Using Mapper Graphs to Reveal Morphological Relationships in Passiflora Leaves

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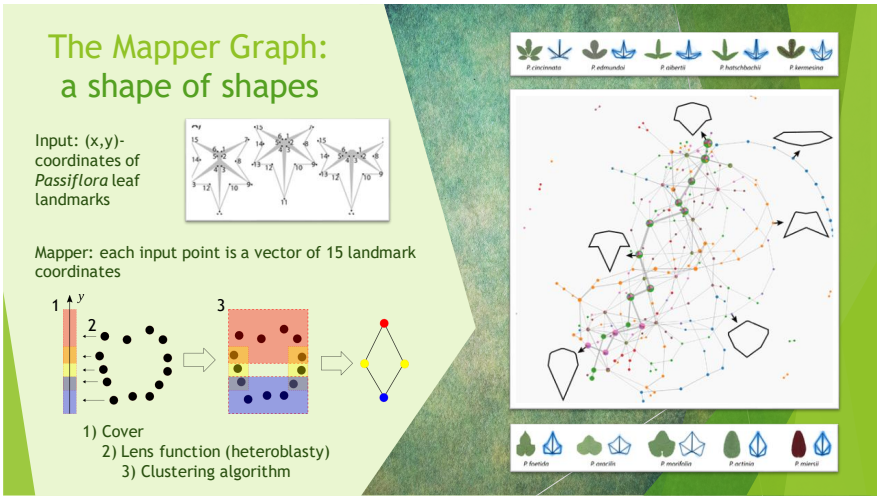
Abstract

As collections of data grow in size, it is increasingly important to have an efficient means of analyzing large data sets. Topological data analysis (TDA) applies concepts from the mathematical field of topology to not only efficiently examine large data sets, but to make inferences related to the overall "shape" of data. In this project, we use Mapper, a tool from TDA that summarizes data into a graph, to discover an underlying structure relating the shapes of more than 3,300 Passiflora leaves from 40 different species. We choose to study leaves of the Passiflora species in particular due to their extraordinary diversity of shape. As the Mapper graph has a structure, or "shape" of its own, we think of it as a "shape of shapes" that provides information on the interplay between the developmental processes determining leaf shape within a single plant and the evolutionary processes between species. In particular, we examine the interactions between leaf species and both heteroblasty and leaf area by constructing a Mapper graph for each measure. For each node in the resulting graphs, we then compute the average leaf shape to obtain a graph structure that reveals how morphometric differences between species relate to the developmental changes that must occur for those shapes to be realized.



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ABSTRACT

As collections of data grow in size, it is increasingly important to have an efficient means of analyzing large data sets. Topological data analysis (TDA) applies concepts from the mathematical field of topology to not only efficiently examine large data sets, but to make inferences related to the overall "shape" of data. In this project, we use Mapper , a tool from TDA that summarizes data into a graph, to discover an underlying structure relating the shapes of more than 3,300 *Passiflora* leaves from 40 different species. We choose to study leaves of the *Passiflora* species in particular due to their extraordinary diversity of shape. As the Mapper graph has a structure, or "shape" of its own, we think of it as a "shape of shapes" that provides information on the interplay between the developmental processes determining leaf shape within a single plant and the evolutionary processes between species. In particular, we examine the interactions between leaf species and both heteroblasty and leaf area by constructing a Mapper graph for each measure. For each node in the resulting graphs, we then compute the average leaf shape to obtain a graph structure that reveals how morphometric differences between species relate to the developmental changes that must occur for those shapes to be realized.

Keywords: Topological data analysis, Mapper, Passiflora

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