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Application of parallel calculations in large scale optimization problems

In large-scale optimization problems of artificial intelligence, cybersecurity, robotic, as a rule, a feasible region is described by a huge number of nonlinear inequalities and variables. One of the important issues is developing state-of-the-art technologies that allow increasing the solution algorithm efficiency. The basic idea of the proposed technique is based on the decomposition algorithm that reduces the large-scale problem to a sequence of the sub-problems with significantly smaller dimension. The optimization strategy involves the following stages: generating of feasible starting points, sequential construction of feasible sub-regions; forming of the system of active ε-inequalities; searching for local extrema in the selected feasible sub-regions. It should be noted that, depending on the value of the decomposition parameter, a sequence of sub-problems can be quite large, and the computational time is also significant. This is because of forming sub-problem requires substituting the obtained starting point into the inequality system, which describes the original large-scale problem, and to separate from it a new sub-system of inequalities. Since the system of inequalities describing feasible region is determined by a large number of nonlinear inequalities, it takes a long time to calculate such inequalities and form a new sub-system.

The computational costs have been sought in the application of modern parallel computing technologies. Simply migrating a sequential program algorithm to a system with many processors without substantially reworking it does not generally accelerate the computation. An analysis of the subtask formation algorithm when searching for a local extremum showed that it supports both task parallelism and data concurrency.

The basic principle of the developed algorithm of parallelization of calculations in the formation of sub-tasks of local optimization is based on the fact that the used functions are max-min functions.

An algorithm for forming a subsystem that specifies the area of admissible solutions of each subtask can be represented as a graph in a tier-parallel form having four tiers. The tasks of the first three tiers support data parallelism, since they use the same computational procedures to execute them, but over different data sets. The fourth tier tasks support task parallelism, since the tasks of this tier are implemented by separate procedures.

In order to perform parallel calculations of the algorithm, it is necessary to ensure synchronization of the execution of parallel tasks of the second and third tiers, since the results of the procedures of these tiers depend on the results obtained on the third and fourth tiers, respectively.

To implement the presented scheme of parallel computing, modern parallel computing tools are used that provide the program with mechanisms for automatic generation of parallel computations, problem scaling, and synchronization.

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