

Pre-research Study based on Bibliometrics, Deep Learning Research for Aspect-Based Sentiment Analysis



Kajian Pra-Riset Berbasis Bibliometrik Penelitian Deep Learning untuk Aspect-Based Sentiment Analysis

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Abstract

Background: Massive publications on deep learning research for aspect-based sentiment analysis are challenging for interested researchers who want to research this area. **Purpose:** to provide an overview and comprehensive analysis on the research trend, which include the growth of publications, the most used keywords, the most popular publication sources to publish and find literature, the most cited publication, the most productive researcher, the most productive institution and country affiliation. **Method:** This study used a bibliometric method to analyze Scopus's indexed publications from 2014 (the year when the first publication was first indexed) to 2020. A total of 222 publications were analyzed and visualized using the VosViewer software. **Result:** In general, there is an increase in the number of publications from year to year. Keyword visualization shows keywords related to text-based processing, deep learning architectures, the research object and media, and the application of the method. The most popular sources to publish and to find literature are the "Lecture Notes in Computer Science" and the "Expert Systems with Applications". The most cited publication is "Deep Learning for Aspect-Based Sentiment Analysis: A Comparative Review", written by Do, Prasad (cited 81 times). The most productive researcher is Zhang Y from China. The most productive institution is Nanyang Technological University (6 publications), and China has the highest number of publications (76 documents). **Conclusion:** The bibliometric method can provide a conclusive and comprehensive preliminary overview of research trends for interested researchers who want to start research about deep learning for aspect-based sentiment analysis.

Keywords: Bibliometrics; Deep learning; Aspect-based sentiment analysis; VosViewer

Abstrak

Latar Balakang: Banyaknya publikasi mengenai penelitian deep learning untuk aspect-based sentiment analysis menjadi tantangan tersendiri bagi peneliti yang tertarik dan ingin memulai penelitian terkait topik ini. **Tujuan:** memberikan gambaran umum serta analisis komprehensif tren penelitian meliputi pertumbuhan jumlah publikasi, kata kunci yang banyak digunakan, sumber publikasi populer yang dapat dimanfaatkan untuk tujuan publikasi maupun menemukan literatur, publikasi utama yang paling banyak disitir, peneliti paling produktif dan pola kolaborasi peneliti, serta afiliasi institusi dan negara paling produktif. **Metode:** Kajian ini menggunakan metode bibliometrik untuk menganalisis publikasi terindeks Scopus dari tahun 2014 (tahun pertama kali publikasi terindeks) hingga tahun 2020. Sebanyak 222 judul publikasi dianalisis, kemudian divisualisasikan dengan software VosViewer. **Hasil:** Secara umum jumlah publikasi mengalami peningkatan dari tahun ke tahun. Visualisasi kata kunci menggambarkan kata kunci yang berkaitan dengan pemrosesan berbasis teks, arsitektur deep learning, obyek dan media penelitian, serta aplikasi aspect-based sentiment analysis dengan metode deep learning. Sumber publikasi terpopuler untuk tujuan publikasi dan sumber literatur utama berturut-turut adalah Lecture notes in Computer Science dan Expert Systems with Applications. Publikasi yang paling banyak disitir adalah Deep Learning for Aspect-Based Sentiment Analysis: A Comparative Review oleh Do, Prasad (disitir 81 kali). Peneliti paling produktif adalah Zhang Y dari Cina. Institusi yang paling produktif adalah Nanyang Technological University (6 publikasi), dan Cina menjadi negara paling produktif dengan jumlah publikasi sebanyak 76 dokumen. **Kesimpulan:** Kajian menggunakan metode

bibliometrik dapat memberikan gambaran awal tren penelitian yang konklusif dan komprehensif bagi peneliti yang tertarik dan ingin memulai penelitian tentang topik deep learning untuk aspect-based sentiment analysis.

