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An Efficient Framework for Oxygen Transport and Viability Prediction in Organ-scale Vascularized Tissues

There is a lack of practical models to simulate oxygen dynamics in organ-scale tissue. Such a model will provide a platform to study the dynamics of vasculature and gas transport to improve medical technologies. Existing transport models are either time and computationally intensive, geometry-specific, or impose unrealistic kinetic assumptions that limit applicability to real-world applications. Additionally, there are currently no methods for computing distributed blood flow in arterial tree networks, local oxygen distributions inside both the blood vessels and surrounding tissue, and cell viability maps resulting from these oxygen gradients in seconds or near-interactive times.

The DeSimone and Shaqfeh Lab at Stanford have developed an efficient computational framework for evaluating oxygen transport and viability prediction in organ-scale vascularized tissues. The overall framework enables the user to generate a vascular network inside an arbitrary 3D tissue domain. Then the framework can be used to solve parameters such as pressures and flows, oxygen depletion within vessels, and intratissue oxygenation gradients. The model leverages a reduced-order modeling technique with physical formulations, resulting in computationally efficient organ-scale analyses that can be conducted on a personal computer. This fast, organ-scale vascular design and oxygen/viability simulation platform can be integrated into tools for surgical planning, engineering design, and tissue engineering.

Stage of Development
Prototype

Applications

- Software for surgical planning
- Bioprinting and design
- Tissue engineering and research

Advantages

- Speed and scalability: Organ-scale simulation in seconds instead of hours-days
- Fully discrete vascular representation that resolves large vascular structures
- Geometrical design, flow estimation, oxygen distribution, and viability prediction all in one workflow
- **Not just for oxygen**: with minimal to no modification, works for any other reactive chemical, including certain tracers, glucose, proteins, etc.

Innovators

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