

Publication trends on the arXiv repository of academic articles

Gabi Dadush

(dadushg@post.bgu.ac.il)

Ben-Gurion University of the Negev

Abstract - This paper explores the shifting landscape of academic publishing, focusing on evolving research themes and collaboration dynamics. It underscores the expanding scope and specialization of academic inquiry, propelled by technological advancements and societal shifts. Emphasis is placed on the growing significance of collaborative endeavors in academia, characterized by interdisciplinary partnerships and cross-institutional collaborations. Drawing from an analysis of publication trends in the arXiv database, the study reveals the shifts in publication patterns between industry and academia. Moreover, the data indicates a rising prevalence of multi-category publications, indicative of the interconnected nature of contemporary research endeavors. These findings offer valuable insights into the current trajectory of academic publishing and its implications for future research endeavors. The sources of this paper, as well as the figures, are available at: https://github.com/gabidrepo/arXiv_analysis

0 INTRODUCTION

In recent years, the landscape of academic publications has witnessed significant transformations marked by discernible trends. Notably, there has been a discernible shift in the thematic focus of scholarly works, reflecting the dynamic evolution of research interests and priorities across various disciplines.

This evolution is underscored by a palpable diversification and specialization within academic topics, driven by advancements in technology, changes in societal needs, and emerging interdisciplinary intersections. Concurrently, collaboration has emerged as a central pillar of academic discourse, with researchers increasingly engaging in interdisciplinary partnerships and fostering cross-institutional collaborations. This collaborative ethos is not only indicative of the growing complexity of research questions but also underscores the recognition of the synergistic benefits derived from pooling diverse expertise and perspectives.

Consequently, academic publications are increasingly characterized by a rich tapestry of multidisciplinary contributions, reflecting a collective endeavor to address multifaceted challenges and push the boundaries of knowledge.

A study of academic publication trends from the arXiv database is presented in this work, along with interesting findings.

arXiv.org [<https://arxiv.org/>] is an open-access repository housing academic papers across disciplines like physics, mathematics, computer science,

biology, finance, and more. It offers preprints and post-prints without peer review, using a moderation system for categorization and scholarly assessment.

1 Related work

The arXiv publication database serves as a focal point of interest within the scientific community, offering a rich repository of academic works across various disciplines, particularly in the exact sciences. Its extensive collection of preprints and post-prints provides researchers with a valuable resource for analyzing and forecasting trends in scientific research. By delving into the vast array of publications housed within arXiv, scholars can glean insights into emerging topics, advancements, and shifts in focus within their respective fields. This database not only facilitates the dissemination of knowledge but also serves as a cornerstone for the exploration of cutting-edge research endeavors and the anticipation of future developments in the exact sciences[1].

In recent years, there has been a notable surge in research related to Large Language Models (LLMs), particularly concerning their societal implications. This trend is underscored by a substantial twentyfold increase in submissions to the Computers and Society sub-category within the arXiv repository. Concurrently, there appears to be a discernible decline in the share of publications originating from the industry, notably prominent among Big Tech companies, as evidenced by the data from 2023. Con-

versely, there is a discernible uptick in publication activity from universities in Asia during this period. Despite these trends, there is a conspicuous lack of cross-country collaboration noted within the research landscape, indicating potential opportunities for fostering international research partnerships and knowledge exchange initiatives[2].

2 Methods

Data analysis was conducted using the arXiv database available on the Kaggle platform. A Python-based Kaggle notebook facilitated code composition for the analysis. This endeavor employed prevalent data manipulation libraries like Pandas and Vaex. Additionally, web scraping techniques were applied to retrieve categories and subcategories of articles from the arXiv website automatically.

Moreover, the data analysis centered on examining the temporal evolution of diverse parameters and categories within the database. This rigorous examination aimed to elucidate the fluctuations and trends observed across different categories and parameters over successive years.

3 Result analysis

3.1 An increase in the number of writers

With technological advancements and improved connectivity, academic circles have seen a marked change when it comes to collaborative efforts and information sharing. A growing number of writers are pursuing scientific pursuits as evidence of this trend as shown in Figure 1. The adoption of collaborative tools and platforms has enabled seamless interaction and collaboration among researchers throughout the world. As a result of these developments, authors now have easier access to resources and workflows that are more efficient, creating an environment that is conducive to forming wide networks. It emphasizes the importance of technology in changing academic communication practices to usher in an era of interdisciplinary collaboration and knowledge sharing.

