

Controlling Ant- Based Construction

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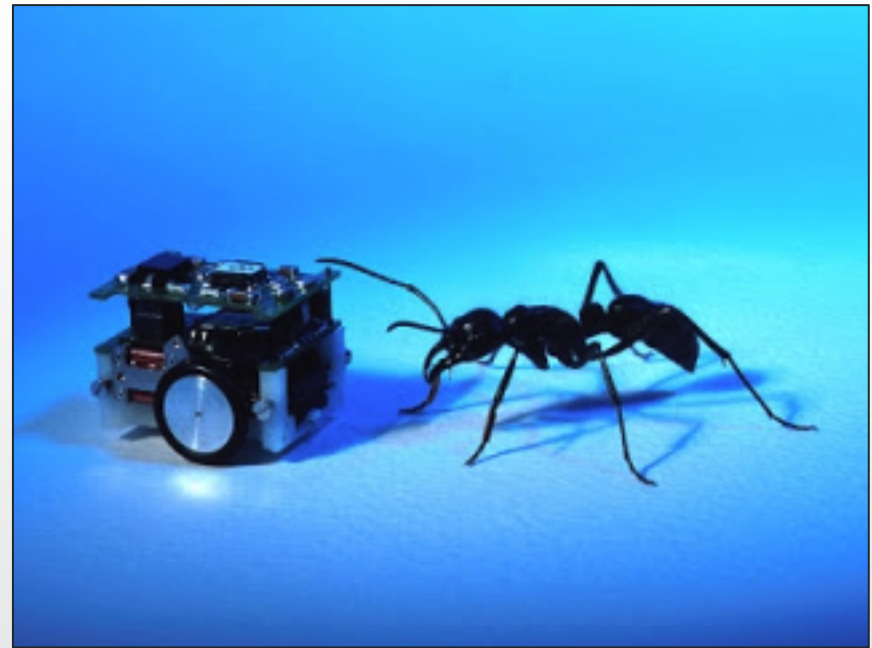
Construction in Nature

- Natural collective construction:
 - Limited sensory and memory capabilities -> complex structures
 - Stigmergy (ants, wasps)
 - Pheromone template (termites)
- This is cool but can we use it?



Robotic Construction

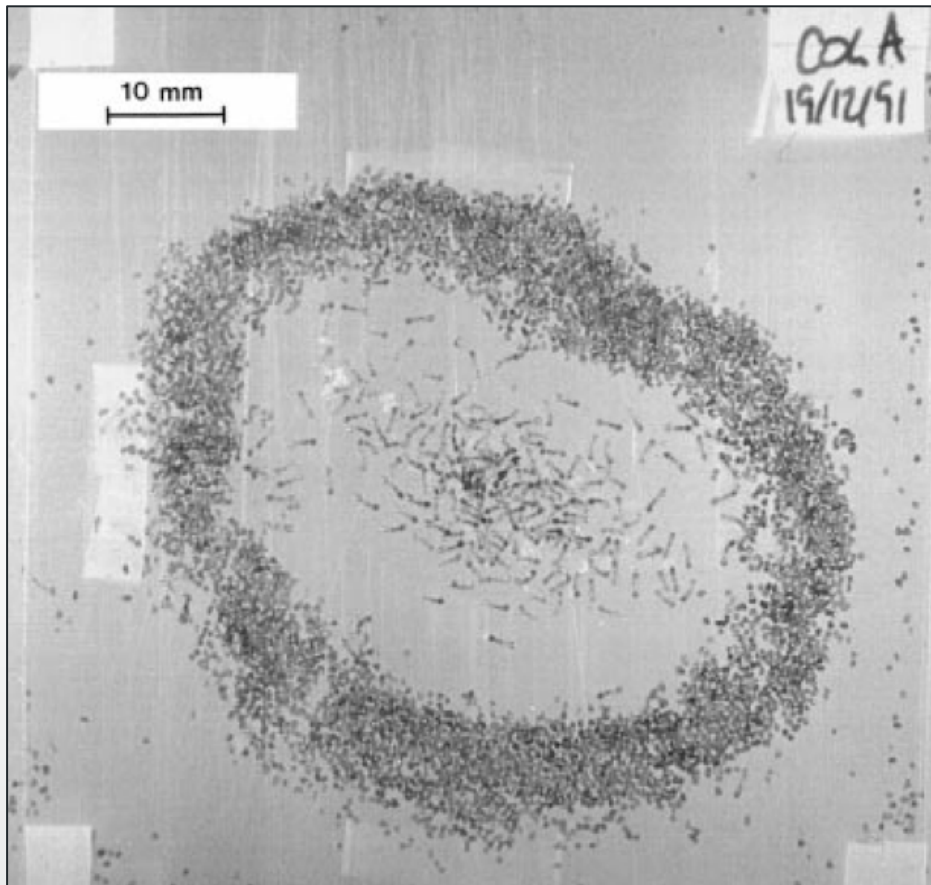
- Limited understanding of nature
- Difficult to see how to build structures that we want
- We need simulations



