Numismatic Databases: History of Bulgarian Interdisciplinary Studies

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Abstract: *The report briefly presents the path followed by Bulgarian scientists from the 1990s to today in the direction of using artificial intelligence (AI) in historical research. Emphasis is placed on the creation, the general functional scheme, the data structure, and the functionalities of the Bulgarian expert system for the identification and classification of ancient coins, PSAMS, as a new, modern way of analyzing numismatic material.*

Keywords: Artificial Intelligence, Symbolic and Algebraic Manipulation, Special-purpose algebraic systems, Applications, Interdisciplinary Studies, Numismatic databases

Ключови думи: изкуствен интелект, символни и алгебрични преобразования, системи за компютърна алгебра, компютърни приложения, интердисциплинарни изследвания, нумизматични бази данни

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At the end of 2020, with Protocol 72 of the regular meeting of the Council of Ministers on December 16, 2020, a Concept for the development of artificial intelligence in Bulgaria until 2030 was adopted. According to the official website of the Ministry of e-Government, "the document offers a comprehensive vision for the development and use of artificial intelligence in Bulgaria. It is based on the strategy and program documents of the European Commission, which consider artificial intelligence as one of the main drivers of digital transformation in Europe.

The main objective of the concept is to unite efforts in the development and implementation of artificial intelligence systems by creating scientific, expert, business and management capacity. It is planned to provide modern communication and scientific infrastructure for the development of new generation digital technologies. The education and lifelong learning system will be improved. The development of scientific research and the implementation of innovations in key sectors will be supported, and work will be done to introduce an ethical legal and regulatory frame-

work that enjoys public trust[1].

This is the current situation. Since December 2023, the INSAIT Institute at Sofia University has been operational in Bulgaria, joining approximately 50 organizations worldwide as part of the historic first global Alliance for Artificial Intelligence. Recently announced in the US by IBM and Meta, this initiative aims to unite the world's foremost minds from the private sector, academia, and institutions to develop open, safe, and accountable AI. The Alliance carefully selected its founding members, including some of the strongest universities and development centers globally. Notably, the Bulgarian INSAIT Institute aligns itself with esteemed scientific institutions such as NASA, CERN, Harvard University, Yale University, University of California, Berkeley, ETH Zurich, among others, as well as leading technology companies like Sony, Linux, Intel, AMD, and Dell.

The Bulgarian Institute not only participates in the Alliance but also registers its name among the founders of the initiative, which aims to reshape the future of AI on a global scale. The collective impact of the organizations involved is underscored by aggregated data: their combined budget for development activities exceeds $80 billion annually, they employ a total of 1 million individuals, and they educate 400,000 students. Further confirming its active role in AI technology development is the information available on the institution's official website: "INSAIT is developing BgGPT, the first specialized Bulgarian language model tailored for Bulgarian users, institutions, and businesses. As part of BgGPT, INSAIT will release a series of free and open language models" (source: https://bggpt.ai).

After presenting these impressive contemporary statistics, let us now revisit the history of AI in Bulgaria. Establishing the undeniable leading position of our country in the development and application of AI today necessitates a stable foundation. Despite the presence of the Iron Curtain at the time, scientific interest in AI in Bulgaria emerged nearly simultaneously with other European countries, which were closely following trends in the USA. The initial research projects took place within scientific units of the Bulgarian Academy of Sciences, including the Institute of Mathematics (IM), the Institute of Technical Cybernetics (ITK), which was transformed in 1978 into the Institute of Technical Cybernetics and Robotics (ITKR), the Center for Scientific Information, the Center for Science, and the Institute of Philosophy.

The journey began back in 1968 with a team of scientists from the "Mathematical Assurance" section, led by Prof. Petar Barnev, at the Institute of Mathematics of the BAS. This team embarked on projects involving the computer implementation of the first Bulgarian intellectual game, heuristic programming, and learning languages such as "LISP" and "Prolog." Under the guidance of Prof. Valentin Tomov, the focus shifted to analytical transformations, particularly Symbolic and Algebraic Transformations (SAP), known internationally and gaining popularity in Bulgaria as "systems for computer algebra". These systems were specialized in various mathematical fields, such as indefinite integrals, rational functions, matrices, and continued fractions. An expert system was developed, along with language tools, to utilize mathematical knowledge within the Reduce-2 system for analytical transformations.

