Predictive Hybrid Digital Twins: Theory, Methods, and Applications.

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Advances in digital-twin technology within the healthcare sector are confronted with a long-standing challenge: instead of a one-time static construction that fits observed data, a digital twin needs to rapidly adapt to live data and to provide predictive decision support beyond what has been observed. Attaining these breakthroughs face two fundamental hurdles. First, current mechanistic models struggle with rapid adaptation and imperfect knowledge, while data-driven models are limited in interpretability and generalizability. Second, the prevalent twinning strategies based on data-fitting, previously largely tailored for mechanistic models, become the root cause of an un-identifiable data-driven model with limited predictive capabilities. In this talk, we discuss our recent efforts in addressing these challenges towards the ultimate goal of predictive twinning: a what-how & when meta-learning framework for learning to rapidly and continually personalize a latent forecasting function endowed with strong predictive ability owing to its theoretical identifiability, and hybrid neural-mechanistic modeling that combines the generalizable and interpretable mechanistic know-how with flexible data-driven learning to resolve the residual between general knowledge and individuals' data. We will extend these discussions to applications in learning personalized digital twins of the heart.