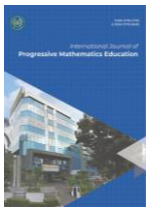

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Stochastic Block Model Reveals Maps of in Applied Mathematics Studies Using VOS Viewer

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Abstract.
Background. Bibliometric analysis is the mapping of research trends by processing metadata from Google Scholar. **The purpose** of the study is to find out research trends in applied mathematics. The research was conducted on April 30, 2021, by searching the Google Scholar database with the keywords applied mathematics with the publication name journal. The maximum number of results is 500 journals as a sample. Metadata retrieval uses the Publish or Perish (POP) application version 7.31. The PoP data were analyzed descriptively based on the publication year, publisher name, researcher productivity, and journal ranking. PoP data is exported to Excel CSV and Result as RIS file formats to get an accurate map of research developments. The CSV data was created in a pivot table, and the RIS data was analyzed using the VOSViewer (VV) application. **The research results** showed that the number of publications of research results in the years 2005-2021 has fluctuated and is mostly published in Elsevier. The most prolific foreign researcher in publishing research results is Biher Bist, with 14 articles. The VV visualization showed that the development map of applied mathematics research is divided into 5 clusters. Cluster 1 consists of 27 topics; cluster 2 consists of 15 topics; cluster 3 consists of 10 topics; cluster 4 consists of 7 topics; cluster 5 consists of 3 topics with the most research covering mathematics, paper, problem, solution, system, university, department, and science.

Keywords: Applied Mathematics, VOSViewer, Bibliometric, Google Scholar, Publish or Perish

Abstrak
Latar belakang. Analisis bibliometrik merupakan pemetaan tren penelitian dengan mengolah metadata dari Google Scholar. Tujuan penelitian adalah untuk mengetahui tren penelitian dalam matematika terapan. Penelitian dilakukan pada tanggal 30 April 2021 dengan pencarian database Google Scholar dengan kata kunci matematika terapan dengan nama publikasi jurnal. Jumlah hasil maksimal 500 jurnal sebagai sampel. Pengambilan metadata menggunakan aplikasi Publish or Perish (POP) versi 7.31. Data PoP dianalisis secara deskriptif berdasarkan tahun penerbitan, nama penerbit, produktivitas peneliti, dan pemeringkatan jurnal. Data PoP diekspor ke Excel CSV dan Result sebagai format file RIS untuk mendapatkan peta perkembangan penelitian yang akurat. Data CSV dibuat dalam tabel pivot, dan data RIS dianalisis menggunakan aplikasi VOSViewer (VV). Hasil penelitian menunjukkan bahwa jumlah publikasi hasil penelitian pada tahun 2005-2021 mengalami fluktuasi dan sebagian besar dimuat di Elsevier. Peneliti asing yang paling produktif mempublikasikan hasil penelitiannya adalah Biher Bist dengan 14 artikel. Visualisasi VV menunjukkan peta perkembangan penelitian matematika terapan terbagi menjadi 5 cluster. Cluster 1 terdiri dari 27 topik; cluster 2 terdiri dari 15 topik; cluster 3 terdiri dari 10 topik; cluster 4 terdiri dari 7 topik; cluster 5 terdiri dari 3 topik dengan penelitian terbanyak meliputi matematika, makalah, masalah, solusi, sistem, universitas, departemen, dan sains.

Kata Kunci: Matematika Terapan, VOSViewer, Bibliometrik, Google Scholar, Publish or Perish

1. Introduction

The research trend of applied mathematics is increasing significantly in many aspects of the applied mathematics sub-science (Julia et al., 2020; Studies, 2016; Vamvakoussi, 2017). The extensive research options cover a wide range of applications of mathematics in many fields. In recent years, the number of publications has increased (G. Chen & Shen, 2007; Itkin, 2017).

Many students experience difficulties in applied mathematics in college. According to Saputra & Purwanti (2010), Applied Mathematics I course is an introductory course that is the basis for the Scientific and Skills Course (MKK) in the Diploma III of Electrical Engineering study program of UNNES. This course covers material on Number Systems, Complex Numbers, Determinants and Matrices, Functions and Limits, Differentials, and Integrals. As a fundamental science, the Applied Mathematics I course will support other courses, especially in exact sciences and engineering, so every student should "have to master" mathematics courses to master other subjects. However, in reality, most students always think that mathematics courses are difficult to understand, boring and synonymous with problems that are difficult to solve. This can be indicated from the results of student learning achievements in the last 5 (five) years, which are always below the desired standard.

