# GROW YOUR OWN PROGRAMS

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Wouldn't it be great if computers could actually write the programs?

- Genetic programming is the automatic production of programs by evolving a population of programs.
- GP uses the principles of Darwin's natural selection to breed programs of increasing fitness.
- GP has been used to solve problems, such as pole balancing and reversing an articulated lorry, by evolving programs which are increasingly better (ie are more fit).

## 1 Genetic Programming

Genetic programming works by combining two existing programs to produce a new one, and does so in a way as to ensure the new program is syntactically correct and executable. Progressive improvement is made by testing each change and only keeping the better ones.

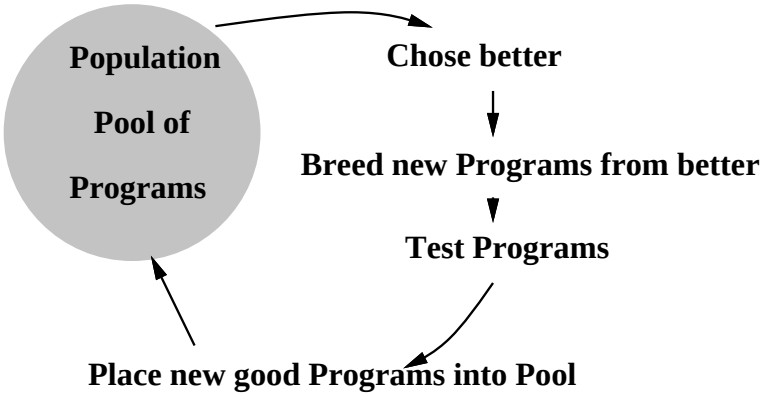


Figure 1: Evolving Computer Programs

Genetic programming represents programs as trees. Crossover combines parts of two trees to yield a third tree which has a legal syntax (Figures 2 and 3 show two trees which are crossedover to yield a third shown in figure 4).

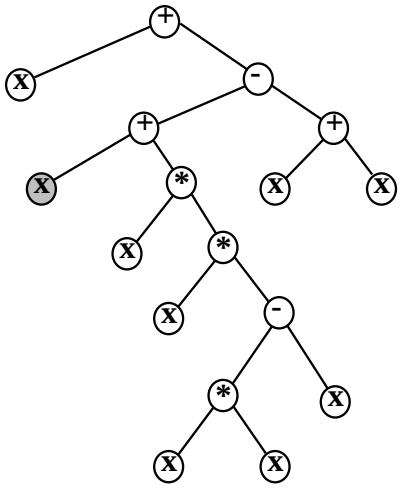

Figure 2: Mum: $2x + x^2(x^2 - x) - 2x$, fitness .71429, Discarded sub tree shaded

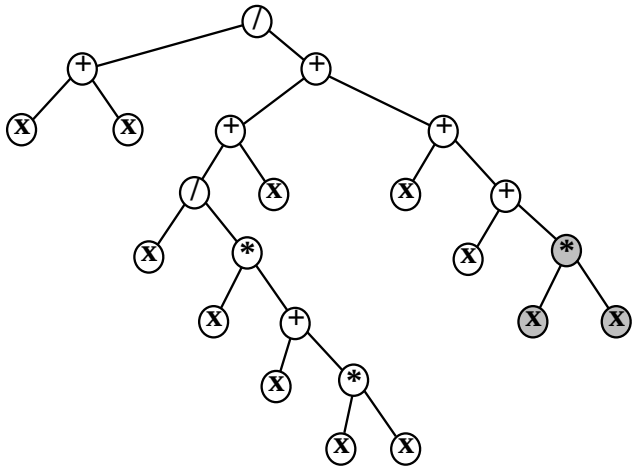

Figure 3: Dad: $\frac{2x}{\frac{x}{x(x+x^2)}+3x+x^2}$, fitness .66793, Donated sub tree shaded

## 1.1 A Simple Example of Genetic Programming

Figures 2, 3, 4 and 5 show genetic programming generating C code which calculates $x^4 - x^3 + x^2 - x$ starting from a random mixture of $+$, $-$, $\div$, $\times$ and $x$.

Each program generated is tested by comparing its answer with that desired. The absolute difference gives us a value of how bad the program is. The program fitness, ie how good it is, is obtained by inverting.

Figure 5 shows the values of the two parent programs against the test points (which their offspring matches exactly).

