NexTech 2023 & NetWare 2023

Theme

Achievements and Challenges of AI on Medicine and Healthcare

Key topics

- Health Data Exchange Requirements for building precise AI.
- Healthcare Applications of AI in Interactive Voice Response Systems.
- Health Digital Twins as tools for Precision medicine.
- Advanced AI applications in Biomedical research and Healthcare.
- Application of machine learning to gait analysis of dialysis patients.
- Achievements and Challenges of Radar-Based AI on Digital Health.

CONTRIBUTORS

PORTO
September 2023

Moderator

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Achievements and Challenges of AI on Medicine and Healthcare

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September 2023

Key terms

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Artificial Intelligence(AI) deals with development of **intelligent computer systems** designed to analyze data, extract knowledge from patterns, allow decision making and solve problems through processing Big data resources. AI systems mimic intelligence in human behavior such as language processing, reasoning and problem solving.

Generative AI (GA) allows to generate text, images or other media employing generative models like large language model chatbots (ChatGPT, Bing Chat) tuned to target conversational usage.

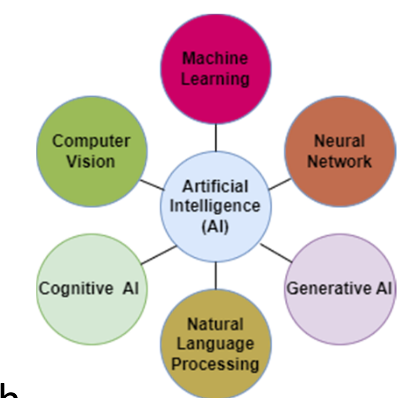
Cognitive AI (CA) has emerged alongside **GA**, as a formidable approach redefining human-machine interactions by simulating human thought processes, encompassing functions such as understanding language, reasoning, learning, and decision-making.

Machine Learning (ML) is a branch in AI that deals with algorithms and models enabling systems to learn from data, make predictions and facilitate decision making without explicit programming. **Deep Learning (DL)** is a subset of **ML** for processing complex data such as image, speech, and text with little human intervention but requires more time and computational resources.

Neural Networks (NN) make up the backbone of **DL** algorithms where several layers of **NN** are used to identify elementary correlations among large amounts of data by resembling the reasoning activity of the human brain through lots of neurons.

Natural language processing (**NLP**) is a branch in AI that deals with the development of methods for searching, analyzing, comprehending, and extracting meaningful information from textual input.

Computer vision (CV) is a branch in AI that enables the computer to identify, analyze, and interpret visual input from real-world images and visuals by capturing and intercepting it. Makes use of **DL** and pattern recognition to extract visual information from data sources like MRI scans, X-rays in healthcare for evaluating the patient’s health status.



Achievements and Challenges of AI on Medicine and Healthcare

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Major AI achievements in Medicine and Healthcare include:

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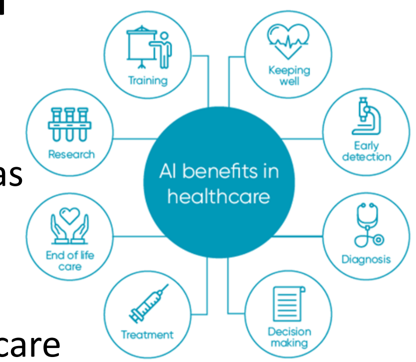
Virtual Health Assistants. **GA** applications automate tasks related to management of medical information, diagnosis and treatment, automate chronic disease management such as remote monitoring, preventive care, patient intake, and referral assistance. **AI** chatbots carry out front-line triage in urgent care, assist medical professionals with providing care services or recommending tests to rule out a diagnosis by comparing patient history and symptoms.

Enhance Diagnostics Through Big Data. Mining large amounts of medical records is one of foremost potential-showing AI applications in healthcare. **Clinical Decision Support** tools allow to explore the hidden rules and standards of medical diagnosis in the electronic medical record system, provide assistant decision-making for physicians in the diagnosis and treatment of diseases and reduce chances for diagnostic errors.

Treatment of Rare Diseases. Discovery and development of cutting-edge breakthrough drugs and vaccines, revolutionizing the way healthcare is provided. **CA** tools allow the discovery of top-ranked genes proved to be linked to a rare disease.

Analysing Medical Images. AI can examine enormous amounts of data from Electronic Health Records (EHRs), radiography, **CT** scans, and magnetic resonance images. By comparing data across patients, finding patterns, and detecting associations, **AI** systems can help with early symptom predictions.



