Artificial Intelligence and Optimization in Medical Sciences

نسیبه رادی راز

Nasibeh Rady Raz

PhD in Artificial Intelligence and Robotics

Department of Artificial Intelligence in Medicine, Faculty of Advanced Technologies in Medicine, Iran University of Medical Sciences, Tehran, Iran

radyraz.n@iums.ac.ir

بسم الله الرحمن الرحیم

دانشگاه علوم پزشکی و خدمات بهداشتی درمانی ایران

عنوان دوره آنلاین:

هوش مصنوعی در پزشکی با رویکرد بالینی

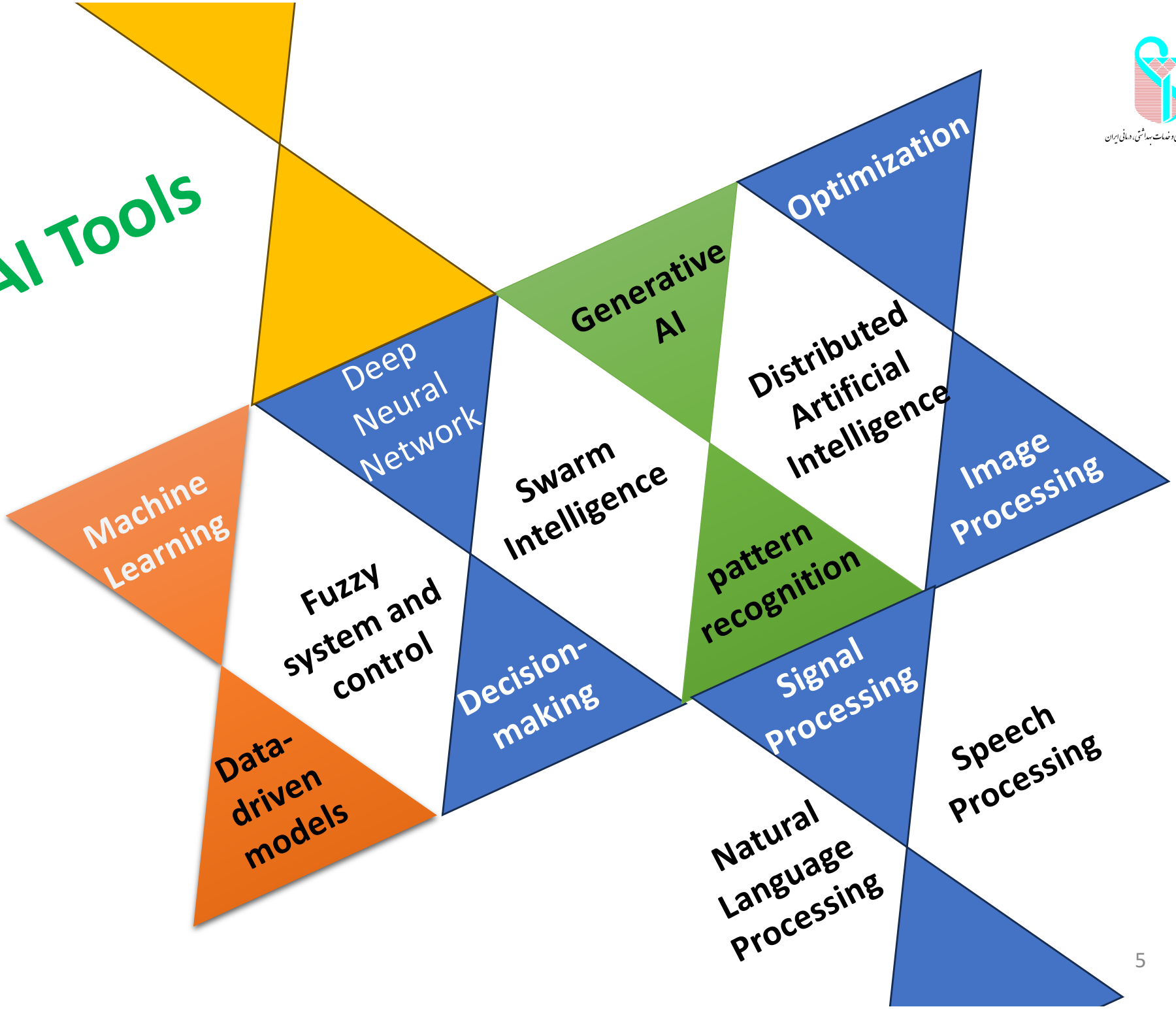
Online Course: Artificial Intelligence in Medicine with Clinical Approach

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

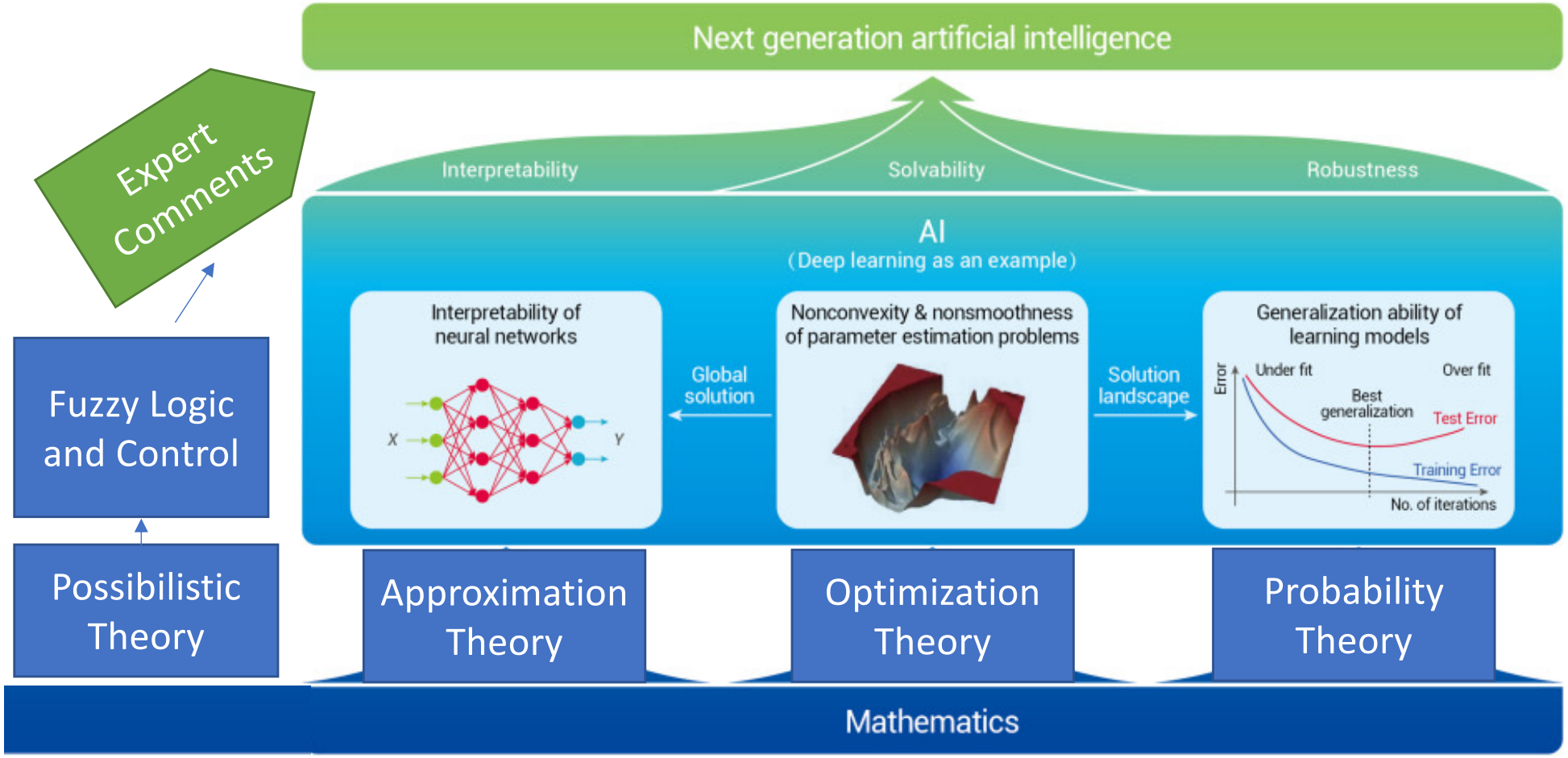
Artificial Intelligence

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

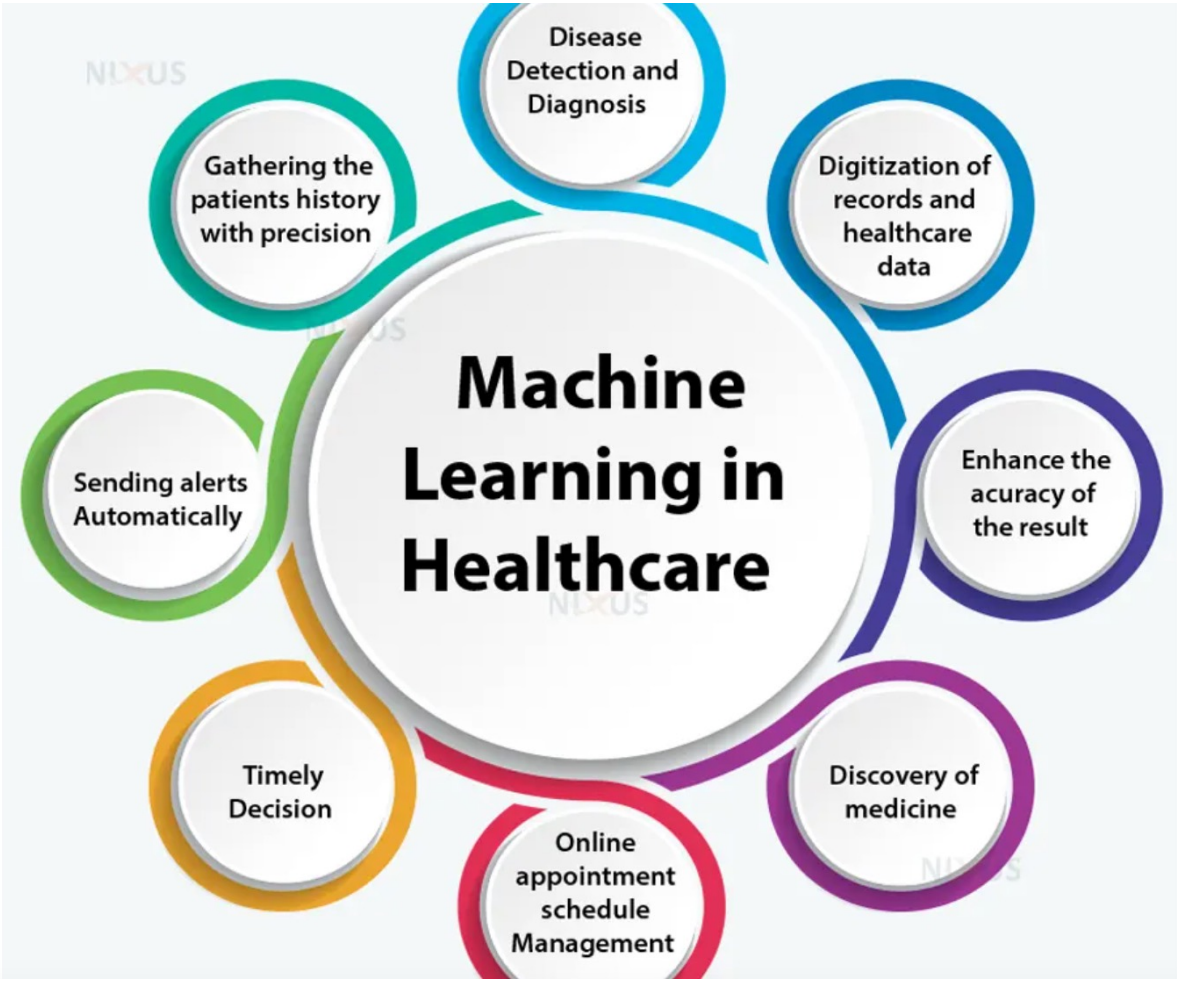
Artificial Intelligence



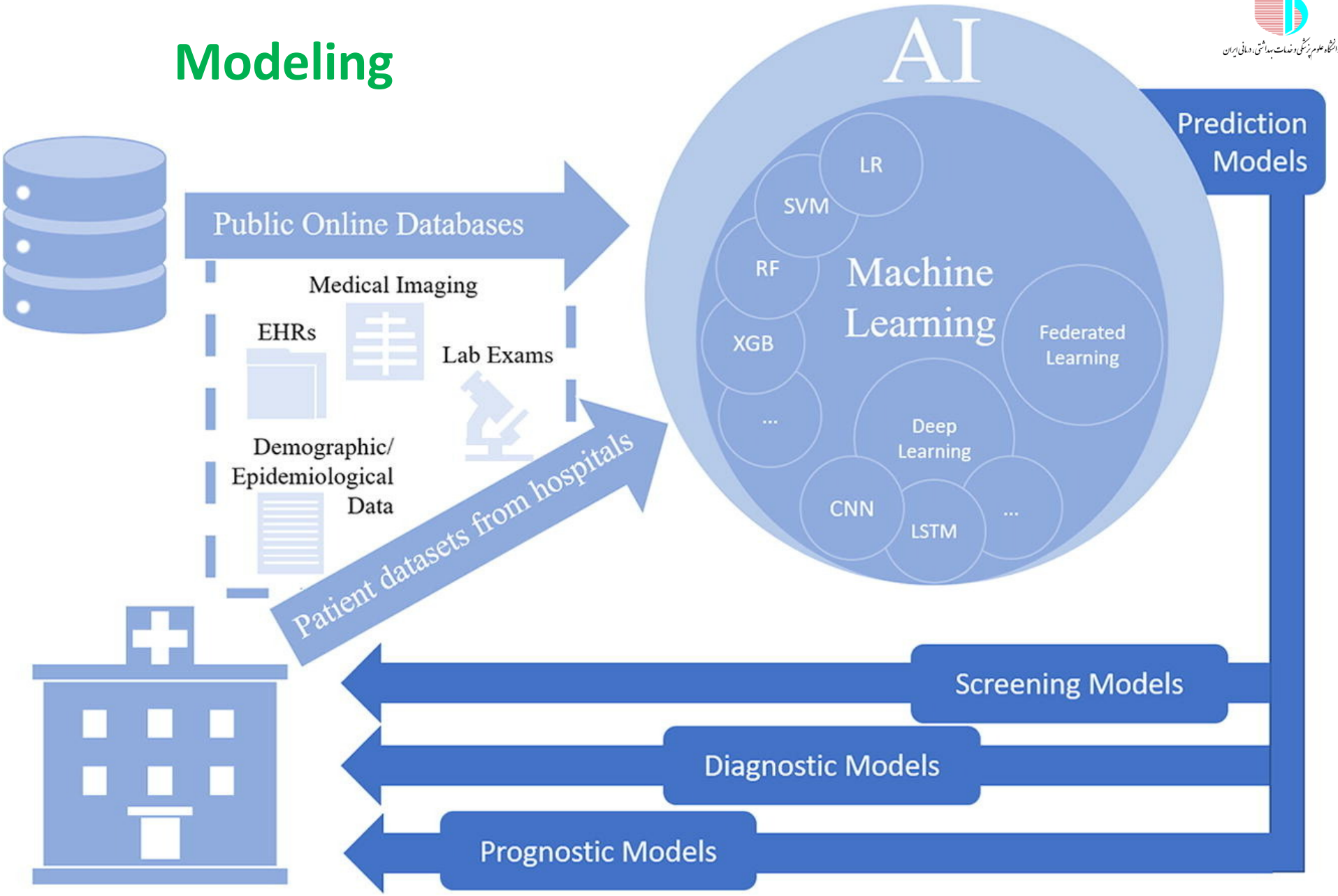
Aspect of Intelligence

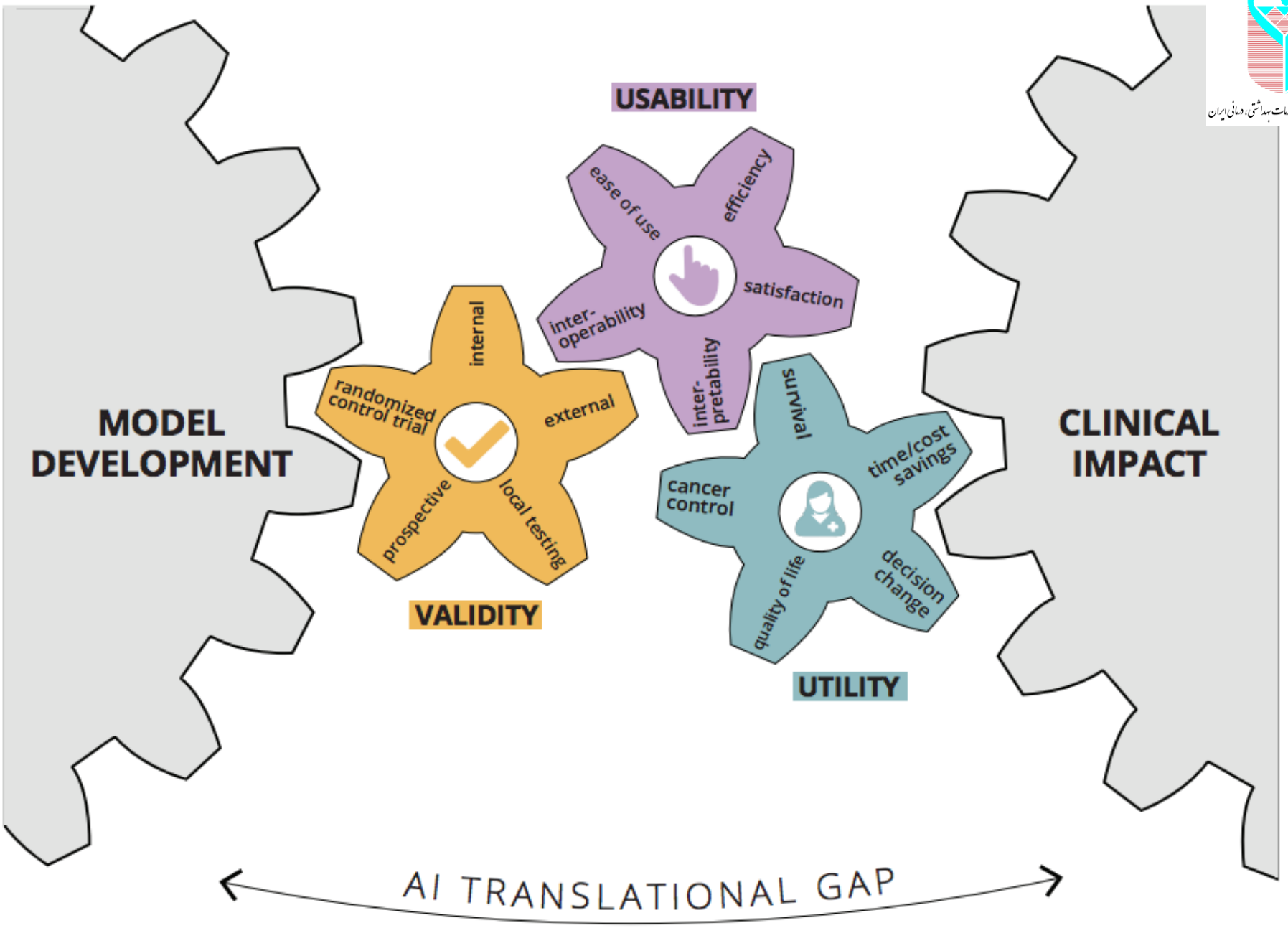
- Generalization
- learning/adapting
- Optimization
- Social Interaction
- Cognition

ML in medicine



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

You may face …

- Extensive emergency department boarding, including overnight holds
- Crowded surgical units, especially on weekends
- High or low occupancy units
- Hallway placement of inpatients
- Bottleneck units
- High readmission rates to particular units
- The excessively long length of stay, particularly in higher levels of care

Not able to align hospital capacity with patient demand

- system stress
- widespread waste and inefficiency
- Overcrowding
- readmissions
- medical errors,
- hospital-acquired infections
- delays,
- lack of preferred beds,
- cancellations,
- underutilization of existing resources
- inflated cost,
- nurse and physician burnout.

traditional solutions is to add more physical capacity or increase staffing

Optimization

The act of making the best or most effective use of a situation or resource.

but how is it achieved in real time?

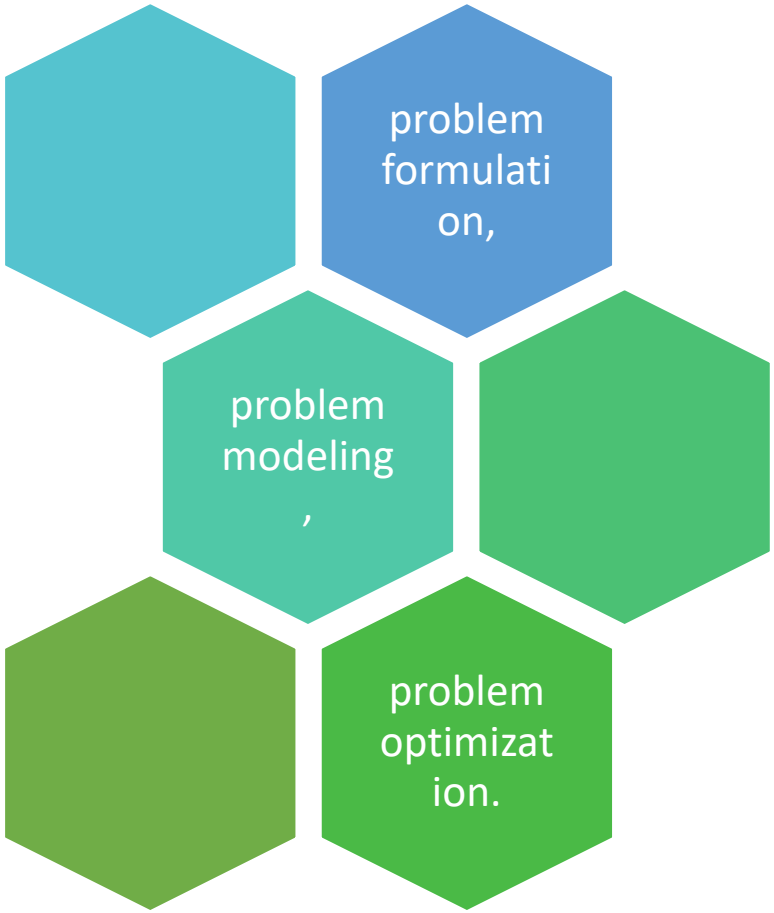
Optimizing workflows at hospital and health systems

Through using optimization

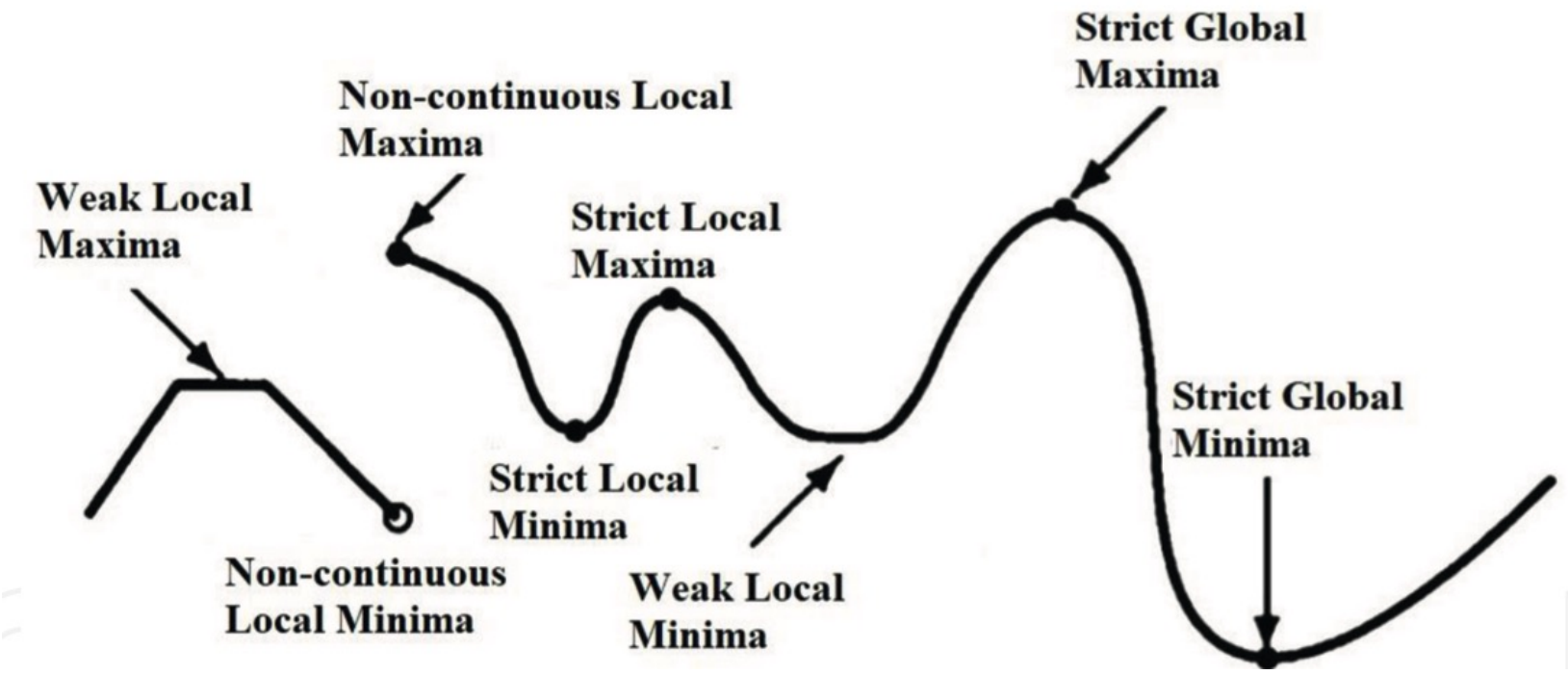
- Eliminating unnecessary peaks and valleys in their patient flow
- Increasing the number of patients that can be treated
- Reducing nursing overload, overtime, and turnover
- Achieving maximum compliance with patient-per-nurse ratios without hiring new staff
- Assuring patients are placed in the correct beds
- Improving patient, doctor, and nurse satisfaction
- Improving the quality and safety of patient care
- Reducing patient wait times for services
- Reducing hospital overcrowding
- Lower overall hospital length of stay

What is optimization?

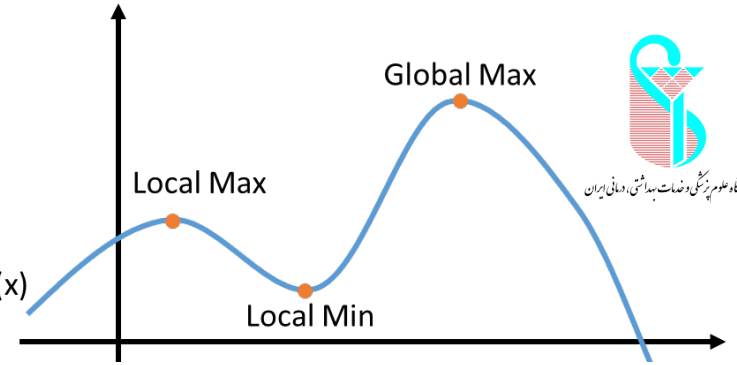
- The decision-making process consists of three steps:

