Genetic Algorithm - Based Multidimensional Technological Process Optimization

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A technological process is considered multidimensional, if defects of diverse types occur, are being detected and corrected simultaneously, within the process execution. The tasks of technological process optimization, involve the finding of such a process structure choice, which provides the necessary output level of product quality with cost limits [1].

Typical examples of such tasks are:

- optimal allocation of checking procedures in a technological process;
- optimal choice of multiplicity of checking-retrofit procedures;
- optimal choice of variants of work and checking procedures;

This type of problems would be classified as a typical integer optimization task with constraints. An initial perspective would be to handle such problems, with the use of well-known mathematical programming methods [2]. However, taking into account that the contamination of many diverse types, increases the dimensionality of the state space, it becomes clear that the use of conventional mathematical programming approaches, proves impractical. The above assertion is clearly stated in a special monograph [1], which claims that the standard optimization algorithms are applicable in practice, only in the case of single-dimension technological processes.

In this paper the task of multidimensional technological process optimization is solved using genetic algorithms. Genetic algorithms [3, 4] in general, were inspired by the Darwinian principle, which explains adequately the natural evolvement, by applying in living nature the competitive rule for the survival of the fittest. Genetic algorithms differ from direct search methods, where one candidate solution is optimized through succeeding repetitions of the algorithm. In genetic algorithms, a set of solutions, called population, is maintained, and the optimum solution is found by subsequent genetic operations among the members of the population that are called chromosomes or, individuals. These individuals are evaluated according to the problem and a fitness measure is given to them. In the most common approaches of genetic algorithms, two populations are used, one for keeping the current population and the second for keeping the next population. When all individuals are evaluated, then a generation is supposed to be completed. As a next step, the new population becomes the current and the procedure continues. In steady-state genetic algorithms only one population is maintained and each new individual with better fitness is inserted to the current population taking the place of a less fitted individual. The genetic operations may differ slightly between implementations, but they can be classified in three major types: selection (or reproduction), crossover and mutation. The selection mechanism ensures that good individuals (namely those having large fitness) will be preferred among less fitted members. There exists a number of methods for selection, such as stochastic sampling with/without replacement, tournament with/without elitist strategy, etc. Crossover is the operation of exchanging genetic material between two selected individuals (named parents) in order to produce two new individuals (named off-springs). Mutation is the random substitution of a part of the genetic material of a selected individual.

The application of genetic algorithms allows the cutting of the solution time of the problem, on the account of simultaneous optimum search from various initial points. This is provided by the availability of the initial set of technological process variants, on which the genetic operations of crossover, mutation and selection are applied. Extensive computational experiments carried out, show that, the utility /usability of using genetic algorithms in comparison to traditional techniques of discrete process optimization based on the gradient search and the branch and bound method [1], is growing as the problem complexity and the technological process dimension increases.

References

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