This illustrates that applied mathematics is beneficial and that many still have difficulties. Mathematics has been applied in various fields of modern life such as statistics, mechanical engineering, information technology and others. For example, in the field of statistics, mathematics is used in quick calculations of elections and population growth. Furthermore, according to (Kosiret et al., 2021; Maulidiya et al., 2018; Rachmawati et al., 2020; Soebagyo, 2017): one of the disciplines that use and applies mathematics the most is engineering. For example, differential equations are used in industrial engineering and mechanical engineering to calculate the magnitude of the damping force, integral to calculate the area and volume of irregular objects. The field of informatics engineering uses discrete mathematics to process digital data in computer operating systems, and many other disciplines use mathematics in their work.

Applying mathematics in various fields of modern life requires high-level skills that must be instilled in elementary education. The National Council of Teacher Mathematics stipulates that there are 5 process skills that students must master through learning mathematics, namely: (1) problem solving; (2) reasoning and proof; (3) connection; (4) communication, and (5)

representation. Based on the NCTM, it can be seen that one of the main focuses of mathematics learning objectives is problem-solving ability.

Problem-solving ability is beneficial for students because it is the basic capital in applying mathematics in the real world (Hastuti et al., 2021; Ikram & Ikram, 2021; Mulligan, 2015; Umam et al., 2019). The application of mathematics in modern life is a valuable asset for a nation. The number of applications of mathematics in the field of life shows that human resources in a country are of high quality and will give birth to many innovations that make human life easier. On that basis, it is necessary to map the development of research results on applied mathematics that researchers have carried out. The contribution of this research is to find research on applied mathematics that is still rarely studied and for the development of applied mathematics in the future.

1.1 Research Question

This research wants to answer the following problems:

a. How are many international scientific publications in the field of applied mathematics from 2005-2021 in the Google Scholar database?
b. How is the productivity level of researchers in the field of Applied Mathematics?
c. How to map the development of international publications in the field of applied mathematics based on keywords?

2. Theoretical Framework

2.1. Database of Google Scholar

Google Scholar was launched in 2004 by the parent company Google (X. Chen, 2010). Google Scholar provides a database of scientific publications with features in the form of online search services for reputable journals both nationally and internationally. According to (Rafika et al., 2017): In 2004 Google launched its newest service, Google Scholar or also called Google Scholar in Indonesia. Google Scholar provides services such as information that is certainly useful in the form of PDF (Portable Document Format) completely and free of charge. In general, Google Scholar is used by students and college students to find references in making scientific papers (Bronshteyn & Tvaruzka, 2008; Salisbury & Tekawade, 2006).

The Google Scholar database offers an easy and free search for academic literature (Cathcart & Roberts, 2014; X. Chen, 2010; Howland et al., 2009). Researchers can find all fields of science and scientific references from one place for free. The database on Google Scholar includes peer-reviewed papers, theses, books, abstracts, and articles from academic publishers,

professional communities, preprint databases, universities, and other academic organizations. Google Scholar will work by identifying the most relevant research from all academic research. The most relevant results will always appear on the first page.

Google Scholar has advanced tools to track, analyze, and visualize research results very quickly in zero-point seconds (Cathcart & Roberts, 2014; Howland et al., 2009). Google Scholar can map research results based on the year of research, author, keywords, publisher, year of publication, and keywords, set in the dashboard on the left.

2.2. Publish or Perish

Publish or perish or PoP is a software that can retrieve metadata of scientific works of all fields of science for free. PoP provides free metadata access services on CrossRef, Google Scholar, Google Scholar Profiles, Microsoft Academic*, PubMed, Scopus*, and WoS. According to (Asy'ari et al., 2021): Harzing's publish or perish software is a tool that can be used for free that makes it easier for the article search process to be neatly arranged and connected to various publication sites (until now, the metadata covered in Harzing's Publish or Perish (Google Scholar, Microsoft Academic, Scopus, and Web of Science) to make it easier for researchers to find articles that can be used as reference material in literature studies. Furthermore, the collected data were analyzed using the literature review method through traditional review techniques.