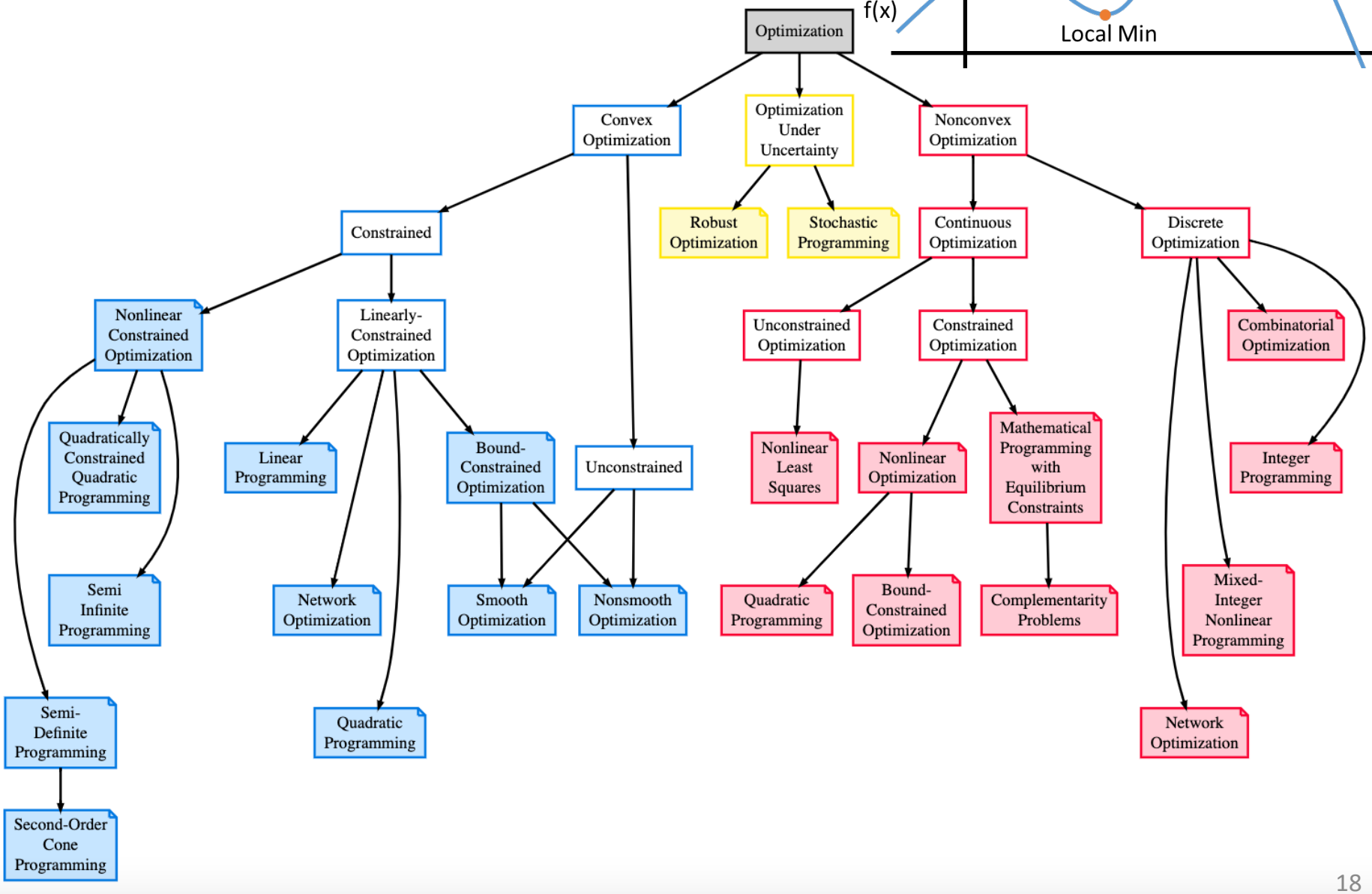


Local and Global

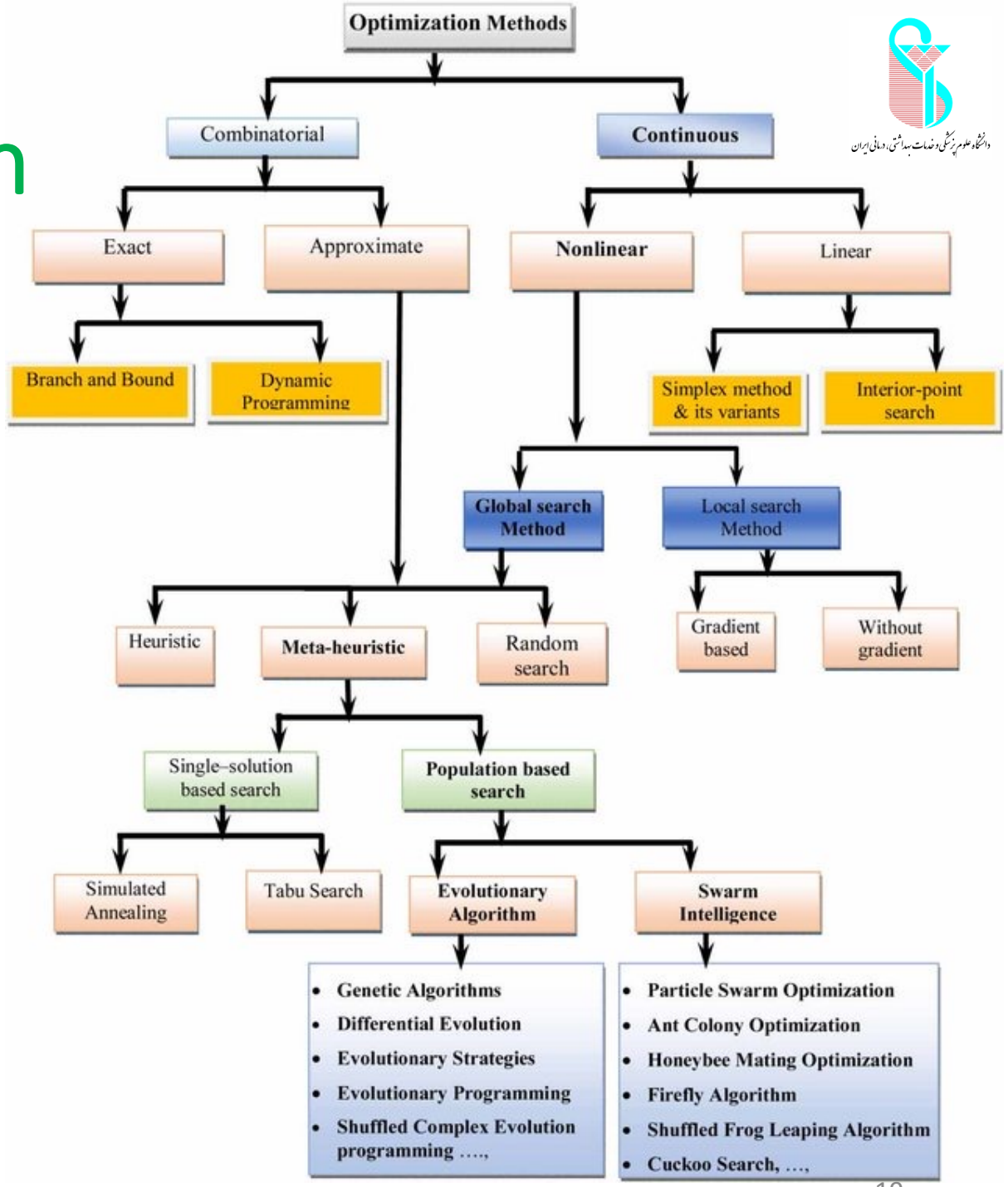


Optimization

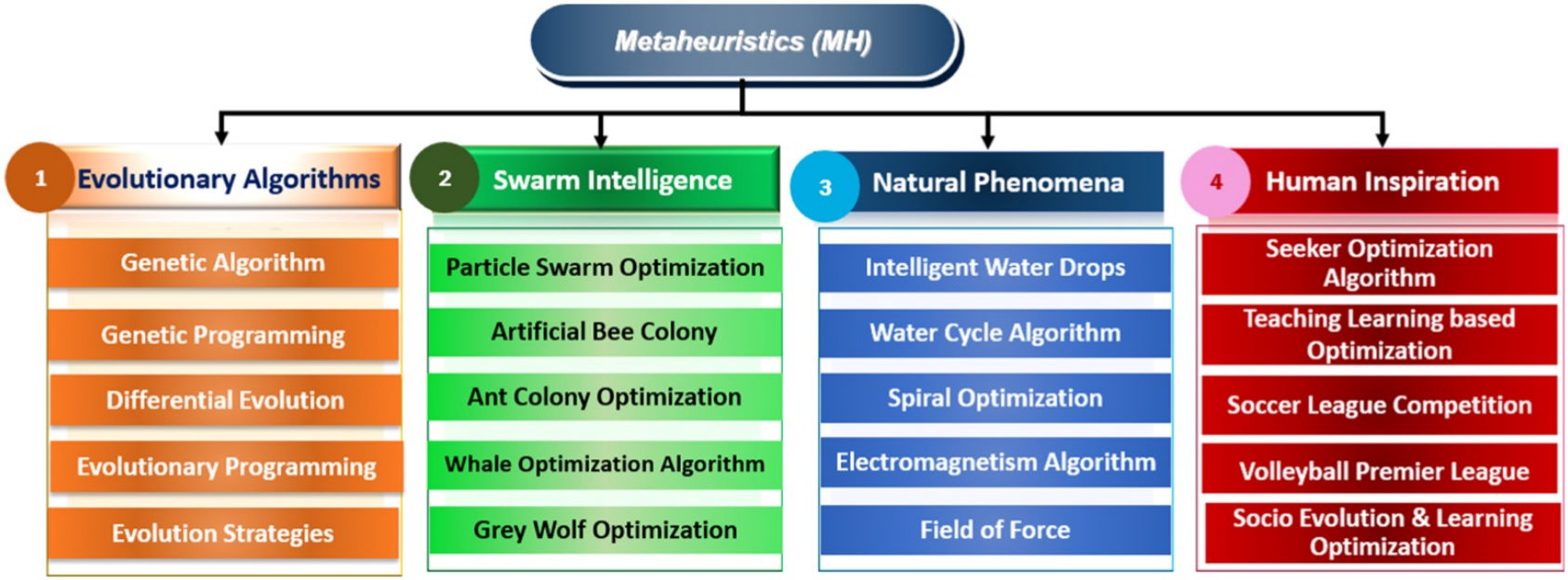




Optimization



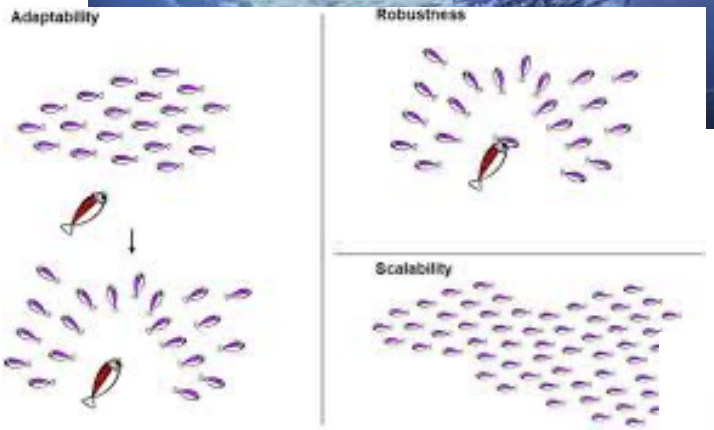
Optimization

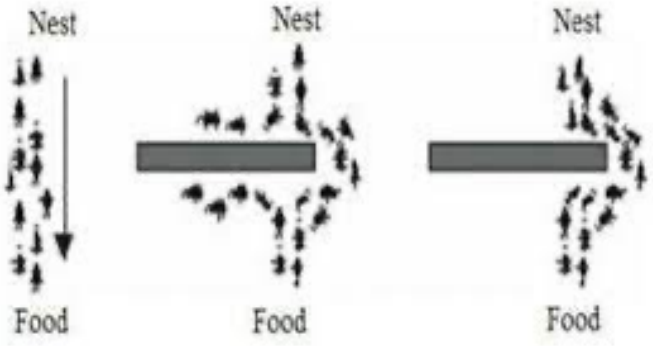


Optimization by Nature

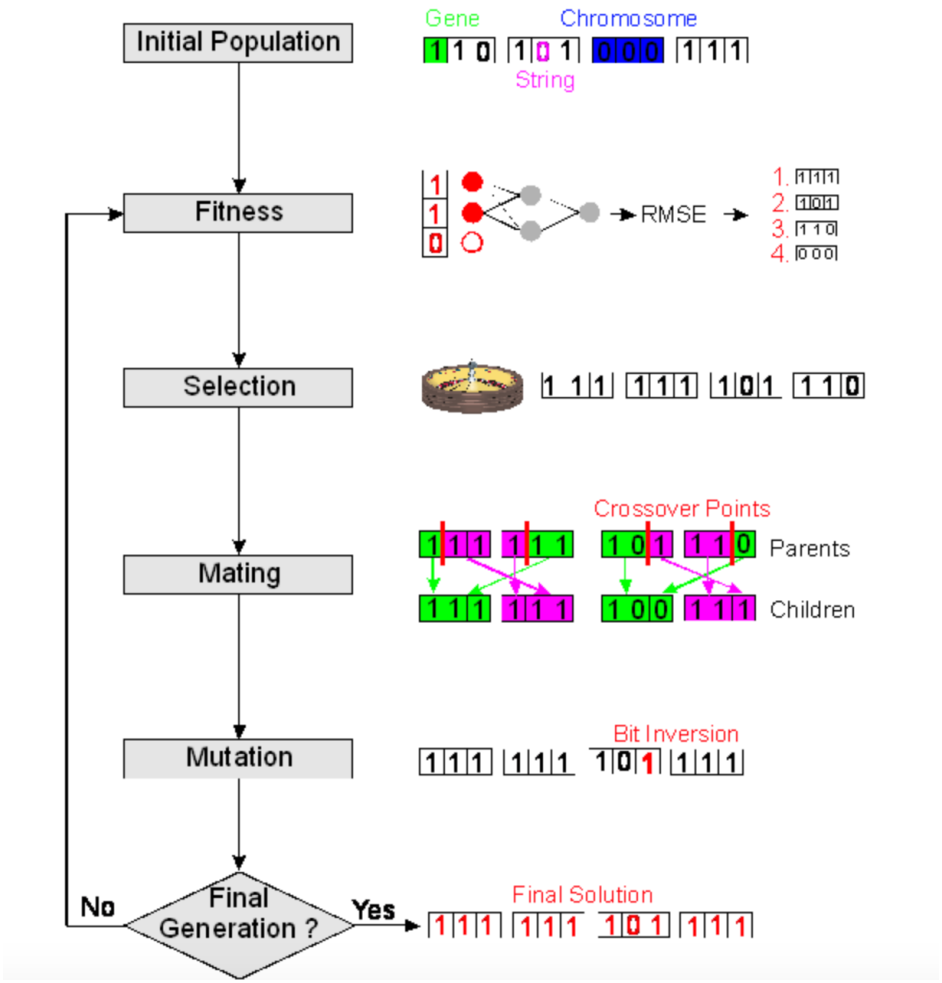
- Using nature-inspired algorithms.
- These are rooted in biology, ethology and physics.
- Such as
  - evolutionary and genetic algorithms that stem from biology;
  - particle swarm,
  - Leaping frogs and their fly-hunting process,
  - migrating birds and their exchange of leadership roles during long-distance flights,
  - honey-bees with their communication dance for their colonies about sweet flowers,
  - spiders with their web-based communication,
  - Cukoos' clever use of other birds' nests to host their eggs,
  - ants with their pheromone and stigmergic communication,
  - bacteria with their foraging behavior
  - as well as those that imitate the laws of physics such as magnetism and gravity.
- This list is endless.

Optimization by Nature

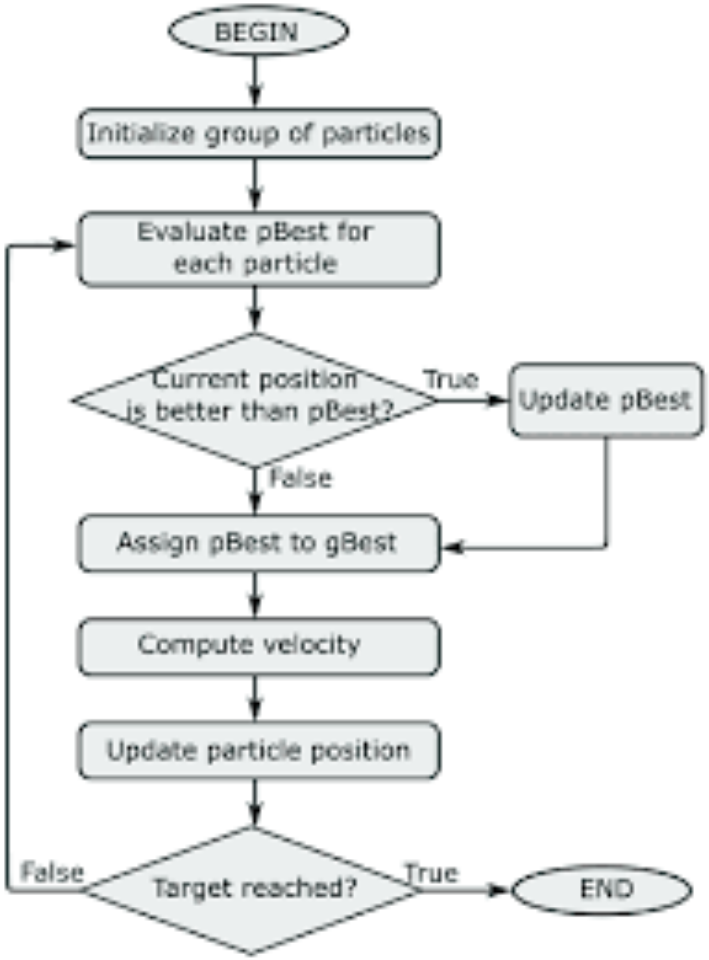


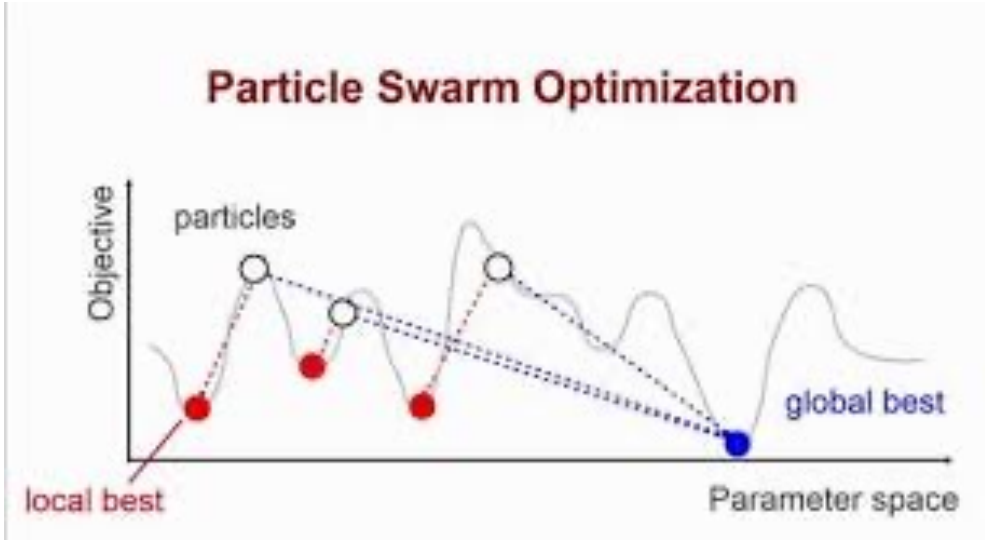


GA Algorithm

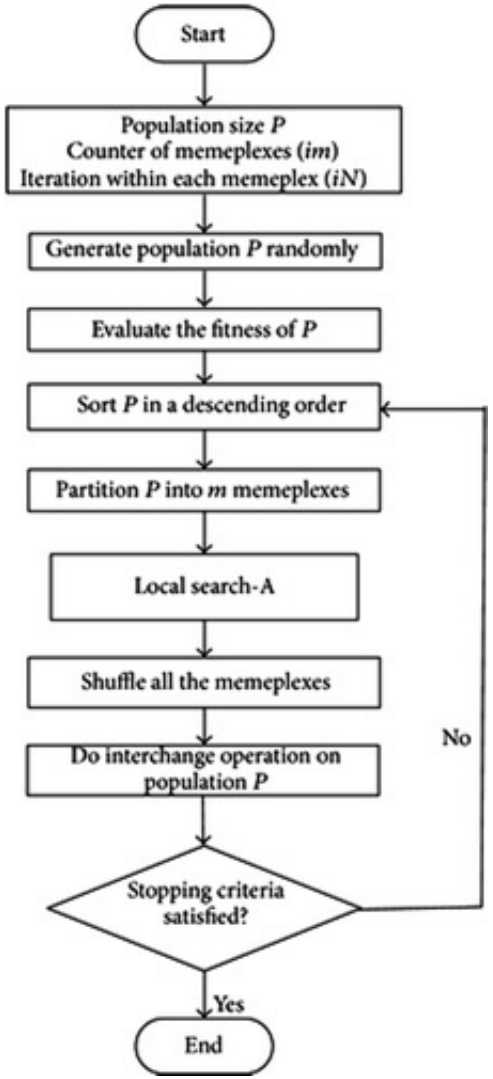


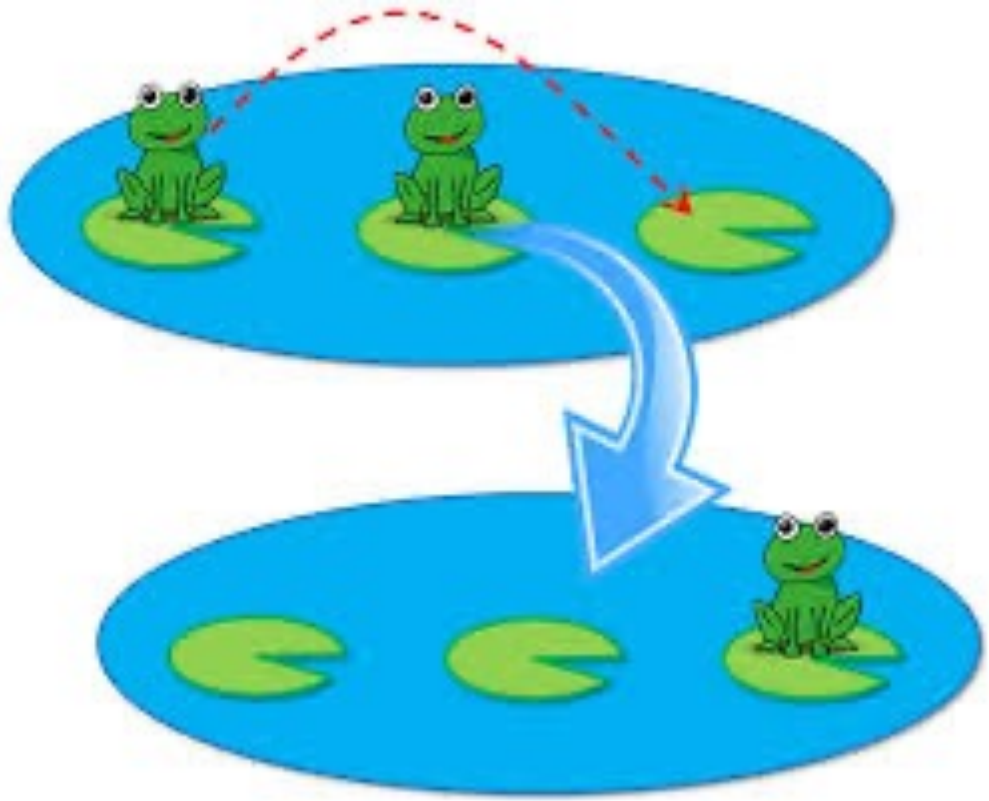
PSO


BEGIN
Initialize group of particles
Evaluate pBest for each particle
Current position is better than pBest?
True
Update pBest
False
Assign pBest to gBest
Compute velocity
Update particle position
Target reached?
False
True
END


Particle Swarm Optimization
Objective
particles
global best
local best
Parameter space

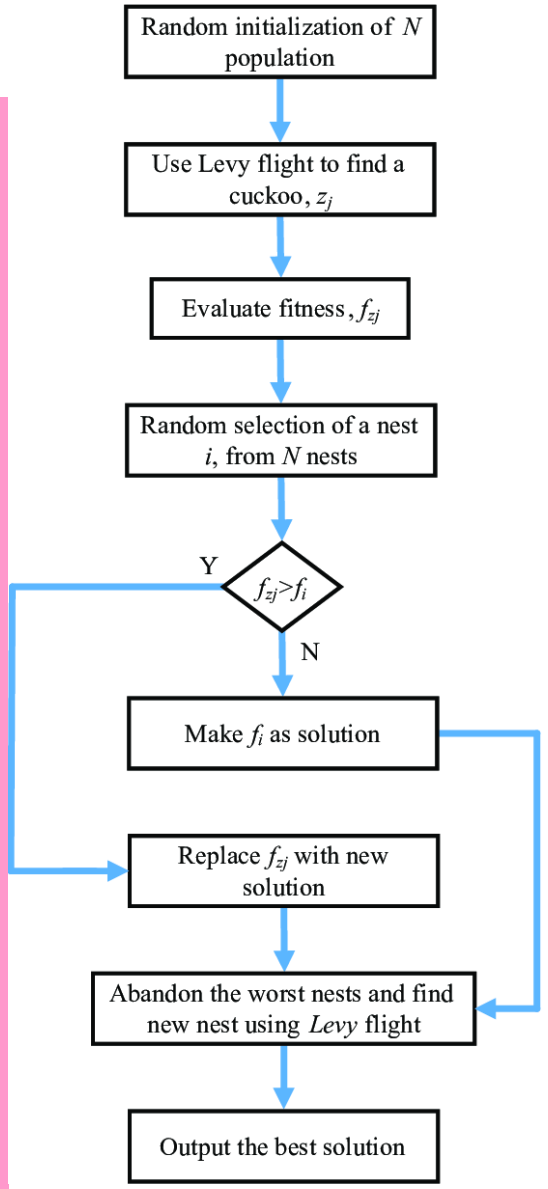
Leaping frogs



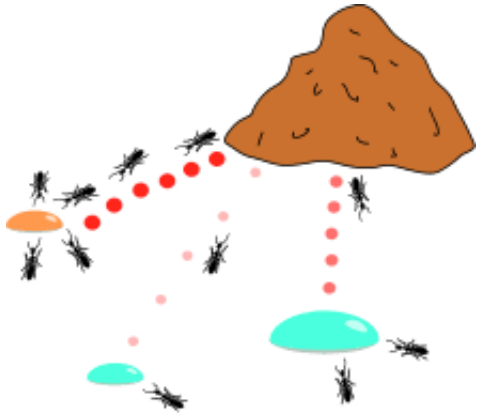


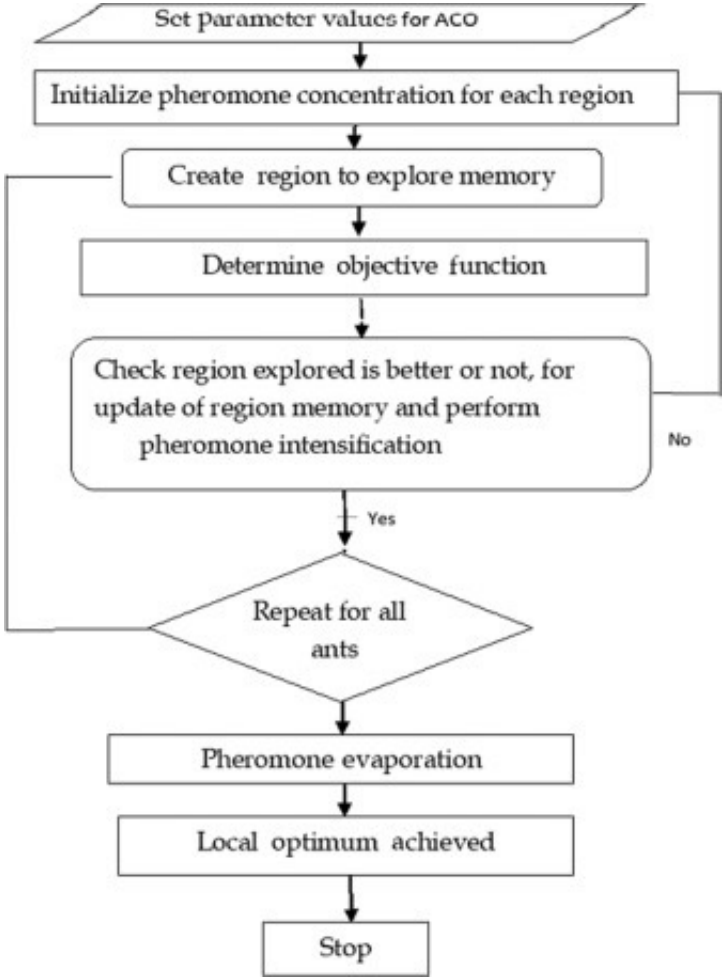
Cuckoo search (CS)

- Cuckoo search (CS) uses the following representations:
- Each egg in a nest represents a solution, and a cuckoo egg represents a new solution. The aim is to use new and potentially better solutions (cuckoos) to replace a not-so-good solution in the nests. In the simplest form, each nest has one egg. The algorithm can be extended to more complicated cases in which each nest has multiple eggs representing a set of solutions.
- CS is based on three idealized rules:
  - Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest;
  - The best nests with high-quality of eggs will carry over to the next generation;
  - The number of available hosts' nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability (0,1). In this case, the host bird can throw the egg away/abandon the nest, and build a completely new nest.