Today's Talk

- Ant builders
- Our model
 - Effect of parameters
 - Building of designed structures
- Future

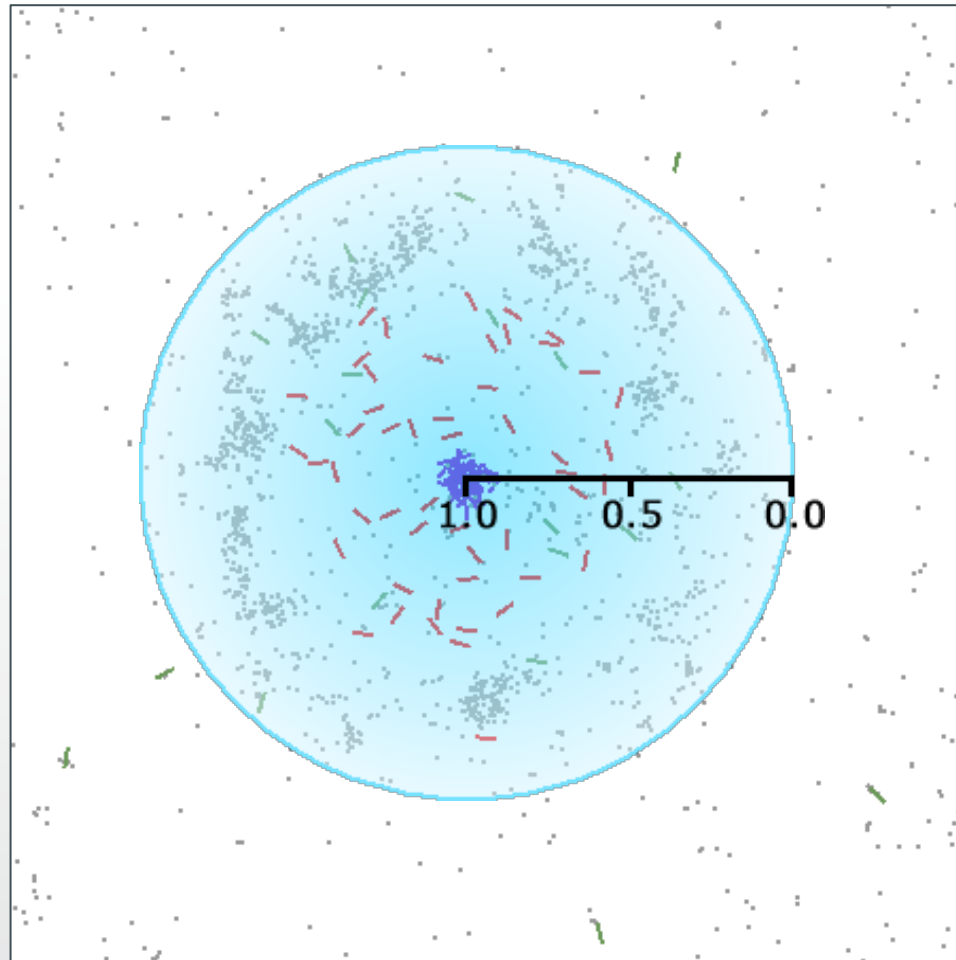
Ant Builders



- ‘Internal’ and ‘external’
- Brood cluster as a physical template
- Brood also emanates pheromone