In this analysis, the researcher takes data from Google Scholar using Pop because Pop provides advanced features for filtering the category of metadata type, namely journal type publication name. Pop also provides keyword and title word features that allow researchers to find accurate journal metadata.

2.3. VOS Viewer

VOS Viewer, also called VV, is software used to visualize bibliometric maps (Barra & Zotti, 2017; Hu et al., 2020; Mundt & Mundt, 2020) or data sets containing bibliographic fields such as title, author, journal, and others. In the world of research, VV is used for bibliometric analysis, mapping topics for the latest research, finding the most widely used references in certain fields, and others. VV can read datasets from various online journal sites such as Google Scholar, Web of Science, Scopus, Dimension, and Pubmed (Ahlgren et al., 2003; Cathcart & Roberts, 2014; Hric et al., 2018). VV can also read the RIS, Endnote, and RefWorks dataset formats. Through

API features, VV can read/fetch data from Crossref, Pubmed PMC, Semantic Scholar, OCC, COCI, and Wikidata.

Map publication as stated by (Ahlgren et al., 2003; Tupan, 2016): VOSViewer is a computer program that can be developed to build and view bibliometric maps. Offers a text-mining function that can be used to build and visualize a network/relationship (correlation) in a citation of an article/publication. Publication maps are displayed in various ways and functions, such as mapping the zoom system, scrolling, and searching for mapping articles/publications in more detail (Boyack et al., 2005; Waltman et al., 2010). VOSViewer can present and represent special information about bibliometric graphic maps. Through VOSViewer, we can easily display large bibliometric maps to interpret a relationship (Ji & Obata, 2009; Van Eck & Waltman, 2010; Zhang et al., 2019).

3. Research Methodology

3.1 Research Methodology

The method used in this research is bibliometrics through metadata mapping of scientific journals in Applied Mathematics obtained from the Google Scholar site. The reason is that bibliometric studies are one of the easiest and cost-effective information research studies in library science. This topic study was conducted on the literature by applying mathematical and statistical methods. According to (Hakim, 2020): the notion of bibliometrics is a study that measures the development of research, literature, books, or documents in a particular field either quantitatively or qualitatively using statistical methods. Bibliometrics are divided into two major groups, namely descriptive bibliometrics and behavioural bibliometrics. Descriptive bibliometrics describes the characteristics of literature, while behavioural bibliometrics examines the relationships formed between the components of the literature (Cathcart & Roberts, 2014; Taylor & Hudson, 2008).

Furthermore, (Tupan, 2016; White, 2003) explain that bibliometric applications can be divided into two parts, namely: 1) bibliometric calculations (performance) indicators at different behavioural levels; and 2) analysis and visualization of bibliometric networks. Using bibliometric indicators is divided into descriptive bibliometrics and evaluative bibliometrics (Drewett, 1969; Taylor & Hudson, 2008; Vallejo & Dimitrakopoulos, 2019). Descriptive bibliometrics takes a top-down approach to get a big picture, such as a country's research output in various fields, the proportions of various fields, and changes over time. Meanwhile, evaluative bibliometrics is a tool to assess the research performance of smaller units such as research groups or individuals using a bottom-up approach to collect all relevant publications from each unit.

The researcher uses the Google Scholar database base with the PoP application because the PoP feature can filter the journal category in question; the application is free to pay. Data collection was carried out on April 30, 2021, with the Journal's Publication Name and keywords Applied Mathematical in 2005-2021, as shown in Figure 1.

Based on the search results obtained in the form of publications as many as 500 article titles. The data in the form of the number of publications per year containing articles on applied mathematics, authors, the author's origin, productivity, and publishers were analyzed using Microsoft Excel 2016. Meanwhile, maps of the development of international publications in applied mathematics were analyzed using the VOSViewer application because this application can create research clusters and is free to pay.

