

Artificial Intelligence (AI) in medicine

Terms, definitions, Applications, Challenges, and Future perspective

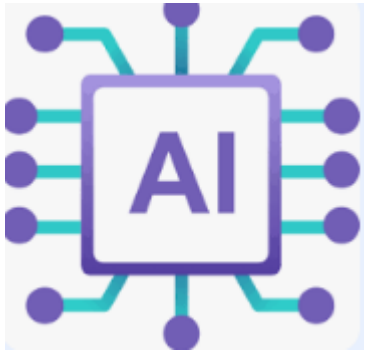
Presented by: Dr. Sajjad Farashi

Neurophysiology Research Center, Hamadan University of Medical Sciences, Hamadan, Iran

Common applications of AI in medicine

Medical research

- Helpful Comments to be a researcher
- Manuscript/thesis/proposal preparation
- Literature review process
- Summarizing a scientific document



Medical education

Teacher tasks

Lesson design: determine the main topic of the lesson and its place in the unit and the course.

Content creation **(PowerPoint design, Image design,…)**

Evaluation **(quiz, Homework, Final exam,…)**

Student tasks

Note taking

Create contents

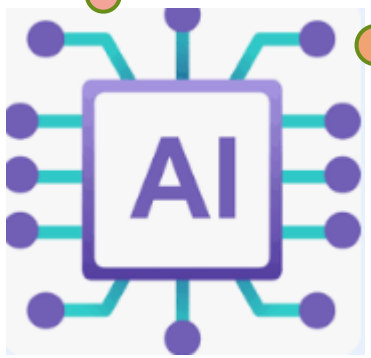
Make presentations

Common applications of AI in medicine

Robots in medicine
Chabots in medicine

Biomedical system design and modeling

- Machine learning
- Deep learning
- Neural Networks

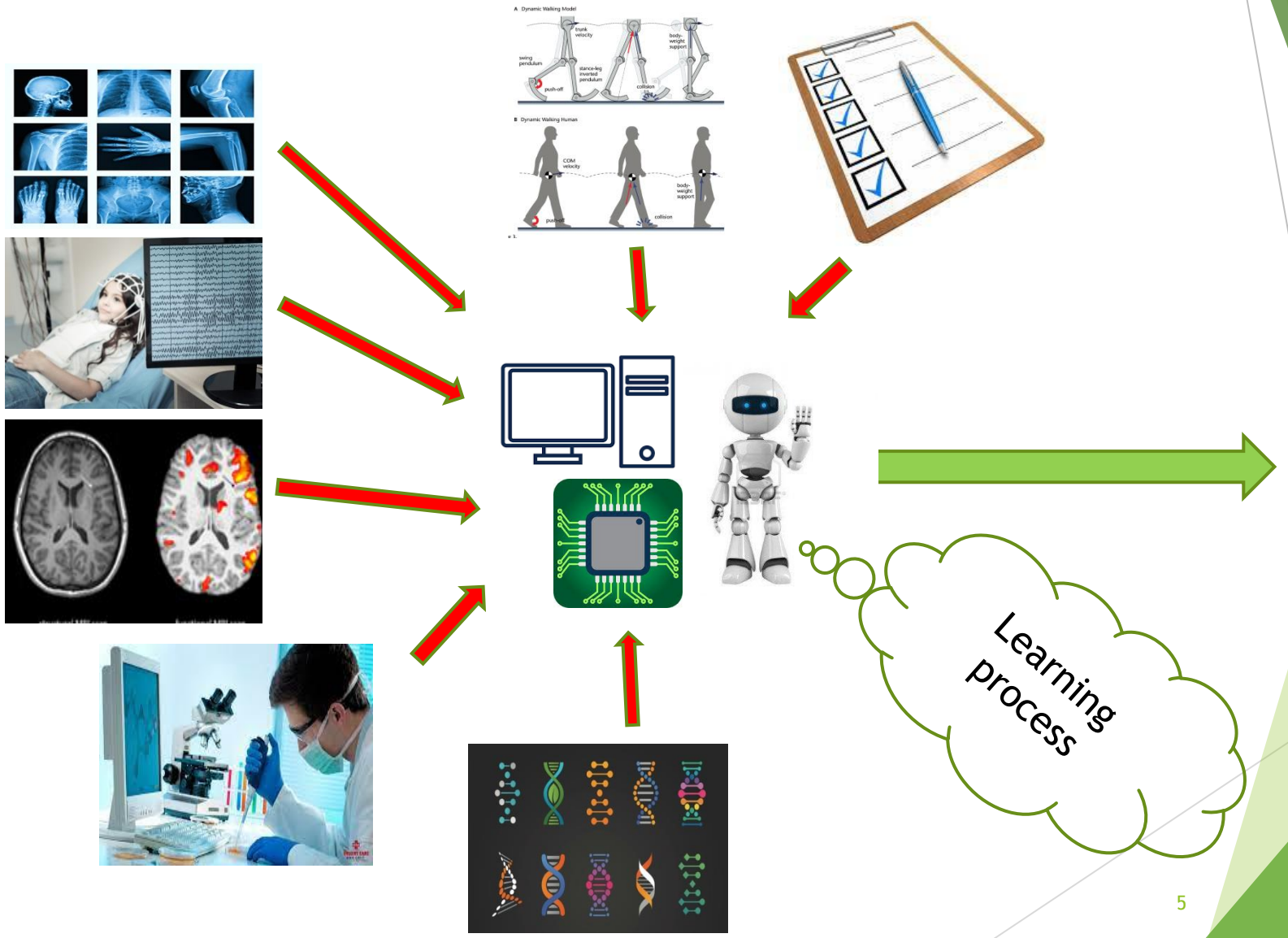


What Is Artificial intelligence (AI)?

- An old human dream→ synthesize **intelligent beings** with human functionality (decision-making, perception, recognition, motor actions and so on) to perform human tasks **automatically**

- The theory and development of computer systems enabled the human to facilitate such dream.

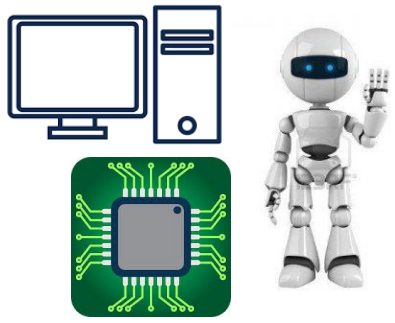
What Is Artificial intelligence (AI)?

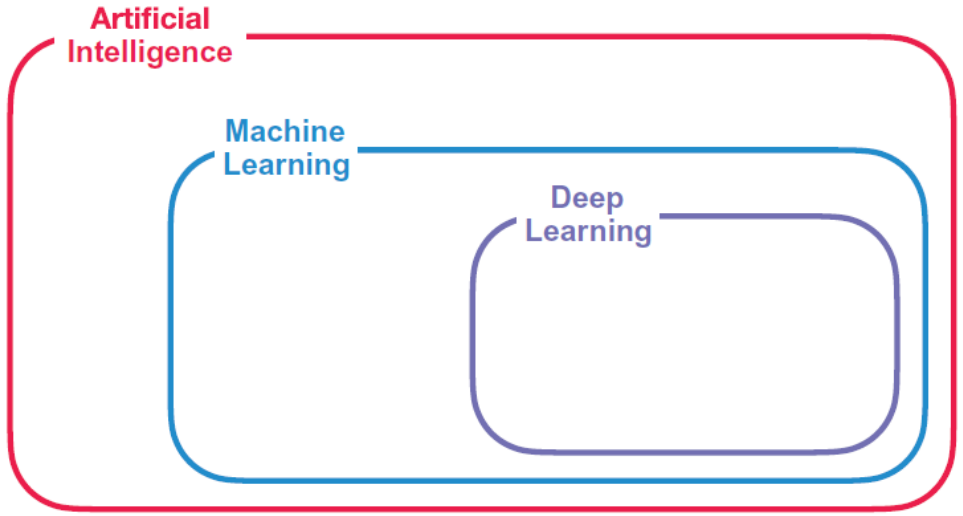


Automatically:
Make a decision
Make a prediction
Make a diagnosis
Make a detection
.
.
.

What Is AI?[Cont.]
Machine learning

In AI, the system should be trained.
How?
With **machine learning (ML)** strategies (algorithms) according to **reliable data**



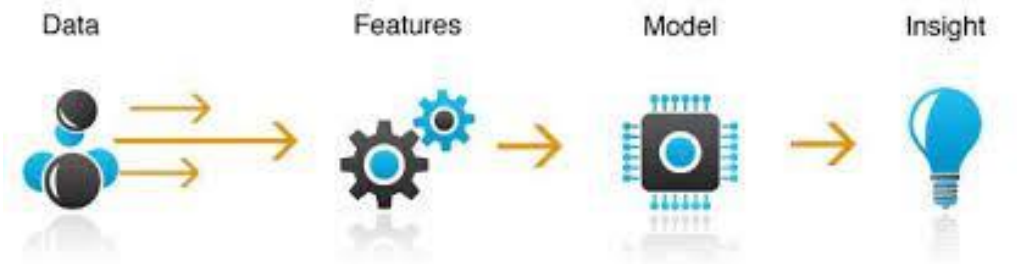


The relationship between AI, machine learning, and deep learning. Machine learning refers to a large collection of algorithms and is the main approach used in AI today. Deep learning refers to a specific class of algorithms within machine learning, that are particularly effective at handling "unstructured data": images, text, etc. *AI*, Artificial intelligence.

What Is AI?[Cont.]

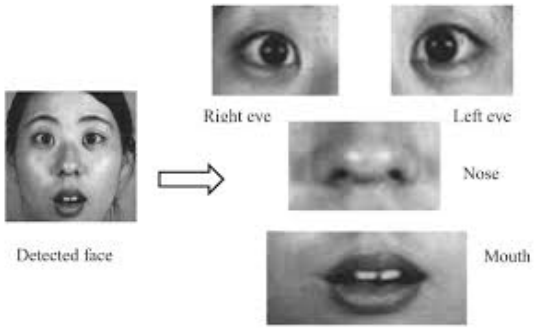
Machine learning

Feature space



Initial data

Features

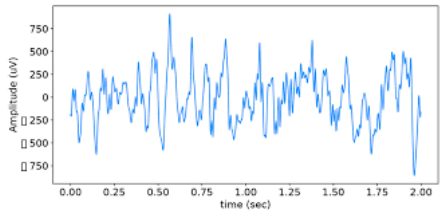


pupil size

eye curvature circumstance

distance between nostril

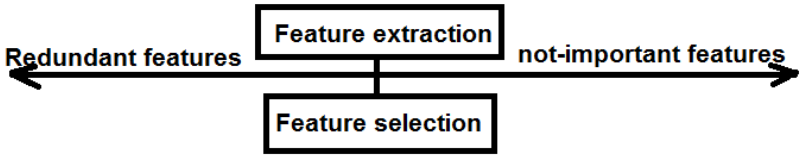
width/height



Statistical features:
*Mean
*Median
*std
*Kurtosis
*Skewness
*Higher order statistics

Shannon Entropy
Sample entropy

Peak power
Maximum frequency
.
.
.

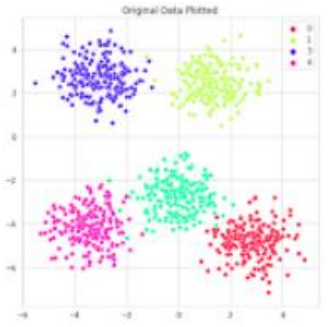


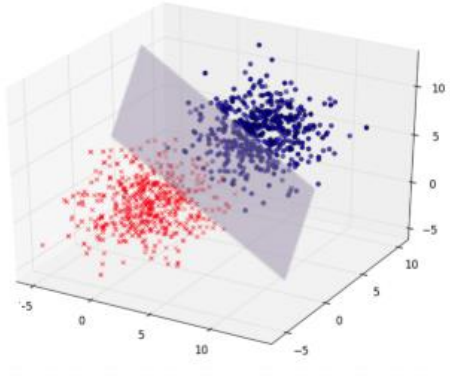
What Is AI?[Cont.]

Machine learning

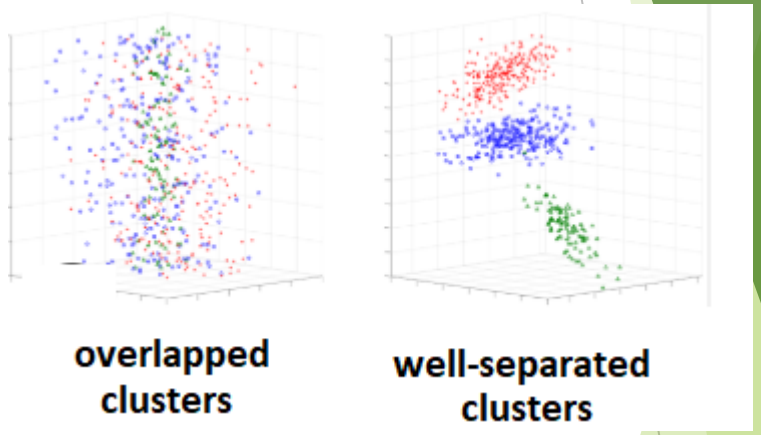
Feature space

- Dimension of feature space: 1D, 2D,3D,….,Nd

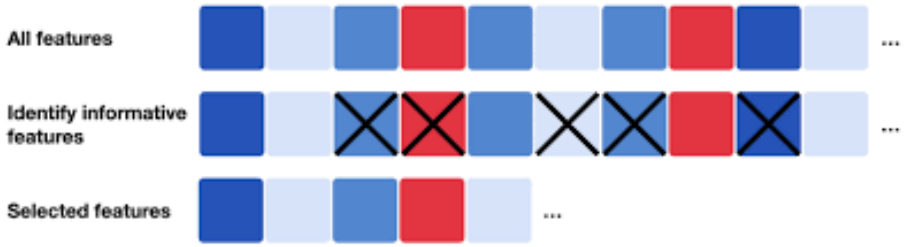




Discrimination capability of a feature set (**feature importance**)



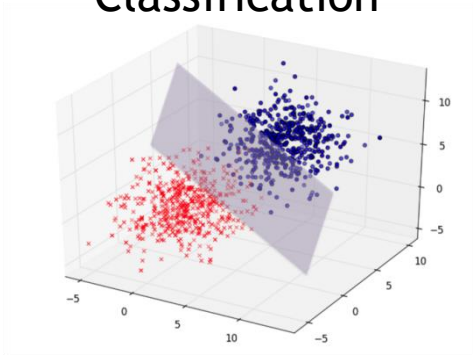
Feature redundancy: feature generation and feature selection



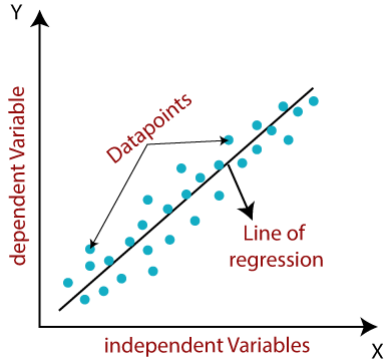
What Is AI?[Cont.]
Machine learning

- The purpose of machine learning?

