

## Research Trends and Collaboration at the University of Debrecen's Faculty of Informatics: A Bibliometric Analysis

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*Received: 17 January 2025; Accepted: 23 April 2025*

This study examines research trends and collaboration at the University of Debrecen's Faculty of Informatics over nearly two decades. Utilizing a bibliometric analysis based on Scopus-indexed publications from 2004 to 2023, the study explores annual scientific output, citation metrics, document age, leading journals, and collaboration patterns among authors and institutions. Key aspects analyzed include the prevalence of Open Access publishing, primary funding sources, and emerging research domains. The findings reveal a significant increase in the faculty's publication activity, particularly between 2010 and 2014, coinciding with multiple European-funded projects. The study also identifies a growing research emphasis on machine learning, virtual reality, and deep learning, reflecting global scientific trends. Despite a rise in scholarly output, citation impact remains moderate, indicating room for further engagement and visibility within the research community. Furthermore, the faculty's collaboration networks span national and international institutions, with strong connections to Hungarian and European partners. By mapping the conceptual structure of research fields, the study highlights shift in dominant themes over time, providing insights into the faculty's evolving scientific contributions. These findings offer a comprehensive scholarly productivity and collaboration perspective, supporting future research strategies and institutional development.

**Keywords:** Bibliometrics, Publications, Collaboration, Open Access, Research Trends.

### Introduction

Literature shows that Alan Pritchard first introduced the term bibliometrics<sup>1,2</sup> and was first used in the Journal of Documentation in 1969<sup>3</sup>. In 1969, Pritchard defined bibliometrics as “the application of mathematical and statistical methods to books and other media of communication,” cited by Glänzel<sup>1</sup>. Historically, bibliometrics has sharply risen since 1963 when deSolla Price laid the foundation for modern research evaluation techniques in his book “Little Science – Big Science”<sup>1</sup>. Since 1969, bibliometrics has grown in popularity and is used to describe the study of science growth, structure, interrelationships, and productivity<sup>4</sup>. Bibliometrics is a quantitative analysis of publications to ascertain specific phenomena such as characteristics of materials used, and intellectual content of published materials<sup>5</sup>.

**With increasing research performance**<sup>6,7</sup> **Bibliometrics** has become a standard tool of science policy and research management, particularly in recent decades<sup>1,8</sup>. Especially, after the development of major bibliographic databases such as Web of Science and Scopus, bibliometrics has been broadly

used in the research performance evaluation of individual researchers, research groups, universities, research institutes, and countries<sup>8,9</sup> to speculate on the contribution to science development. Due to this, bibliometrics became a method by which the state of science and technology can be observed through the overall production of scientific literature<sup>10</sup> and its wide potential applicability in applying quantitative knowledge of scientific growth to the science policy<sup>11</sup>. Literature showed that the bibliometrics method provides important information for quality assessment when it comes to comparing many research units, such as research groups or universities<sup>12</sup>. Because individual experts are not capable of handling so much information in a single evaluation procedure<sup>13</sup>. Bibliometrics-based research evaluation is mostly based on indicators such as the count of publications output, number of citations, and h-index received by a paper or journal, which can be easily computed and interpreted.

Moreover, bibliometrics is used in science mapping<sup>14, 15, 12</sup> to understand the research field and its connections with other domains<sup>16</sup>. With the advances in graphics and network visualization tools<sup>17</sup>, researchers

can easily understand the trending topic<sup>14</sup>, and the themes researched, to identify shifts in the boundaries of the disciplines, to detect the most prolific scholars or institutions<sup>18, 19</sup>

Furthermore, bibliometrics allows for the identification of trends in authorship and collaboration patterns<sup>20</sup>. Bibliometric analysis is a very important in-depth analysis of national and international collaboration among authors and research groups, and for the analysis of the thematic structure of publications and the detection of emerging hot topics for the research agenda<sup>21</sup>. Finally, bibliometrics is also helpful in identifying areas of research strength and weakness<sup>22</sup>, and identification of emerging research areas<sup>23</sup>. This paper analyzes the publication activities and the development of a new research field in the Faculty of Informatics at the University of Debrecen, one of Hungary's most prominent higher education institutions. Currently, the University of Debrecen runs fourteen faculties on different campuses. This study aims to examine the publication activities of the Faculty of Informatics at the University of Debrecen, focusing on annual scientific production, average citation per document, document age, authors' collaboration patterns, top-producing journals, and authors' productions. Types of open access, primary funding sources, and author-term co-occurrence are also examined.

### **Research Objective.**

This study uses data from the Scopus database to analyze the research activities and development of the research fields in the Faculty of Informatics at the University of Debrecen.

### **Specific Objectives**

To achieve the research objective, we formulated specific objectives focusing on the Faculty of Informatics' publications activities at the University of Debrecen. The specific objectives of this study are to:

1. Evaluate the yearly scientific contributions of the faculty, including the various types of documents, their average age, the citation rate, and the average citation per document.
2. Examine all categories of Open-Access publications.
3. Identify the key funding sources.
4. Identify the most relevant sources of production of the Faculty of Informatics publications.
5. Visualize the collaborative networks among authors and institutions associated with the faculty.

6. Analyze the conceptual structure of research disciplines and how they evolve

### **Methodology**

As **bibliometric analysis** relies upon extensive quantitative data from relevant databases,<sup>13,12</sup> we used bibliographic data from Scopus of Elsevier. Publications affiliated with the University of Debrecen, Faculty of Informatics, were collected from the Scopus database on 6<sup>th</sup> January 2024. A Search technique (AF-ID ("Debreceni Egyetem Informatikai Kar" 60108578)) was used to retrieve the required publication data from 2004 to 2023. All scholarly output published in the English language has been considered. Then, 1006 publications were exported in the CSV file format. However, 32(3.28%) publications' metadata missed entries such as affiliation, sources, language, and document types. After removing the missed entries, 973(96.72%) data about documents, source titles, and authors were used for analysis. Document title, year of publication, type of document (article, conference paper, letter, book, book chapter, review, note, short survey, erratum, and editorial), number of citations (cited by), keywords (author keywords are used for analysis). Concerning the sources' titles, we extracted the source type (Journals, conference proceedings, books, and book series) and types of access (open access or non-open access). Types of open-access routes and the primary funding sources are also identified.

