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Programmable self-assembly in a thousand-robot swarm:

The study created and test **artificial robot swarms** relying on **local interactions** and developing based on **collective algorithm** to achieve natural-like capabilities. It takes inspiration from collective intelligence that can be observed in nature at different scales, such as development of multicellular organisms or among insects like bees and ants to create nest or bridge like structures for overcoming hurdles.

Although previous studies have developed self-assembly robots, this project addresses to **larger scale** of robotic swarms in terms of **algorithm and hardware design** by developing and testing 1000 low cost ‘kilobot’ robots to achieve self-assembly for a user defined shape.

The robots in this swarm ‘Kilobots’ were designed with **minimal individual capabilities** such as approximate holonomic motion, communication with neighboring robots within a fixed radius, measuring distance to communicating neighbors and **basic computation capabilities** and internal memory, and were **designed to work on a collective algorithm** that could generate **predictable behavior**.

The ‘seed-initiated’ self-assembly **algorithm combined primitive collective behaviors** of ‘edge-following’, where a robot can move along the edge of a group, by measuring distances from robots on the edge; ‘gradient formation’, where a source robot can, generate a gradient value message that increments, as it propagates through the swarm, giving each robot a geodesic distance from the source; and ‘localization’, where robots can form a local coordinate system using communication with, and measured distances to, neighbors.

Applying algorithms on physical robots brought in **technical challenges and errors** such as from imprecise locomotion, noisy distance sensing, and message loss, while the large scale of swarm added nonideal behaviors such as systematic errors and high variability in robot locomotion and sensing, and statistically rare events, such as a technical failures.

Design of the **algorithm addressed to such challenges by using a continuous-space shape representation**

that offered flexibility for location of robots within that shape, thus enabling for higher tolerance and preventing small position errors that could result into large assembly failures **and by incorporating information exchange with neighbors** for ‘co-operative’ monitoring.

Experiments from the study **demonstrated natural-like ability in a large-scale autonomous** swarm to achieve complex global behavior from the cooperation of many limited and noisy individuals, which suggests further development of **complex robotic systems and advanced collective algorithms**.

Some questions:

1. What are some of the ethical considerations to computing collective intelligence or artificially creating it?
2. In what ways is human collective behavior different from that of other organisms?
3. What about rules of interactions and engagement that apply to our own human collective? Should we ever engineer the human collective? What could errors mean in the context of human collective?