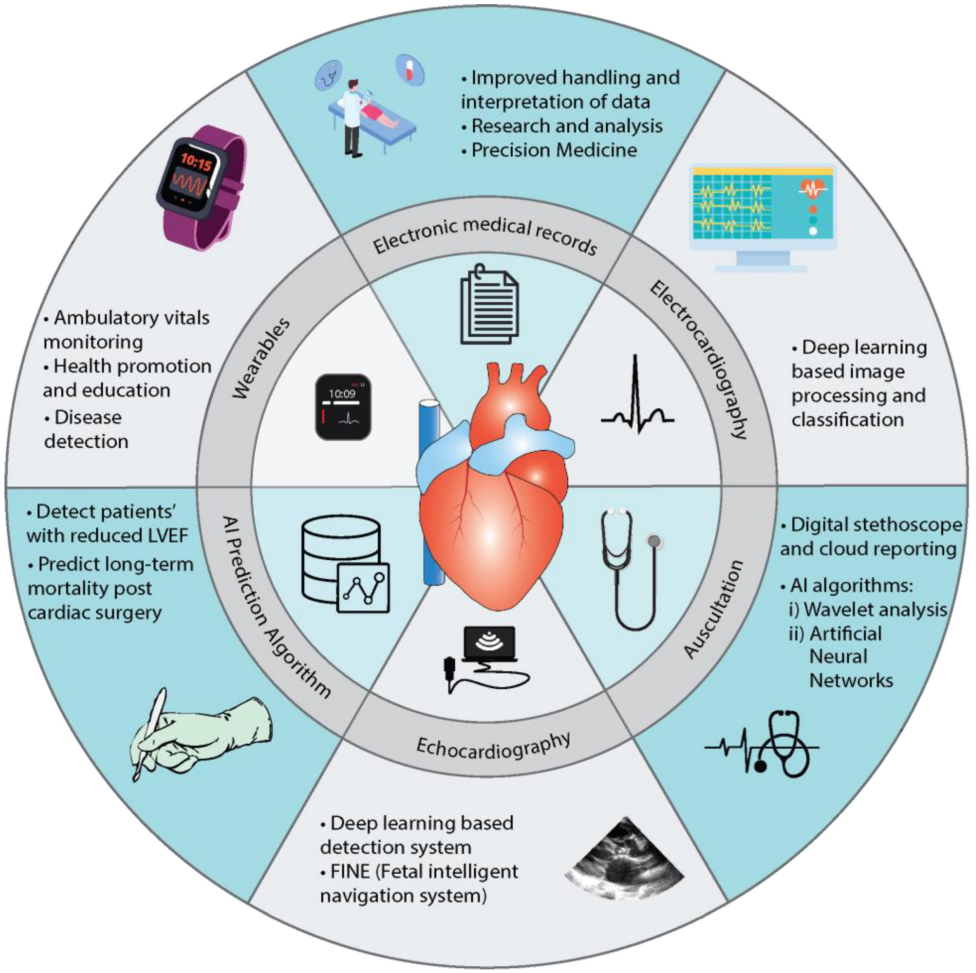


endometriosis

Artificial intelligence in Fertility technologies



AI in Pediatrics



[1] Sitek Et al., "Artificial intelligence in the diagnosis of necrotising enterocolitis in newborns,"*Pediatric Research,* 2022.

[2] H. Liang Et al., "Evaluation and accurate diagnoses of pediatric diseases using artificial intelligence," *Nature Medicine,* vol. 25, pp.433–438, 2019.