Classification



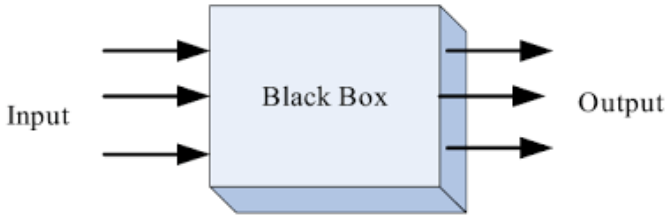
Regression



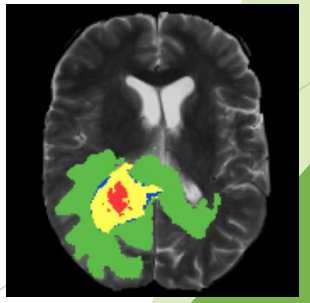
Prediction

Detection

System Identification

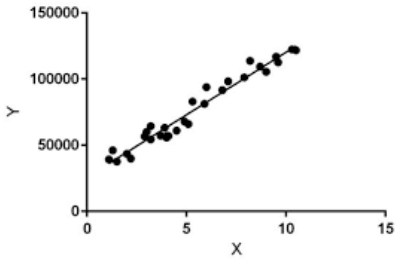


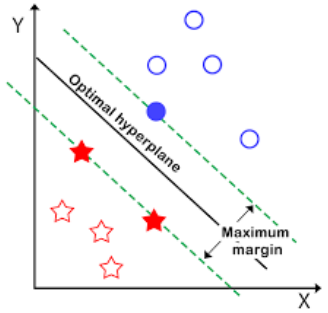
Segmentation

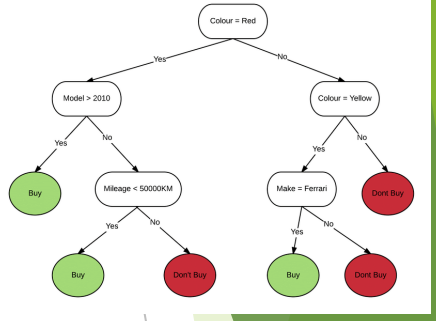


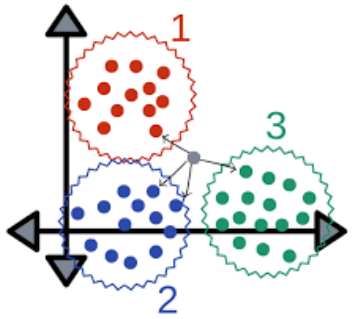
Most famous algorithm in machine learning

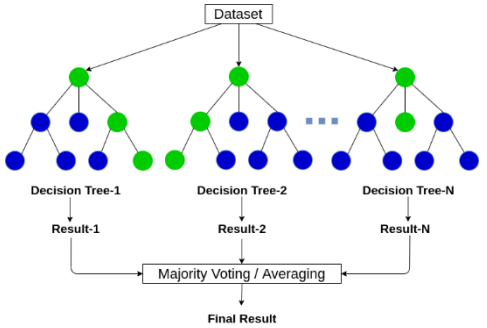
- Linear regression
- Logistic regression
- Decision tree
- SVM algorithm
- Naive Bayes algorithm
- KNN algorithm
- K-means
- Random forest algorithm
- Dimensionality reduction algorithms
- Gradient boosting algorithm and AdaBoosting algorithm

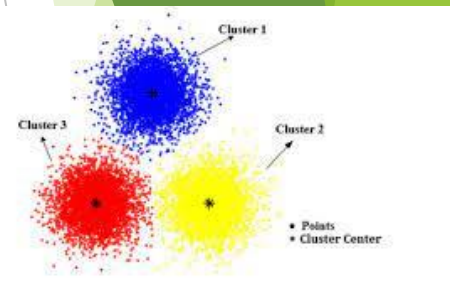


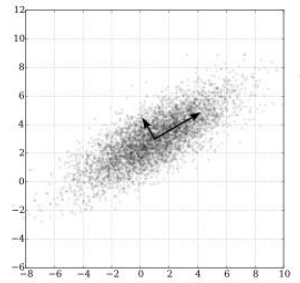






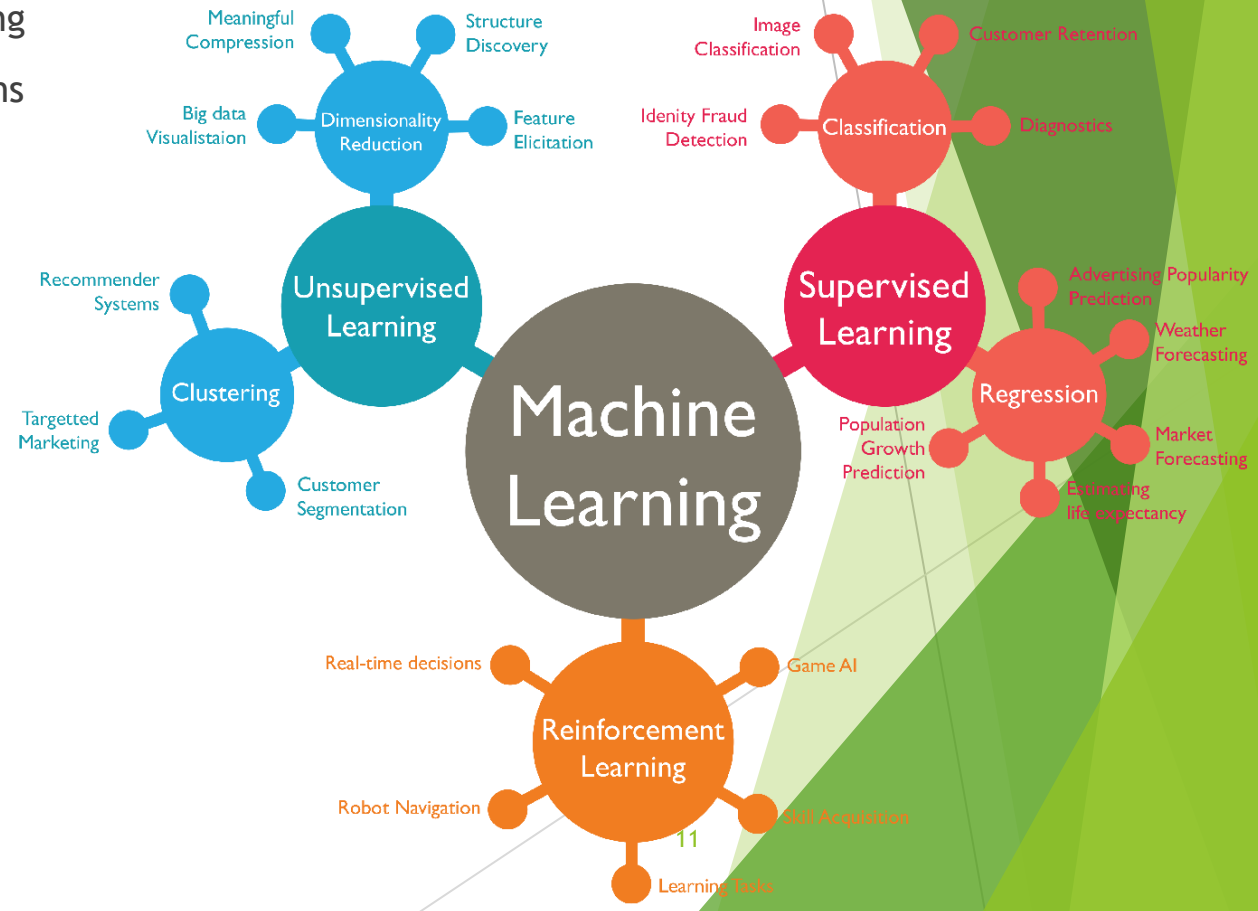






What Is AI?[Cont.]
Machine learning

- Supervised learning→ Labeled data are available for training
- Unsupervised learning→ work according to common patterns



Examples of ML algorithms

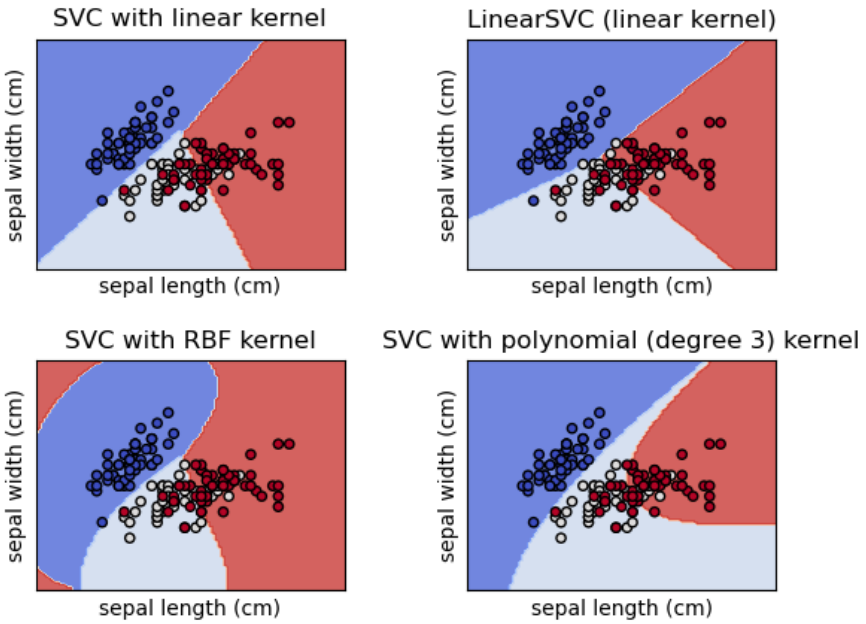
Support vector machines (SVM)

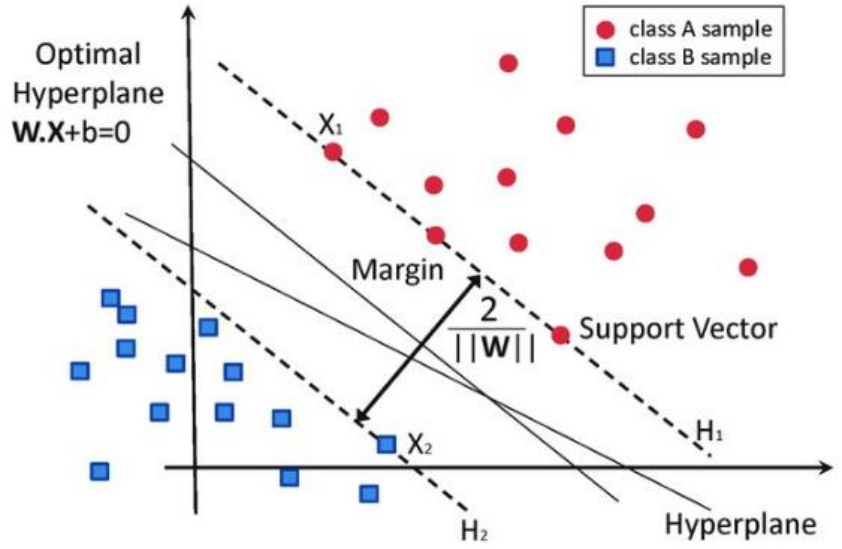
- The purpose of SVM is to find a line (2D feature space), a plane (in 3D feature space), or a hyperplane (in >2D feature space) to separate data of different classes.