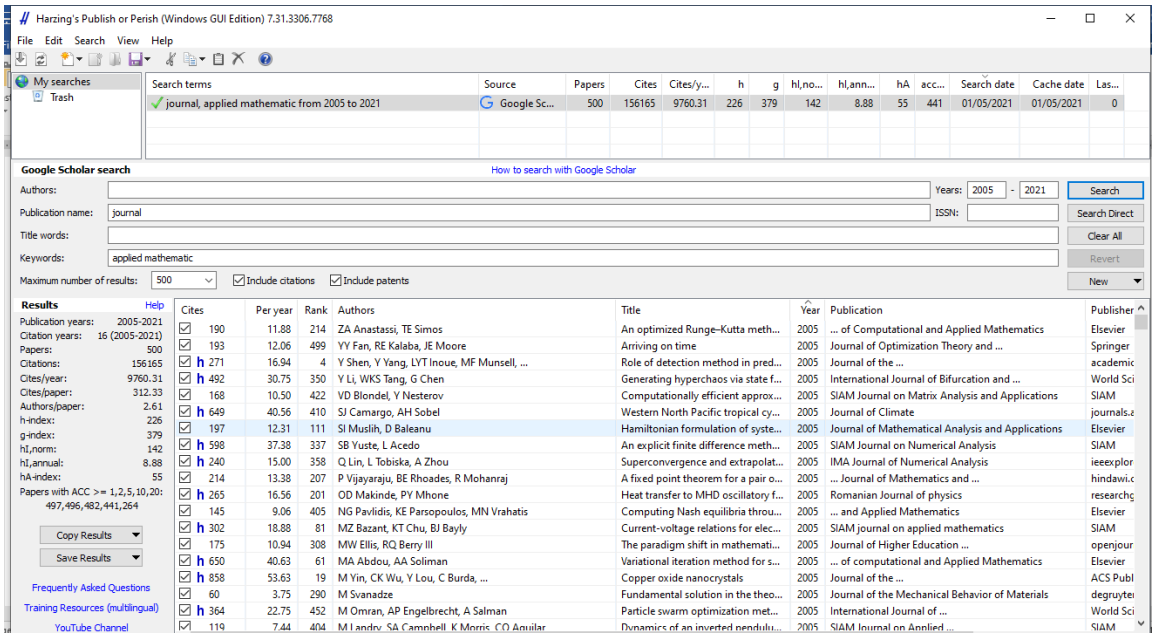

Figure 1. Metadata search results via PoP Version 7.31

4. Results and Discussion

4.1 Number of Research

The search results on the Google Scholar database show that the development of applied mathematics research during the period 2005-2021 experienced fluctuating conditions. Research development in applied mathematics increased significantly from 2006-2008, as shown in Table 1. After that, the number of scientific publications on applied mathematics went up and down. For 2020, it has decreased drastically.

Table 1. Number of publications on the development of applied mathematics research by the year

Year of Publication	**Amount**
2005	54
2006	38
2007	68
2008	54
2009	49
2010	44
2011	27
2012	31
2013	36
2014	27
2015	13
2016	9
2017	37
2018	4
2019	4
2020	2
2021	1
Jumlah	498

Interestingly, in 2012 and 2013, there was another increase due to the circular letter of the Director-General of Higher Education No. 152 of 2012. Every bachelor, master, and doctorate to graduate must publish his final assignment in national, accredited, and international journals. In addition, there are regulations regarding the promotion of the ranks of several available positions requiring the publication of research results and ideas in international scientific journals. After 2013, research on applied mathematics experienced ups and downs.

2.1. Core Journal in Applied Mathematics International Publications

Based on 500 research articles obtained from search results through the Google Scholar database, they were selected into 498 journal titles. Of the 498 journals, the top 10 core journals in applied mathematics publications in Google Scholar are Elvesier, Siam, and Wiley Online Library.

Table 2 shows that the ranking of the top 10 journals that publish research results in the field of applied mathematics are Elvesier with 112 articles, followed by Siam with 34 articles, Wiley Online Library with 32 articles, Springer and acadpubl.eu with 30 articles each, World Scientific 26 articles, journals sagepub.com and degruyter.com 19 articles respectively and so on.

