第 1284 回生物科学セミナー

日時：**5 月 20 日（月） 10:30 – 12:00**

演者： Dr. Daniel H. Chitwood
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演題: Topological Data Analysis (TDA)
as a method to comprehensively measure the plant form

Embedded in all shapes is information. For all lifeforms, morphology—at the cellular, tissue, organ, and organismal levels—arises from genetic and environmental influences, and their interaction. These influences on the organismal form can be statistically determined, and mathematical models derived to predict which forms will arise under certain genetic and environmental scenarios. The diversity of plant forms that have arisen through evolution, and the domesticated morphologies of plants that have been artificially selected to create the major crops of the world, have benefited humanity incalculably, and directly result from alterations to plant architecture. Despite morphology being intrinsically linked to the sizes of grains and fruits, the yields of branching inflorescences, the canopies of fields, and the economics of root architectures, and even with intense interest in developing sophisticated genetic technologies and statistics to model these traits, we lack methods to adequately quantify plant morphology comprehensively and across scales. 1) Technologies that can comprehensively measure plant morphology in 3D at high resolution remain underused, 2) the real “shape” of plants that is dynamic and 4D, revealing itself through time, has almost never been captured, and 3) even if 3D and 4D datasets of plant morphology are produced, a mathematical framework to quantify the data is lacking.

Here, the use of X-ray Computed Tomography (CT) to create 3D models of plants and time-lapses of plant growth is proposed. A mathematical method that measures shapes comprehensively in any number of dimensions, Topological Data Analysis (TDA), will be used as a universal framework to analyze the resulting volumetric image data from any plant species and for any application.

In this talk, I will first introduce TDA using the 2D example of leaf shape. Current morphometric methods that comprehensively measure shape cannot compare the disparate leaf shapes found in seed plants and are sensitive to processing artifacts. I will present the use of persistent homology, a TDA method, to overcome these limitations. The described method isolates subsets of shape features and measures the spatial relationship of neighboring pixel densities in a shape. We apply the method to the analysis of 182,707 leaves, both published and unpublished, representing 141 plant families collected from 75 sites throughout the world. After introducing TDA using the 2D example of leaves, I will then describe current efforts to extend these methods to 3D. X-ray CT creates 3D volumetric images of plant morphology, in which voxels represent X-ray density. The connectedness of voxel space is an ideal opportunity to apply TDA, which relies on a graph (network) structure. I will describe on-going work to represent X-ray CT images of plants as graphs using different filtration functions and methods such as Mapper and Reeb graphs. Preliminary data from current projects to comprehensively measure morphology and determine its genetic and developmental basis will be presented from barley, citrus, and walnuts.

参考文献：

Bucksch et al. (2017) Morphological Plant Modeling: Unleashing Geometric and Topological Potential within the Plant Sciences. *Front. Plant Sci.,* 09 June 2017 | **https://doi.org/10.3389/fpls.2017.00900**

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