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Editorial

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Swarm intelligence studies the collective behavior of systems composed of many individuals that interact locally with each other and with their environment, and that use forms of decentralized control and self-organization to achieve their goals.

Research in swarm intelligence encompasses both science and engineering. Science oriented research is focused on trying to understand and model naturally occurring swarm systems. More recently, a growing body of engineering-minded researchers have been studying how to create and control swarms of physical or software-based artifacts. This engineering oriented research often, but not always, takes inspiration from scientific studies of natural swarm systems.

The scientific interest in natural swarms needs little justification. It is, however, worth taking a second to consider the value of studying artificial swarm systems. Why are we interested in designing swarms of artifacts (be they software or hardware) and trying to solve problems with them? What is it we hope these systems will provide that current technologies cannot?

Put simply, creators of artificial swarms are trying to copy the observable success and efficiency of natural swarm systems. Despite the relative simplicity of individual agents, natural swarm systems can often display extremely complex behavior. Natural swarm systems are highly scalable—they are sometimes made up of many millions of individuals. In addition, such systems tend to be flexible and robust. They respond well to rapidly changing environments, and continue to function even if many of the individual agents are incapacitated.

Studies have shown that in many cases simple behavioral rules at the level of the individual are sufficient to explain complex group behavior. These models also do not require any global communication—they rely only on local sensing and communication.

Researchers have started to use similar behavioral models in artificially created swarms. In the robotics research domain, for example, swarm principles have recently come into

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vogue. So called swarm robotic systems are attractive, as individual robots can potentially be simple, reliable and cheap. Through cooperation, these relatively simple robots can together accomplish difficult tasks in a robust and scalable way.

Swarm intelligence thus provides a new framework for the design and implementation of systems made of many agents that are capable of cooperation for the solution of complex problems. The potential advantages of the swarm intelligence approach are manifold:

- collective robustness—the failure of individual components does not significantly hinder performance;
- individual simplicity—cooperative behavior makes it possible to reduce the complexity of the individuals;
- scalability—the control mechanisms used are not dependent on the number of agents in the swarm.

So far, we have only just scratched the surface of swarm intelligence as a practical engineering approach. The majority of research to date has focused on demonstrating the cooperative problem solving capabilities of swarm intelligent systems. Very encouraging results have been obtained, especially in optimization applications. I refer, in particular, to ant colony optimization and to particle swarm optimization, where swarms of software agents cooperate to search for good solutions to difficult optimization problems. Swarm robotics is another area that is producing a number of interesting results. Swarm of robots, capable of cooperative problem solving, have been built and tested, and in some cases a degree of robustness and scalability has been demonstrated.

I strongly believe that we will start seeing more and more applications of swarm intelligence in the near future. My personal opinion is that swarm robotics will play an important role in these developments. It is, however, difficult to forecast which direction the field will take. This journal, Swarm Intelligence, will document the most significant research results in this exciting field. It will act as a point of contact between the biologists, proposing models of natural swarm systems, and the engineers and computer scientists, interested in making practical use of their scientific insights.

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Editor-in-Chief