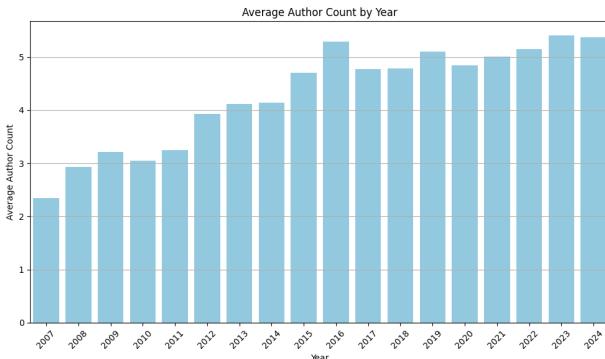


Fig. 1: Average authors count by year

3.2 Minor change in the number of versions during each publication

In recent years, the proliferation of digital platforms aimed at facilitating version control and collaborative editing processes has significantly transformed the landscape of document management. Despite the advancements in technology, the analysis of the number of versions per article in Figure 2 reveals a minor trend in the evolution of document versions associated with academic publications.

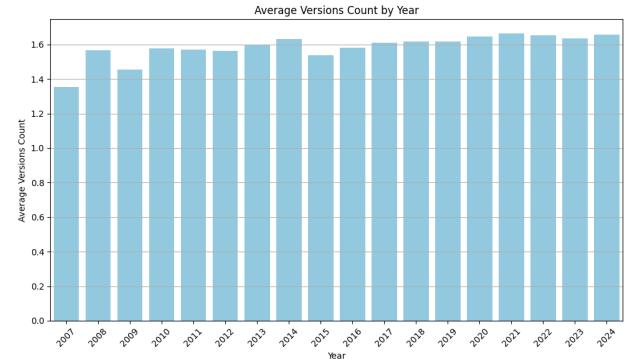


Fig. 2: Average versions count per article by year

3.3 Changes in the publication categories

In order to analyze categorical data pertaining to academic publications, a web scraping project was initiated. To achieve this goal, it was necessary to convert category codes into full names and create an encompassing category that would encompass widespread themes within primary categories. Through meticulous examination of category data, various discernible trends were identified, including those related to category topics, publication volumes, inter-category relationships, and other relevant themes, all of which will be elaborated upon in the subsequent chapter.

3.3.1 Changes in the number of categories defined for each publication

The analysis of the dataset reveals a notable occurrence of publications tagged with multiple categories. For instance, examination of article 0704.0002 reveals its association with the categories math.CO and cs.CG, denoting Combinatorics and Computational Geometry, respectively. Furthermore, a discernible trend emerges from the data indicating a gradual rise in the average number of categories per article over the years. Specifically, the average number of categories per article has increased from 1.46 in 2007 to 1.88 in 2023 as seen in Figure 3. This observed shift signifies a tendency towards interdisciplinary combinations within distinct realms of research, reflecting evolving scholarly perspectives.

3.3.2 Changes in the top categories

Over the last several years, the landscape of academic discourse has undergone notable transformations, characterized by shifts in the leading categories that govern scholarly inquiry. These shifts, reflective of the dynamic na-

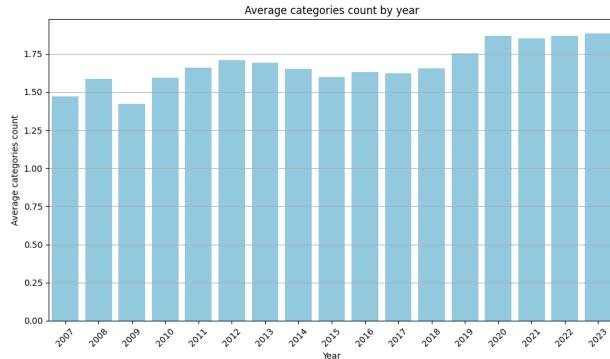


Fig. 3: Average categories count by year

ture of research paradigms, are likely attributable to advancements in various research domains and the growing propensity to amalgamate disparate thematic areas. As illustrated in Figure 7, artificial intelligence machine learning and computer vision have achieved a discernible upward trend within scholarly circles.

