

Case Example 2

Twelve machines from Xu et al., (2018),] are another illustration. Tables 6, 7, and 8 respectively display the amount of material flow, the unit material handling cost, and the rectilinear separation between equipment sites.

Table 6. Material flow between equipment

From/To	1	2	3	4	5	6	7	8	9	10	11	12
1	0	3	2	2	1	3	0	2	1	4	2	1
2	3	0	2	3	2	4	1	0	0	3	1	2
3	2	2	0	1	0	2	2	3	2	0	3	2
4	2	3	1	0	2	3	3	2	1	0	2	1
5	1	2	0	2	0	1	3	0	1	2	2	1
6	3	4	2	3	1	0	2	1	0	3	1	1
7	0	1	2	3	3	2	0	2	3	0	1	3
8	2	0	3	2	0	1	2	0	3	2	2	0
9	1	0	2	1	1	0	3	3	0	2	2	3
10	4	3	0	0	2	3	0	2	2	0	2	1
11	2	1	3	2	2	1	1	2	2	2	0	2
12	1	2	2	1	1	1	3	0	3	1	2	0

Table 7. Unit material handling cost

From/To	1	2	3	4	5	6	7	8	9	10	11	12
1	0	6	8	4	7	3	4	11	9	4	7	5
2	6	0	5	7	9	4	6	6	3	5	11	8
3	8	5	0	6	9	8	12	4	6	8	10	6
4	4	7	6	0	4	3	8	6	12	9	7	8
5	7	9	9	4	0	6	8	5	10	9	6	8
6	3	4	8	3	6	0	5	7	4	8	9	6
7	4	6	12	8	8	5	0	7	3	5	10	8
8	11	6	4	6	5	7	7	0	4	9	7	5
9	9	3	6	12	10	4	3	4	0	6	9	7
10	4	5	8	9	9	8	5	9	6	0	10	6
11	7	11	10	7	6	9	10	7	9	10	0	8
12	5	8	6	8	8	6	8	5	7	6	8	0

Table 8 Rectilinear distance between equipment

From/To	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0	1.0	1.8	1.5	1.2	1.4	2.0	1.3	1.6	1.5	2.0	1.0
2	1.0	0.0	2.0	1.6	1.0	1.8	1.4	1.0	1.8	1.2	1.0	2.0
3	1.8	2.0	0.0	1.2	1.6	1.4	2.0	1.4	1.4	2.0	1.2	1.0
4	1.5	1.6	1.2	0.0	1.5	1.0	1.4	1.6	1.0	1.6	1.4	1.5
5	1.2	1.0	1.6	1.5	0.0	1.2	2.0	1.8	1.0	2.0	1.7	1.0
6	1.4	1.8	1.4	1.0	1.2	0.0	1.4	1.0	1.5	1.2	1.4	1.9
7	2.0	1.4	2.0	1.4	2.0	1.4	0.0	2.0	1.2	1.4	1.0	1.6
8	1.3	1.0	1.4	1.6	1.8	1.0	2.0	0.0	2.0	1.3	1.4	1.2
9	1.6	1.8	1.4	1.0	1.0	1.5	1.2	2.0	0.0	1.4	1.6	1.3
10	1.5	1.2	2.0	1.6	2.0	1.2	1.4	1.3	1.4	0.0	2.0	1.5
11	2.0	1.0	1.2	1.4	1.7	1.4	1.0	1.4	1.6	2.0	0.0	1.6
12	1.0	2.0	1.0	1.5	1.0	1.9	1.6	1.2	1.3	1.5	1.6	0.0

In this illustration, both the population and the number of generations rise at the same time to evaluate the behavior of the best possible solution. GA's first starting point consists of 50 people and 50 generations. For all simulations, the crossover and mutation probabilities are set at 0.7 and 0.8, respectively. In 20 trials, the best answer is contrasted. Table 9 displays the objective value and associated facility locations for several experiments that used 50 participants and 50 generations. The facility locations are displayed in fig. and the best answer in this example comes from trial number 14, which is 2050.6. 4.

Table 9. Objective value and facilities location for 50 individuals and 50 generations

Trial	Objective Value	Facility											
		1	2	3	4	5	6	7	8	9	10	11	12
1	2082.8	5	7	1	8	12	2	11	6	9	4	3	10
2	2078.6	2	10	7	3	6	12	1	5	11	9	8	4
3	2078.6	12	7	9	1	4	2	10	3	8	6	5	11
4	2112.4	4	2	7	3	1	11	10	12	8	9	5	6
5	2053.4	6	3	5	7	2	4	9	1	12	8	11	10
6	2089.8	6	8	2	11	7	3	9	10	4	1	12	5
7	2110.4	3	10	12	2	6	11	5	8	4	1	9	7
8	2080.4	5	7	1	3	12	9	10	4	11	6	8	2
9	2113.8	6	5	4	11	10	3	12	7	1	9	2	8
10	2075.8	6	8	12	4	3	11	5	1	7	10	9	2
11	2108.4	12	2	8	9	3	11	6	1	4	5	10	7
12	2088.4	6	10	1	12	11	4	9	2	7	5	8	3
13	2064.4	8	10	3	7	9	4	2	1	12	5	6	11
14	2050.6	4	7	1	6	5	11	9	3	10	12	8	2
15	2087.8	11	9	2	6	12	10	4	1	7	8	5	3
16	2107.8	1	10	12	7	11	4	5	6	8	2	9	3
17	2092.0	5	11	9	12	4	1	6	8	2	10	3	7
18	2067.0	12	7	1	8	5	11	6	3	10	9	4	2
19	2069.0	12	5	8	11	2	3	10	7	1	9	6	4
20	2089.4	11	8	6	2	7	5	4	10	12	9	1	3