Kata kunci: Bibliometrika; Deep learning; Aspect-based sentiment analysis; VosViewer

I. INTRODUCTION

The rapid development of scientific literature from a discipline on a particular research topic is a challenge for researchers and practitioners in finding relevant information. Bibliometric method is able to provide a solution by providing macroscopy pictures from a large amount of scientific literature. Bibliometric method is one of Library Science research methods which uses quantitative analysis of bibliographic data in portraying characteristic and development of scientific output from a certain field (J. Li & Hale, 2016; van Nunen *et al.*, 2018). From this method, performance and research patterns related to the research topic, authorship, country, institution, and collaboration or relationships between them can also be portrayed and identified (W. Li & Zhao, 2015). Moreover, bibliometric method can show the researchers and influential publications on one topic along with the most productive countries and institutions from one research topic. Main journal and other publication sources which publish the research topic along with subject categories related to publication can also be identified, so that it can provide an indication of the variety of themes and the multidisciplinary character of a research field (van Nunen *et al.*, 2018). Bibliometric also allows the identification of research gaps in a field, both content and geographically. Broadly speaking, the bibliometric method is useful in providing input for researchers regarding the latest developments in information, research directions, challenges and potential research topics that are mostly carried out in a field bidang (Wang *et al.*, 2014; W. Li & Zhao, 2015; van Nunen *et al.*, 2018). Review services based on bibliometric methods have been provided by the PDDI-LIPI Library for researchers before starting research activities (pre-research). This study was conducted at the request of one of the researchers at the LIPI Informatics Research Centre, namely about the general description and development of deep learning methods for aspect-based sentiment analysis. This study was also prepared by the librarian by obtaining corrections and input from researchers in related fields.

Issues. In this study, a bibliometric method is used to analyze research publications with the utilization topic of deep learning for aspect-based sentiment analysis. The rapid growth of publications related to sentiment analysis and the benefits that can be obtained from sentiment analysis research have prompted the need for an approach to analyze the publications. Sentiment analysis is a research field which detects a person's opinions, sentiments, judgments, attitudes and emotions towards something that is (generally) expressed through text (Keramatfar & Amirkhani, 2019), whereas aspect-based sentiment analysis detects an aspect of the text and it analyzes trends related to that aspect (Keramatfar & Amirkhani, 2019). User's opinion (for example, it is related to social activities, products, brands, services, or politics) is data/information that is needed by organizations and individuals to improve the quality of their products and services (Ray & Chakrabarti, 2020; Yadav & Vishwakarma, 2020). With the spread of World Wide Web technology along with various social networking platforms, review sites, online forums, and blogs, sentiment analysis is widely used in various fields, for example to analyze educational data (Sultana *et al.*, 2018); hotel data, online website and e-commerce (Haque *et al.*, 2018); politics (Haselmayer & Jenny, 2017), disaster management (Ragini *et al.*, 2018), etc. These are the background of the large number of

publications related to sentiment analysis. Bibliometric approach is needed to analyze the publication of deep learning for aspect-based sentiment analysis so that it is resulting an information that is concise, fast and understandable for researchers who want to start a research.

Previous Literature Review. Bibliometric research is used to analyze the publication of sentiment analysis as well as the publication of deep learning. The bibliometric research is generally carried out separately to achieve an overview of sentiment analysis and deep learning research. Mäntylä *et al.* analyzed Scopus indexed publications and used the LDA (Latent Dirichlet Allocation) topic modeling algorithm to determine the evolution of research topics, publication-producing countries, and the most cited publications (Mäntylä *et al.*, 2018). An analysis of research areas, topic distribution, and collaboration patterns in sentiment analysis research using the STM (semi-automated machine learning) approach has also been carried out by Chen & Xie using WoS indexed articles (Chen & Xie, 2020). The deep learning bibliometric research conducted by Y. Li *et al.* portrayed the publication structure such as the number of publications per year, the most productive countries and institutions, the most productive researchers using VosViewer and Cite Space software (Y. Li *et al.*, 2020).

State of The Art. Although bibliometric research on sentiment analysis and deep learning has been widely carried out, bibliometric research on the use of deep learning methods for aspect-based sentiment analysis has not been carried out. Therefore, this study analyzes deep learning research publications for aspect-based sentiment analysis using a bibliometric approach and is supported by visualization with VosViewer software.

Purpose. This study aims to provide an overview of research trends which are the growth in the number of publications, the most widely used keywords, popular publication sources that can be used for publication purposes and to find literature, the most cited main publications, the most productive researchers and research collaboration patterns, institutional affiliations. and the most productive countries. In general, this study is expected to contribute to the development of bibliometric. The information presented in this study is expected to provide an overview for informatics researchers who want to start research related to deep learning topics for aspect-based sentiment analysis.