In 1980, the "Artificial Intelligence in Mathematical Assurance" (IIMO) research group was established within the Department of Mathematics and Physics, led by Prof. Valentin Tomov. Its research primarily focused on the REDUCE 2 and SAC-2 systems, as well as the group's ideas for further developments using these systems.

In 1981, systematic training in artificial intelligence was initiated at the Faculty of Mathematics and Mechanics at St. Kliment Ohridski University. The lecture course was logically led by Associate Professor V. Tomov, who was the first Bulgarian scientist to defend a doctoral dissertation in informatics (1975).

[1] <https://egov.government.bg/wps/portal/ministry-meu/strategies-policies/digital.transformation/itis-national-strategic-documents/ai.development.concept.2030> (accessed 26.02.2024).

He was also the founder and initial head of the "Artificial Intelligence" section at the Institute of Mathematics of the BAS, laying the groundwork for interdisciplinary research utilizing AI.

By 1985, the IIMO group evolved into the "Artificial Intelligence" section under the continued leadership of Prof. Valentin Tomov. Following his untimely death in 1995, Prof. Alexander Gerov assumed leadership of the section. In 2010, several members of the section retired, leading to its closure at the end of the year. Throughout its decades-long existence, the section was characterized by active research and scientific-applied endeavors.

As early as 1974, Prof. V. Tomov conducted the pioneering interdisciplinary research utilizing AI, alongside Ivan Velchev, focusing on the design and management of ventilation systems in mines to prevent explosions (known as the Hades system). Over the following two decades, scientists from the AI section at the Institute of Mathematics of the BAS embarked on numerous projects in the field of informatics, collaborating with researchers from diverse disciplines. These collaborations included ventures in archaeology with Prof. Henrietta Todorova, history with Prof. Margarita Tacheva, and music composition with Simeon Pironkov. Additionally, collaborations extended to fields such as mechanics, led by Prof. Kolyo Minkov from the Institute of Mechanics of the BAS, and neurophysiology and sensory systems with Prof. Angel Vassilev, focusing on information processing in the visual system, among others.

The first collaborative project in the realm of humanities was initiated alongside the Problem Group on Interdisciplinary Research at the Archaeological Institute, later evolving into the Section for Interdisciplinary Research at NAIM-BAS under the leadership of Prof. H. Todorova. Scientists from the AI section embarked on developing a system for the recognition and classification of archaeological ceramics employing production rules. Efforts were made to integrate the newly formulated fuzzy set theory by the esteemed American scientist Prof. Lutfi Zadeh.

A significant milestone in the advancement of AI in Bulgaria was the organization of an international conference on AI, featuring invitations extended to prominent foreign scientists. The initiative stemmed from Assoc. Prof. Dr. Vasil Sgurev, the acting director of ITKR at the BAS, and Assoc. Prof. Dr. Boris Petkov from the Center for Science and Technology at the BAS. The inaugural scientific conference AIMSA'84 (Artificial Intelligence, Methodology, Systems, and Applications) took place in September 1984 in the Golden Sands resort, near Varna. Prof. Wolfgang Bibel, a West German scientist and chairman of ECCAI (European Coordination Committee on Artificial Intelligence), provided active support in the organization. Conference proceedings were published by the "Nord-Holland" publishing house. It was decided that the AIMSA international conference would be held biennially under the auspices of ECCAI. During this pivotal inaugural conference, Assoc. Prof. V. Tomov's team presented the outcomes of their interdisciplinary research in the fields of archaeology and history[2].

The Second International Conference AIMSA'86 stands out as particularly successful, with the participation of an International Program Committee chaired by Prof. Philippe Joran, director of the Laboratory of Informatics and Artificial Intelligence in Grenoble, France. The presence of renowned British scientist Prof. Robert (Bob) Kowalski, a leading figure in the development of the Prolog language, generated significant interest. Notably, a substantial delegation of leading scientists from the Computing Center of the Academy of Sciences of the USSR, led by Academician Hermogen Pospelov, contributed to the conference proceedings. During this event, Bulgarian scientists showcased their advancements in AI, presenting progress in interdisciplinary studies and unveiling the ESIT expert system for analyzing ancient historical-geographical texts about Ancient Thrace[3].