Table 2: Top 10 Publishers of Applied Mathematics Scientific Journals

No	Name of Publisher	Amount
1	Elvesier	112
2	Siam	34
3	Wiley Online Library	32
4	Springer dan acadpubl.eu	30
5	World Scientific	26
6	journals.sagepub.com dan degruyter.com	19
7	hindawi.com	16
8	Taylor & Francis dan arc.aiaa.org	15
9	researchgate.net	12
10	ACS Publications	11

4.2 The Most Productive Researchers

Mapping the development of applied mathematics research using VOSViewer 1.6.16. In selecting the type of data, the researcher uses a map based on bibliographic data. Then in the data source using read data from reference manager files with supported file types RIS. Then the counting method uses complete counting with a maximum number of authors per document as much as 20 and a minimum number of documents of an author as many as 4. As a result, out of 1059 researchers, there are 10 who meet the criteria.

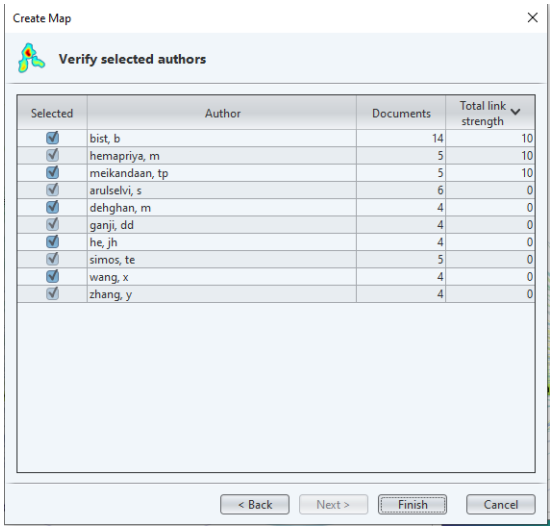

Figure 1. The most prolific researchers in applied mathematics

10 researchers have published the most research on applied mathematics. The researcher who publishes the most research results is Biher Bist, Assistant Professor of the Department of Mechanical Engineering at Barath University, India, with 14 articles. In second place is M. Hemapriya, Assistant Professor of the Department of Civil Engineering at Barath University, India. Then the third place is TP Meikandan, Assistant Professor of the Department of Civil Engineering at Barath University, India. The three researchers often publish the results of joint research. The correlation of the three can be seen in Figure 2.

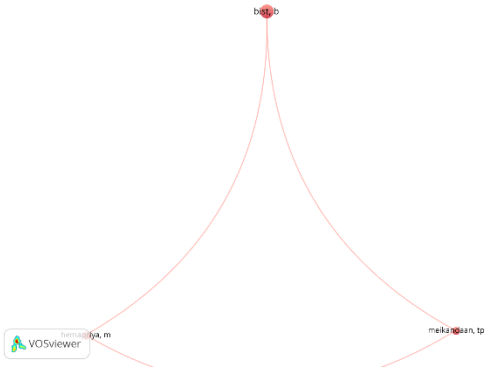

Figure 2: Correlation of the most productive researchers in applied mathematics

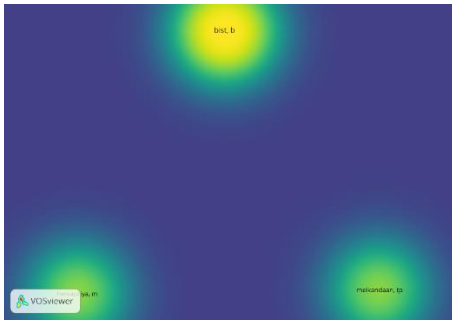

Figure 3: Correlation The most productive researchers in applied mathematics in density mode

4.3 Applied Mathematics Research Development Map

Mapping the development of applied mathematics research using VOSViewer 1.6.16. In selecting the type of data, the researcher uses to create map-based text data. Then in the data source using read data from reference manager files with supported file types RIS. Then the counting method uses Binary counting with a minimum number of occurrences of the term as many as 8 and the number of the term to be selected as many as 63.

