Double Trouble

An Ethical Analysis of Health Digital Twins

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April 8, 2023

Overview[1]

Simply put, health digital twins (HDT's) are virtual representations of an individual's health. These are complete visualizations that are generated from patient, population and medical data that is compiled instantaneously. Patient data is collected through scanning (full body MRI), sampling (urine, blood, saliva) and surveying (i.e., family medical history, current lifestyle) to create the digital twin. When combined with real-time medical data (i.e., disease information, medication interaction information), the HDT system generates predictions about potential health risks, or changes. These data-driven predictions can directly impact diagnosis, treatment, and post-op care.

Retrieving, comparing, and processing large quantities of data require the HDT system to employ a couple technical concepts. To coordinate data processing and synchronization (input), the HDT uses a *Cyber-Physical System* (CPS). The CPS consists of artificial intelligence to imitate human reasoning using big data and machine learning and the Internet of Things (IoT) so to quickly integrate data about the actual patient into the digital twin. For data analysis and predicting, *Closed-Loop Optimization* (CLO) is used. This process permits quick computation of large numerical functions and simulations using machine learning (i.e., predictive analysis). To wrap all of this up into the HDT, *Deep Phenotyping* is used to automate data collection and mapping to create the HDT.

HDT is a new technology, but there are a few companies that are leading the development race; notably, q.Bio. This American company boasts a testing clinic, the *Mark 1* full-body scanner and the *Gemini Dashboard* to review results and risks. After collecting bio data using blood, urine, saliva samples, the scanner, and a vital signs measurement, the HDT system predicts health risks and metabolic changes. The platform used to store the data, *Gemini*, is easy to interface with and allows for fast and secure data sharing (i.e., medical professionals all around the world can access a patient's data with ease). The main limitation to this technology is the cost. For a single year membership, $3495 (USD) gets you a year of an HDT and permanent access to your medical data. However, every time an individual wishes to complete a test, they must pay the membership fee. Another pitfall of this tech is the necessity of large equipment to collect data and energy to process it. The need for the Mark 1 full body scanners makes this system exclusive and big data processing that happens in the CPS and CLO stage is every intensive and costly.

This technology is based on the Digital Twin Theory that states a digital twin is a tool to increase productivity in the age of digitization. One of the earliest implementations of the digital twin concept was done by NASA when simulating rocket performance in the 1960's. The intention was to find a way to predict and mitigate the effects of substantial changes to the environment or the integrity of the rocket's systems. Over time, digital twins became increasingly prevalent in the engineering manufacturing industry, specifically for large, mechanically complex objects, objects with high power consumption, and manufacturing projects.

[1] From proposal submission

Ethical Analysis

As the benefits of a mirroring, digital society grows, the demand for simulation technology steadily rises. This growth is reflected across all industries, regardless of any preconceived need and demonstrates the speed of modern technology adoption. Digital twins[2] are the pinnacle of modern simulation technology. 'Health digital twins' are set to revolutionize how medical professionals interact with artificial intelligence by creating a digital biological model of an individual. This essay posits that ethical gaps in privacy and accountability on the technological front must be taken into consideration as the HDT continues to evolve. Although this technology is new, specific examples pertaining to *decisional privacy, dataveillance,* and the concept of *many hands* help justify my argument.

Current Take

Right now, the market for health digital twins is in infancy. It can be divided into 3 user groups. Technology suppliers, or *parent benefactors* are creating opportunities for sleek and usable systems that can be seamlessly integrated in medical settings. Medical facilities (private/public clinics, hospitals, etc.) are beneficiaries of HDT simulation software and *benefactors* to patients. HDT systems will improve healthcare and greatly contribute the bottom line. Moreover, in large public health centres like hospitals, public relations can be expected to improve. The third user group is healthcare patients. This group directly benefits from HDT technology and has the latent function of improving the technology through data collection.

The narrative surrounding HDT systems is positive: tech leaders in development, information resources, and the media communicate just how important this opportunity is. HDT has the ability to create models that improve hospital efficiency[3] and the medical 'bottom line'. It gives doctors real time access to critical data and offers predictive analysis for surgery, treatment, and diagnosis. Lastly, HDT systems are capable of improving the general perception of artificial intelligence by facilitating positive experiences with AI through personalized healthcare.

Privacy

Typically, it's just you and your physician when you go for your check-up. There is openness and honesty between the 2 in the room. Based on the recommendation of the doctor, you have complete *decisional privacy*[4]. As HDT technology becomes more popular, patients may not receive the same *transparency* as before because doctors may have limited knowledge regarding how the bit-crunching software actually works. As a result, patients may obliviously make decisions swayed by the HDT system.

Another privacy issue is the access unknown groups may have to the biological information that comprises your digital twin. *Dataveillance* by the data centres that house twin info may stand to gain more by providing other parties with patient's HDTs. Similar to how data collected via internet cookies can eventually fall into the hands of advertisers, such can happen

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[2] *Digital Twins: Potentials, Ethical Issues, and Limitations*. Helbing, Sánchez-Vaquerizo.
[3] Another benefit of HDT tech is optimizing the use of hospital resources (i.e., beds). Via referenced Forbes article.
[4] *Decisional privacy* indicates the individual does not need to worry about interference in their own personal affairs.

for twin data. A possible example is UberEATS tailoring the ads it sends to individuals' phones based on users' dietary restrictions extracted from their twin dataset. Strict policy about the integrity of these data houses should guide *how* HDT systems maintain strong user privacy standards.

Accountability

Who takes responsibility when someone is diagnosed with a cold instead of Covid-19? The *person* who performed the diagnosis. It is important to note the singularity of the accountable in this example. Currently, there is limited policy regarding what accountability looks like after a misdiagnosis by an HDT predictive analysis. When a human-technological system ready to help decide on what surgery should be performed, what medication should be prescribed, or what post-op rehabilitation looks like, the accountable *person* turns into an accountable *group*. Here, the software developers, doctors, and government can *all* be accountable. This is a practical example of the 'many hands'[5] concept. Classically, individuals would bear the weight of accountability for an accident. However, in this system, the HDT and doctor (and/or other groups if applicable) should have *unified* accountability as both contribute to decision-making. If not, we could see stalemates: was the predictive analysis software poorly developed? Why did the hospital decide to integrate the HDT system with current technology if it was not accurate enough? Are doctors using it to *make* decisions instead of *informing* on the right course of action? Moral responsibility creates confusion about how blame for an incident can sometimes be exclusionary[6]. Clear *accountability* is necessary and should be an ethical pillar during the integration of HDTs in the medical industry.

Closing Remarks

This paper provided an analysis of some of the potential ethical gaps present in 'Health Digital Twin' technology. Looking forwards, the results of applying a Utilitarian framework to analyse HDT tech would be interesting and could help answer equivocal questions like: is life in an over-populated world with limited resources ethically worth saving? The benefits of digital twins in healthcare should not be ignored. Other than drastically improving the quality of our biological data and mitigating the effects of serious illness, HDTs will help pave the way for AI development across all industries.

[5] Software is developed by a team/teams (depending on size) of engineers, scientists, and analysts. It takes *many hands* to complete (4.5.2 in *Ethics and Technology*).

[6] When there are multiple actors who are deemed responsible for something negative happening to another party, the responsibility is *nonexclusionary* (Tavani, 2013, p. 119)

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