- The separation can be done using different types of

Separators (linear, polynomial, RBF, or other nonlinear)→ It is called **KERNEL**

Separators are selected in way that the margin of class samples be maximum from separator



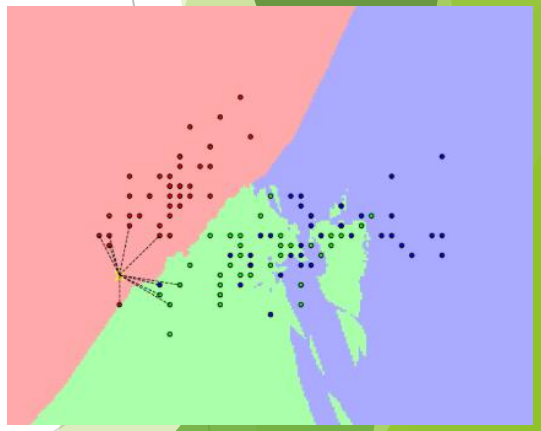


Examples of ML algorithms
K-nearest neighbors(KNN)

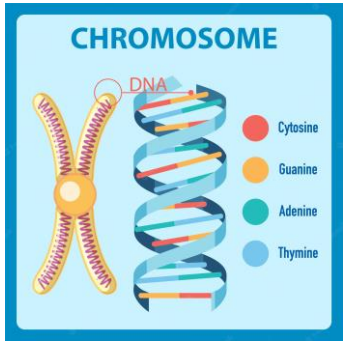
- Hypothesis: similar members gather together (make a cluster)

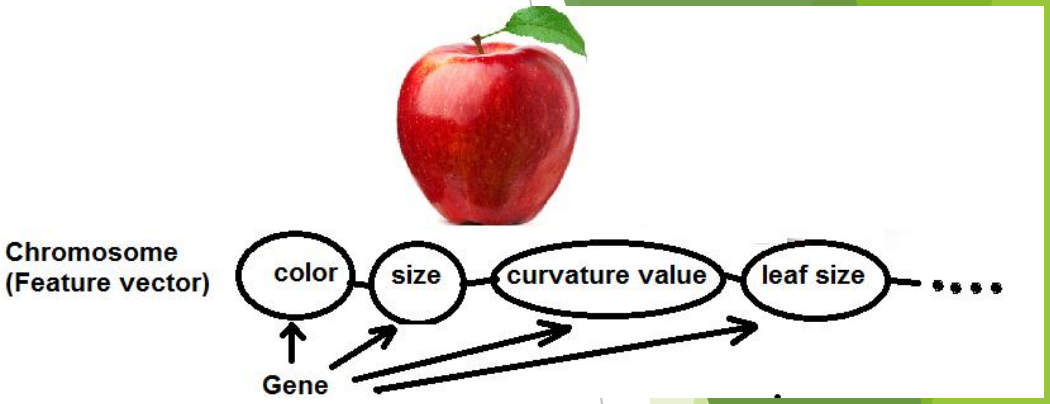
KNN works in three main steps:

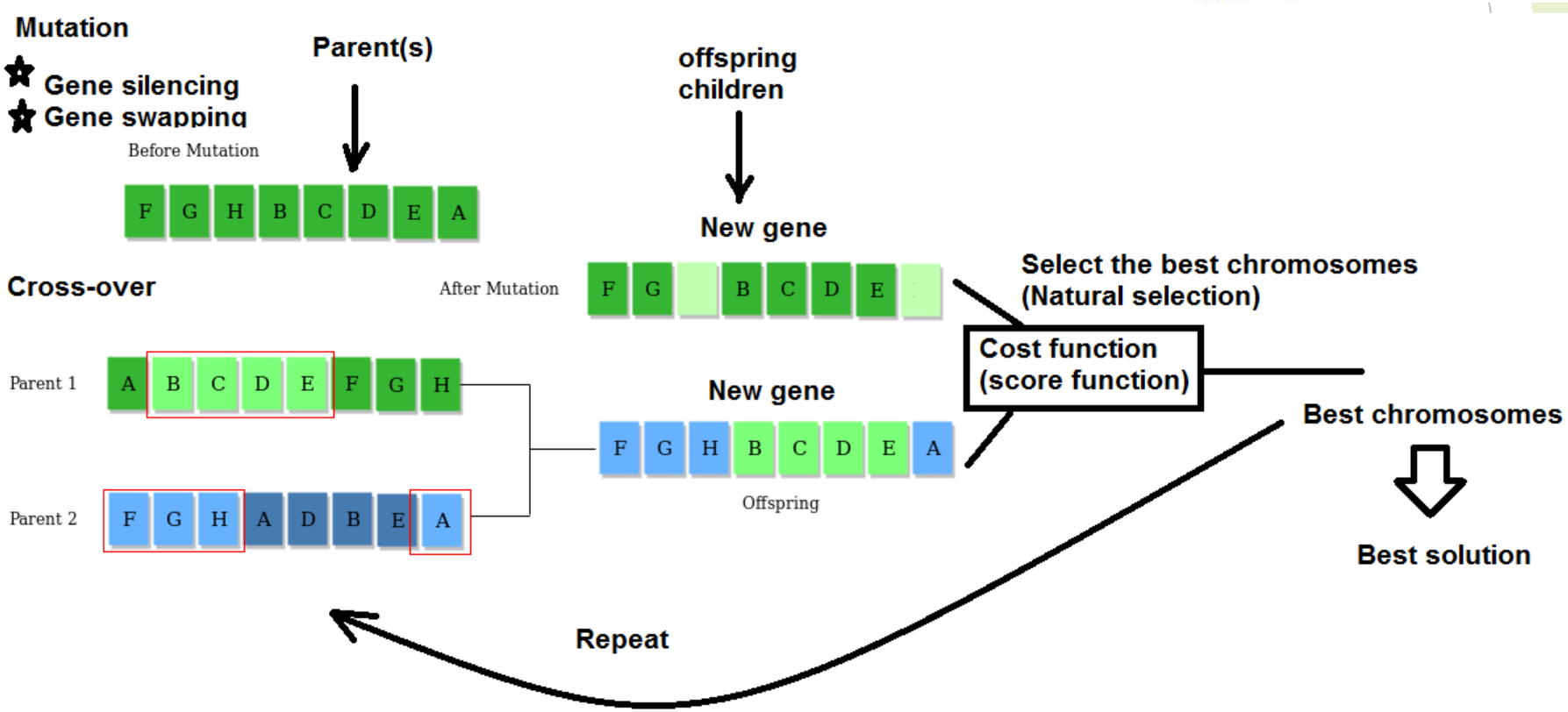
- Chose a value for K
- calculating the distance between the query point and each training point
- Sort the distances (and also indices)
- selecting the k-nearest neighbors to the query point
- predicting the class or value of the query point based on the majority class or the mean value of the neighbors.



Examples of AI models
Biologically inspired techniques
Genetic algorithm

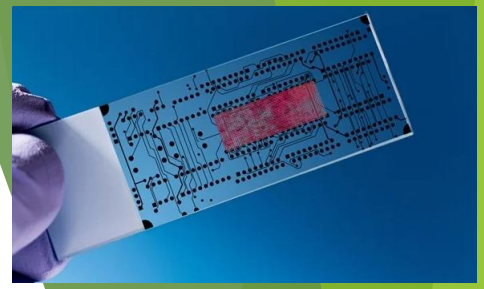






Special terms which AI will be seen in the future

Lab-on-a chip (LOC)

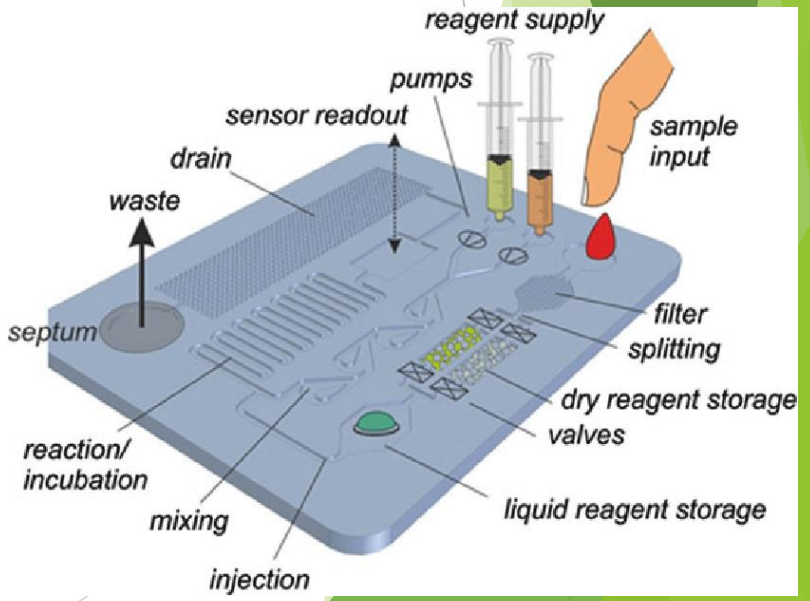


- A lab-on-a-chip is a **miniaturized** device that integrates into **a single chip** one or **several analyses.**

- LOC→ Microchannels (microfluidic technique) + pumps+ electrodes + electronics

- Current applications:
  - DNA/RNA amplification and detection (HIV detection)
  - protein analysis (Glucose meters)
  - microsized and highly parallelized micro chemical reactors

- **Advantages:**
  - cost efficiency
  - Parallelization
  - diagnostic speed
  - sensitivity



Wearable technologies

- Devices attached to human body to capture biomedical symptoms.

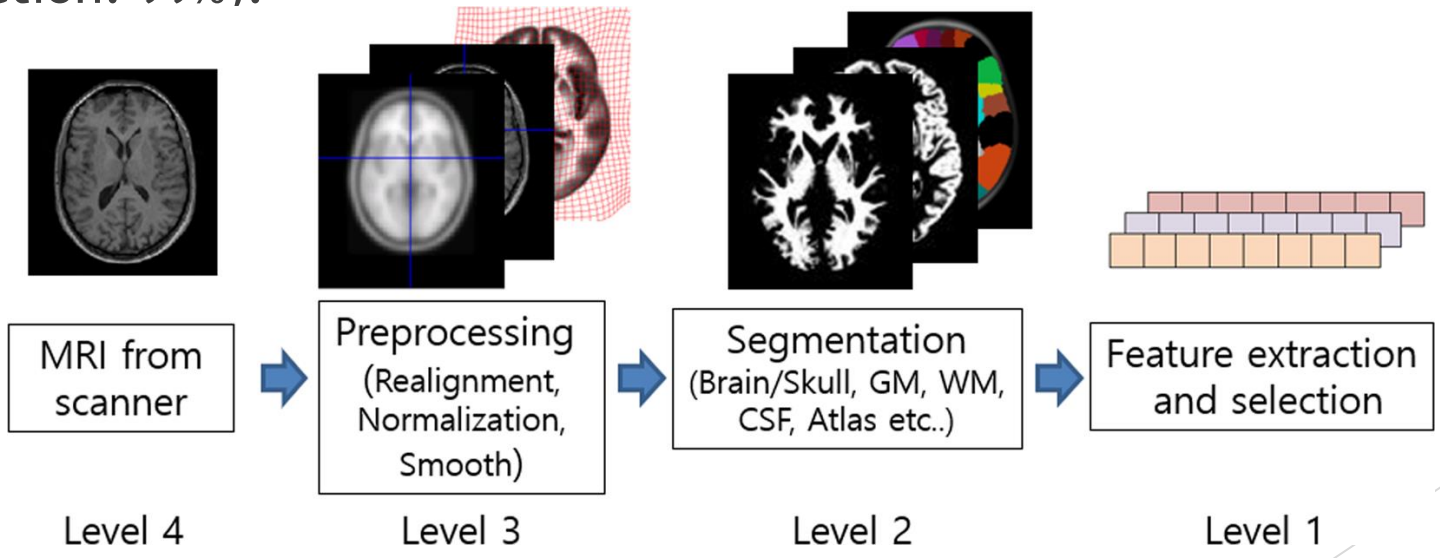
Internet of medical things (IOmT)

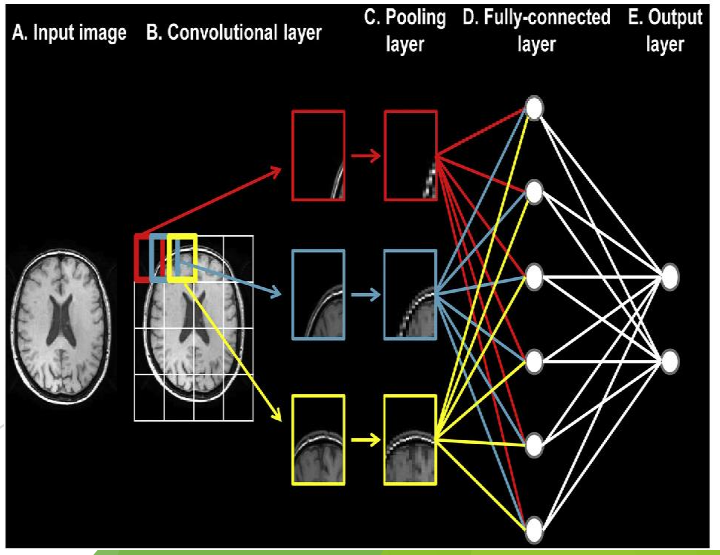
- The **Internet of things** (**IoT**) → sensors + processing software and +connect and exchange data with Internet or other communications networks

