# A REVIEW OF MODERN OPTIMIZATION TECHNIQUES

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***Abstract – Today in rapidly changing world, demand of high quality and accuracy is essential. To fulfill these requirements applications of optimization techniques in metal cutting processes is crucial for a manufacturing unit to respond effectively. In this paper an attempt is made to review the literature on different modern optimisation techniques for cutting parameters in machining. The review is kept general in nature, without considering special cases like, multi-objective optimization problems, linear programming, multidisciplinary optimization problems, convex problems, etc. Although various optimization methods have been proposed in recent years, but some more popular optimization techniques such as Genetic Algorithm, Ant colony method, Honey Bee Algorithm, Simulated Annealing are presented here.***

***Index Terms – Modern optimization techniques, Genetic Algorithm, Ant colony method, Honey Bee Algorithm, Simulated Annealing.***

## I. INTRODUCTION

Optimization techniques are path to attain decision making that will approach goals that have been set in response to given problem. The development of optimization techniques began during World War 2. So many techniques were developed to satisfy different types of problems like single objective, multi-objective, linear, non-linear, etc.

We always intend to maximize or minimize something which is simply known is the objective function. Organizations are implementing these techniques to maximize their profits, minimize their costs, minimize tool or part travel, maximize strength, minimize defects, etc. The complexity of the problem of interest makes it impossible to search every possible solution or combination, the aim is to find good, feasible solutions in an acceptable timescale. Traditional techniques finds these kind of difficulties for some problems. Modern optimization techniques like

## II. MODERN OPTIMIZATION TECHNIQUES

### 1. Genetic Algorithm

Genetic algorithm is a class of stochastic search strategies modeled after evolutionary mechanisms. It is a popular strategy to optimize non-linear systems with a large number of variables. Genetic algorithms evaluate the target function to be optimized at some randomly selected points of the definition domain. Taking this information into account, a new set of points (a new population) is generated. Gradually the points in the population approach local maxima and minima of the function. The function itself does not need to be continuous or differentiable. Genetic algorithms can still achieve good results even in cases in which the function has several local minima or maxima.

These properties of genetic algorithms have their price: unlike traditional random search, the function is not examined at a single place, constructing a possible path to the local maximum or minimum, but many different places are considered simultaneously. The function must be calculated for all elements of the population. The creation of new populations also requires additional calculations. In this way the optimum of the function is sought in several directions simultaneously and many paths to the optimum are processed in parallel. The calculations required for this feat are obviously much more extensive than for a simple random search.

However, compared to other stochastic methods genetic algorithms have the advantage that they can be parallelized with little effort. Since the calculations of the function on all points of a population are independent from each other, they can be carried out in several processors. Genetic algorithms are thus inherently parallel. A clear improvement in performance can be achieved with them in comparison to other non-parallelizable optimization methods.

Compared to purely local methods (e.g., gradient descent) genetic algorithms have the advantage that they do not necessarily remain trapped in a suboptimal local maximum or minimum of the target function. Since information from many different regions is used, a genetic algorithm can move away from a local maximum or minimum if the population finds better function values in other areas of the definition domain. Even without this practical motivation the analysis of genetic algorithms is important, because in the course of evolution the networking pattern of biological neural networks has been created and improved. Through an evolutionary organization process nerve systems were continuously modified until they attained an enormous complexity.

A problem can be solved by following steps of Genetic Algorithm: [2]

**1. Initialization**: genetic algorithm are generally start with an initial population that is generated randomly some research has been conducted using special technique to produce a higher quality initial population. Thus an approach is designed to give the GA a good start and speed up the evolutionary process.

**2. Selection:** It select the two parent chromosome from a population according to their fitness better the fitness bigger the chance to be selected.

**3.Reproduction :-** It select the two chromosomes according to current selection procedure perform crossover on them and obtain one or two children, perhaps apply mutation as well and install the result back into that population, the least fit of population is destroyed.

**4. Crossover:** With a crossover probability crossover the parent to form new offspring (children).

**5. Mutation:-**After a crossover this operator is performed. Mutation is a genetic operator used to maintain genetic diversity from one generation of a population of chromosomes to next.

**6. Replacement**: Use new generated population for a further run of algorithm.

## 2. Ant Colony Method

Ant colony optimization method is Probabilistic technique. It is searching for optimal path in the graph based on behavior of ants seeking a path between their colony and source of food. It is a Meta-heuristic optimization method.

