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Analysis of the adaptive algorithms behaviour applied to the railway optimization problems

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Abstract

In this article we will analyse the proposed adaptive algorithm used for the search of the best timetables and ensuring train locomotives as the task of finding the global extremum of the objective function, taking into account various types of interference in the input data. The focus of this paper is on the convergence and speed, as well as the impact of noise on the results obtained.

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1. Introduction

In recent years, considerable attention is paid to the establishment and development of decision support systems (DSS) in the intelligent transport systems. One of the problems solved by similar systems, is to build the best timetables. This task is quite time consuming. The complexity of this task depends on the system parameters and the constraints on the targets, and on their number. There are many approaches to solving the optimization and identification problems. Direct, non-iterative, non-recurrent method involves carrying out a certain number of experiments with the fixation of their results. After the last test of using one method or another, we find the desired characteristics, for example, the weighting function or parameters of the model or optimal decision. It is clear that these methods have significant drawbacks:

- We can not say anything about the identifiable characteristics until all the experiments and experimental data processing are not finished. Knowledge about the object does not grow from experiment to experiment, but changes abruptly. In the study of complex systems experiments can last a long time. During the experiments

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the objects themselves can vary significantly and cease to exist in some cases. Therefore, the results of complete study in these cases may be useless.

- For the implementation of direct, non-iterative methods, we must store and form a large amount of data. This requires the use of computers with large memory, high speed and reliability. For example, if you use OLS, the number of computations increases in proportion to the number of inputs or the order of the dynamic model.
- You cannot use the results before the end of the identification process for forecasting, decision-making and management.
- These methods cannot be used in control systems in real time.

When the results of identification are to be used to correct the regulating devices, to adjust systems, in self-adjusting systems, self-learning systems, adaptive systems and self-organizing systems, these deficiencies are particularly important. The development of these classes of systems led to the development and widespread use of adaptive, iterative algorithms. Usage of these algorithms means that when the i-th experiment is finished and approximate solution of the identification problem is obtained, the results of the next $(i + 1)$-th experiment is used to refine solution. In this case a researcher or control system has a model evaluation of the managed object starting with the first iteration. This model is gradually became more precise from iteration to iteration. If the object is non-stationary, adaptive algorithms of identification follow the changes of characteristics of management object.
In this article we will analyse the proposed adaptive algorithm used for the search of the best timetables and ensuring train locomotives as the task of finding the global extremum of the objective function, taking into account various types of interference in the input data. The focus of this paper is on the convergence and speed, as well as the impact of noise on the results obtained.

2. Task description

Formally, the problem can be formulated as follows: there are raw data - the state and location of the locomotives at the beginning of the planning period, their parameters, as well as train routes and chosen threads of variant schedule for them. It is necessary to form a scheme locomotives attachment to the train for the planning period that provides the best performance of the transport plan in compliance with the given limitations and technological standards of operation of locomotives. Given freight scheduling problem is described in more details in[9]
This problem may have many solutions varying degrees of optimality. For the qualitative evaluation of any destination option let us introduce an objective function of a pair "i-th departure of the train composition plan (or a reserve locomotive transfer plan) - assigned to him the locomotive x_i" $u_i(x_i)$. The departure of the train composition plan contains information about the exact time of departure of the train, the station of departure and arrival and the train number. Locomotive reserve transfer plan contains similar information on forwarding the necessary backup.
When we are considering the optimization of attachment of locomotives to trains altogether throughout the planning area, we are using the summing objective function $F(X) = \Sigma u_i(x_i)$, which is equal to the sum of the objective functions that make up the shipment schedule plans. See[9] for more detailed description of the objective function.
Consider the total cost function as a multi-dimensional function of a vector argument $X = [x_1, x_2, ..., x_m]^T$, where the vector X is any decision of the task of attachment of locomotives and transfer plans (with the train or reserve), presented in the form of $[loco_1, loco_2, ..., loco_m]^T$, where $loco_i$ - the locomotive number assigned to the i-th plan, m - number of trains shipment plans and back-up locomotives in the whole planning area. Then to solve of the optimization problem of rail transportation planning is necessary to solve the general problem of finding the extremum of the mentioned above function with the given constraints:

$$F(X) = \sum_{i=1} u_i(x_i) \to extr(max); X^* = argextrF; g_j(X^*) \leq b_j, j = 1, ..., k \quad (1)$$

where X^* - required solution; $g_j(X^*) \leq b_j$ - limit set; k - the number of restrictions. In general, the extremum search algorithm can be presented as follows:

$$X^{n+1} = ||A||X^n, ||A|| < 1 \quad (2)$$

where $||A||$ - the iterative operator. The search is performing on the set of constraints associated with technological features in the railway sector. Then it is necessary to find the kind of iterative operator A, that make the above-