AI-Boosted Precision Medicine through Continual in situ Monitoring of Microtissue Behaviors on Organs-on-Chips

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Key Challenges

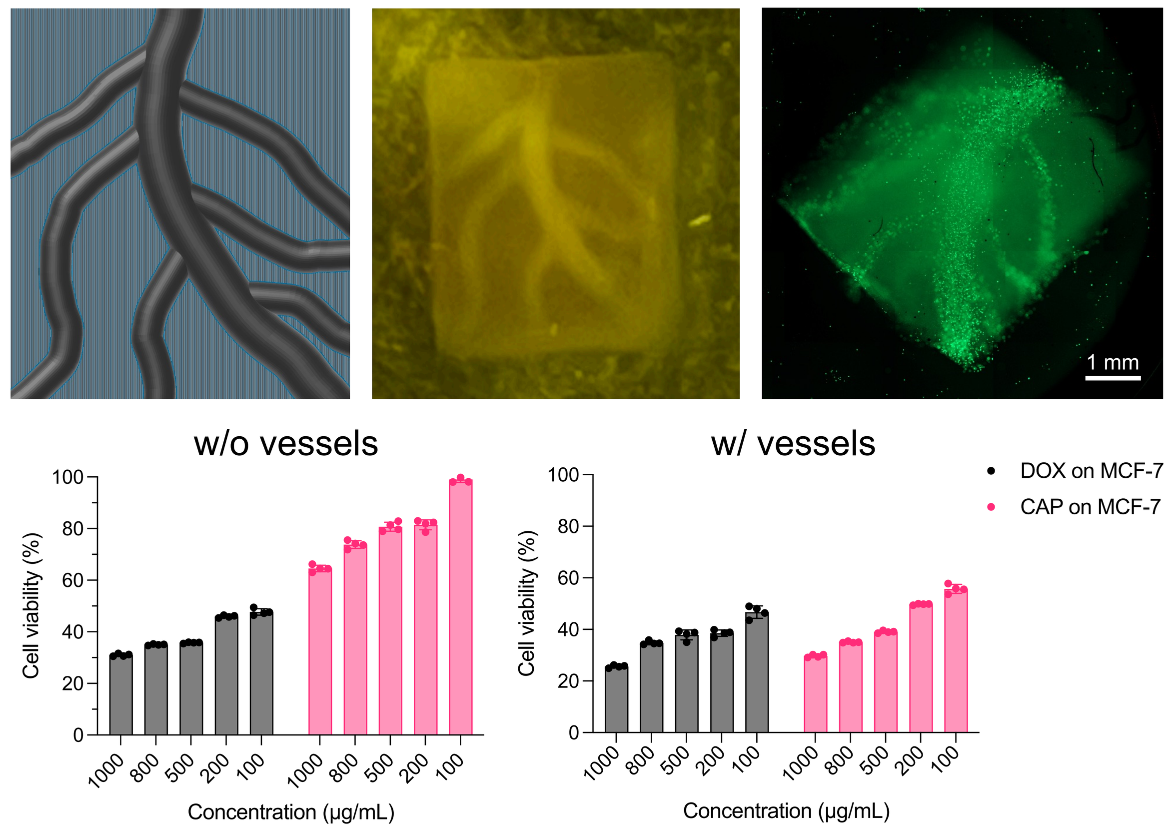
- The ability to predict patient responses to anti-cancer therapeutic agents remains a Holy Grail.
- Getting the right choice of therapy early can mean superior anti-tumor outcomes and increased survival, while the wrong choice means tumor relapse, development of resistance, side effects without the desired benefit, and increased cost of treatment.
- There is a need to develop an engineered cyber-physical system that combines advanced biological models with state-of-the-art AI methods for predictive, automated screening of anti-cancer drugs and optimizations of their dosing.

