https://www.proconference.org/index.php/usc/article/view/usc27-00-017
DOI: 10.30888/2709-2267.2024-27-00-017

UDC 81`32

MATHEMATICAL OPTIMIZATION IN PHILOLOGY

Krasniuk S.O.
senior lecturer
ORCID: 0000-0002-5987-8681
Kyiv National University of Technologies and Design,
Mala Shyianovska Street 2, Kyiv, Ukraine

Abstract. *Mathematical programming (or optimization) is a key tool in solving many problems of philology and machine linguistics. His methods are used to analyze textual data, develop natural language processing (NLP) models, and create automated language processing systems. This approach makes it possible to formulate complex language tasks as optimization tasks that can be effectively solved using modern algorithms.*

The article presents the results of a study of the use of mathematical optimization in modern philology, in particular, the relevance and importance of mathematical programming both for applied problems of machine linguistics and in modern philological scientific and practical research is proven; appropriate cybernetic methods and algorithms of mathematical programming for mathematical linguistics are determined; proposed main areas of application of mathematical optimization in philology; successful cases were analyzed.

Key words: *philology, machine linguistics, mathematical optimization*

Introduction.

Mathematical linguistics is an interdisciplinary field that uses mathematical methods, models, and formalisms to analyze linguistic phenomena, construct linguistic theories, and solve applied problems in linguistics [1, 2]. It combines knowledge of theoretical and applied linguistics, computer science, statistics and other mathematical disciplines [3].

Mathematical optimization (or mathematical programming) is a branch of mathematics that deals with the search for the best (optimal) solution to a certain problem under given constraints [4, 5]. The goal of optimization is to minimize or maximize some objective function that describes a system or process.

Mathematical optimization in philology is a powerful tool for solving problems related to text analysis, modeling linguistic phenomena, building linguistic models, and automating a number of processes [6]. It allows finding the best solutions for specific problems by minimizing or maximizing certain functions that describe linguistic or textual properties.

Main text.

The main areas of application of mathematical optimization in philology:

1. Automatic text analysis

1.1. Optimization of text classification: It is used to classify texts by genre, subject or style [7]. Optimization algorithms help find the best parameters for machine learning, which are used for more accurate classification.

1.2. Text compression (Summarization): Optimization methods allow you to automatically create condensed summaries of texts, selecting the most important sentences or fragments.

2. Natural Language Processing (NLP)

2.1. Optimization of language models: Modern language models, such as GPT or BERT, are trained using optimization techniques (eg, stochastic gradient descent) to minimize the loss function when training on large text corpora [8].

2.2. Machine translation: Optimization algorithms help find the best matches between texts in two languages, improving translation accuracy.

3. Lexicography

3.3. Optimization is used to automatically create electronic dictionaries, find the best matches in multilingual texts and build semantic fields.

3.4. It is possible to use optimization to analyze the frequency of use of lexical units, their semantic connections and build optimal dictionary entries.

4. Stylometry

4.1. In stylometry, mathematical optimization helps to highlight the key parameters of the text to identify authorship, compare the style of different authors, or determine stylistic changes in the work of one author.

4.2. Optimization is used to adjust models that analyze lexical, syntactic or stylistic features of texts.

5. Discourse analysis

5.1. Optimizing discourse structure: Algorithms can find the best ways to represent discourse, determine connections between different parts of a text (for example, identifying topics and subtopics in scientific articles or literary works).

6. Network analysis of language phenomena

6.1. Used to optimize graphs that model linguistic relationships, such as

relationships between words, phrases, or texts.

6.2. Optimization approaches help to build models of interaction of lexical and semantic units, minimizing "noise" in such networks.

7. Sentiment analysis

Optimization of text tonality classification algorithms makes it possible to better determine the emotional tone (positive, negative, neutral) in texts, in particular in media, social networks or literary works.

8. Modeling of language evolution

Mathematical optimization is used to model changes in language, find optimal ways to represent language evolution, analyze lexical borrowings or change grammatical structures.

Methods of mathematical optimization in philology:

- Gradient Descent: Used to train neural networks that are used for text analysis, classification or translation.
- Linear programming: Can be used for lexicography tasks, for example, building dictionaries that take into account the frequency of word use in texts.
- Stochastic methods: Used in machine learning tasks to optimize model parameters.
- Evolutionary algorithms: They allow to find optimal solutions in tasks of text classification or modeling of linguistic phenomena.
- Integer optimization algorithms: Used for discrete tasks, for example, constructing optimal paths in graphs simulating text links.

Examples of practical application of mathematical optimization in philology:

- Analysis of large text corpora: Optimization helps to analyze multilingual corpora to identify semantic patterns, frequency and contextual use of words.
- Automatic translation: Optimization is used to improve the match between sources and translation.
- Analysis of social networks: Optimization algorithms allow analysis of large text data to identify sentiments and trends in society.

Summary and conclusions.

Mathematical linguistics is the foundation for automating work with language, understanding its structure and analysis. It provides the basis for the creation of modern natural language processing technologies used in search engines, translators, speech recognition systems and intelligent assistants.

Mathematical optimization is a universal tool used in many fields of science and technology. Its main value is the ability to help find the best solution for complex multifactorial problems.

Mathematical optimization in philology provides efficiency and accuracy in the analysis of linguistic phenomena, automation of textual tasks and creation of models that take into account the complexity and multifaceted nature of language. This makes optimization an important tool in modern interdisciplinary research.

