

Mathematical Technology for BDT Design and Applications

Addressing Gaps and Challenges to
Successful BDT Implementation:
How to fill in what is missing?

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September 30, 2024
IMAG/MSM Teaming4BDT Meeting

$$\frac{\mathbf{p}}{m} \Delta t, \mathbf{p} + \mathbf{F} \Delta t, t + \Delta t) d^3 \mathbf{r} d^3 \mathbf{p} = f(\mathbf{r}, \mathbf{p}, t) d^3 \mathbf{r} d^3 \mathbf{p}$$

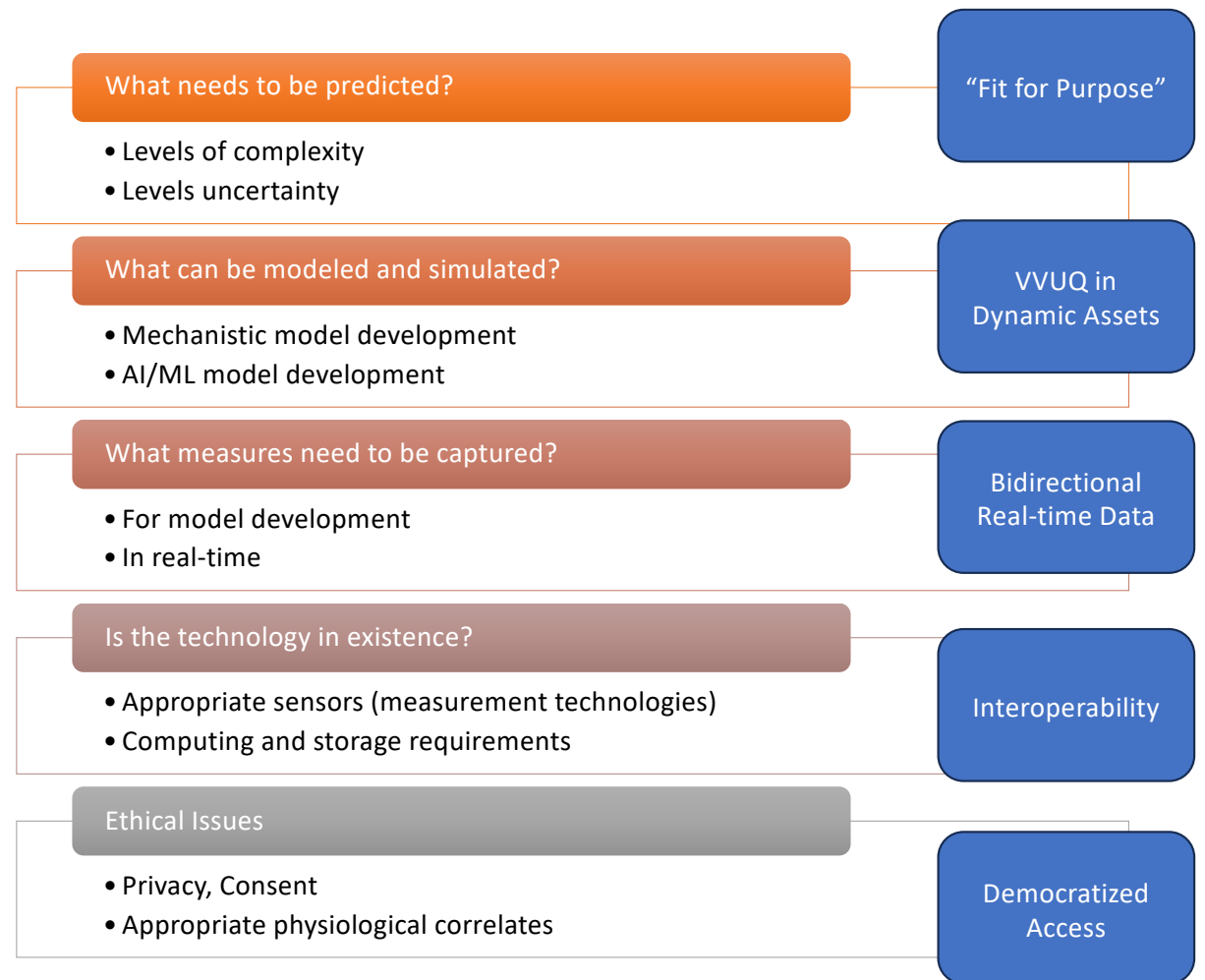
$$dN = f(\mathbf{r}, \mathbf{p}, t) d^3 \mathbf{r} d^3 \mathbf{p}$$

$$\frac{\mathbf{p}_i}{m_i} \cdot \nabla f_i + \mathbf{F} \cdot \frac{\partial f_i}{\partial \mathbf{p}_i} = \left(\frac{\partial f_i}{\partial t} \right)_{\text{coll}}$$

