Proceeding International Conference on Religion, Science and Education (2024) **3**, 121-129

Mapping the Evolution of Ethical Dimension on Artificial Intelligence Research through Co-word Analysis

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Abstract: Artificial Intelligence (AI) has experienced very rapid development in the last few decades. Apart from that, AI has and will change many aspects of human life. However, as AI technology continues to develop, questions arise in the ethical dimension related to how ethically we as humans interact in utilizing or using Artificial Intelligence (AI). Therefore, this research aims to explore the extent to which research related to ethical dimensions in relation to the use of AI has been carried out. This research will use a bibliometric approach, specifically in Co-word analysis to identify core research themes and trends related to ethical dimensions in the use of Artificial Intelligence (AI). The results of this research are: 1) the research on the ethical dimension in AI has been massively discussed. It can be seen from the total number of occurrences of the words "artificial intelligence" and "ethics" that reach 1608 and 1223 times. 2) there are 4 clusters where each cluster consists of 155, 28, 19 and 19 keywords. The biggest keyword is "artificial intelligence" with 1608 total accuracy and 3964 link strength, followed by the word "ethic" with 1223 total accuracy and 3180 total accuracy 3) in the Evolution of the words Artificial Intelligence and the word Ethics are still often mentioned to this day and have given rise to other words related to the two such as the words AI ethics, Ethics of AI, Machine Ethics, artificial Intelligence ethics etc. 4) the words "information technology" and "decision-making" which are in the Niche themes quadrant on the thematic map graphic indicate that although this theme has experienced an increase in interest, not much research has been conducted regarding this theme.

Keywords: Monitoring AI Ethics through Co-word Analysis

Introduction

Artificial intelligence (AI) has become one of the most dynamic and significant areas of research in the last decade. Tremendous advances in computing technology, especially in data processing and storage, have become a very strong basis for the development of AI in terms of developing more sophisticated algorithms and more effective machine learning methods (Rios-Campos et al., 2023). Rapid developments in computing technology are key drivers of AI advancement. Advances in artificial intelligence have enabled AI systems to understand and respond to unstructured data, such as images and human language. This has opened up new opportunities in a variety of industries, from healthcare to transportation, even business to education.

However, along with this rapid growth comes a very important ethical issue related to the use of AI in various aspects of our lives. Advances in AI technology have raised serious issues of privacy, fairness, and social impact. (Galaz et al., 2021). There are concerns related to how personal data is used and exchanged even in cyberspace, to obtain Big Data to perform further data analysis or the risk of deliberate manipulation of existing data (Chu et al., 2020). In addition, there are concerns that AI algorithms can become a source of bias and discrimination if not managed wisely (Al-Tkhayneh et al., 2023) even The development of AI for autonomous weapons can increase the risk of genocide and mass murder in certain groups.(Poghosyan, 2020).

ISSN 2829-3355| EISSN 2828-8467

Decisions taken by AI systems can also have significant consequences on society, including in terms of unemployment due to automation of human jobs. It is undeniable that AI advancements have had a significant impact on almost all sectors, from healthcare to transportation, and from business to education. Although AI has brought many tremendous benefits and potentials, rapid advances in artificial intelligence (AI) have also raised concerns about potential risks. This risk can be categorized into several areas. First, there is the risk of malicious use, where individuals or groups intentionally use AI to cause harm. Second, there is the risk of an AI race, where the competitive environment could lead to insecure deployment of AI or handover of control to AI (Hendrycks et al., 2023). Third, there is organizational risk, which highlights how human factors and complex systems can increase the likelihood of catastrophic accidents. (Gündo\ugar &; Niauronis, 2023). Finally, there is the risk of rogue AI, which refers to the difficulty in controlling agents much more intelligent than humans (Al-Tkhayneh et al., 2023). These risks include social, security, safety, and ethical challenges (Passas et al., 2022). Ethical issues also grow with the development of AI; a lack of control and regulation over AI technology can lead to large-scale risks and non-compliance with moral norms. There are concerns related to privacy, algorithm discrimination, and the potential social harm that AI decisions can cause.Because of some of the above, researchers feel it is important to consider the ethical dimension in AI development and identify solutions that can overcome both the various problems that have occurred and the possible problems that will occur in the future.(Huang et al., 2022).