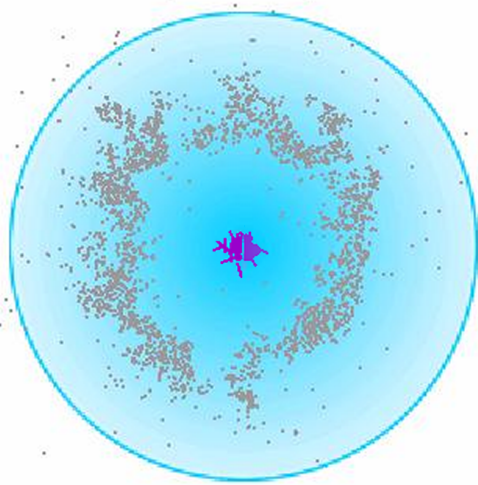
Franks, N. & Deneubourg, J., 1997. Self-organizing nest construction in ants: Individual worker behaviour and the nest's dynamics. *Animal Behaviour*, 54(4), pp.779–796

Ant Simulation

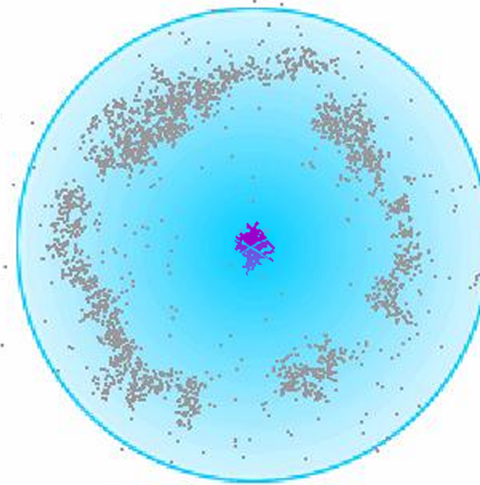


- Continuous space and time
- Random movement
- Stone bulldozing
- Dropping probability increases with amount of bulldozed stones
- Moving along walls
- Pheromone cloud
 - Orientation
 - Building Template

