Research Plan

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In mathematical sciences, I specialize in the representation theory of finite-dimensional algebra and its application to topological data analysis. A finite-dimensional algebra is an extension of a complex number field, and representation theory is to investigate the category consisting of its representations.

One of the main tools of topological data analysis is persistent homology. It is a multiscale analysis method that focuses on the “shape” of data. It has been applied to materials such as glass, for example, with remarkable results. Persistent homology is a representation of some finite-dimensional algebra. Thus, the representation theory of finite-dimensional algebra is the theoretical part of persistent homology.

The other tool for topological data analysis is called Mapper, a variant of Reeb graphs that uses singularities to represent the structure of objects. For example, Mapper is used for single-cell analysis and Reeb graphs are used for computer graphics.

(I) Multidimensional persistence module and its robustness to noise

I work on extending persistent homology to multiparametric data. Namely, I will study the representation theory of multidimensional persistence modules with their robustness to noise. Note that the robustness is one of the foundations of topological data analysis and is needed to be the practical realization of multidimensional persistence modules.

(I)-1: First, I would like to further investigate our results (with Asashiba, Escolar, and Nakashima) on multidimensional persistence modules, especially interval representations that are important for topological data analysis.

(I)-2: Second, I would like to use another approach to robustness. That is, I will use a characterization of the derived category called the Bridgeland stability condition. In addition, I would like to use the result with homological mirror symmetry to robustness to noise for Reeb graphs and Mapper.

(II) The others.

In addition, I organize conferences to foster interaction among the theory of persistence modules, the representation theory of finite-dimensional algebras, geometry, and machine learning.