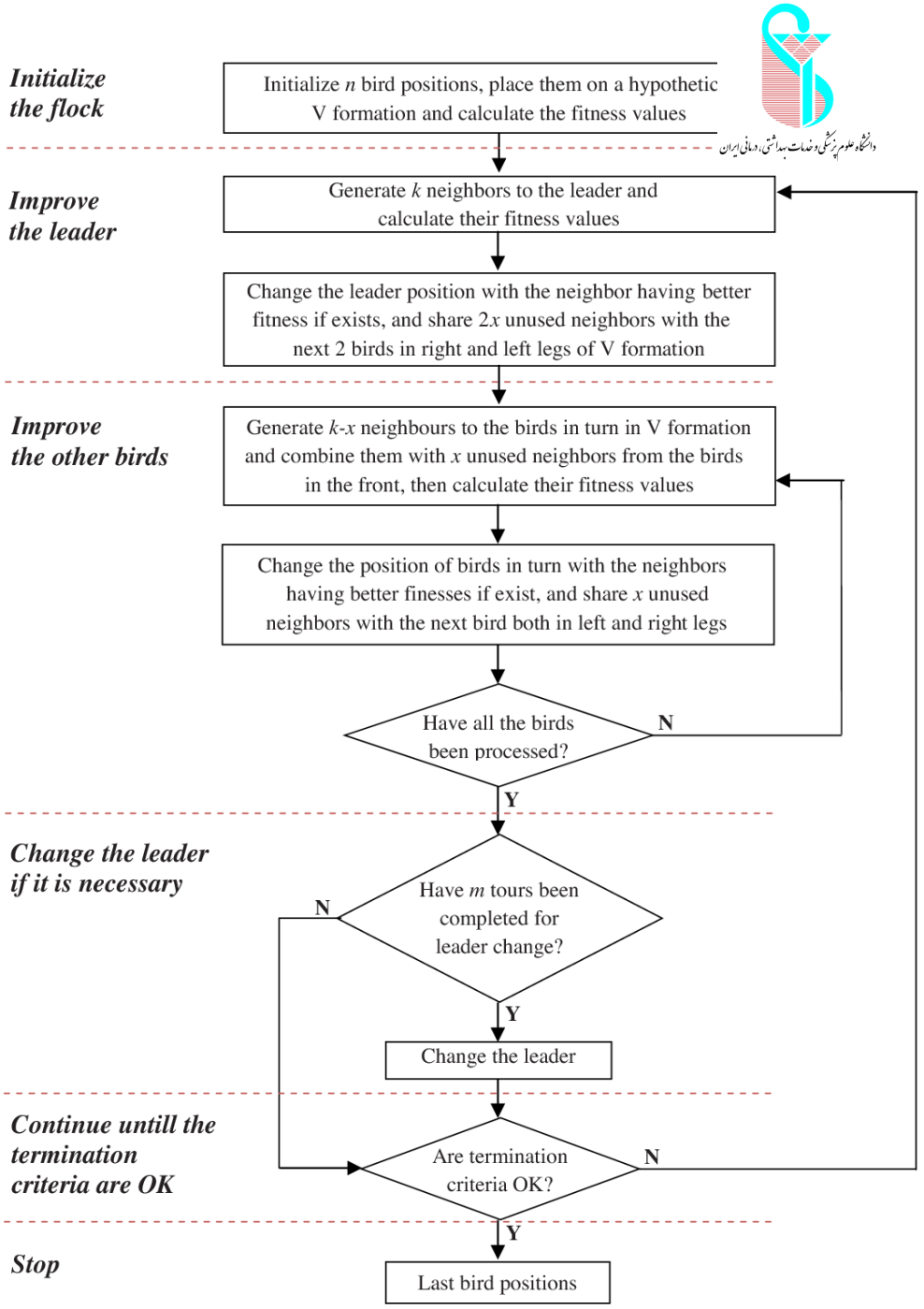


Ant Colony Optimization

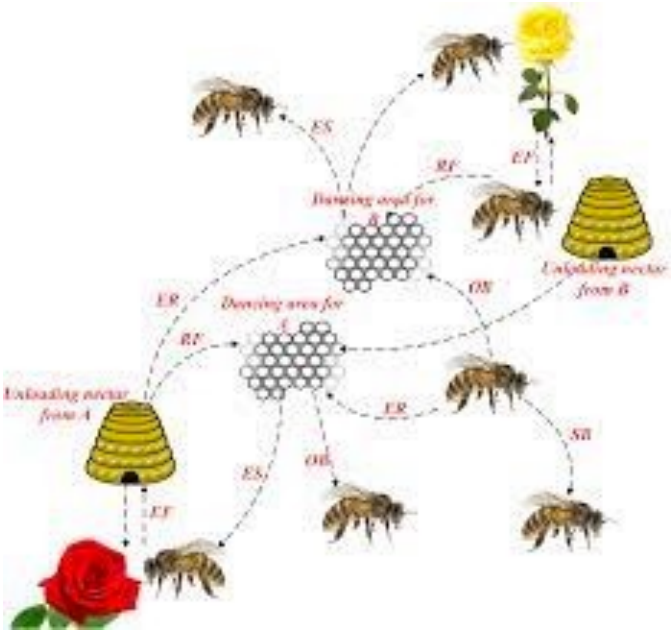


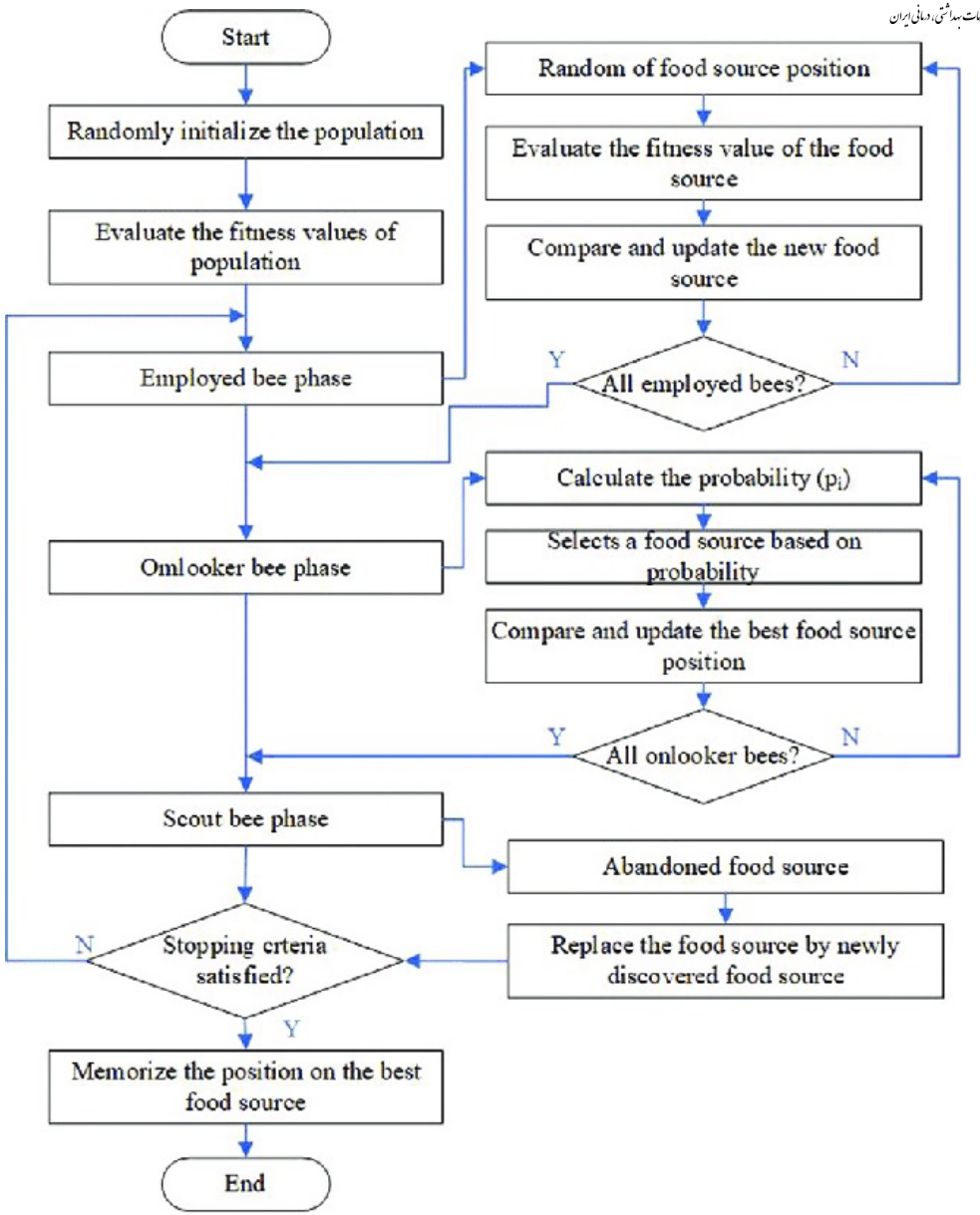


Migrating Birds Optimization

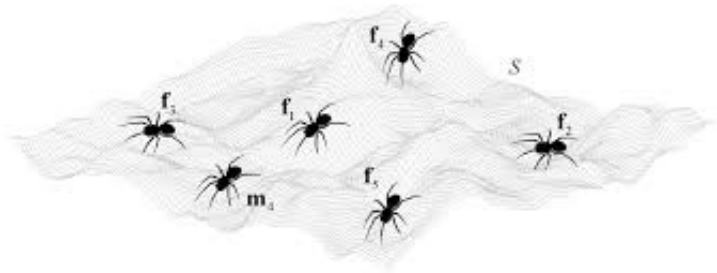


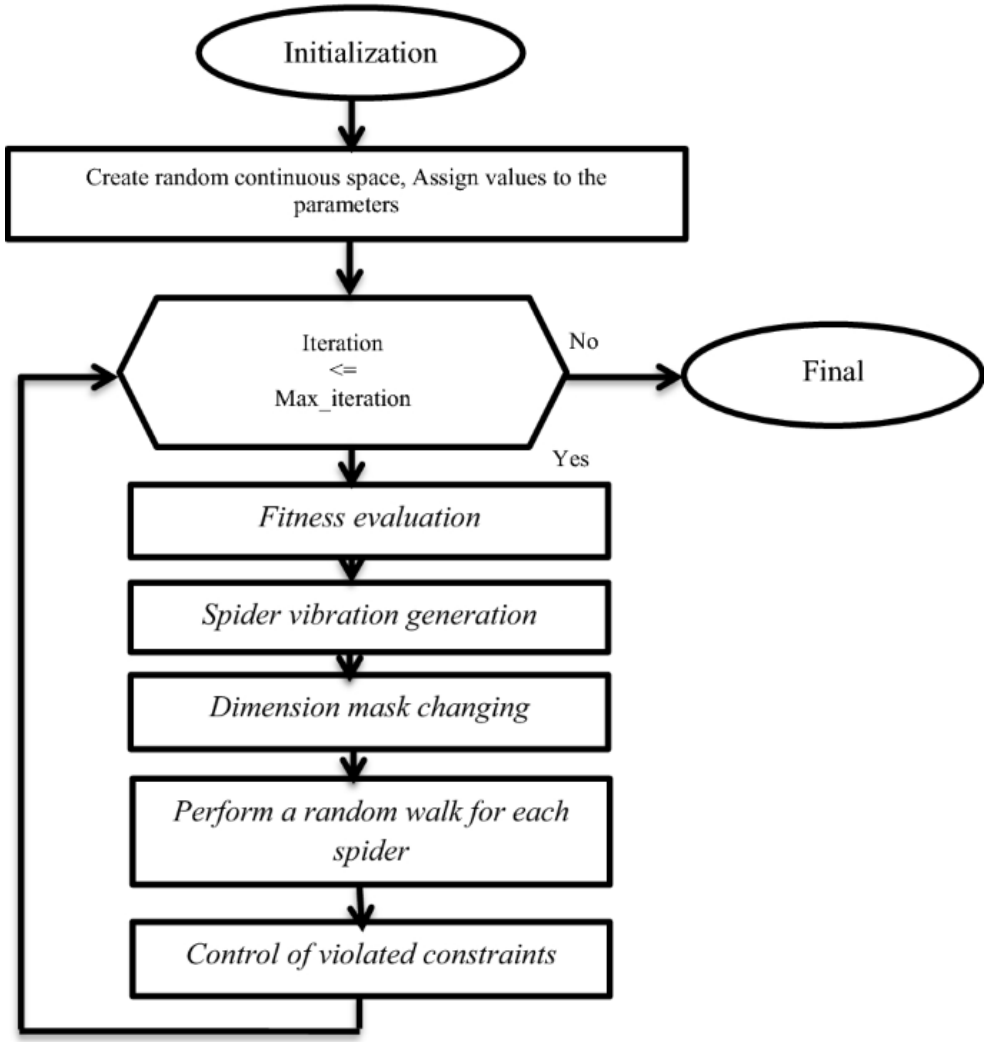
Bee Algorithm



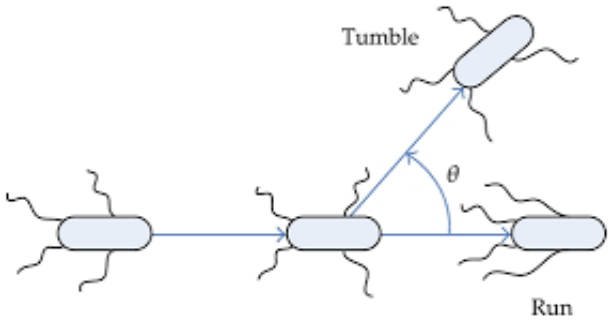


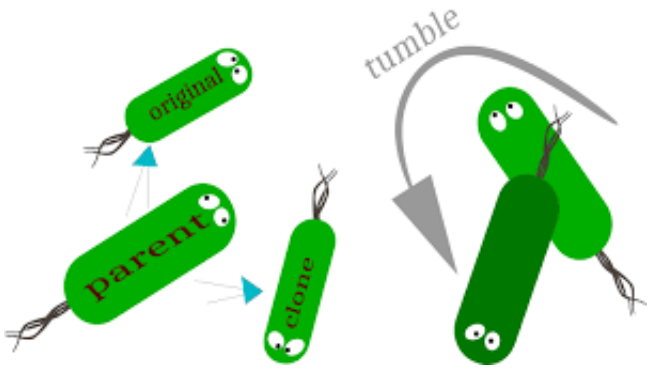
Spiders Optimization

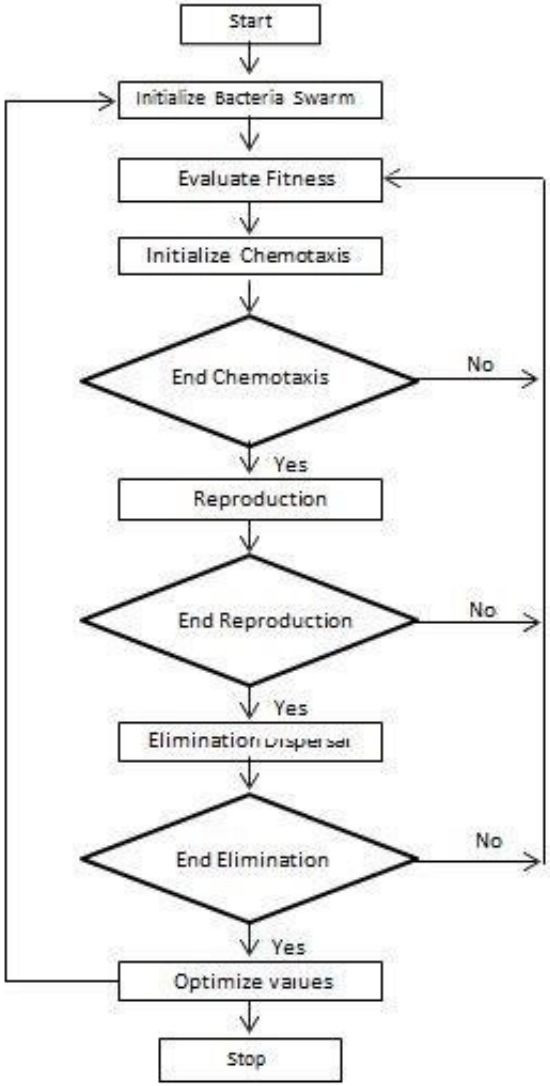




Bacteria Optimization



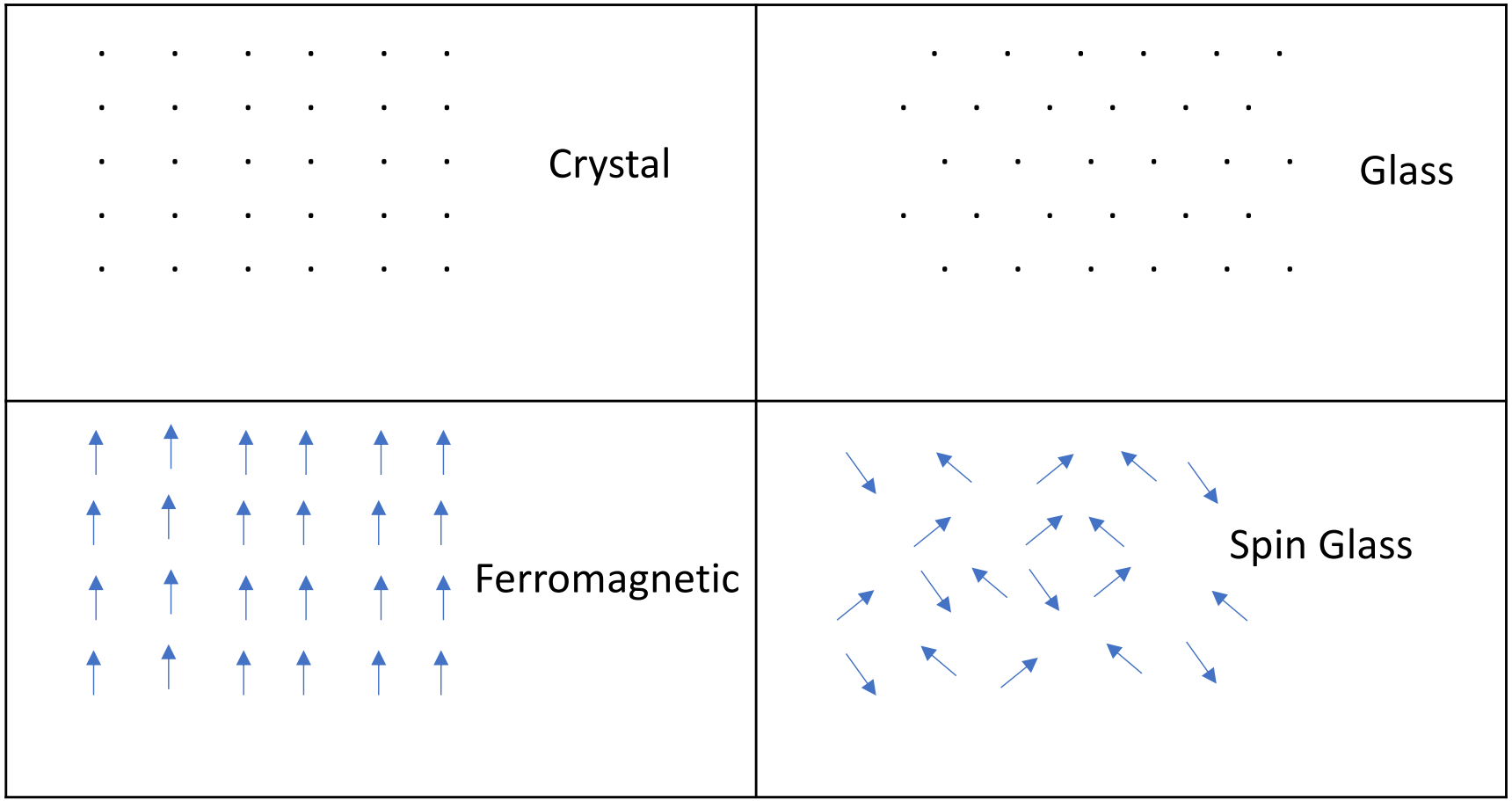




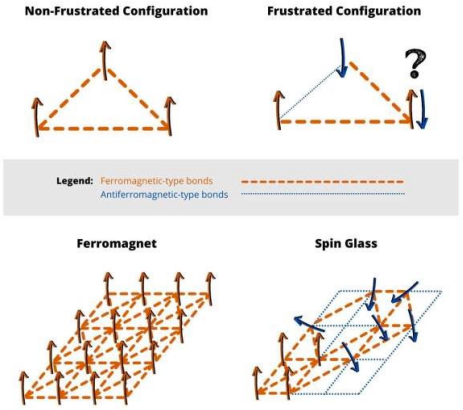
Optimization by Nature

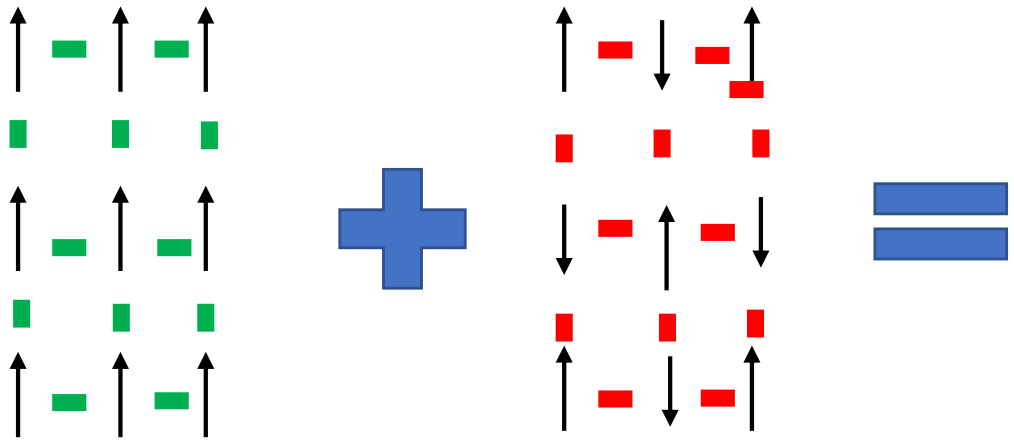
- Physics has also been a great source of inspiration such as in spin glasses and their temperature-based magnetic behavior, as well as gravitational forces, quantum-inspired variable coding and operations, and water drops and their path formation towards rivers.

Spin Glass



Spin Glass



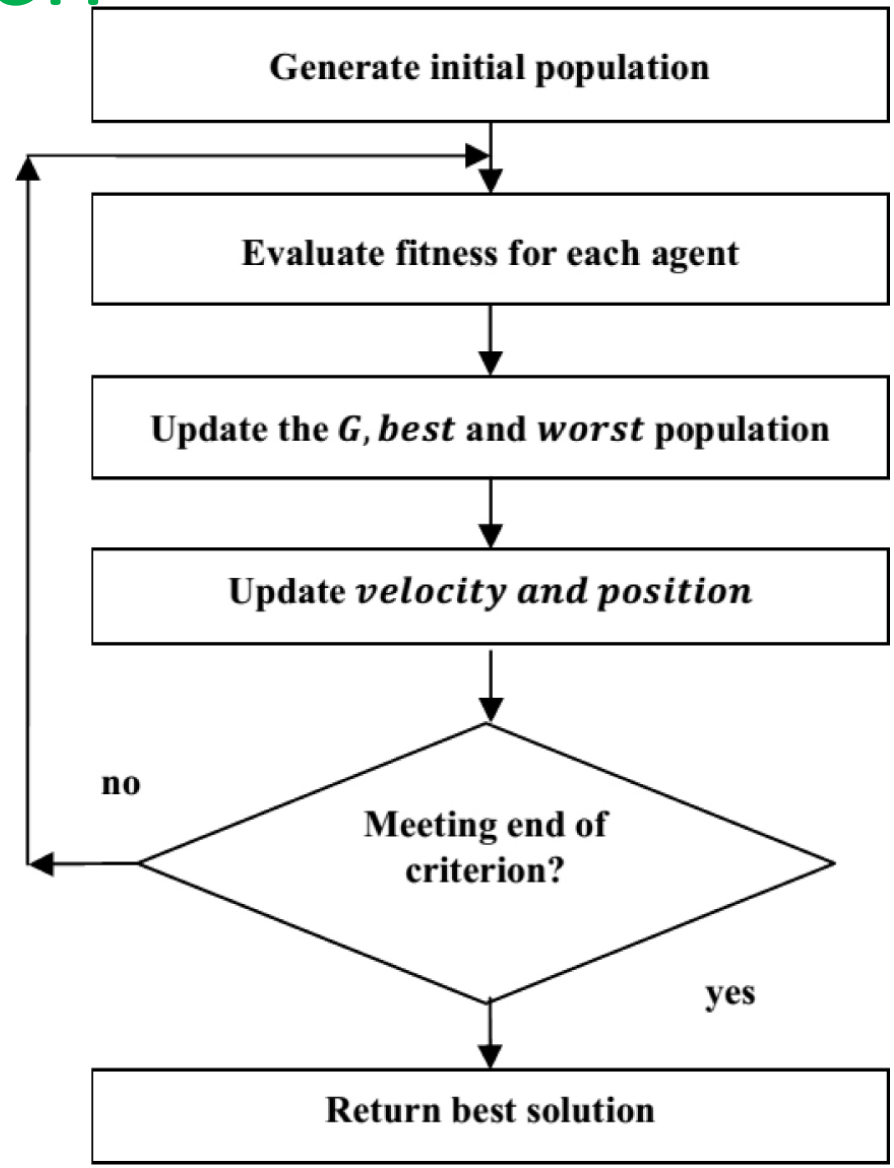


Ferromagnetic

Anti-ferromagnetic

Spin Glass

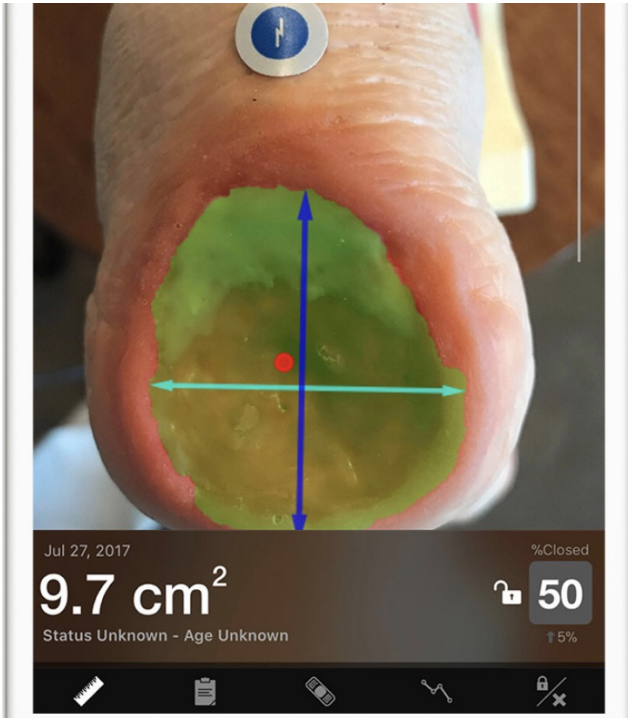
Gravitational Search

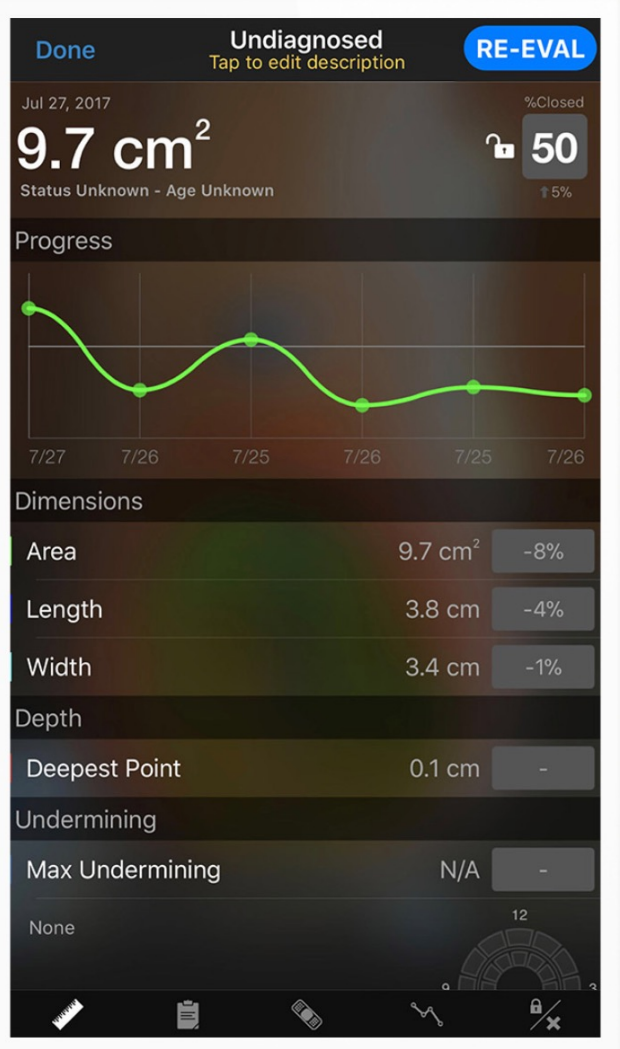


Exploration and Exploitation

- Exploration and Exploitation are two main functions in almost any optimization process.
- Competition among solution decomposing solutions into several sub-solutions random motion for better exploration and recombining genetic codes for better exploration.
- Some of these involve parametric operators and some are structure alternating behaviors.

Healogics Photo+: Automate Wound Measurement

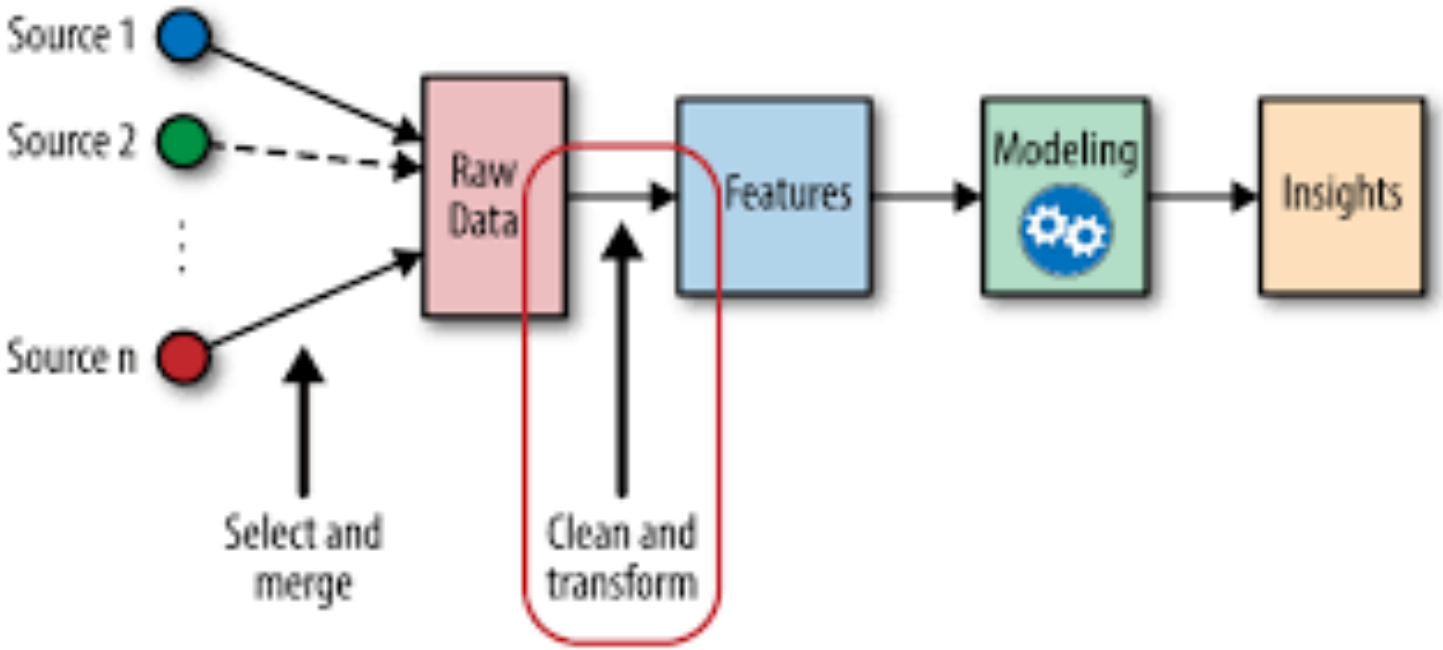




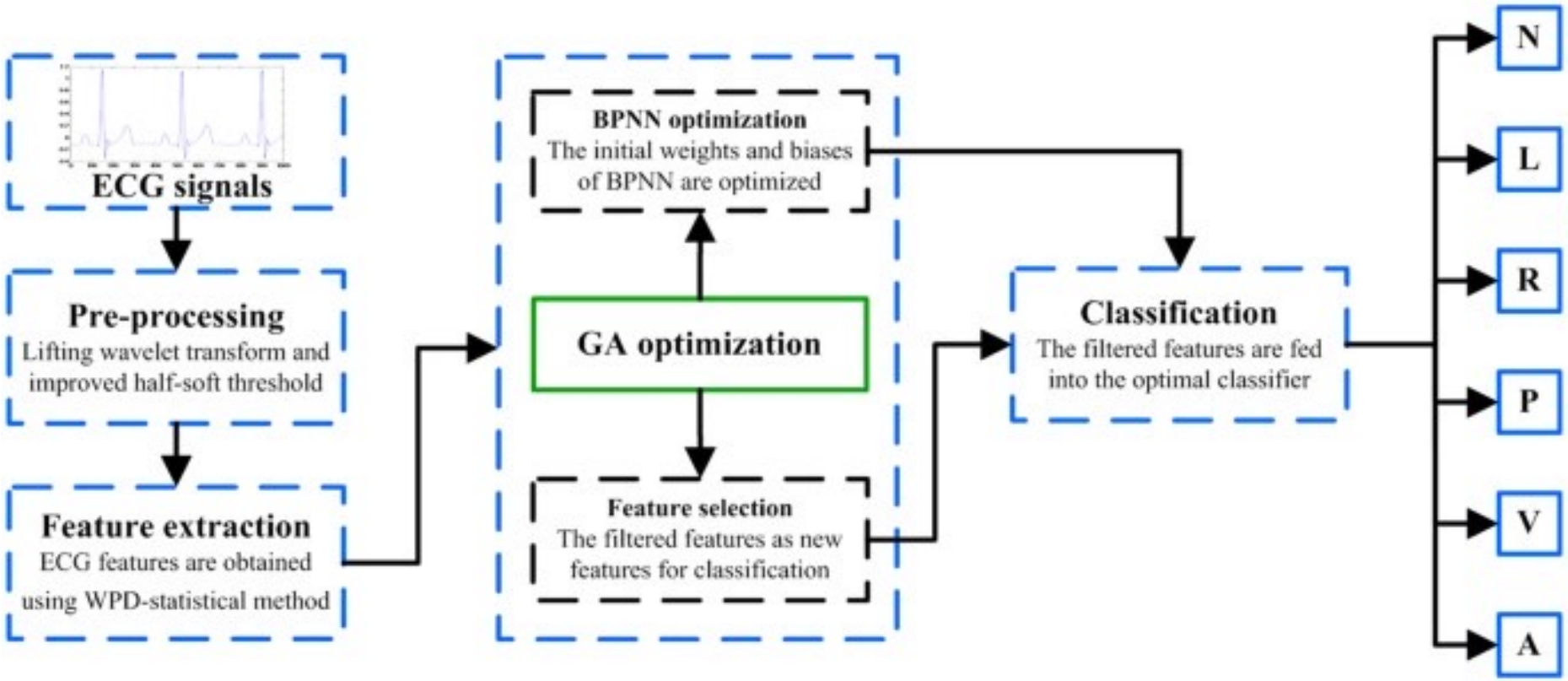
Identifying patients with sepsis at the right time

- Identify at-risk patient 6 hours earlier from EHR

Feature


Source 1
Source 2
Source n
Raw Data
Features
Modeling
Insights
Select and merge
Clean and transform

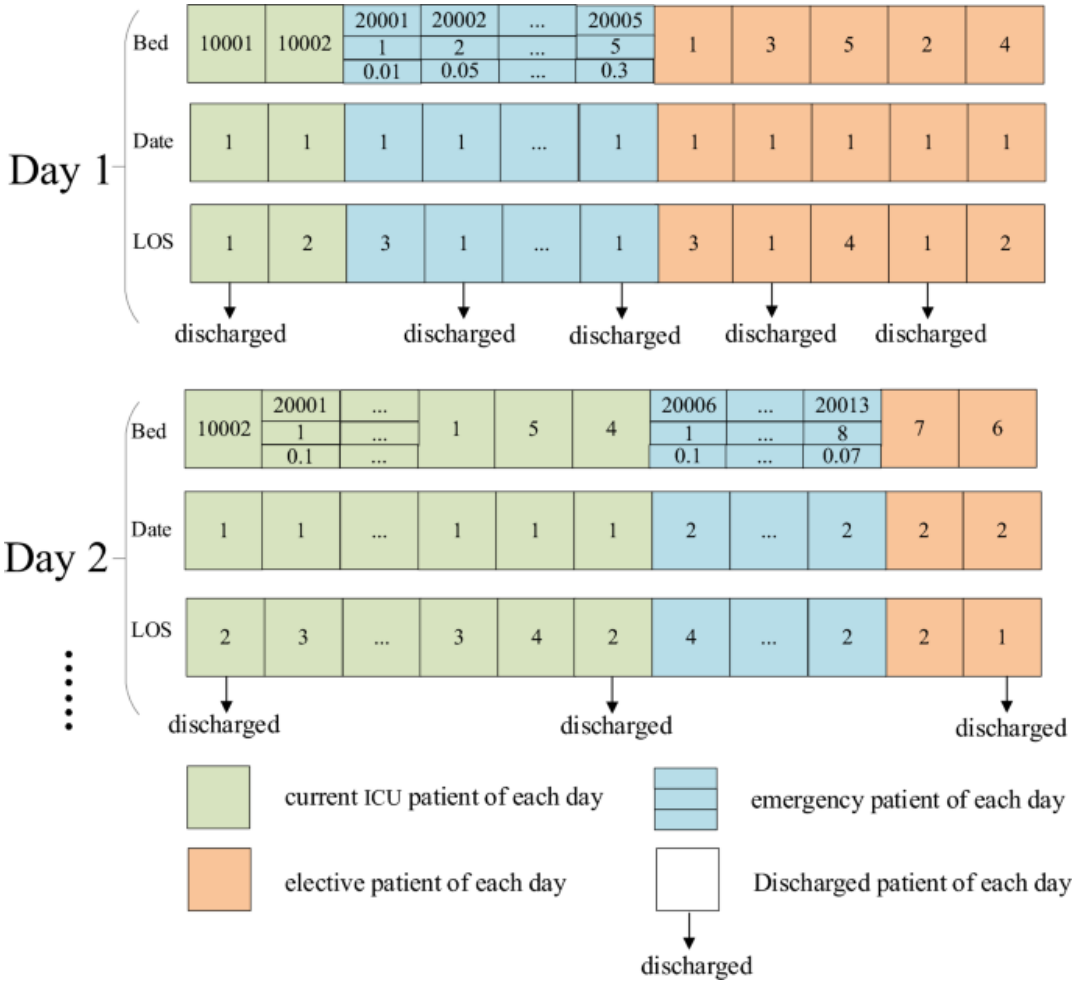
Feature selection/engineering /reduction

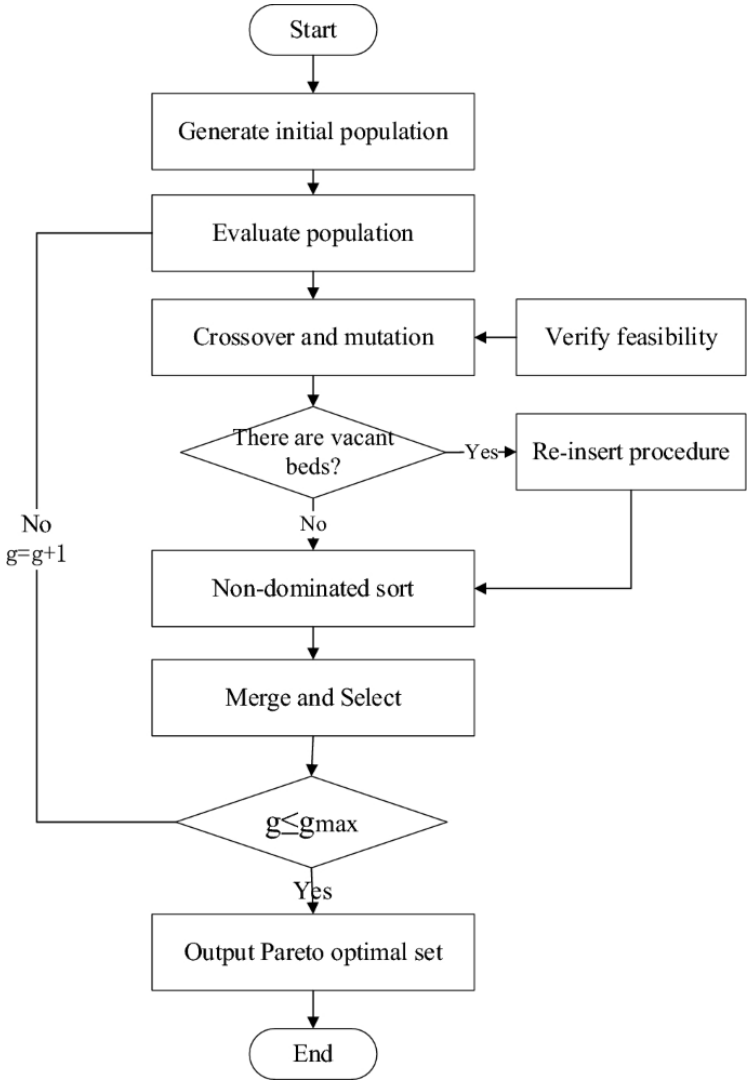


Genetic algorithm for the optimization of features and neural networks in ECG signals classification

Optimization in Healthcare Scheduling

ICU/operating Room Scheduling Optimization

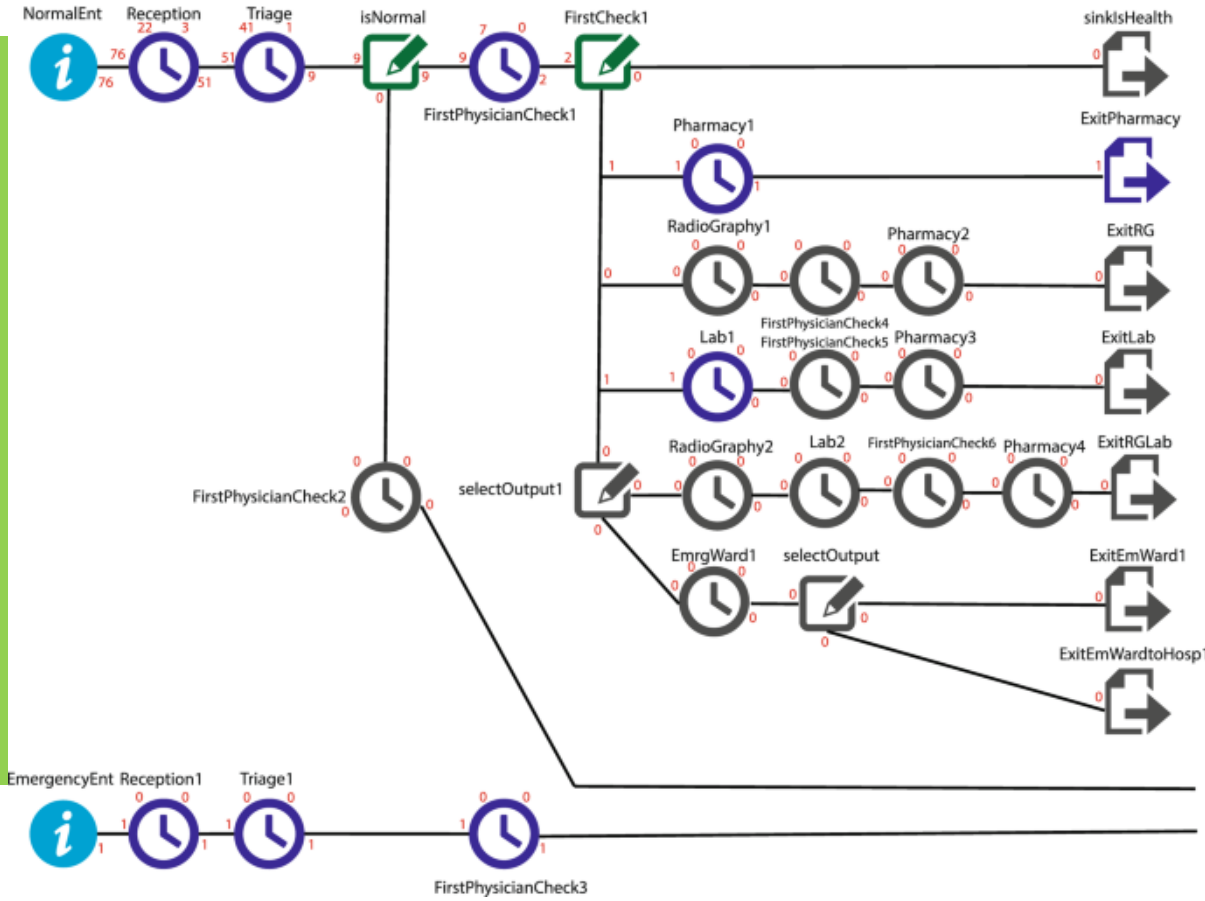




Two-stage multi-objective optimization for ICU bed allocation under multiple sources of uncertainty, *Scientific Reports* **volume 13**, Article number: 18925 (2023)

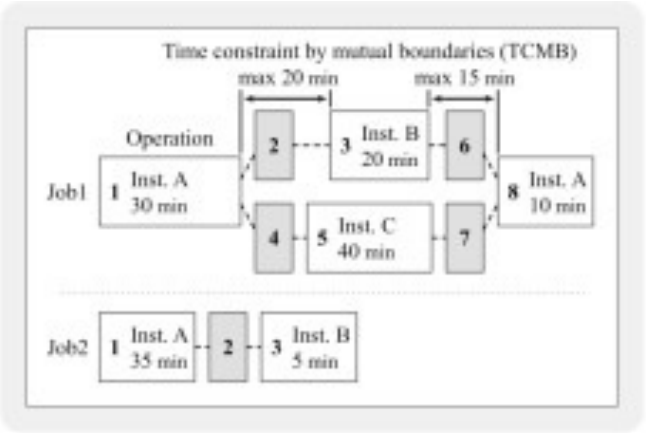
Physician Scheduling Optimization

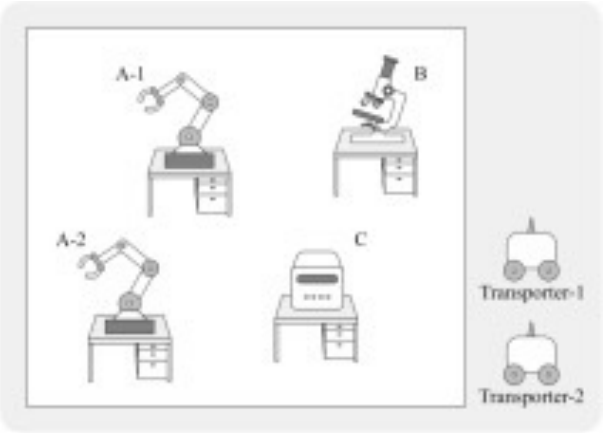
- Physicians are one of the most expensive resources in hospitals and are considered the bottleneck of the care-providing process.

