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# Combined Processing of Geospatial and Symbolic Information for Mobile Robots

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**Abstract:** In the study the researchers consider the computational processes for processing geospatial and symbolic information. The modern mobile robot uses such information for analyzing cartographic information and independent decision making. Combining geospatial and symbolic information increases the intellectual capabilities of the mobile robot. The imposition of hierarchical graphical objects of the external environment and the values of the attributes of such objects allows us to construct for mobile robots a compact model of the external environment. This property is the basis for parallel computing using of the data flow model.

**Key words:** Geoinformation data, symbolic computing, mobile robot, data flow model, graphical objects, data flow model

## INTRODUCTION

**Relevance of work:** Large tracked robotic vehicles are part of the promising land mobile robots. These machines are designed to solve large-scale tasks of monitoring and control in extreme natural and man-made conditions. General features of these tasks are:

- The minimum time to achieve the goal
- Limited opportunities for human participation in machine control
- The inadmissibility of a stop in the process of movement

Large mobile robots need increasing the level of automation of computing and action intellectualization. Independent orientation on the terrain and preparation of a plan of movement over long distances are based on the combined processing of geospatial and symbolic information. Thus, the following urgent tasks arise (Kelly and Dodds, 2003):

- The study of the properties and characteristics of geospatial and symbolic data
- The use of geospatial and symbolic data in the control system of a robotized machine

The importance of intellectual processing of geospatial and symbolic information for mobile robots is associated with the emergence and intensive development of artificial intelligence systems. Artificial intelligence systems for mobile robots provide computational models based on data flow control. The data flow has great potential for paralleling. This feature is, especially important for parallel processing of geospatial data on terrain objects. Particular tasks of building a digital matrix of terrain, vectorization of maps, recognition of geometric objects will be solved much more efficiently than on computational models based on command flow control.

Symbolic data sets attributes of objects on a terrain map. This data has special presentation formats and special operations for converting individual symbols or groups of symbols. With the purpose of efficient processing of symbolic information it is necessary to systematize properties and develop a method of multiple transformation of symbolic data.

## MATERIALS AND METHODS

**Methods for symbolic information processing control:** The symbolic computing with the elements of intelligent computing can be understood as tasks of search and parallel generation of new states from the available set of initial states and a set of mathematical rules which have a permissive nature of performance, i.e. which are based on enumerative systems (Wah *et al*., 1989).

The execute of the parallel computations on an equal basis is connected with the dynamic generation of specific objects that provide a quantitative assessment of the branching process along different computation trajectories. Static methods for parallel computing in processing of numerical information are based on the placement of a dynamically modifiable set of branching processes in homogeneous computing modules. To remove this limitation, the following are implementations

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Table 1: Methods of control at the subsystem level

| Type of the control | Commands flow control | Data flow control | Requirements flow control |
|---|---|---|---|
| Description | The usual execution of the operators at their place of in the control system | "Greedy" execution of all operators for which all operands are available | "Lazy" execution of the operators, without which there cannot be the results of the further calculations |
| Advantages | Full control easy realization of complex data structures and control structures | The high degree of parallelism high performance | Execution of only the necessary operators The independence of computing |
| Disadvantages | low efficiency complexity of programming | Complexity of control of data structures, resources expenditures for storage of the unnecessary operands complexity of control | Time costs for the transfer of markers The complexity of public access to the structures of local representation |

of symbolic calculations at the operation level. At the operation level of implementation of parallel computing there are three control methods of the computing process, consisting of many interacting flows which are commands flow control (the traditional von Neumann method), data flow control and requirements flow control (switching) (Wah *et al*., 1989).

For parallel computing the model of computation controlled by data flow model (Zanoon *et al*., 2012). According to this model, any computational process is directed by data flow graph. In this graph, nodes (vertices) are computer operators and the special data structures-tokens are moving along the arcs of the graph. The special structures (tokens) contain operating fields describing the formats and types of operands. The coincidence of the operands to the format automatically determines the type of command being performed and its readiness to perform. Refusal of addressing of memory cells and the transition to management through conformity of the data fields of various tokens characterize the fundamental difference between symbolic computers and the machines with the von Neumann architecture at the subsystem level. The detection of all operands relating to the common vertex of the graph is executed by the tops names and indicates initialization of computation by a processing unit for the given tops. Such principle of control eliminates the problem of synchronization and racing of flows, provides an asynchronous data flow promotion by pipelined to the ring of computers controlled by the data flow. The composition of computing operators, connections between nodes in a graph are set in advance at the stage of writing the program, thereby setting the graph structure. Computers of data flow architecture implement the direct execution of the graph. It provides parallelism of computing processes, set by the program and excludes the conflict situations with data. The main feature of the model of calculations controlled by the data flow is command execution not according to the counter but to readiness of input operands for the current nodes of the graph. Execution of this rule leads to an asynchronous execution of multiple commands at the nodes of the graph as a result of which its input from the arcs are absorbed and the output arcs are generated by the results of computations in a node.

The requirements flow control is a hybrid variant of control that is based on the union of a sequence of commands in a single unit with a control in its flow control and flow control between blocks of commands. In essence, the task is poorly described by the connected graph macrotops (block of commands) having a low rate of exchange flows between macrotops. Summary Table 1 contains the general characteristics of the three methods of control at the subsystem level (Wah *et al*., 1989).

## RESULTS AND DISCUSSION

**Method of processing of geospatial information:** The specifics of geoinformation information are relatively high structuredness and combination of geometric (geographic) and quantitative (attribute) data in one object. This combination is based on a Geoinformation Database (GDB).

The granularity of attribute data is an important criterion for parallel computing. In view of processing the most important distinctive property of geoinformation data is multi-level detailing and scalability of spatial data, taking into account attribute characteristics. Therewithal, methods and algorithms of scalability of spatial data must be supplemented with multi-level detailing of attribute (symbolic) data.

The features of geospatial processing set the conceptual shift in the multi-level representation of terrain objects and the very terrain. The object should be considered as a composition of two hierarchical data representations in which in the general case, the dimension of geographic data in levels does not coincide with the dimension of the attribute data. The meaning of the conceptual shift is to obtain the additional information (data flow) due to the discrepancy between the dimensions of the spatial and attribute components with the addition of data from the corresponding component.

For the immediate solution of geospatial processing problems, two options of moving and/or filling data are expedient:

- A fixed level of geographic data is filled with attribute data
- The attribute data of the current level is inherited in the next level of geographic data

The first option allows the refinement of attribute data. In fact, this means obtaining attribute data from masked (invisible) graphic levels, the quantitative data of which are output to the current visible graphic level. The originality of this level is determined by the saturation effect of attribute data. The second option is associated with inter-level movement of quantitative data to the next graphical level if it is necessary. Thus, the obligatory component of the heterogeneous data is the masking of the data of their structures which is customized for the tasks solved by the mobile robot.

## CONCLUSION

The current stage of development of the mobile robots control systems is characterized by a quantitative accumulation of theoretical and hardware-software tools for the organization of symbolic computing and geoprocessing. In the near future intellectualization of computations, i.e., the transition from data processing systems to knowledge processing systems will lead to the emergence of combined models of calculations, combining graphic and symbolic data structures and basic operations on them (Wu *et al*., 2013; Shi and Walford, 2012). The combination of the multi-level representation of graphic (geometric) objects and the inheritance of the values of object attributes when they are scaled provide a compact model of processing of geospatial data. This specific of the mobile robot control systems provides computational parallelism based on data flow model.

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