Location	1	2	3	4	5	6	7	8	9	10	11	12
Facility	4	7	1	6	5	11	9	3	10	12	8	2

Figure 3. Best facility locations for 50 individuals and 50 generations

Table 10 Objective value at different number of individuals and generations

Individual/Generation	50	100	150	200	250	300
50	2050.6	2040.2	2044.4	2046.6	2040.2	2043.4
100	2047.4	2045.2	2040.2	2041.8	2040.2	2041.8
150	2045.8	2041.8	2041.8	2043.4	2041.8	2041.8
200	2045.0	2040.2	2040.2	2044.4	2040.2	2040.2
250	2044.4	2043.4	2041.8	2040.2	2040.2	2040.2
300	2041.8	2040.2	2041.8	2040.2	2040.2	2040.2

The starting parameter of GA is gradually increased by 50 until it reaches 300 for both individuals and generations. Table 10 shows the optimal objective value at different individuals and generations. Figure 5 depicts the ideal facility placements based on Table 10's optimal answer, which is 2040.2. Figure 6 depicts the graphical behavior of the objective value as more people and generations are added. Compared to an increase in individuals, an increase in generation leads to an increased objective value.

Location	1	2	3	4	5	6	7	8	9	10	11	12
Facility	6	4	5	11	2	3	9	7	1	8	12	10

Figure 4. Optimal facility location

Figure 5 indicates that an increase in generations results in a rise in the objective value, but it does not express the impact of an increase in individuals very clearly. The algorithm may be more sensitive to changes in the number of generations than the number of individuals, as this may suggest. However, because genetic algorithms are heuristic optimization approaches that might not always discover the global optimum, the ideal objective value achieved may not necessarily reflect the best feasible solution.

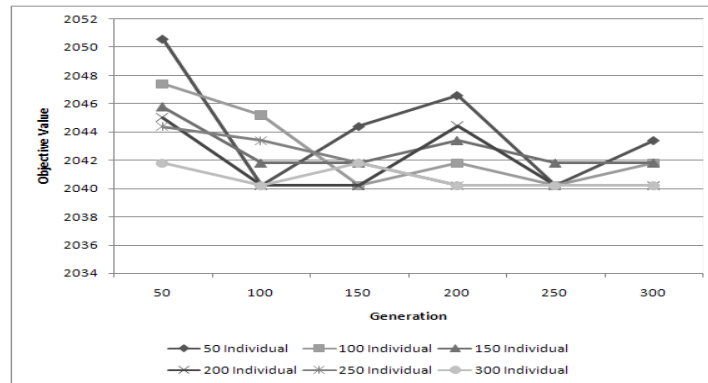


Figure 5. Graphical representation comparing the objective values at different individuals and generations

Conclusion and Future works

In this study, we created a method and modify the genetic algorithm process to reduce overall material handling expenses. Multipoint Swapped cross over was applied. In a comparison utilizing a benchmark numerical example, the proposed method is significantly more effective than the other methods in the literature. The solution demonstrates that an increase in generation has a positive impact on objective value more so than an increase in individual. Despite being simple, the coding is robust and produces good results.

Genetic Algorithm perform better compared to other solutions for several reasons. First, the performance of the GA might be significantly impacted by the standards of the initial population. Finding high-quality solutions is more likely if the initial population is good because it can serve as a better starting point for the search process, Second, the genetic operators used, such as swapped-crossover and mutation, can have an impact on how well the GA performs. The population's variety can be preserved and early convergence to less-than-ideal solutions can be avoided with the proper application of crossover and mutation operators. Third, the process utilized to choose individuals for the next generation may also have an effect on the standard of the solutions produced. Better outcomes may result from appropriate selection processes that give the fittest candidates priority. And Lastly, the fitness function's design, which is how the solutions are evaluated, is also very important. The goals of the facility layout problem should be accurately captured by a well-designed fitness function, which should also give an indication of how effectively each solution is working. Regarding the proposed technique of swapped crossover and mutation in the context of facility layout problem using genetic algorithms, The effectiveness of the swapped crossover and mutation technique may vary depending on the specific instance of the facility layout problem being solved. It may work well for some instances but not for others. The technique may not scale well to larger problem instances with a higher number of facilities or constraints. There is a risk of the algorithm converging prematurely to suboptimal solutions due to the limited exploration of the search space. The technique may require a large number of fitness function evaluations and can become computationally expensive for complex problems. The effectiveness of the swapped crossover and mutation technique may also depend on the selection of appropriate crossover and mutation operators, which can be challenging and require domain expertise. The methodology outlined in this research may be applied and tested in future work to a wide number of facilities and case studies from the real world applications considering multiple constraints and objectives.

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