Drug discovery and development. AI assists in structure-based drug discovery by predicting the 3D protein structure as well as predict drug–protein interactions. **AI** reduces time and costs for clinical trials for identifying the best drug targets to test for various diseases, deliver appropriate treatment to the required patients at the right time (**Targeted treatment**)

Medical Virtual Reality. Healthcare simulations are broadly used to improve the safety, effectiveness and efficiency of healthcare services such as preoperative planning and training of surgeons. **Surgical robots** use **CV** to maximize visualization and precision in minimally invasive, robotic-assisted surgeries.

IARIA

Achievements and Challenges of AI on Medicine and Healthcare

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AI challenges in Medicine and Healthcare include:

- **Lack of quality medical data** that is needed for the validation of AI models. The sensitive nature and ethical constraints attached to medical data make it difficult to share. **Limited availability and interpretability** of large amounts of data, which are key for training AI models, present a pressing practical challenge for implementation
- **Clinically irrelevant performance metrics** that do not reflect the real-world impact of AI models. The discrepancy between the clinical efficacy demonstrated in the real world and the technical precision of AI tests is referred to as the AI chasm.
- **Methodological research flaws** that may compromise the validity and reliability of AI models. Most research studies are retrospective and based on historical patient medical records, while to realize the true value of AI diagnosis in real-world settings, physicians must study current patients over time, which means prospective research.
- **Regulatory requirements and gaps** that may limit the scope and speed of AI deployment.
- AI models become more complicated to deliver better outcomes. This complexity causes **trust issues** with machine learning results that may affect the acceptance and adoption of AI by clinicians and patients.
- **Patient reluctance** is another major challenge in implementing AI in healthcare. People are resistant to change and are more inclined to accept familiar things, especially when it comes to healthcare.
- **No consensus on safety, ethics, and privacy issues** related to AI.

Cleansing data before training the predictive model takes up to **80%** of data scientists' time

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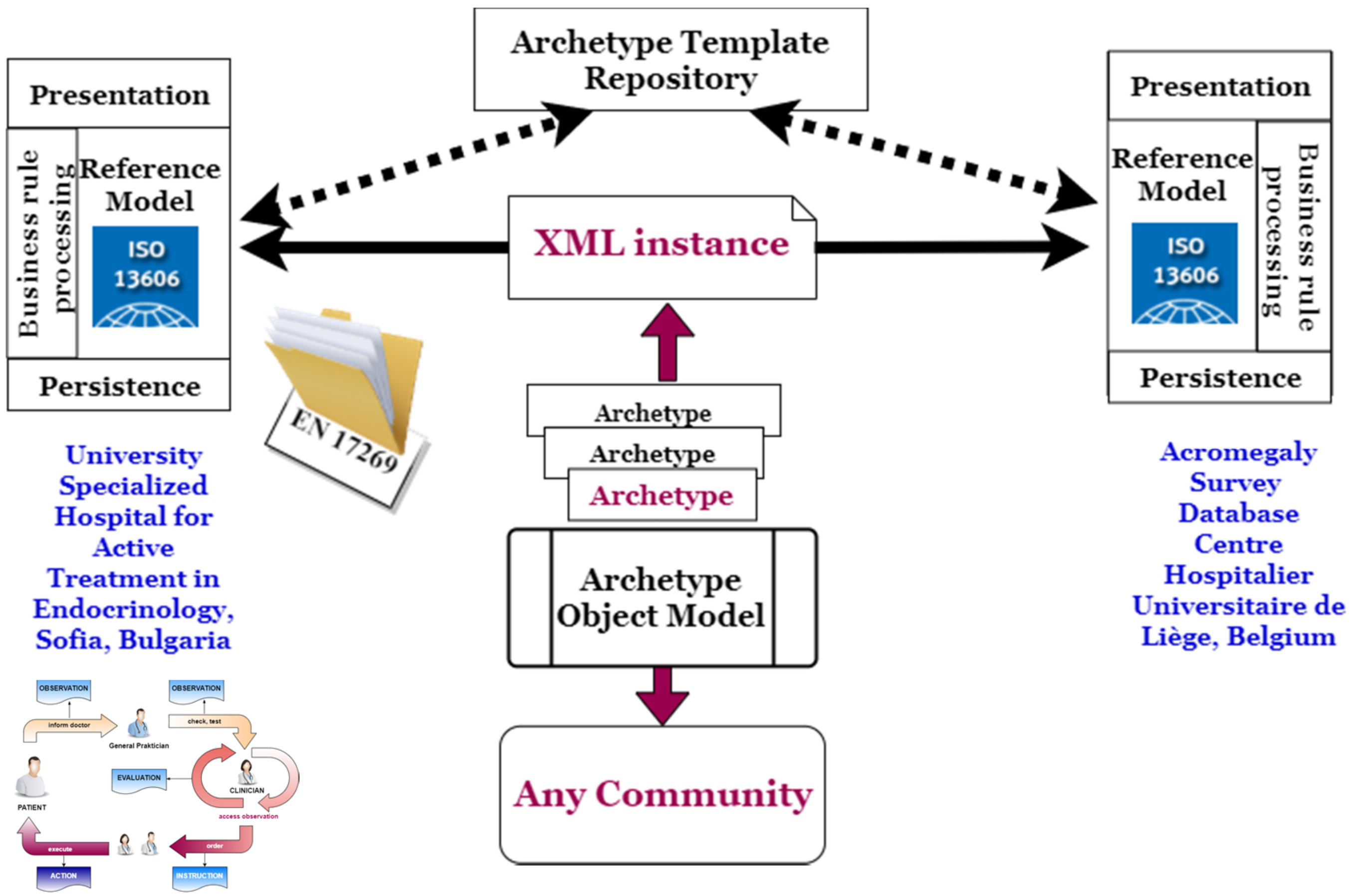
Health Data Exchange Requirements for building precise AI



