INTRODUCTION TO THE DIFFERENTIAL EVOLUTION ALGORITHM

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THE DIFFERENTIAL EVOLUTION ALGORITHM [1]

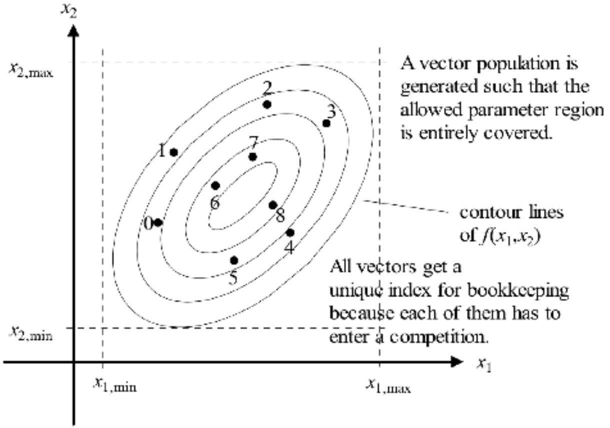

Figure: Initializing the DE population.

THE DIFFERENTIAL EVOLUTION ALGORITHM

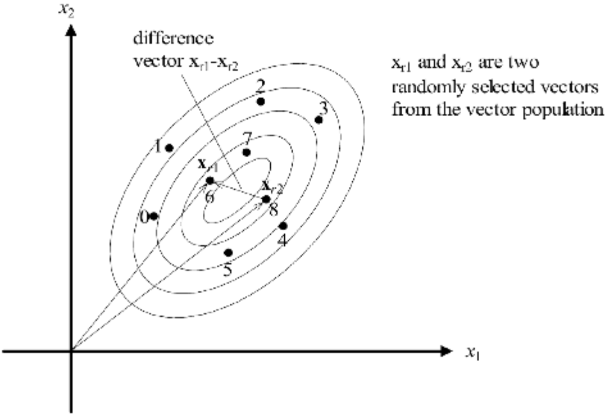

Figure: Generating the perturbation: $x_{r1} - x_{r2}$.

THE DIFFERENTIAL EVOLUTION ALGORITHM

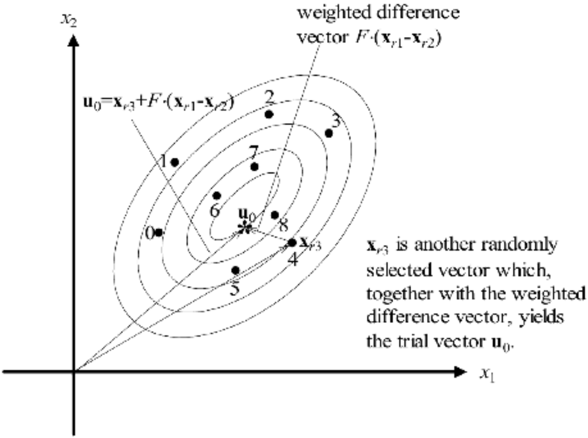

Figure: Mutation.

THE DIFFERENTIAL EVOLUTION ALGORITHM

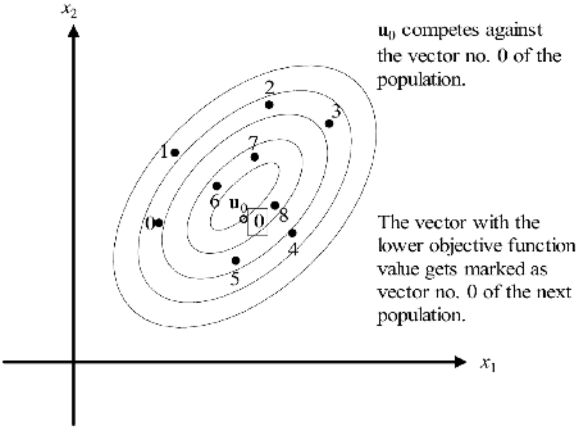

Figure: Selection. Because it has a lower function value, u_0 replaces the vector with index 0 in the next generation.