Built Nests



10 internal ants

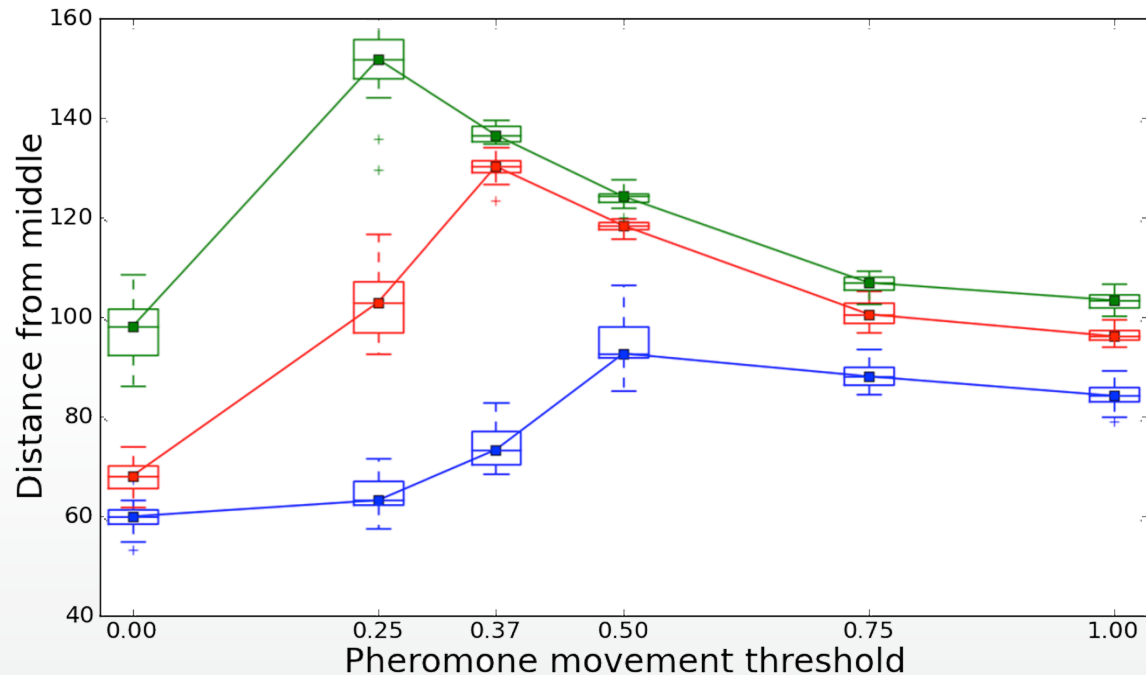


50 internal ants

- Generally circular with entrances, shape and size depend on:
 - Number of internal ants
 - Distance internal ants roam
 - Number of external ants

Internal ants

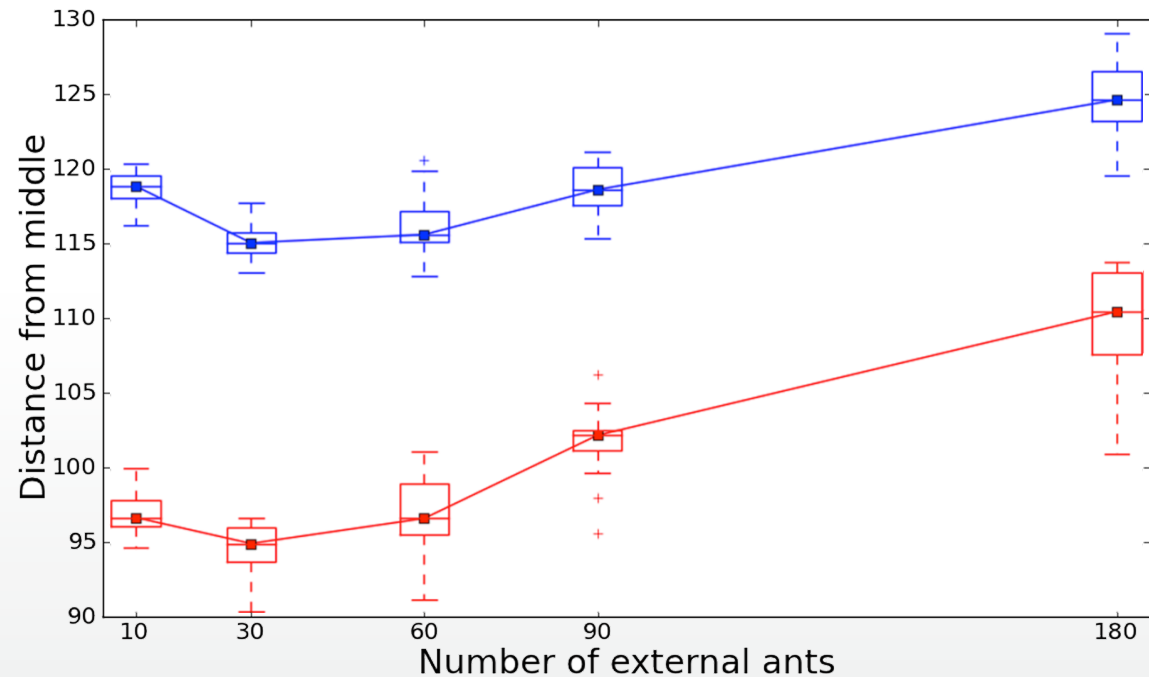
- Nest size depends on how far they roam
- If they roam too far, walls collapse inwards
- Amount of them also affects nest size