Then, the bibliometric analysis was performed based on the following bibliometric indicators: number of articles published per year (annual scientific production), average citations per document (including self-citation), the annual growth rate of publication, and institutional collaboration, co-authorship, co-author per document, and document average age. Moreover, we examined the conceptual structure and main research fields of the faculty of informatics. We used the word cloud, trend topic, and author keyword co-occurrence over time to depict the conceptual structure and the research fields. Finally, we used the free and open-source software Biblioshiny<sup>14</sup> and VOSviewer<sup>17</sup>, for analysis and visualization purposes.

### **Result and Discussion.**

#### **Document Type.**

Regarding document type, almost all types of scholarly output were submitted to various sources. Most of the scholarly output was journal articles,

which account for 503(51.7%), conference papers 441(45.32%), 14(1.44) book chapters, 3(0.31%) editorial, 2(0.21%) erratum, 1(0.1%) note, 8(0.82%) review, and 1(0.1%) short survey have Has contributed to the scholarly system (see Table 1).

Table 2 shows the summarized information about publications affiliated with the Faculty of Informatics at the University of Debrecen. The table was generated by Biblioshiny software based on bibliographic data from Scopus. The publications span from 2004 to 2023, published in 421 sources (Journals and book chapters), containing 973 scholarly outputs with an annual growth rate of 24.77%. Since 2004, 1059 authors from different local and international institutions have contributed to scholarly systems. Our data reveals that the Faculty of Informatics has collaborated with more than 42 institutions, of which 29.39% are international collaborations, with 3.23 co-authors per document and 56 authors of single-authored documents. Moreover, as depicted in Table 2, the document's average age and the average citation per document were 8.1 and 7.58, respectively.

### Annual Scientific Production

Since its establishment in 2004, the Faculty of Informatics at the University of Debrecen has mainly contributed journal articles and conference papers in Computer Science and Mathematics. Figure 1 shows the annual scientific production of the Faculty of Informatics. As one can observe, the first publication was indexed in the Scopus database in the year 2004 during the establishment of the faculty. Then, publications increased to 20 and 24 in 2005 and 2006, respectively. Until 2009, the number of publications was less than 30. The annual scientific production of the faculty has significantly increased since its establishment, particularly during the years 2010-2014, when the publications of the Faculty of Informatics were continuously increased. During these periods, the faculty was involved in several European projects funded (see Table 3), which led to stable publication growth. Also, the University of Debrecen changed its model, which introduced performance reporting and prioritized science metrics. As observed from Figure 1, the highest annual scientific publication of the faculty was recorded

Table 1 — Document Type.

Type	N	Percentage (%)
Article	503	51.70
book chapter	14	1.44
conference paper	441	45.32
Editorial	3	0.31
Erratum	2	0.21
Note	1	0.1
Review	8	0.82
short survey	1	0.1
Total	973	100.00

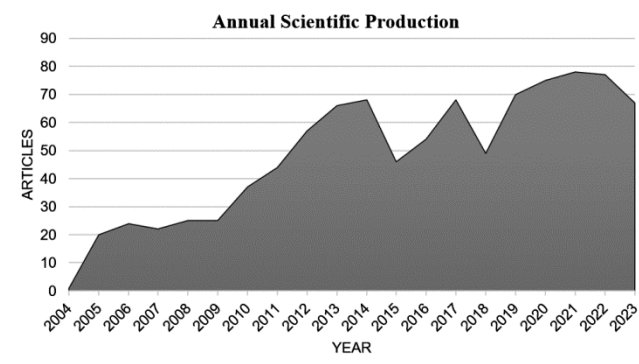


Fig. 1 — Annual Scientific Production of Faculty of Informatics, University of Debrecen.

Table 2 — Overall publication data based on the Scopus database.

Timespan <b>2004:2023</b>	Sources <b>421</b>	Documents <b>973</b>	Annual Growth Rate <b>24.77 %</b>
Authors <b>1059</b>	Authors of single-authored docs <b>56</b>	International Co-Authorship <b>29.39 %</b>	Co-Authors per Doc <b>3.23</b>
Author's Keywords (DE) <b>2599</b>	References <b>21538</b>	Document Average Age <b>8.1</b>	Average citations per doc <b>7.585</b>

(N=78) in 2021. However, the above figure only shows the articles in the final publication stage, with no ‘articles in press’ included. The data for 2022 and 2023 will be altered after this study. Generally, the annual scientific production of the Faculty of Informatics at the University of Debrecen is significantly increasing.

**Types of Open-Access**

To identify the open-access document, we used ‘Scopus exported refine values’ using a specified query. Then, we identified All Open-Access documents spanning from 2004 to 2023. Then, we identified 453 All Open Access (Green, Gold, Hybrid Gold, and Bronze) publications as shown in Figure 2. The data shows that only 46.60% of the publications of the Faculty of Informatics at the University of Debrecen were All Open Access. More than half (53%) of faculty publications were still published in a pay wall or traditional way. Most of the faculty's open-access publications were gold routes, accounting for 193(42.60%). Only 156(34.44%) of the publications were green routes.

Table 3 — Major Research Funding Sources at Faculty of Informatics.

