Contribution ID: **25** Type: **not specified**

The Impacts of Dimensionality, Diffusion, and Directedness on Intrinsic Cross-Model Simulation in Tile-Based Self-Assembly

Tuesday, July 11, 2023 11:45 AM (20 minutes)

Daniel Hader and Matthew Patitz

Abstract: Algorithmic self-assembly occurs when components in a disorganized collection autonomously combine to form structures and, by their design and the dynamics of the system, are forced to intrinsically follow the execution of algorithms. Motivated by applications in DNA-nanotechnology, theoretical investigations in algorithmic tile-based self-assembly have blossomed into a mature theory with research strongly leveraging tools from computational theory, complexity theory, information theory, and graph theory to develop a wide range of models and to show that many are computationally universal, while also exposing a wide variety of powers and limitations of each. In addition to computational universality, the abstract Tile-Assembly Model (aTAM) was shown to be intrinsically universal (FOCS 2012), a strong notion of completeness where a single tile set is capable of simulating the full dynamics of all systems within the model; however, this result fundamentally required non-deterministic tile attachments. This was later confirmed necessary when it was shown that the class of directed aTAM systems, those in which all possible sequences of tile attachments eventually result in the same terminal assembly, is not intrinsically universal (FOCS 2016). Furthermore, it was shown that the non-cooperative aTAM, where tiles only need to match on 1 side to bind rather than 2 or more, is not intrinsically universal (SODA 2014) nor computationally universal (STOC 2017). Building on these results to further investigate the impacts of other dynamics, Hader et al. examined several tile-assembly models which varied across (1) the numbers of dimensions used, (2) restrictions imposed on the diffusion of tiles through space, and (3) whether each system is directed, and determined which models exhibited intrinsic universality (SODA 2020). Such results have shed much light on the roles of various aspects of the dynamics of tile-assembly and their effects on the universality of each model. In this paper we extend that previous work to provide direct comparisons of the various models against each other by considering intrinsic simulations between models. Our results show that in some cases, one model is strictly more powerful than another, and in others, pairs of models have mutually exclusive capabilities. This direct comparison of models helps expose the impacts of these three important aspects of self-assembling systems, and further helps to define a hierarchy of tile-assembly models analogous to the hierarchies studied in traditional models of computation.

Presenter: HADER, Daniel

Session Classification: Track A-4