Co-word analysis is a valuable research tool that aids in comprehending the evolution and ethical trends within the scientific literature associated with AI. It enables the identification and detailed exploration of key words such as 'Ethics' in AI research that commonly co-occur in metadata. This method assists in uncovering the links and relationships between ethics and other interrelated concepts in artificial intelligence, such as 'data processing,' 'privacy,' 'machine learning,' and more. Furthermore, Co-word analysis facilitates the examination of changes and advancements in the concept of ethics within AI research literature, highlighting emerging topics in recent years. This approach enables the identification of significant trends and focal points in ethical discussions related to AI, including the mapping of clusters or groups of concepts linked to AI ethics. Consequently, researchers can identify themes or associated terms close to 'ethics' that require further exploration in future research endeavors. Enhancing our understanding of these ethical issues allows for a more responsible utilization of AI technology, thereby minimizing its adverse impacts on society. Given this description, researchers are keen on assessing the extent and scope of research pertaining to ethical dimensions in the utilization of AI. This research aim to employ bibliometric methods, particularly Co-word analysis, to unveil core research themes and trends concerning ethical dimensions in AI utilization.

Materials and Methods

Research method

This study used a bibliometric approach by utilizing co-word analysis. The co-word analysis method is based on the assumption that keywords in a paper or article adequately reflect or represent the content of its content. Diodato argues that co-word analysis is rooted in the analysis of the co-occurrence (co-accurance) of two or more keywords in the text used to index articles or other documents. (Tupan, 2016: 107). Co-word analysis aims to explore content, patterns, and trends in a group of documents by measuring the strength of relationships between specific terms or keywords (De Looze &; Lemarie, 1997: 271).

Data collection

Data collection is carried out by extracting the metadata of scientific articles contained in international journals that have been indexed by Scopus by typing the search keywords "ethics" and "artificial intelligence" and filtering searches based on keywords on the Scopus website. From the search, researchers found 2,937 documents

consisting of 1408 articles, 665 conference papers, 364 reviews, 129 notes, 120 editorials, 112 book chapters, 81 letters, 27 books, 27 short surveys, and 3 conference reviews. Some of these documents have been published, from the oldest in 1985 to the one that will be officially published in 2025.

Data Analysis

After extracting the metadata into CSV format, the researcher then checks the metadata that has been collected to ensure that there is no incomplete or repeated data. Next, the metadata will be processed using the Biblioshiny application based web browser from Bibliomatrix. While Bibliomatrix is a package in the R program that can be used to analyze various analytical methods needed to carry out bibliometric studies, one of which is Co-Word Analysis. Apart from that, to get a broader picture, researchers also used VosViewer software to get visualization results from the evolution of the ethical dimension in Artificial Intelligence in this research.

Results and Discussion

In general, co-word analysis is based on observing the co-occurrence of two or more keywords or words in indexing text for other publications or documents. Co-word analysis could therefore be applied to many documents. These may be keywords or words from the text itself. To describe the dynamics of knowledge, the co-word analysis method was initially presented. Utilizing measuring methods to assess the power of information in today's scientific society is a typical strategy utilized to comprehend the progress of knowledge. In co-word analysis, "actor network" is a framework for describing knowledge dynamics.(Budiman, 2012)

The main premise of co-word analysis is that keywords extracted from an article can indicate the direction of research, the research topic, or a particular field. When two keywords appear together in an article, it suggests that their respective subjects are linked. The greater co-occurrence of the two terms shows a stronger association between them, which further demonstrates their significance to a specific research topic.(Cambrosio et al., 1993) Co-word analysis is a subset of Bibliometric analysis (Amin et al., 2023) It offers advantages over co-citation and co-author analysis by identifying linkages between subjects in a specific field of research, following the scientific development of a field, and disclosing knowledge in a specific field(Bai &; Li, 2022).

Co-Word analysis takes into account the occurrence of keywords aiming to identify groups of related keywords (Mangalaraj et al., 2023). This quantitative technique helps in understanding the complex relationships between sub-disciplines and finding relationships between them, thus tracing the development of those disciplines (He, 1999). This enables the mapping of correlations between thoughts and ideas discovered by a small number of specialists, such as in bibliometrics. Co-word analysis has been utilized to find underlying study themes and intellectual structures across numerous disciplines or research domains, including Internet of Things.(Misra et al., 2016), information retrieval research (Ding et al., 2001) and SOX-IS research (Mangalaraj et al., 2023).

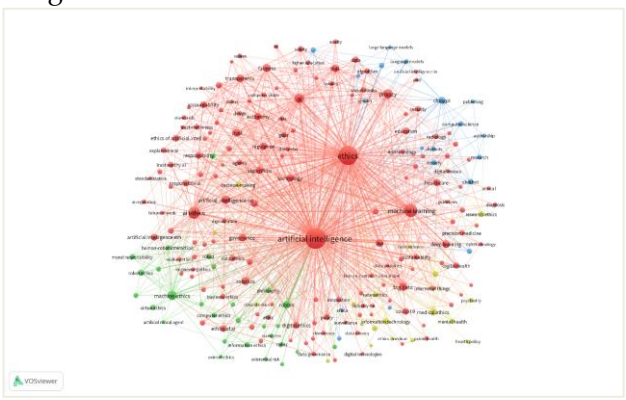
Cluster analysis

Co-word analysis in this study was carried out using the help of Vos Viewer and Biblioshiny software, as mentioned earlier in the research method, after the metadata was successfully extracted into CSV format, then the researcher checked the data for further processing to conduct various analyses. Among them is cluster analysis which can be observed through Co-Accurance analysis by identifying the extent to which two or more keywords or concepts appear together in a text or scientific literature.