THE DIFFERENTIAL EVOLUTION ALGORITHM

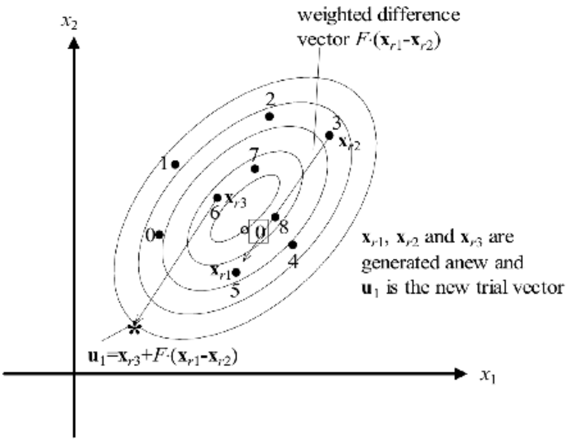

Figure: A new population vecotr is mutated with a randomly generated perturbation.

THE DIFFERENTIAL EVOLUTION ALGORITHM

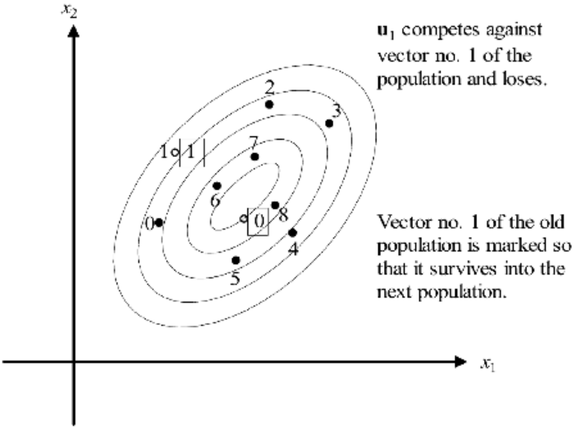

Figure: Selection. This time, the trial vector loses.

PSEUDO CODE

```
while (convergence criterion not yet met) do
    % x_i defines a vector of the current population
    % y_i defines a vector of the new population
    for (i = 0; i < N_p, i++) do
        r1=rand(N_p); % select a random index from 1,...,N_p
        r2=rand(N_p); % select a random index from 1,2,...,N_p
        r3=rand(N_p); % select a random index from 1,2,...,N_p
        u_i = x_r3 + F * (x_r1 - x_r2);
        if (f(u_i) <= f(x_i)) then
            y_i = u_i;
        else
            y_i = x_i;
        end if
    end for
end while
```

EFFECT OF SCALING FACTOR

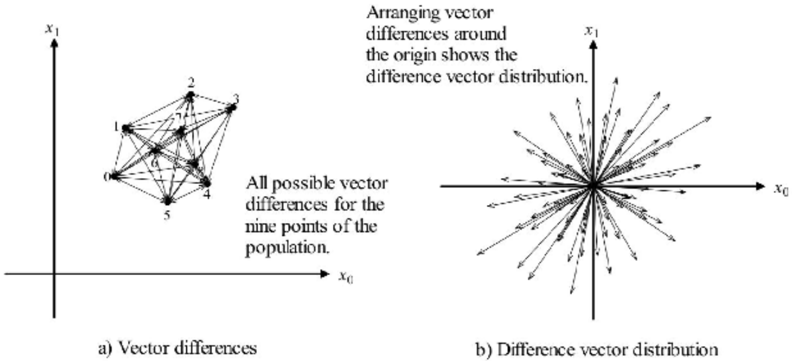

Figure: Nine vectors **a**, and their corresponding difference distribution **b**.

EFFECT OF SCALING FACTOR

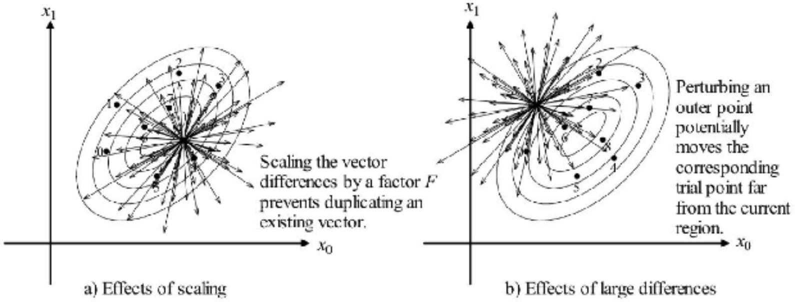

Figure: The effects of scaling **a**, and large vector differences **b**. Scaling factor of F=0.9 is usually used.