[2] *Tomov, Sahno* 1985.

[3] *Tomov, Tacheva, Grigorov* 1987; *Tomov, Tacheva, Grigorov* 1989. The team of the historians from the Sofia University was led by Prof. M. Tacheva and included also her students, and then colleagues Dilyana Boteva and Konstantin Boshnakov.

The tradition of hosting the AIMSA conference persisted even after the democratic changes in Bulgaria. From 1994 to 2018, seventeen editions of the conference were held, marking the longest series of events with international participation organized by BAS. This achievement stands as a testament to the remarkable contributions of Bulgarian scientists in the field of AI.

The development of an expert system for the recognition, classification, and archiving of coins and coin treasures using AI, known as PSAMS, commenced in the late 1980s. The team from the "Artificial Intelligence" section at the Institute of Mathematics of the BAS, led by Prof. V. Tomov, collaborated with Prof. M. Tacheva, Dr. Ilya Prokopov, director of RIM Kyustendil, and Valentina Grigorova, a graduate student in the Department of Ancient History and Thracology at Sofia University St. Kliment Ohridski[4]. The primary objective of the system is to educate the machine in recognizing coins, establish a comprehensive database, and effectively manage and utilize it.

The PSAMS system operates in three primary modes: first, creating a knowledge base and populating the database with detailed descriptions of specific coins; second, recognizing and categorizing coins based on their descriptions in the database; and third, fulfilling user requests. Through these functionalities, users can search for specific coins within the database, modify or edit entered data, conduct statistical analyses, and generate reports. An important feature of PSAMS is its ability to incorporate confidence factors in coin descriptions stored in the database and the rules of the knowledge base. This coefficient enables the relativization of numismatic information, particularly for coins with a low degree of preservation and illegible legends.

The expert system underwent successful testing at the History Museum in Kyustendil, utilizing various types of ancient coins from its numismatic collection. The next phase of system development aimed to incorporate Roman provincial coins from Lower Moesia and Thrace (2nd – 3rd centuries) into the database for automatic identification and classification. Unfortunately, the untimely passing of Prof. Valentin Tomov, and Dr. Ilya Prokopov's transition to another role interrupted further progress on this innovative interdisciplinary project, which was partially funded by the Ministry of Education, Science, and Culture.

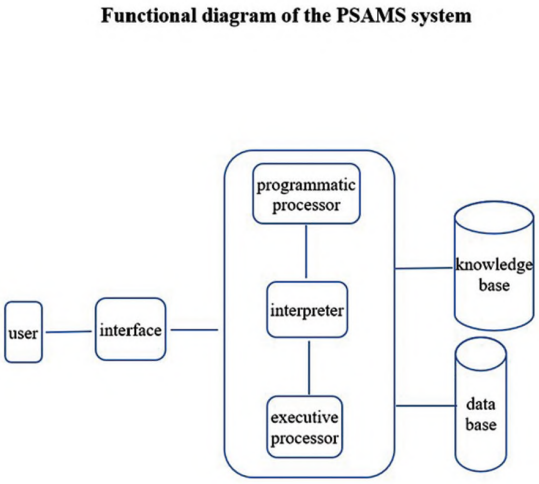

Figure 1. Functional diagram of the PSAMS system.

Continuing the endeavor, Dilyana Boteva took up the task of creating a unified, publicly accessible database in the field of ancient world research. Since 1994, she had been developing a database featuring reliefs of the Thracian Horseman under a project financed by the "Young Scientists" fund of the Ministry of Education and Culture. The project garnered recognition in 1996 with a nomination for the most successful project. Dilyana Boteva continued to populate this database until 2006, and the outcomes of her efforts led to the defense of her degree of "Doctor of Sciences" in 2007[5].

