ISSN 2350-109X
www.indianscholar.co.in

Indian Scholar

An International Multidisciplinary Research e-Journal

COMPUTATIONAL MODELLING IN PRECISION MEDICINE- DIGITAL TWINS

Girija A. Abhyankar
Children's Academy Thakur Complex

Abstract

First proposed by Grieves in 2002, digital twins are a form of computational modelling and simulation used to virtually represent complex systems. Meanwhile, precision medicine intends to develop treatments and preventive measures, considering the diversity in patients. This papershowcases the contributions made by digital twins to the development of precision medicine due to their ability to accurately represent biophysical systems. Based on suitable examples, the paper discusses the merits of using digital twins in precision medicine therapies. This paper also highlights the required changes in contemporary healthcare and society to truly reap the benefits of digital twins.

Keywords:- ***'Computational Modelling', 'Precision Medicine', 'Digital Twin'***

INTRODUCTION

Computational Modelling and Simulation

Computational modelling and Simulation is the use of computers to study and adjust complex systems with numerous variables using an algorithmic or mechanistic approach while observing the outcomes. Due to the inherent complexity of biological systems, the development of computationalmodels is intrinsic to achieving a quantitative understanding of their structure and function in healthand disease. The thousands of computer experiments identify the handful of laboratory experimentsthat are most likely to provide a solution to the problem under study, thus saving time and resources.

Precision Medicine

According to statistics reported by the FDA in 2013, 38% to 75% of patients received ineffective medicines, for numerous conditions from depression to cancer. This is because the variabilities among patients who receive a similar prognosis are not considered. Precision medicine is an innovative approach to customising disease prevention and treatment that takes into consideration the differences in the genes, environments, and lifestyles of people. It aims to provide treatments that reduce the exposure of patients to adverse effects of unnecessary diagnostic testing and therapies and shift healthcare from disease management to disease risk prevention. Large-scale assembly of bioinformatics datasets from a variety of sources sets the stage for a powerful precision medicine ecosystem. Emerging computational techniques such as machine learning and artificial intelligenceis essential for the optimal usage of these datasets.

ISSN 2350-109X
www.indianscholar.co.in
Indian Scholar
An International Multidisciplinary Research e-Journal

Theory: Digital Twins

In 2002, Michael Grieves introduced the initial conceptual model of digital twins in manufacturing management under the names 'Mirror Space Model' and later 'Information Mirror Model'. A digital twin is a virtual model of a physical object, process, or service that dynamically pairs the physical and digital worlds. It leverages modern technologies, such as smart sensor technology, data analytics, and artificial intelligence (AI) to facilitate rapid testing and explore innovative opportunities. Contemporary scientific knowledge and simulation capabilities enable digital twins to be constructedfor modelling various aspects or functions such as protein structures of the human body. By utilising electronic medical records of individual patients and patient-generated data, digital twin technologycan also empower precision medicine research in understanding drug interactions, treatment efficacyand procedure safety. Integration of artificial intelligence and advanced analytics enables digital twins to predict how an object or process will perform with heightened accuracy.

DISCUSSION

Applications of Digital Twins

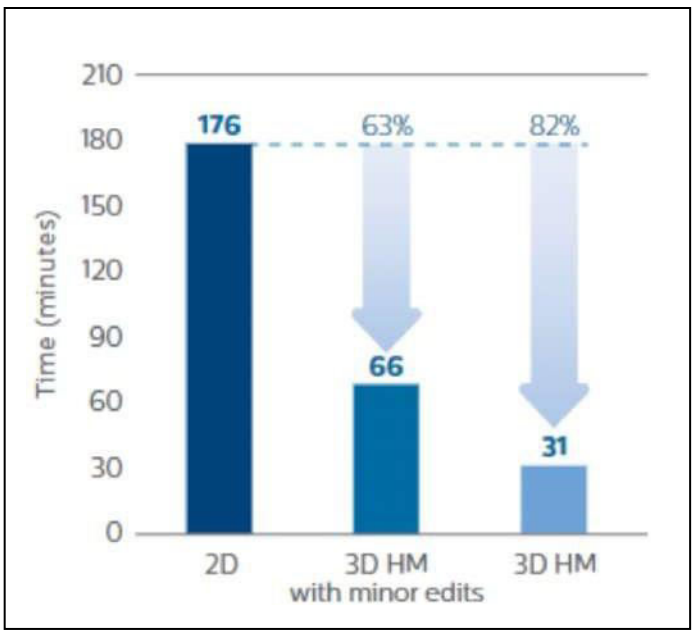
1) Orthodontics:

In a study Cho et al. demonstrated the use of digital twins in the provision of suitable orthodontic treatment to Korean adult females by examining their facial profiles using facial scans and three- dimensional (3D) imaging (cone-beam computed tomography, CBCT). These treatments took into account the differences in the facial structures of Korean and Caucasian patients, thus increasing theefficacy of the treatments.