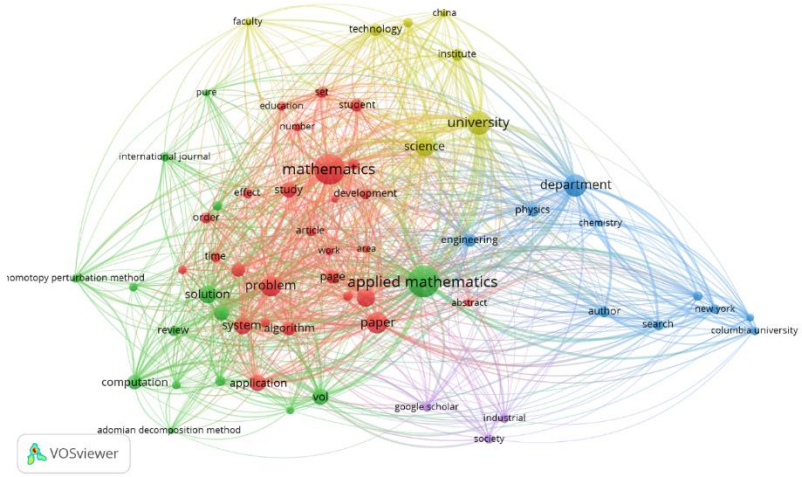

Figure 4: Results of mathematical mapping with Network Visualization display mode

There are 62 items divided into 5 clusters. Cluster 1 consists of 27 items consisting of abstract, algorithm, analysis, application, approach, area, article, development, education, effect,

field, mathematics, number, numerical solution, order, page, paper, parameter, problem, research, set, student, study, system, time, work, and year. Cluster 2 consists of 15 adomian decomposition, applied mathematics, comparison, computation, computational, homotopy perturbation method, international journal, journal, math, mechanics, pure, review, solution, variational iteration method, and vol. Cluster 3 consists of 10 items consisting of applied physics, author, chemistry, Columbia University, department, engineering, New York, physics, search, and USA. Cluster 4 consists of 7 items: China, faculty, institute, school, science, technology, and university. While cluster 5 consists of 3 items consisting of Google Scholar, Industrial, and Society.

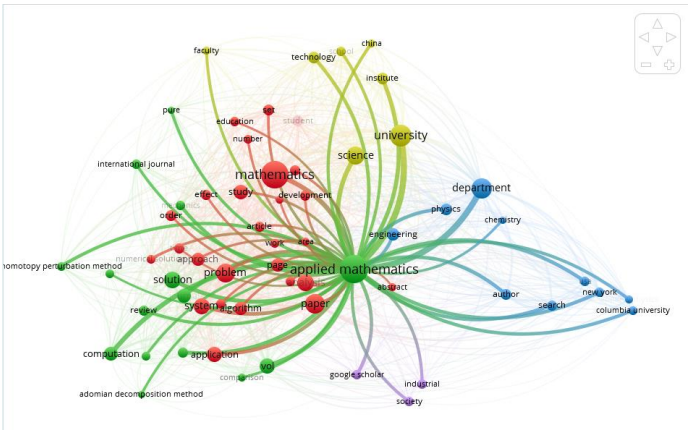

Figure 5: Results of mathematical mapping with Network Visualization display mode

Applied mathematics is connected to 60 research links in 5 clusters. Some of the strongest links with applied mathematics are mathematics, university, science, and department. While the related links are not so strong, namely comparison, adomian decomposition method, abstract, numerical solution, and so on. Links that are not so strongly related are spread over 5 clusters marked with small circles. There are still not many research results on these small circles, and there is an opportunity for renewable research to be carried out.