Development of Networks to **exchange and share health records** and documents through **semantic interoperability standards** [1] .

ISO 13606 openEHR HL7 International HL7 FHIR

Health technology assessment(HTA) and **transformation policies** for healthcare digitalization through CDM [2].

OMOP Common Data Model

The Observational Medical Outcomes Partnership (OMOP) Common Data Model (CDM) is an open community data standard, designed to standardize the structure and content of observational data and to enable efficient analyses that can produce reliable evidence.

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EFMI Institutional Member
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EHDEN *Data Partner*

GDHP Global Digital Health Partnership

[1] E. Krastev et al. "**International Patient Summary Standard Based on Archetype Concepts**" *Int. J. on Adv. in Life Sc., vol. 12,, (2020),* http://www.iariajournals.org/life_sciences/
[2] E. Krastev et al. ,"**Common Data Model for Interoperability of Observational Health Data: Bulgarian Diabetes Register Pharmacology Case Study",**

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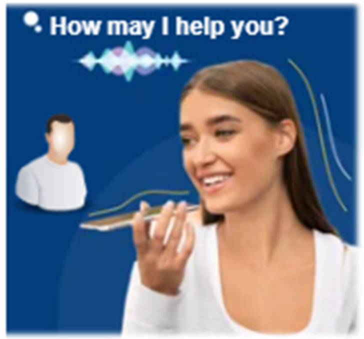
Healthcare Applications of AI in Interactive Voice Response Systems

Voice-Controlled Intelligent Personal Assistants (PA) in Health Care (ChatGPT, Bing Chat)

Use cases include: [3]



1. Create an intuitive, personalized first point of contact using "*voiceprint*".
2. Deliver natural, conversational interactions (*Infer intent and ask questions, Understand next steps, Recognize the unrecognizable, Predict and anticipate*).
3. Identify patterns and connections that may not be immediately apparent to a human clinician.
4. Provide education-level services answering frequently asked questions based on a knowledge database
5. Perform data collection services
6. Optimization of processes (medication reminders, prescription refills etc)

Challenge:

PA like **ChatGPT** may be biased from its learning. As we know: "...*ask three doctors, and you'll get three differing opinions*", while PA provides a single opinion. **The question is which one is the "right" opinion**? [4]

[3] Lee H. et al., Interactive voice response system (IVRS) in health care services. Nurs OutlookNov-Dec;51(6):277-83. (2003) doi: 10.1016/s0029-6554(03)00161-1.
[4] Ermolina, A and Tiberius, V. Voice-Controlled Intelligent Personal Assistants in Health Care: International Delphi Study. J. of Med. Int. R, 23(4), e25312. (2021). doi:10.2196/25312