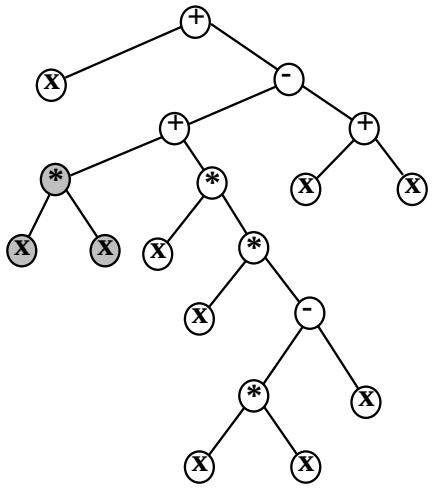


Figure 4: Correct Program: $x + x^2 + x^2(x^2 - x) - 2x$

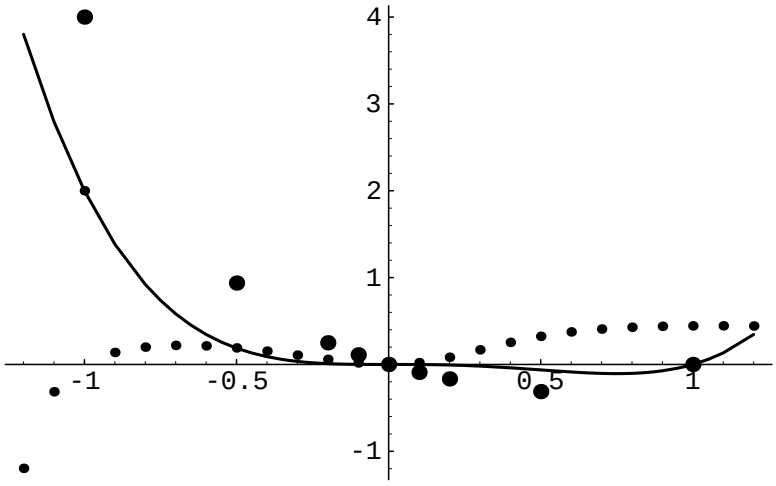


Figure 5: Values returned by *mum* (solid) and *dad* (small dots) against target values (large dots)

# 2 Application: Scheduling Maintenance of the National Grid

National Grid plc. is responsible for the maintenance of the extensive high voltage electricity power transmission network within England and Wales. It must plan maintenance so as to minimise costs whilst taking into account:

- location and size of electricity demand,
- generator capacities and availabilities,
- electricity carrying capacity of the remaining network.

The largest costs are caused when expensive generators have to be used because maintenance prevents the use of cheaper generators.

National Grid's Technology and Science Laboratories in Leatherhead and UCL are investigating using genetic methods to minimise these costs.

The initial demonstration network (figure 6) has nine generators of various capacities and availabilities, eight transmission circuits again of various capacity and two nodes with varying demands for electricity. All eight circuits must be maintained during a number of weeks, each planned maintenance takes a week.

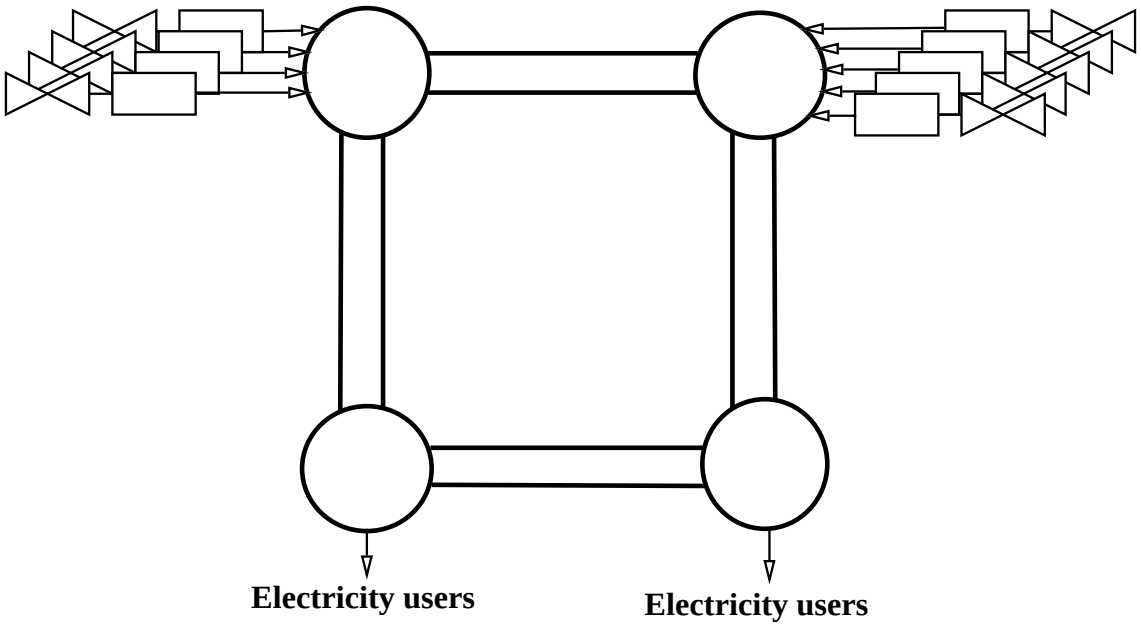


Figure 6: Demonstration Network

The code used for the example in section 1.1 is available via anonymous ftp from `cs.ucl.ac.uk`, directory `genetic`, please try it for yourself!