A significant increase in publications from these domains parallels this rise in prominence, indicating a burgeoning interest and investment in these cutting-edge areas. Conversely, Figure 8 provides insight into the evolving landscape of academic publications, particularly in the realms of physics and computer science. Here, a noteworthy decline in publications originating from the field of physics is observed, commencing around 2015. This decline, juxtaposed with a concurrent surge in publications from the domain of computer science, underscores a shifting dynamic in scholarly output. By the year 2022, this trend reaches a pivotal juncture, with the aggregate number of computer science publications eclipsing that of physics publications—a significant milestone indicative of a transformative shift in the scholarly landscape.

This divergence in publication trends not only reflects the evolving interests and priorities within the academic community but also underscores the growing influence and relevance of computer science as a discipline.

3.3.3 Relationships between categories

As elucidated earlier, an observable pattern emerges from the dataset, indicating a gradual escalation in the diversity of categories affiliated with each published scholarly work. The assignment of an article to multiple categories implies a nuanced nexus between these categorical domains, wherein the thematic essence of the article serves as the linchpin that binds together disparate categories. Through meticulous scrutiny of the dataset, an intricate network graph was constructed (Figure 9) using the networkx package, offering insights into the interplay among the 40 most prevalent categories. Within this graph, each vertex symbolizes a distinct category, while the edges denote connections forged through shared publications across these categories. Remarkably, the size of each vertex corresponds to its centrality within the network, reflecting the degree of connectivity attributed to it. Thus, this visual representation

unveils the intricate web of relationships among categories, providing a nuanced portrayal of their interconnectedness and relative prominence within the research domain.

Furthermore, Figure 4 depicts the ten categories boasting the highest betweenness centrality values, denoting their profound significance across diverse realms of research inquiry. The elevated betweenness centrality of these categories underscores their pivotal role in facilitating knowledge dissemination and scholarly discourse across various research domains. This observation underscores the imperative for continual expansion and innovation within research fields, methodologies, and analytical tools to maintain a competitive edge and sustain scholarly leadership in the ever-evolving research landscape.

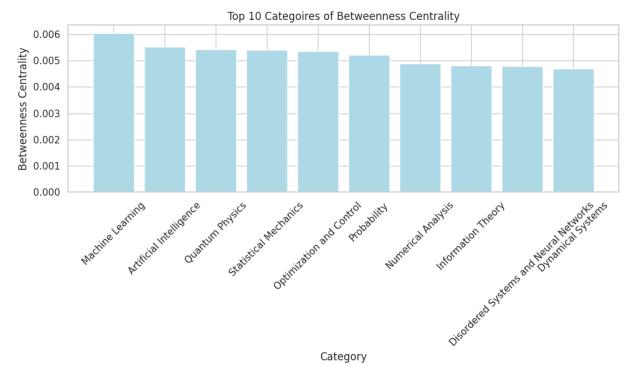


Fig. 4: Categories betweenness centrality

3.4 Changes in topics over time

Over time, the landscape of academic publications has undergone significant transformations, notably in the thematic composition of scholarly works. These changes reflect not only the evolution of research interests but also the shifting paradigms within various academic disciplines as reflected in Figure 10. Across various scientific disciplines, one can observe distinct patterns in the emergence, rise, and subsequent decline of topical themes. These fluctuations are often influenced by a myriad of factors, including technological advancements, societal needs, and interdisciplinary collaborations. Furthermore, the interplay between different research domains has led to the emergence of novel interdisciplinary fields and the reconfiguration of traditional disciplinary boundaries. As such, an exploration of the changes in academic topics over time provides valuable insights into the dynamic nature of scholarly inquiry and the ever-evolving quest for knowledge and innovation.

3.5 Key topics in the top categories

Considering the evolving trends delineated through data analysis, it emerges that computer science stands as the foremost domain in terms of publication volume. Within this sphere, machine learning emerges prominently as the primary subdiscipline, garnering the focus of numerous scholarly works. To delineate the principal research domains comprehensively, an analytical inquiry was un-

dertaken employing latent Dirichlet allocation (LDA), a Bayesian framework renowned for automatically discerning topical themes within textual corpora. Figure 5 illustrates the predominant topics within the realm of machine learning, emphasizing key areas such as model development, performance evaluation methodologies, advancements in deep learning, algorithmic approaches, and architectural considerations. These focal points signify the growing involvement, enhancement, and inventive strides within the sphere of artificial intelligence and machine learning.

