Chapter X

Particle Swarms:
Optimization Based on Sociocognition

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ABSTRACT

Particle swarm optimization is a computer paradigm that is based on human social influence and cognition. Candidate problem solutions are randomly initialized, and improvements are found through interactions among them. Social-psychological aspects of the algorithm are described, followed by implementation details. The particle swarm operates in three kinds of spaces, namely a topological space comprising the "social network" structure of the population, a parameter space of problem variables, and a one-dimensional evaluative space. Variations in the algorithm are described, and finally it is compared to evolutionary computation models.

INTRODUCTION

This chapter introduces the particle swarm algorithm, which is used to optimize hard problems. The algorithm is sometimes compared to evolutionary algorithms (EAs) of various sorts, as it comprises a population of individuals and random fluctuation, which are characteristic of EAs. The particle swarm arose from research in social psychology, and differs significantly from evolutionary methods. This chapter develops the algorithm from the sociocognitive perspective, describes some variations of the algorithm, and finally draws comparisons between particle swarms and related paradigms.

Mind and Logic

There is not only a close analogy between the operations of the mind in general reasoning and its operation in the particular science of Algebra, but there is to a considerable extent an exact agreement in the laws by which the two classes of operations are conducted. (Boole, 1854, p. 6)

George Boole's volume, *An Investigation into the Laws of Thought, on Which are founded the Mathematical Theories of Logic and Probabilities*, assumed, even in the title, that human thought was rational, that our minds obeyed the laws of logic, and that once these were properly understood, the mind itself would be explained (Boole, 1854). *Logic.* The word is chilling, the process cuts like a fast-moving razor, deducing, deciding, pressing forward relentlessly, freezing the vermin of vagueness in the cold light of truth. It always seemed that, if the rules were just known, if we only understood a little better how a conclusion follows from a premise, and under what conditions — given the correct premises, we should be able to master all knowledge and happily live out the utopian dream.

The computer changed all that. Finally, with the invention of the electronic computer, the laws of reason that had been well established over the millennia could be implemented in a machine; pure logical processes could run all on their own, without dirty, disorganized, *biological,* humans to mess it all up with egocentric, biased, wishful thinking.

And guess what: it didn't work.

The first "artificial intelligence" programs were great for solving well-defined mathematical and logical problems, but the dreams of exceeding or even challenging human intelligence just never materialized. Even though some hard things, such as theorem-proving, were fairly easy to accomplish, it turned out that the easy things are too hard. Picking out a friend in a crowd; interpreting language (which any four-year-old can do); walking and chewing gum, separately or at the same time — these ordinary things, it was discovered, were extremely hard for a machine to do.

There is irony of course in the fact that the quest of civilized intellect arrives at the realization that the goal was not worth striving for. Pure logical reasoning, it turns out, is extremely limited, too weak to handle the interesting challenges of a normal day, never-mind the complex dimensions of real engineering problems. The elusive quality we call intelligence has a logical component — ability to reason is an important part of any IQ test for humans — but we find that perfect crisp logic as instantiated in the von Neumann computer is an inert and sterile capacity.

The Sociocognitive Solution

So it is time to look somewhere else for techniques, if we want to use the computer to find solutions to nasty, gnarly problems. In keeping with the theme of this volume, this chapter recommends that we look for techniques in a really successful biological system, a system that has improved itself over time, and that has resulted in the almost-too-good reproductive success of a species. I am talking about human social behavior.

This chapter will describe a computational problem-solving or optimization method that is based on a social psychological description of human behavior. Social psychology is the empirical study of the individual in his or her social context. Being a topic within

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