UDC 81`32

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LINGUISTIC MODELING BASED ON SYMBOLIC CALCULATIONS

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Анотація

Дана стаття містить інформацію про символьних обчисленнях і системах комп'ютерної алгебри, за допомогою яких символьні обчислення виконуються. Про системи символьних обчислень, як ефективні інструменти в моделюванні лінгвістичних феноменів.

Ключові слова: *лінгвістичне моделювання, символьні обчислення, лінгвістика, комп'ютерна алгебра, комп'ютерне моделювання*

Abstract

This article contains information about symbol calculations and computer algebra systems, through which the symbolic computations are performed. About systems of symbolic calculations, as effective tools in modeling of linguistic phenomena.

Key words: *linguistic modeling, symbolic calculations, linguistics, computer algebra, computer modeling*

Symbolic computation involves the processing of mathematical expressions and their elements as sequences of symbols (as opposed to numerical calculations that operate with numeric values behind mathematical expressions). Modern symbolic calculations are represented as dynamically developing field of mathematical modeling. The development of symbolic methods of modeling carried out through computer algebra. Practical implementation of symbolic modeling is made on the basis of the use of computer algebra system (CAS): Maple, Sage, Maxima, Reduce, etc.

Most of the cases solved by computer algebra systems are purely mathematical in their essence: the mathematical nature (the disclosure of products and degrees, factorization, differentiation, integration, calculation of the limits of functions and sequences, the solution of equations, operating with series, etc.). However, the universality of symbolic calculations and their potential in modeling linguistic phenomena has never been questioned. And the MATHLAB, one of the first systems of computer algebra, was created within the framework of the project of research of artificial intelligence (MITRE) on the basis of language LISP. Modern systems of symbolic computing are rapidly expanding their fields of application. At the same time, the narrowness of the engineering approach to understanding the computations is overcome and their epistemological universality in the NKS paradigm is substantiated [1].

Linguistics, along with biology, sociology and logistics, is one of the most promising areas for the successful advancement in the scientific study of symbolic computations and it rely on the development of computer algebra, a model of which can serve as a toolkit that includes the computer algebra system Mathematica, the programming language Wolfram, Wolfram|Alpha, CDF (format of computed documents) and Wolfram Programming Cloud.

Mathematica represents a system of computer algebra based on one of the most powerful case-oriented languages of high-level functional programming, made for solving various problems (including linguistic ones) that can be used as an interactive system for solving most problems in the interactive mode without traditional programming. Mathematica was conceived to automate the research practices in a wide variety of areas and, therefore, originally possessed versatility and functional redundancy with a user-friendly interface, ease of mastering, and high computational speed.

The key element of the Mathematica system is Wolfram Language [2] - a multi-paradigmatic (general purpose) language of symbolic calculations, functional and logical programming with the ability to implement arbitrary structures and data. The universality of the Wolfram Language is provided by the richness of numerous, often specialized, data, algorithms, knowledge bases, integrated into it, designed to represent the "complete computable world model" and to automate the modeling of its objects, processes, relationships as much as possible.

On basis of Wolfram Language and Mathematica, Wolfram|Alpha [3] is made - a computational knowledge engine that computes responses to user requests (including those specified in natural language), based on its own knowledge base and network resources, the library of algorithms and NKS-approach for answering queries. Wolfram|Alpha, in particular, is used by Siri-personal assistant for iOS.

Mathematica and Wolfram | Alpha combine the possibilities of performing complex character calculations (and numerical calculations) with the presentation of results in the form of a wide range of multimedia models (graphics, sound, animation, interactivity, etc.). This is largely due to the use of the Open Computable Document Format (CDF) format, designed to facilitate the creation of dynamically generated multimedia interactive content.

CDF format, thanks to integration with Wolfram Language, Mathematica and Wolfram | Alpha, extends the communication channel of conventional text and graphic material to the functionality of an interactive application and provides the ability to manage content and generate results in real time. The built-in ability to make calculations on the content material (text, numeric, formula, table, graphic, cartographic, infographic, etc.) allows not only to analyze the material, but from the information provided, to obtain new knowledge. Files in CDF format can be included in web pages or viewed directly in the browser as full-screen documents, their contents are updated using the built-in computing subsystem when interacting with graphical user elements. Due to the fact that the free program CDF-Player [5] entirely contains the Mathematica run-time library, the contents of the document can be generated in response to user action using any algorithms or visualization functions. This makes the CDF particularly suitable for visualizing material that operates with a large number of diverse data.

The general algorithm for creating an interactive linguistic CDF-model in Mathematica on the basis of a set of arbitrary data and without traditional programming will look like this:

Generating a set of random data using the built-in generator based on the syntactic constructions described in the documentation and copying the finished code;

Graphical display of the received data set based on the selection of built-in objects from the list. Calculation and copying of the finished code;

Symbolic calculations based on the selection of the required functions and syntax conditions;

Visualization and copying of the finished code;

Adding various elements to the graphical display;

Transformation of a graphic display into an interactive model based on the definition of controls, data set, variable variables, initial values, ranges of value changes. Calculation and copying of the finished code.

Design an interactive model and add an initialization option;

Converting an interactive model to a CDF format.

On the Internet, hundreds of interactive models derived from the symbolic calculations in Mathematica are presented [6], in several dozens of them models various aspects of Textual Analysis and School Language Arts (section Our World, subsection Linguistics). These models can be used in illustrative quality for research or educational activities, they can also be of interest as objects of study and the basis for own linguistic modeling based on symbolic calculations, especially in the context of teaching computer linguistics for students of humanitarian specialties.

In June 2014, Wolfram Programming Cloud (Wolfram Programming Cloud) was opened, which allows you to create ready-made CDF-documents, applications, work with direct APIs, create automatically generated reports, deferred tasks, web pages in any browser and any device and much more [7].

Although the toolkit is based on the use of English, there are sufficient resources on the Internet to study Wolfram Language and Mathematica in Russian [8].

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