- 10 external ants
- 30 internal ants
- 10 internal ants
- 50 internal ants

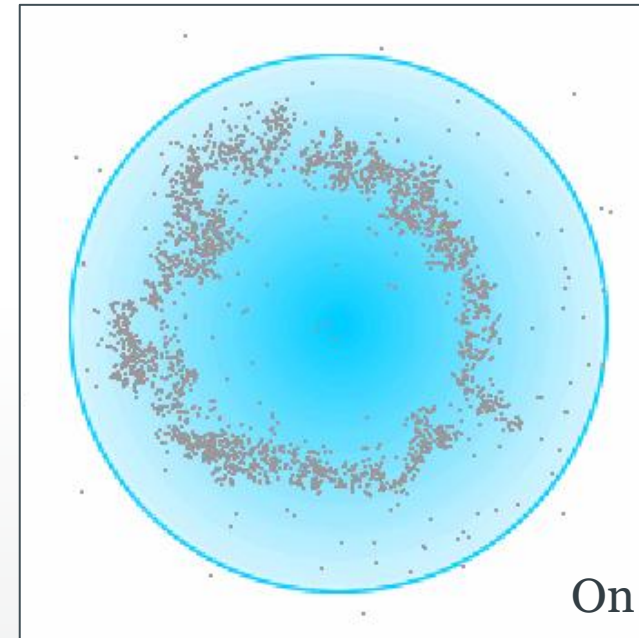
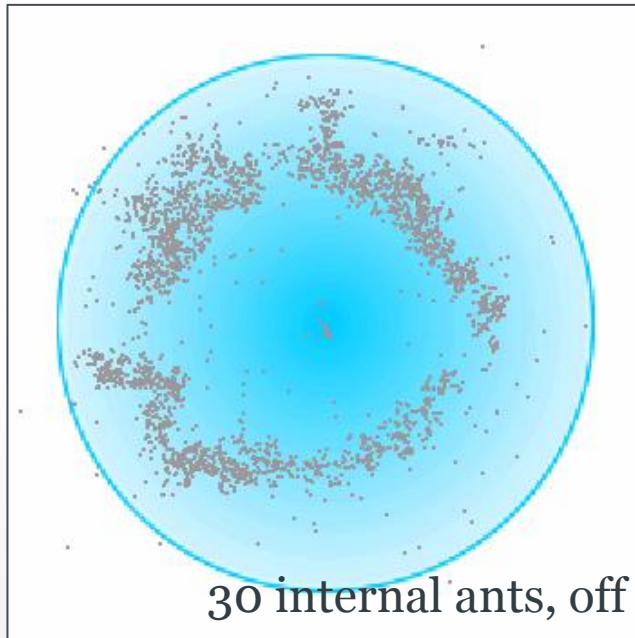
External Ants

- More external ants = pressure inwards
- If too many, they also serve as outward pressure
- Consistent for different nest sizes