Our Solutions

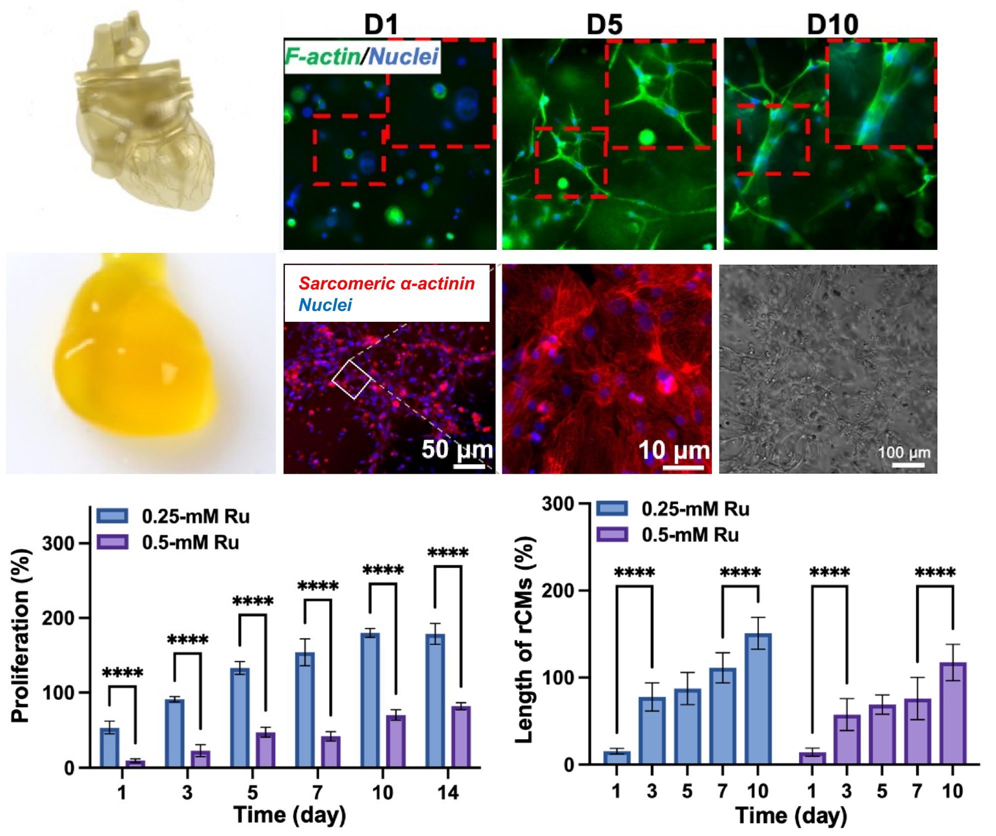
- First, the built multi-organ-on-a-chip platform will serve as a standard prototype and template for many other 3D-bioprinted or microfabricated human-based tissue models integratable with multi-dimensional biophysicochemical parameter monitoring.
- Second, the dynamic real-time biophysicochemical parameter readings would enable self-dose-optimization on the chips through a novel joint Bayes modeling implemented by two deep-learning models capable of addressing multiple-instance learning, and dependency in sequences of multi-dimensional data, respectively.
- Overall, the successful development of the proposed framework and multi-organ-on-a-chip platform can be naturally extended to other cancer treatment, drug combination, and AI-driven dose-optimization in anticancer regimen as a rapid and safe testing-bed.

Preliminary Data

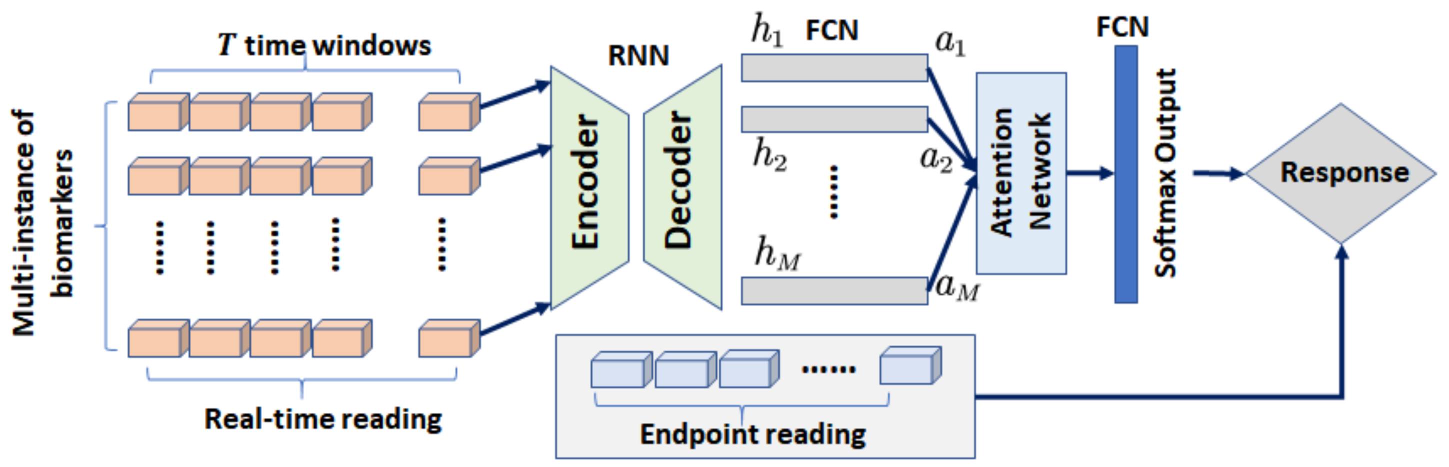
Bioprinted vascularized breast cancer tissue models show more physiologically relevant IC_{50} values of anti-cancer drugs than the cancer models bioprinted without vascular channels.



Bioprinted cardiac tissue model is able to reproduce to a good extend the structure of the human heart as well as its cellular spreading, biomarker expressions, and contraction functions.



The real-time yet non-invasive sensing will generate large-scale multi-dimensional data to enable accurate data-driven predictive modeling.



Broader Impact (Society)

The project has strong social impacts, including minimizing the exponentially growing ethical issues surrounding the use of animals in the past years through increased adoption of the engineered human cancer and heart tissue model systems. The success of the project will eventually allow to accurately predict both efficacy and safety of anti-cancer therapeutics promoting patient welfare.

Broader Impact (Education and Outreach)

The project will provide opportunities to promote STEM education for K-12 students, train students, especially those from under-represented group. The research outcomes will be delivered through workshops and tutorials in leading conferences and further promoted through collaboration with research institutes from the pharmaceutics industry in the Greater Boston area.

Quantified Broader Impact

Cancers are among the leading causes of death around the world with an estimated annual mortality of close to 10 million, within which a total of 1,688,780 new cases and 600,9200 deaths are expected to occur in the US alone. The proposed AI-Boosted Precision Medicine will enable improved anti-tumor outcomes and increased survival to benefit patients worldwide.

Collaborative Research: CPS: Medium: AI-Boosted Precision Medicine through Continual in situ Monitoring of Microtissue Behaviors on Organs-on-Chips

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