A pumping lemma for non-cooperative self-assembly

Damien Regnault*[1]

[1]Informatique, Biologie Intégrative et Systèmes Complexes (IBISC) – Université d'Évry-Val-d'Essonne – 40 rue du Pelvoux, Courcouronnes ; 91020 Evry Cedex, France

Résumé

Vidéos de la preuve complète
diaporama
We prove here a result which strongly hints at the computational weakness of a model of tile assembly that has so far resisted many attempts of formal analysis or positive constructions. Specifically, we prove that, in Winfree's abstract Tile Assembly Model, when restricted to use only noncooperative bindings, any long enough path starting from the seed that can grow in all terminal assemblies is {pumpable}, meaning that this path can be extended into an infinite, ultimately periodic path.

This result can be seen as a geometric generalization of the pumping lemma of finite state automata, and is a great step to solve the question of what can be computed deterministically in this model. Moreover, this question has motivated the development of a new method called {visible glues}.

Tile assembly (including non-cooperative tile assembly) was originally introduced by Winfree and Rothemund to understand how to {program shapes}. The non-cooperative variant, also known as temperature 1 tile assembly, is the model where tiles are allowed to bind as soon as they match on one side, whereas in cooperative tile assembly, some tiles need to match on several sides in order to bind. Previously, exactly one known result showed a restriction on the assemblies general non-cooperative self-assembly could achieve, without any implication on its computational expressiveness. With non-square tiles (like polyominos), other recent works have shown that the model quickly becomes computationally powerful.

*Intervenant