Current practical applications of AI in healthcare

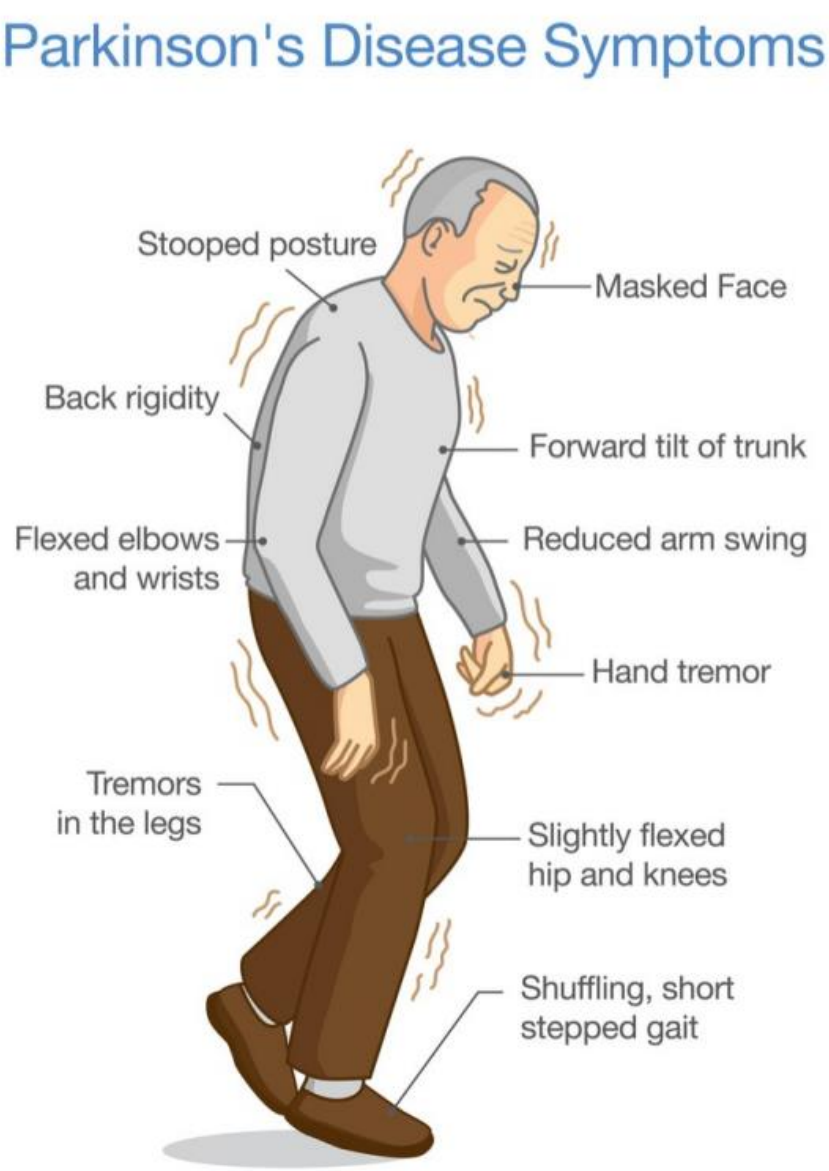
Alzheimer's Disease

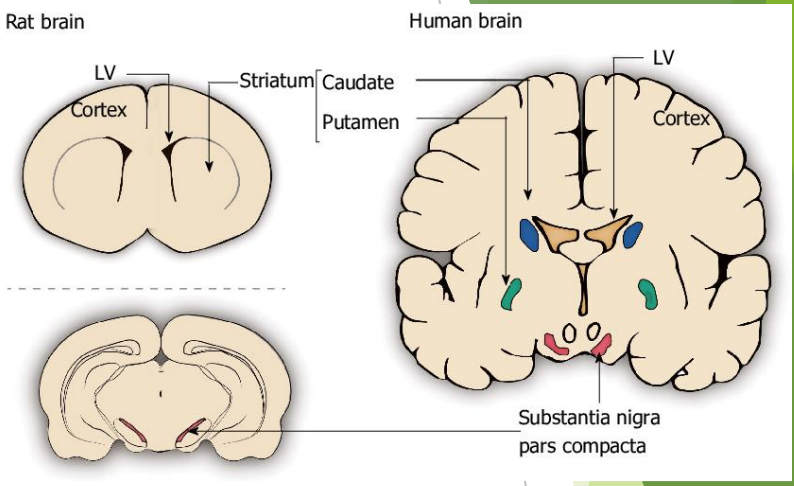
- Purpose: early Alzheimer's diagnosis
- microscopic abnormalities in brain tissues found in MRI scan may be early indicators of Alzheimer's Disease.
- Problem: accurate and fast MRI data processing is time-consuming and difficult.
- Solution:
- AI with image processing is a promising tool (accuracy for AD prediction: 99%).





AI researches in Parkinson's disease





Parkinson's disease:

- **Motor symptoms**
- **Tremors**
- **Stiffness**
- **Rigidity**
- **Slowness**
- **Imbalance**

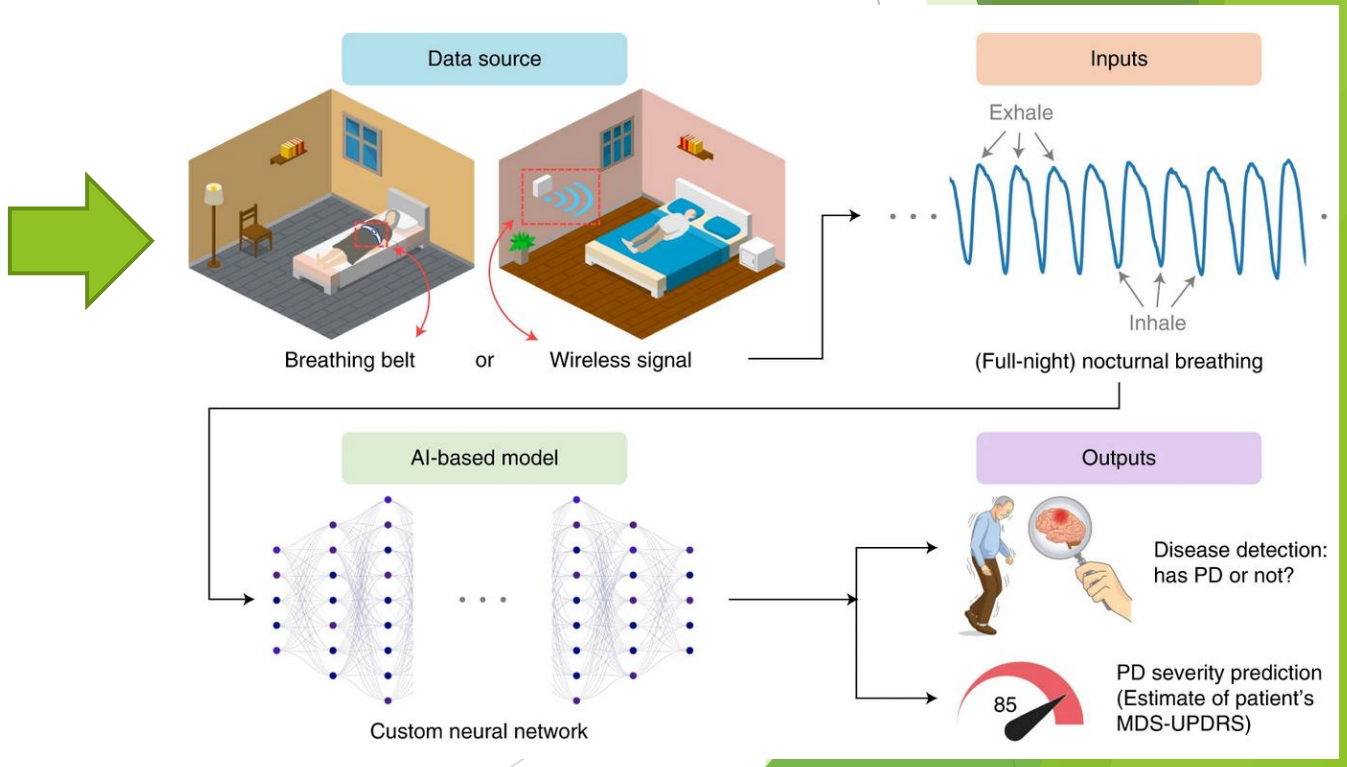
These symptoms often appear several years (about 5 years) after the disease

AI researches in Parkinson's disease

- PD prediction models based on AI
- An artificial intelligence model that can detect Parkinson's from reading a person's breathing patterns.

A relationship between Parkinson's and breathing was noted as early as 1817, in the work of Dr. James Parkinson. This motivated us to consider the potential of detecting the disease from one's breathing without looking at movements,

Some medical studies have shown that respiratory symptoms manifest years before motor symptoms



Yang, Y., Yuan, Y., Zhang, G. *et al*. Artificial intelligence-enabled detection and assessment of Parkinson's disease using nocturnal breathing signals. *Nat Med* **28**, 2207–2215 (2022). https://doi.org/10.1038/s41591-022-01932-x

AI researches in Parkinson's disease
Gait analysis

- Pr

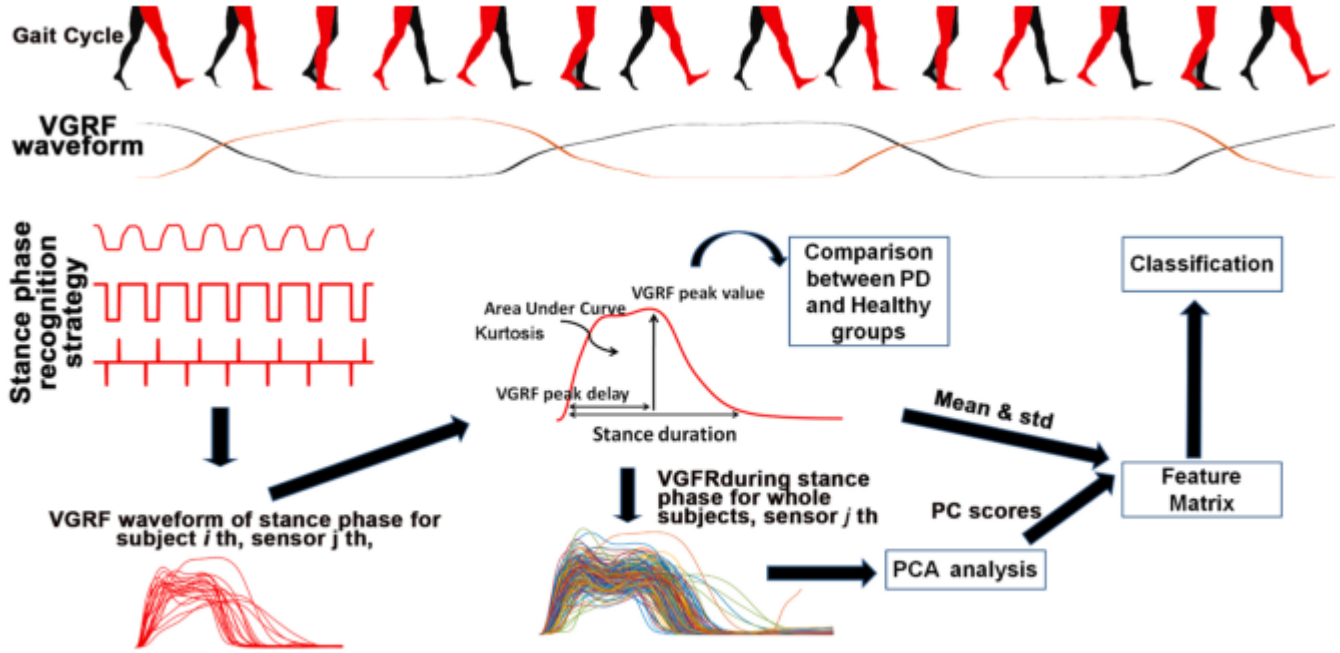
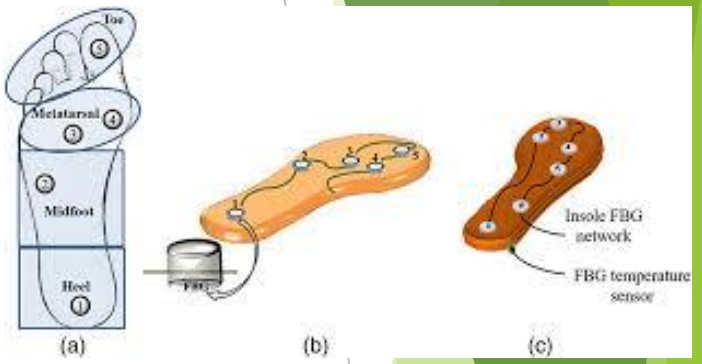


Fig. 1. Block diagram of the proposed method for the stance analysis based on VGRF data.



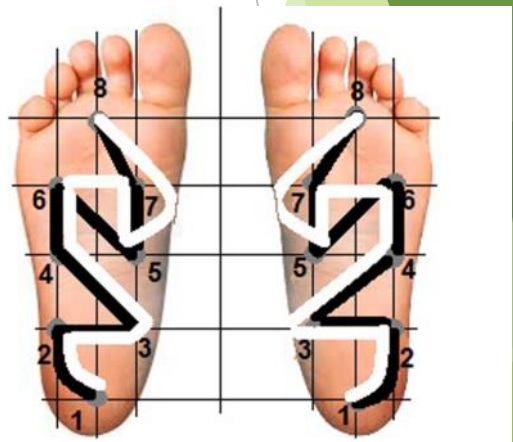


Fig. 2. Order of the activation of pressure sensors during the stance phase of a gait cycle. Sensors at the heel were activated first. The route showed the activation order for PD patients (dark route) and healthy individuals (bright route).

Farashi S, Analysis of the stance phase of the gait cycle in Parkinson's disease and its potency for Parkinson's disease discrimination, Journal of Biomechanics, 129,2021

AI in electronic health records

- Electronic health records (EHR)
  - digital version of a patient's paper chart
  - may include a range of data, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, vital signs, personal statistics like age and weight, and billing information
- Advantages of EHR :
  - Records are **shared** through network-connected systems.
  - Can be up-to-date easily
  - Security
  - More quick access

- **Problem:** According to a recent study, physicians devote 62 percent of their time per patient reviewing EHRs (clinical data review).
- **Solution**: Reduce the time needed to extract clinical information from patient referral records using AI.

AI in electronic health records

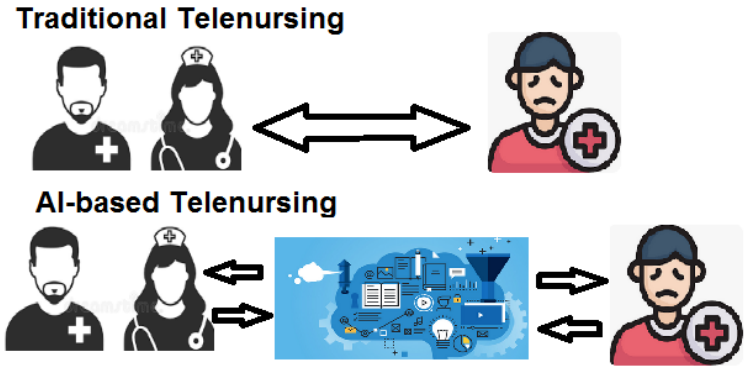
- a pipeline of AI algorithms → organize relevant clinical information from a patient referral record →present information to the clinician in a web interface.