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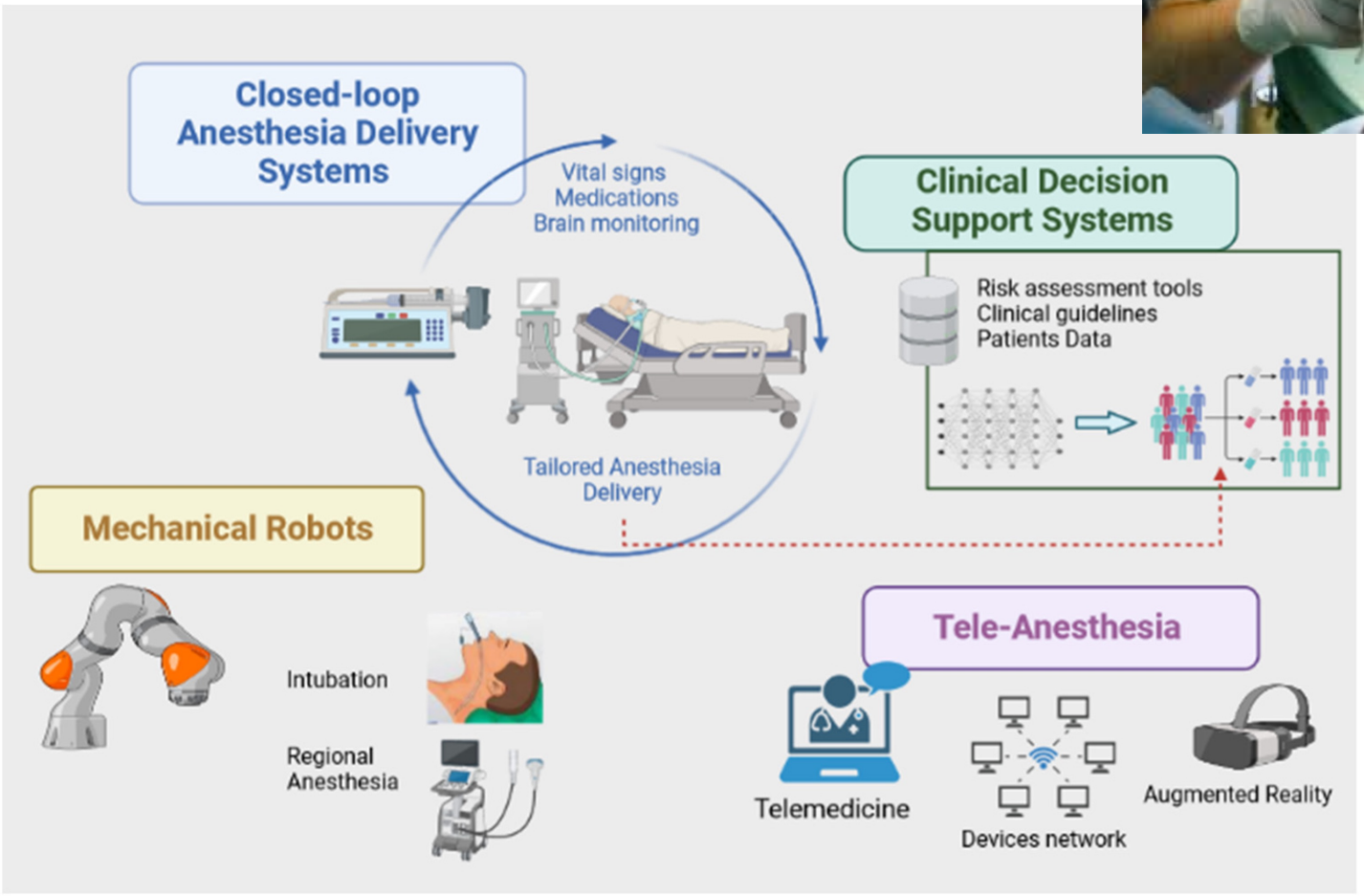
Anesthesiology



[1]N. Miyaguchi Et al., "Predicting anesthetic infusion events using machine learning," *Scientific Reports,* vol. 11, No. 23648, 2021.

AI in Emergency Medicine

Triage

- Triaging patients faster, cheaper, and with equal accuracy
- Predicting likelihood of cardiac arrest or sepsis at 72 hours

Documentation

- Automated Scribes - using speech recognition and natural language processing to start documenting patient encounter in real time

Pre-Hospital

- ED volumes predictions
- Computer assisted emeregency dispatch
- Using wearables to predict and trigger alarm for seizures & falls