II. METHOD

The research begins with a literature search related to the topic of deep learning for aspect-based sentiment analysis. A literature search was carried out on the Scopus database on January 6, 2021. The Scopus database was chosen because it is one of the largest databases of abstracts and citations of peer-reviewed literature (scientific journals, books, conference proceedings, and other types of literature.) in the field of science and technology (van Nunen *et al.*, 2018). In this study, only the Scopus database was used based on the research considerations of Mongeon & Paul-Hus and Appel *et al.* that publications on sentiment analysis indexed by Scopus and Web of Sciences/ WoS (another large database of abstracts and citations subscribed to by LIPI) are likely to overlap (Mongeon & Paul-Hus, 2016:Appel *et al.*, 2015). Scopus is also the most reliable and comprehensive database according to research objectives, because it provides search results analysis features and allows offline analysis of the results of bibliographic data exports. Several variations of the keywords on sentiment analysis used in the search were obtained from the influential literature review on sentiment analysis by Mäntylä *et al.* (Mäntylä *et al.*, 2018) and bibliometric sentiment analysis research by Chen & Xie (Chen & Xie, 2020).

The search is targeted to find literature by title (TITLE), abstract (ABS) and keywords (KEY), both keywords by author and indexed keywords. Hyphens (-) in aspect-based phrases are not used because Scopus ignores the use of punctuation marks by searching

for all phrases, either “aspect based” or “aspect-based”. Quotation marks are used in sentiment analysis keyword variations to find literature that contains the exact same phrase in the title, abstract and keywords. In general, the search can be written as follows “TITLE-ABS-KEY (“*deep learning*”) AND TITLE-ABS-KEY (*aspect based*) AND TITLE-ABS-KEY (“*sentiment analysis*” OR “*sentiment classification*” OR “*sentiment mining*” OR “*opinion analysis*” OR “*opinion classification*” OR “*opinion mining*” OR “*subjectivity analysis*” OR “*subjectivity classification*” OR “*polarity classification*”)”.

The search results found as many as 222 literature titles from 2014 (the year this topic was first indexed by Scopus) to 2020. All types of publications were selected to get a comprehensive coverage of the literature on this topic. The next step, the literature bibliographic metadata is exported into CSV format and then visualized using VosViewer software. This text mining-based software was chosen because it is available for free and can visualize the relationship between terms (terms), authorship patterns/collaboration of authors, countries, institutions, and provide information related to the number of citations. The relationship of topics is displayed in a two-dimensional map, where the distance between the two topics describes the similarity or interrelationship of the topics as accurately as possible (Nadzar *et al.*, 2017). This software will be used to produce keyword portraying visualizations through co-occurrence, research collaboration, and collaboration between publication-producing countries. The results of the analysis of the trend of growth in the number of publications, sources of popular publications related to the topic, the most cited main publications and research topics related to these publications, the most productive researchers, and the most productive institutional and country affiliations will be shown in tables and figures.

III. RESULTS AND DISCUSSION

The trend of growth in the number of publications per year. The trend of growth in the number of publications related to deep learning topics for aspect-based sentiment analysis has generally increased since 2014 (the year this topic was first indexed in the Scopus database) until 2020. In Figure 1 it can be seen that during the period from 2014 to 2017, there was no significant increase in the number of publications. The total number of publications in the period 2014 to 2017 was 22 documents or 10.36% of the total publications (n=222). The percentage growth of publications in this period only ranged from 0.9% to 1.35%. The trend of growth in the number of publications began to be clearly seen between 2017 and 2018, where there was an increase in the number of publications from 9 documents (4%) to 31 documents (13.96%). This trend is increasing with the increasing number of Scopus-indexed publications in 2019 to 2020, namely 73 documents (32%) and 95 documents (42.79%). According to van Nunen *et al.* (2018), the number of peer-reviewed publications is one indicator to determine the development of scientific research on a subject. Thus, the increase in the number of publications related to aspect-based sentiment analysis using the deep learning method over the past six years can indicate that research is growing, both in method and application.

Based on Picture 2, it can be shown that it is generating eight clusters of keywords. On Cluster 1 (the red color), the most prominent keywords are data mining, Natural Language Processing (NLP), and aspect-based sentiment analysis. Aspect-based sentiment analysis keyword is directly related with the research so it appears dominant. According to Yadav & Vishwakarma, this type of sentiment analysis involves identifying features or aspects in a sentence (user-generated content), then it categorizes into different polarity classification, and lastly it classifies sentiment value of every aspect (Yadav & Vishwakarma, 2020). Furthermore, because research and application of aspect-based sentiment analysis focus mainly on written texts, research related to deep learning for aspect-based sentiment analysis is more active in the NLP area, it is indicated by the keyword Natural Language Processing and related keywords such as term extraction and syntactic.