Basic concept behind this method is inspired from behavior of ant. Ants navigate from nest to food source. Ants are blind! They discover shortest path via pheromone trails. Each ant moves at random path. Pheromone is deposited on path. More pheromone on path increases probability of path being followed.

"ACO is characterized as a policy search strategy aimed at learning the distributed parameters (called pheromone variables in accordance with the biological metaphor) of the stochastic decision policy which is used by so-called ant agents to generate solutions."

The premise of ACO is fairly simple, in nature, ant [colonies] rely on a complex system of fairly unsophisticated autonomous agents which individually cooperate to provide for the basic needs of the collective. ACO itself developed from studies of ant-behavior when foraging for food, specifically the methods by which ants choose the shortest path to a particular source even in the presence of multiple trails. Using trails of pheromones, ants indicate the presence of food to the rest of the colony.

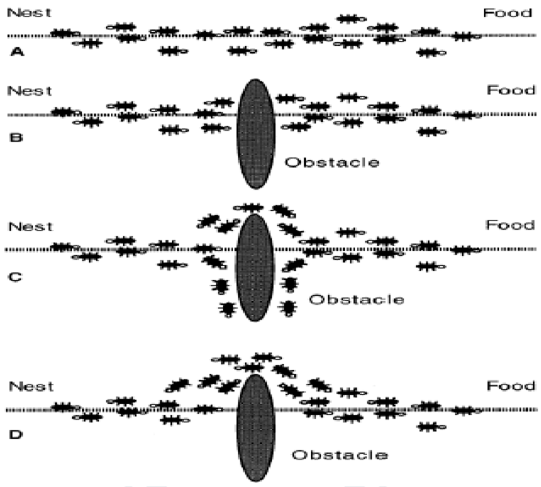


*Figure 1* ***how real ant finds the shortest path*** **[9, 10]**

Ant algorithms (also known as Ant Colony Optimization) are a class of metaheuristic search algorithms that have been successfully applied to solving NP hard problems. Ant algorithms are biologically inspired from the behavior of colonies of real ants, and in particular how they forage for food. One of the main ideas behind this approach is that the ants can communicate with one another through indirect means by making modifications to the concentration of highly volatile chemicals called pheromones in their immediate environment.

Consider Fig. 1A Ants arrive at a decision point in which they have to decide whether to turn left or right. Since they have no clue about which is the best choice, they choose randomly. It can be expected that, on average, half of the ants decide to turn left and the other half to turn right. This happens both to ants moving from left to right (those whose name begins with an L) and to those moving from right to left (name begins with a R). Figs. 1B and 1C show what happens in the immediately following instants, supposing all ants walk at approximately the same speed. The number of dashed lines is roughly proportional to the amount of pheromone that the ants have deposited on the ground. Since the lower path is shorter than the upper one, more ants will visit it on average, and therefore pheromone accumulates faster. After a short transitory period the difference in the amount of pheromone on the two path is sufficiently large so as to influence the decision of new ants coming into the system (this is shown by Fig. 1D). From now on, new ants will prefer in probability to choose the lower path, since at the decision point they perceive a greater amount of pheromone on the lower path. This in turn increases, with a positive feedback effect, the number of ants choosing the lower, and shorter, path. Very soon all ants will be using the shorter path. [9, 10]

## 3. Honey Bee Algorithm

Honey bees are one of the most well studied social insects. In the early years many studies based on the different bee behaviors have been developed to solve complex combinatorial and numerical optimization problems. [3]

Behavior of bees in nature Social insect colonies can be considered as dynamical system gathering information from the environment and adjusting their behavior in accordance to it. While gathering information and adjustment processes, individual insects do not perform all the tasks because of their specializations. Generally, all social insect colonies behave according to their own division of labors related to their morphology.[4]

The bees algorithm is a population-based search algorithm inspired by the natural foraging behavior of honey bees first developed in 200 [11]. In its basic version, the algorithm starts by scout bees being placed randomly in the search space. Then the fitnesses of the sites visited by the scout bees are evaluated and Bees that have the highest fitnesses are chosen as “selected bees” and sites visited by them are chosen for neighborhood search. Then, the algorithm conducts searches in the neighborhood of the selected sites, assigning more bees to search near to the best e sites. Searches in the neighborhood of the best e sites are made more detailed by recruiting more bees to follow them than the other selected bees. Together with scouting, this differential recruitment is a key operation of the Bees Algorithm. The remaining bees in the population are assigned randomly around the search space scouting for new potential solutions. These steps are repeated until a stopping criterion is met. At the end of each iteration, the colony will have two parts, those that were the fittest representatives from a patch and those that have been sent out randomly. The algorithm performs a kind of neighborhood search combined with random search and can be used for both combinatorial and functional optimization. [4, 5]