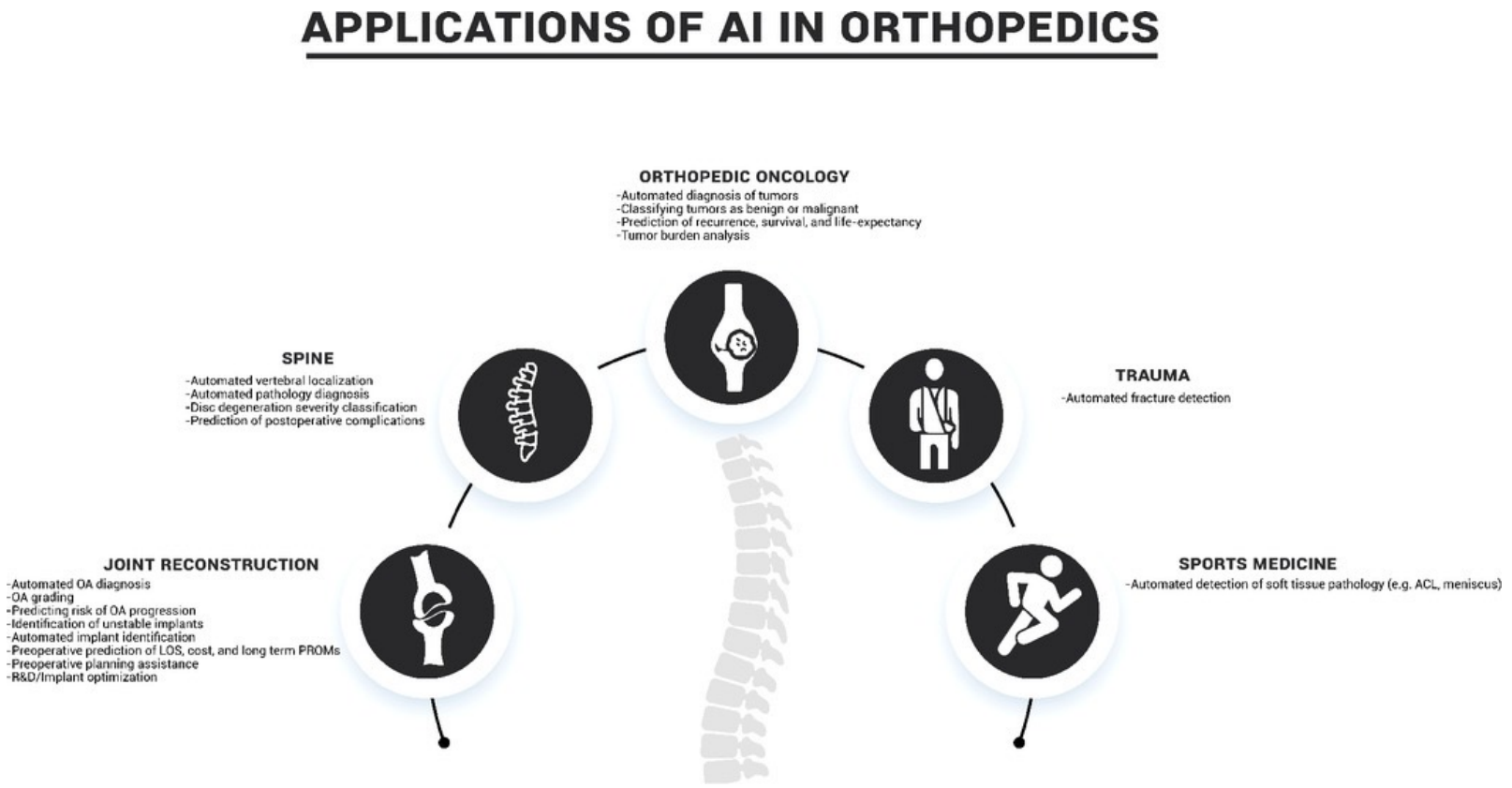
Investigations

- Point of care blood testing
- Interpreting diagnostic imaging for:
  * Common fracture
  * Pneumonia
  * Ejection fraction

Disposition

- Monitoring vitals to predict likelihood of future complications such as sepsis or cardiac arrest

Orthopedics



[1] Zibo Gong Et al., " Automated identification of hip arthroplasty implants using artificial intelligence," *Scientific Reports,* vol. 12, No. 12179, 2022.