Cluster 2 (green color) includes keywords such as social aspects, forecasting, decision making, financial markets, and commerce. These keywords can indicate the application of deep learning methods in aspect-based sentiment analysis used to predict the sentiment of economic actors, for example in investment or trading.

Cluster 3 (dark blue color), the most prominent keywords are social networking (online) and opinion mining keywords. Other keywords such as aspect sentiment classification, social media platforms, e-learning, and learning techniques indicate that research analysis is mostly done from social media data, one of which is the analysis of sentiment/opinions of online learning users. Twitter's keywords indicate that this platform is the most widely used as a data source in aspect-based sentiment analysis research compared to other social media platforms.

Cluster 4 (yellow color) or deep learning architecture cluster. In this cluster, apart from the prominent aspect based sentiment analysis keywords, there are also several keywords such as convolution, convolutional networks, convolutional neural networks, attention mechanisms, long-short term memory, and classification accuracy related to deep learning architecture. Besides RNN, aspect-based sentiment analysis research also uses another deep learning method, namely CNN (Convolutional Neural Network).

According to Do *et al.* (2019), this model is widely used to analyze the sentiments of users of restaurants, hotels, mobile applications, electronic products, films, and others through the reviews provided.

Cluster 5 (purple color) shows keywords which stand out the most among other keywords from the entire cluster, namely deep learning and sentiment analysis keywords. This is understandable because these two keywords are directly related to the research topic. Other keywords such as learning systems, text mining, extraction, computational linguistics, and support vector machines indicate that aspect-based sentiment analysis research is mostly done using text mining to extract features/aspects at the level of sentence text and the classification method that is widely used is support vector machines.

Cluster 6 (light blue color) includes main keywords such as sentiment classification and classification (of information). Other keywords such as surveys, classification performance, linguistics, text processing, and text classification indicate that research uses classification algorithms to classify user sentiment in the form of text generated from survey results. Research is also possible to emphasize more practical aspects, such as text processing and testing the performance of classification models.

In cluster 7 (orange color), the keywords that stand out include convolutional neural networks, deep neural networks, and neural networks. This can indicate a deep learning method for aspect-based sentiment analysis that uses deep convolutional neural networks algorithms. According to Poria *et al.*, this deep learning feature uses deep multilayer text processing techniques that offer higher accuracy in abstraction Poria *et*

al. (2016). Minor keywords such as electronic commerce, recommender systems, and user reviews indicate research conducted to analyze the sentiment of online buying and selling users through a system that can provide recommendations for users/consumers. This, according to Chen & Xie is one of the advantages of using sentiment analysis, where sellers can promote products/services based on consumer behavior and opinions of a brand (Chen & Xie, 2020).

Cluster 8 (brown color) only consists of four keywords which are convolutional neural networks, sentiment, machine learning, and textual information. The possibility of aspect-based sentiment analysis research using deep learning methods included in this cluster only uses the CNN algorithm to analyze text-based sentiment.

In general, it can be concluded that some of the keywords that appear the most are keywords related to text-based processing (such as text mining, text extraction and classifications, NLP, and others); keywords related to deep learning architectures (such as neural networks, CNN or RNN); keywords that describe the object of research (such as user reviews and the media, namely social media platforms); and keywords related to the application of aspect-based sentiment analysis research using deep learning methods (for forecasting, e-commerce, decision-making, and others).

Popular publication sources. Table 1 shows the top five publication sources that contain the most topics on deep learning for aspect-based sentiment analysis. Information on the source of this publication can be useful for researchers in finding references and as a material for consideration when deciding which journal to publish. There are as many as 27.03% of documents (n = 66/222) related to research topics published in the sources of this publication. In general, Lecture notes in Computer Science are in the first rank of the most popular publication sources for publication purposes (25 documents), while Expert Systems with Applications are in fifth place with a total of 4 documents. The subject areas of the five major publication sources are mostly related to computer science, mathematics, and engineering.