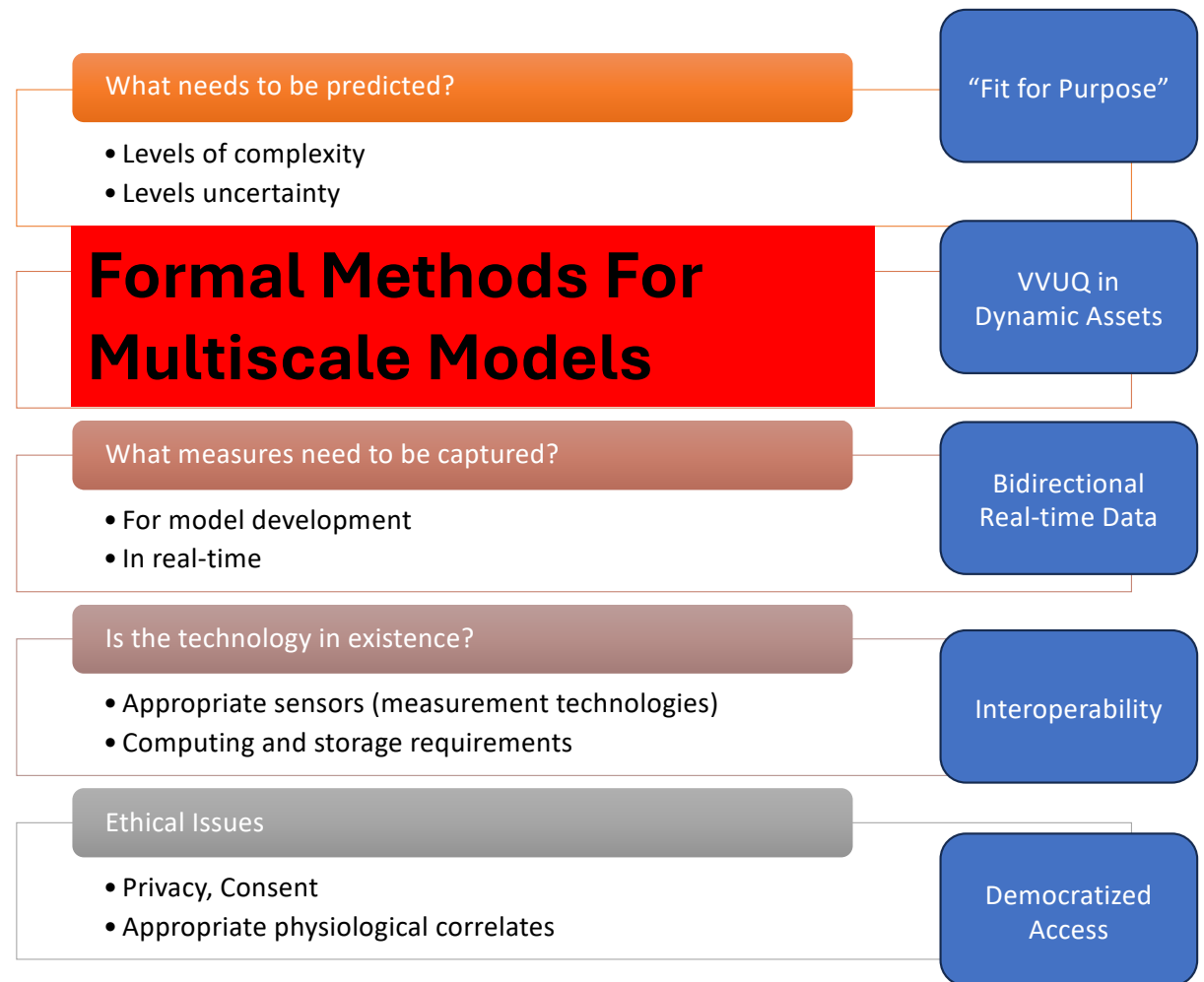
$$\int A F_j \frac{\partial f}{\partial p_j} d^3 \mathbf{p} = -n F_j \left\langle \frac{\partial}{\partial p_j} \right\rangle$$

$$\frac{\partial}{\partial t} + \frac{\mathbf{p}}{m} \cdot \nabla + \mathbf{F} \cdot \frac{\partial}{\partial \mathbf{p}}$$