Mathematical optimization methods have become an important tool in scientific research in philology [9], allowing efficient analysis of large text corpora, modeling of linguistic structures, and automating the processing of linguistic data. Their implementation expands the possibilities of researchers, providing new tools for the study of language, literature and cultural phenomena. In the future, mathematical optimization will continue to play a key role in the development of philological sciences, especially in the conditions of growing volumes of textual data and the complexity of the researched problems.

Discussion.

As a promising direction of his future research, the author puts forward the following debatable thesis: mathematical optimization is relevant for a more qualitative and at the same time productive analysis & analytics of large linguistic data, helping to solve multidimensional interdisciplinary tasks related to the processing, modeling and interpretation of both semi-structured text and and unstructured information (natural language) of extremely large volumes [10]. Big Data have become an important resource in philology, opening new perspectives for the analysis of natural language, library collections, and cultural collections. Thanks to digital technologies, philologists have gained access to arrays of textual

information — from historical documents and literary works to modern publications on the Internet [11]. This creates opportunities for the application of the latest intelligent methods for their analysis, analytics and even modeling []. Thanks to the use of optimization methods, it is possible to work more efficiently with huge corpora of texts, create linguistic models and automate linguistic processes.

It is this promising direction of the author's future scientific research that will be reflected in future publications.

References:

1. Krasniuk , S., & Goncharenko , S. (2024). Modern mathematical linguistics. *Collection of Scientific Papers «SCIENTIA»*, (September 13, 2024; Pisa, Italia), 115–119. Retrieved from https://previous.scientia.report/index.php/archive/article/view/2060

2. Krasniuk S. Modern innovative machine linguistics / S. Krasniuk // *Scientific review of the actual events, achievements and problems* : collection of scientific papers "SCIENTIA" with Proceedings of the III International Scientific and Theoretical Conference, Berlin, Federal Republic of Germany, October 18, 2024. – Berlin, Federal Republic of Germany : International Center of Scientific Research, 2024. – P. 118-122. – URL: https://previous.scientia.report/index.php/archive/issue/view/18.10.2024

3. Krasniuk S. Modern computational linguistics / S. Krasniuk // *Scientific Collection "InterConf"*, (№ 220, October, 2024) with the Proceedings of the 7th International Scientific and Practical Conference "Experimental and Theoretical Research in Modern Science", Toronto, Canada, October 16-18, 2024 / comp. by LLC SPC "InterConf", Toronto : Aeropanzer, 2024. – P. 129-133. – Retrieved from https://archive.interconf.center/index.php/conference-proceeding/issue/view/16-18.10.2024

4. Naumenko, M., & Krasnyuk, M. (2024). Effective application of genetic algorithms in solving multi-extrema optimization problems in the management of a competitive enterprise. *Grail of Science*, (41), 65–73. https://doi.org/10.36074/grail-

of-science.05.07.2024.008

5. Kulynych Y., Krasnyuk M., Krasniuk S. (2022) Efficiency of evolutionary algorithms in solving optimization problems on the example of the fintech industry. *Grail of Science*, №14-15, May 2022. 63-70. https://doi.org/10.36074/grail-of-science.27.05.2022

6. Maxim Krasnyuk, Svitlana Krasniuk (2024). Chapter 6. Evolutionary technologies and genetic algorithms in machine translation. *Innovation in modern science: Education and Pedagogy, Philosophy, Philology, Art History and Culture, Medicine and Healthcare. Monographic series «European Science».* Book 30. Part 3. 2024. pp. 91-98, Published by: ScientificWorld-NetAkhat AV, Lußstr. 1376227 Karlsruhe, Germany. https://desymp.promonograph.org/index.php/sge/issue/view/sge30-03/sge30-03

7. Krasniuk S. Advanced text mining in philology / S. Krasniuk // Interdisciplinary research: scientific horizons and perspectives : *collection of scientific papers "SCIENTIA"* with Proceedings of the VI International Scientific and Theoretical Conference, Stockholm, Kingdom of Sweden, September 27, 2024. – Stockholm, Kingdom of Sweden : International Center of Scientific Research, 2024. – P. 68-72. – URL: https://previous.scientia.report/index.php/archive/issue/view/27.09.2024

8. Krasniuk S. Innovative artificial intelligence in philology / S. Krasniuk // *Innovations and New Directions in Scientific Research* : proceedings of the International Scientific Conference, Manchester, United Kingdom, October 14, 2024. – Manchester, UK : IEDC ; Bookmundo, 2024. – P. 134-137. – URL: https://researcheurope.org/book-64/

9. Krasniuk S.O. (2024). Management of research studies in philology. *Сучасні проблеми менеджменту*: матеріали XX Міжнародної науковопрактичної конференції, Київ, 2024, Національний авіаційний університет / Редакційна колегія: Кириленко О. [та інші]. – К.: НАУ, 2024. – 455 с. – Електронне наукове видання.

10. Krasniuk S. Structured, semi-structured and unstructured Batch and stream

data in philology (2024). *Science and Global Challenges in the Modern World:* proceedings of the International Scientific Conference, Lester, United Kingdom, November, 2024. – Lester, UK : IEDC ; Bookmundo, 2024.

11. Krasniuk, S., & Goncharenko, S. (2024). Big data in philology *Collection of Scientific Papers «ΛΟΓΟΣ»*, (September 20, 2024; Paris, France), 159–165. https://doi.org/10.36074/logos-20.09.2024.031

Article sent: 23.11.2024