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Bridging the Gap between Real Macro-Scale Vascular Networks and in vitro Biomimetic Models

Artificial tissue synthesis is a novel technology that promises to help thousands of people on the organ donor waiting list. One method of generating synthetic tissue is through bioprinting. These methods print a scaffold consisting of vascular components, which is then seeded with cells to grow synthetic tissue volumes. The challenge lies in synthesizing capillaries, which serve as sites for exchanging small molecules, like oxygen and glucose, between blood cells and surrounding tissue. Compared to arteries and veins, capillaries are much smaller in diameter (5-10 μm), denser, do not form tree-like structures, and exhibit wide variability across organisms, making analysis challenging. We are developing computational models for generating synthetic capillary systems that are statistically similar to vasculature found in real tissue samples, facilitating the design of functional scaffolds. To build these models, we first collect large-volume images of vascular networks composed of several cubic millimeters. We have developed a range of methods to reconstruct, visualize, and characterize these vascular models to produce a wide range of statistical metrics. The resulting metrics are used as input to a mathematical model that generates stochastic capillary networks that attempt to replicate the functionality of the original while applying constraints on complexity that facilitate building synthetic scaffolds.