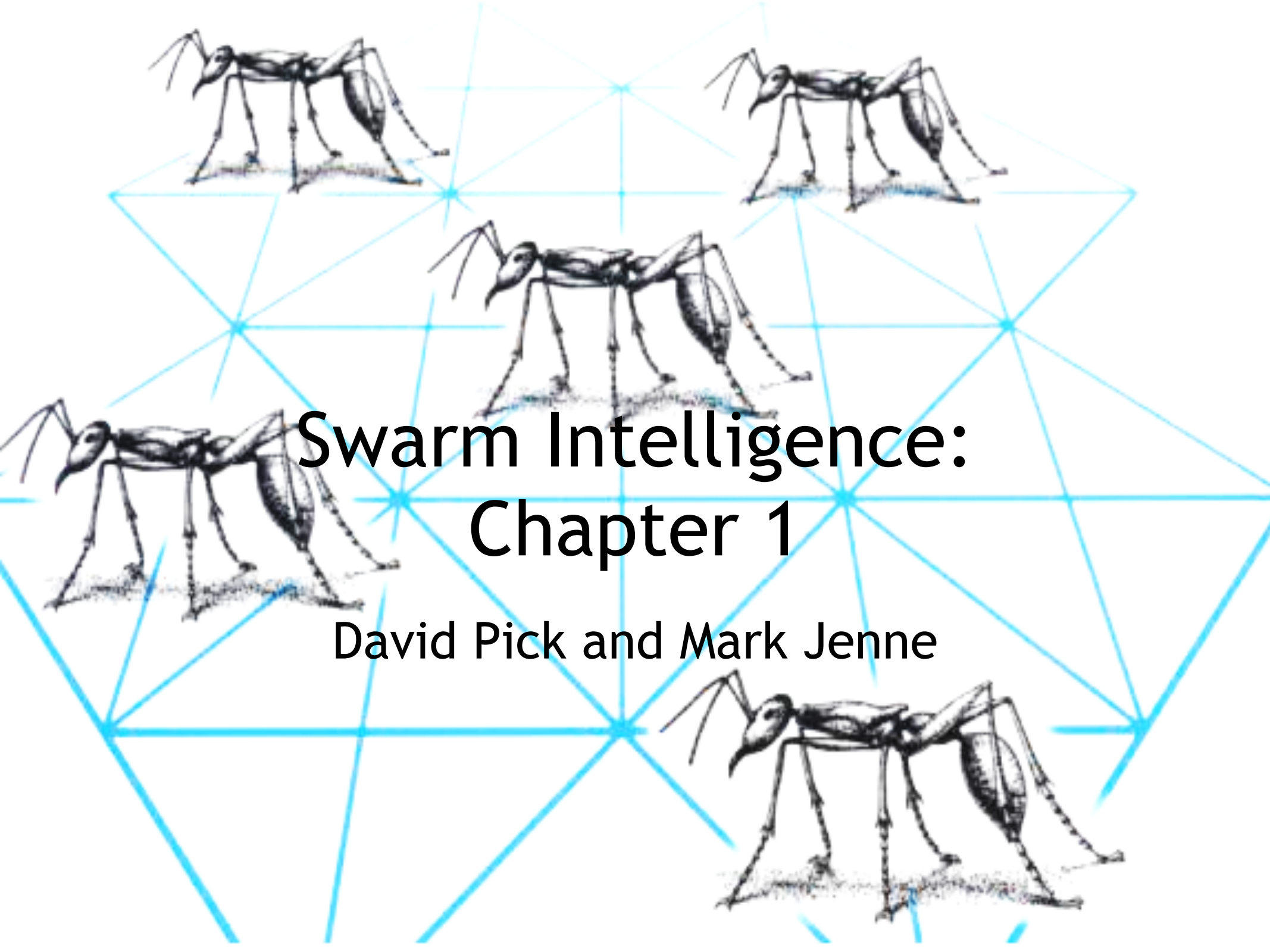

Swarm Intelligence: Chapter 1

David Pick and Mark Jenne

Insect Colonies

- Generally a strong division of labor
  - Workers specialize in a set of tasks
    - Based on age, morphology, and chance
  - Believed to be more efficient than having non-specialized workers

Leafcutter ants gathering leaves

How does individual behavior connect to collective performance?

- Some of it is genetically determined
  - Anatomical differences will determine an individuals job
- Much of it is determined by self-organization (SO)
  - Self-Organization is the process by which a structure or pattern appears without an external element planning it
- A social insect colony is in effect a decentralized problem-solving system
- Using these techniques insects solve problems in a very flexible and robust manner

"Swarm Intelligence"

- First used by Beni, Hackwood, and Wang in the context of cellular robotic systems
- Now used to describe any system that tries to solve a problem using techniques inspired by the collective behavior of social insect colonies

Nest of a *Parachartergus* wasp species

Modeling Collective Behavior

- Attempt to uncover how the physical system works
- The structures created should be consistent with what is being represented
- While the system should be plausible, engineers do not have to consider the exact same constraints as nature

Modeling Self-Organization

- Self-Organization is composed of four main components
  - Positive Feedback
  - Negative Feedback
  - Importance of fluctuations (i.e. randomness)
  - Multiple Interactions

Characteristics of Self-Organization

- Creation of structures in a homogeneous medium
- The possibility of several stable states coexisting
  - With 2 food sources available, ants will only go after one, completely ignoring the other
- The actions being performed will change when the parameters change

Stigmergy

- Interactions through both direct and indirect communication
- Direct communications occur in the "obvious" ways
- *"Driven by the mark"*
- Indirect communication occurs when something modifies
  the environment and another one reacts to that change

Termites construct their mound through the self-organizing process of stigmergy.

Reasons For The Success of Collective Robotics

- Relative failure of traditional AI techniques
- Huge hardware improvements in the last decade
- Collective Robotics has taken off through positive feedback from people in the field of AI

Simple robots act collectively to solve a problem

Questions?