Table 1 also shows indicators that can be used to assess the impact of publication sources which are the Scimago Journal Rank (SJR) and citation value (CiteScore) based on Scopus data. SJR describes the average number of citations obtained in a given year by documents published in a journal over the previous three-year period. SJR is a journal indicator that is almost the same as the Impact Factor (IF), but with a citation period of 3 years and all citations are not treated the same. It means citations from well-known reputable journals are considered more important than citations from unknown reputable journals (Keramatfar & Amirkhani, 2019). There are two CiteScores used in this study which are CiteScore 2019 and CiteScore tracker 2020 (these two are used to find out the latest citation count). CiteScore 2019 shows the number of citations from 2016 to 2019 divided by the number of documents from 2016 to 2019, while the CiteScore tracker 2020 shows the number of citations obtained during 2020 divided by the number of documents up to 2020 (Scopus, n.d.). In general, it appears that the most cited documents in 2019 and 2020 are documents published in the Expert Systems with Applications journal. Although the number of citations and the SJR ranking of the journal is far above other journals, even though it has the least number of documents (4 documents). This may indicate that the Expert Systems with Applications journal is more influential than other publication sources in research related to deep learning for aspect-based sentiment analysis, so it can be considered when searching for primary literature sources.

Tabel 1.

Top Five Popular Publication Sources

No.	Publication Source	Total Doc	Cite Score 2019	Cite Score tracker 2020	SJR	Subject
1	<i>Lecture notes in Computer Science</i>	25	1.9	1.7	0.427	Computer science: general computer science; Mathematics: theoretical computer science
2	<i>ACM International Conference Proceeding Series</i>	12	0.8	1	0.2	Computer science: computer networks and communications, Human-computer interaction, computer vision and pattern recognition, software
3	<i>IEEE Access</i>	9	3.9	4.6	0.775	Engineering: general engineering; Computer science: general computer science; Materials science: general material science
4	<i>Communication in Computer and Information Science</i>	5	0.7	0.7	0.188	Mathematics: general mathematics; Computer science: general computer science
4	<i>Journal of Advanced Research in Dynamical and Control Systems</i>	5	0.4	-	0.129	Engineering: general engineering; Computer science: general computer science
5	<i>Expert Systems With Applications</i>	4	11	12.1	1.494	Engineering: general engineering; Computer science: computer science applications, artificial intelligence

*Publication sources with the same number of documents have the same rating.

Source: Scopus, 2021

The most cited major publications and the research topics/areas. Table 2 lists the top five major publications related to the topic of deep learning for aspect-based sentiment analysis which have been cited the most in similar studies. These publications can be used as a reference source for researchers who wish to conduct research in this field. Based on Table 2, the most cited publication is entitled Deep Learning for Aspect-Based Sentiment Analysis: A Comparative Review by Do, Prasad. Until the end of 2020, the article published in 2019 in the journal Expert Systems with Applications has been cited 81 times. The next most cited article is the article entitled Deep Recurrent neural network vs. support vector machine for aspect-based sentiment analysis of Arabic hotels' reviews by Al Smadi (2018) with 77 citations and NLANGP at SemEval-2016 Task 5: Improving Aspect Based Sentiment Analysis using neural network features by Toh Zu (2016) 50 times.

Related to the number of citations, Van Nunen et al. revealed that the number of times a publication was cited was closely related to the length of time since the publication was published, or in other words, the publication that was published earlier was likely to have more citations than the latest publication (Van Nunen et al., 2018). However, this does not rule out the possibility for new publications to have a greater impact, namely if the publication contains more important or up-to-date information (Milfont & Page, 2013). Furthermore, Ugolini et al. also revealed that the number of citations describes the influence and visibility of a publication (Ugolini et al., 2015). In this case, journals with open access are likely to be cited more because they are easier to access. In this study,

publications of Do, Prasad (published in 2019 in non-open access journals) are cited more than publications published in 2016, for example, publications of Ruder, S. i.e. 81 times vs. 41 times. This shows that Do, Prasad's research is more influential in the fields of deep learning research and aspect-based sentiment analysis, and shows the tendency of technology research to always use the latest publications.

Table 2.