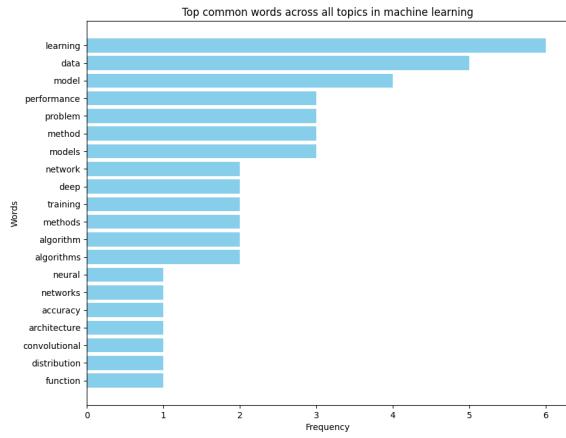


Fig. 5: Common words in the most published topics in machine learning

3.6 Machine learning topic word scores

To characterize the main subtopics under the machine learning category, the BERTopic library was used. BERTopic utilizes BERT embeddings and c-TF-IDF to generate dense clusters, facilitating the creation of easily interpretable topics. This approach ensures that significant words are retained within the topic descriptions. Due to resource constraints under using Kaggle Notebook it was necessary to sample 10,000 articles from the machine learning subcategory. This sampling was done randomly to preserve the distribution of subjects and to produce a representative sampling. As depicted in Figure 11, the ten primary topics generated by BERTopic are characterized by key keywords that encapsulate their thematic essence.

Figure 6 illustrates the distances between various subject groups. The visualization reveals notable overlaps and proximities among certain subjects, indicating a high degree of similarity. Conversely, other subjects exhibit greater distances between them, delineating distinct clusters associated with disparate topics. These observed patterns underscore the underlying structure of the data, highlighting both the cohesion and divergence among subject groups.

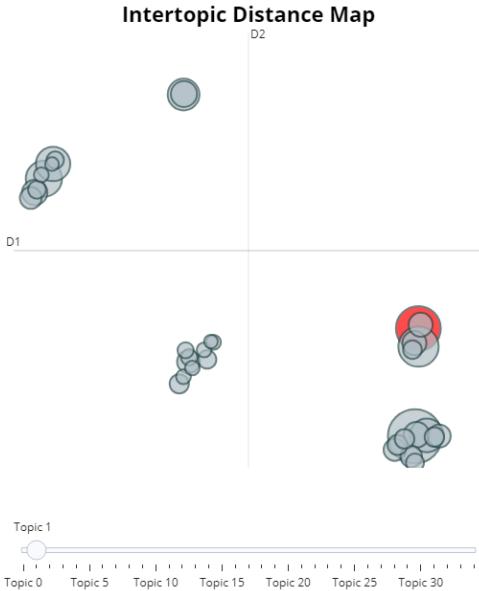


Fig. 6: Intertopic distance map

4 SUMMARY

The article presents an in-depth analysis of the changing dynamics within the realm of academic publishing, with a particular emphasis on the arXiv repository. It underscores the growing significance of interdisciplinary research and collaboration, which are being propelled by rapid technological advancements and shifts in societal paradigms. The study meticulously scrutinizes patterns in publication, revealing an upward trend in multi-category publications, indicative of the increasingly interconnected nature of contemporary research. It also highlights shifts in thematic focus, such as the ascendance of computer science, particularly machine learning, and a relative decline in physics publications. The paper further discusses the role of collaborative tools in fostering expansive global research networks, thereby facilitating the exchange of knowledge and ideas across geographical boundaries. The findings of the study underscore the dynamic and evolving nature of academic research, emphasizing the need for adaptability and flexibility in scholarly discourse. While acknowledging the limitations of the arXiv repository, particularly its pre-peer-review nature, the paper recognizes its instrumental role in providing insights into current research trends. This comprehensive analysis serves as a resource for understanding the complexities and nuances of the academic publishing landscape.

5 CONCLUSION

The ArXiv article repository, while a notable resource in the landscape of scientific literature, may not comprehensively encapsulate the entirety of research trends within the exact sciences. Its distinct characteristic as a platform facilitating the early dissemination of research findings, often preceding formal peer review and publication in esteemed

scientific journals or conference proceedings, engenders a potential for biases and distortions. Indeed, it is conceivable that certain submissions to ArXiv are motivated primarily by a desire to establish precedence within scholarly discourse, even at preliminary stages of research inquiry. Nevertheless, notwithstanding these inherent limitations, ArXiv has garnered widespread recognition and adoption within both academic and commercial research spheres. Hence, it persists as a significant repository from which valuable insights into prevailing research trajectories can be discerned.