The project "Measuring Ancient Thrace: Re-evaluating Antiquity in Digital Age," (Project no. КП-06-Н 50/3 from 30.11.2020, financed by BNSF) under the scientific leadership of Assoc. Prof. Dr. Julia Tzvetkova, aims to stimulate necessary methodological discus-

[4] *Tomov et al.* 1989; *Grigorova* 1994; *Tomov, Grigorov, Vakarelov* 1994; *Tomov et al.* 1994; *Grigorov, Vassileva* 1994.
[5] *Boteva* 2002; *Boteva* 2006; *Boteva-Boyanova* 2006; *Boteva* 2007; *Boteva-Boyanova* 2007.

sions regarding the role of digital technologies and exact scientific methods in researching the history of ancient Thrace, both theoretically and practically[6]. As part of the project, the development of a web-based application is envisioned to encompass data from various sources, including written records, archaeological sites, epigraphic documents, and numismatic data, with a particular emphasis on the outcomes of archaeometric studies – an integral aspect of the project. This conceptually innovative database seeks to establish standards for describing heterogeneous objects, enabling search, extraction, and visualization of information. It is envisioned as a pivotal research and analytical tool, with its web-based nature ensuring widespread accessibility and the "democratization of information". Fulfilling dual public functions, it aims to aid in building an international academic network while providing expert scientific opinions to the public on contentious topics related to the cultural and historical heritage of ancient Thrace.

The initial phase of product development entails expanding the data model created by Corpus Nummorum to handle both numismatic and epigraphic data simultaneously within a single system.

Corpus Nummorum (CN) Online is a web portal dedicated to ancient coins from historical regions including Lower Moesia, Thrace, Mysia (Asia Minor), and Troad. The project involves collaboration among three institutions: the Berlin-Brandenburg Academy of Sciences (BBAW), the Mint Cabinet at the State Museums in Berlin (Münzkabinett der Staatlichen Museen zu Berlin), and the Big Data Lab at the University of Frankfurt. Funding is channeled through projects aimed at processing ancient Greek coinage by regions and mints, aligned with scientific research objectives and cultural heritage preservation. While there are variations in available data and outcomes across sub-projects targeting specific regions, the overarching goal is to produce type catalogs for relevant mints[7].

The research database for collecting and categorizing numismatic data comprises two primary collections. Drawing from material sourced from approximately 100 mints within the designated regions, it incorporates segments of the collection from the Mint Office, Berlin, as well as the plaster cast collection at the Berlin-Brandenburg Academy of Sciences (BBAW). These collections consist of coin copies from various mints, originating from historically rich yet partially lost collections. Moreover, digital museum catalogs are integrated, and ongoing efforts are made to process new materials. Embracing the ethos of public science, the platform allows for data upload via an online form, thereby enriching the portal. The database facilitates the scientific classification of individual coins, which can be linked to the stamps used for their issue and grouped by type. Users have the ability to sort types, distinguish subtypes, or amalgamate them into larger groups (series/issues). All coins featured on the portal are meticulously detailed in both German and English.

Corpus Nummorum is evolving through an expanding network of partners. Notably, Bulgarian participants within the team have made a significant contribution by introducing the Bulgarian language as the third primary language for the portal. Clear criteria have been established for both image descriptions of individual coins and types, aiding in the enforcement of standardization (accessible via the "Help" button for description rules when adding a coin). Such a concise and multilingual standardization is unprecedented in numismatics, where traditionally each scientist or national school describes coins according to their own set of rules and regulations[8].

The portal cooperates closely with an international initiative under the supervision of the International Numismatic Council (INC) aimed at processing the types of Greek coins in the Semantic Web (https://www.greekcoinage.org/). All relevant fields in the database are linked to normed data (http://nomisma.org).

[6] <https://digithrace.uni-sofia.bg/about/>, (accessed 01.07.2024).
[7] *Peter* 2021; *Peter et al.* 2024.
[8] *Grozdanova* 2018; *Grozdanova* 2021; *Grozdanova, Ivanova-Aanaplioti* (forthcoming).