S. N	Funding Sponsor	Number of Documents
1	European Commission	265
2	European Social Fund	241
3	Hungarian Scientific Research Fund	87
4	Nemzeti Kutatási Fejlesztési és Innovációs Hivatal	85
5	Directorate-General for Employment, Social Affairs and Inclusion	84
6	European Regional Development Fund	71
7	Magyar Tudományos Akadémia	66
8	National Natural Science Foundation of China	45
9	Deutsche Forschungsgemeinschaft	44
10	National Science Foundation	41

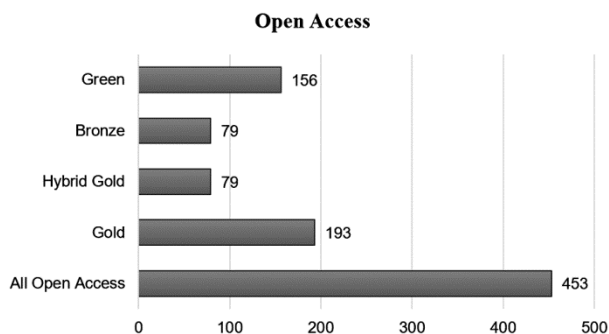


Fig. 2 — All Open-Access publications

**Funding Sources.**

This study identified various funding sources from multiple institutions and countries from which the faculty received funding. To maintain clarity and relevance, only the primary funding sources are illustrated in Table 3. Notably, the European Commission and the European Social Fund emerged as the two predominant funding entities, followed by Hungarian-based institutions, including the Hungarian Scientific Research Fund, Nemzeti Kutatási Fejlesztési és Innovációs Hivatal, and the Directorate-General for Employment, Social Affairs and Inclusion.

Figure 3 shows the mean total citation per year (Mean TC per Year). The average citation per year is calculated by dividing the total number of citations by the total number of papers published in that particular year. The average number of citations per article counts the cumulative number of times an author’s articles have been cited by other articles, then divides this number by the author’s total number of articles written. In this study, the data shows the average citation for the year 2004 was 0.33 and continued to grow until 2006. From 2006 to 2009, the average citation per year decreased because of the high number of publications and low citations received. The average citation per year was less than two, and it varies to a certain extent. As observed from Figure 3, there is no indication that earlier publications received more citations than recent ones. Conversely, the average citation per year continues to increase, and the maximum average citation per year was received in 2018. The increase in average citations per year may be attributed to the emergence of new fields of study, such as Machine Learning, Virtual Reality, and Deep Learning, which attracted the attention of researchers in the early 2010s.

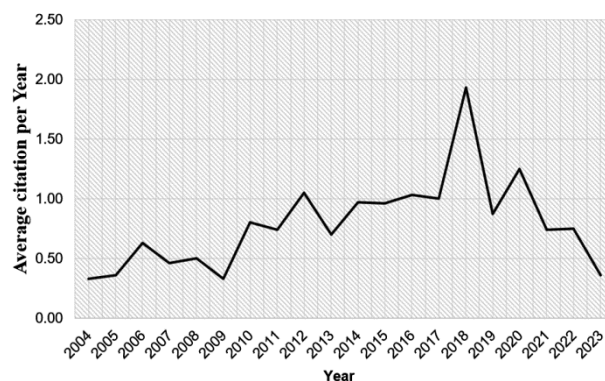


Fig. 3 — Average Citation Per Year

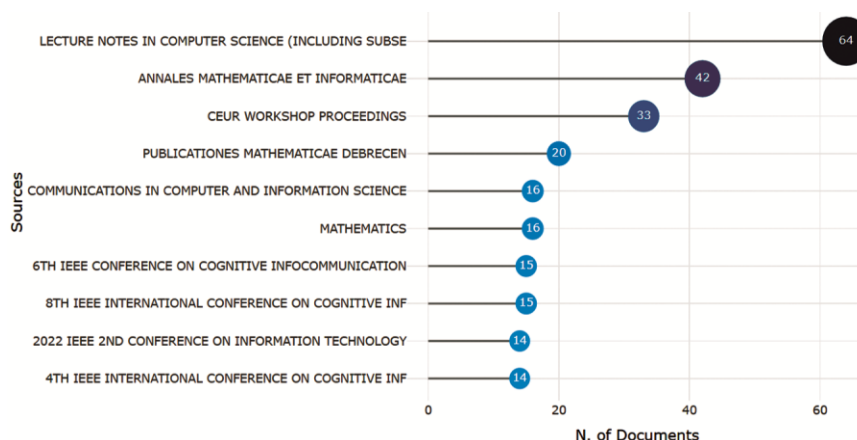


Fig. 4 — Most relevant sources.

### Primary Source of Production Over Time.

In this section, we explore how to answer the research question regarding major sources of the Faculty of Informatics over time. Hence, we identified the most relevant sources (journals) where researchers from the Faculty of Informatics published their research work. Then, we identified ten major sources based on the number of publications indicated in Figure 4. The number in the circle indicates the total number of articles published in that source. Accordingly, Lecture Notes In Computer Science (Including Subseries Lecture Notes in Artificial Intelligence And Lecture Notes In Bioinformatics), Annales Mathematicae, Ceur Workshop Proceedings, Publicationes Mathematicae Debrecen, Communications in Computer and Information Science, 6th IEEE Conference on Cognitive Info communications, Coginfocom 2015 – Proceedings, 8th IEEE International Conference on Cognitive Info communications, Coginfocom 2017 – Proceedings, 2022 IEEE 2nd Conference On Information Technology And Data Science, Citds 2022– Proceedings and 4th IEEE International Conference on Cognitive Infocommunications, Coginfocom 2013 – Proceedings. These are the top 10 and most relevant sources that the authors from the Faculty of Informatics publish.