Biomedical Digital Twin (BDT) Design Challenges



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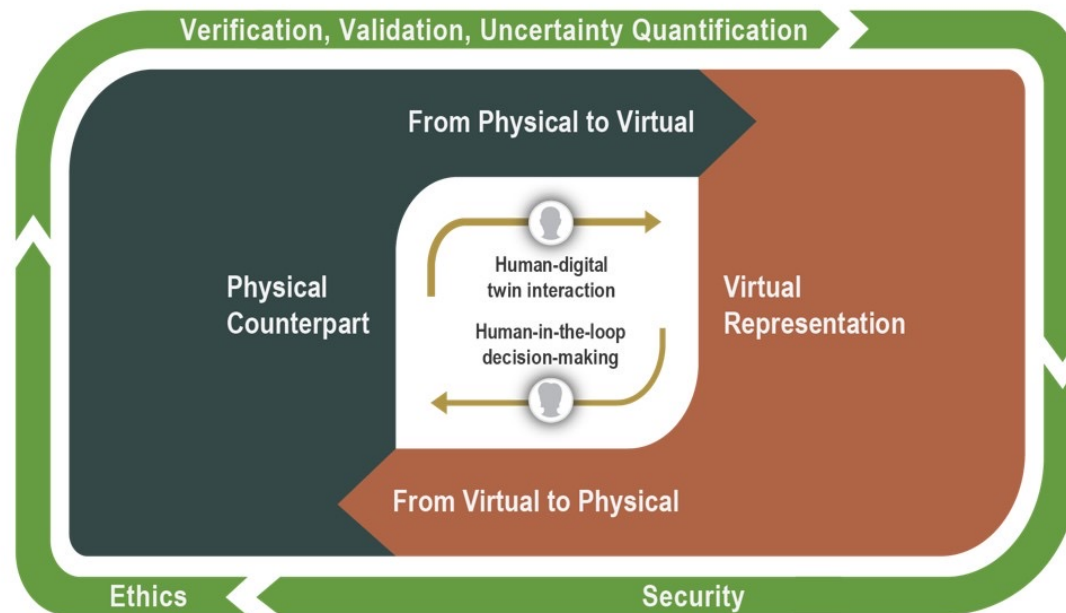


EFFECT -- A Method and Metric to Assess the Reproducibility of Stochastic Simulation Studies

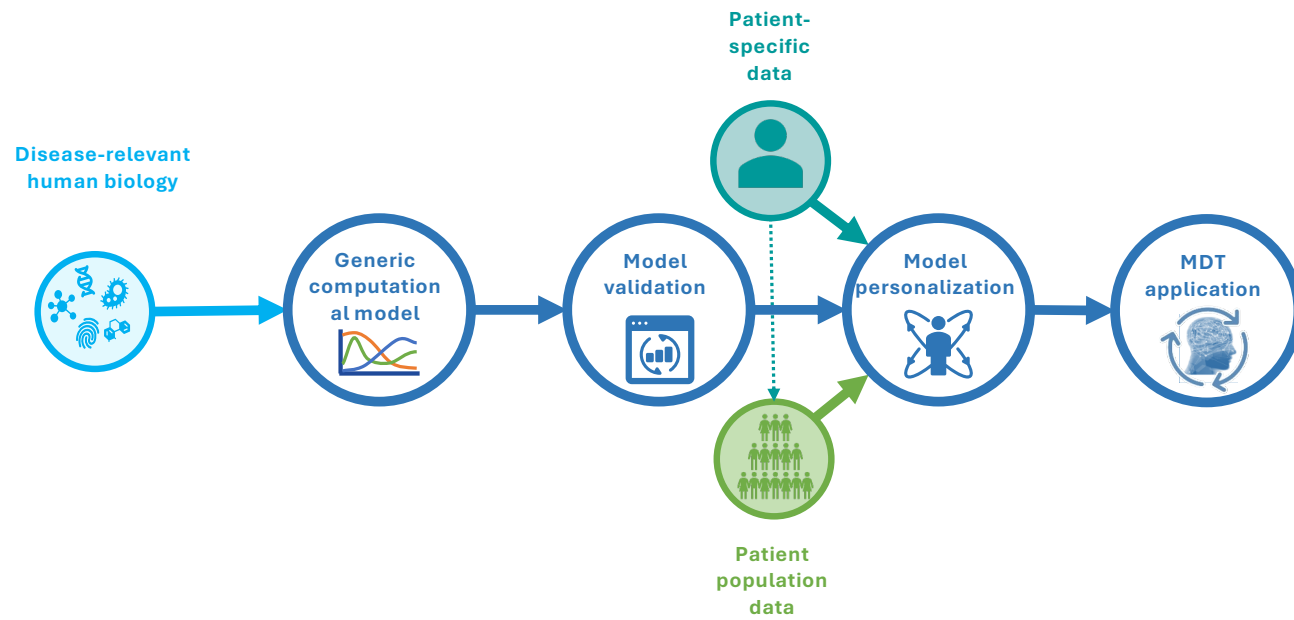
T.J. Sego, Matthias König, Luis L. Fonseca, Baylor Fain, Adam C. Knapp, Krishna Tiwari, Henning Hermjakob, Herbert M. Sauro, James A. Glazier, Reinhard C. Laubenbacher, Rahuman S. Malik-Sheriff