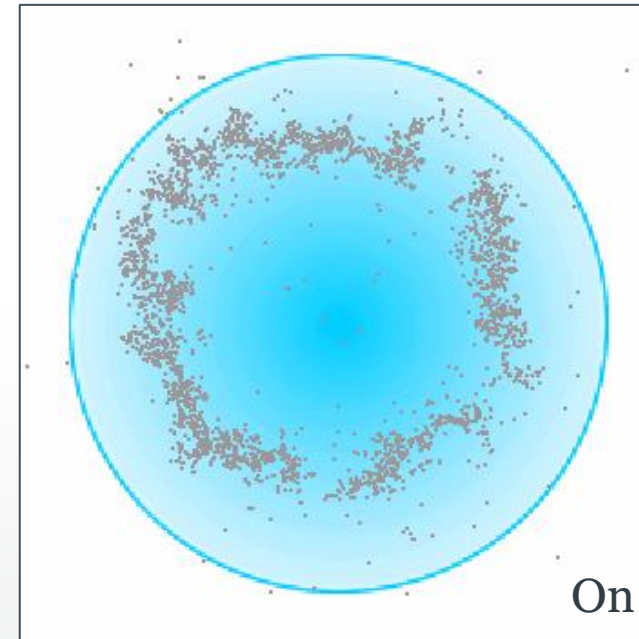
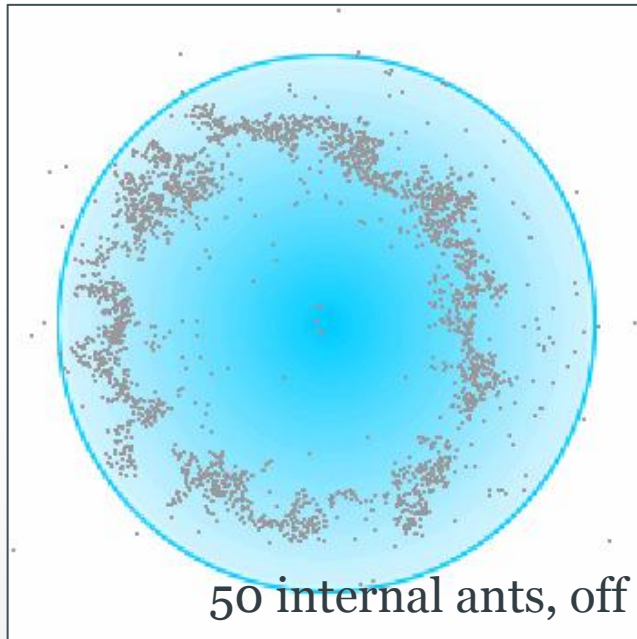
- 30 internal ants
- 1.0 pheromone movement threshold
- 0.5 pheromone movement threshold

Pheromone as a building template



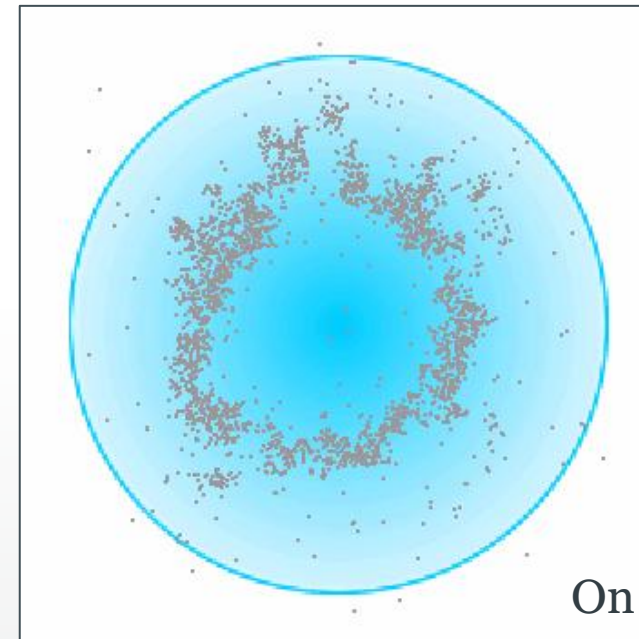
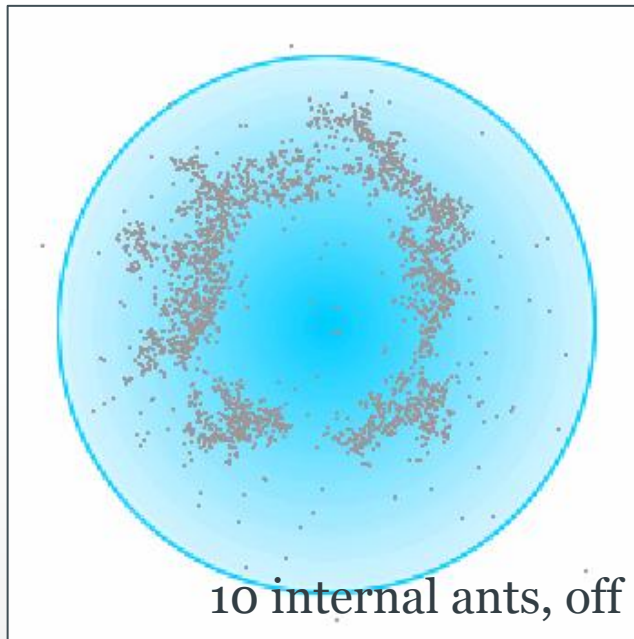
- Turned off: nest building possible (but sensitive)
- Turned on:
 - Low pheromone = more probable to drop stones
 - Increases regularity