### Sources' Production Over Time.

To illustrate the sources' production over time, we selected the five most relevant journals and one workshop proceedings in which researchers from the School of Informatics have published their research articles in the last two decades. The first article of the Faculty of Informatics was published in

'Publicationes Mathematicae Debrecen' in 2004. Then in 2011, the number of articles published on Publicationes Mathematicae Debrecen was increased to 12 and the journal remain one of the preferred sources. However, since 2019 'Annales Mathematicae et Informaticae' has become more preferred source than Publicationes Mathematicae Debrecen. Currently the number of articles published in 'Publicationes Mathematicae Debrecen' is far behind Mathematicae et Informaticae.

Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) has remained the most preferred source by the Faculty of Informatics since 2006 and currently, more than 6.5 % of faculty publications have been published in this source. Recently, Ceur Workshop Proceeding, Communications in Computer and Information Science and Mathematics are also becoming top relevant sources. Figure 5 shows the top five and the most pertinent sources in which faculty members published their research.

### Authors' Productivity.

From the Scopus database we observed that, in the last two decades, more than 973 scientific papers have been published by authors from the Faculty of Informatics, at the University of Debrecen in collaboration with several researchers from different local institutions and across the world. Figure 6 shows some of the prominent and senior researchers of the Faculty of Informatics. The number in the circle indicates the total number of publications the authors contributed as of 6<sup>th</sup> January 2024.

### Authors' Production Over Time.

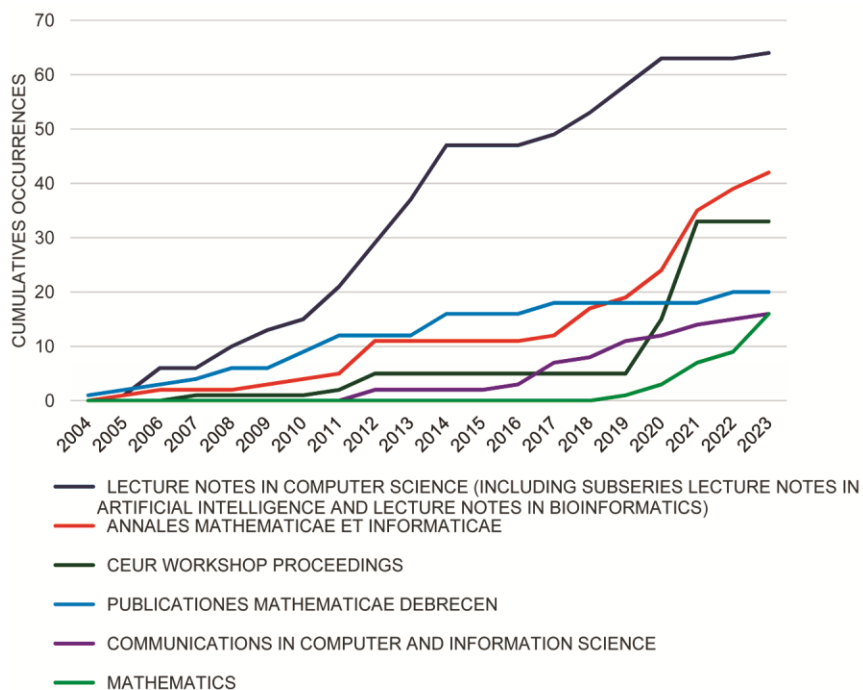


Fig. 5 — Source Growth.

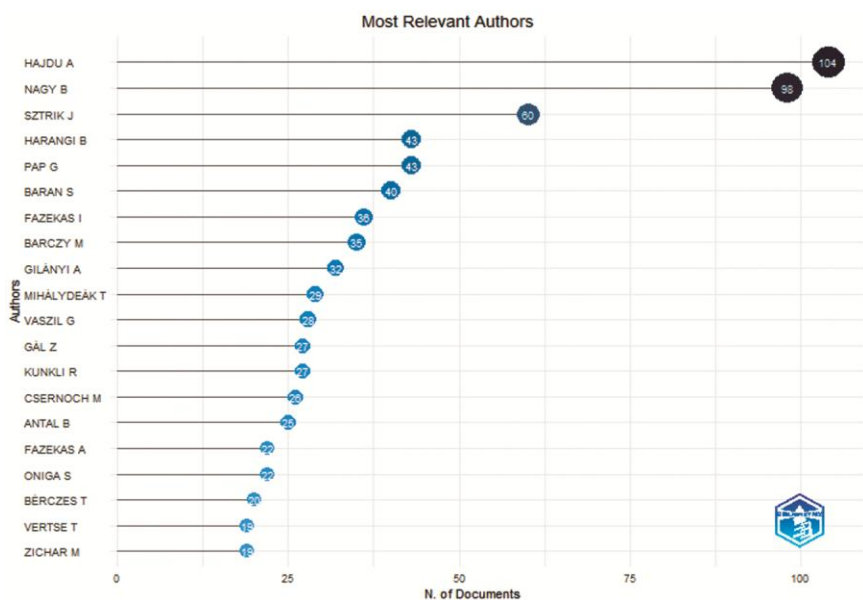


Fig. 6 — The author's research production based on the Scopus database.

To examine the author's production over time, we used Biblioshiny software as shown in Figure 6. The bigger circle indicates the more articles published by the author in that year, and the darker the circle, the more citations received in that particular year. Based on the Scopus database, we identified the top ten authors from the Faculty of Informatics. This visualization aid helps us to examine authors'

publishing patterns and citations received in a particular year. Hence, looking at the authors' production over time, we identified authors who have a long publication history and young researchers in the faculty. At the same time, one can easily identify the current and past publications of faculty members as illustrated in Figure 7.

