The usage of digital twins in healthcare for personalised care

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research data sharing without barriers
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After having dealt, in our last two virtual sessions, on “Transparency and Trust in Health Data” (P16 Costa Rica) and “Achieving anonymity and correcting bias with synthetic data through generative AI” (P17 Edinburgh), today’s topic for the HDIG is:

The usage of digital twins in healthcare for personalised care

Our discussion will aim at defining:

- The broad concept of the Digital Twin (DT)
- What is its specific meaning in healthcare (DTH)
- What is its further outlook for a comprehensive Human Digital Twin (HDT)
- What initiatives are ongoing for developing a DTH ecosystem
- What can be the usage of a repository and a simulation platform for DTH
- What can be a roadmap for attaining these goals and integrate multiple DTH into a multiscale, multi-organ and multi-disease HDT
Generally speaking, a DT is a virtual/digital replica of physical entities, processes, or systems that allow to simulate the consequences of model-driven decisions.

When applied to healthcare, DTH allows to virtualize healthcare experience, in view of optimising personalised patient care and improving operational efficiency of providers’ performance.
Potential applications of DTH

- **Personalisation of medical care:** DTH can take the shape of in silico models of organs and organ systems to
  - test various treatment options
  - customise therapy
  - plan surgery.

- **Development of medical therapies (drugs and devices):** DTH can be used as a tool throughout the R&D process to
  - identify knowledge gaps and flaws
  - obtain a holistic and better understanding of a patient's disease
  - design novel strategies
  - optimise therapies
  - increase safety (for example, by providing additional scrutiny)
  - shorten the time to market.

- **Helping improve healthcare organisations:** DTH can help in driving efficiency, optimising operational performance and enhancing both patient and caregiver experience.
The EC, within its Digital Europe Work Programme 2021-2022, launched a call (DIGITAL-2021-DEPLOY-01-TWINS-HEALTH) for a Coordination and Support Action leading to:

- develop an ecosystem of digital twins for healthcare
- a framework to structure cooperation and leverage on synergies between academia, private sector, regulators and end-users
- in view of better prevention approaches, faster and more accurate diagnoses, personalised treatments and care.

The three requested objectives of the CSA have been indicated as consisting of:

1. A roadmap for the development of a strategic approach to accelerate the uptake of DTH-based solutions and for further integrating the resources towards a comprehensive virtual representation of the human body.
2. A governance framework for a federated, cloud-based repository, combining DTH resources, as well as the subsequent use and deployment of the repository.
3. The blueprint and technical specifications for a simulation platform for DTHs, and early prototypes.
Last week, the European Commission communicated the exciting news that EDITH is the winning proposal for this 24-months CSA.

The acronym stands for “An Ecosystem for Digital Twins in Healthcare”.

EDITH is a consortium comprising 19 partners, led by the VPHi.

It includes, in its Multi-Stakeholder Advisory Board, also non-European partners, such as the 12 Labours project, coordinated by Prof Peter Hunter (University of Auckland), and the SimVascular project and the Cardiovascular Biomechanics Computation Lab, directed by Prof Alison Marsden (Stanford University).
The goal of a Human Digital Twin (HDT)

- **The European Commission definition:**
  “a validated, integrated multi-scale, -time and -discipline digital twin of the whole body enabling the comprehensive characterization of the physiological and the pathological state in its full complexity and heterogeneity”

- **EDITH’s proposed vision for human digital twins:**

  *The HDT can be a distributed digital infrastructure, made of data and model standards, standard operative procedures (SOPs), and APIs, that allow the DTH community to accrue the predictive models as they develop and all experimental and clinical data employed in building and validating the models, into a shared facility for reuse and collaboration.*
What is needed

A combination of following areas is necessary to deliver this vision for HDTs:

1. **In silico medicine**
   • Predictive models of human (patho)physiology: both mechanistic and data-driven.

2. **Artificial Intelligence**
   • Extend image processing from one system to another
   • Aid mechanistic models and quantify uncertainties.

3. **Wearable technologies**
   • Gather real-time data and enable its exploitation through predictive models

4. **Data standardization, availability, and access**
   • Federated learning technology
   • Privacy preserving utilisation of personal health data

5. **Research Infrastructures, repositories and platforms**
   • Multiple sites for contributing research data and multiple supercomputing facilities
   • Open repositories for models and codes, including curated catalogues for searching
   • Platforms that enable open access to models, codes, and data: also allowing simulation

6. **Engagement with ALL stakeholders for maximum exploitation of HDTs.**
A community effort: engagement with ALL stakeholders is critical

- Key stakeholders:
  - Clinicians, engineering, and scientists
  - Data providers, repositories and platform managers
  - Medical device and pharmaceutical industry
  - Policy makers
  - Regulatory bodies

- An AI-enabled crowdsourcing platform can be used for engagement and collaboration with all the stakeholders in a time-sensitive manner. This can
  - enable stakeholders to assess and provide feedback in real-time on the evolution of the HDT ecosystem.
  - allow rewarding and meaningful exchange leading to co-creation and consensus for the HDT ecosystem.
  - allow continuous input, open scrutiny, and representation of all interests.
  - allow the evolution of policy and regulatory decision-making.
Challenges and opportunities

- A yet nascent ecosystem which needs to be built
- Many players, diverse interests, and many applications
- Policy and regulatory uncertainty
- Lack of data repositories
- Concerns around privacy when human data is utilized
- Lack of secure data infrastructure and secure computation
- Lack of consensus on the practical utility and exploitation of real-world and synthetic data
- Lack of data and model standards
- Lack of EU consensus on HDT verification and validation
- Lack of open simulation platforms available to users
- Fragmentation of predictive models and siloed data repositories
- Ethics, reliability, and explainability of AI in healthcare