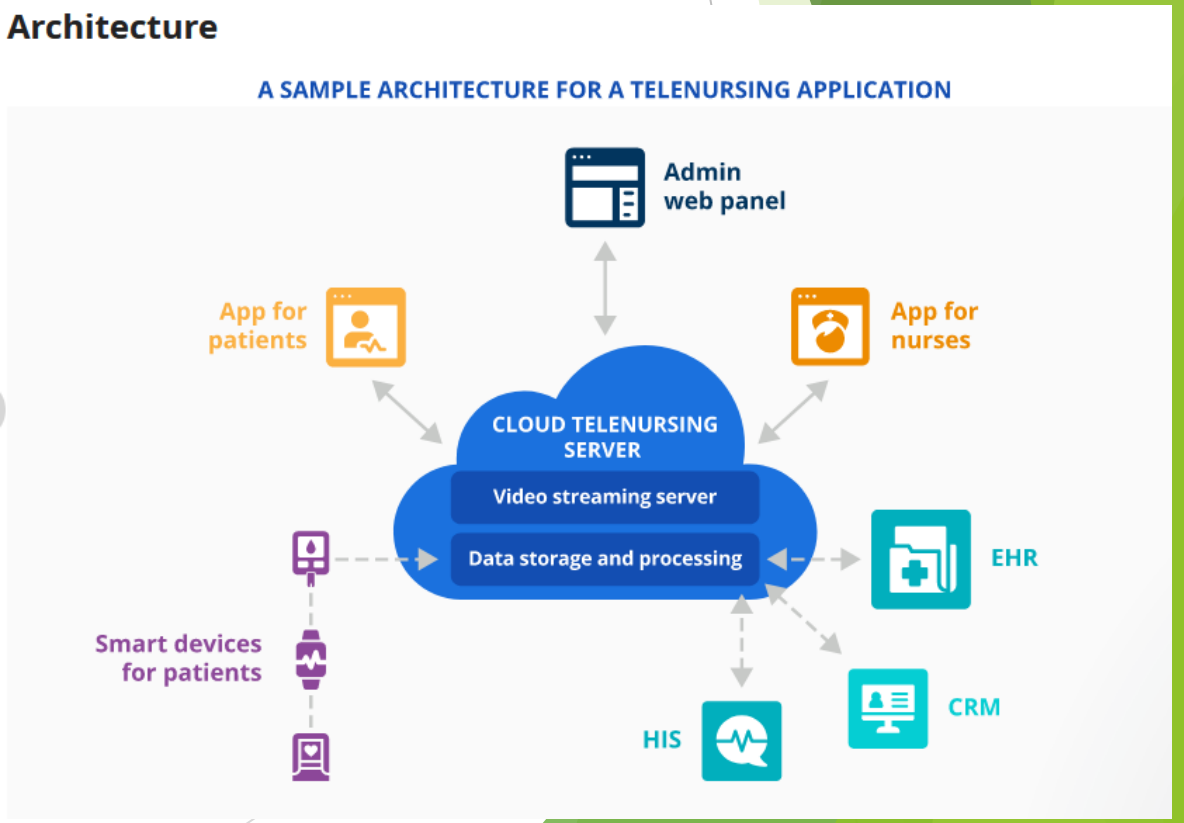
- Algorithms:
- Read text in PDF to extract dates, laboratory findings, and social history
- Text-processing algorithm for laboratory and note information(keyword searching).
- Organize the record's pages by content category
- Convolutional neural networks for image processing (First page of scanned documents, clinical images,…)
- Reporting obtained (refined) results in a user-friendly interface.

Chi EA, Chi G, Tsui CT, et al. Development and Validation of an Artificial Intelligence System to Optimize Clinician Review of Patient Records. *JAMA Netw Open*. 2021;4(7):e2117391. doi:10.1001/jamanetworkopen.2021.17391

AI in nursing

- **Telenursing (Remote nursing against face-to-face nursing)**
  - remote care
  - remote health state monitoring
  - remote consultations on symptoms
  - remote rehabilitation
- **Purposes**
  - Reduce workload on nurses
  - Reduce re-admission



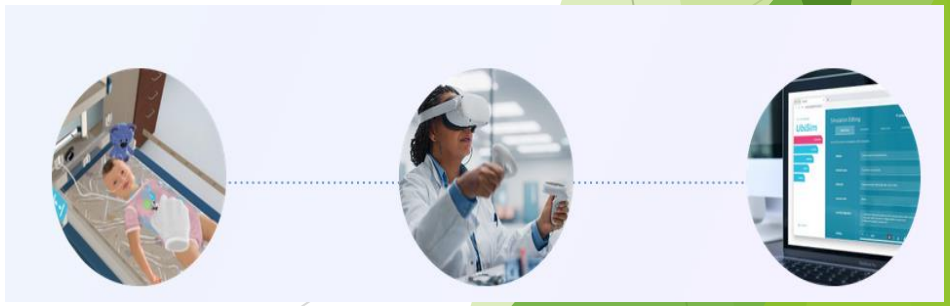


AI in nursing

- **Patient data gathering (data capture) and analysis**
  - **Data gathering in dangerous situation → wearable devices + IOT**
- **Performing automated tasks in nursing**
  - **Clinical decision making**: Nurses are constantly faced with important decisions→ impact of **decision fatigue** and **false alarm frustration.**
  - **How does AI help?**
    - **Sensor-based technology** →remote sensor technology →AI can help **gather data** and facilitate **patient monitoring**, as well as **recommend treatments** based on the data.
    - **Mobile technology**: AI can help interpretation of data for mobile technology.
  - **Voice assistants and robotics**: A voice assistant can remind patients to take medication.

AI in nursing

- **AI in nursing education**
  - **Evaluation of student emotions during procedures**
    - **Face tracker software*:** A software that uses ML to evaluate emotional factors in patient care during clinical scenarios through **facial analysis.**
    - This technology may help students to better understand emotion in their patients
  - **Evaluating the quality of procedure**
    - Myo wearable armband to measure correctness of hand washing #
    - sensors to recognize the activity of the forearm, palm and fingers + signal processing + Machine learning→ quality assessment
  - Simulating real situation using virtual reality

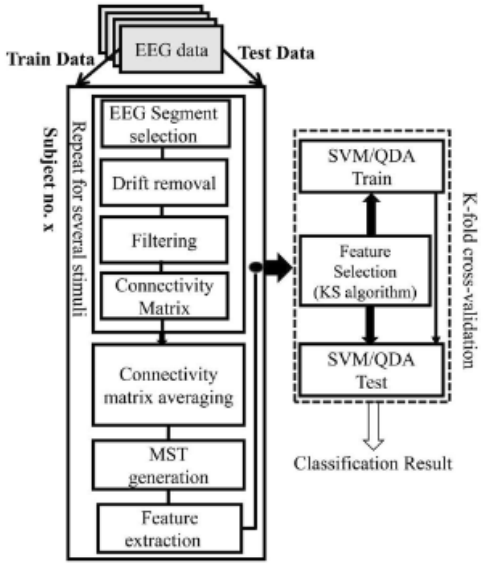


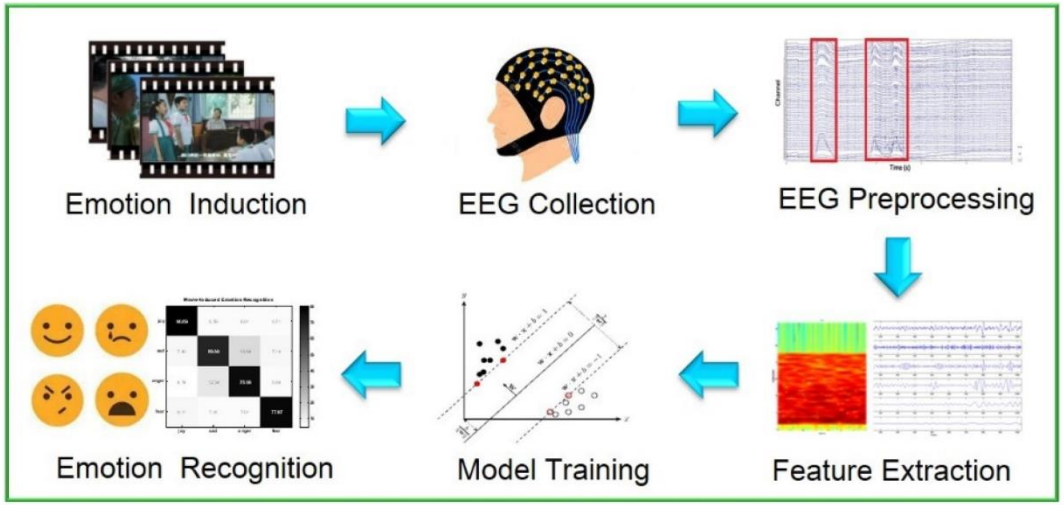
*Mano L, Mazzo A, Neto J, Meska M, Giancristofaro G, Ueyama J, et al. Using emotion recognition to assess simulation-based learning. Nurse Educ Pract 2019 Mar;36:13-19

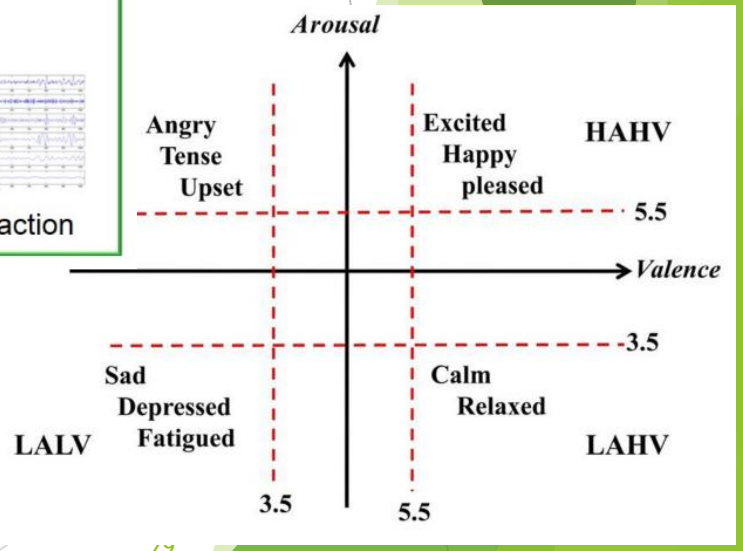
#Kutafina E, Laukamp D, Jonas S. Wearable Sensors in Medical Education: Supporting Hand Hygiene Training with a Forearm EMG. Stud Health Technol Inform 2015;211:286-291.