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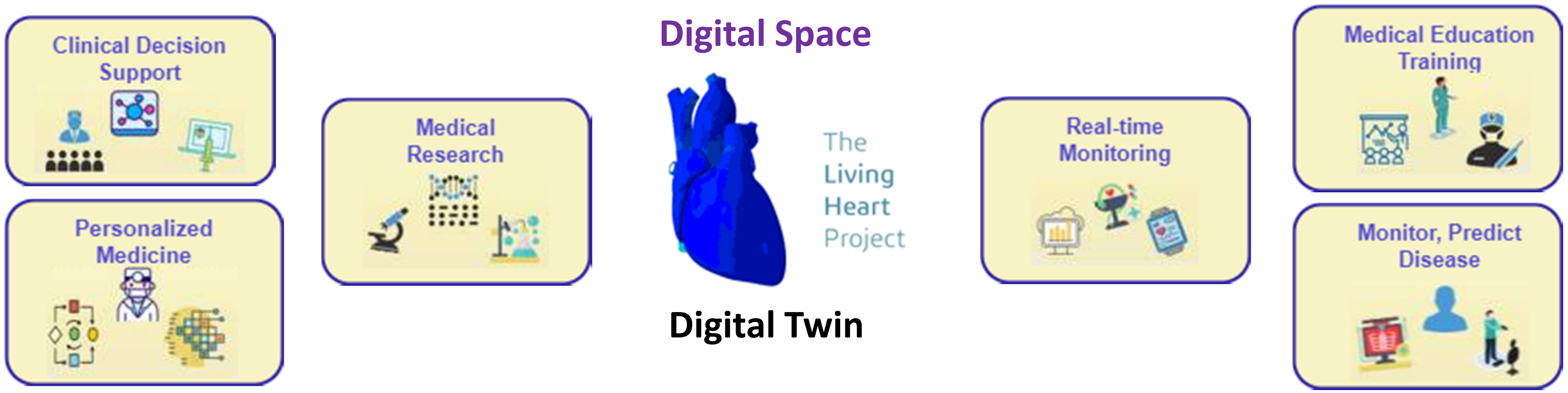
Health Digital Twins (DT) as tools for precision medicine



The **DT** is **a virtual representation** of a patient, its **Physical twin** (**PT**) , that is generated from multimodal patient data, population data, and real-time updates on patient and environmental variables. It requires closed-loop real-time optimization of two components:

(1) **AI** systems that simulate human reasoning using **Big data processing** and **Pattern recognition** and

(2) **Internet of Things** (**IoT**)

to facilitate **rapid data synchronization** between the **PT** and the **DT** [5]. Additionally, the **DT** needs a virtual representation of the **DT environment** where it will operate.

The **DT** allows to **monitor**, **diagnose**, **predict disease** and **optimize treatment** ***in real-time*** [6].

[5] Kamel Boulos, M.N.; Zhang, P. Digital Twins: From Personalized Medicine to Precision Public Health. J. Pers. Med. 2021, 11, 745. https://doi.org/10.3390/jpm11080745
[6] Coorey, G. et al. The health digital twin to tackle cardiovascular disease-a review of an emerging interdisciplinary field. NPJ Digit. Med. 5, 126 (2022).

Output highlights

- **AI-powered algorithms** can analyze vast amounts of patient data, enabling physicians to make more informed decisions in real-time.
- The progress of **AI-driven personalized medicine** depends on the **integration of Big data** from several disparate data sources containing heterogeneous information.
- **Health data digital transformation** based on **Semantic interoperability standards** and **Common Data Models** is a **key requirement** to build **precise AI models.**
- **Health Digital Twin technology** is about to bring health care one step closer to truly personalized medicine.
- AI technologies have **great impact on Advanced Biomedical Research**.
- **Machine learning algorithms** can be successfully implemented for the gait analysis of dialysis patients
- **Radar-Based AI** has a broad set of useful applications in monitoring different aspects of patient's health status.

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Panelist Position

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Achievements and Challenges of Radar-Based AI on Digital Health

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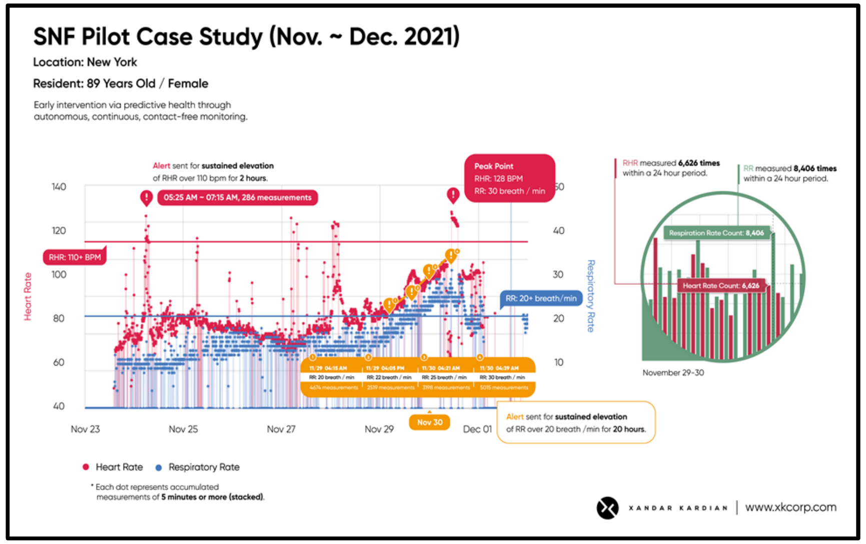
- **Why Radar?**
  - » A non-contact method for convenience of practical use
  - » Personalized and continuous monitoring
  - » Well suited for prediction, prevention (or early screening), and timely intervention
  - » No privacy issues
  - » Low Cost
- **Radar-Based Achievements**
  - » Vital sign monitoring (VSM):
    Breathing and heart rates, Arrhythmia detection,
    Heart rate variability (HRV), Fatigue, Stress, VSM for dogs
  - » Sleep Monitoring:
    Sleep apnea, Sleep efficiency, Sleep stage classification
  - » Emergency:
    Fall detection, Fall risk prediction,
    Personal emergency response system (PERS)
  - » Indoor Activity Monitoring:
    Gait analysis, Presence detection, People counting, Gesture recognition,
    In-air writing, Movement quantification, Movement/behavior classification