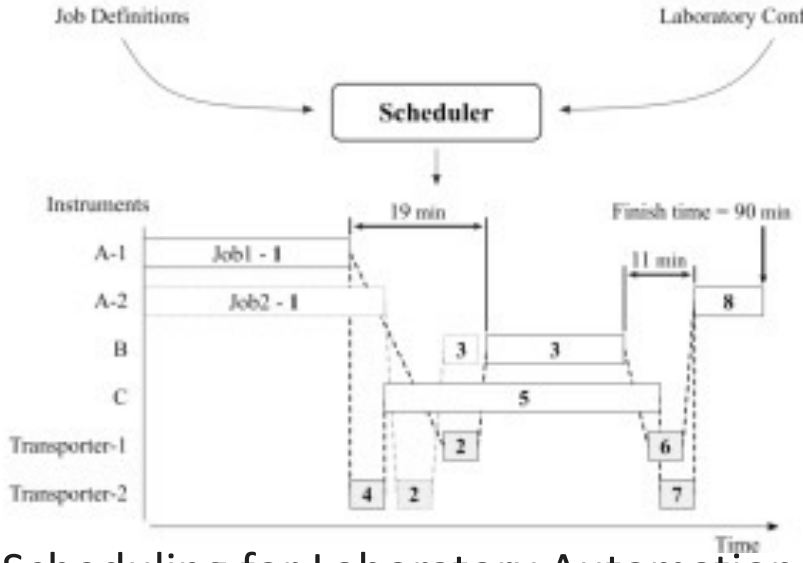


Optimization of an appointment scheduling problem for healthcare systems based on the quality of fairness service using whale optimization algorithm and NSGA-II, *Scientific Reports* **volume 11**, Article number: 19816 (2021)

Laboratory Scheduling Optimization



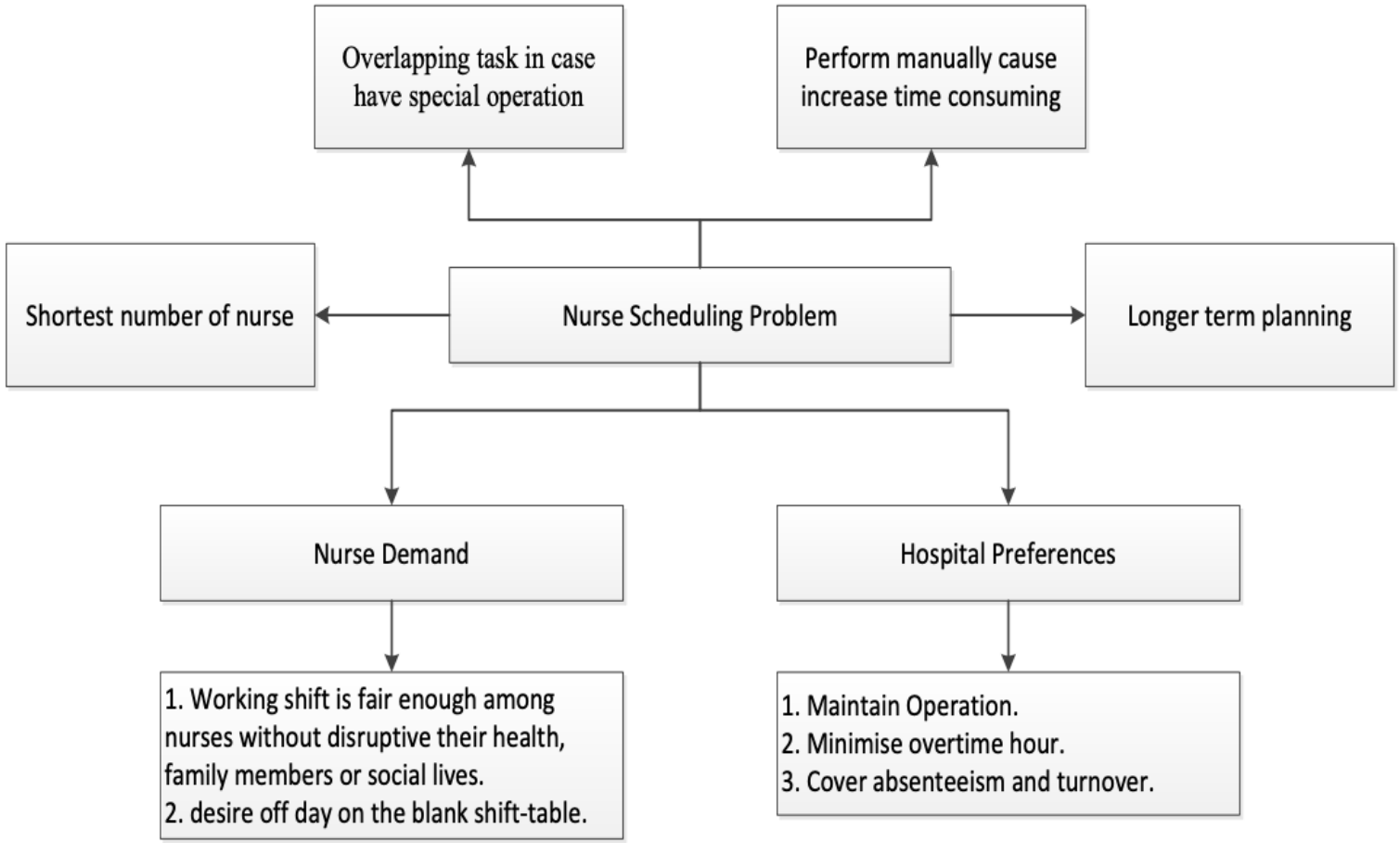




Optimal Scheduling for Laboratory Automation of Life Science Experiments with Time Constraints, SLAS Technology Volume 26, Issue 6, December 2021, Pages 650-659

Nurse Scheduling Optimization

Factors in Nurse Scheduling



Hard Constraint

- [H1] Each nurse is available to work only one shift a day
- [H2] Maximum of three night shifts per two weeks
- [H3] Unavailable for a morning shift after a night shift.

Soft Constraint

- [C1] Fairness in working shifts and day off among nurses.
- [C2] Preference hospital based on working shift for each day.
- [C3] At least each nurse is given one day off per week.
- [C4] At least one experienced nurse is allocated for each working shift for one day.
- [C5] Attempt to give a day off after the night shift.
- [C6] At least three-night shifts per two weeks for each nurse.

PSO Solution

- 1. Particle: represented by a nurse schedule
- 2. Search Space: contains the pattern of a nurse schedule that is generated randomly.
- 3. Fitness Value: represented by value of a schedule that is generated randomly that follows the constraints
- 4. Velocity: represented by path direction value of the particle (schedule)
- 5. Personal Best: represented by minimum fitness value of a particle in the local population
- 6. Global Best: represented by minimum fitness value of a particle in the global population
- 7. Best Fitness: represented by as fitness value that reaches 0 where PSO has optimised the nurse schedule that follows all the constraints.

Table 2 : Nurse scheduling is done manually

Nurses /Days	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	O	M	E	N
1	O	N	O	M	O	E	E	O	N	M	4	2	2	2
2	O	N	M	N	O	E	M	O	O	E	4	2	2	2
3	O	N	M	N	E	E	M	O	O	O	4	2	2	2
4	E	O	M	N	M	O	E	O	O	N	4	2	2	2
5	E	O	M	O	N	O	O	M	E	N	4	2	2	2
6	M	O	M	O	N	O	O	E	E	N	4	2	2	2
7	O	E	M	O	N	N	O	E	M	O	4	2	2	2
8	E	E	M	O	O	N	N	M	O	O	4	2	2	2
9	M	E	O	O	O	N	N	M	O	E	4	2	2	2
10	N	M	O	E	O	O	N	O	E	M	4	2	2	2
11	N	O	O	M	E	O	O	N	E	M	4	2	2	2
12	N	O	M	O	E	O	O	N	M	E	4	2	2	2
13	O	O	M	E	M	E	O	N	N	O	4	2	2	2
14	O	N	M	E	O	E	M	O	N	O	4	2	2	2
O	5	5	4	5	5	5	5	5	5	5				
M	2	1	3	2	2	0	3	3	2	3				
E	3	3	0	3	3	3	2	2	3	3				
N	3	3	0	3	3	3	3	3	3	3				
Q	2.712	2.838	2.914	2.712	2.712	2.712	2.712	2.712	3.002	3.002				

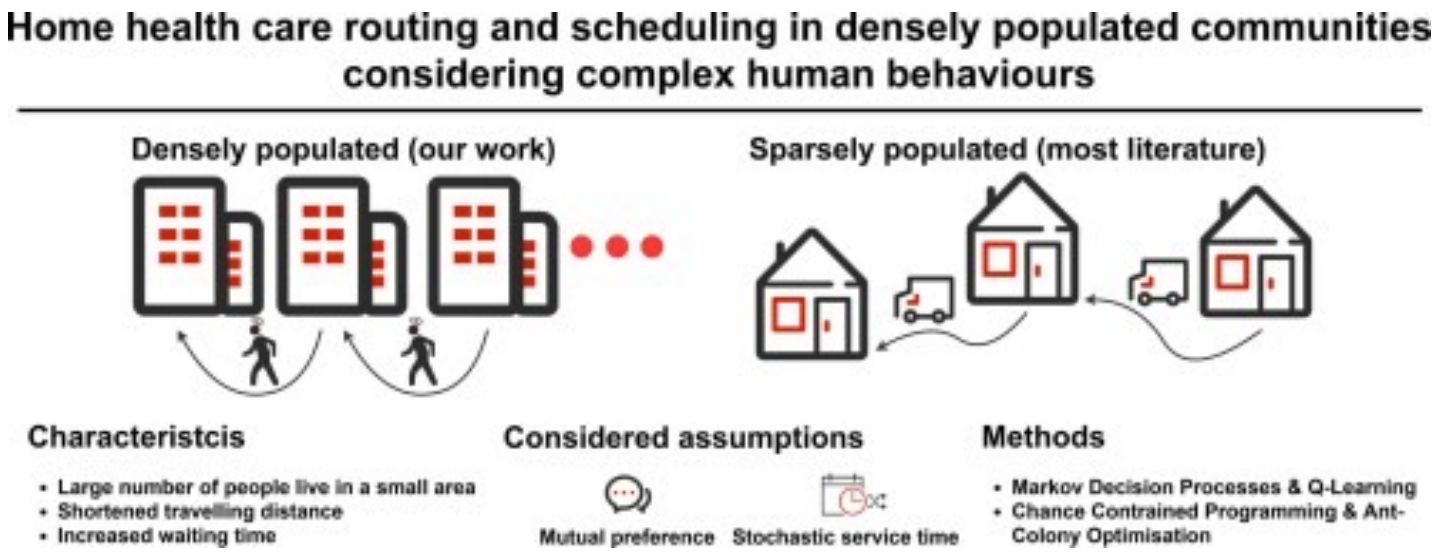
Expert Less experience

Table 4: Nurse scheduling optimise by PSO

Nurses /Days	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	O	M	E	N
1	E	E	N	O	M	O	N	M	O	O	4	2	2	2
2	M	E	N	M	O	O	O	N	O	E	4	2	2	2
3	M	N	O	O	O	E	O	E	N	M	4	2	2	2
4	O	E	N	E	M	M	N	O	O	O	4	2	2	2
5	O	O	O	N	M	N	O	E	E	M	4	2	2	2
6	N	M	O	O	O	O	E	N	E	M	4	2	2	2
7	O	O	E	N	N	E	O	O	M	M	4	2	2	2
8	N	N	O	O	E	O	O	M	M	E	4	2	2	2
9	O	N	E	N	O	M	E	O	O	M	4	2	2	2
10	M	O	O	O	E	M	E	N	N	O	4	2	2	2
11	N	M	E	M	E	O	N	O	O	O	4	2	2	2
12	E	O	M	M	N	E	O	O	N	O	4	2	2	2
13	O	O	M	E	O	N	M	E	O	N	4	2	2	2
14	E	M	M	E	N	N	O	O	O	O	4	2	2	2
O	5	5	5	5	5	5	5	5	5	5				
M	3	3	3	3	3	3	1	2	2	3				
E	3	3	3	3	3	3	3	3	2	2				
N	3	3	3	3	3	3	3	3	3	1				
Q	3.002	3.002	3.002	3.002	3.002	3.002	2.4422	2.712	2.4422	2.46				

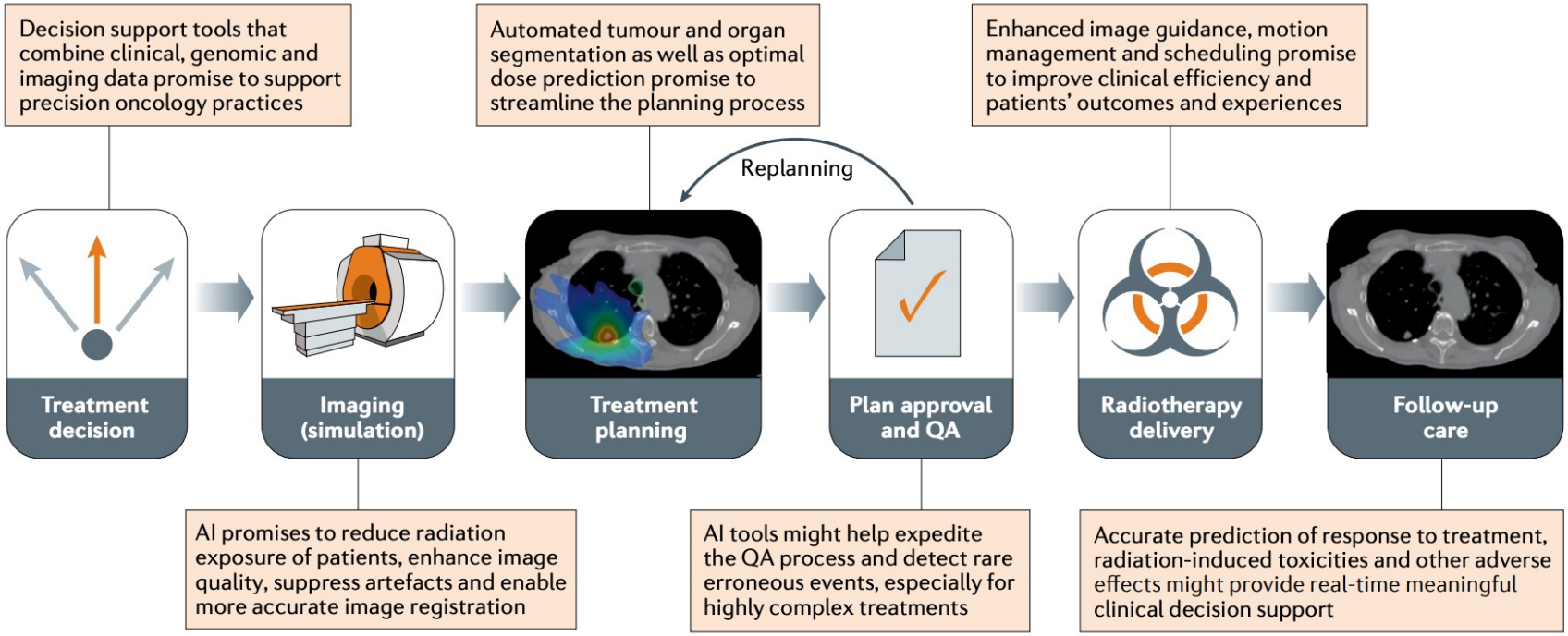
Expert Less experience

Home Healthcare Routing and Scheduling Optimization



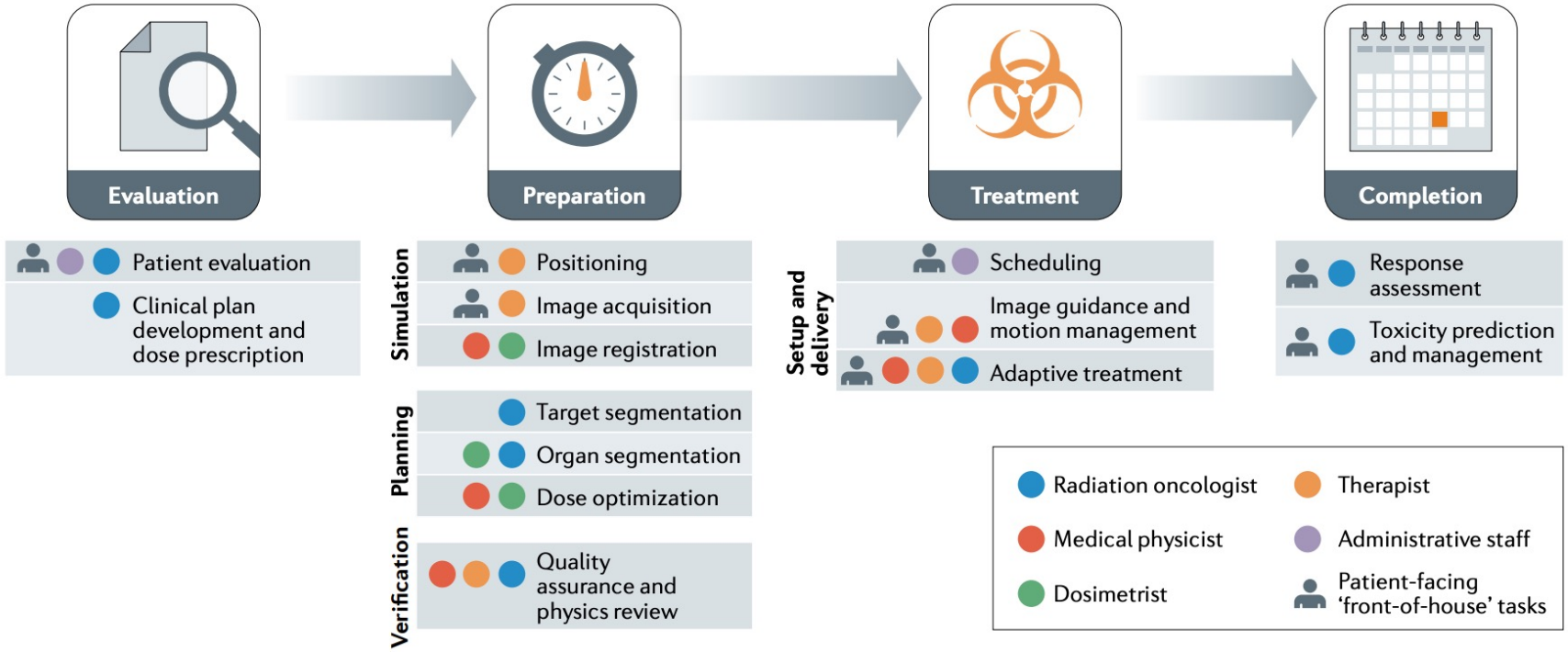
Home health care routing and scheduling in densely populated communities considering complex human behaviours, Computers & Industrial Engineering Volume 182, August 2023, 109332

Radiotherapy Treatment Scheduling Optimization



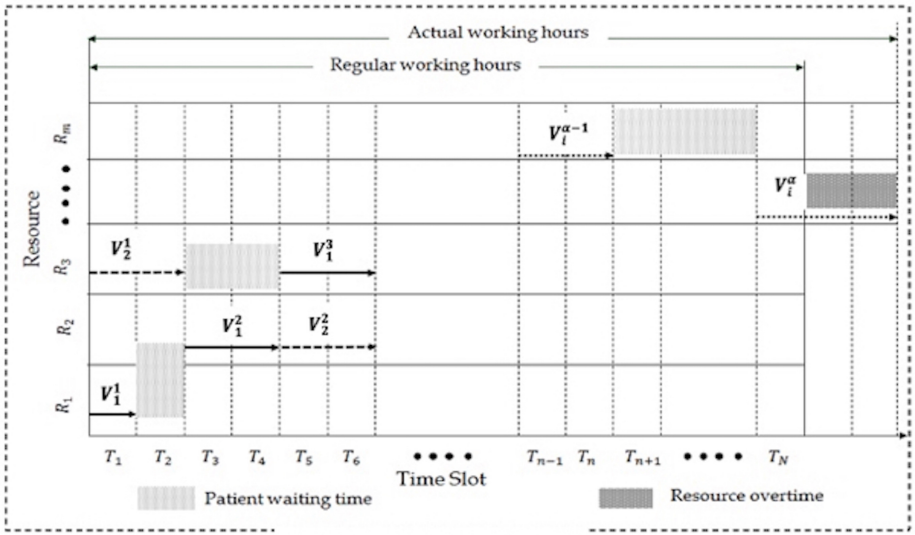
Artificial intelligence in radiation oncology. *Nat Rev Clin Oncol* **17**, 771–781 (2020). https://doi.org/10.1038/s41571-020-0417-8

Radiotherapy Treatment Scheduling Optimization

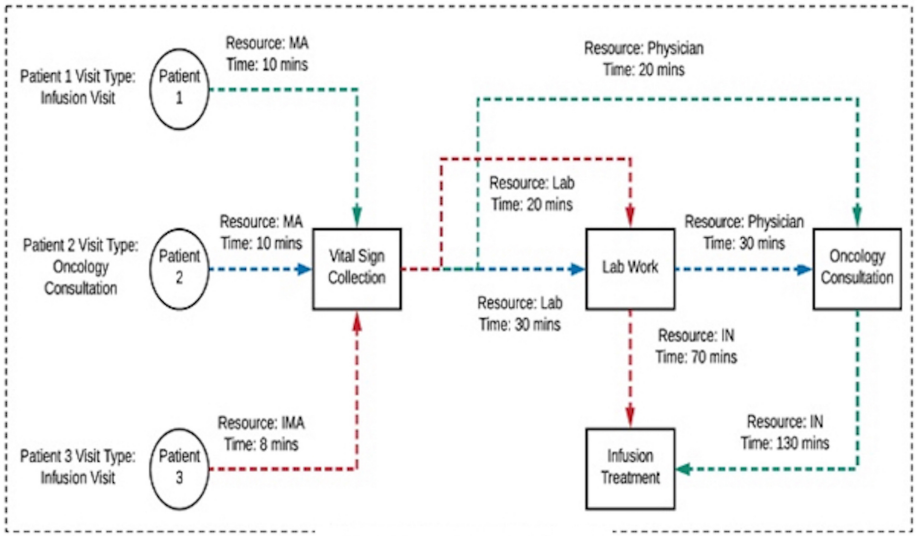


Artificial intelligence in radiation oncology. *Nat Rev Clin Oncol* **17**, 771–781 (2020). https://doi.org/10.1038/s41571-020-0417-8

Patient Multi-appointment Scheduling Optimization



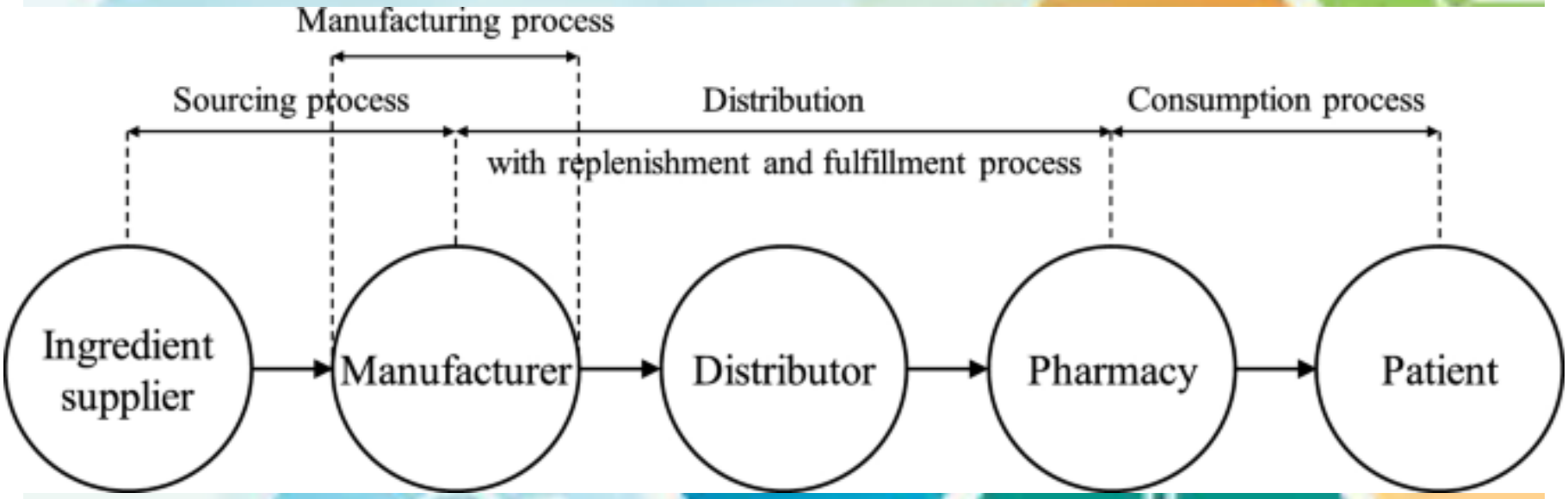
(a) concept of multi-appointments



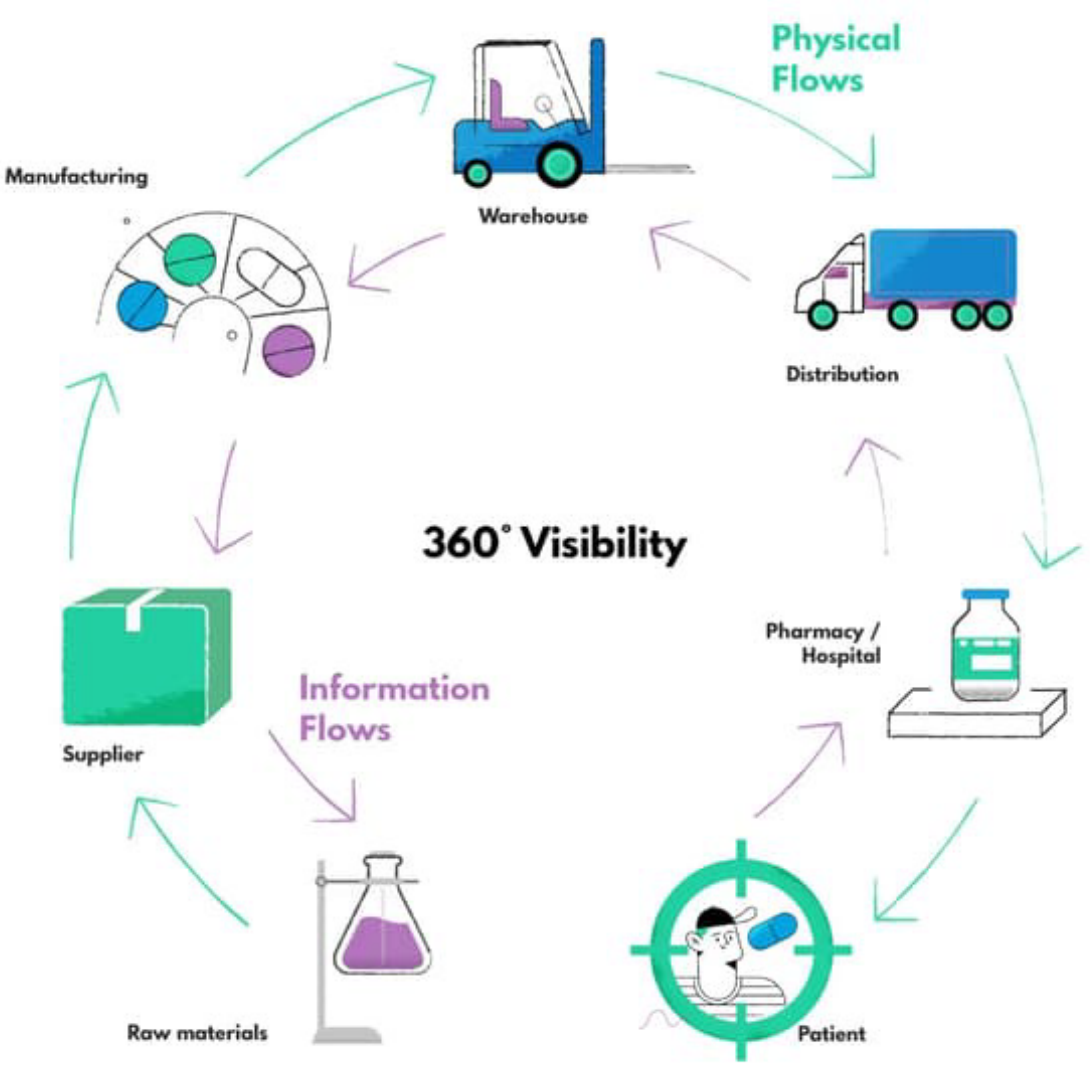
(b) multi-appointment pathways

A multi-appointment patient scheduling system with machine learning and optimization, Decision Analytics Journal Volume 10, March 2024, 100392