The study in this paper reveals an evolution in academic publishing, with a rise in interdisciplinary and collaborative research. This shift is facilitated by technological advancements and is reflected in the increase in multi-category publications. These trends highlight the dynamic nature of academic research and the importance of adaptability in scholarly discourse.

6 ACKNOWLEDGMENT

I authorize the use of ChatGPT [<https://chat.openai.com/>] to generate ideas and material for background research and more careful drafting of the writing in this assignment.

7 REFERENCES

- [1] S. Eger, C. Li, F. Netzer, I. Gurevych, “Predicting Research Trends From Arxiv,” (2019).
- [2] R. Movva, S. Balachandar, K. Peng, G. Agostini, N. Garg, E. Pierson, “Topics, Authors, and Institutions in Large Language Model Research: Trends from 17K arXiv Papers,” (2024).

APPENDIX

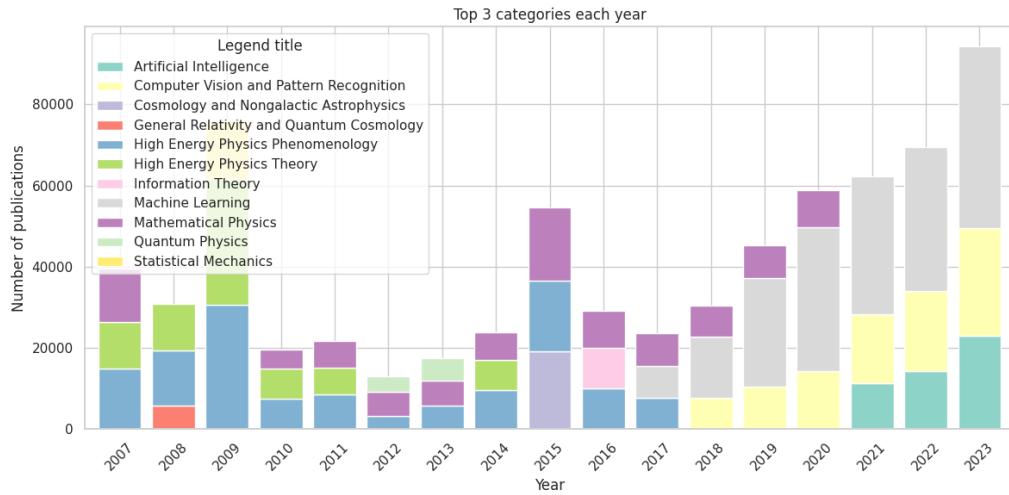


Fig. 7: Top 3 categories each year

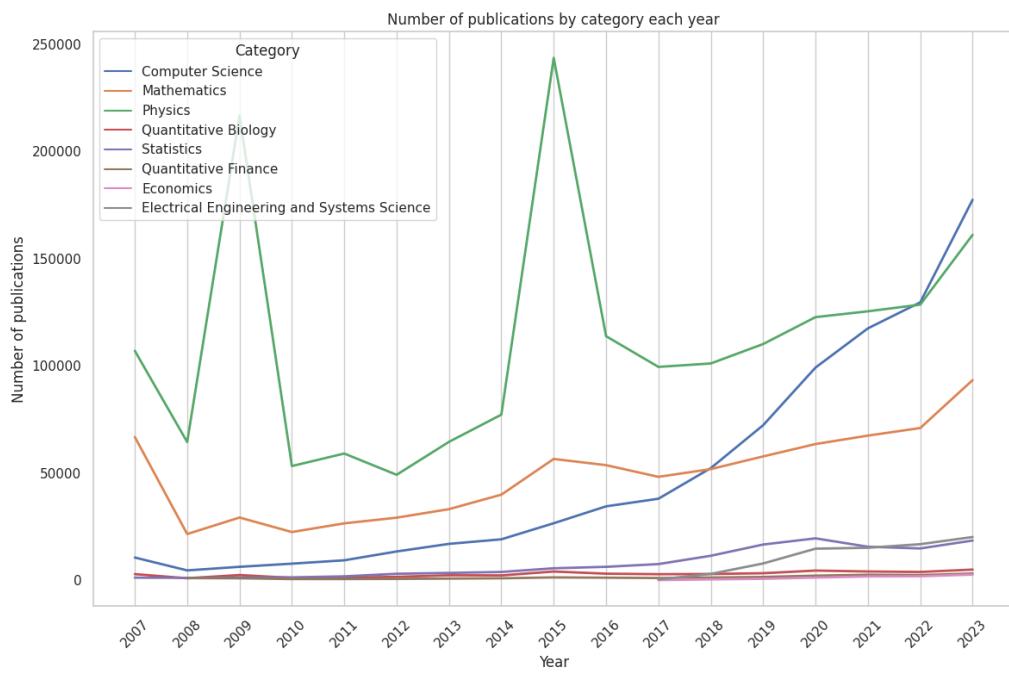


Fig. 8: Average categories count by year

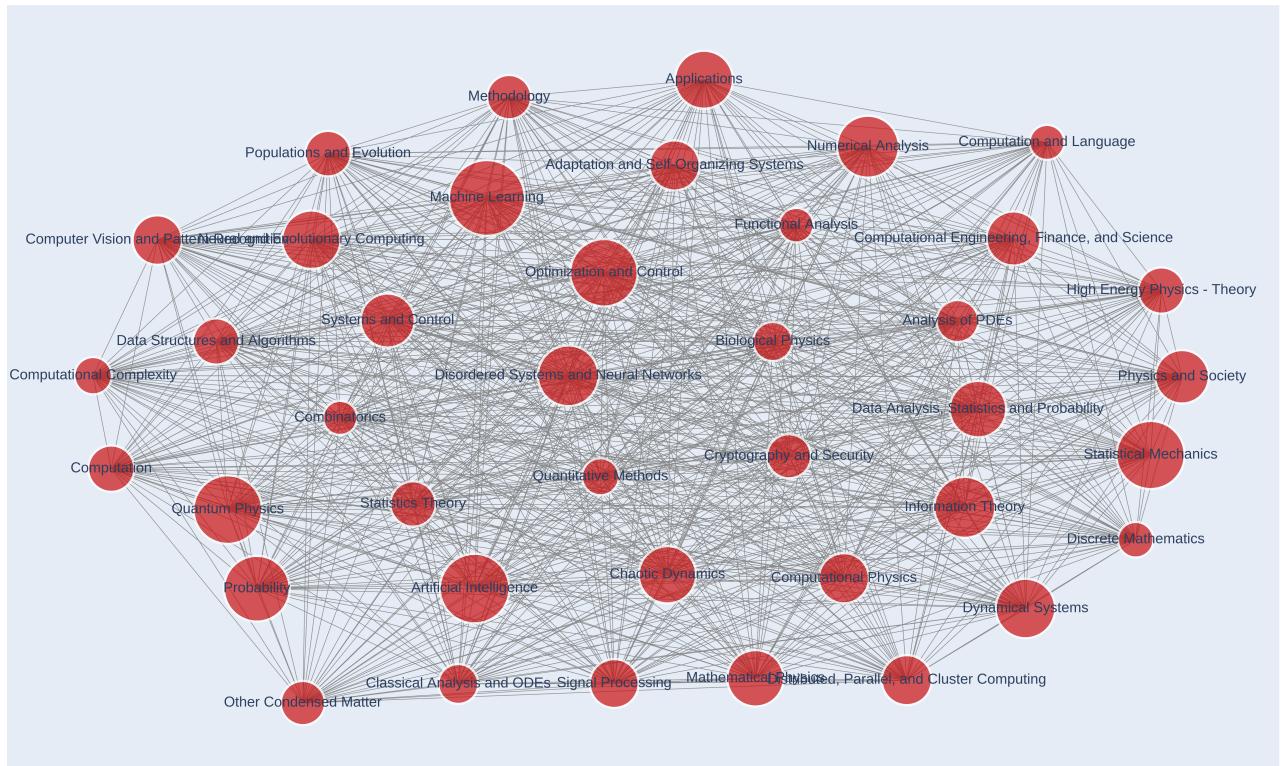


Fig. 9: Top 40 connected categories



Fig. 10: This figure provides a comprehensive depiction of publication distribution across various categories and sub-categories. It illustrates the relative proportion of publications over time and delineates the evolving trends within each category.



Fig. 11: This figure shows the topic word scores created by BERTTopics