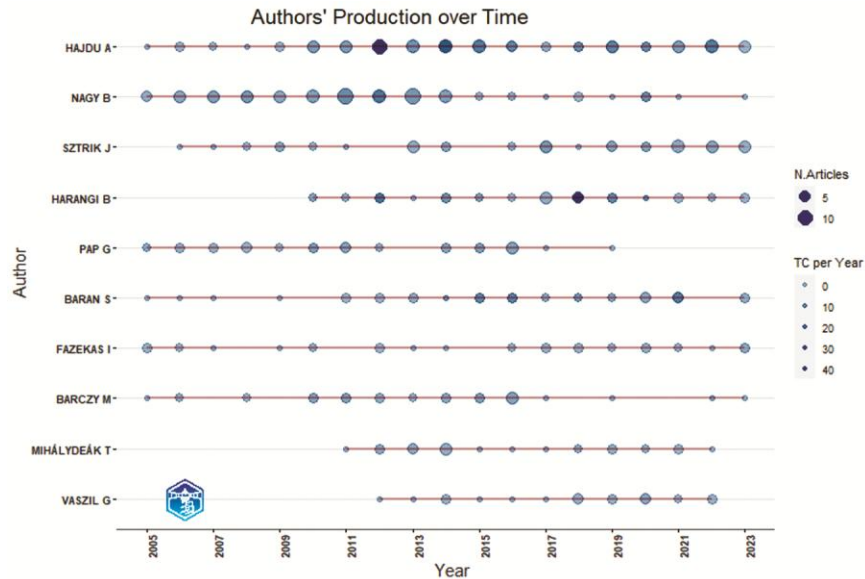


Fig. 7 — Top 10 Authors' Production Over Time

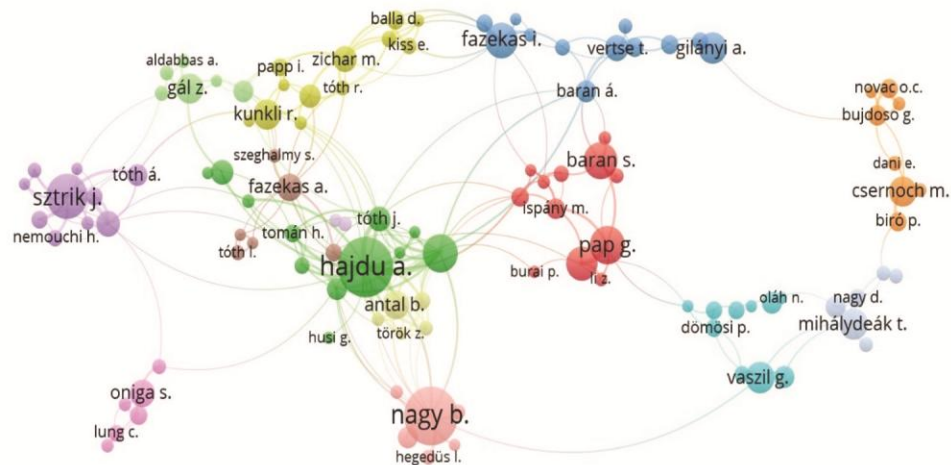


Fig. 8 — Co-authorship network.

**Scholarly and Institutional collaboration network.**

**Author Collaboration Network.**

To visualize the co-authorship of the researchers, we used VOSviewer software. Then, Scopus-based bibliographic data in CSV format was imported to the VOSviewer software. Following the procedure, we created a map based on bibliographic data. First, we choose the types of analysis ‘co-author’ and unit of analysis, author’. Counting method, ‘full counting’, the maximum number of authors per document = ‘25’ which is a default value of VOSviewer. Chosen thresholds: a minimum of five documents per author and a minimum of zero citations per author. Out of 967 authors, 124 met these thresholds. For each of the

124 authors, the total strengths of the co-authorship links with other authors were calculated. Then, authors with the greatest total link strength were selected. Finally, the largest set of connected authors consisted of 113, with 14 clusters as displayed in Figure 8. The rest of the 11 authors did not collaborate with other researchers. So, we were not included in the author collaboration network. The authors were labelled by their names in a circle and the size of the label, and the circle indicated that the authors have many publications in the Scopus database.

To analyze the author collaboration network and the impact of researchers, we evaluated the co-authorship pattern of researchers based on the

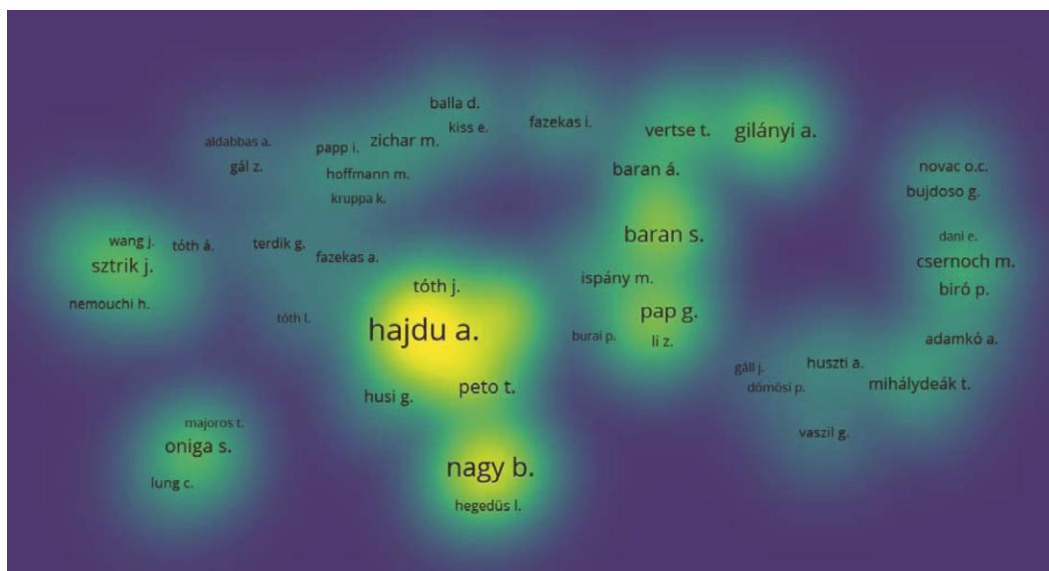


Fig. 9 — Item (Author) Density Visualization Based on Citations.

