Genetic Algorithms

5.4.5 Three Parent Crossover

In this crossover technique, three parents are randomly chosen. Each bit of the first parent is compared with the bit of the second parent. If both are the same, the bit is taken for the offspring otherwise; the bit from the third parent is taken for the offspring. This concept is illustrated in Fig.11

Parent 1	1 1 0 1 0 0 0 1
Parent 2	0 1 1 0 1 0 0 1
Parent 3	0 1 1 0 1 1 0 0
Child	0 1 1 0 1 0 0 1

Fig.11 three parent *Crossover*

5.4.6 Precedence Preservative Crossover (PPX)

PPX was independently developed for vehicle routing problems by Blanton and Wainwright (1993) and for scheduling problems by Bierwirth et al. (1996). The operator passes on precedence relations of operations given in two parental permutations to one offspring at the same rate, while no new precedence relations are introduced. PPX is illustrated in below, for a problem consisting of six operations A–F.

The operator works as follows:

• A vector of length Sigma, sub i=1to mi, representing the number of operations involved in the problem, is randomly filled with elements of the set {1, 2}.
• This vector defines the order in which the operations are successively drawn from parent 1 and parent 2.
• We can also consider the parent and offspring permutations as lists, for which the operations ‘append’ and ‘delete’ are defined.
• First we start by initializing an empty offspring.
• The leftmost operation in one of the two parents is selected in accordance with the order of parents given in the vector.
• After an operation is selected it is deleted in both parents.

• Finally the selected operation is appended to the offspring.
• This step is repeated until both parents are empty and the offspring contains all operations involved.
• Note that PPX does not work in a uniform-crossover manner due to the ‘deletion append’ scheme used.
Example is shown in Fig.12

Parent permutation 1	A	B	C	D	E	F
Parent permutation 2	C	A	B	F	D	E
Select parent no. (1/2)	1	2	1	1	2	2
Offspring permutation	A	C	B	D	F	E

Fig.12 PPX *Crossover*

5.4.7 Ordered Crossover

Ordered two-point crossover is used when the problem is of order based, for example in U-shaped assembly line balancing etc. Given two parent chromosomes, two random crossover points are selected partitioning them into a left, middle and right portion. The ordered two-point crossover behaves in the following way: child 1 inherits its left and right section from parent 1, and its middle section is determined

by the genes in the middle section of parent 1 in the order in which the values appear in parent 2. A similar process is applied to determine child 2. This is shown in Fig.13

Parent 1 : 4 2 | 1 3 | 6 5 Child 1 : 4 2 | 3 1 | 6 5
Parent 2 : 2 3 | 1 4 | 5 6 Child 2 : 2 3 | 4 1 | 5 6

Fig.13 ordered *Crossover*

5.4.8 PartiallyMatched Crossover (PMX)

PMX can be applied usefully in the TSP. Indeed, TSP chromosomes are simply sequences of integers, where each integer represents a different city and the order represents the time at which a city is visited. Under this representation, known as permutation encoding, we are only interested in labels . It may be viewed as a crossover of permutations that guarantees that all positions are found exactly once in each offspring, i.e. both

offspring receive a full complement of genes, followed by the corresponding filling in of alleles from their parents.
PMX proceeds as follows:

1. The two chromosomes are aligned.
2. Two crossing sites are selected uniformly at random along the strings, defining a matching section

- The matching section is used to effect a cross through position-by-position exchange operation
- Alleles are moved to their new positions in the offspring
- The following illustrates how PMX works.
- Consider the two strings shown in Fig. 3.14
- Where, the dots mark the selected cross points.
- The matching section defines the position-wise exchanges that must take place in both parents to produce the offspring.
- The exchanges are read from the matching section of one chromosome to that of the other.
- In the example, the numbers that exchange places are 5 and 2, 6 and 3, and 7 and 10.
- The resulting offspring are as shown in Fig. 3.14

Name 9 8 4 . 5 6 7 . 1 3 2 1 0   Allele 1 0 1 . 0 0 1 . 1 1 0 0
Name 8 7 1 . 2 3 1 0 . 9 5 4 6   Allele 1 1 1 . 0 1 1 . 1 1 0 1

Name 9 8 4 . 2 3 1 0 . 1 6 5 7   **Allele** 1 0 1 . 0 1 0 . 1 0 0 1
Name 8 1 0 1 . 5 6 7 . 9 2 4 3   **Allele** 1 1 1 . 1 1 1 . 1 0 0 1

Fig.14 PMX *Crossover*

5.6.Mutation

After crossover, the strings are subjected to mutation. Mutation prevents the algorithm to be trapped in a local minimum. Mutation plays the role of recovering the lost genetic materials as well as for randomly disturbing genetic information. Mutation of a bit involves flipping a bit, changing 0 to 1 and vice-versa.

Flipping

Flipping of a bit involves changing 0 to 1 and 1 to 0 based on a mutation chromosome generated.

5.7 Replacement

Replacement is the last stage of any breeding cycle. Two parents are drawn from a fixed size population, they breed two children, but not all four can return to the population, so two must be replaced i.e., once off springs are produced, a method must determine which of the current members of the population, if any, should be replaced by the new solutions. The technique used to decide which individual stay in a population and which are replaced in on a par with the selection in influencing convergence . Basically, there are two kinds of methods for maintaining the population; generational updates and steady state updates.
In a steady state update, new individuals are inserted in the population as soon as they are created, as opposed to the generational update where an entire new generation is produced at each time step. The insertion of a new individual usually necessitates the replacement of another population member.

5.7.1 Random Replacement

The children replace two randomly chosen individuals in the population. The parents are also candidates for selection. This can be useful for continuing the search in small populations, since weak individuals can be introduced into the population.

5.7.2 Weak Parent Replacement

In weak parent replacement, a weaker parent is replaced by a strong child. With the four individuals only the fittest two, parent or child, return to population. This process improves the overall fitness of the population when paired with a selection technique that selects both fit and weak parents for crossing, but if weak individuals and discriminated against in selection the opportunity will never raise to replace them.

5.7.3 Both Parents

Both parents replacement is simple. The child replaces the parent. In this case, each individual only gets to breed once. As a result, the population and genetic material moves around but leads to a problem when combined with a selection technique that strongly favors fit parents: the fit breed and then are disposed of.