Achievements and Challenges of AI on Medicine and Healthcare

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Achievements and Challenges of Radar-Based AI on Digital Health

- **Radar-Based Challenges I (R&D Aspects)**
  - » Chronic Diseases:
    Hypertension, Diabetes, Insomnia, Asthma, Pain
  - » Mental Disorder:
    Depression, Generalized anxiety disorder,
    Neurological disorder (Dementia), Schizophrenia
  - » Behavior Disorder:
    Substance use disorder (SUD), Opioid use disorder (OUD),
    Obesity, Attention deficit hyperactivity disorder (ADHD),
    Autism spectrum disorder
  - » Neonates, Newborns, and Infants:
    Sleep disorder, Growth delay, Developmental disorder,
    Neurodevelopmental impairments (NDI)

- **Radar-Based Challenges II (Commercialization Aspects)**
  - » Recruiting a sufficient number of participants:
    Patient group vs. Control group, Training group vs. Test group
  - » Clinical validation:
    Radar vs. Gold standard, Radar vs. Human decision (video, questionnaire, interview, etc.)
  - » Medical certificates:
    European Medicines Agency (EMA) – Community Authorization vs. National Authorization,
    U.S. Food and Drug Administration (FDA), Korea Ministry of Food and Drug Safety (MFDS)

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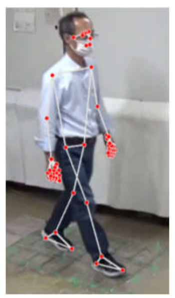
Our research related to AI

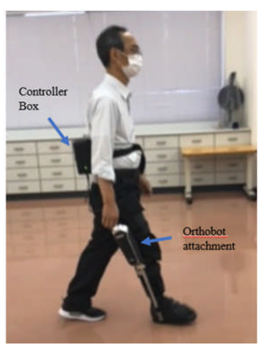
Gait analysis using MediaPipe (Global health 2022, 2023)



Without motion restriction

With motion restriction

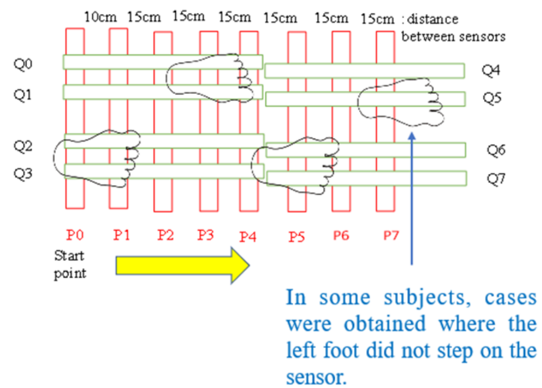
Results of skeletal analysis of movement using a media pipe to analyze video from oblique above. The angle of the knee, etc. can be obtained by calculation.



The Orthobot, which can control the knee, was attached to a conventional knee and ankle orthosis to determine its effectiveness.

Ref. Y Uchida, et. al.,IARIA, 2022. ISBN: 978-1-61208-995-9, J. of Advances in Life science, vol.15, no 1&2, 2023, pp. 45-55.

Application of machine learning analysis to the gait of dialysis patients before and after hemodialysis



Sample No	v (km/h)	nL	nR	|⊿n|/ n
1	1.44	3	4	0.143
2	1.245	3	0	1
3	3.112	1	2	0.333
4	1.859	5	2	0.429
5	1.286	3	2	0.333
6	0.873	6	0	1
7	1.507	3	4	0.143
8	2.878	2	1	0.333
9	1.34	3	5	0.286
10	0.487	1	7	0.857
11	1.294	4	0	1
				⊿n=nL-nR
				n=nL+nR

Each sensor measured voltage at 1 kHz the signals from 16 sensors were considered in pairs, with the PC connected to an Arduino Mega2560 R3, using a program created with Processing3.