AI in Pain Management

Behavioral methods

Facial expressions

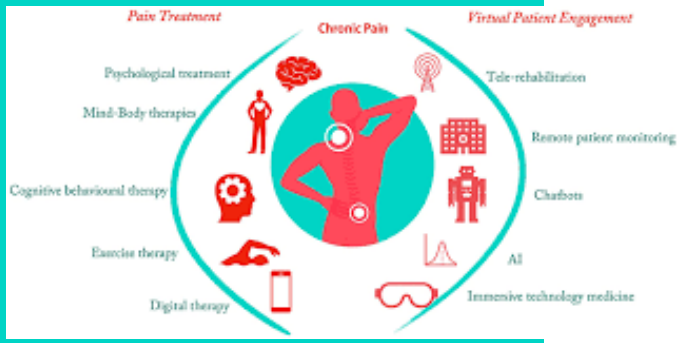
Language analysis

Electroencephalography

Electrodermal activity

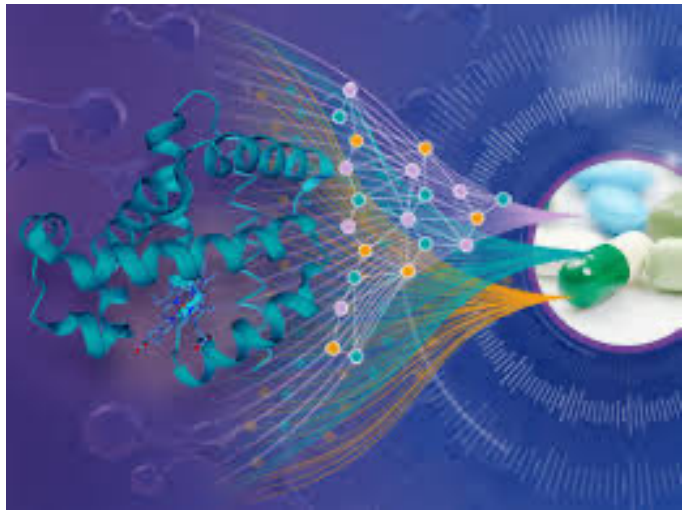
Heart rate variability

- Automatically personalize the intensity and type of patient support.
- Assess each patient's pain symptoms frequently
- Integrated pain management.
- Effective treatment plan for each patient.
- Correct dosing for opioid prescriptions

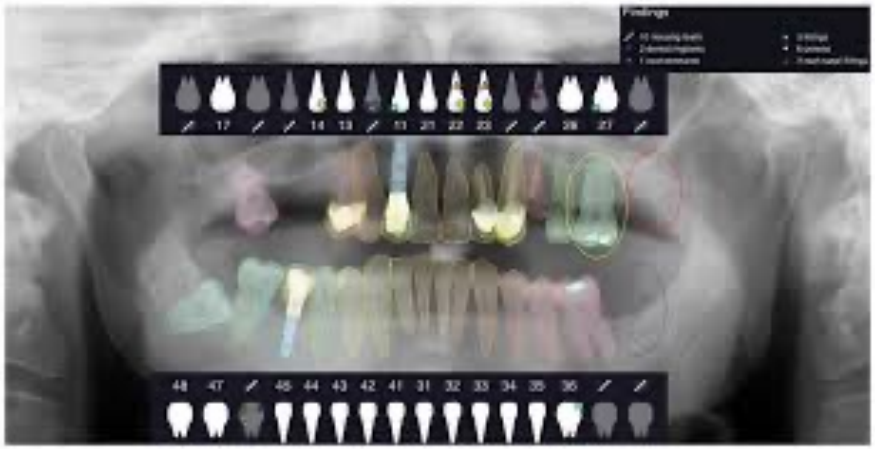


[1] S. D. Tagliaferri Et al., "Artificial intelligence to improve back pain outcomes and lessons learnt from clinical classification approaches: three systematic reviews," *npj Digital Medicine,* vol 3, No. 93, 2020.

AI and Pharmacology
Drug Discovery and Targeted Drug Delivery



AI in Dentistry



Benefits of AI

Data Analysis

improve the accuracy and speed of diagnoses

Cost reduction

Time management

AI Challenges

- Bias in data sets, and selection of algorithms
- Lack of transparency ≠ Explainable artificial intelligence (XAI)
- Inaccurate results
- Dependence on technology
- Ethical concerns

Note that!!

- AI may not replace human doctors.
- Since doctors are trained to not only diagnose and treat diseases but also to provide emotional support to patients.
- AI cannot replace the empathy and compassion that doctors bring to their work.

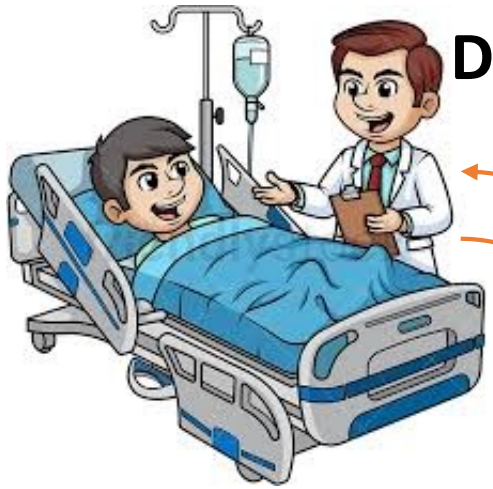
8-AI Medical Application

Prevention	Screening
Early Detection	Diagnosis
Recurrence Prediction	Critical Decision Making
Treatment Selection and Analysis	Mortality and Morbidity Prediction
Triage	…