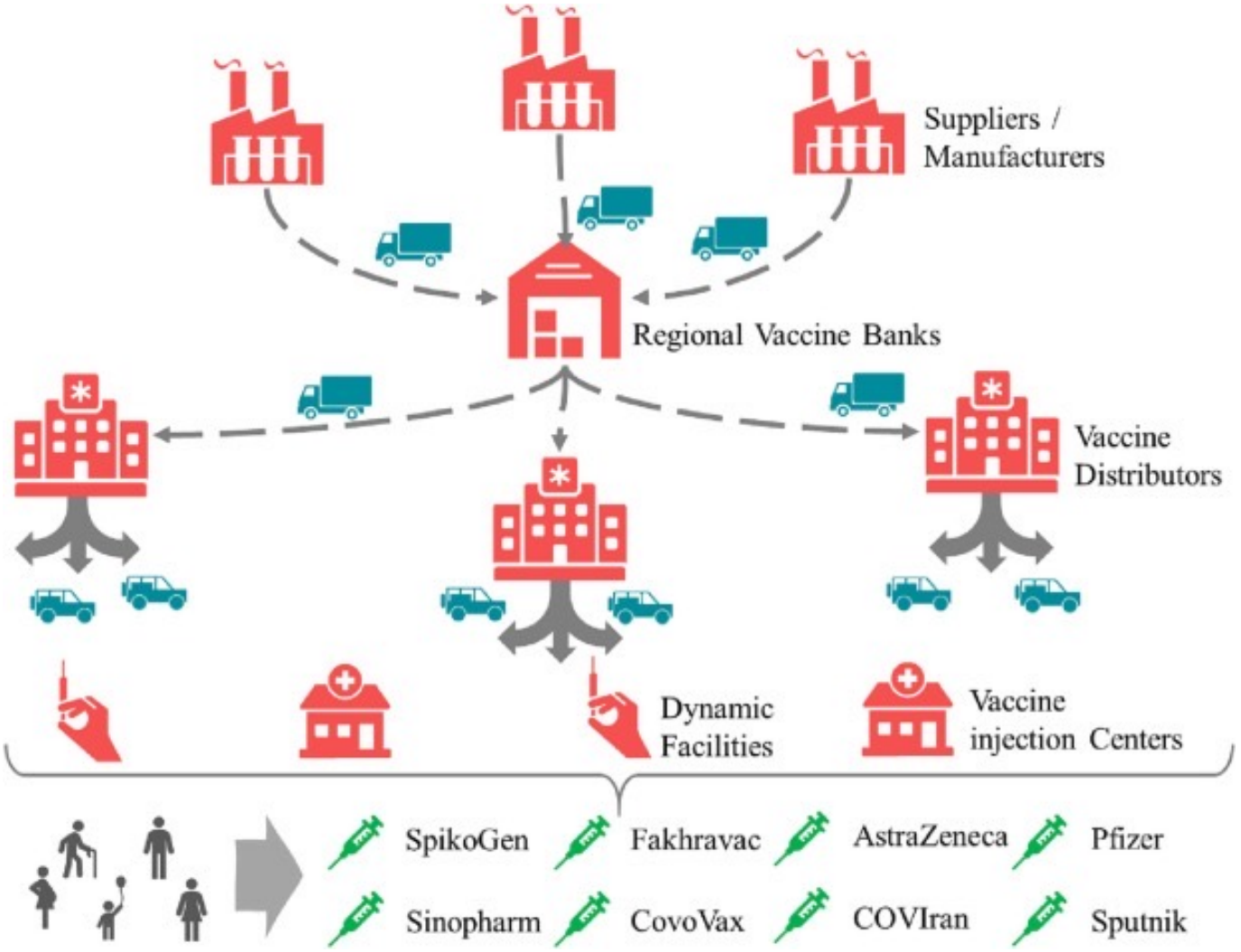
Optimization in Healthcare Supply Chain



Pharmaceutical Inventory Optimization

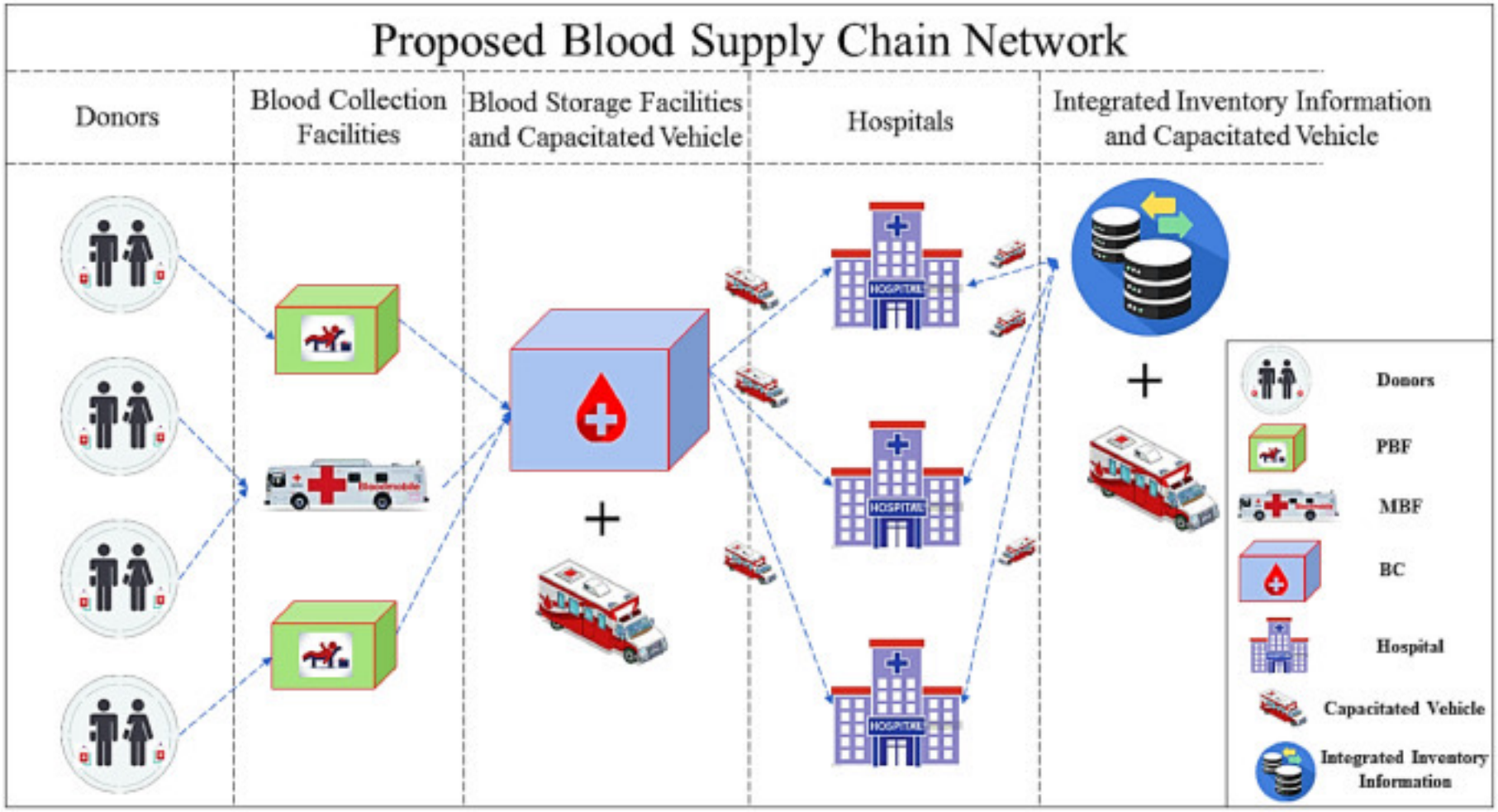


Vaccine Supply Chain Optimizatio



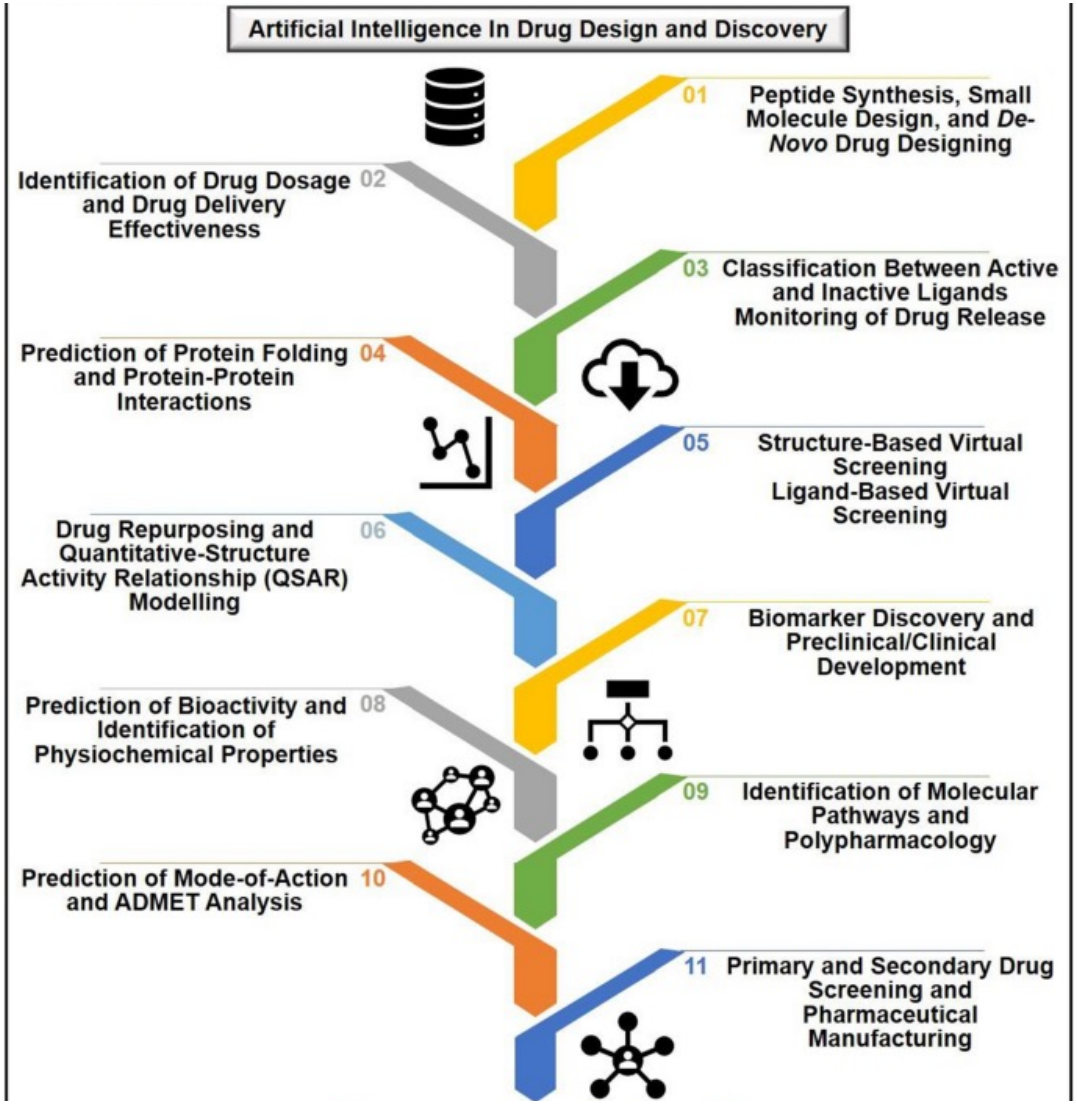
A robust vaccine supply chain model in pandemics: Case of Covid-19 in Iran, Computers & Industrial Engineering Volume 183, September 2023, 109465

Blood Supply Chain Optimization

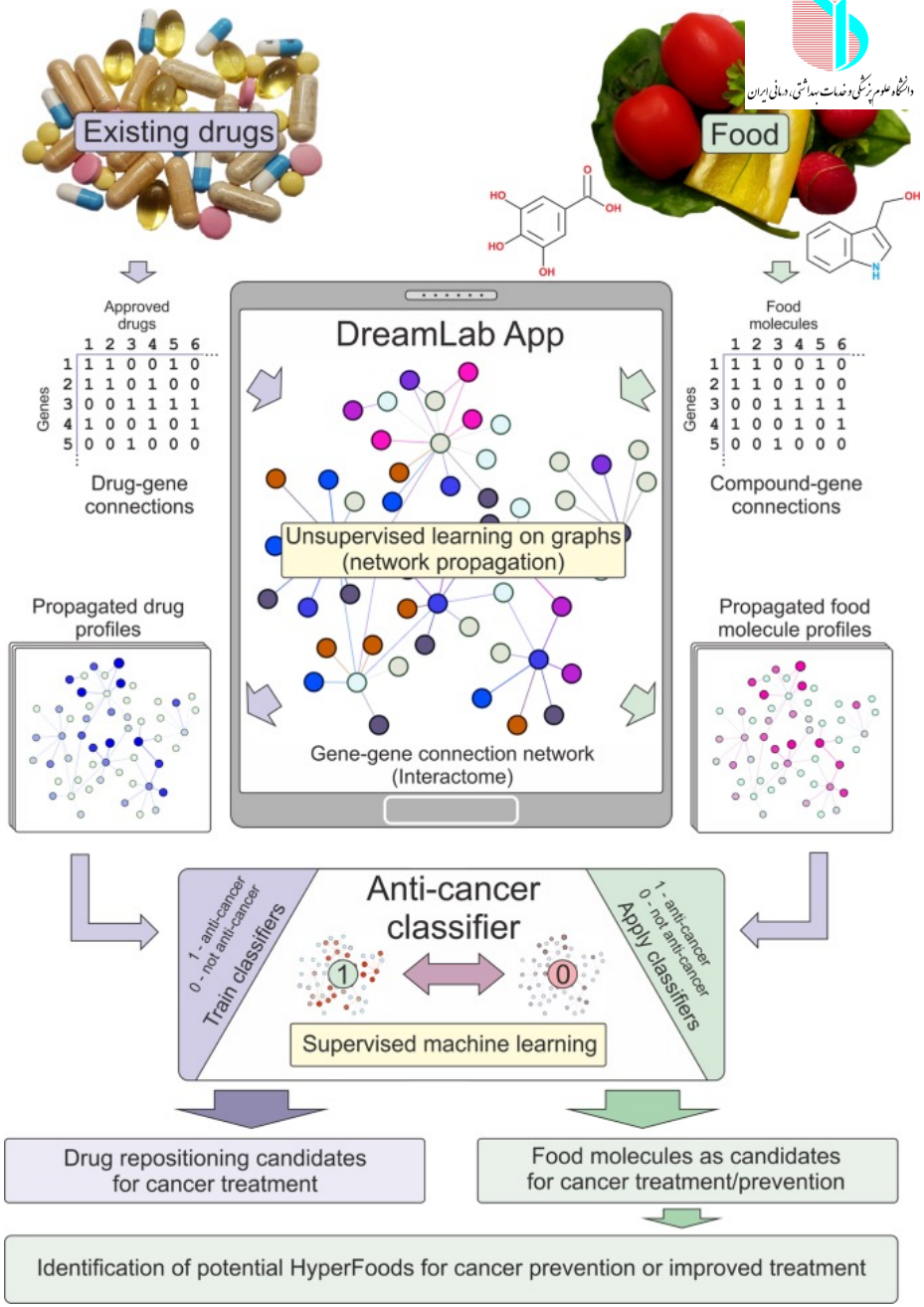


A lateral resupply blood supply chain network design under uncertainties, Applied Mathematical Modelling Volume 93, May 2021, Pages 165-187

Optimization in Drug Design and Discovery

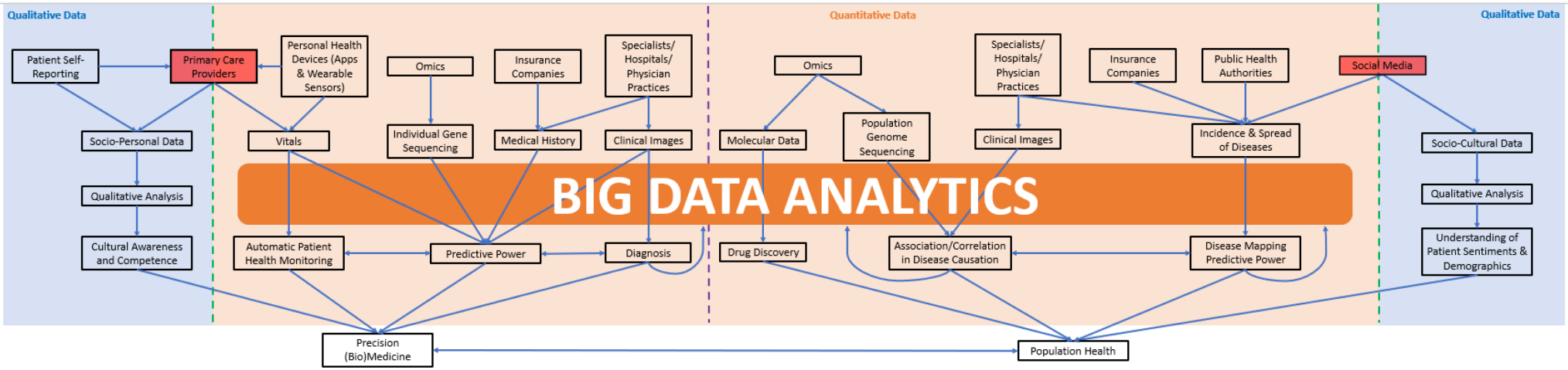


Diet Optimization

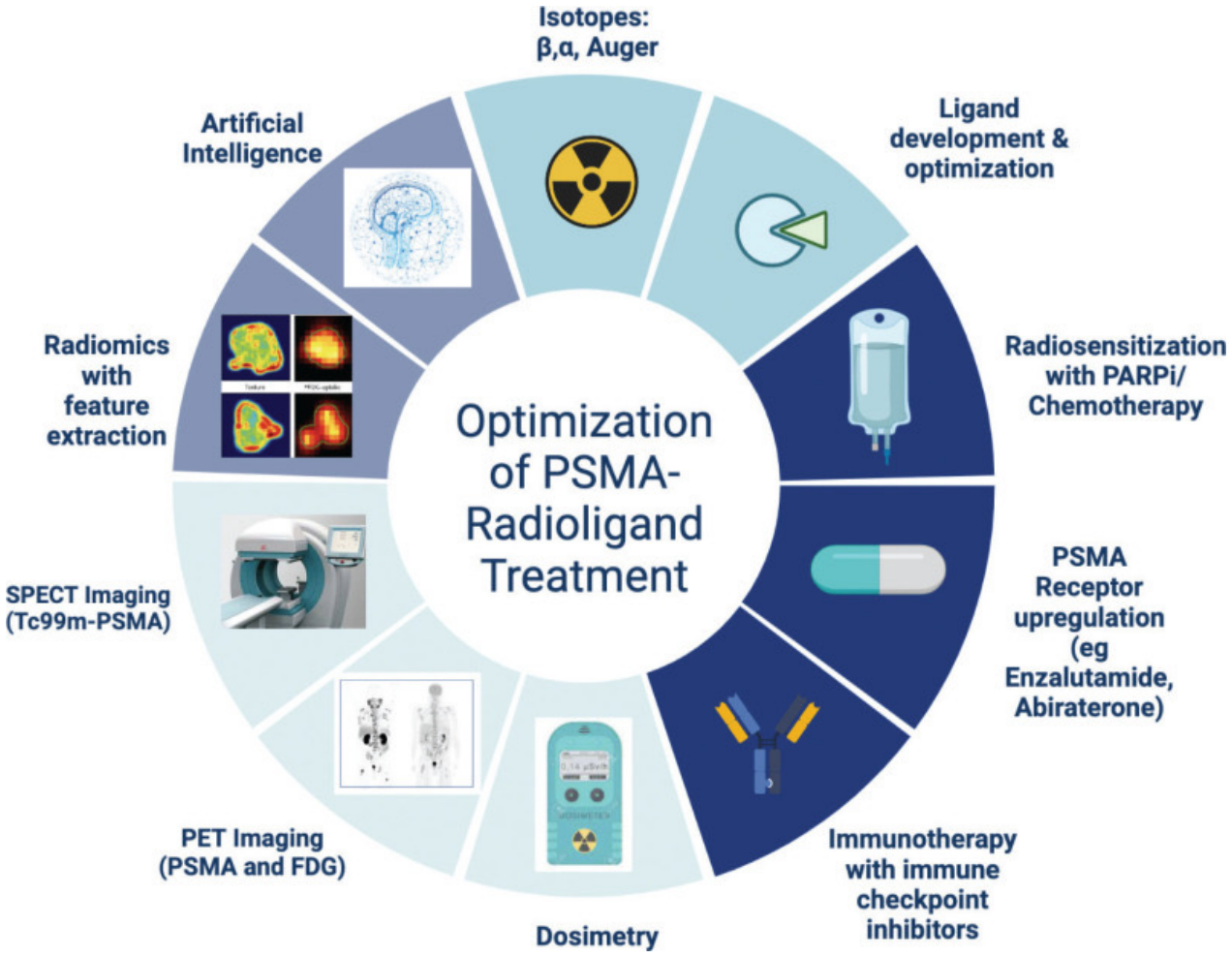


HyperFoods: Machine intelligent mapping of cancer-beating molecules in foods, *Scientific Reports* **volume 9**, Article number: 9237 (2019)

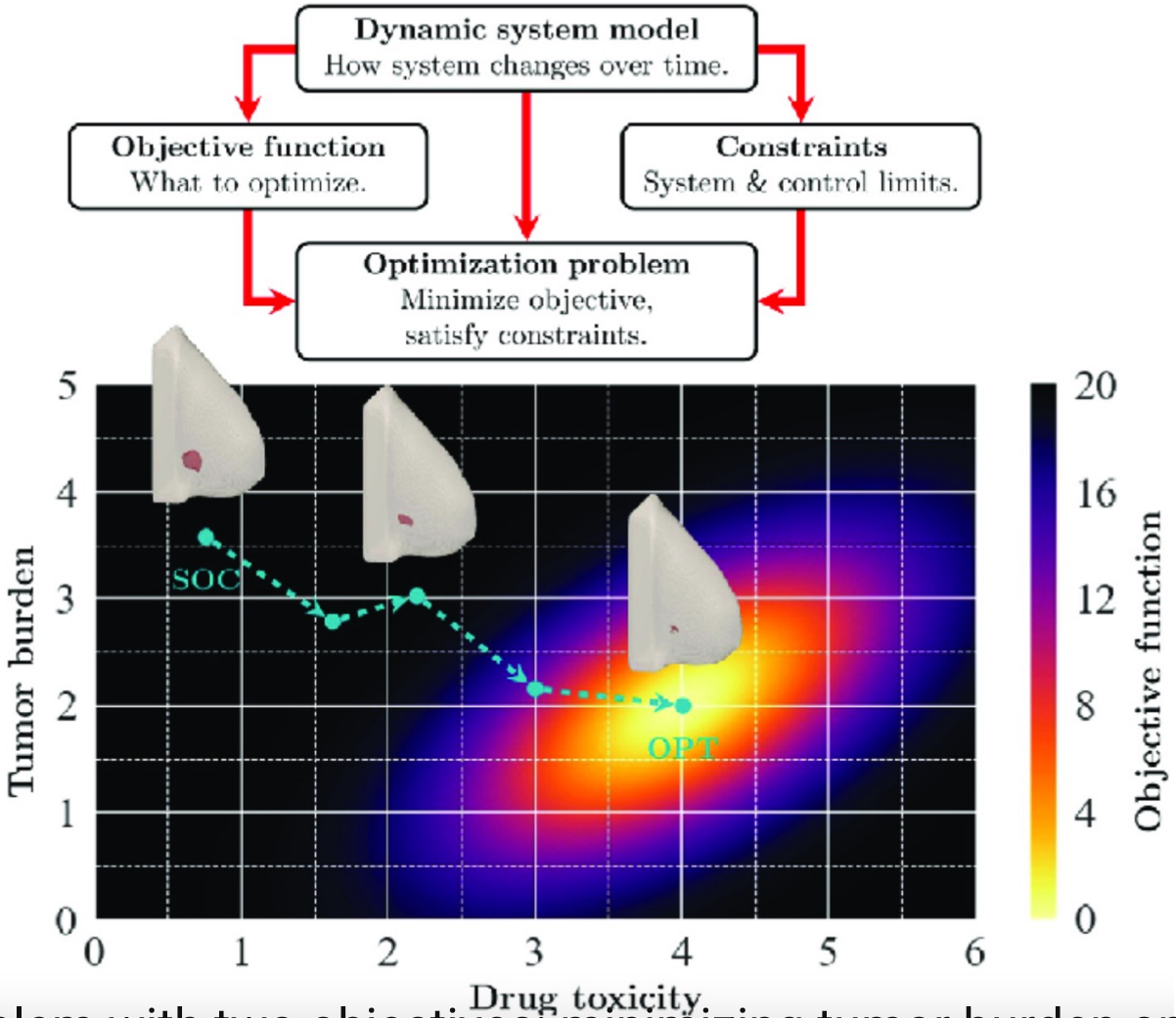
Optimization and Big Data Analytics



Optimization for radioligand Treatment

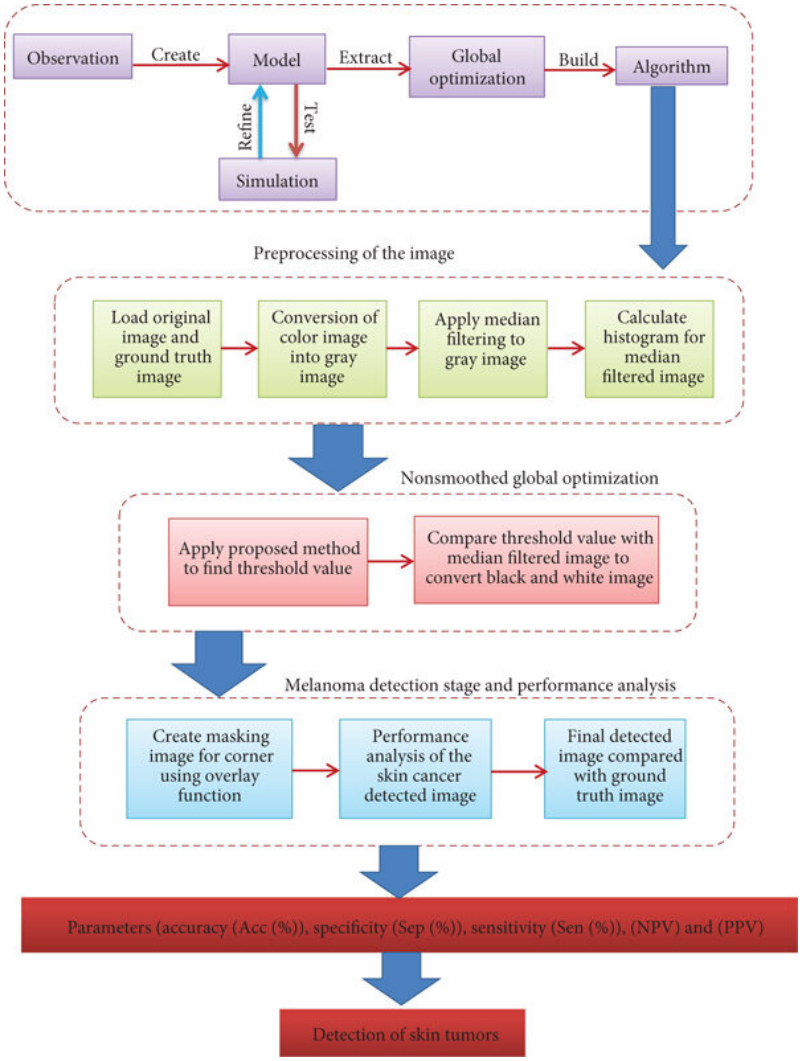


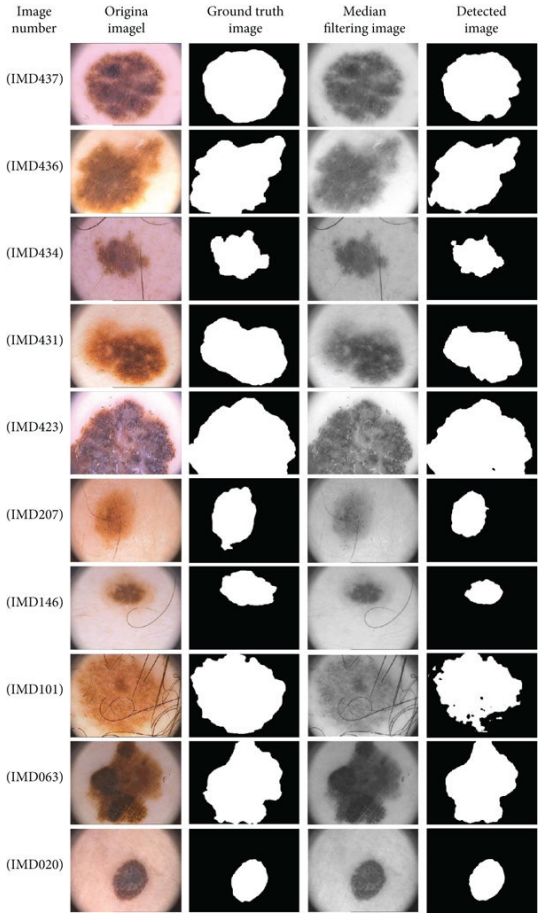
Optimization of a breast cancer treatment protocol



optimization problem with two objectives: minimizing tumor burden and minimizing drug toxicity.

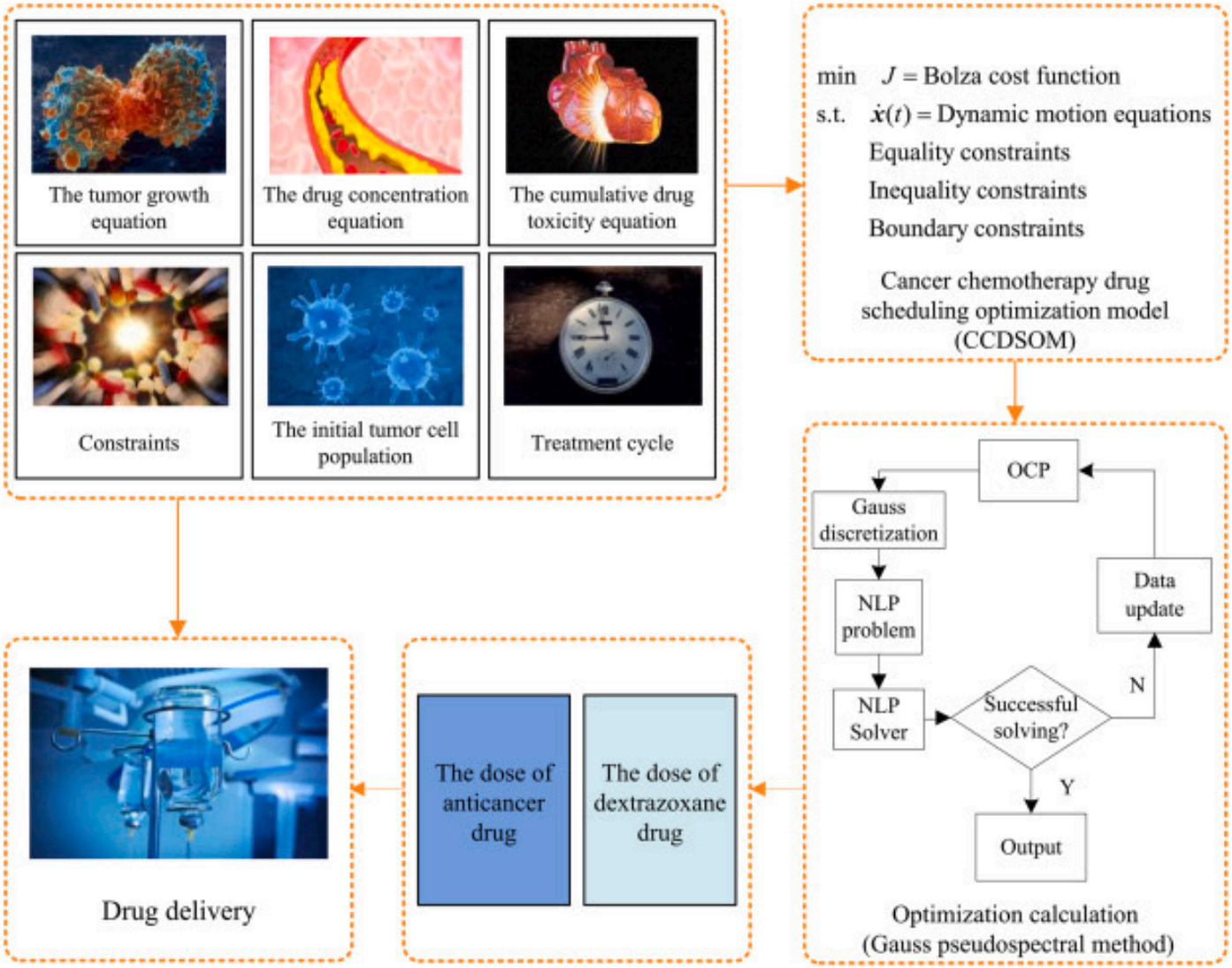
global optimization method for skin cancer segmentation





New Auxiliary Function with Properties in Nonsmooth Global Optimization for Melanoma Skin Cancer Segmentation, Biomed Res Int

Optimization of drug scheduling for chemotherapy with reducing drug toxicity

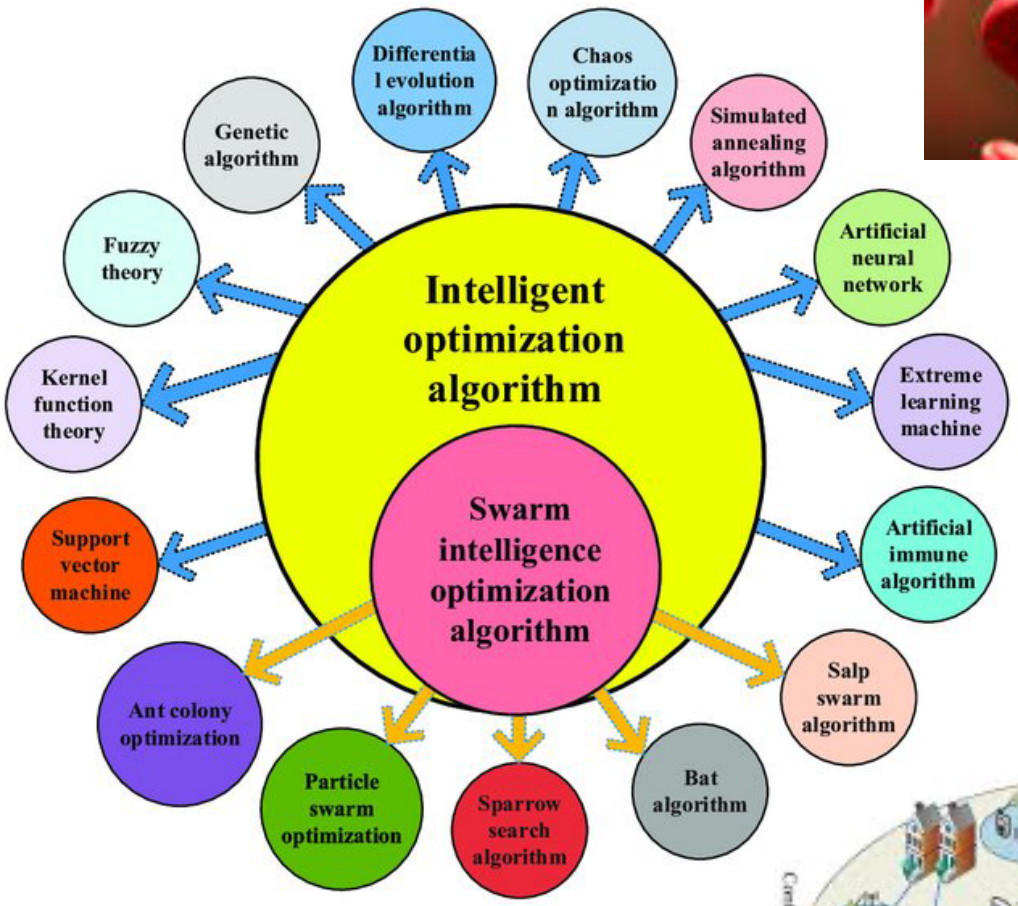


Optimization of drug scheduling for cancer chemotherapy with considering reducing cumulative drug toxicity, Volume 9, Issue 6, June 2023