Bee behavior:

1) Foraging behavior:

a) Nest site searching: the most prosperous colonies reproduce by swarming. In early spring, some queen cells are produced to generate new queen. Before its birth, the old queen leaves the colony with the half of the colony components to form a new colony. They search new nest

site. The scouts seek about twelve nest sites. They indicate the various locations of new nests by waggle dances. The dance quality is related to the nest site quality. Thus, and over time, selected sites decrease until a single site will be found.
b) Food source searching: first, some bees “scouts” navigate and explore the region in aim to find a food source. In the positive case, they come at the hive in place called “dance floor” to transmit and share this discovery with the others through dance language (round or waggle dance relating to the discovery distance). Some bees are recruited and then, become foragers. Their number is proportional to the food quantity information communicated by the scouts. We call this step exploration phases which is followed by the exploitation step. Bee collects food and calculates their quantity to make a new decision. Either it continues collecting by the memorization of this best location, or it leaves the source and returns to hive as simple bee.
2) Marriage behavior: the reproduction phenomenon in the bee colony is guaranteed by the queen. After its birth, the young queen will engage in nuptial flights. It will join a gathering point with some drones. The queen will mate with several males in full flight, until her sperm theca is full. After three days, it lays eggs. The unfertilized egg will give rise to a drone, while, the fertilized egg gives rise to worker or queen depending on food quality given to larvae. [3]

### 4. Simulated Annealing Algorithm

Simulated annealing algorithm of the original idea was proposed in 1953, in the Metropolis, Kirkpatrick put it successful application in the combinatorial optimization problems in 1983.

Simulated annealing algorithm from the solid annealing principle, the solid heating to fully high, let its slowly cooling, heating, solid internal particle with temperature rise into disordered shape, internal energy increases, and slowly cooling particles gradually orderly, and in each temperature are to reach an equilibrium state, and the last in the room temperature reaches ground state, internal energy is reduced to the minimum. According to the Metropolis criterion, particle in temperature T when the probability of equilibrium is e-ΔE/(kT), including E for temperature T of internal energy, ΔE for its change quantity, k for Boltzmann constant. With solid annealing simulation combination optimization problem, the internal energy E simulation for the objective function value f, temperature T evolution into control parameter T, namely get solution combination optimization problem of simulated annealing algorithm: the initial solution i and control parameter initial t start, on the current solution repeat "produce data processing to calculate target function difference - to accept or to reject" iteration, and gradually attenuation t value, the algorithm at the end of the current solution is the income approximate optimal solution, this is based on the Montecarlo’s iteration method of a kind of heuristic random search process. Annealing process by Cooling Schedule (Cooling Schedule) control, including the control parameters of the initial t and its attenuation factor Δt, every t value the iteration number L and stop condition S. [7]

<u>Simulated annealing algorithm basic ideas:</u>

**(1)** Initialization: initial temperature T (Sufficiently large), initial solution state S (is the starting point of the iterative algorithm), each T value the iteration number L
**(2)** The k = 1,... , L do the first (3) to step 6.
**(3)** Produce 'S data processing
**(4)** Calculation incremental Δ t '= C(' S) - C(S), including C(S) as evaluation function
**(5)** If Δt` < 0 is accepted as a new S' current solution, or otherwise the probability exp(- Δt '/ t) accept S' as a new current solution.
**(6)** If meet the termination condition is output current solution as the optimal solution, end program. Termination condition usually takes for continuous several data processing are not accepted end algorithm.
**(7)** T gradually reduce, and T->0, then turn step 2. [7]

## III. CONCLUSION

In this paper different optimization techniques are discussed. A brief description of four methods, Genetic Algorithm, Ant colony method, Honey Bee Algorithm, Simulated Annealing are given with their basic steps. Modern optimization techniques are utilized to settle Non Linear and non-differentiable optimization problems which are unrealistic to explain by conventional optimization techniques.

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