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Reading 7: Self-Assembly - Construction

**Paper 1:** Modelling the Collective Building of Complex Architectures in Social Insects with Lattice Swarms, J Theo. Bio., 1995

*Paragraph or two on any/some of the following points:*

*What do you feel the main contribution of this paper is? What's the essential principle that the paper exploits? What did you find most interesting about this work?*

In this paper, the authors present models of coordinated building algorithms, inspired by the stimergetic building behavior of social wasps. Simulated agents are placed in a lattice, they deposit bricks based on the local configuration of the architecture available to them. The authors make an interesting conclusion that configurations of different building stages do not overlap—all individuals work on the same subshape at a given time.

I appreciate the architecture of this paper. The authors begin by describing the biological system of nest building behavior of social wasps. From the literature and experiments, we can observe the modular nature of the nests resulting from cyclic building activity of the individual wasps. An important point is made: During the construction process, many building activities can occur at the same time. Unlike solitary insects, social insects do not rely on a sequential algorithm but a stimergetic one. This biological system inspires the authors to explore the characteristics of the nest architecture at the individual level. The model consists of agents randomly moving independently on a 3D lattice. A lookup table determines which type of brick should be deposited at a site based on the site's stimulating configuration.

*Short answers to the questions below*

*One major strength of the paper*

I think it's very interesting that the authors discuss the two viewpoints regarding the relationship between the architectures and coordination: that coordination leads to particular architectures, and that, conversely, coherent architectures induce coordination. Either way, building in the physical world inevitable encounters constraints of various kinds, and studies like this paper illuminates some mechanisms employed by the inhabitants of this world and allow us to make some conjectures about the course of evolution.

### *One weakness of this paper*

I would like a clearer definition of a “biological-like shape,” which is one of the foundations of this paper. The authors state that it’s difficult to define formally but is intuitive, but I don’t find it so!

### *Short discussion of*

*One question or future work direction you think should be followed. Or some insight/connection you think is interesting to pursue.*

Why must there be different types of bricks? 

I imagine that bio-inspired algorithms such as the one presented here may one day replace architects, or at least construction builders. Are we able to design local rules for individual agents with a global goal/structure in mind?

So far, we have been reading about models/algorithms that have one thing in common: they assume agents who need not be aware of their global goal and/or of their cooperation with team members. If we have agents who are aware of such but still act based on a set of rules as limited agents do, would that disrupt the emergence of the collective structures/goals we observe?

This is more a broad question: How can we reasonably make conjectures about a biological system in the evolutionary context?

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**Paper 2:** Designing Collective Behavior in a Termite-Inspired Robot Construction Team, Science, 2014

### *Paragraph or two on any/some of the following points:*

*What do you feel the main contribution of this paper is? What's the essential principle that the paper exploits? What did you find most interesting about this work?*

This paper addresses the question I have just listed in the above paper! Given local rules individual agents live by, we can predict the high-level results. The inverse problem is also of interest: How can we find local rules that produce a specific outcome? In this paper, the authors present a multi-agent model of stigmergic construction inspired by the mound-

building termites. The user of the model can specify a final structure, and the algorithm can generate local rules for individual robots to follow to build that final structure. The authors identify two types of building processes: a system that produce a predetermined outcome and a system that may vary and lead to a variable outcome. The paper focuses on the predetermined process, to follow the human building context in which a blueprint for building is followed to produce a specific target structure.

***Short answers to the questions below***

*One major strength of the paper*

This paper is awesome just for the reason that it investigates the question that was in my mind while reading our papers so far. Furthermore, I appreciate that the authors demonstrated this decentralized multi-robot construction system with a hardware implementation. This is proof of concept that such a system have the potential to be applied to real-life situations, especially ones that are dangerous or difficult for humans as the authors mentioned.

*One weakness of this paper*

I thoroughly enjoyed this paper. But I would've liked a more quantitative explanation of the model, especially for those who might be interested in reproducing or expanding on this paper. Because I am new to this field, I would also like to understand better the nature and effects of centralized vs decentralized systems.

***Short discussion of***

*One question or future work direction you think should be followed. Or some insight/connection you think is interesting to pursue.*

Does the “seed” brick’s position matter for the final structure and/or the paths leading to it?

So far, we have been reading about stigmergic systems. In this paper, the authors mention that centralized systems provide global computing authority and precise positioning information, resulting in advantages in efficiency and flexibility. On the other hand, decentralized systems have better scalability and robustness. I would like to read a paper that attempts to implement both types of systems and compare their nature and the efficiency.