AI researches in emotion perception/recognition

- Emotion recognition using brain waves, connectivity and ML



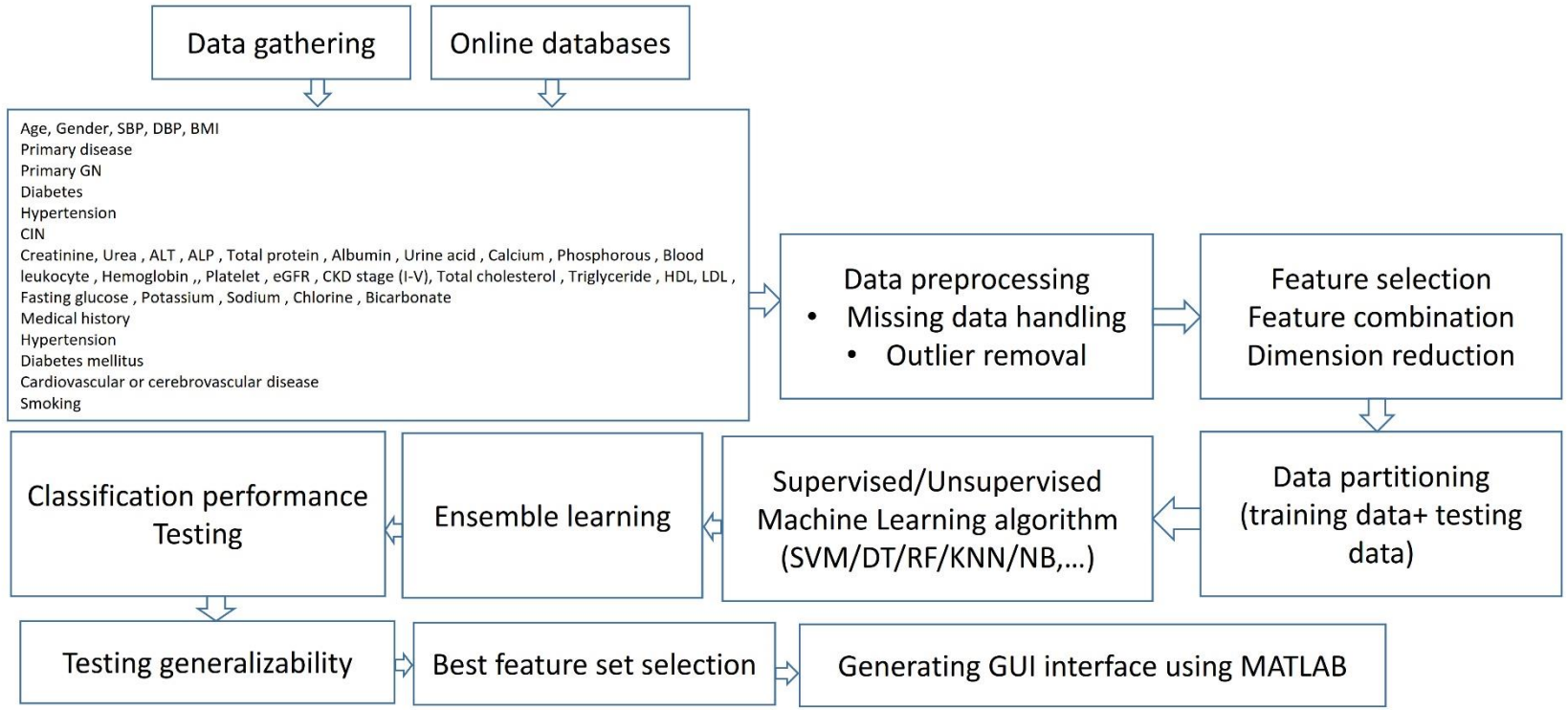




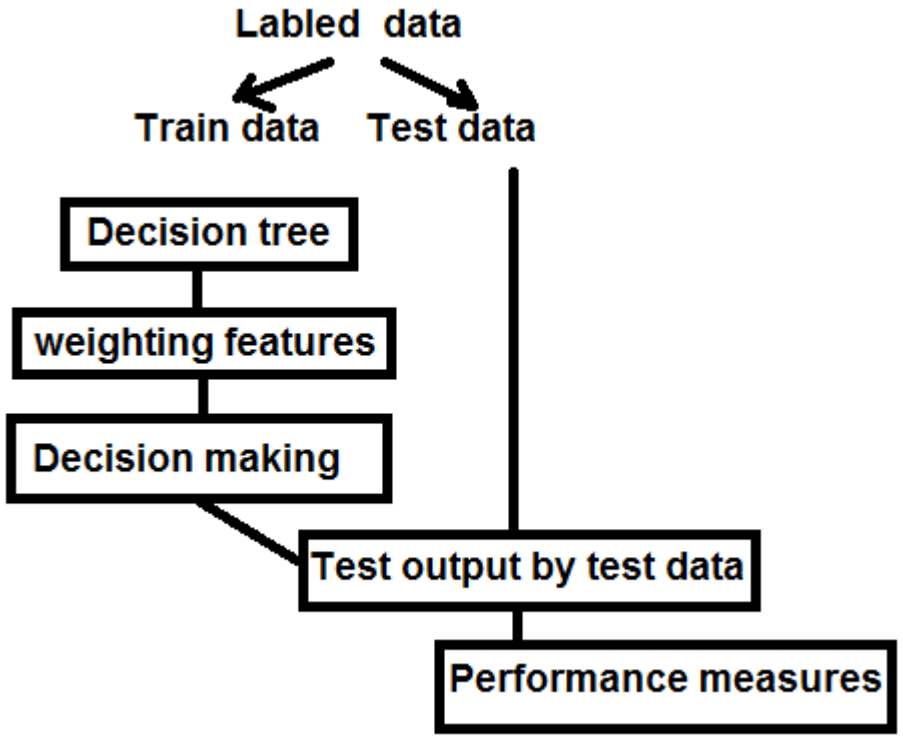
S Farashi, R Khosrowabadi , EEG based emotion recognition using minimum spanning tree, Physical and Engineering Sciences in Medicine, 2020

AI research in urinary tract infection (UTI) diseases

- **Gold standard for suspected UTI cases**→ urinary examination
- **Problem**: it needs at least 48 hours for test response (Golden time for antibiotic prescription).
- **Solution**: An automatic algorithm for predicting the chance of UTI



AI in traditional medicine



D1: وقتی اطرافیان، دست شما را لمس می‌کنند در مورد گرمی و سردی آن چه می‌گویند؟
D2: وضعیت تری و خشکی پوست شما چگونه است؟
D3: وضعیت چاقی و لاغری شما نسبت به سایرین چگونه است؟
D4: نسبت عضلات و چربی در بدن شما چگونه است؟
D5: سرعت رشد موی شما نسبت به همسالانتان چگونه است؟
D6: وضعیت موی سر شما از نظر پرپشتی یا کم‌پشتی چگونه است؟
D7: ضخامت موی سر شما نسبت به سایرین در چه حدی است؟
D8: حالت موی سر شما نسبت به سایرین چگونه است؟
D9: رنگ موی سر شما در محدودهٔ کدام گزینه است؟
D10: رنگ پوست بدن شما در محدودهٔ کدام‌یک از گزینه‌ها می‌باشد؟
D11: وضعیت کف دست شما در چه حد می‌باشد؟

D13: وضعیت پهنای کف پای شما در چه حد می‌باشد؟
D14: وضعیت غضروف حنجره (برجستگی سفت جلوی گردن) شما نسبت به بافت نرم اطراف آن چگونه می‌باشد؟
D15: وضعیت شکل بینی شما چگونه می‌باشد؟
D16: سرعت تأثیرپذیری شما ازسرما و گرما چگونه است؟
D17: سرعت تأثیرپذیری شما از غذاهای با طبع گرم مانند عسل، ادویه‌جات، فلفل یا غذاهای با طبع سرد مانند دوغ، ماست و خیار چگونه است؟
D18: اگرمحدودیت زمانی جهت خواب نداشته باشید به‌طور متوسط به چند ساعت خواب در شبانه‌روز نیاز دارید؟
D19: در نوجوانی سرعت رشد جسمی شما نسبت به همسالانتان چگونه بوده است؟
D20: قوت صدای شما نسبت به اطرافیان چگونه است؟

رضایی و همکاران، ارائه مدلی بر مبنای درخت تصمیم فازی جهت تشخیص مزاج در طب سنتی ایرانی، مجله طب سنتی، جلد ۹ شماره ۳ صفحات ۲۲۷-۲۳۷

AI is the future of surgery

- Preoperative planning
  - The stage in which surgeons plan the surgical intervention
    - Image-analysis techniques
      - identify from CT scans abnormalities such as:
      - calvarial fracture
      - intracranial hemorrhage
    - Classification
- Intraoperative planning
  - tracking of tissue deformation

AI is the future of surgery [Cont.]
Microsure's MUS : A device for Lymphedema treatment

- **Microsure** : AI-driven robot in a microsurgery intervention

Problem

- Lymphedema, accumulation of protein-rich fluid that's usually drained through the body's lymphatic
- Lymphedema is often a side effect that occurs during treatment of breast cancer that causes swelling.

Solution New treatment using AI : super-microsurgery,

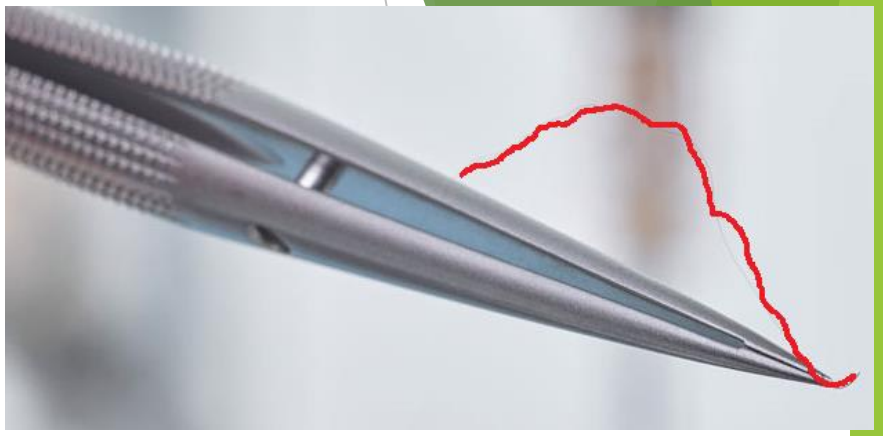
- Small lymphatic vessels are connected to blood vessels to restore the flow of lymphatic fluid and alleviate swelling.
- The surgical robot was used to suture blood **vessels between 0.03 and 0.08 millimeters** in a patient affected by lymphedema (**needs very accurate intervention**).

AI is the future of surgery [Cont.]

Microsure's MUS : A device for Lymphedema treatment

How does it work?

- Camera captures surgeon hand position.
- A software analyzes the image, calculates hand movement
- The trembles in surgeon's movement are canceled.
- The hand movement is translated to very fine movement



AI in cancer treatments

BioTrace: real-time monitoring and control system for thermal ablation

- Cancer treatment
  - Surgery
  - Chemotherapy
  - Radiotherapy
  - Tumor treating fields (TTFields)
  - Thermal ablation : **to destroy an entire tumor by using heat (Hyperthermia) to kill the malignant cells in a minimally invasive fashion without damaging adjacent vital structures.**

  - Thermal ablation techniques are effective treatment options for

1)patients who might have difficulty with surgery

2) whose tumors are less than one and a half inches in diameter.

AI in cancer tumor treatments

BioTrace: real-time monitoring and control system for thermal ablation

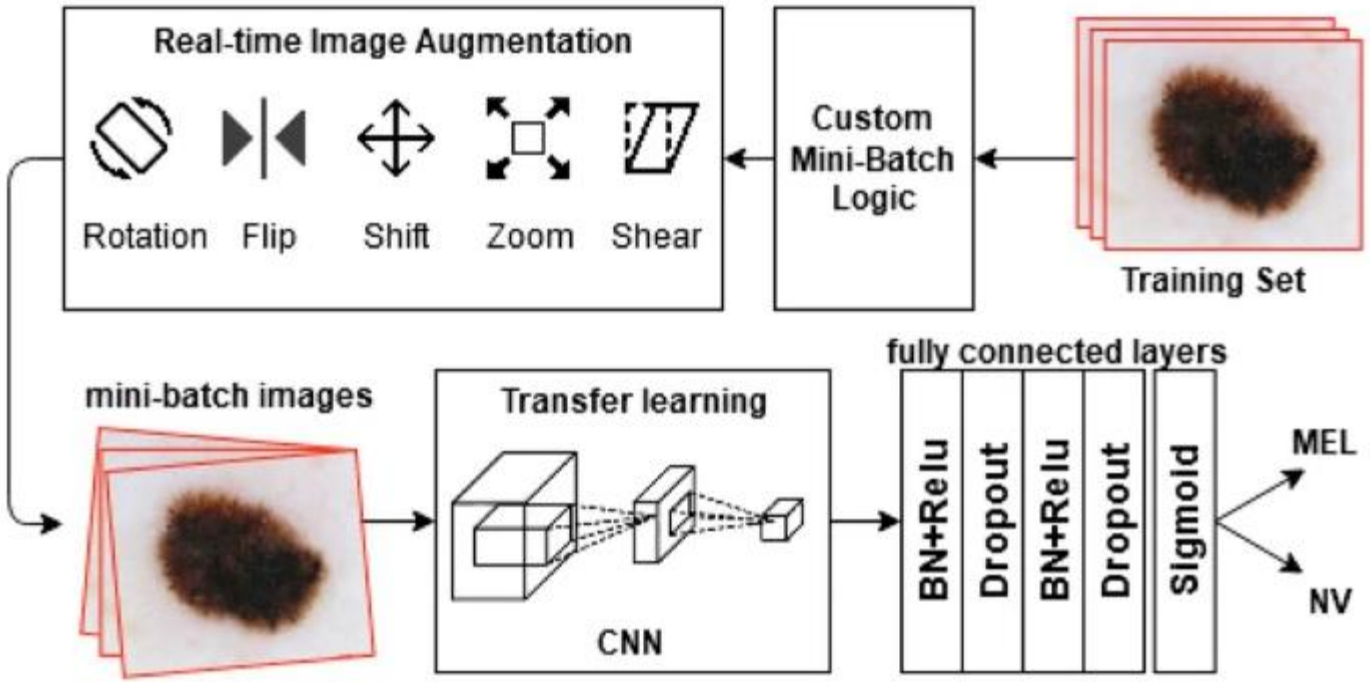
- Purpose
  - Radiofrequency ablation → direct application of RF energy to a target volume of tissue
- Problem
  - In practice, imprecise alignment of the ablation zone and the target results in incomplete destruction of the target
- Solution
  - AI helps to precisely locate the probe in tissue

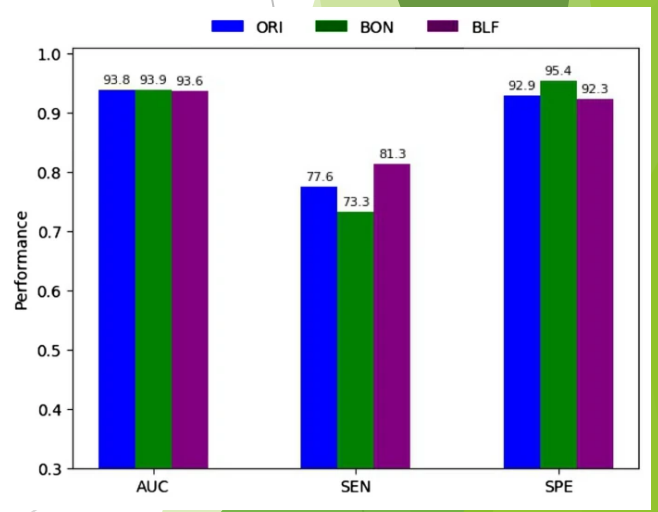
AI in skin cancer diagnosis

- Skin cancers(especially melanoma)
- Current diagnostic solution: **Dermoscopy**
  - is a noninvasive, in vivo technique
  - is performed with a handheld instrument called a dermatoscope
  - visualization of subsurface skin structures in the epidermis, dermis (these structures are usually not visible to the naked eye)

- Purpose of AI in dermatology:
  - developing machine learning systems that facilitate classification and decision support for skin cancer management.

AI in skin cancer diagnosis [Cont.]





Pham, TC., Luong, CM., Hoang, VD. *et al*. AI outperformed every dermatologist in dermoscopic melanoma diagnosis, using an optimized deep-CNN architecture with custom mini-batch logic and loss function. *Sci Rep* **11**, 17485 (2021). https://doi.org/10.1038/s41598-021-96707-8

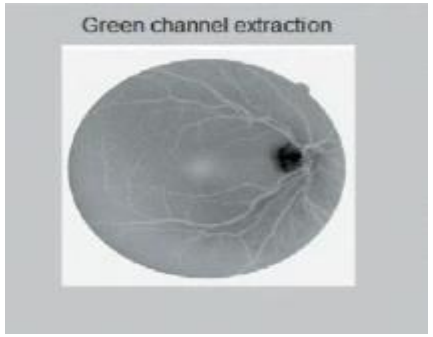
Cardiovascular disease prediction using eye images

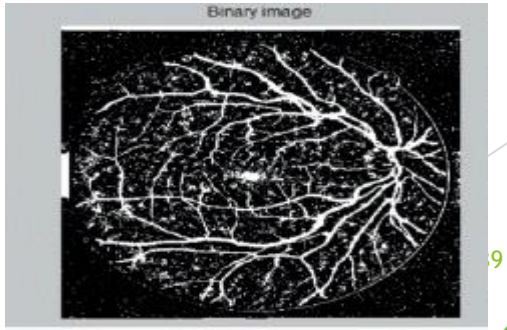
- Cardiovascular disease (CVD) accounts for 80% of death in males and 75% in females.