Based on the results, the numbers of steps *nL* with the left foot (L) and *nR* with the right foot (R) were counted. The new balance index is defined as follows;

$$\frac{|\Delta n|}{n} = \frac{|nL - nR|}{nL + nR}$$

Ref. Y. Uchida et. al., Sensors & transducers, Vol.259, pp.29-36

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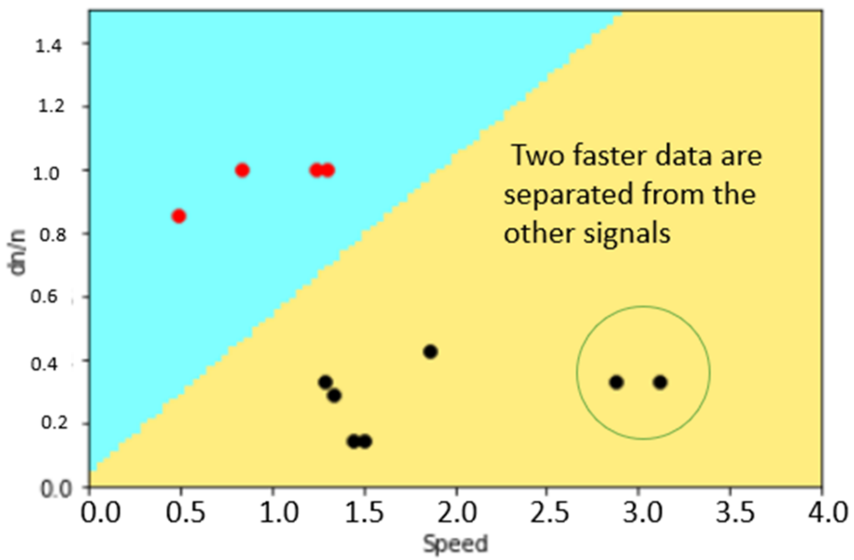
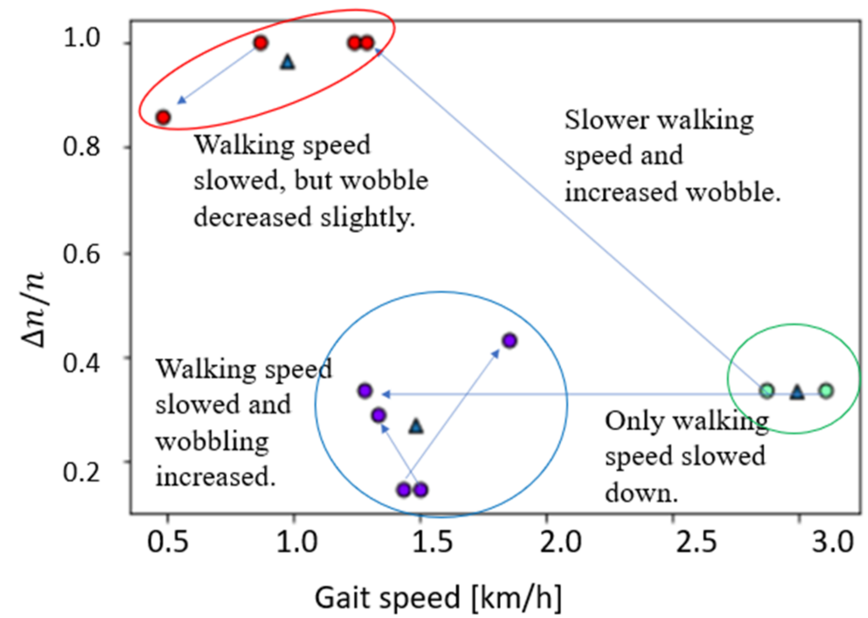
Panelist Position

Analysis by SVM Method



Although the features could be classified into two regions, it was also found that they did not adequately reflect the subject's condition.

Analysis by K-Mean Method



The ▲ in the figure represents the center of gravity of the clusters. The differences in walking speed and number of steps between the left and right sensors before and after dialysis allowed classification that reflected the characteristics of the subjects.

NexTech Panel I
Achievements and Challenges of AI on Medicine and Healthcare

NexTech 2023

Panellist Position

The Role of AI-rich Biomedical Informatics in Advancing Biomedical research and Healthcare