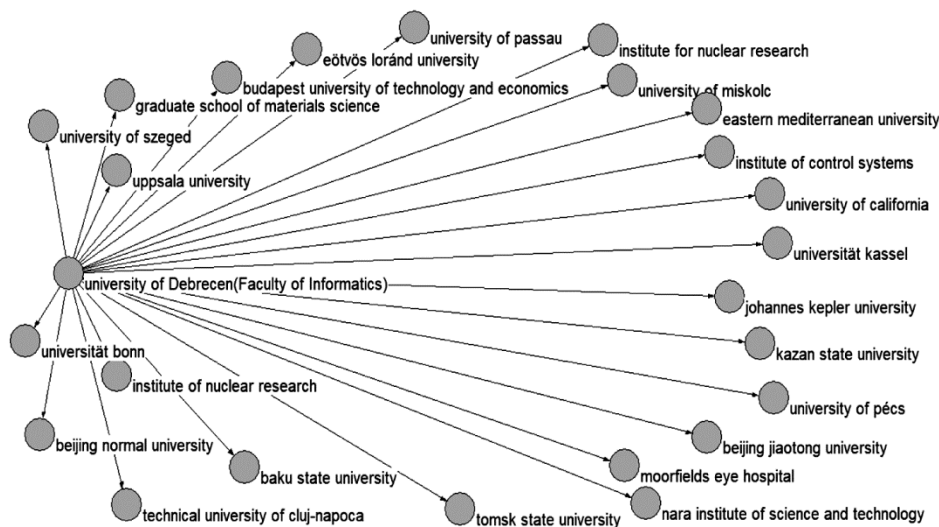


Fig. 10 — Institutional collaboration.

number of ‘documents’, citations’, ‘average citations’, and ‘links. The link indicates the co-authorship status of researchers, or several documents published together with other researchers. Researchers whose name is labeled in bold font indicate higher weights in terms of publication, citations received, and links. For instance, as visualized in Figure 8, Hajdu A. was the most collaborative author and currently has 104 publications, 1669 citations, 16.04 average citations, and 25 links or co-authored. The item (author) density visualization diagram in Figure 9 also shows Hajdu A. is the most cited author at the Faculty of Informatics. The item density visualization depicted in Figure 9 is a default color range from blue to green to yellow<sup>17</sup>.

“The larger the number of items in the neighborhood of a point and the higher the weights of the neighboring items, the closer the color of the point is yellow, and the lower the weights of the neighboring items, the closer the color of the point is to blue” In our analysis, the number of citations was taken as the weight of the item(author).

**Institutional Collaboration.**

Institutional collaboration is one of the most important aspects of scholarly publication. In the past two decades, the University of Debrecen Faculty of Informatics has collaborated with many national and international institutions (see Figure 10). To depict

the institutional collaboration network. The description of the collaboration network is elaborated as follows: The network layout ‘sphere’, normalization ‘association’, and clustering algorithm,’ Louvian’.

Finally, we identified 42 institutions were collaborated with the Faculty of Informatics. However, to avoid overlay, we only visualized the most relevant affiliated institutions that have published more than five articles with the Faculty of Informatics. Accordingly, the most relevant affiliations from Hungary are the Institute of

Nuclear Research, the University of Szeged, Budapest University of Technology and Economics, and Eötvös Loránd University. The most affiliated institutions from various countries are shown in Table 4.

**The Conceptual Structure of Scholarly Fields. Word cloud.**

To examine the most representative keywords, we used word cloud visualization (see Figure 11) based on the author keywords. The word cloud analysis shows the dominant author keywords include: - ‘machine learning’ 19(4%), ‘deep learning’ 17 (4%), and ‘virtual reality’ 17(4%) almost equally appeared in the publications. However, these keywords started to evolve in late 2014, 2015, and 2017 respectively, and continue to grow (see Figure 12). ‘Rough set theory’ ‘Simulation’, and ‘ensemble model output statistics’ were also more frequently occurring in author keywords.

To analyze the structure of scholarly fields and their development over time, we examined the term frequency of author keywords in publications. We used graphs to depict the term's sequence over time and trend topics based on the Author's Keyword. Figure 12 shows the frequency of author keywords that have been used in articles over several years. For example, from 2004-2010, the two most frequently observed author keywords were ‘digital geometry’ and ‘triangular grid’, which progressively appeared until 2014 and then remained stagnant at their peak. The term ‘triangular grid’ emerged at the same time

Table 4 — Most collaborative institutions

Affiliation	Country	Number of Articles
Institute of Nuclear Research	Hungary	46
University of Szeged	Hungary	29
Universität Bonn	Germany	28
Institut De Recherches Subatomiques	France	25
Niels Bohr Institute	Denmark	17
Forschungszentrum Jülich	Germany	16
Uppsala University	Sweden	15
Graduate School of Materials Science	Japan	14
Budapest University of Technology and Economics	Hungary	13
Eötvös Loránd University	Hungary	12
Rovira I Virgili University	Spain	12
University of Passau	Germany	12



Fig. 11 — Word cloud based on author keywords.

