Les Balzer discusses quantitative techniques which emulate biological reproduction and evolve towards optimal solutions to complex financial problems.

Genetic algorithms
or, a mating game for investment managers

The Quant Report in the December 1992 issue of JASSA discussed the dangers inherent in using a simple and widespread quantitative technique, IRR. This report explores an evolutionary approach to more complex problems.

Humans may spend countless hours in the intellectually demanding but sometimes fruitless pursuit of the perfect answer to a question. Even made computer programs often make only slow progress towards finding optimal solutions to complex financial problems.

In contrast, other living organisms seem to take an undirected wander through myriad possibilities to reach quite elegant solutions. Through a process of genetic adaptation, they can work their way towards answers to complex biological challenges.

For centuries, mankind has been harnessing the power of selection and crossbreeding in the search for better dogs, racehorses, crops, flowers and so on. It seems a logical extension, then, that mathematicians should attempt to harness the processes of evolution and crossbreeding in solving computer-based optimisation problems. Genetic algorithms are the result.

Typically, genetic algorithms start by creating a population of "organisms", hundreds of randomly different solutions which cover the complete range of possibilities. The equivalent of a DNA string, consisting of a series of zeros and ones, is then created for each solution. A one represents the presence of some feature of the solution, and a zero its absence.

Each solution is then tested for its quality or value. For example, in a portfolio investment the quality criterion might be portfolio return or risk, or some combination of the two. High-quality strings are retained (and survive) while low strings are discarded (and perish) — the quantitative equivalent of Darwinian natural selection.

High-quality strings are then mated, pair by pair, in a process with overtones of genetic engineering. Within each pair, the strings are broken at the same arbitrary point and the first part of each is combined with the second part of the other. The offspring replace the low-quality strings which have been discarded, while the parent strings are retained. The process of selection and mating continues until one or more solutions of sufficiently high quality are found.

A small number of mutations can be introduced at each generation to guard against the possibility of insufficient genetic diversity in the initial population. Parasites which attack the weak organisms can also be added to increase the rate at which poor-quality solutions perish.

Genetic algorithms are inherently efficient. Eliminating low-quality parents eliminates their children, their children's children, etc, without further calculations.

In addition, because pairs of parents can be evaluated and mated or discarded in parallel, the computations can be performed on multi-processor parallel computers, which are much faster than conventional computers.

Perhaps the greatest advantage of using genetic algorithms is the much higher probability of finding global rather than local optima than is the case with most conventional methods. For example, consider finding the top of a hill. Many hill-climbing algorithms for optimisation proceed from a single starting-point, look for the direction of steepest ascent and take a step in that direction. The new direction of steepest ascent is then found and another step taken; and so forth, until the summit is reached.

Most optimisation problems in the real financial world, however, involve craggy mountains with many false or local peaks, not smooth, rounded hills. Most hill-climbing methods end up on the top of a false peak. If the equivalents of cliffs, tunnels, bridges or caves exist, the journey becomes even more difficult. By spreading a net across the whole mountain and searching in many directions at once, genetic algorithms have a much greater chance of finding the true summit — or global optimum.

In practice, genetic algorithms tend to evolve to very good solutions. Rarely do they find the best solution exactly, but equally rarely in business do we need the theoretically perfect answer.

Genetic algorithms have been used to detect stolen credit cards from abnormal usage patterns, to improve engineering designs and to simulate commodity trading where the traders are only partially rational. Genetic algorithms combined with neural nets are being tested in various investment management tasks including manager classification.

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