The most cited major publications and their topics/research areas

No	Title of Publication	Researchers	Publication Source	Year	Total Cite	Research Topic/Area
1	<i>Deep Learning for Aspect-Based Sentiment Analysis: A Comparative Review</i>	Do, H.H., Prasad, P.W.C., Maag, A., Alsadoon, A.	<i>Expert Systems with Applications</i> 118, pp. 272-299	2019	81	<i>Sentiment Classification, Opinion Mining, Product Review</i>
2	<i>Deep Recurrent neural network vs. support vector machine for aspect-based sentiment analysis of Arabic hotels' reviews</i>	Al-Smadi, M., Qawasmeh, O., Al-Ayyoub, M., Jararweh, Y., Gupta, B.	<i>Journal of Computational Science</i> 27, pp. 386-393	2018	77	<i>Sentiment Classification, opinion mining, product review</i>
3	<i>NLANGP at SemEval-2016 Task 5: Improving Aspect Based Sentiment Analysis using neural network features</i>	Toh, Z., Su, J.	<i>SemEval 2016 - 10th International Workshop on Semantic Evaluation, Proceedings pp. 282-288 (open access)</i>	2016	50	<i>Sentiment Classification, Opinion Mining, Product Review</i>
4	<i>Double embeddings and CNN-based sequence labeling for aspect extraction</i>	Xu, H., Liu, B., Shu, L., Yu, P.S.	<i>ACL 2018 - 56th Annual Meeting of the Association for Computational Linguistics, Proceedings of the Conference (Long Papers) 2, pp. 592-598 (open access)</i>	2018	42	<i>Sentiment Classification, Opinion Mining, Product Review</i>
5	<i>Using long short-term memory deep neural networks for aspect-based sentiment analysis of Arabic reviews</i>	Al-Smadi, M., Talafha, B., Al-Ayyoub, M., Jararweh, Y.	<i>International Journal of Machine Learning and Cybernetics</i> , 10(8), pp. 2163-2175	2019	41	<i>Sentiment Classification, Opinion Mining, Product Review</i>
5	<i>INSIGHT-1 at SemEval-2016 Task 5: Deep learning for multilingual aspect-based sentiment analysis</i>	Ruder, S., Ghaffari, P., Breslin, J.G.	<i>2016 SemEval 2016 - 10th International Workshop on Semantic Evaluation, Proceedings pp. 330-336 (open access)</i>	2016	41	<i>Sentiment Classification, Named Entity Recognition, Entailment</i>

*Publications with the same number of citations have the same rating

Source: Scopus, 2021

The most prolific researcher. The total number of researchers who produced Scopus indexed publications on the topic of aspect-based sentiment analysis using the deep learning method was 616 researchers. Thus, there is a small group of researchers who are prolific and contribute significantly to the number of publications on this topic. This is shown in Table 3 which summarizes the top three researchers with the highest number of publications. The data obtained indicate that the maximum number of publications produced by researchers on this topic is 6 documents, namely by Zhang Y (cited 18 times). Meanwhile, Wang Z is placed in second place with the number of publications of 5 documents (cited 18 times). Third place with total publications of 4 documents is Liu N (cited 16 times), Shen B (cited 16 times), Wu Y and Wang Y cited 0 times.

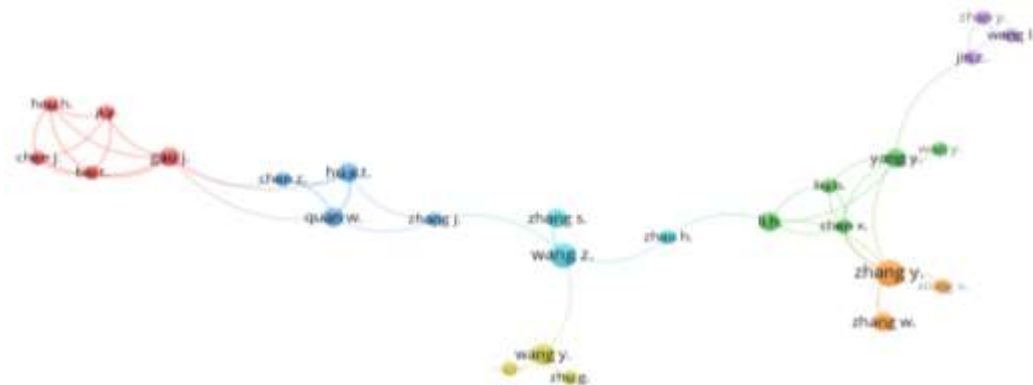
Table 3.
Top three most prolific researchers

