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Genetic Algorithms in Plain English

Introduction

The aim of this tutorial is to explain genetic algorithms sufficiently for you to be able to use them in your own projects. This is a stripped-down to-the-bare-essentials type of tutorial. I'm not going to go into a great deal of depth and I'm not going to scare those of you with math anxiety by throwing evil equations at you every few sentences. In fact, I'm not going to throw any nasty equations at you at all! Not in this particular tutorial anyway... <smile>

This tutorial is designed to be read through *twice*... so don't worry if little of it makes sense the first time you study it.

(A reader, Daniel, has kindly translated this tutorial into German. You can find it here.)
(Another reader, David Lewin, has translated the tutorial into French. You can find it here.)

First, a Biology Lesson

Every organism has a set of rules, a blueprint so to speak, describing how that organism is built up from the tiny building blocks of life. These rules are encoded in the *genes* of an organism, which in turn are connected together into long strings called *chromosomes*. Each gene represents a specific trait of the organism, like eye colour or hair colour, and has several different settings. For example, the settings for a hair colour gene may be blonde, black or auburn. These genes and their settings are usually referred to as an organism's *genotype*. The physical expression of the genotype - the organism itself - is called the *phenotype*.

When two organisms mate they share their genes. The resultant offspring may end up having half the genes from one parent and half from the other. This process is called *recombination*. Very occasionally a gene may be *mutated*. Normally this mutated gene will not affect the development of the phenotype but very occasionally it will be expressed in the organism as a completely new trait.

Life on earth has evolved to be as it is through the processes of natural selection, recombination and mutation. To illustrate how these processes work together to produce the diverse range of flora and fauna we share our planet with let me tell you a little story....

> *Once upon a time there lived a species of creatures called Hooters. Hooters had evolved entirely within the darkened confines of a vast cave system hidden deep in the bowels of a mountain range. They'd had an easy life, feeling and smelling around the*

damp cave walls for the algae they so loved to eat, oozing between rocks and, at mating time, listening intently for the hoots of other Hooters. There were no predators in the caves, it was just the Hooters, the algae and the occasional friendly slug, so the Hooters never had anything to fear (except for maybe the occasional bad tempered Hooter). An underground river flowed through the cave system and water continuously dripped down through the water table bringing with it the fresh nutrients the algae thrived on so there was always plenty to eat and drink. However, although Hooters could feel and hear well they never had any need for eyes in the pitch blackness of the caves and as a result were totally blind. This never seemed to concern any of the Hooters though and they all had a whale of a time munching away and hooting in the darkness.

Then one day an earthquake caused part of the cave system to collapse and for the first time in many millennia the Hooters felt the warmth of sunlight upon their skin and the soft springiness of moss beneath their feet. A few daring Hooters tasted the moss and found that it was even better eating than the cave algae. "Oooooooooh!" they hooted between mouthfuls of moss and promptly got gobbled up by the marauding eagles who had flown in to see what all the commotion was about.

For a while it looked as though the Hooters may be hunted to extinction, for although they liked to eat the moss they could never tell if an eagle was flying above. Not only that, they couldn't even tell if they were concealed beneath a rock or not unless it was low enough to reach for with their feelers. Every day many Hooters would stumble out from the caves with the sweet smell of moss in their nostrils only to be swiftly carried away and eaten by an eagle. Their situation seemed grim indeed.

Fortunately, over the years, the population of Hooters had grown to be enormous in the safety of the caves and enough of them were surviving to mate - after all, an eagle can only eat so much. One day, a brood of Hooters was born that shared a mutated skin cell gene. This particular gene was responsible for the development of the skin cells on their foreheads. During the development of the baby Hooters, when their skin cells grew from the mutated gene instructions they were slightly light sensitive. Each new baby Hooter could sense if something was blocking the light to its forehead or not. When these little baby Hooters grew up into bigger Hooters and ventured into the light to eat the moss they could tell if something was swooping overhead or not. So these Hooters grew up to have a slightly better chance of survival than their totally blind cousins. And because they had a better chance of survival, they reproduced much more, therefore passing the new light sensitive skin cell gene to their offspring. After a very short while the population became dominated by the Hooters with this slight advantage.

Now let's zip a few thousand generations into the future. If you extrapolate this process over very many years and involving lots of tiny mutations occurring in the skin cell genes it's easy to imagine a process where one light sensitive cell may become a clump of light sensitive cells, and then how the interior cells of the clump may mutate to harden into a tiny lens shaped area, which would help to gather the light and focus it into one place. It's not too difficult to envision a mutation that gives rise to two of these light *gathering areas thereby bestowing binocular vision upon the Hooters. This would be a huge advantage over their Cyclopsian cousins as the Hooters would now be able to judge distances accurately and have a greater field of view.*

As you can see the processes of natural selection - survival of the fittest - and gene mutation have very powerful roles to play in the evolution of an organism. But how does recombination fit into the scheme of things? Well to show you that I need to tell about some other Hooters...

At around the same time the Hooters with the light sensitive cells were frolicking around in the moss and teasing the eagles, another brood of Hooters had been born who shared a mutated gene that affected their hooter. This mutation gave rise to a slightly bigger hooter than their cousins, and because it was bigger they could now hoot over longer distances. This turned out to be useful in the rapidly diminishing population because the Hooters with the bigger hooters could call out to potential mates situated far away. Not only that but the female Hooters began to show a slight preference to males with larger hooters . The upshot of this of course was that the better endowed Hooters stood a much better chance of mating than any not so well off Hooters. Over a period of time, large hooters became prevalent in the population.

Then one fine day a female Hooter with the gene for light sensitive skin cells met a male Hooter with the gene for producing huge hooters. They fell in love, and shortly afterwards produced a brood of lovely baby Hooters. Now, because the babies chromosomes were a recombination of both parents chromosomes, some of the babies shared both the special genes and grew up not only to have light sensitive skin cells, but huge hooters too! These new offspring were extremely good at avoiding the eagles and reproducing so the process of evolution began to favour them and once again this new improved type of Hooter became dominant in the population.

And so on. And so on...

Genetic Algorithms are a way of solving problems by mimicking the same processes mother nature uses. They use the same combination of selection, recombination and mutation to evolve a solution to a problem. Neat huh? Turn the page to find out exactly how it's done.

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