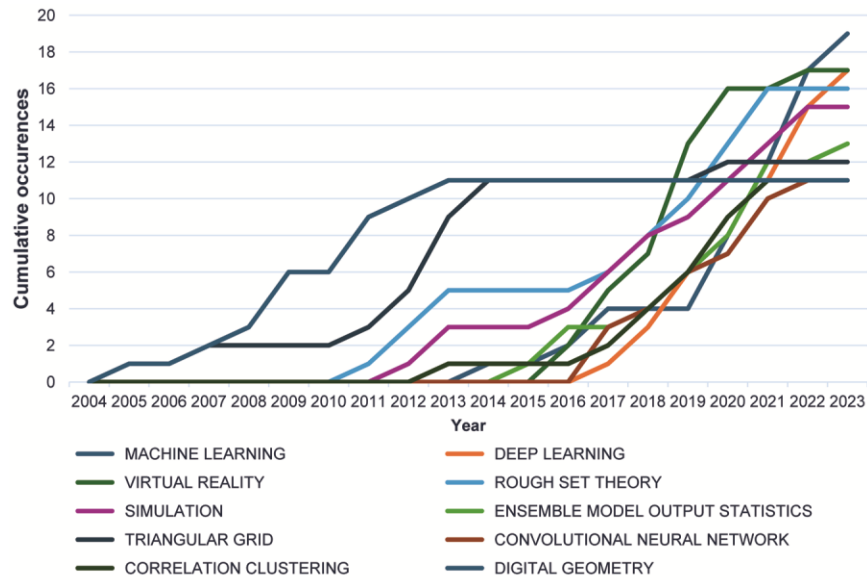


Fig. 12 — Term frequency over time.

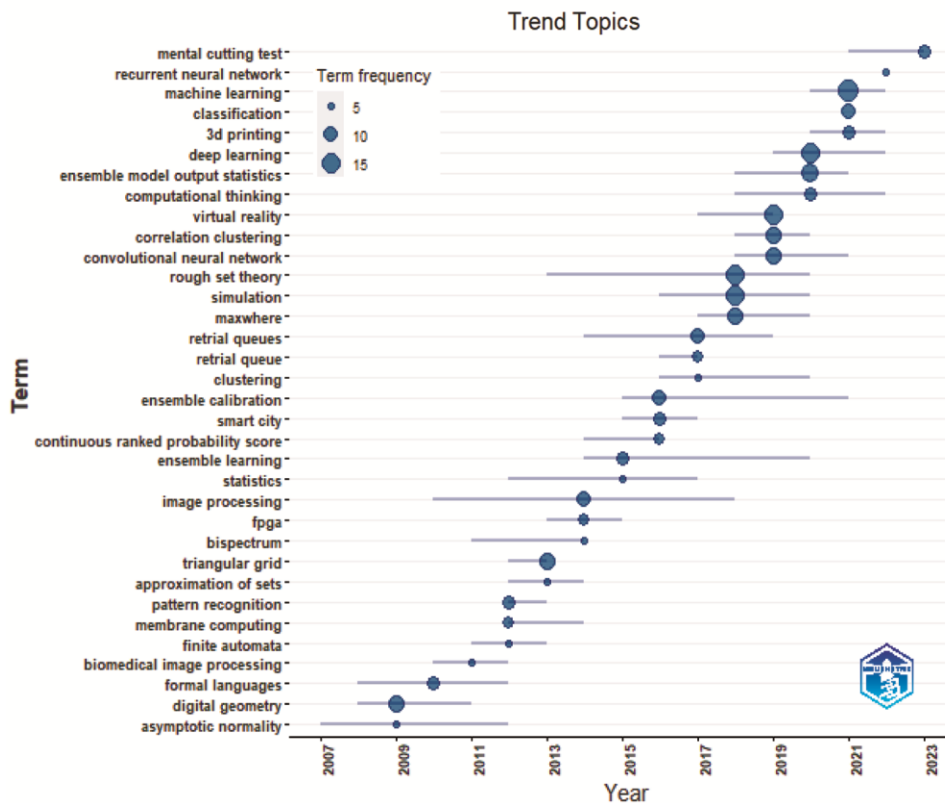


Fig. 13 — Trending topics over plot.

as digital geometry’ but slightly less than digital geometry’ until 2014. Moreover, as we observed from Figure 12, from 2010-2017, every year, new author keywords like ‘rough set theory’, ‘simulation’, ‘correlation clustering’, ‘machine learning’,

‘ensemble model output statistics’, ‘virtual reality’, and ‘deep learning’ have been respectively introduced. Currently, machine learning, deep learning, and virtual reality are the most frequently observed author keywords.

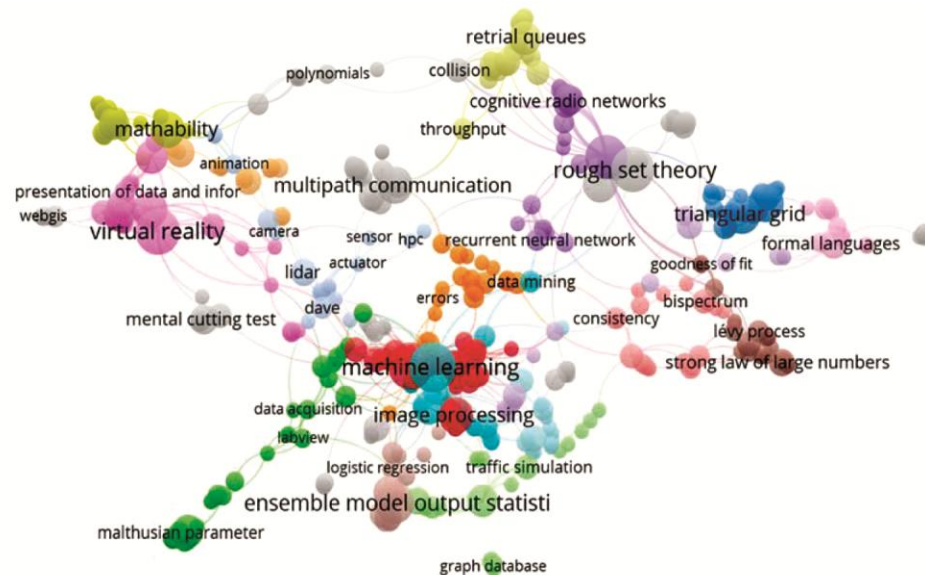


Fig. 14 — Author keyword co-occurrence network.