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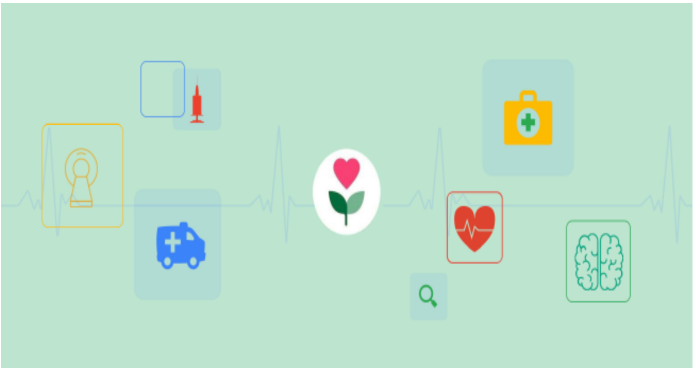
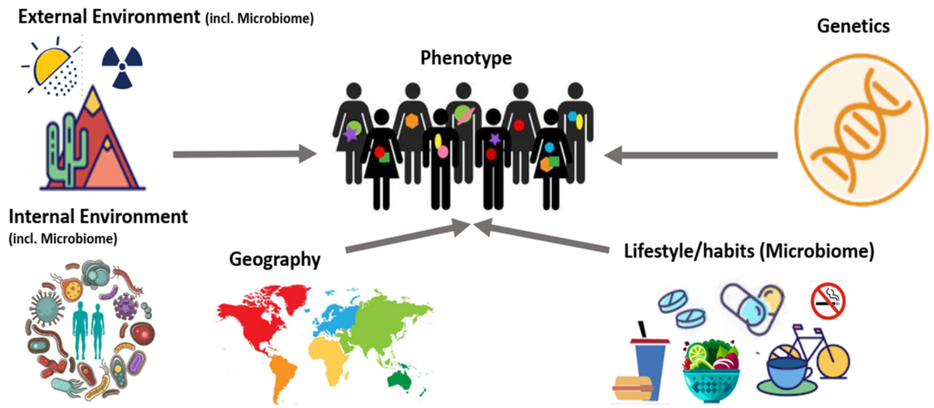
Summary of position:

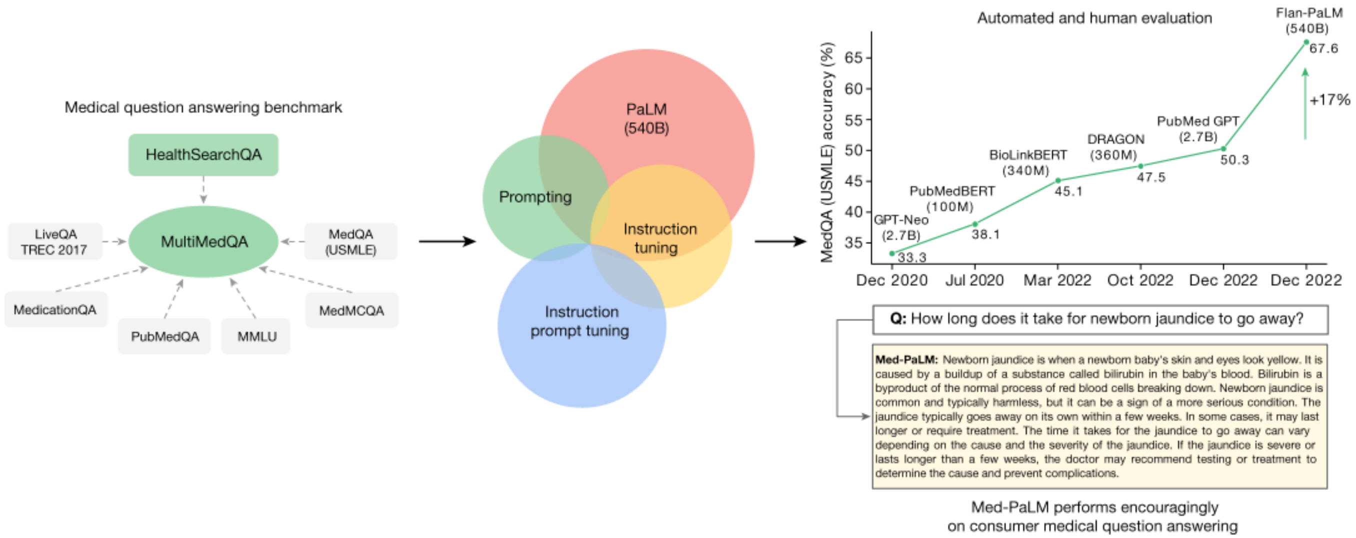
- Every generation, a scientific discipline emerges with a bang and promises to change the way we do things and dominates the scientific scene
- Biomedical Informatics (BMI) has that potential to be a dominant force in next generation science and significantly impact biosciences and healthcare.
- The impact of AI emerging tools on healthcare and biomedical research is likely to have a wide-range of impact levels. For example, The impact on mainstream common healthcare issues may be significant while the impact on advanced biomedical research may be gradual and less immediate.
- Hopefully, the expected impact will push medical education to focus on advanced topics and personalized healthcare rather than the widely used general or generic education.
- Next generation BMI tools are expected to focus on developing data integration approaches and advanced algorithms for detecting weak phenotype signals.