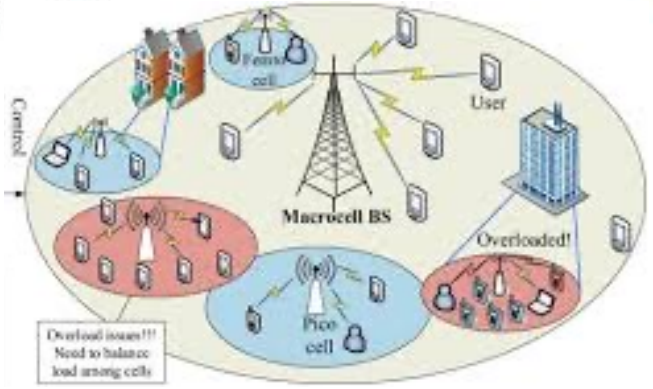
Swarm Intelligence

Example


Nano-Robots


Intelligent optimization algorithm
Swarm intelligence optimization algorithm
Differential evolution algorithm
Chaos optimization algorithm
Simulated annealing algorithm
Genetic algorithm
Fuzzy theory
Artificial neural network
Kernel function theory
Extreme learning machine
Support vector machine
Artificial immune algorithm
Ant colony optimization
Salp swarm algorithm
Particle swarm optimization
Sparrow search algorithm
Bat algorithm


Near-body Monitoring
Off-body Detection
Disease Prediction and CDSS
AI


User
Macrocell BS
Overloaded!
Pico cell
Femto cell

Wearable for wellness monitoring

Blood pressure monitor

Cell population biosensor

A digital bandage for vitals signs

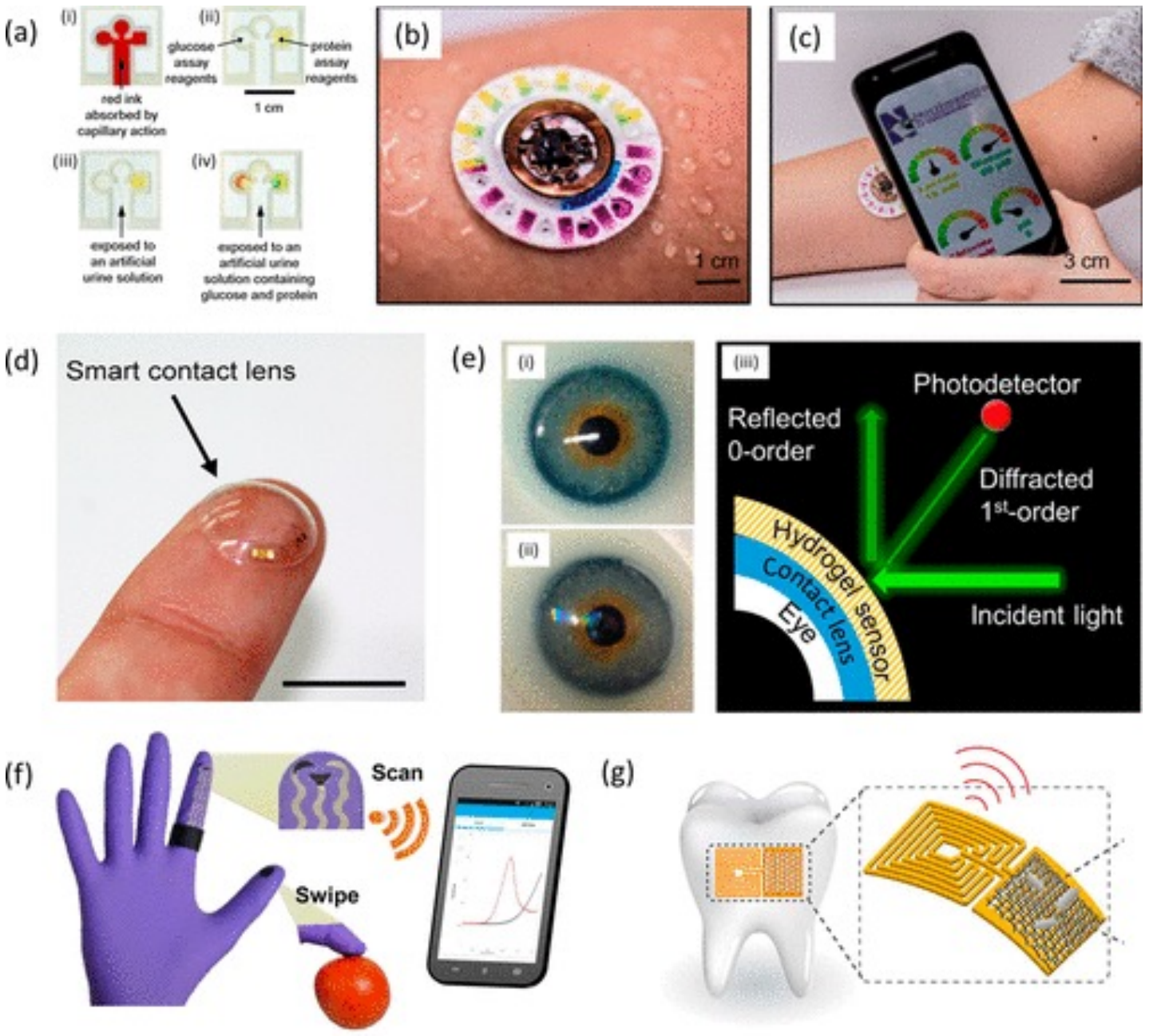
Pregnancy test biosensor

A FitBit band

A saliva-based glucose biosensor

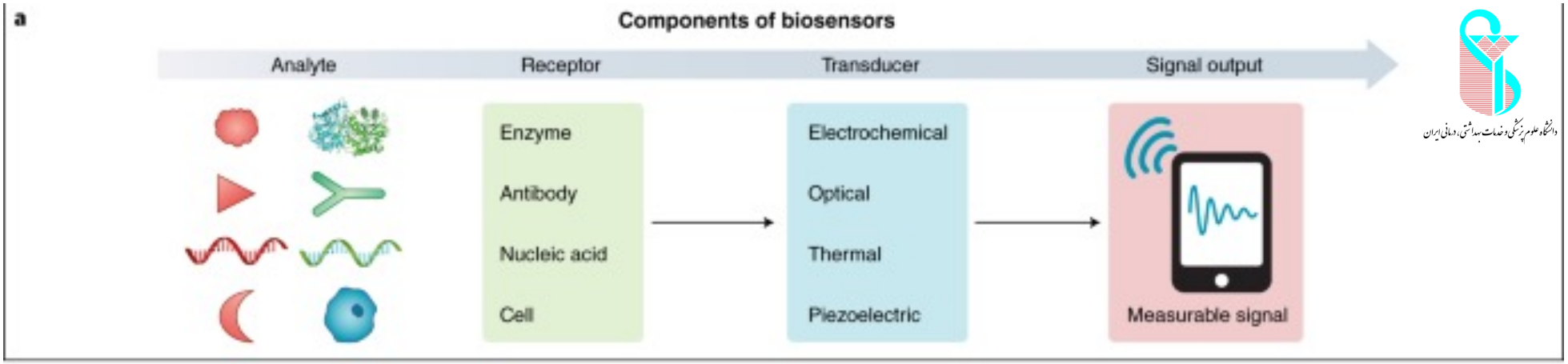
A blood- sugar monitor

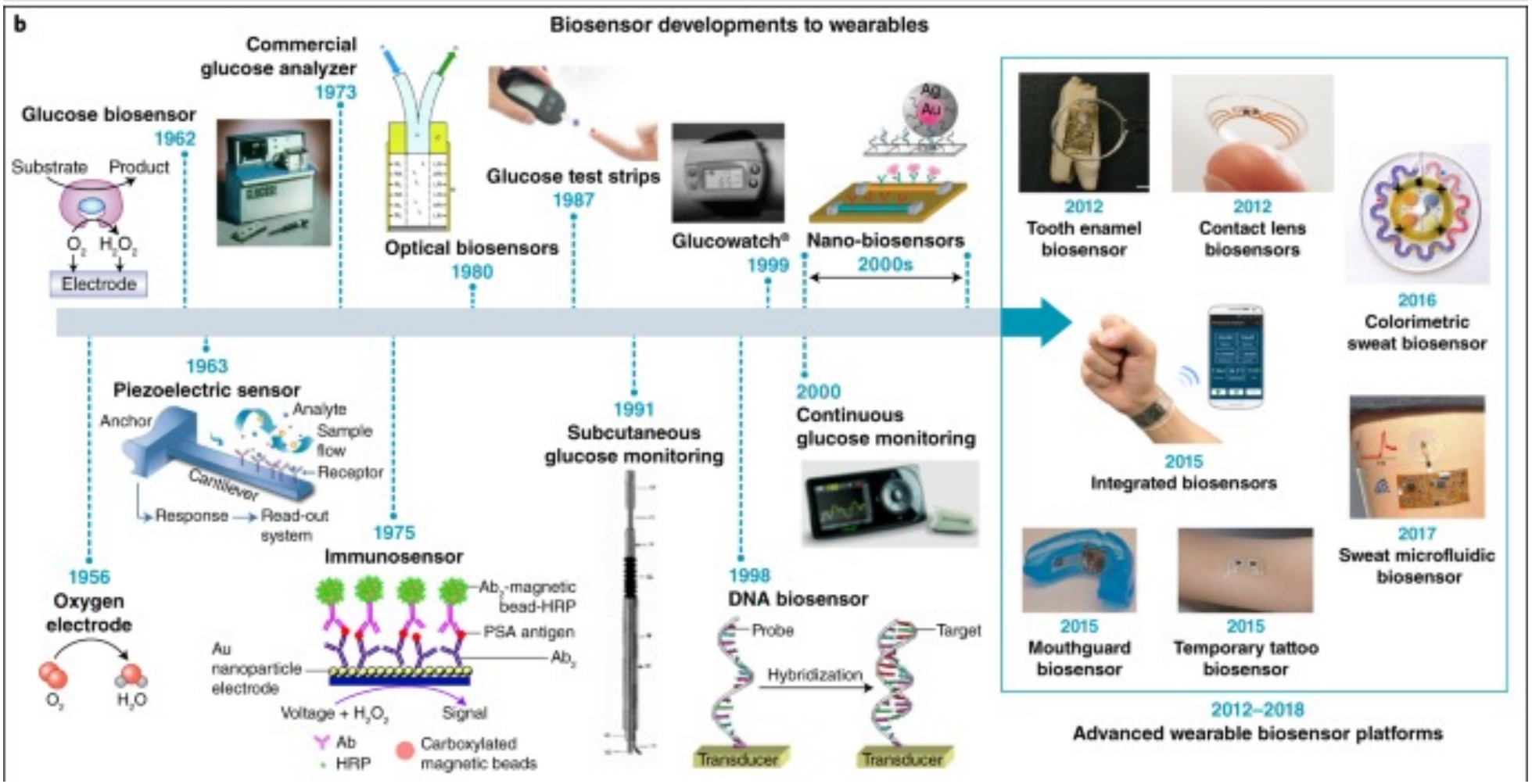
A glucometer


(a)
(i)
(ii)
glucose assay reagents
protein assay reagents
red ink absorbed by capillary action
1 cm
(iii)
(iv)
exposed to an artificial urine solution
exposed to an artificial urine solution containing glucose and protein
(b)
1 cm
(c)
3 cm
(d)
Smart contact lens
(e)
(i)
(ii)
(iii)
Photodetector
Reflected 0-order
Diffracted 1st-order
Hydrogel sensor
Contact lens
Eye
Incident light
(f)
Scan
Swipe
(g)

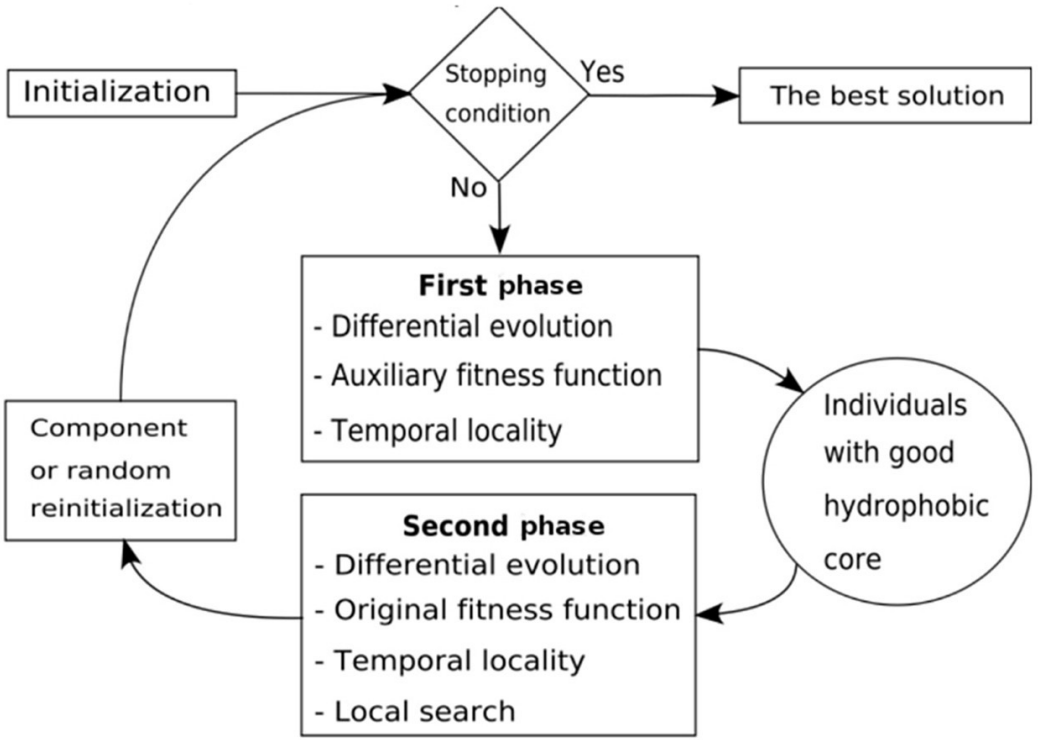

a
Diet
Lifestyle
Gut microbiota
Amino acids
COVID-19
Central fatigue
Cardiac hypertrophy
Hepatic lipid storage
T2DM
b
NutriTrek
+/– Target
Current
Voltage
Recognition
In situ regeneration
Artificial antibody
Oxidation
Reduction
System on body
c
Sweat biosensors
T sensor
Sweat stimulation electrodes
d
PI film
Sensors
Carbachol gel
Channel layers
Inlet layers
Skin
e
f
g
Charging/load sharing circuit
Boost converter
Battery
Voltage regulator
MCU
GPIO
SPI 1
CPU
ADC 1
ADC 2
ADC 3
ADC 4
UART
SPI 2
Protection circuit
Current source
Dual DAC
V_{REF}
Potentiostat interface
TIA 1
TIA 2
In-amp
Voltage divider
Bluetooth
Display
Iontophoresis electrodes
IP +
IP –
Sweat biosensors
CE
WE_{DPV1}
WE_{DPV2}
RE
WE_{POT}
T sensor
User interface
h
NutriTrek
Collected data
Raw Voltammogram
Corrected Voltammogram
i

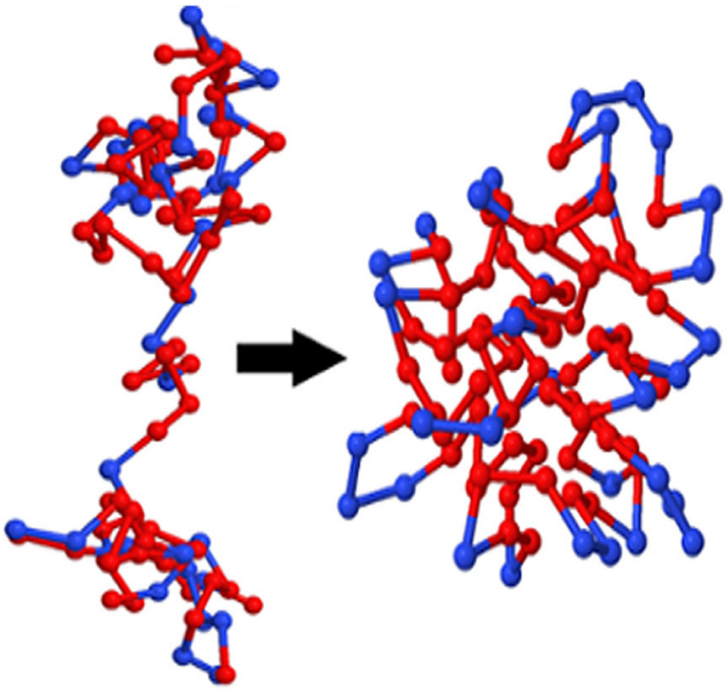
دانشگاه علوم پزشکی و خدمات بهداشتی، درمانی ایران





Protein Folding



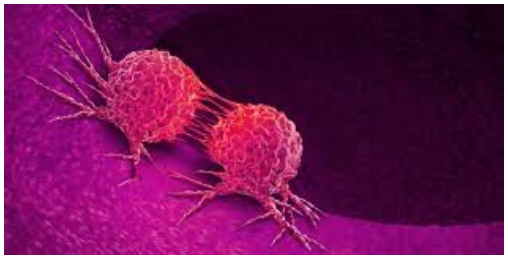


Two-phase protein folding optimization on a three-dimensional AB off-lattice model

Early Detection of Disease

New Tools
New Biopsy
Non-invasive

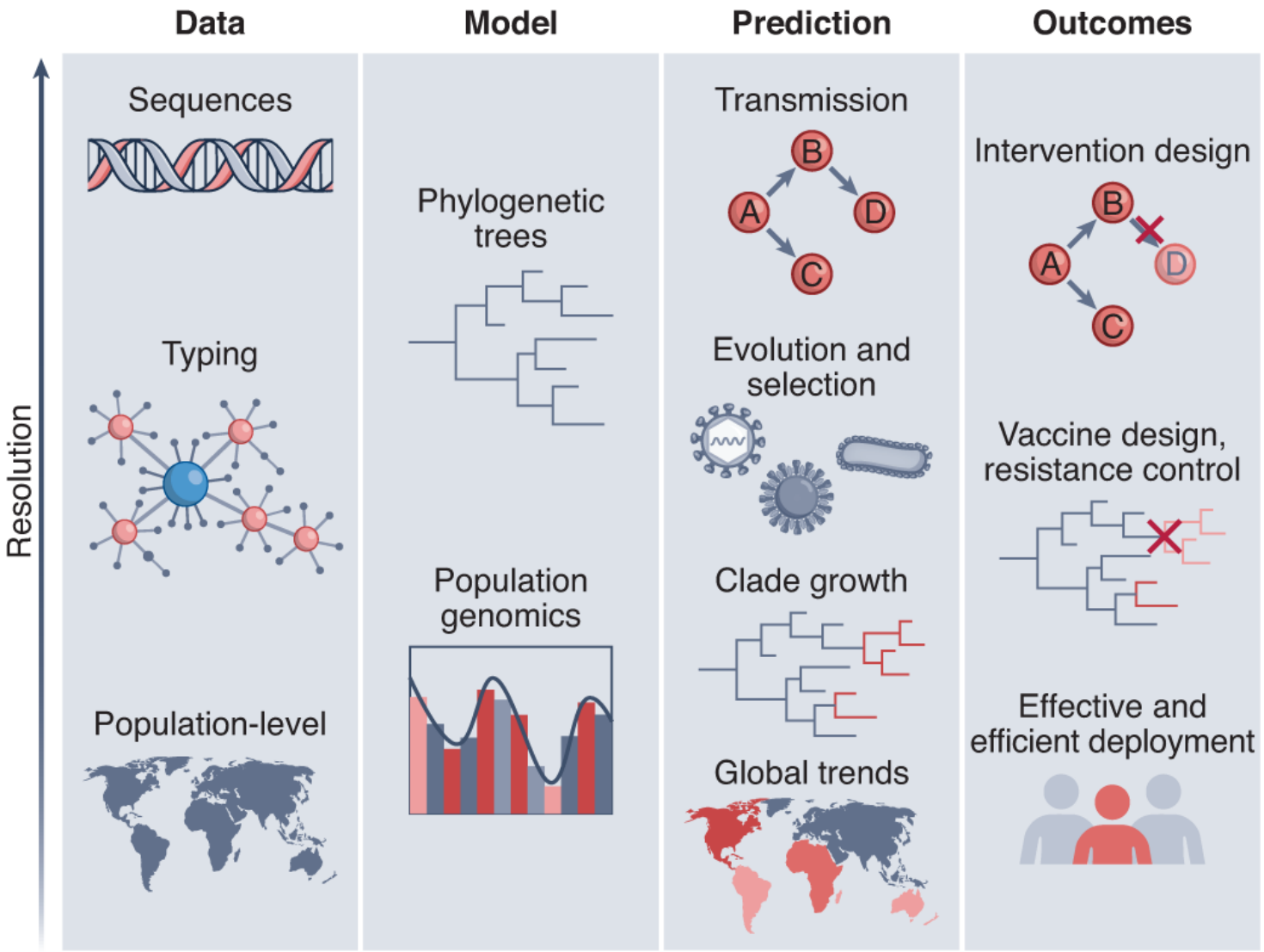
New type of Data in all scale

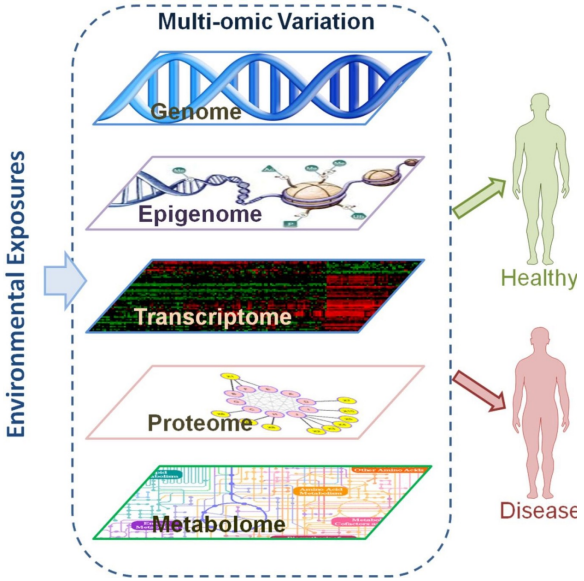


Complex for human understanding proper for AI

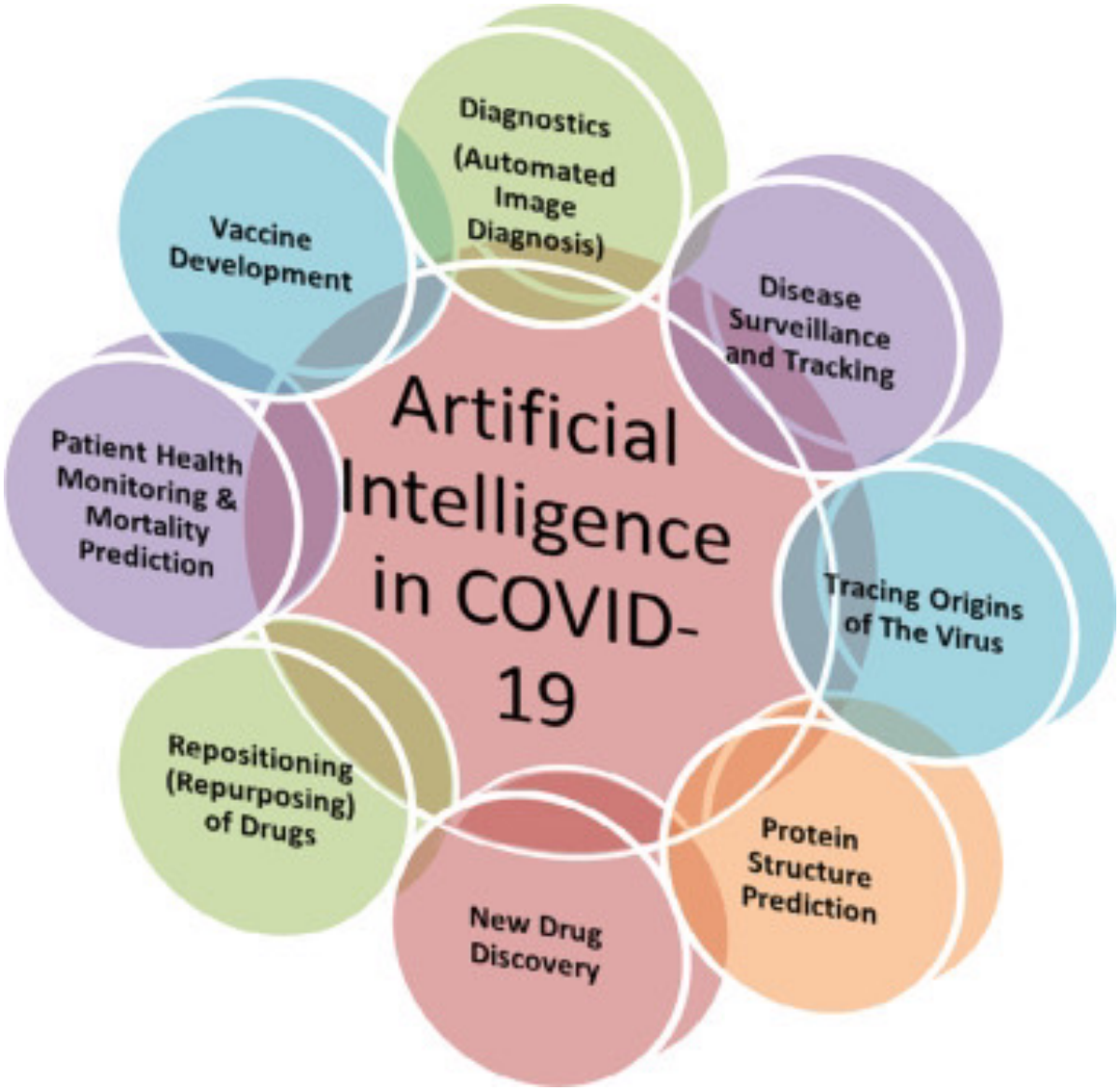
Patient data
Patient family and ancestors ' data
Patient environment data
Doctor evaluation