EFFECT OF CROSSOVER

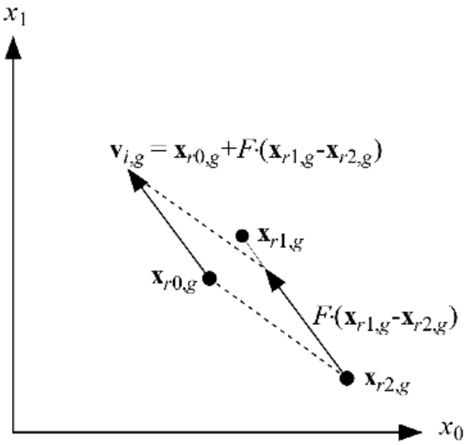

Figure: Differential mutation: the weighted differential, $F \cdot (x_{r1,g} - x_{r2,g})$, is added to the base vector, $x_{r0,g}$, to produce a mutant, $v_{i,g}$.

EFFECT OF CROSSOVER

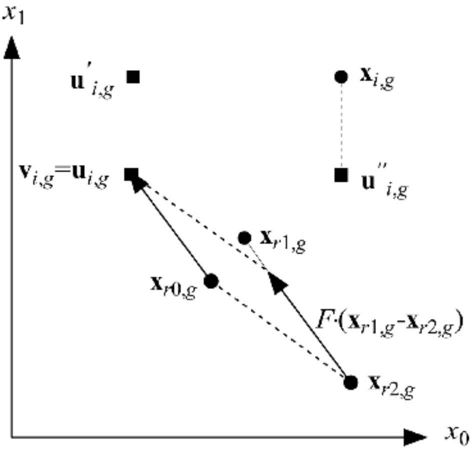

Figure: The possible additional trial vectors $u'_{i,g}$, $u''_{i,g}$ when $x_{i,g}$ and $v_{i,g}$ are uniformly crossed. Usually crossover coefficient is set to 0.9.

STEP BY STEP EVOLUTION

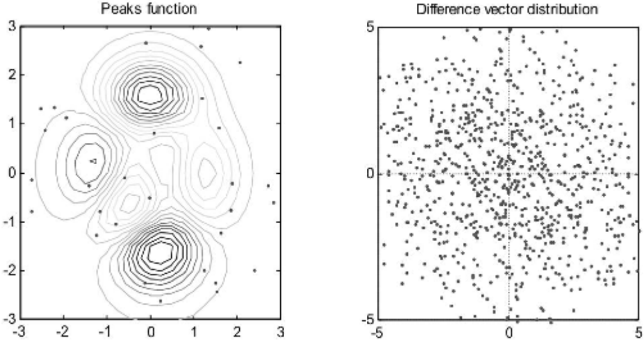

Figure: Generation 1: DE's population and difference vector distributions.

STEP BY STEP EVOLUTION

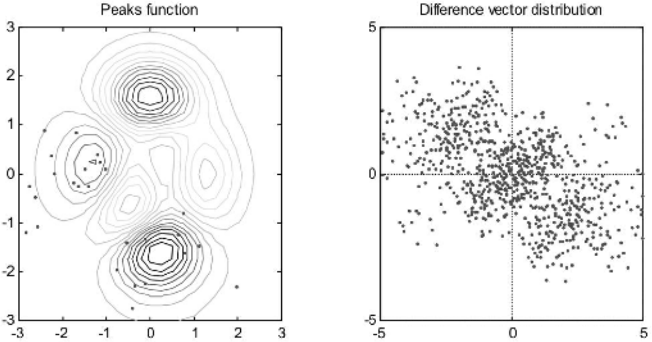

Figure: Generation 6: The population coalesces around the two main minima.

STEP BY STEP EVOLUTION

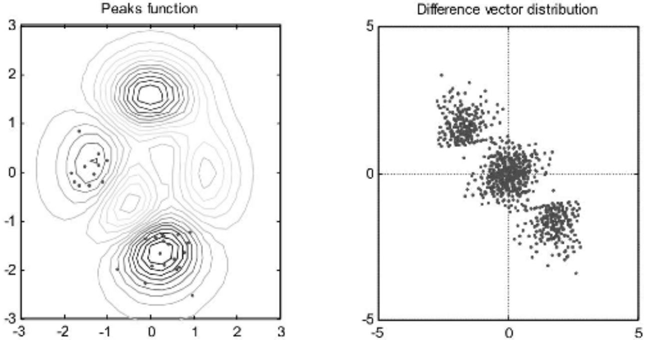

Figure: Generation 12: The difference vector distribution contains three main clouds – one for local searches and two for moving between the two main minima.

