Chapter XI

Swarm-Based Techniques in E-Learning:
Methodologies and Experiences

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ABSTRACT

This chapter provides an overview of the use of swarm-intelligence techniques in the field of e-learning. Swarm intelligence is an artificial intelligence technique inspired by the behavior of social insects. Taking into account that the Internet connects a high number of users with a negligible delay, some of those techniques can be combined with sociology concepts and applied to e-learning. The chapter analyzes several of such applications and exposes their strong and weak points. The authors hope that understanding the concepts used in the applications described in the chapter will not only inform researchers about an emerging trend, but also provide with interesting ideas that can be applied and combined with any e-learning system.

INTRODUCTION

The World Wide Web does not offer only access to information. It connects many people all around the world in a very short time. New applications, inspired in natural processes (like those that allow social insects to work together) are appearing.

Many research efforts are trying to take advantage of two fundamental characteristics of the Internet: small delays in communications (independent of physical location) and a big number of users. Social systems try to emulate the behavior of social groups in real life. These systems extract some information from the behavior of
the group and use it to get some benefit for the students. In other words, they take advantage of the interactions between the different members of the learning community to help each of its members. This chapter aims at providing the reader with a broad overview of the state of the art on this emerging field, specifically regarding the problems of sequencing and filtering.

BACKGROUND

A swarm may be defined as a population of interacting elements that is able to optimize some global objective through collaborative search of a space (Kennedy & Eberhart, 2001). The elements may be very simple machines or very complex living beings, but there are two restrictions to be observed: they are limited to local interactions and usually interaction is not performed directly but indirectly through the environment. The property that makes swarms interesting is their self-organizing behavior; in other words, it is the fact that a lot of simple processes can lead to complex results.

The behavior of ants is the best-known example of swarm intelligence. In many ant species, ants deposit a chemical substance called pheromone as they move from a food source to the nest. Ants do not communicate directly with each other, but they follow pheromone trails (leaving their own pheromones behind, so the trail is reinforced). Shorter trails are more strongly reinforced, as the ants cross them more times for the same period of time, so they are followed by more ants. In the end, this positive feedback loop ends up in the path connecting the food source and the nest being optimized without any global knowledge of the problem by any of the agents. This process of indirect communication in a swarm is called stigmergy (Bonabeau, Dorigo, & Theraulaz, 1999). Another example of a stigmergic process is nest building by termites, in which the insects are able to construct complex buildings with arcs, hallways, and ventilation systems following very simple and local rules.

Swarm intelligence is a growing field of active research, and its applications outside the Internet are manifold. Swarm intelligence techniques have been applied to many different kinds of problems. Examples include packet routing (Dorigo & Stützle, 2004), graph coloring (Costa, Hertz, & Dubious, 1995), allocating tasks for robots in a factory (Morley, 1996), routing a fleet of trucks (Gambardella, Taillard, & Agazzi, 1999), as well as many robotic applications (Bonabeau et al., 1999). It is common to use the term ant colony optimization (ACO) for the set of heuristics used on these problems.

The Internet allows for low-delay communications for big amounts of people. Communication can be direct (like it is the case for IP-telephony or chats) or indirect (like Internet polls or file interchange), and there are many intermediate cases (like Internet fora). Big number of participants, indirect communication, local awareness, and local actions define a setting for the appearing of emergent behaviors of a swarm by combination of the activities of all its members.

COLLABORATIVE SEQUENCING

The problem of adaptive sequencing is that of, given a set of learning activities, finding the best sequence for a particular student. Given a proper user model, a system can adapt the sequence of learning activities to each student. Unfortunately, most approaches share a common weakness. The role of a human designer is very important and a mistake on her part affects the whole system. The negative effect on students may vary.

Human mistakes may be avoidable (e.g., errors when typing names of activities), but the sequencing designing process is bound to some unavoidable problems. First, teachers have a limited capability and a limited knowledge about activities that may be of interest for their students.
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