Name of Researchers	Total of Publications	Total of Citation	Network Strength
Zhang Y	6	18	7
Wang Z	5	18	5
Liu N	4	16	6
Shen B	4	16	6
Wu Y	4	0	5
Wang Y	4	0	3

Source: Processed primary data, 2021

The pattern of researcher collaboration (co-authorship) on this topic was analyzed using VOSViewer software and is shown in Figure 3. Researchers featured in this network produced a minimum of two publications. Researchers who are not connected to other researchers are not shown. The size of the circle indicates the number of documents, while the connecting line between researchers indicates the strength of collaboration between them. From Figure 3 it can be seen that there are several clusters of researchers who collaborate with each other. The research group with the highest number of publications, Zhang Y (orange color), showed strong collaboration with Yang Y's research group (green color). The research group in red, the prominent researcher being Gao J, has the strongest connecting line. This may indicate strong collaboration among the researchers (these researchers almost always produce joint publications).

Figure 3.
Map of research collaboration (co-authorship)

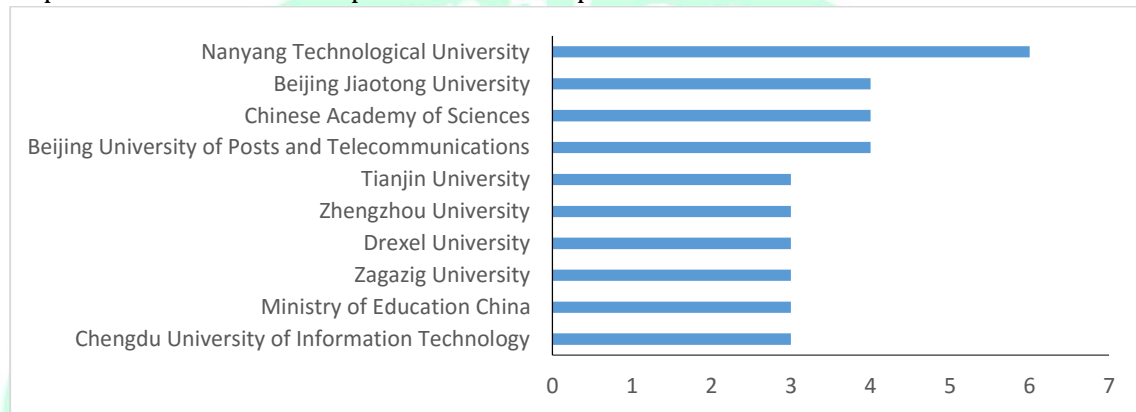


Source: Processed primary data, 2021

The Most Prolific Affiliated Institution. A total of 160 institutions participated in 222 publications related to the topic of this study. Figure 4 shows the top three institutions with the highest number of publications. The institution that publishes the most research on deep learning for aspect-based sentiment analysis is Nanyang Technological University with 6 publications. The majority of the institutions conducting research in this field are Chinese universities (eight institutions). Overall, the low number of publications produced by this institution indicates that the institutions producing publications on this topic are not dominated by certain institutions, or in other words, many other institutions produce only 1 to 2 publications.

Figure 4.

Top three institutions who produce the most publications



Sources: Processed primary data, 2021

The Most Prolific Affiliated Country. Publications on deep learning for aspect-based sentiment analysis indexed by Scopus come from 58 countries spread all over the world. Table 4 shows the top five countries that are most productive in producing research on this topic. China dominates with the number of publications of 76 documents, followed by India and the USA in the second and third places, respectively, with the number of publications of 37 and 16 documents. Singapore, Spain and the UK ranked fourth with the same number of publications, namely 8 documents. Vietnam is in fifth place with 7 documents. Indonesia (not included in the top 5) ranks sixth with a total of 5.

Publications produced by China and India based on the results of citation analysis are cited more than publications produced by other countries. Apart from the large number of publications, this may indicate the influence of Chinese and Indian publications in this field of research. Likewise, the number of citations to publications by Singapore researchers is also high, although the number of publications is only 8 documents. This can also indicate that the publications produced are quite influential in aspect-based sentiment analysis research so that they are widely used as references.

Table 4.