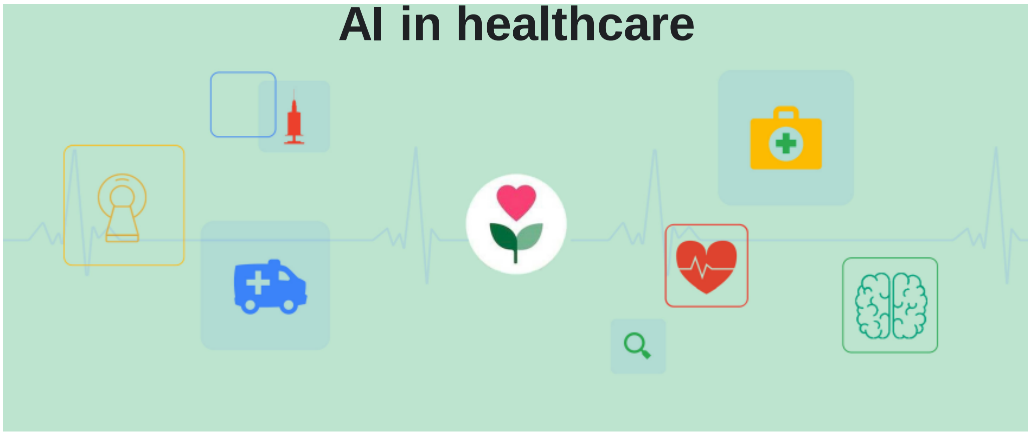


The Role of AI-rich Biomedical Informatics in Advancing Healthcare

- The emergence of Large Language Models (LLM) promises to impact the next generation of healthcare. Med-Palm2 is a glaring example.
- Mainstream healthcare issues which constitutes at least 50% of healthcare transactions can be addressed by these models, example:
  - Interpretating most medical images.
  - Analyzing Pathology Reports.
  - Dealing with general practice type questions.
- Medical experts remain much needed for advanced or non-common medical issues.
- Hopefully, the impact of these emerging systems will be on medical education and not just ad-hoc user applications.

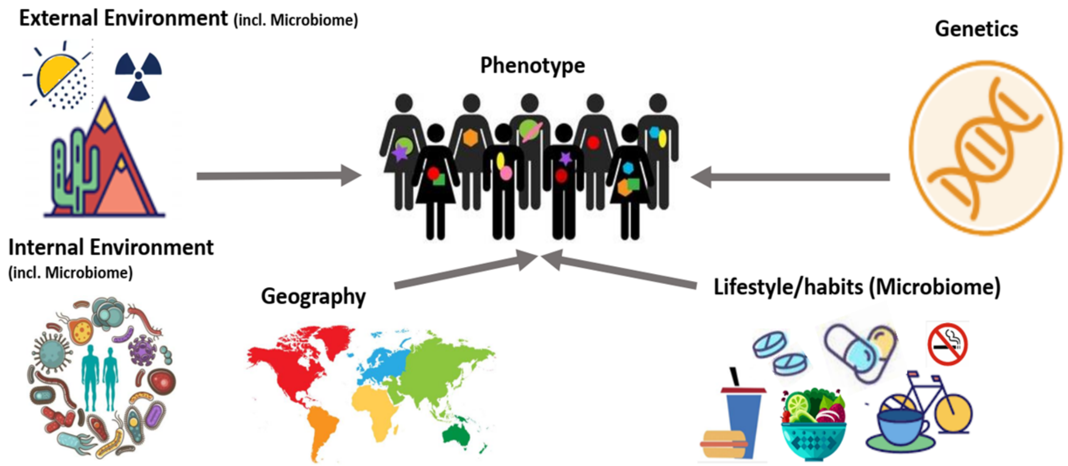


MED–PaLM2: A responsible path to generative AI in healthcare



The Role of AI-rich Biomedical Informatics in Advancing Biomedical Research

- AI is intelligence demonstrated by machines using patterns of available data, unlike the natural intelligence displayed by humans and animals
- Using AI to advance medical research is not new, we have been using data-driven approaches in BMI from the beginning and it continues to evolve.
- With parents in computing and biosciences, Bioinformatics inherited genetic disposition to high degree of trendiness. How long would that continue?
- Popular BMI tools have been using mostly black box models which is not idea for developing and applying AI tools. Would researches adopt glass box models?
- AI tools need structures, such as biological networks, and some customization. Could AI and network biology work together to further advance Bioinformatics and accelerate its impact on biomedical research?



- Every time the continuously evolving biomedical technologies make it possible for researchers to have access to new type of biological data, new research questions attract new studies. Would AI keep up with this trend?
- Sometimes the signal is week and only data integration will allow researchers to obtain stronger (distinguishing) signals.