STEP BY STEP EVOLUTION

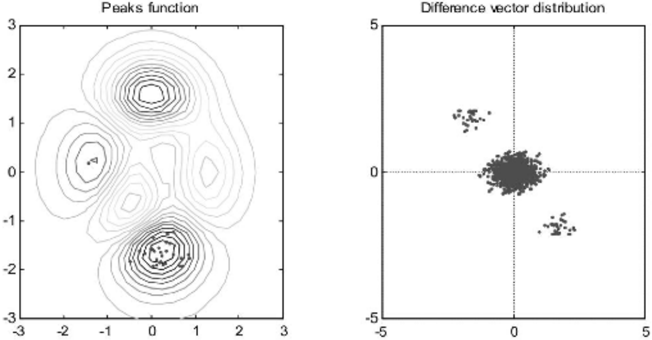

Figure: Generation 16: The population is concentrated on the main minimum.

STEP BY STEP EVOLUTION

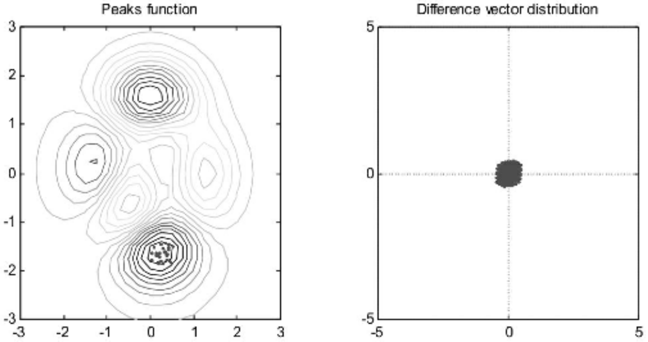

Figure: Generation 20: Convergence is imminent. The difference vectors auto- matically shorten for a fine-grained, local search.

STEP BY STEP EVOLUTION

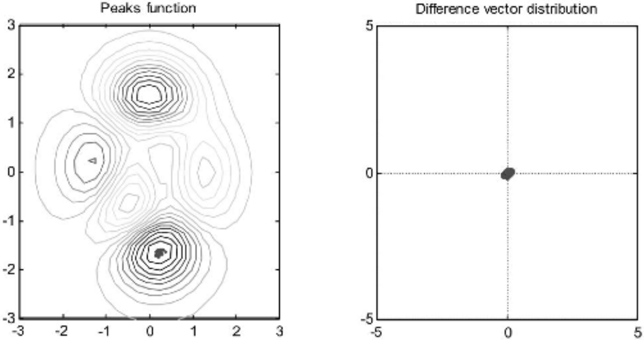

Figure: Generation 26: The population has almost converged.

STEP BY STEP EVOLUTION

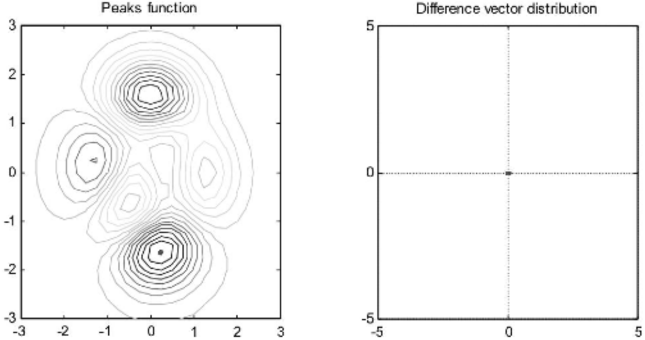

Figure: Generation 34: DE finds the global minimum.

[1] Kenneth Price, Rainer M. Storn, and Jouni A. Lampinen. Differential Evolution: A Practical Approach to Global Optimization. Natural Computing Series. Springer-Verlag, Berlin Heidelberg, 2005.