Multi-omics Data

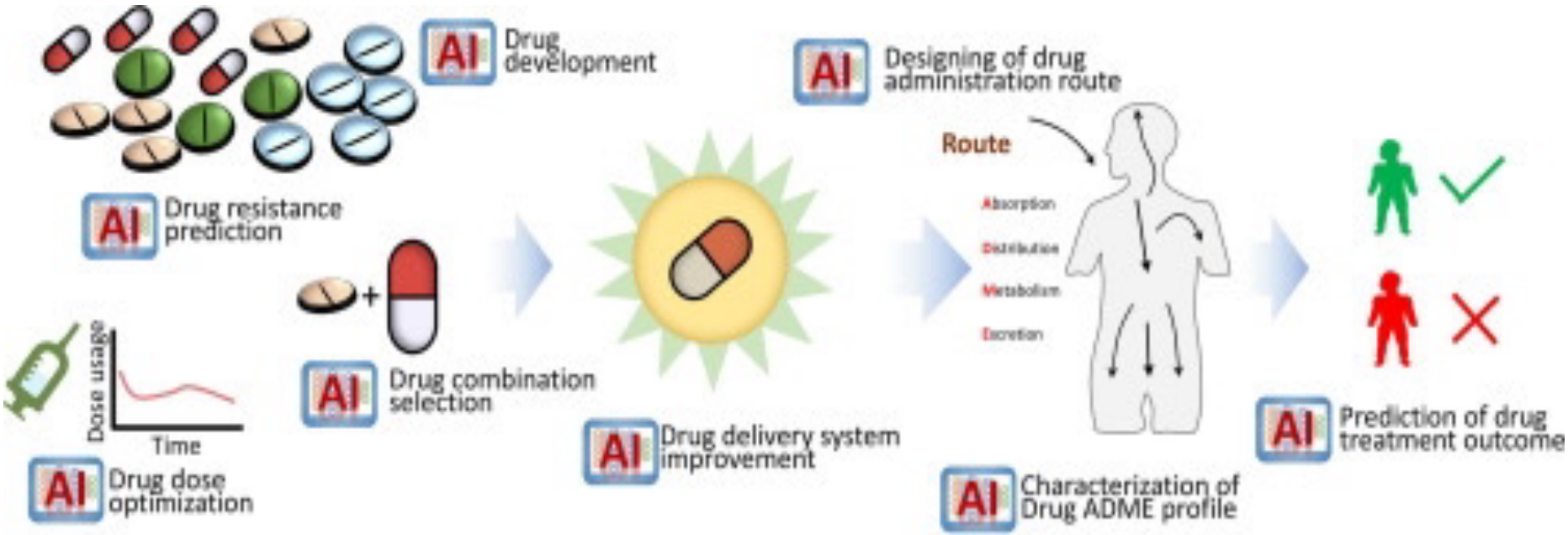




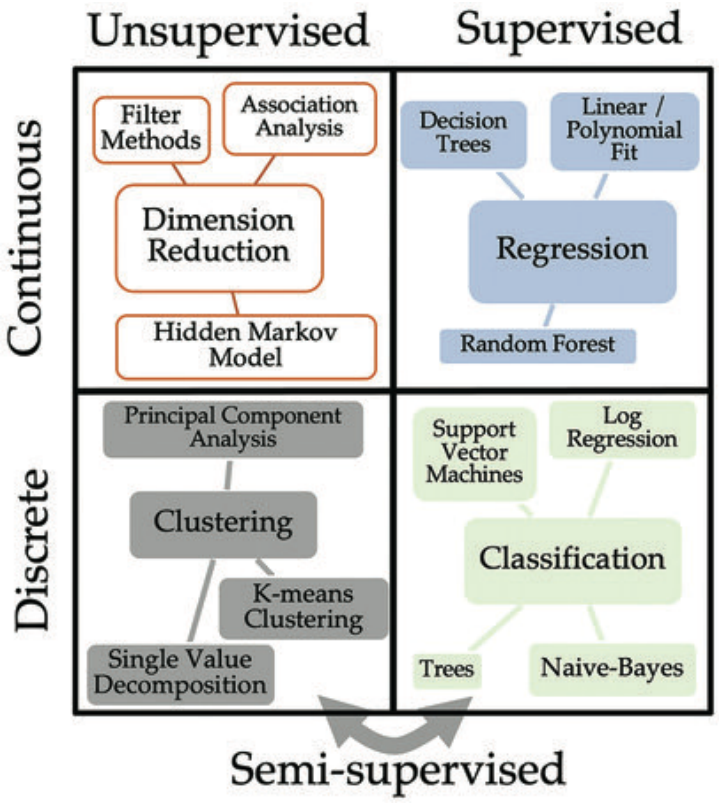
AI and Infectious disease

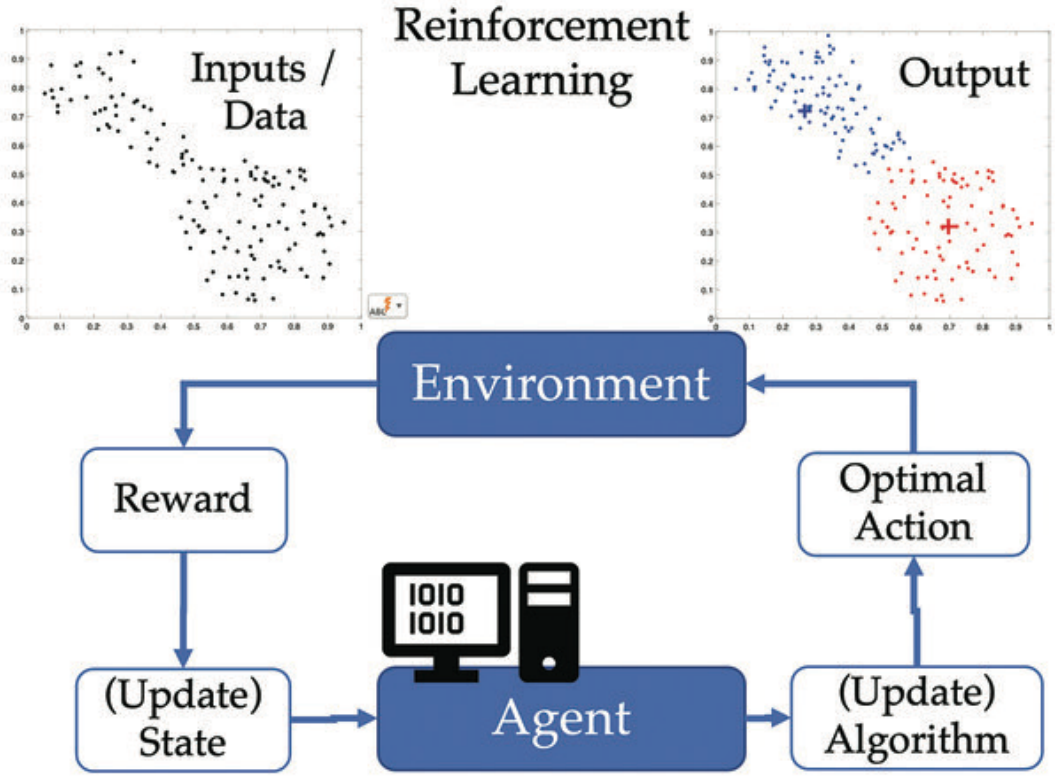


Optimization in drug delivery

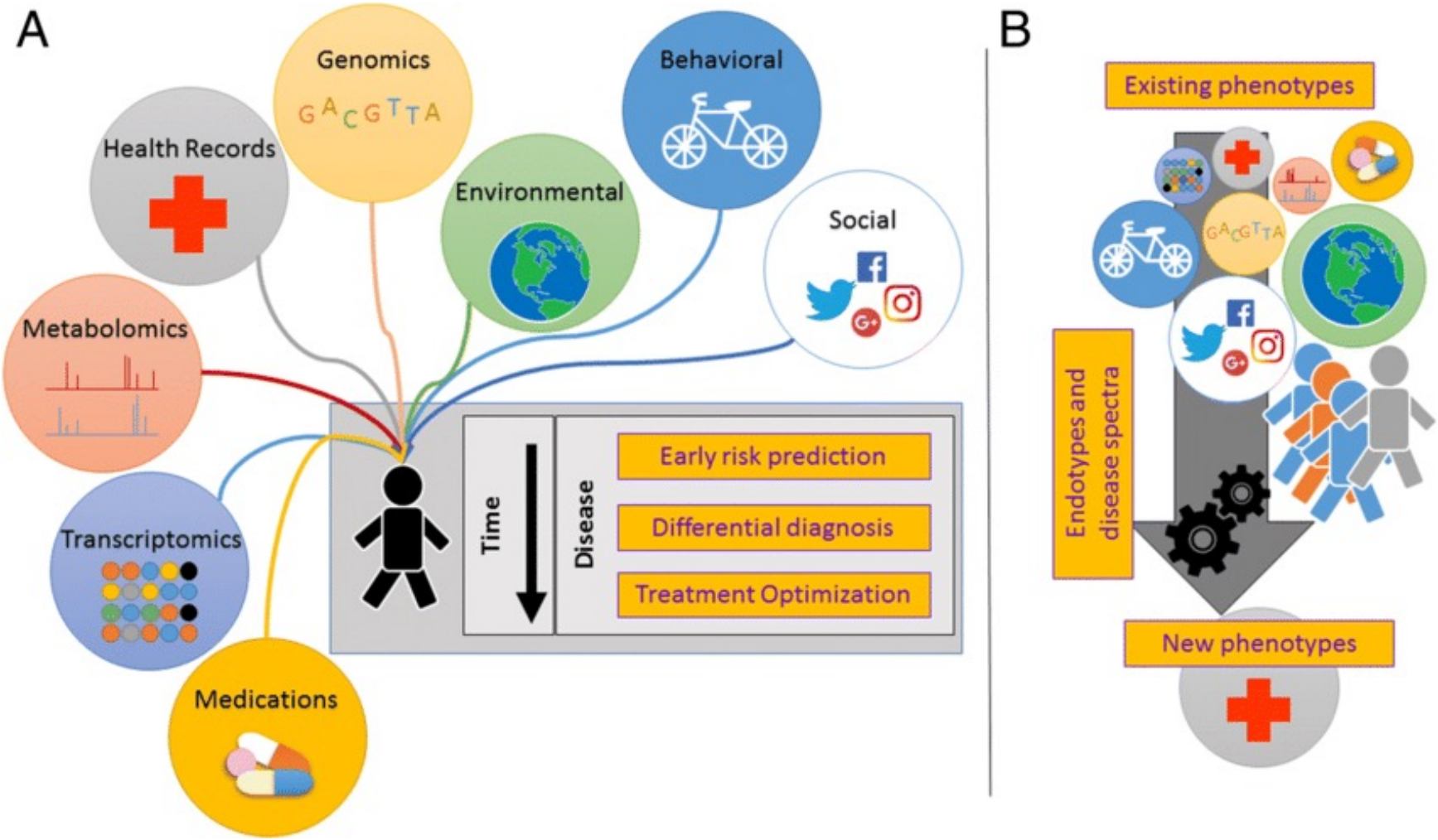


Clinical decision support

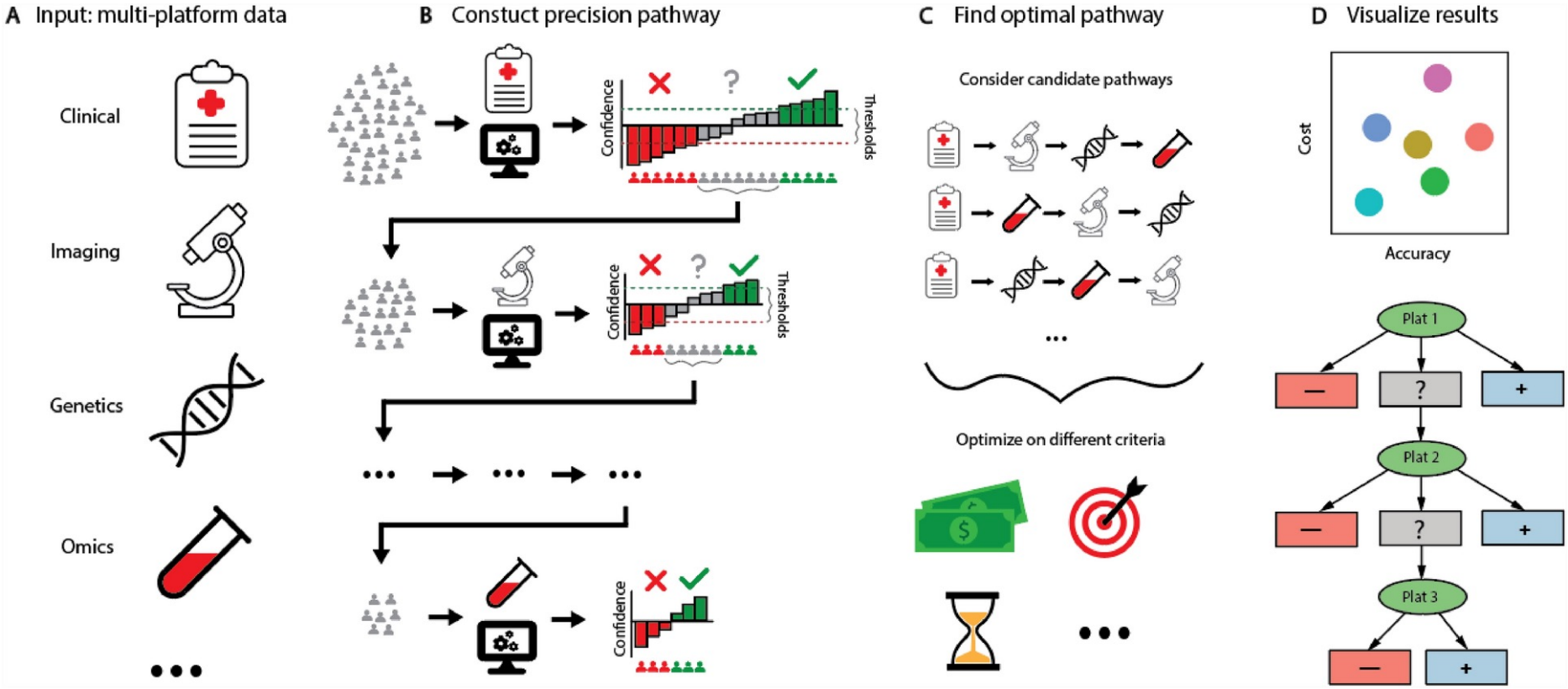




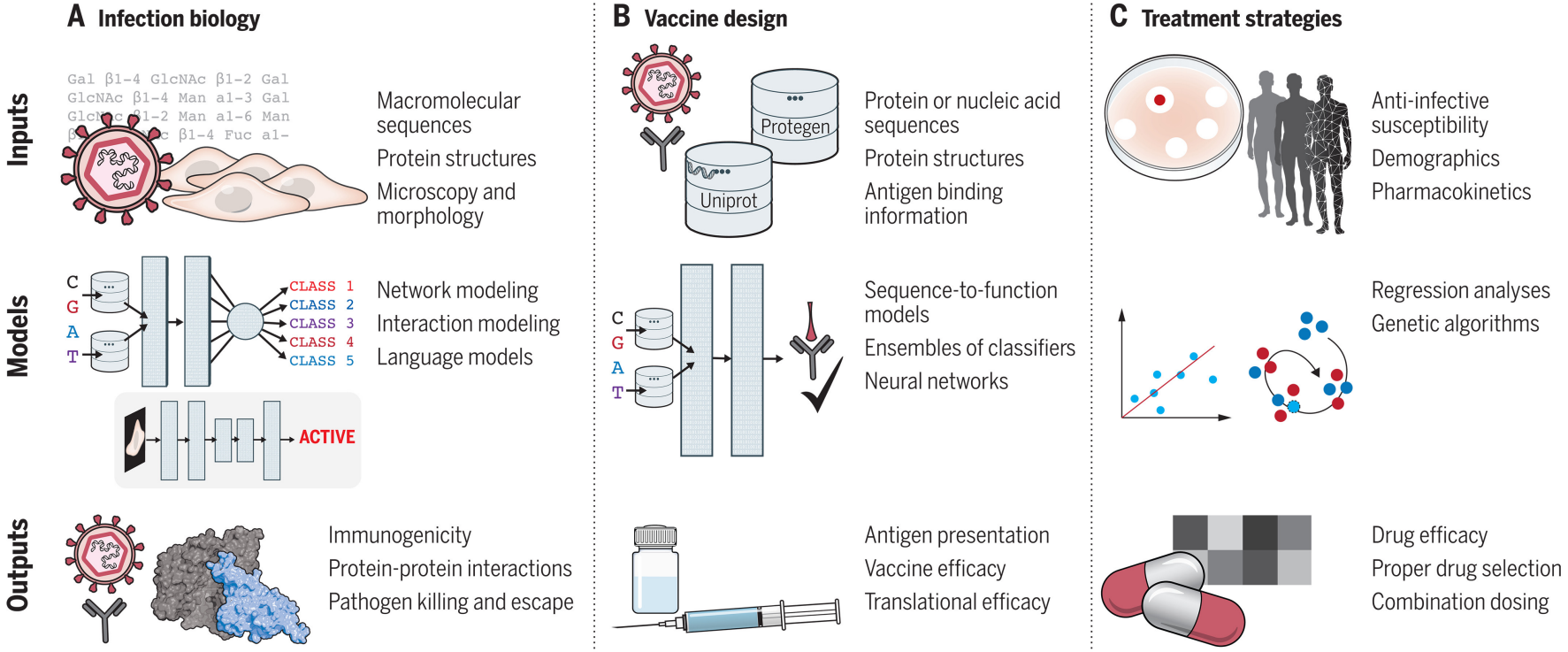
Precision Medicine



Precision Medicine

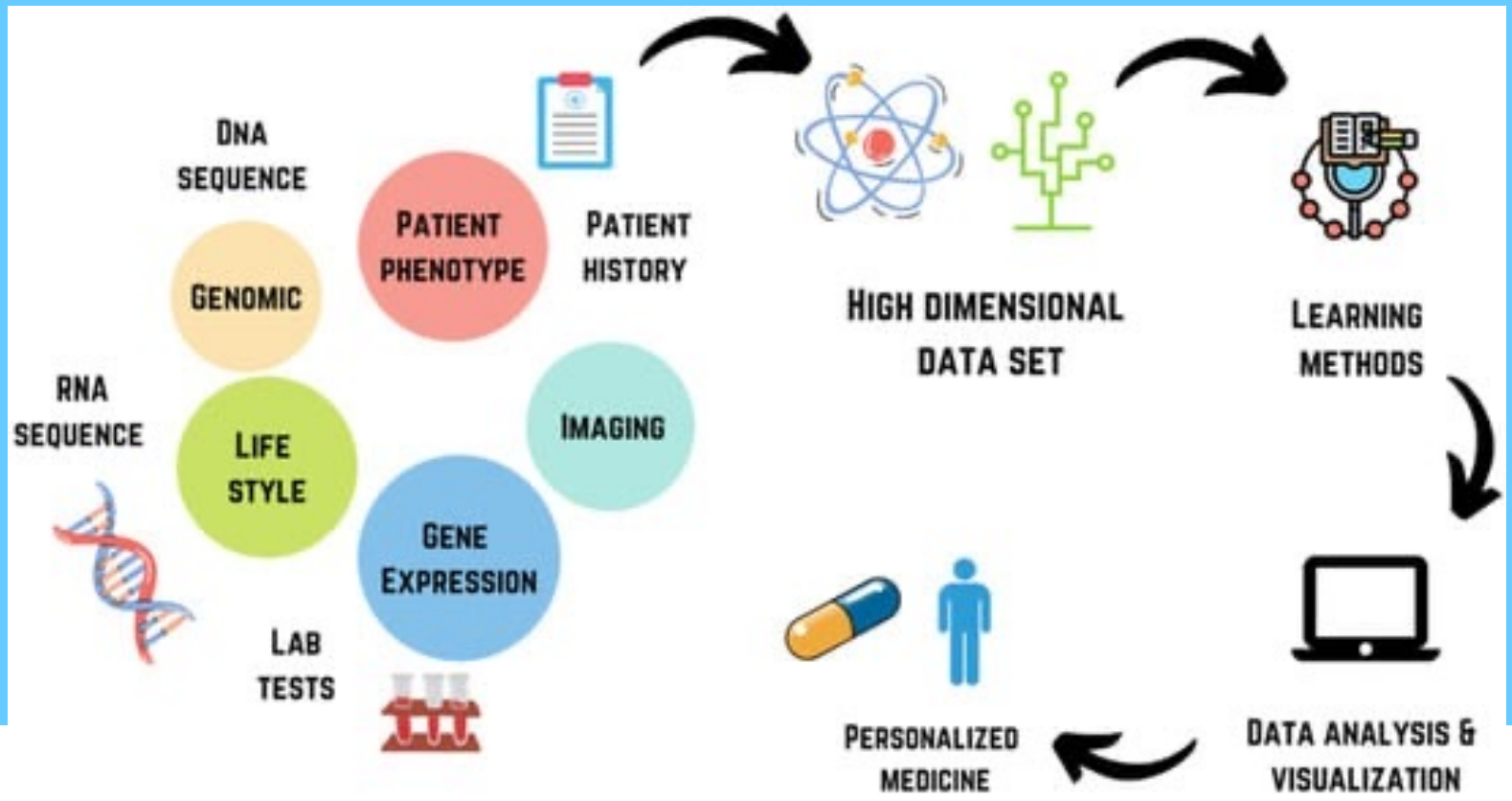


Development of disease models

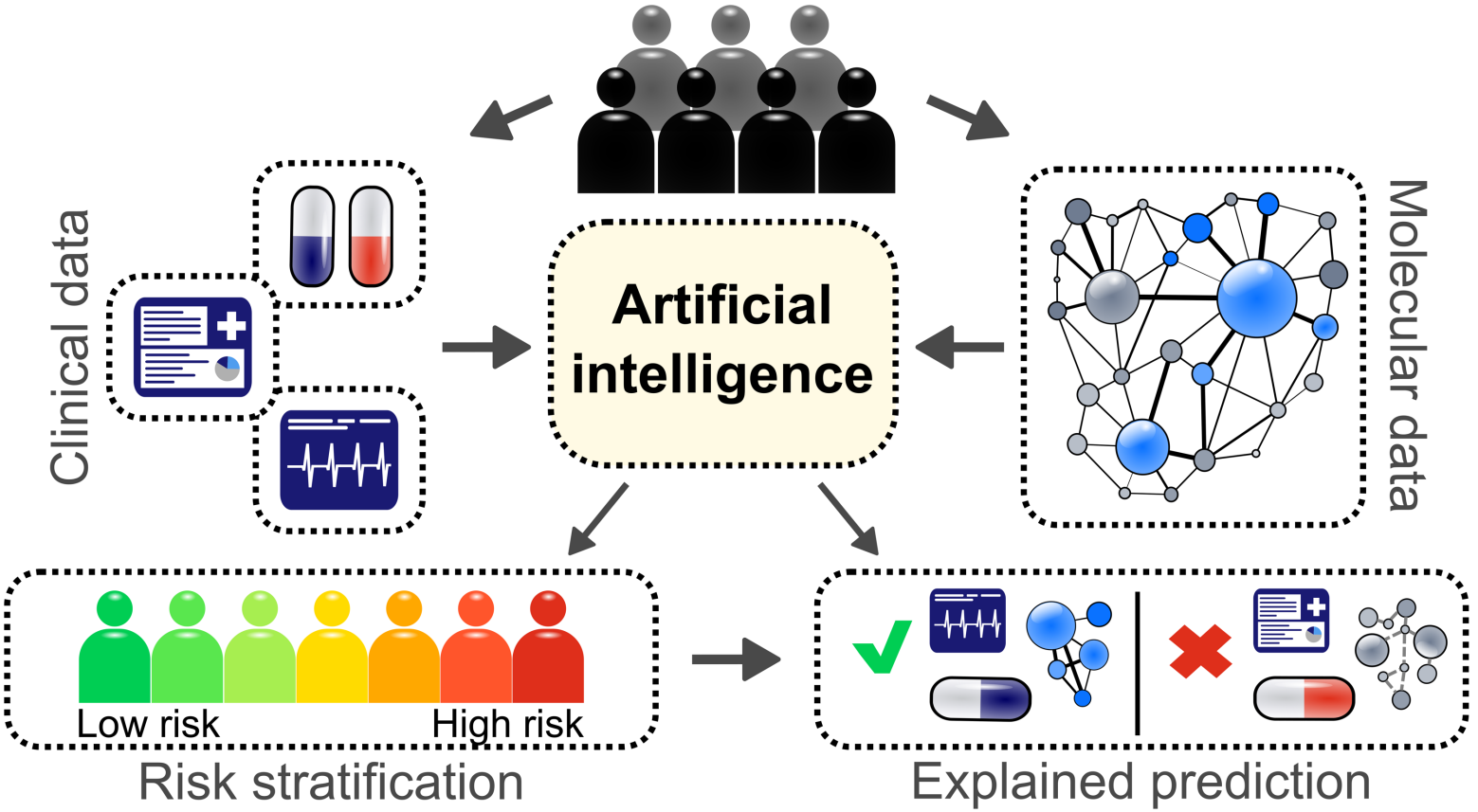


Predictive analytics

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



Disease Risk Assessment

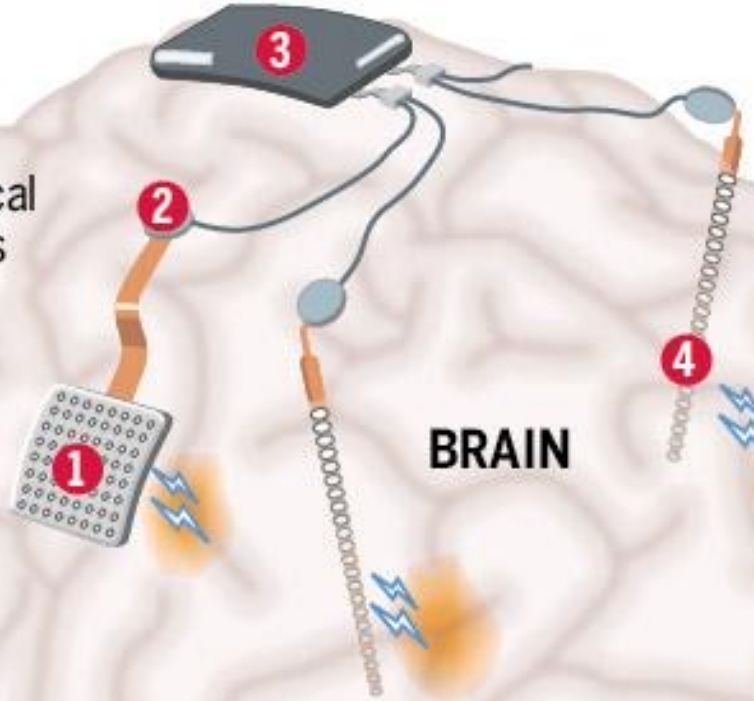


Helping in Medical Decision Making

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.

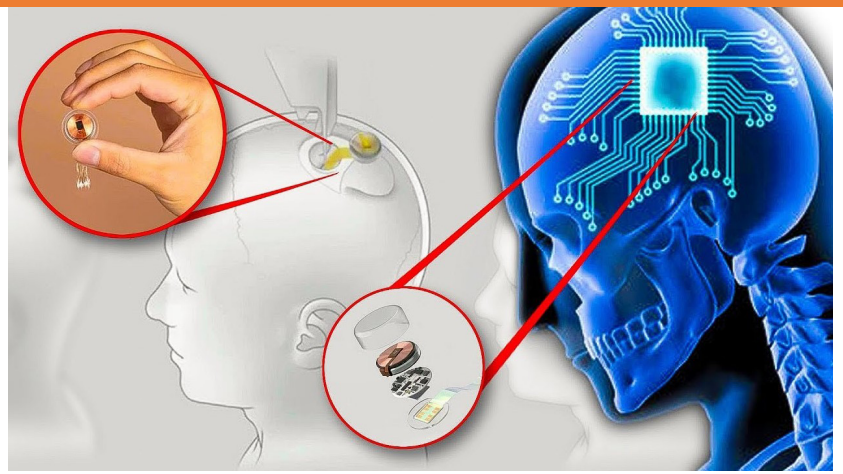
3. **Control module microprocessor** interprets brain signals gathered from neuromodulation chips.

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

Robotics and Automation

neural interface

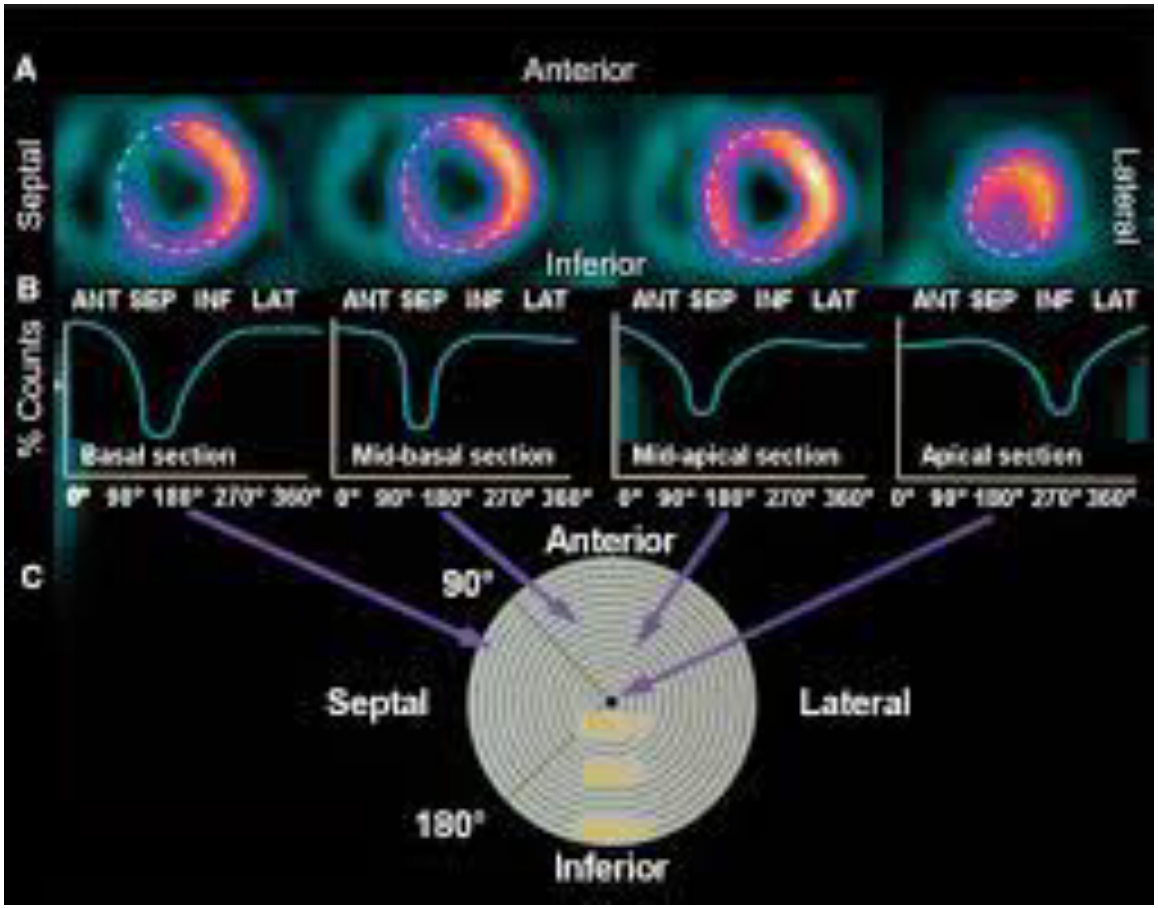
linking the human brain to an external AI system