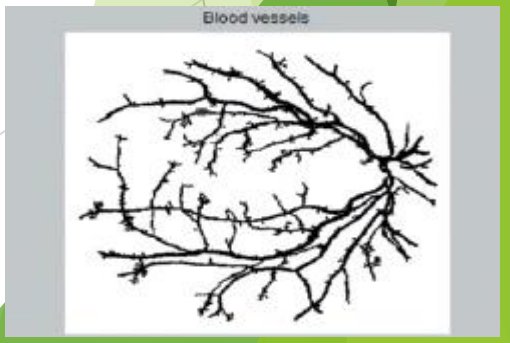
- Retinopathies obtained from fundus photographs were associated with the presence of any degree of coronary artery calcification (CAC)

A new solution for CVD prediction: retinal vessels analysis using AI

- The retinal image is filtered and then segmented
- Arteries and vein classification through the support vector machine (SVM).



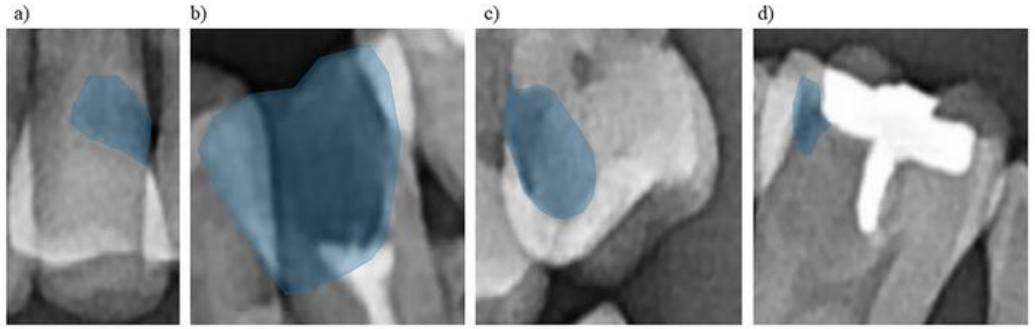




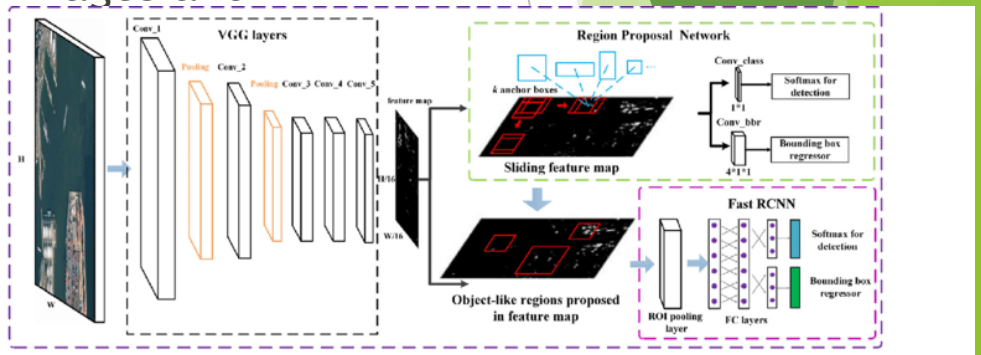
Poplin, R., Varadarajan, A.V., Blumer, K. *et al.* Prediction of cardiovascular risk factors from retinal fundus photographs via deep learning. *Nat Biomed Eng* **2**, 158-164 (2018). https://doi.org/10.1038/s41551-018-0195-0

Applications of AI In Dentistry

- Analysis of Panoramic dental radiography
  - diagnose dental diseases + systemic diseases + osteoporosis
  - Problem: due to **time constraints**, dental clinicians may concentrate **only** on teeth with symptom
  - Solution: **automatic detectors** are needed.
  - AI-based models use convolutional neural networks to classify images and detect objects.



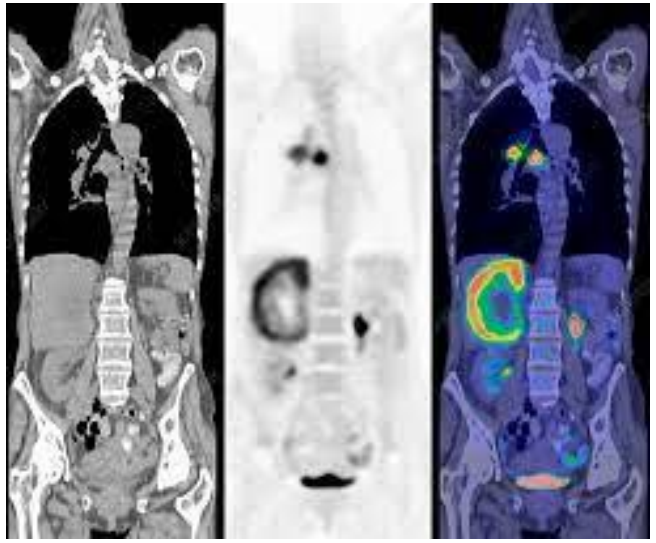
Examples of labelled carious lesions: a) cervical caries or cervical abrasions, b) dental caries or coronal defects, c) proximal caries, and d) secondary caries.



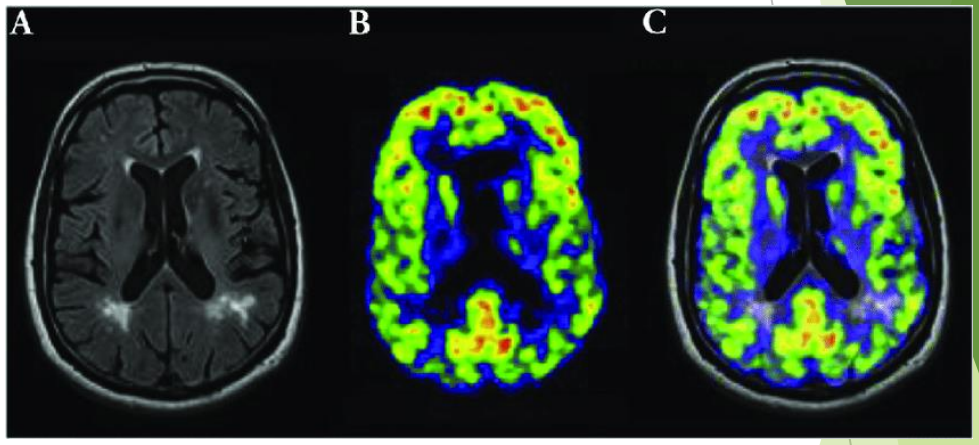
- Root Fractures Detection
- Determination of Working Length
- Morphology of Root and Root Canal System
- Prediction of the Viability of Stem Cells

Imaging modality fusion (Registration)

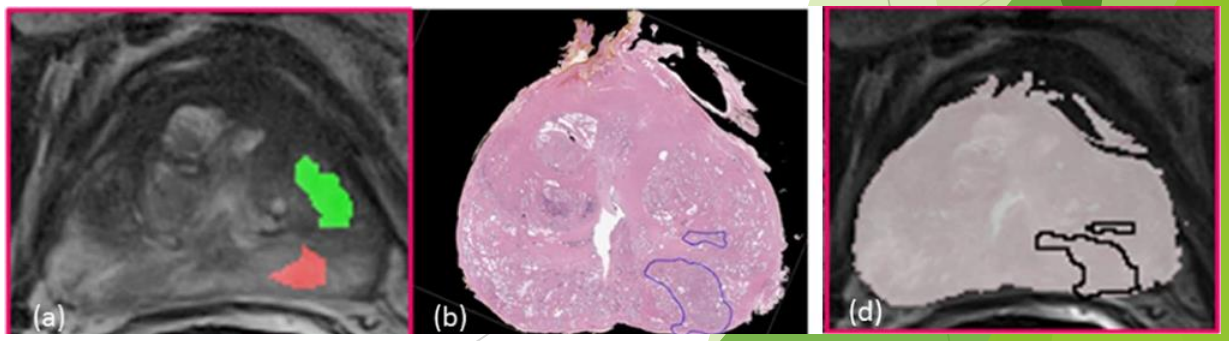
- Pre-operative planning: surgeons plan the surgical procedure on the basis of existing medical records (imaging like X-ray, CT, ultrasound, and MRI, fMRI, PET)



PET-CT scan fusion



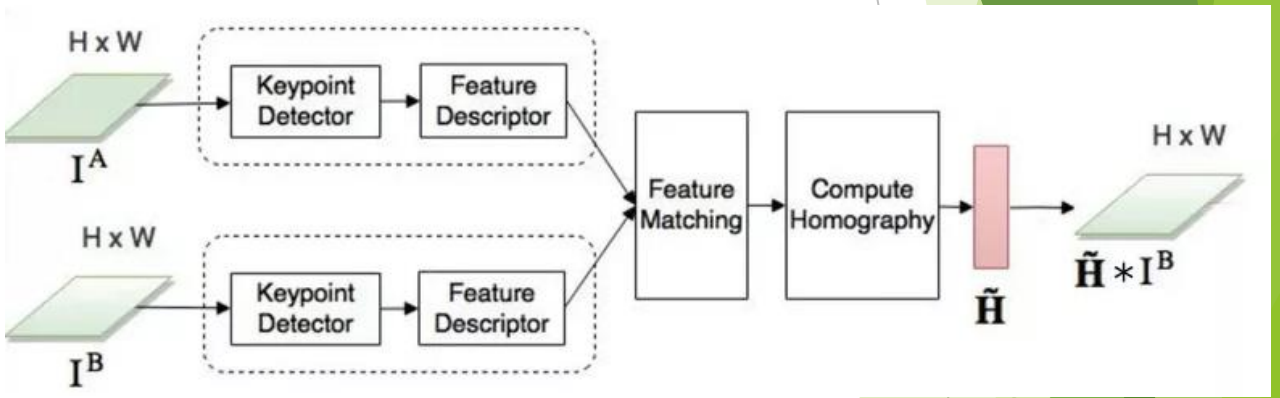
MRI-PET image fusion

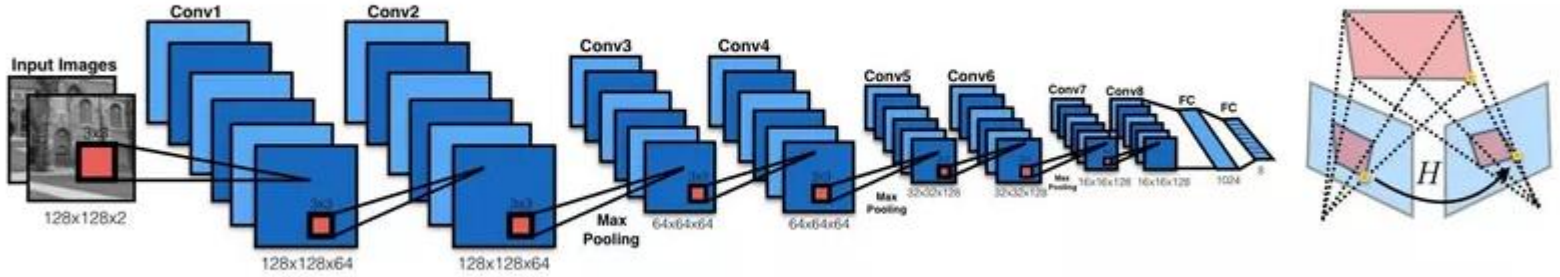


Radiography + Histology image fusion

Imaging modality fusion (Registration)

- Image registration needs:
  - Image segmentation
  - Marker detection
  - Image alignment
  - Image re-scalling and translation





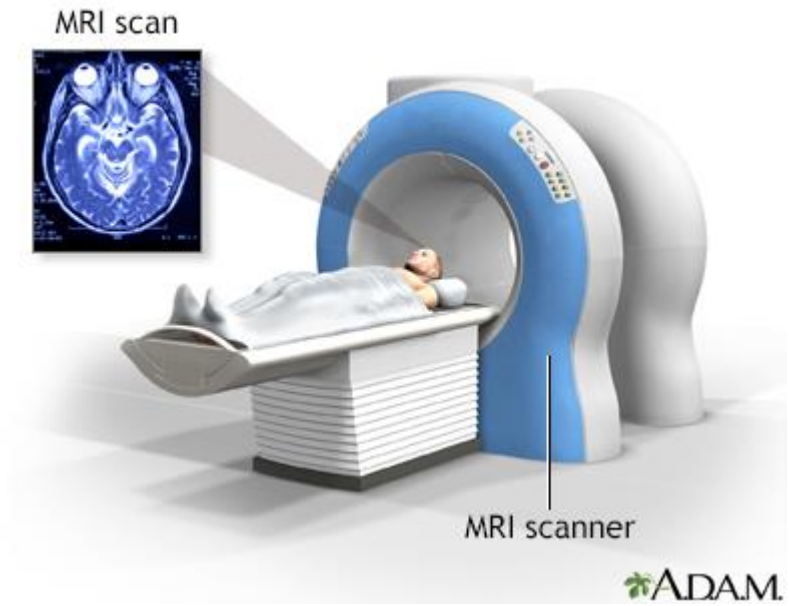
Regression HomographyNet

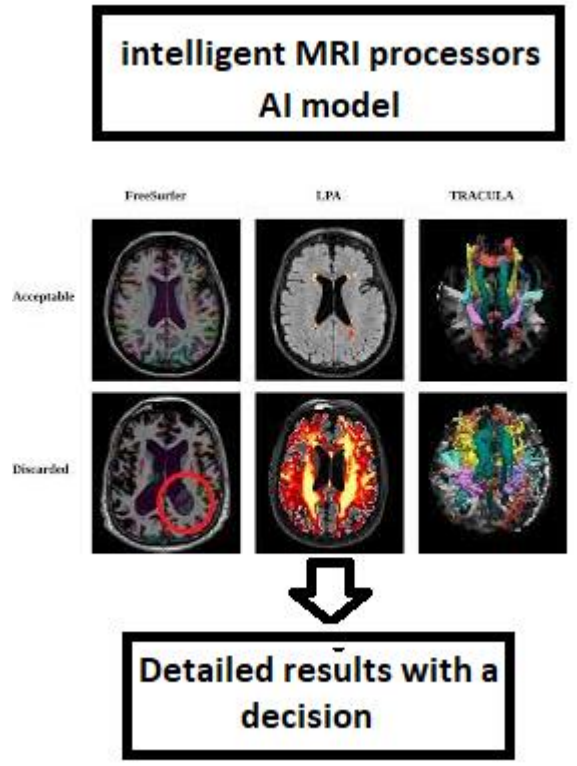
Future of AI in medicine

Are AI systems capable to replace human personnel (physicians, nurses,…)?

