

Generative Digital Twins for Biodynamics

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Medical Device & Diagnostic



> TRL 3
> Pre-clinical

Problem

Microfluidic and organ-on-chip experiments are powerful tools for studying disease and treatment responses, but they remain costly, time-consuming and difficult to scale. Testing every device geometry, injury location, drug, dose and biological condition requires additional laboratory work, while existing mechanistic simulations and general-purpose video models struggle to reproduce complex, time-dependent biological behaviour. Generic models may generate visually plausible outputs yet fail to respect microfluidic boundaries, localised stimuli or realistic response kinetics. These limitations restrict experimental throughput, increase costs and make it difficult to predict biodynamic outcomes under untested conditions, slowing drug discovery, assay optimisation and personalised treatment research across biomedical applications

Solution

This software platform creates digital twins of microfluidic experiments using generative artificial intelligence. It adapts a pretrained video diffusion model through computationally efficient Low-Rank Adaptation, avoiding full-model retraining. The system combines microfluidic device geometry, a spatial mask identifying an injury, stimulus or treatment location, and a text description of the experimental condition. It then generates realistic, time-resolved microscopy-style videos constrained by the chip's physical structure and biological context. The platform can be adapted to organ-on-chip systems using domain-specific experimental videos, supporting predictive simulation, experimental planning, drug-response modelling and synthetic microscopy data generation with lower computational and laboratory requirements than conventional approaches.

Potential Commercial Applications

- Virtual screening and prioritisation of drug candidates
- Prediction of treatment responses in microfluidic disease models
- Digital twins for vascular, cardiac, neural, liver, kidney, immune and tumour chips
- Microfluidic assay design and experimental optimization
- Simulation of untested geometries, stimuli and treatment conditions
- Synthetic microscopy datasets for training biomedical AI models
- Research tools for investigating disease progression and biological mechanisms
- Longer-term personalised medicine and clinical decision-support applications

Inventors

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