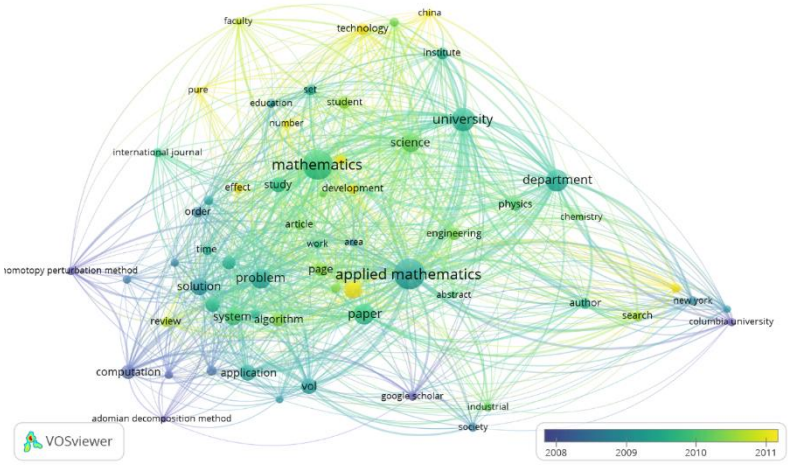

Figure 6: Mathematical mapping results with Overlay Visualization display mode

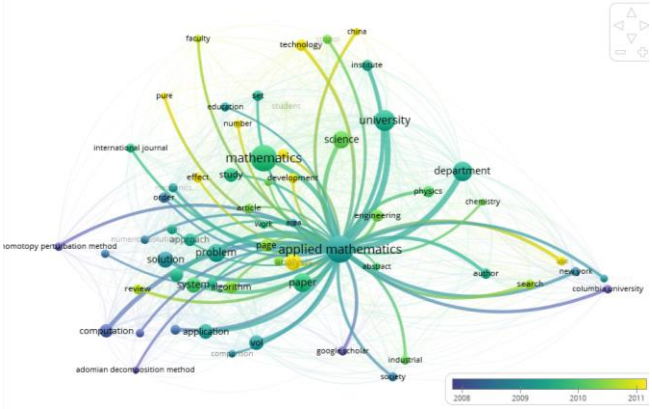

Figure 7: Mathematical mapping results with Overlay Visualization display mode

The latest research that is most closely related to applied mathematics is in 2011. The research is related to the USA, search, review, analysis, algorithms, development, effects, China, technology, numbers, and pure.

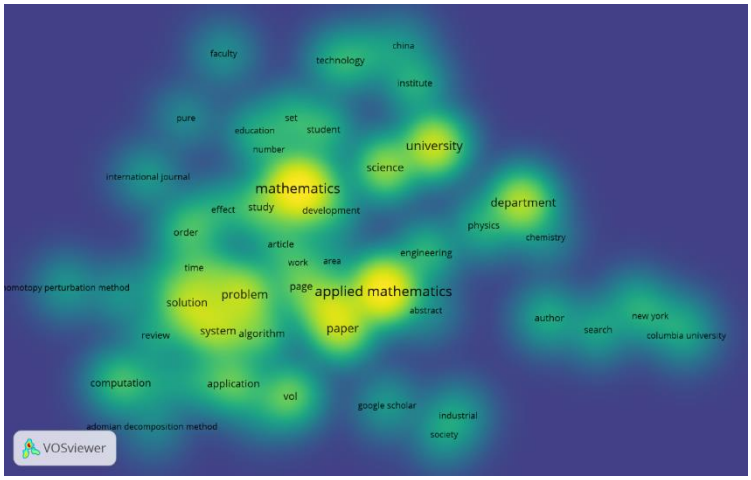

Figure 8 : Mathematical mapping results with Density Visualization display mode

The density display mode above shows that most research related to applied mathematics are mathematics, paper, problem, solution, system, university, department, and science marked in bright yellow. The lighter is the colour, the more is research. The research that is still very little is the adomian decomposition method, homotopy perturbation method, Google Scholar, industrial, engineering, and others marked by not lit colours. Thus, there are opportunities for renewable research by taking these items.

5. Conclusion

Based on the research results above, it can be concluded that the number of studies on applied mathematics fluctuated. Most publications occurred in 2007 as many as 68 articles. The

researcher who publishes the most research results is Biher Bist, Assistant Professor of the Department of Mechanical Engineering, in as many as 14 articles. In second and third place are M. Hemapriya and TP Meikandan from Barath University, India. Most research related to applied mathematics is mathematics, paper, problem, solution, system, university, department, and science marked with a bright yellow colour. The lighter is the colour; the more is research. The research that is still very little is the adomian decomposition method, homotopy perturbation method, Google Scholar, industrial, engineering, and others marked by not lit colours. Thus, there are opportunities for renewable research by taking these items. Based on the conclusions above, the next latest research concerning applied mathematics researchers is related to the adomian decomposition method, homotopy perturbation method, Google Scholar, industrial, and engineering.

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