Yes or No?

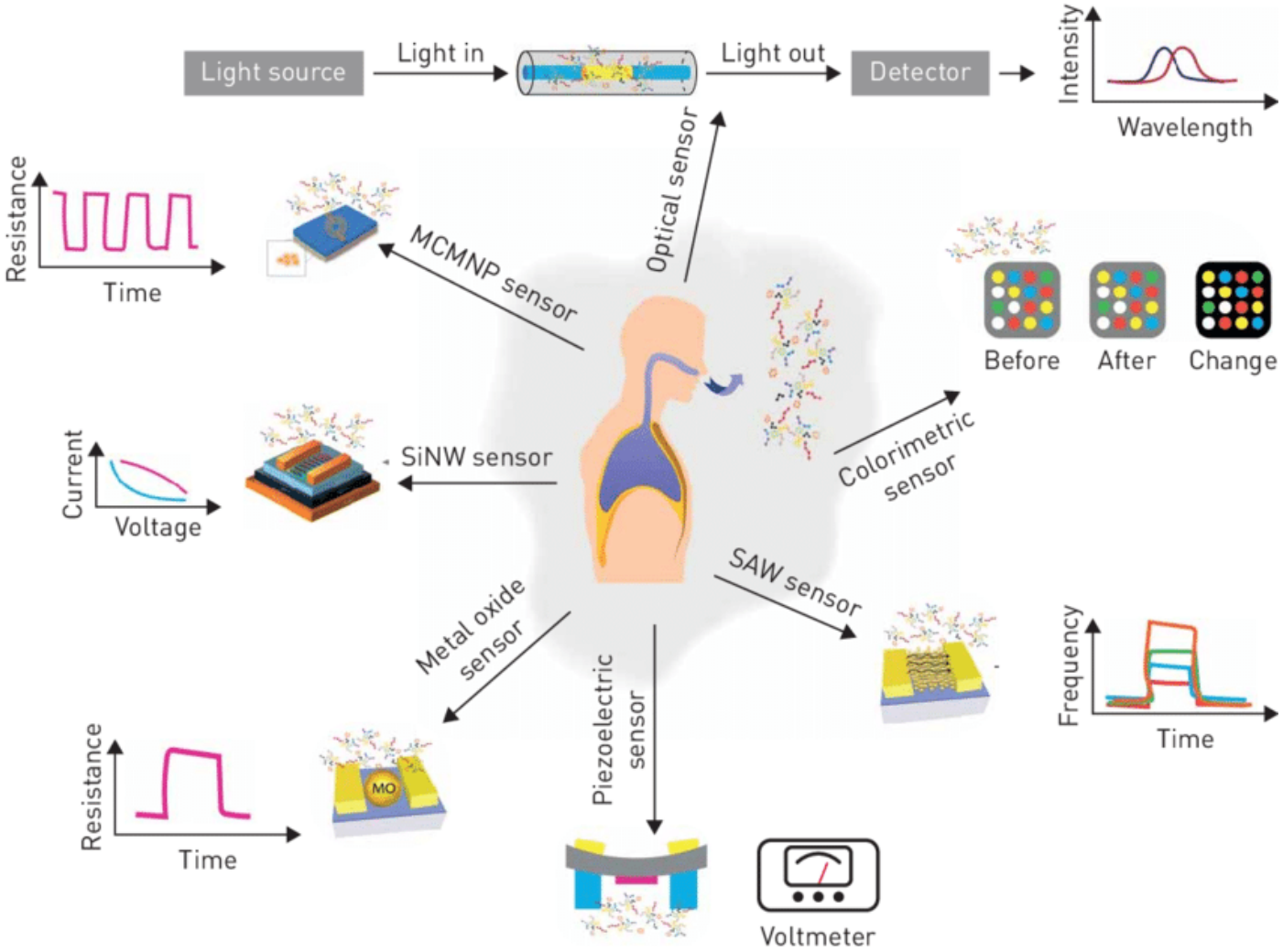
Future MRI scanners

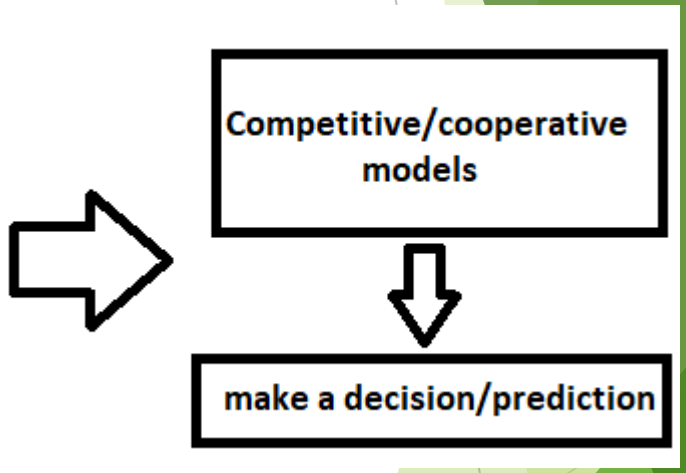




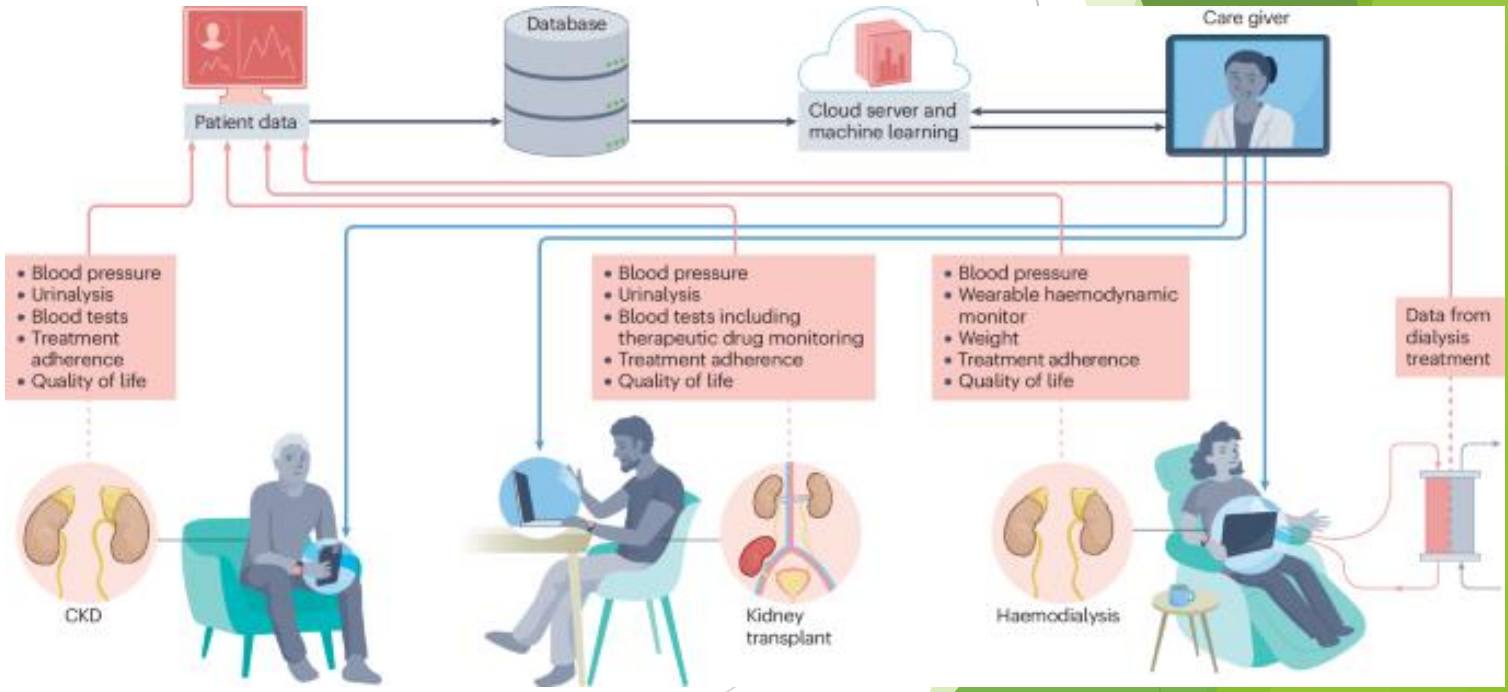
Fast and accurate

Future of medicine with AI
Future of diagnosis



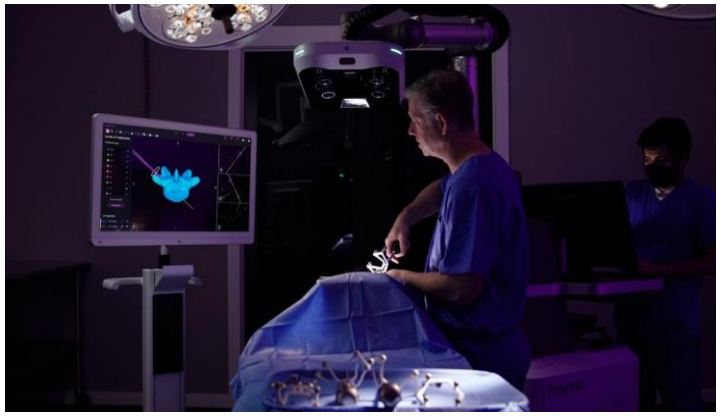


Future of medicine with AI
Patient's at home monitoring



Future of medicine with AI
AI-powered surgery

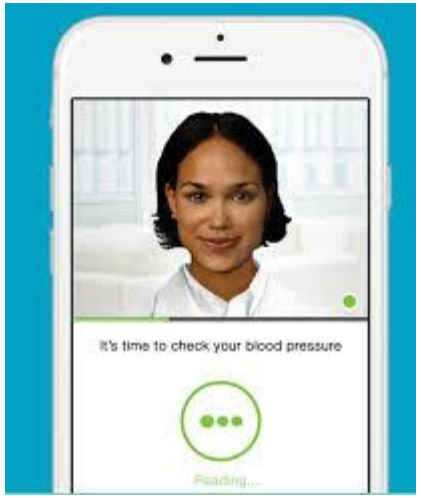
- Planning surgery procedure
- Surgery with AI robots
  - Detailed movements in the body
  - More restricted motion in the sensitive areas
- Processing real-time data from patients



Future of medicine with AI

Virtual Health Assistants

- Thanks for fast development of AI chatbots, virtual health assistance are developing



Challenges of AI in medicine (Data-related issues)

- **Bias and Fairness:**
  - **An AI system return the results according the way that it is trained. Are training test fair? (Rubbish in rubbish out).**
- **Data Quality and Scarcity**: **High-quality**, diverse datasets are crucial, yet difficult to obtain, especially in sensitive domains like healthcare
- Quality means:
  - enough sample size
  - diversity in cases and situations
  - Correct design
  - Accurate
- **Privacy Concerns**: Collecting and using personal data raises privacy issues, necessitating robust anonymization and consent mechanisms.

Challenges of AI in medicine (**Technical Limitations**)

- **Robustness and Generalization:** AI often struggles in unpredictable real-world environments.
- **Narrow AI :** limited real situations are used for training. **What about unseen situations?**
- **Reproducibility**: Variability in datasets and proprietary algorithms can impede replication of research results.
- **Computational complexity**: Training advanced models requires significant computational power, limiting access for smaller entities.
- **Environmental Impact**: Large-scale AI training contributes to carbon emissions, prompting a need for energy-efficient algorithms.

Challenges of AI in medicine (**Ethical and Societal Challenges**)

- **Job Displacement**: Automation risks disrupting labor markets, requiring workforce retraining and economic adaptation.
- **Accountability and Liability**: Legal frameworks lag in addressing liability for AI decisions (e.g., autonomous vehicle accidents).
- **Ethical Misalignment**: Ensuring AI aligns with human values and avoids harmful outcomes.

Challenges of AI in medicine (**Security Risks**)

- **Adversarial Attacks**: Malicious inputs can deceive AI systems (e.g., perturbed images fooling classifiers).
- **Misuse**: AI technologies could be weaponized for surveillance, deepfakes, or cyberattacks.

Challenges of AI in medicine (**Public Perception and Trust**)

- **Adoption Barriers**: Mistrust due to opacity or misuse can hinder acceptance, necessitating transparent and user-friendly designs.

?

Solution: Create a Realistic AI Avatar That Looks & Sounds 100% Like

https://www.youtube.com/watch?v=_n0vJrB_M30

Thanks for your attention