The production of coin type catalogues entails structuring the available material precisely according to the iconographic types associated with individual specimens. Coins are analyzed based on their metric data, provenance information, and descriptions of their legends and images following standardized rules. This approach facilitates the creation of a foundational database for generating type catalogs for each region, which will naturally require ongoing supplementation. Continual additions can be made as coins from other collections within each of the four regions are incorporated into the database. Additionally, registered users have the option to contribute their own coins, thereby expanding access to the scientific community.

The consistent utilization of Linked Open Data and adherence to standardized data formats enable seamless exchange with other collections. Search functionality is accessible both through the general portal and at the level of sub-pages dedicated to individual regions such as Thrace, Lower Moesia, Mysia (Asia Minor), and Troad. For more advanced research endeavors, the SPARQL-endpoint of the portal offers enhanced capabilities: https://www.corpus-nummorum.eu/sparql/

The latest phases of Corpus Nummorum (CN) development are intertwined with the field of artificial intelligence (AI), focusing on applications in natural language processing (NLP) and image recognition (IR). These advancements are available for testing by the general public, with open access provided. https://github.com/Frankfurt-BigDataLab/NLP-on-multilingual-coin-datasets and https://github.com/Frankfurt-BigDataLab/IR-on-coin-datasets

The portal team collaborates closely with Bulgarian researchers and actively participates in various projects, including DiGiThrace and the ACCSN network, established to combat the counterfeiting of ancient coins. The creation of the ACCSN network was supported by the "Humboldt-Alumni-Preis 2021" award from the Alexander von Humboldt Foundation, presented to Prof. DSc Dilyana Boteva-Boyanova. Counterfeiting of numismatic cultural heritage poses a global challenge, impacting historical integrity, scientific authenticity, and the market for cultural artifacts. Counterfeits not only distort historical narratives but also have profound societal and economic repercussions.

In response to this pressing international issue, it is imperative to implement fundamental measures to address the threat. The creation of a robust and proactive academic network represents the most effective approach to prevention. The ACCSN network focuses on enhancing knowledge transfer and fosters academic, cultural, and inter-institutional cooperation. It aims to engage a wide array of international experts and stakeholders, including auction houses, museums, and collectors worldwide. Presently, the network comprises 38 members from 10 countries across three continents.

An essential aspect and objective of the initiative involve the development of an IT-based digital tool to actively combat the proliferation of numismatic counterfeits. There is a critical need for a dedicated platform to facilitate the collection and analysis of data on detected counterfeits. Such a tool is indispensable for refining specialized practices in counterfeit detection and preventing the infiltration of fake numismatic items into collections and historical narratives. The initial stage of tool development involves active collaboration with the CN team. The functionality will be accessible through the CN platform, enabling users to compare suspected counterfeits with original numismatic artifacts. Additionally, the tool will soon be available on the https://accs-network.com website, serving as an essential information resource for advancing scientific processing and identifying fake numismatic objects while disseminating knowledge to mitigate detrimental effects on society.

The collaboration between individual systems is facilitated by the mutual expansion of their databases through the registration of new coins by institutions and individual registered users. A workshop held by the Corpus Nummorum and ACCSN teams in Berlin in December 2023 was dedicated to further developing this collaboration.

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Нумизматични бази-данни: История на българските интердисциплинарни изследвания

Валентина Григорова-Генчева

През 2020 г. България прие Концепция за развитие на изкуствения интелект (ИИ) до 2030 г., като акцентира върху създаването на научен, бизнес и управленски капацитет в подкрепа на напредъка на ИИ. Основните цели включват подобряване на образованието, научните изследвания, иновациите и етичните рамки. От 2023 г. Институтът INSAIT към Софийския университет се присъедини към глобалния алианс за изкуствен интелект, като се нареди до престижни институции като НАСА и Харвард. INSAIT разработва BgGPT, български езиков AI модел. Историята на ИИ в България всъщност започва през 1968 г. с разработки на Българската академия на науките и включва значителни интердисциплинарни проекти и международни сътрудничества, включително и първите приложения на ИИ в исторически изследвания. Системата PSAMS за разпознаване на монети и базата данни BBAW Corpus Nummorum са забележителен принос, интегрирайки ИИ в нумизматиката и насърчавайки международното сътрудничество срещу фалшифицирането на монети.