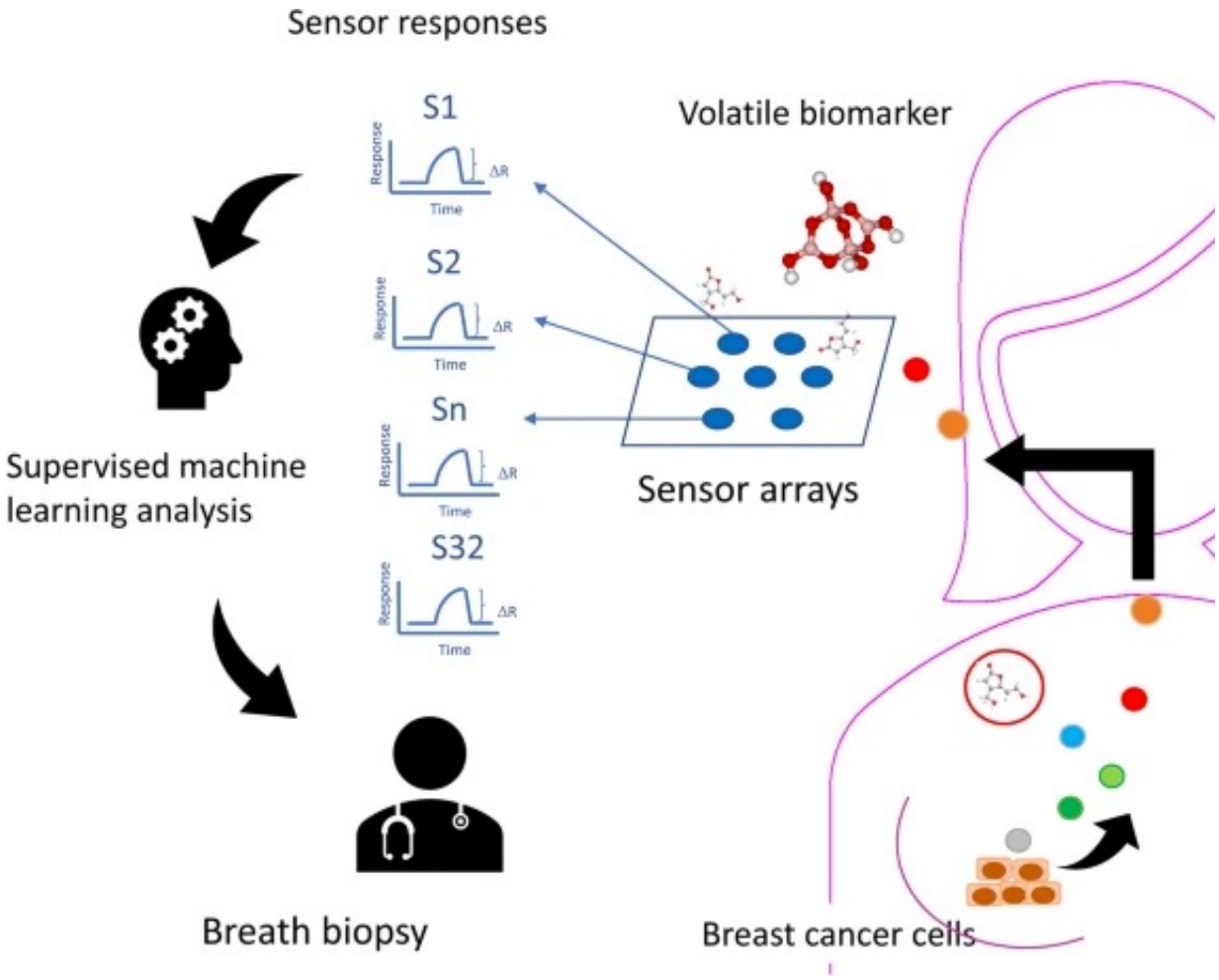
control prosthetic limbs

people with disabilities

Nuclear Cardiology and optimization

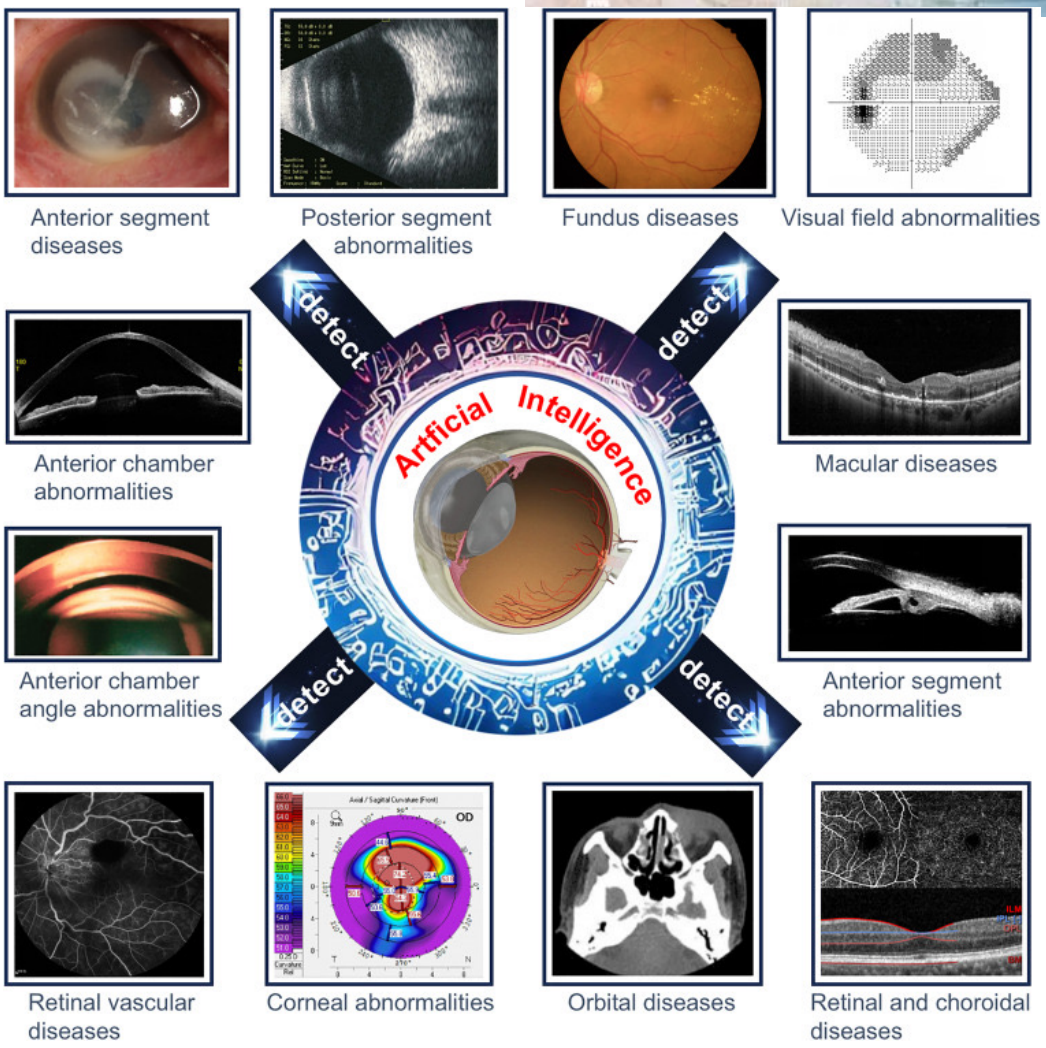


New types of Breast Cancer Biopsy: Breath biopsy



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

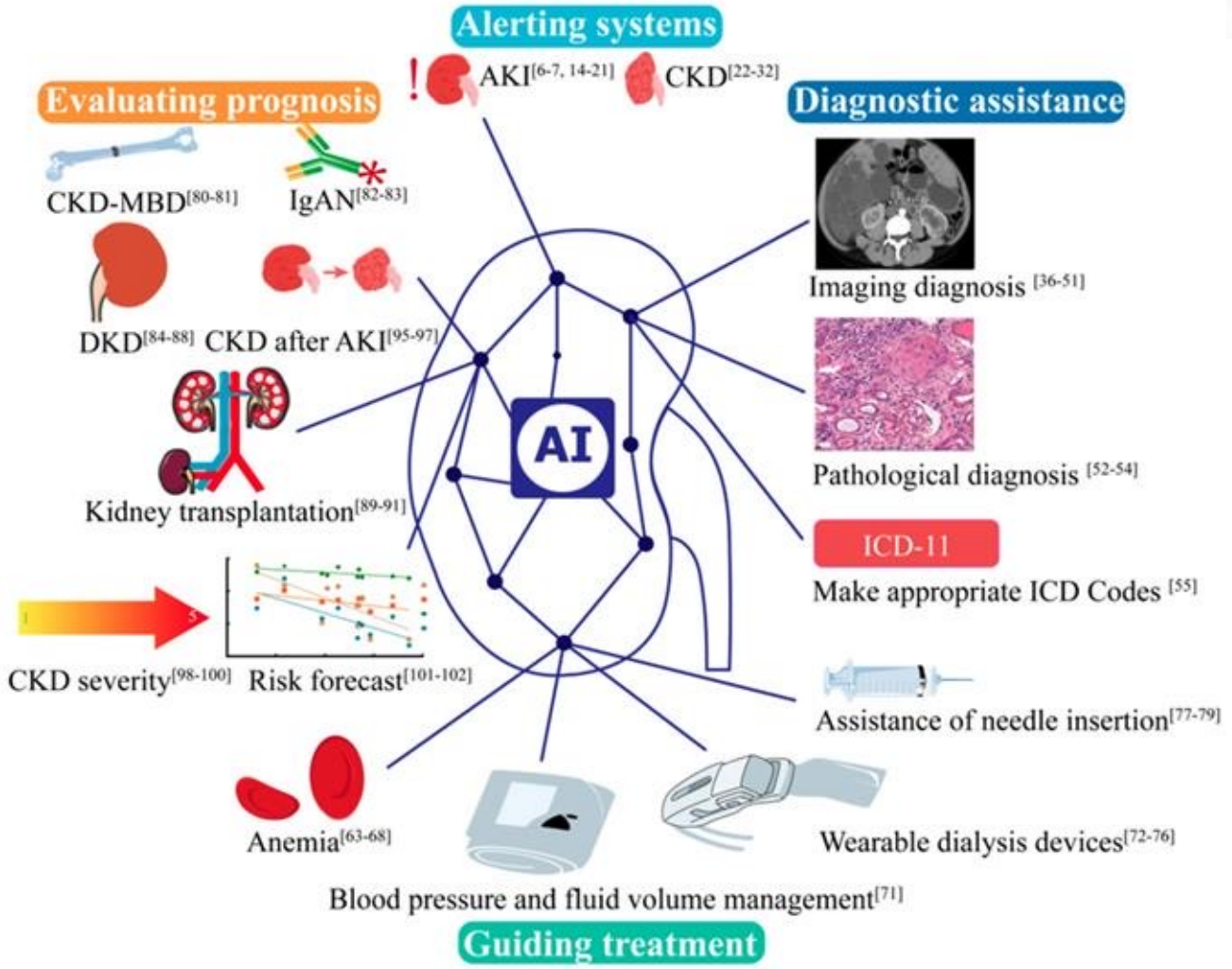
AI in Ophthalmology



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

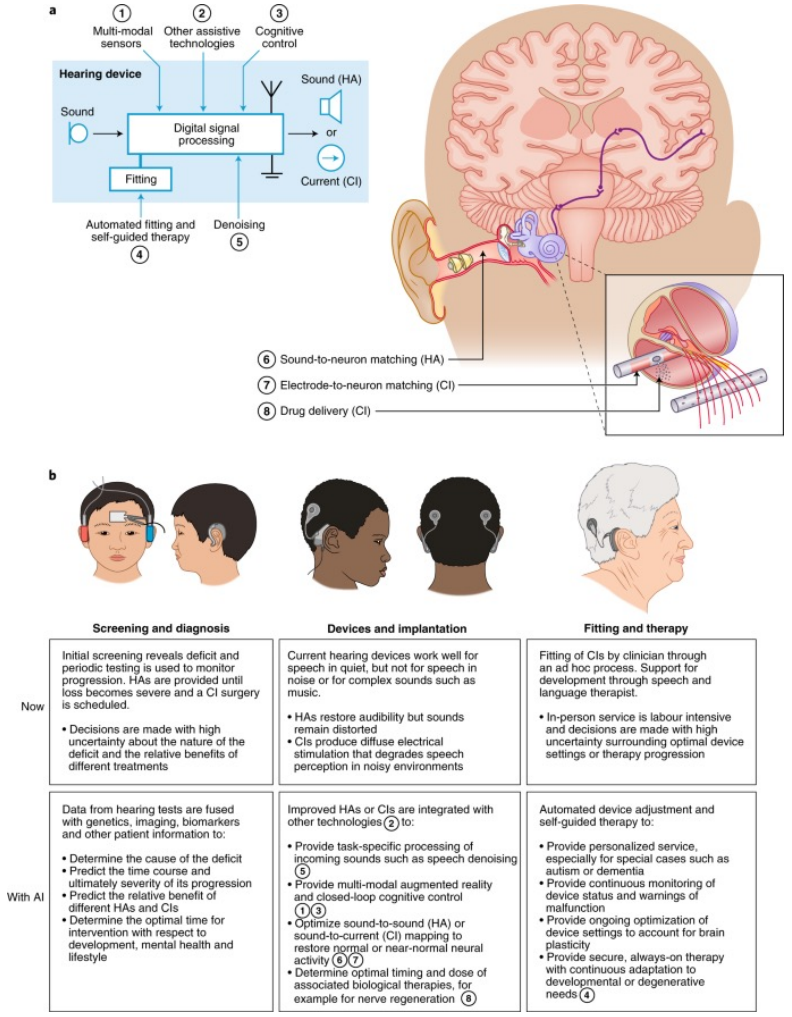
[2] S. Jeon Et al., "AI papers in ophthalmology made simple," *Eye,* vol. 34, pp. 1947–1949, 2020.

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.

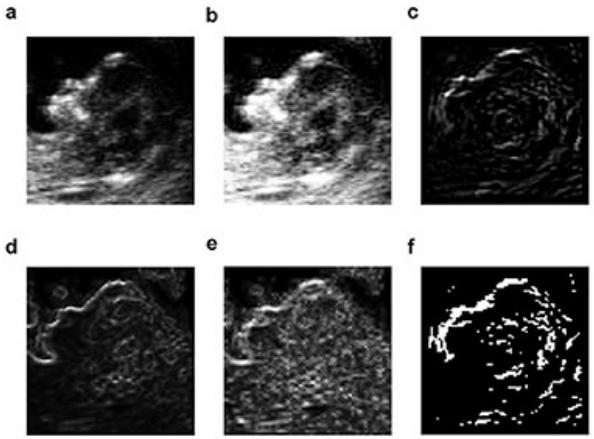
AI in Otolaryngology



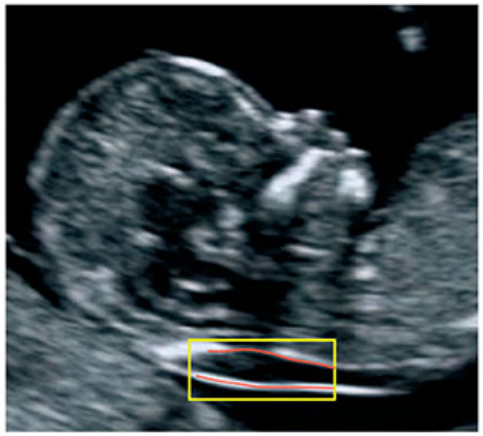
	Screening and diagnosis	Devices and implantation	Fitting and therapy
Now	Initial screening reveals deficit and periodic testing is used to monitor progression. HAs are provided until loss becomes severe and a CI surgery is scheduled. • Decisions are made with high uncertainty about the nature of the deficit and the relative benefits of different treatments	Current hearing devices work well for speech in quiet, but not for speech in noise or for complex sounds such as music. • HAs restore audibility but sounds remain distorted • CIs produce diffuse electrical stimulation that degrades speech perception in noisy environments	Fitting of CIs by clinician through an ad hoc process. Support for development through speech and language therapist. • In-person service is labour intensive and decisions are made with high uncertainty surrounding optimal device settings or therapy progression
With AI	Data from hearing tests are fused with genetics, imaging, biomarkers and other patient information to: • Determine the cause of the deficit • Predict the time course and ultimately severity of its progression • Predict the relative benefit of different HAs and CIs • Determine the optimal time for intervention with respect to development, mental health and lifestyle	Improved HAs or CIs are integrated with other technologies (2) to: • Provide task-specific processing of incoming sounds such as speech denoising (5) • Provide multi-modal augmented reality and closed-loop cognitive control (1)(3) • Optimize sound-to-sound (HA) or sound-to-current (CI) mapping to restore normal or near-normal neural activity (6)(7) • Determine optimal timing and dose of associated biological therapies, for example for nerve regeneration (8)	Automated device adjustment and self-guided therapy to: • Provide personalized service, especially for special cases such as autism or dementia • Provide continuous monitoring of device status and warnings of malfunction • Provide ongoing optimization of device settings to account for brain plasticity • Provide secure, always-on therapy with continuous adaptation to developmental or degenerative needs (4)

[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.

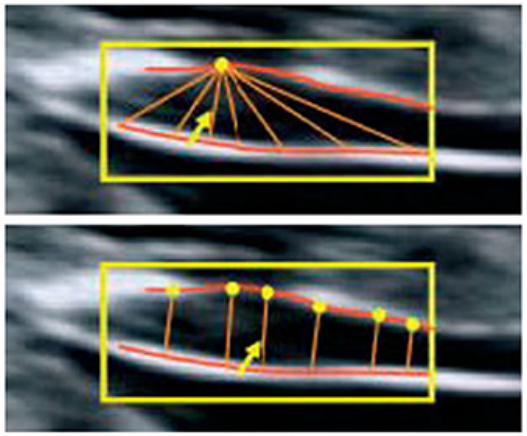
Optimization and Obstetrics and Gynecology



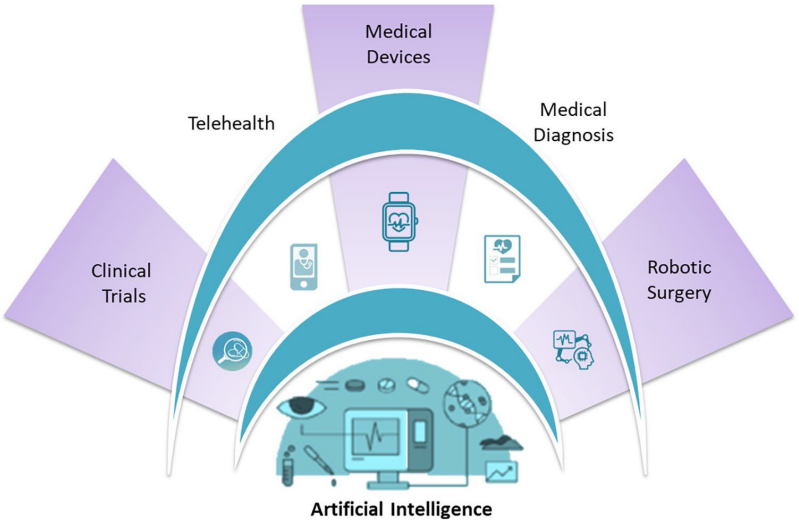
Automatic mid-sagittal plane detection



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

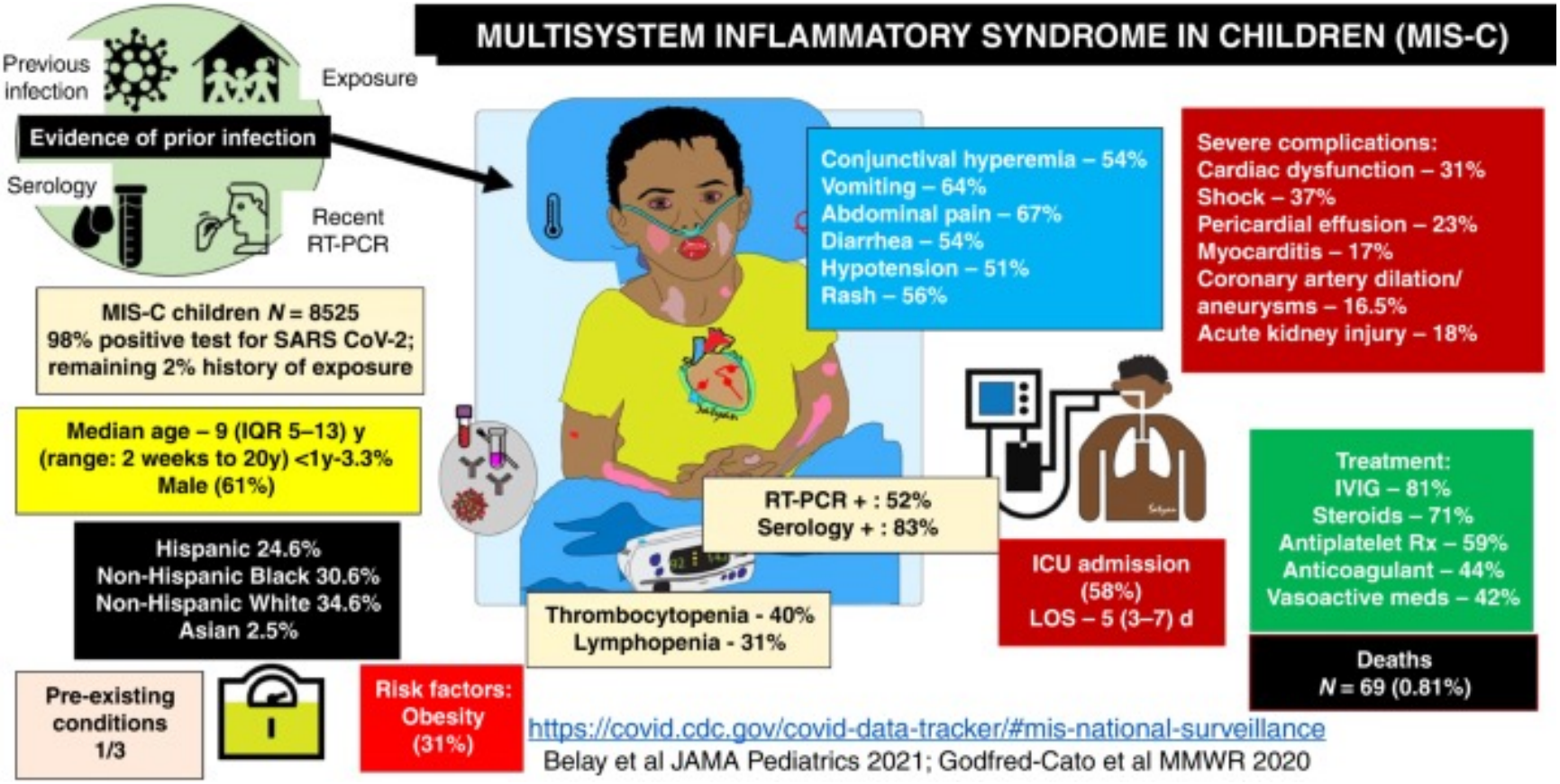


Calculates the minimum vertical distance between the two lines and computes the



endometriosis

Optimization in Pediatrics

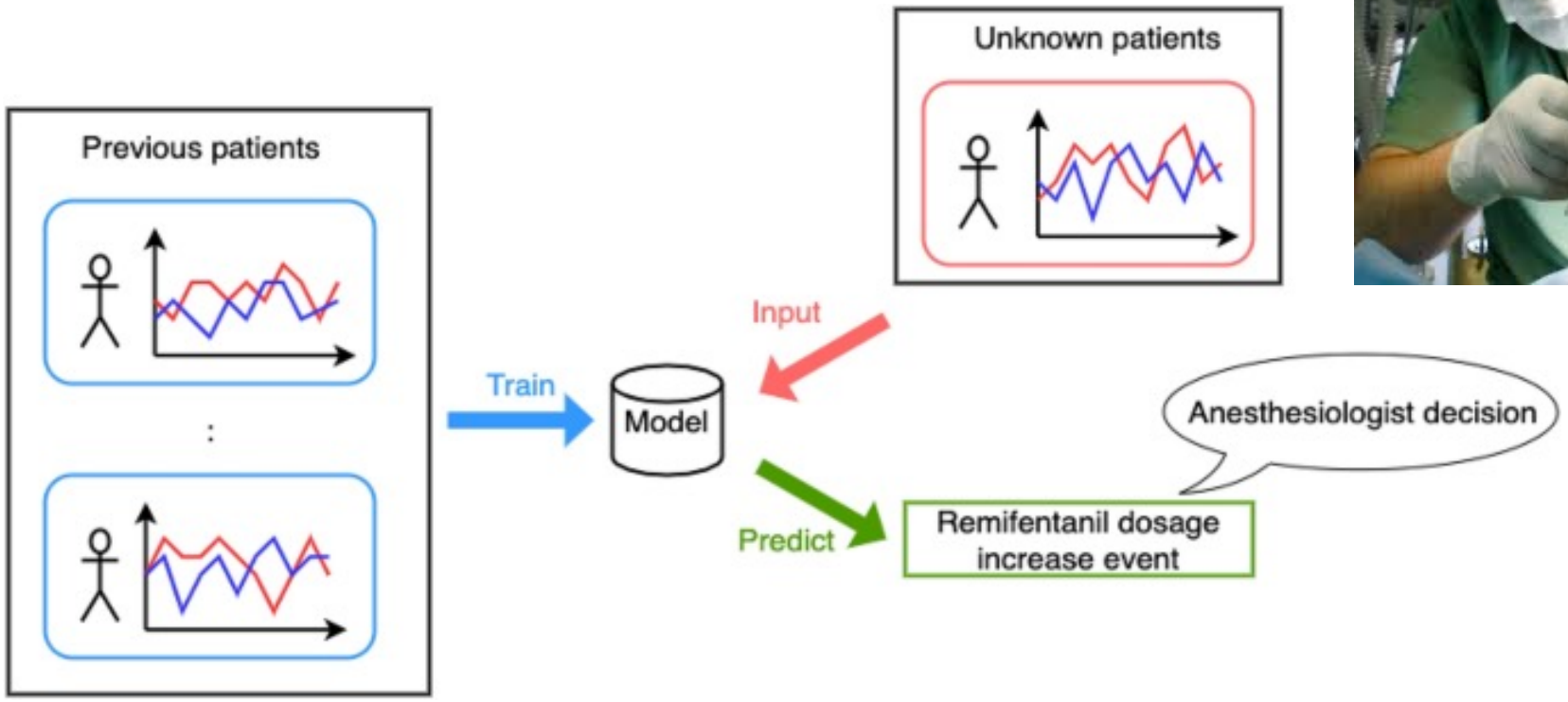


[1] Sitek Et al., "Artificial intelligence in the diagnosis of necrotising enterocolitis in newborns,"*Pediatric Research,* 2022.

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

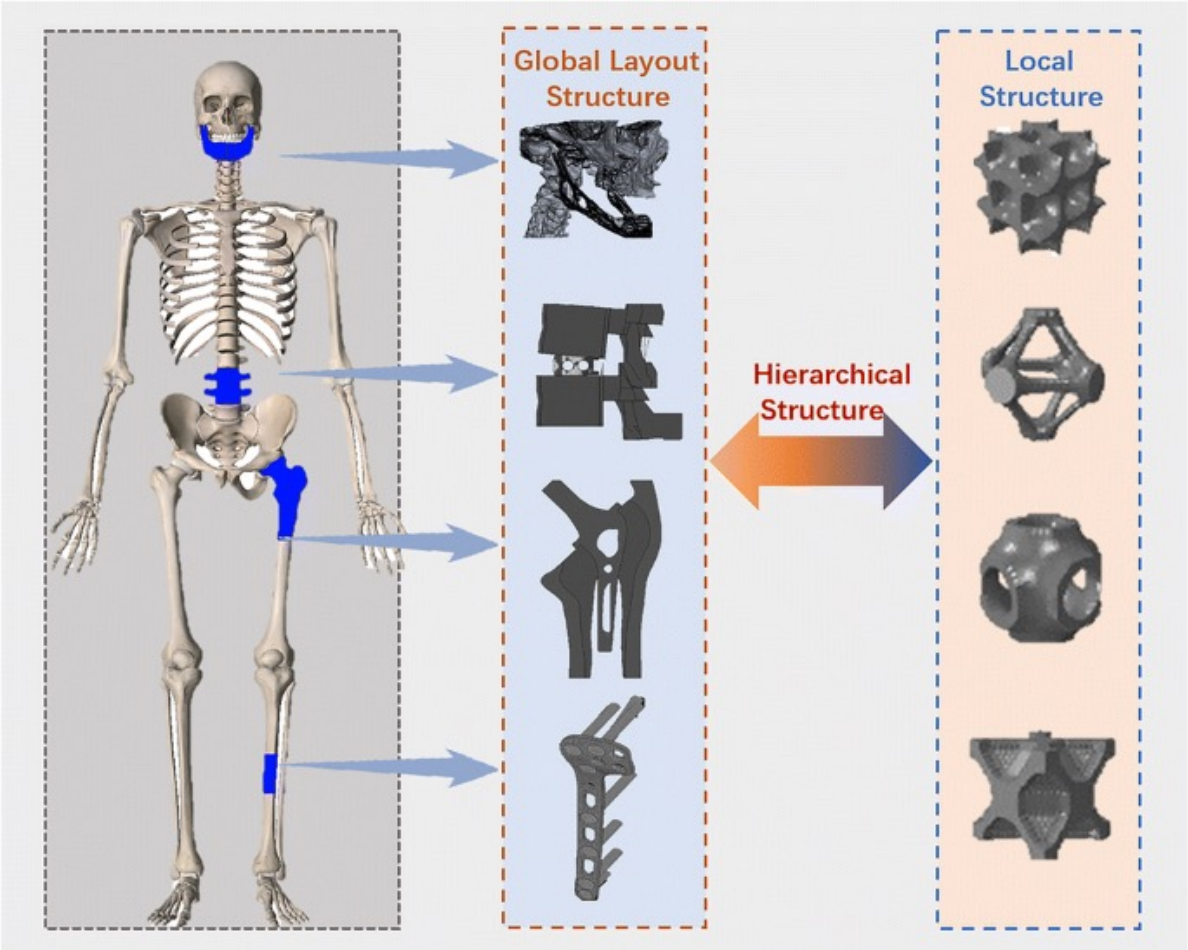
[3] L. A. Knake Et al., "Artificial intelligence in pediatrics: the future is now," *Pediatric Research,* 2022.

Optimization and Anesthesiology



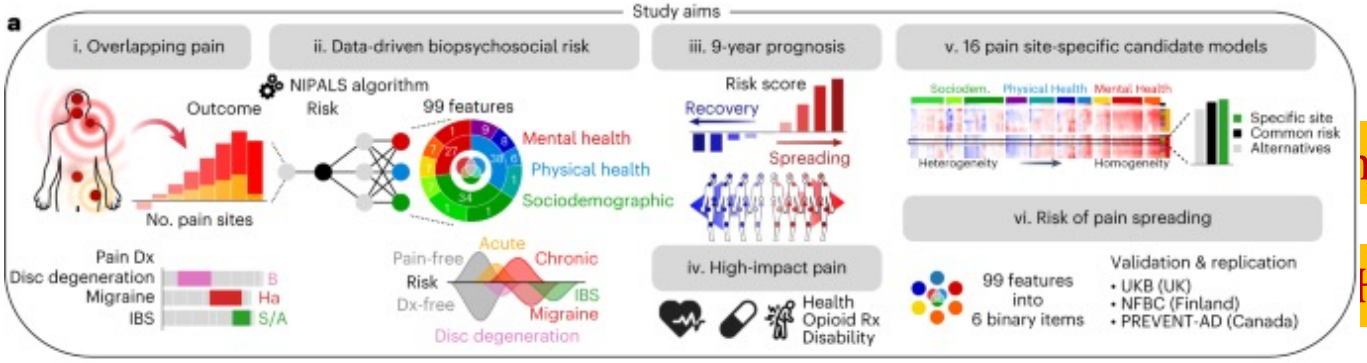
[1]N. Miyaguchi Et al., "Predicting anesthetic infusion events using machine learning," *Scientific Reports,* vol. 11, No. 23648, 2021.

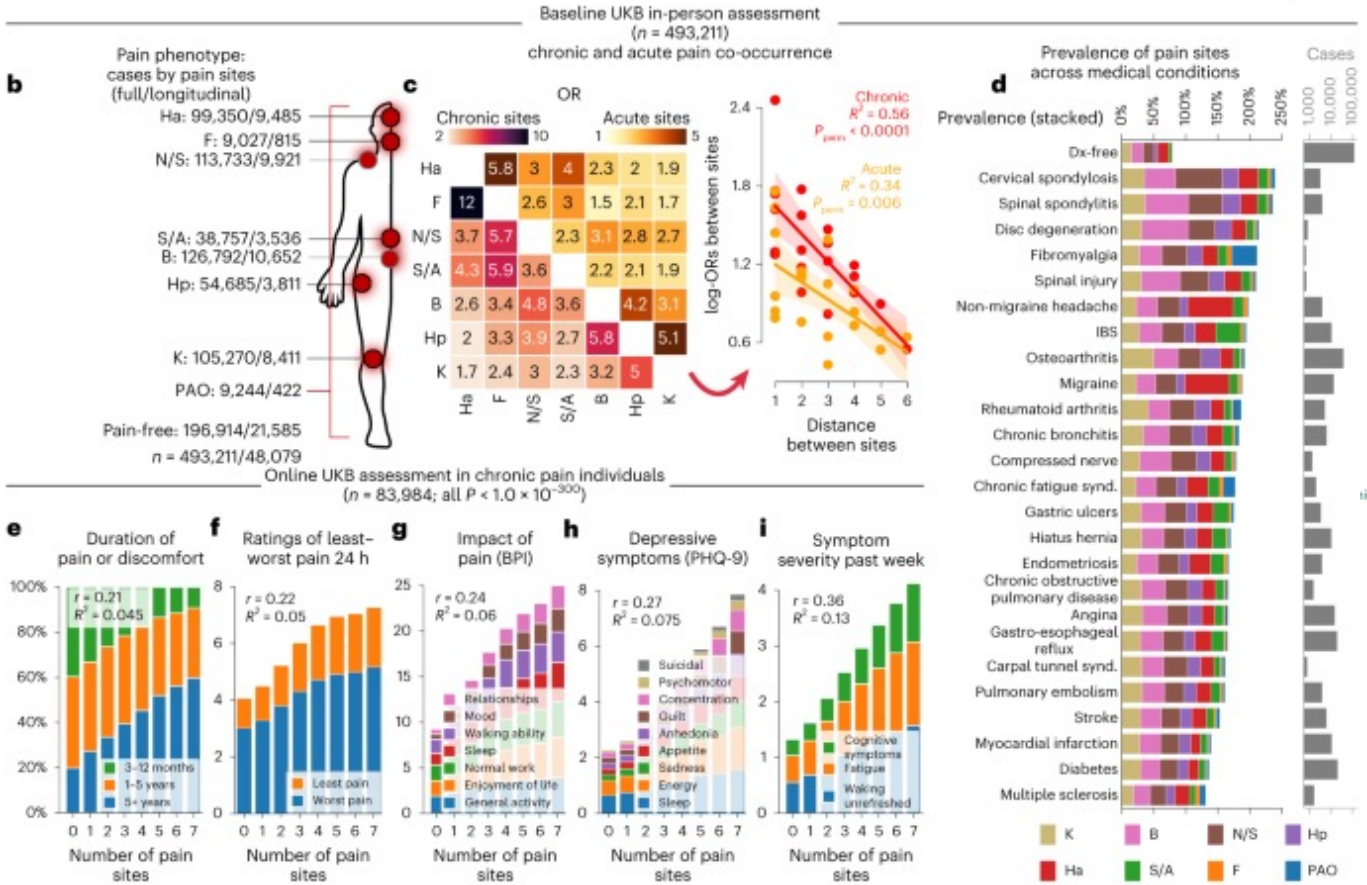
Optimization and Orthopedics



The advances of topology optimization techniques in orthopedic implants

Optimization in Pain Managemen





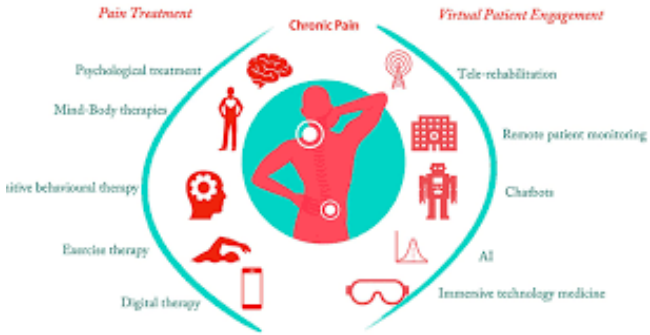
A prognostic risk score for development and spread of chronic pain

nguage analysis

Heart rate variability

Electrodermal activity

Facial expressions



Behavioral methods

Electroencephalography

Benefits of AI

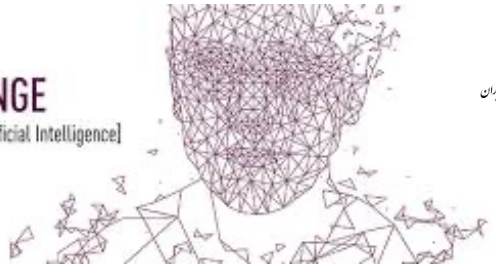
Data Analysis

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.

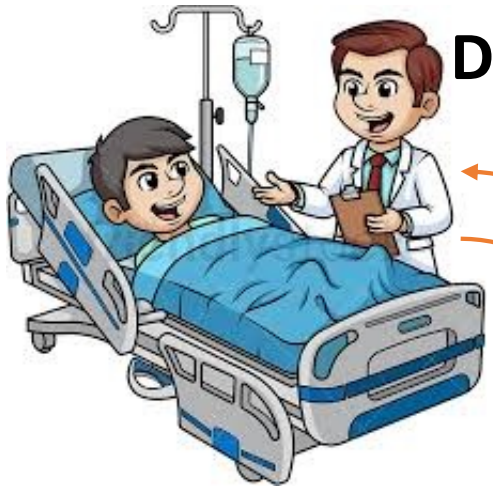
8-AI Medical Application

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

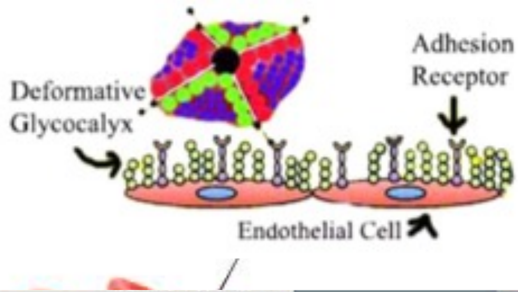


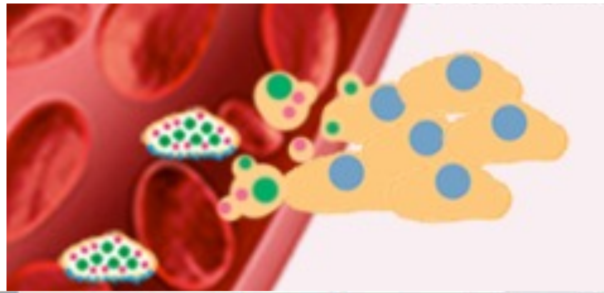
Doctor

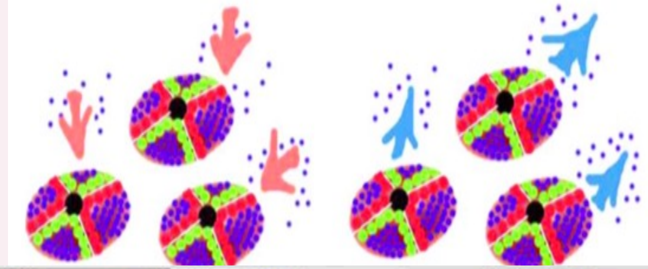
Home

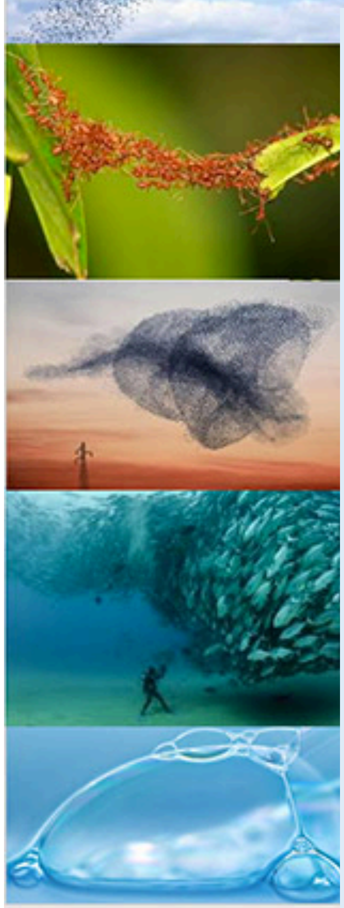
Patient

Post Hospital at Home









Nasibeh Rady Raz, Ph.D.
Department of Artificial Intelligence in Medicine, Faculty of Advanced Technologies in Medicine, Iran University of Medical Sciences, Tehran, Iran

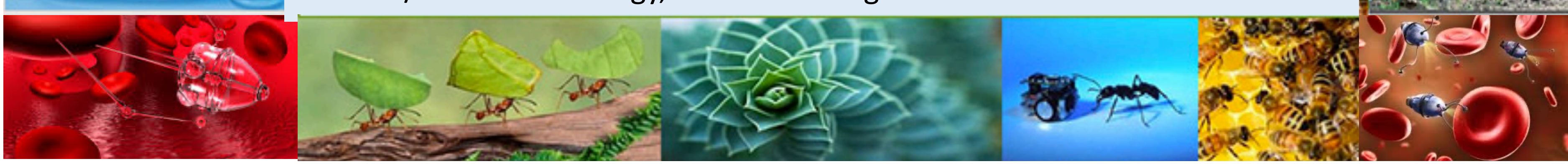
MA, Ph.D., and Postdoc in Artificial Intelligence and Robotics

Website: http://radyraz.student.um.ac.ir/

Email: radyraz.n@iums.ac.ir , radyraz@mail.um.ac.ir, radyraz@yahoo.com

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)