Top Author Keywords' Frequency over Time.

### Trend Topics Based on the Author's Keyword

Figure 13 shows trending topics based on author keywords from the Scopus database, which spans 2004-2023 with a minimum word frequency of 5 and a number of words per year of 3. A total of 34 topics fulfil the minimum threshold. The circle with a large size indicates the high term frequency in a particular year. For instance, 3D printing, classification, and machine learning frequently occurred in 2021. Most recently, recurrent neural networks and mental cutting tests were identified as the most recent trend topics in 2022 and 2023, respectively. Overall, the word cloud, trend topics, and terms sequence over time show that Faculty Informatics has broadly engaged in conducting research in machine learning, virtual Reality, and deep learning over the last decade. This is not surprising because machine learning, virtual reality, and deep learning are subfields of Artificial Intelligence, which currently attracts the attention of many researchers across the world.

However, based on the author's keywords, the mental cutting test has recently become a trending topic. Trending topics show that the Faculty of Informatics researchers have studied mental cutting tests recently. **As observed in Figure 13, the trend topics plot and the circles' size indicate the term's frequency, and the length of the lines shows how long it has been studied.**

### Author Keyword Co-occurrence network.

To examine the co-occurrence of the author keyword, we identified 472 words that co-occurred twice in documents. These words form 29 clusters, as shown in Figure 14. The author keywords that frequently co-occurred were machine learning 31 times, simulation 27 times, deep learning 23 times, classification 20 times, and virtual reality 19 times.

Figure 14 shows the cognitive structure of the Faculty of Informatics' publications. The co-occurrence or connection of the terms shows that many publications share the same concept as a research theme. Rough set theory, image processing, logistic regression, data mining, and pattern recognition frequently co-occur within many publications.

### Conclusion

In this study, we conducted a bibliometric analysis of scholarly publications of the Faculty of Informatics at the University of Debrecen. The main objective of the study was to examine the overall scientific publication activities in terms of annual scientific production, along with types of documents, average document age, average citation per year, and average citation per document. The open-access publication activities and major funding sources were also examined. Furthermore, we examined the faculty's collaboration with external institutions and analyzed the trends in research fields, as well as their development over time. The result of the study shows

that, since the establishment of the faculty, the faculty members have contributed a significant scholarly output, mainly journal articles, conference papers, and book chapters. The annual scientific production of the faculty has shown significant increases since its establishment, especially during the years 2010-2014. This is because the faculty was involved in several projects supported by the European Commission, the European Social Fund, the Hungarian Scientific Research Fund, and many more funding sources. However, from 2015, the annual scientific production of the Faculty of Informatics was unpredictable and slightly characterized by increases and decreases in research production. Despite its fluctuation, data reveals that the highest scientific production was observed in 2021. We observed that the overall publications of the Faculty of Informatics at the University of Debrecen were significantly increasing

Despite a significant increase in annual scientific production, the average citations per year for the faculty remain low compared to the overall scholarly output. The findings indicate that the average citations per document are more promising than the average citations per year. Additionally, this study does not provide evidence that earlier publications received more citations than recent ones. On the contrary, the highest average citation per year was recorded in 2018, surpassing that of earlier publications. The rise in citations during 2018 can be attributed to the emergence of new research fields, such as machine learning, virtual reality, and deep learning, which have garnered substantial attention from researchers over the past decade.

Another key finding concerns the average age of publications. More than half of the Faculty of Informatics' publications at the University of Debrecen have been produced within the last eight years. This raises the question of whether this trend aligns with the rapid expansion of literature in computer science. The average age of publications is closely tied to the growth and evolution of research within specific fields<sup>24</sup>.

In terms of sources, the major source productions over the past publication history of the Faculty of Informatics, Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 'Publicationes Mathematicae Debrecen' and 'Annales Mathematicae' are major sources to produce research.

Journal articles, conference papers, and book chapters largely contributed to the scholarly system, mainly in the second half of the last decade. In this regard, the contribution of faculty members with several local and global collaborations among authors and institutions plays a vital role in increasing scholarly research in Computer Science, Mathematics, and interdisciplinary fields of study.

Regarding the author's collaboration network and co-authorship pattern, we evaluated based on the number of 'documents' published together, the number of citations, average citations', and 'links'. The link indicates the co-authorship status of researchers published together. Most of the publications were published by co-authors among faculty members and a few authors from other institutions. The author's collaboration network of the Faculty of Informatics shows active research groups in their fields of specialization as depicted in network visualization (see Figure 8). The impact of authors' collaboration networks was evaluated based on the number of documents co-authored with other researchers. The global author's collaboration with the Faculty of Informatics is promising but needs to be improved. As to institutional collaborations, we identified many institutions that collaborated with the Faculty of Informatics. Institutions from Germany, France, Denmark, and Japan were top collaborators with the Faculty of Informatics at the University of Debrecen.

Finally, the conceptual structure of the major research themes of the Faculty of Informatics was illustrated using the word cloud, trend topic, and author keyword co-occurrence over time. Accordingly, digital geometry, triangular grid, rough set theory, simulation, and correlation clustering were the predominant research themes of school Informatics before the emergence of the research field in machine learning, virtual reality, and deep learning. Similarly, Image Processing, logistic regression, data mining, and pattern recognition frequently co-occurred in many publications. Most recently, mental cutting tests and recurrent neural networks have appeared at the top of trending topics. From the conceptual structure of research fields, the School of Informatics at the University of Debrecen has been conducting a broad range of research themes that engage researchers from interdisciplinary fields of study.

### Funding statement

The authors did not receive support from any organization for the submitted work

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