mance. Those that improve continue to be modified until highly accurate link weights are evolved.

Genetic algorithms have proved to be an interesting way to determine link weights for neural networks but they have not, as of yet, shown themselves to generate better solutions or even comparable solutions in less time than back propagation does. They also have a problem of getting "stuck" on a suboptimal solution very early in the training, and can never find a better one.

Simulated Annealing and Neural Networks

We have used the analogy that back propagation is using a technique similar to what one does in climbing to the top of a hill. It is constantly trying to move in the direction that improves the network as much as possible, similar to the way one would walk in the direction that is most uphill if one were trying to get to the top of the hill. For neural networks, this means modifying the link weights the most, which will have the biggest impact on improving the performance of the network.

This art of hill climbing is an area that physicists have been interested in for years. In their case, they are looking at how metals cool and materials form crystals, but many of the same effects appear in all three areas. Because of the similarities between searching for the optimal solution and physics, several simulations have been tried in order to speed up the performance of neural network training. One technique is called simulated annealing.

Annealing is the process of cooling a metal or a glass at the right rates of speed, in order to minimize the number of defects that are formed in the structure of the material. Simulated annealing borrows the idea of heating and cooling a metal from the real world and applies it to removing the defects from a neural network. The idea is pretty simple: "Make large changes in the weights of the links early on in training; then slowly decrease the amount of change made to the network so that it can zero in on the best solution."

Allowing for these large changes in the link weights early on in the training process corresponds to a high temperature in a metal where the metal is just barely solid and is very malleable. Likewise, the neural network is "malleable" in the early part of the training, allowing for the trial of many very different values in the link weights. As time goes on, the changes in the link weights become smaller and smaller, and the removal of errors is done at a finer and finer level. The process is analogous to looking around the world for the highest mountain ranges before getting into the details of which particular outcropping of rock at the summit of Mount Everest or K2 is a foot higher than the other.