Hospital

In the Hospital

Pre Hospital

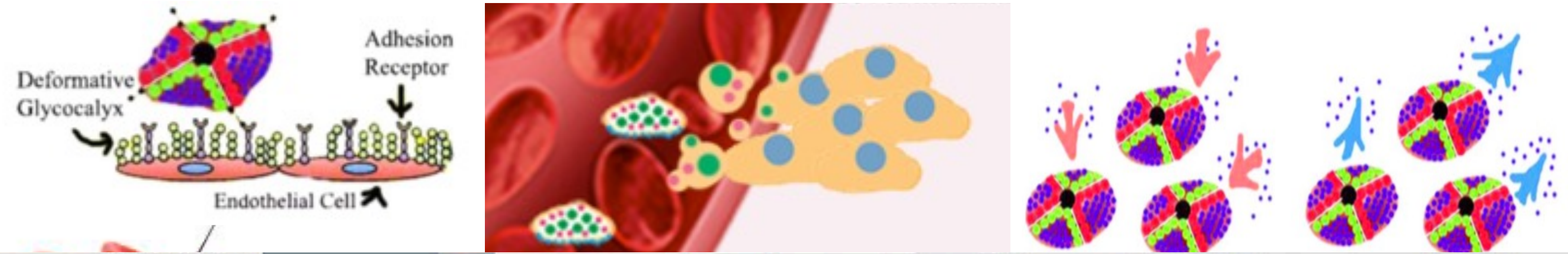


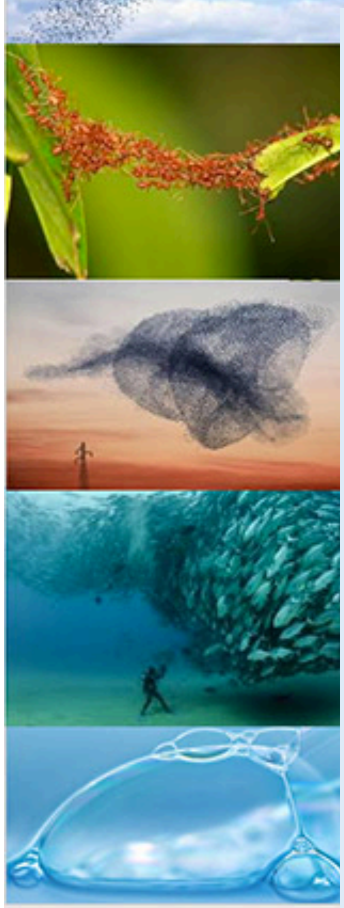
Doctor

Home

Patient

Post Hospital at Home





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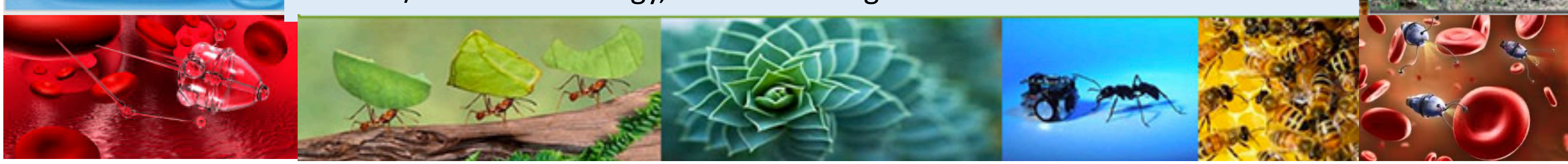
Research Interest:

Artificial Intelligence, Artificial Intelligence in Medicine, Complex Systems, Biomimicry, Cognitive Science, Swarm Intelligence, Nanomedicine, Targeted Drug Delivery, Early Detection of Disease, Swarm Nano Robotics, Cancer Research, Fuzzy Logic and Control, Soft Computing, Neural Networks, Machine Learning, Multi-agent Systems, Distributed Decision Making, Biomarkers, Biophysics, Nature Inspired Algorithms, Computational Cellular/Molecular Biology, Protein Folding



Artificial Intelligence for Good (AI for Good)