<https://doi.org/10.48550/arXiv.2406.16820>

Personalization/Forecasting

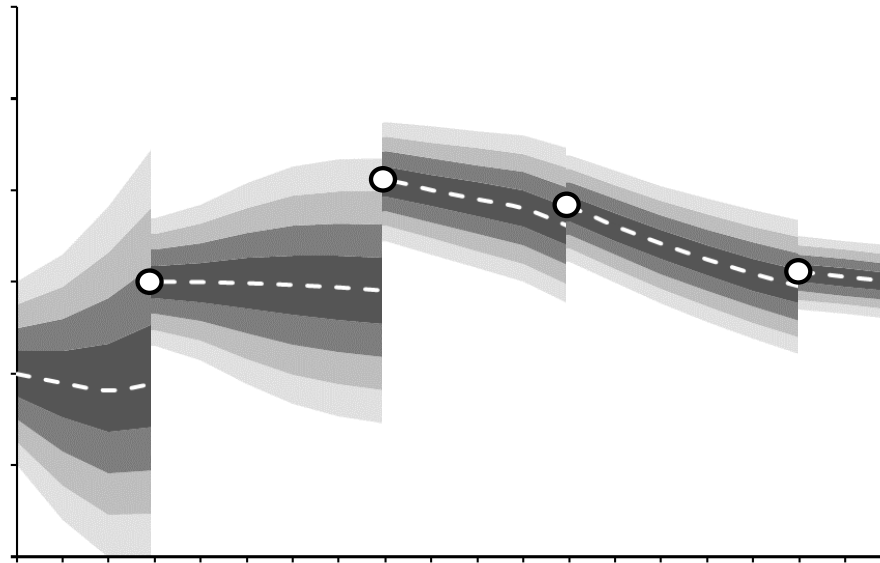


“Control”



R. Laubenbacher *et al.*, Toward mechanistic medical digital twins: some use cases, *Frontiers in Digital Medicine*, 2023.

Personalization/Forecasting



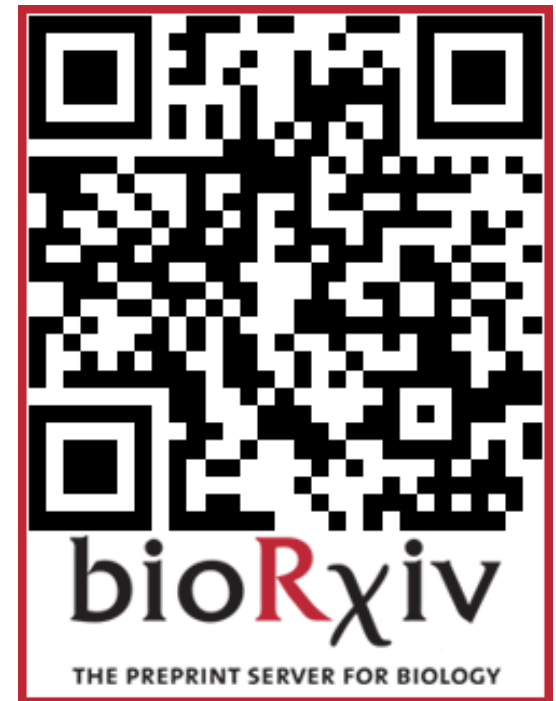
Over time, the patient representation (parameterization) improves and certainty of predictions improves.

Ensemble Kalman filter methods for agent-based medical digital twins

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Control

PHILOSOPHICAL
TRANSACTIONS A

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Research



Control of medical digital
twins with artificial neural
networks

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and Reinhard C. Laubenbacher²

Metamodeling and Control of Medical Digital Twins

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BDT Requirements:

Describe in technical detail how

- the model underlying the BDT is (or is not) FAIR compliant;
- the model is (or is not) calibrated to an individual patient;
- the BDT is (or is not) used for interventions or predictions.

Questions

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