RESEARCH NEWS

Digital transformation of the healthcare sector

Digital Patient Twins for Improved Diagnosis and Treatment

Creating a digital twin of a machine is already a highly complex undertaking. So how difficult must it be to do that with a human organism? Researchers from the Fraunhofer Institute for Experimental Software Engineering IESE are working on the possibilities, challenges and potential of digital patient twins. They aim to test medications on a digital "replica" in the future before a person ever takes their first pill. In this interview, Dr. Theresa Ahrens and Dr. Jonas Marcello, who jointly lead the Digital Health Engineering department at Fraunhofer IESE, explain the benefits and added value of digital patient twins.

What is a digital patient twin?

Theresa Ahrens: Essentially, a digital patient twin is a precise and dynamic virtual counterpart of biological units. This kind of highly developed model can simulate, for example, cell structures, tissue, organs or even entire people, ideally containing all of the information on its real-world counterpart, by which I mean the actual patient. Digital patient twins are dynamic, so they factor in changes occurring over time, and they can simulate fundamental physiological processes. This allows us to make various predictions, such as about physiological functions, which are helpful if doctors are considering certain medications for a patient, for example.

How might digital patient twins improve medical care?

Jonas Marcello: Digital patient twins have vast potential for a wide range of different applications. To give an example, the models could help visualize metabolic processes inside the body. One big opportunity that virtual twins offer in medicine is that they can be used to identify a medication's effects, including drug interactions and side effects, even before the person takes their first pill.

Are there parallels to mechanical production?

Marcello: As with a digital twin in a production environment, where machines can undergo predictive maintenance, the situation is similar here: This paves the way for predictive health monitoring. And the technology also opens new doors when it comes to early screenings and prevention since the virtual replica can provide clues in the beginning stages of a health problem or reveal an elevated, specific risk of illness. This allows

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us to take action early on, which can help prevent long-term consequences for patients.

Might a digital twin affect the handling of treatment methods and research questions?

Marcello: Digital patient twins could have a beneficial effect on clinical trials. Trials involving human subjects could potentially be simplified and accelerated by digitally simulating aspects such as efficacy or dosage on the twin in advance. So far, there have only been a few clinical trials involving digital patient twins worldwide. Diabetes in particular is viewed as a model disease in this regard.

What are the challenges?

Ahrens: In general, we already know quite a lot about the molecular mechanisms involved, meaning how cells work and communicate with each other. And yet, people are not machines. It is impossible to build a precise simulation and predict exactly what will happen. That means there will always be certain limits to digital patient twins since we don't yet have the ability to simulate this full range of complexity at the molecular level. But even just a virtual replica of individual organs can have a big impact.

Which organs lend themselves most effectively to the digital twin approach?

Ahrens: In principle, it would be desirable to have a functioning digital twin model for all organs. Great strides have been made with some of them. One good example is the successful use of a digital twin heart in cardiology. The digital twin brings together all the relevant health information and interacts with AI to collect important cardiovascular data and combine it with other relevant information, such as lab values or the results of medical imaging. Another example is digital lung twins, which are individualized for patients. This form of twin is intended to allow doctors to test certain treatment and ventilation methods on a computer ahead of time, with the goal of providing each and every individual patient with the least burdensome form of ventilation possible.

How is a digital patient created?

Marcello: Creating a digital twin of a patient requires huge amounts of high-quality data — and by that I mean long-term data covering a person's whole life. Assuming you had all the data, it would still be a technical challenge to integrate the information from various data sources into a shared cosmos. And data protection is also a sensitive topic in this context. Who is allowed to access the data and from where? Who authorizes access? The reliability of the algorithms underlying the analysis is also a key factor. With our years of expertise in the development of digital twins, data science and data protection, we aim to help realize digital patient twins in healthcare on a comprehensive and holistic basis and contribute to a paradigm shift in personalized medicine.

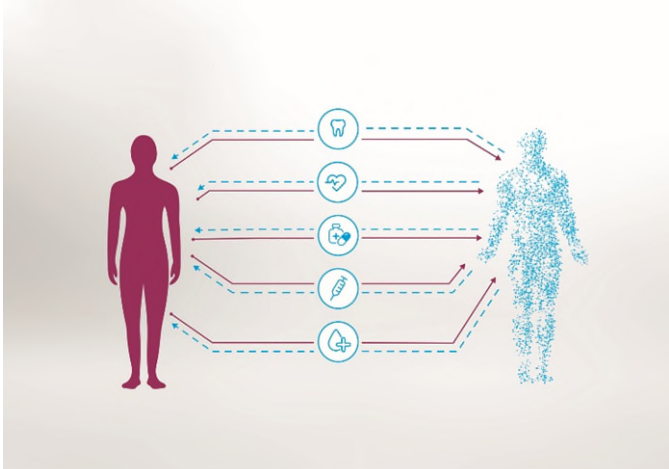

Fig. 1 A digital patient twin can simulate physiological processes taking place inside the human body.

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