2) Cardiology:

Fig. 1: Time taken to complete Left Ventricle and Left Auricle measurements using Philips HeartModel (HM) in comparison to 2D imaging and biplane method of disks.

The usage of 'cardiac digital twins' in precision cardiology is another notable example. The 'Living Heart Project' by Dassault Systèmes unites cardiovascularresearchers and clinicians to develop highly accurate digital human heart models. The Philips HeartModel transforms a person's two- dimensional (2D) scan (using the company's ultrasound equipment) into a full-dimensional model of their heart, enabling users to manipulate the virtual heart model. By producing computational heart models and simulating various pacing strategies on them, Steven Niederer's group at King's College London could identify the ideal area to electrically stimulate the heart and investigate the effects of changing he pacing.



3) Multiple Sclerosis:
The creation of digital twins for patients with multiple sclerosis assists in the provision of optimal intervention therapies and strategies while considering side effects and environmental factors. Due to the heterogeneity of the disorder and its course, vast amounts of data have been collected, presenting good opportunities for data-driven approaches such as the usage of digital twins.

Contributions of Digital Twins

Digital twin technology aims to replace (at least partially) the usually expensive and resource-intensive laboratory experiments with in-silico simulations. Collaboration among mechanistic and statistical models has shown to aid diagnosis, treatment, and prognosis evaluation. A fully developed digital twin will combine population and individual representations to support new hypothesis generation and clinical decision making and could supply doctors with vital information regarding information otherwise inaccessible through conventional experiments. This includes data concerningheart stiffness and potentially cancer prognosis.

Drawbacks of Digital Twins

Data needed for a digital twin is preferably harnessed by wearable sensors and lifestyle information registered by patients. A notable challenge is the integration of this data with healthcare organisations as security and confidentiality are intrinsic to address concerns when handling personal data.

Secondly, it is of great importance to provide accurate assumptions to the model; both models relyingtoo heavily on a vast amount of data and basic-as-possible models, can yield unreliable results. Another key barrier is the absence of supporting IT infrastructure, lack of data standards and interoperability, insufficient decision support technology, and insufficient funding for translational health research.

CONCLUSION

Precision medicine is a field requiring the analysis of large amounts of data from complex systems in order to provide efficient treatments while taking into account the diversity in patients. Computational Modelling in Simulation, specifically digital twin technologies, can greatly assist thedevelopment in this field while reducing the cost and time taken for procedures. To accelerate the development of precision medicine using in-silico technologies, it is essential to build trust among researchers, clinicians and society. Alongside this transparent exchange of information, the development of IT in healthcare is critical to the integration of computational modelling and simulation and precision medicine.

ACKNOWLEDGEMENTS

I wish to express my gratitude to Mrs. Mitu Mehta and Mrs. Deepa Bineesh who mentored me while writing this paper. I would also like to thank Dr. Purna Gadre (Postdoctoral Research Fellow, TIFR) for reviewing this paper and guiding me with regards to this experience. Mr. Debashish Banerjee provided great help in gathering data for this paper.

ISSN 2350-109X
www.indianscholar.co.in
Indian Scholar
An International Multidisciplinary Research e-Journal

REFERENCES

1) "Computational Modeling". *Nibib.Nih.Gov*, 2022, https://www.nibib.nih.gov/science-education/science-topics/computational-modeling. (Accessed 2 May 2022)

2) Kamel Boulos, Maged N., and Peng Zhang. "Digital Twins: From Personalised Medicine To Precision Public Health". *Journal Of Personalized Medicine*, vol 11, no. 8, 2021, p. 745. *MDPI AG*,doi:10.3390/jpm11080745. (Accessed 2 May 2022)

3) Corral-Acero, Jorge et al. "The 'Digital Twin' To Enable The Vision Of Precision Cardiology". *European Heart Journal*, vol 41, no. 48, 2020, pp. 4556-4564. *Oxford University Press* (OUP), doi:10.1093/eurheartj/ehaa159. (Accessed 2 May 2022)

4) "Heartmodel: 3D Echocardiography | Philips Healthcare". *Philips*, 2022, https://www.philips.co.in/healthcare/resources/feature-detail/ultrasound-heartmodel. (Accessed 2 May 2022)