Top Five Most Prolific Country

No	Country	Total of Publications	Total of Citations	Colaboration Strength
1	Cina	76	296	12
2	India	37	196	2
3	USA	16	88	10

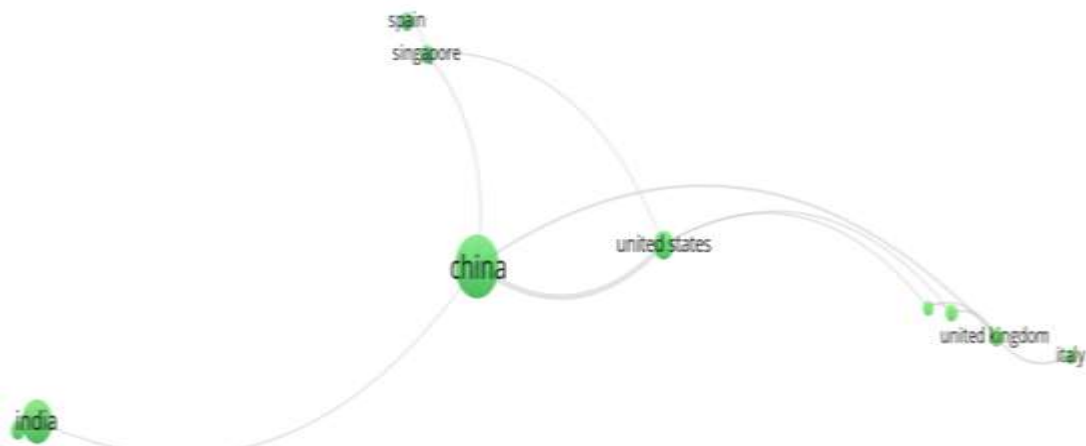
4	Singapura	8	112	4
4	Spanyol	8	59	1
4	UK	8	47	7
5	Vietnam	7	34	1

*Countries with the same number of publications, have the same ranking
Source: primary data processed, 2021

Besides the number of citations, the data above also shows that economic development contributes greatly in terms of academic investment and scientific research. Generally, the field of scientific research is dominated by G7 countries such as the USA, UK, Canada, France, Germany, Japan and Italy (van Nunen et al., 2018). However, in this study, apart from the USA and UK, developed countries such as China, India or Singapore are also the producers of the most publications. This can indicate the high economic activity and academic level of these countries. Especially in China, the government is committed to advancing research in the fields of Science, Technology, Engineering, and Math (STEM) to shift from a manufacturing-based economy to a knowledge-based economy (Han & Appelbaum, 2018).

The research collaboration network between countries producing deep learning publications for aspect-based sentiment analysis is visualized using VOSviewer software in Figure 5. Countries in the network produce at least 5 publications related to this topic. Countries with a number of publications below 5 and countries that are not linked to other countries are not included in the network. The size of the circle indicates the number of publications, and the thickness of the connecting line indicates the strength of the collaboration. From Figure 5 it can be seen that China with the highest number of publications has stronger collaboration with the USA and UK even though the two countries are on different continents. The collaboration of Chinese researchers with geographically closer countries (such as Singapore and India) is weaker (the connecting line is thinner than the USA and UK). This can happen because the large number of Chinese researchers who study and collaborate with researchers in more advanced countries such as the USA and UK.

Figure 5.
Network of Research Collaboration Between Countries



Source: Primary data processed, 2021

IV. CONCLUSION

Using the bibliometric method in this study can provide a conclusive and comprehensive overview of research trends for researchers who are interested and want to start research on the topic of deep learning for aspect-based sentiment analysis. This method can provide preliminary information for researchers, especially researchers in the field of informatics, regarding: (1) the trend of growth in the number of publications; (2) keyword trends that can be used as descriptions related to the research topic area (mostly used methods/media/applications); (3) popular publications that can be the main reference sources or be taken into consideration when deciding the purpose of publication or finding literature; (4) the most cited major publications; (5) the most productive researchers and research collaboration patterns; and (6) the most productive country and institutional affiliations regarding the research topic.

Regarding to the limitations of the study, the researcher realizes that the information in this study is limited to only one database source. To be able to provide more comprehensive and useful analysis results for researchers who want to go deeper into deep learning research for aspect-based sentiment analysis, further researchers need to use additional data from other databases (especially databases with the majority of publication content in the field of technology and information such as the IEEE).

The bibliometric method comprising several stages such as determining keywords, searching, selecting articles, validating, and analyzing data was used to carry out this research

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