Pheromone as a building template



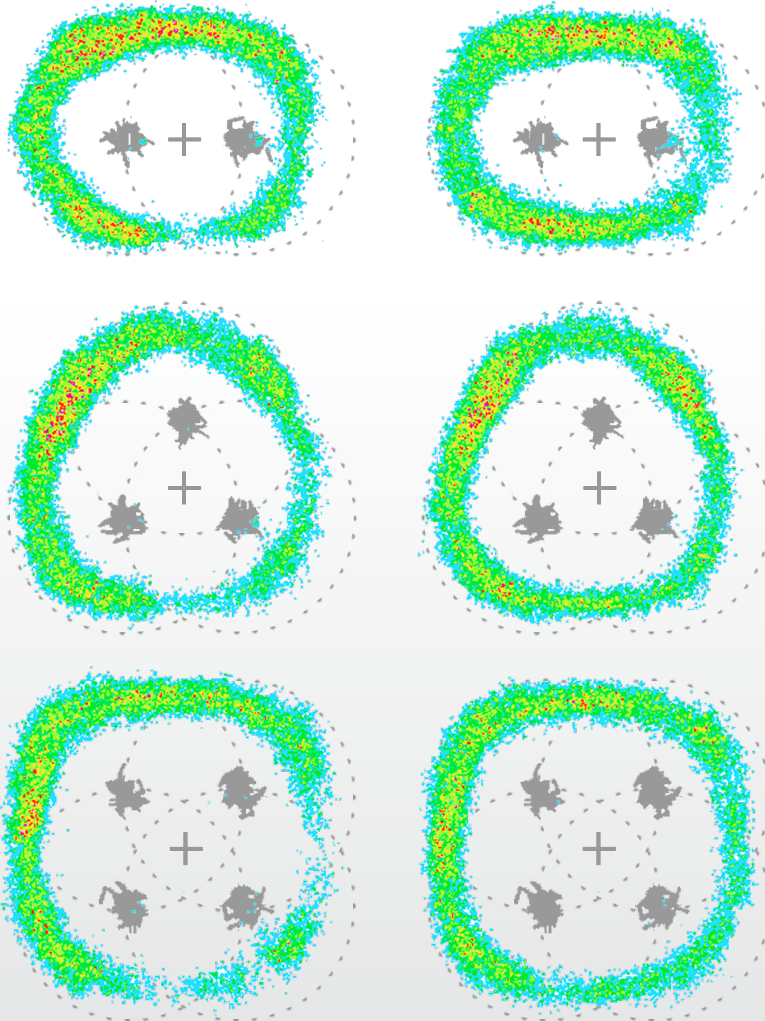
- Turned off: more internal ants = bigger nest, less regular
- Turned on:
 - Increases regularity
 - Makes nest smaller

Pheromone as a building template



- Turned off: less internal ants = smaller nest
- Turned on:
 - Minimal effect

Designing nest shape



- Possible via multiple brood clusters without changing behavioural rules of ants
- Inside gets automatically cleared by internal ants moving between clusters

Conclusion

- Continuous model, reproduces real world data and previous work
- Better understanding of effect of internal and external ants
- Pheromone template not necessary for creation of nests
 - ...but the template can improve nest regularity and standardise nest size
- Indication that we could build more complex structures than those in nature using relatively simple agents / robots
 - Different pheromones to indicate special elements?
 - Nest morphogenesis by more complex local rules?

Thank you!
Questions?