Based on hierarchical cluster analysis, a group of closely related terms might reflect the research topic. In hierarchical cluster analysis, keyword classes are created by continually merging the most similar pairs of keywords and quantifying the degree of link between keywords by computing similarities and dissimilarities between target keywords. The keyword pairs were then integrated using a clustering algorithm to analyze similarities or dissimilarities between keywords based on their

connection relationships and to provide a list of all keywords in the research group ordered by similarity. This approach can handle nonlinear data and is applicable to the analysis of binary, categorical, and data with multiple zero-valued dimensions.(Beals, 1984).

In figure 1 below, we can see the size and relationship of each cluster that symbolizes each keyword in relation to one another, as well as how each cluster's hue represents a portion of that cluster. As seen in the image above, there are four clusters that may be recognized by four different hues. The first cluster is a red cluster with 155 terms that appears to dominate the other clusters. In addition, the second cluster is green and contains 28 terms. This cluster is comprised of 19 keywords and comprises of blue distributed at the top and at the bottom. Lastly, the fourth cluster is a yellow cluster positioned at the bottom of the image that contains 19 terms.



Gambar 1. Co-Accurance by Network Visualisation

the first cluster there are a number of keywords that dominate the discussion and the relationship between keywords is interrelated. "Artificial Intelligence" is the most dominating keyword, with 1608 occurrences, and has the highest "link strength" value of 3964. In addition, ethical issues are also a major concern, which is reflected in the keyword "ethics" with 1223 occurrences and a "link strength" value of 3180. Machine learning is also an important aspect of the discussion, albeit with a lower incidence rate, and has a link strength score of 973. AI ethics also emerged strongly, with 243 appearances and a link strength score of 506.

The 2nd Cluster some crucial keywords that appear are the words ethics, machines and robotics which are associated with ethical issues. "Machine Ethics" was the most prominent keyword in the cluster, appearing 105 times with a "link strength" value of 245. This reflects that ethics related to machines and artificial intelligence are major concerns in the literature analyzed. "Robots" is another important keyword with 53 occurrences and 172 link strengths, suggesting that robotics is also becoming a significant issue in the context of machine ethics. In addition, there are keywords related to philosophical aspects such as "philosophy," "consciousness," and "morality," which have link strength values that describe the extent to which these keywords are related in the literature. All of this data provides a strong overview of the research focus and network of relationships between keywords in this cluster, with particular emphasis on ethical and robotics issues.

Furthermore, in 3rd Cluster, a number of keywords appeared that reflected the dominant topics in the literature analyzed. "ChatGPT" is the dominating keyword with 49 appearances and has the highest "link strength" value of 157. This indicates that ChatGPT, perhaps in the context of its use or development, is the center of attention in this cluster. In addition, the keywords "Justice" and "Chatbot" also have a fairly high occurrence, with the value of "link strength" describing strong relationships in literature. The cluster appears to be concerned with topics such as Natural Language Processing, Health Care Health Care, Society Society, Computer Science Computer Science, as well as social aspects such as gender. Overall, these data provide an overview of the diverse topics emerging in this cluster, focusing on ChatGPT and related topics that reflect the network of relationships in the study.

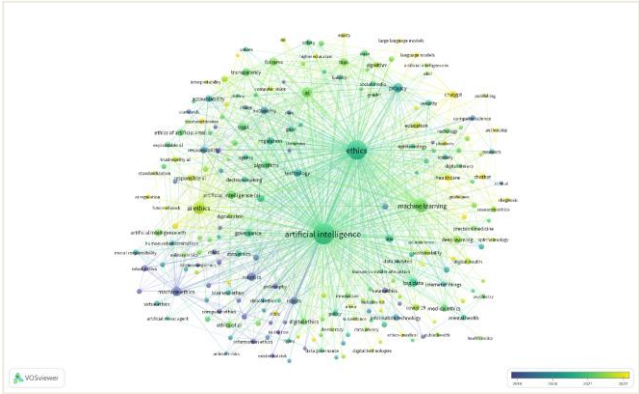
Finally, the 4th Cluster, this cluster highlights a number of keywords related to medical ethics and issues surrounding decision making, as well as topics related to mental health. "Medical Ethics" is the dominating keyword with 47 occurrences and has the highest link strength score of 130. This suggests that medical ethics is a key focus in this cluster. In addition, the keywords "Bioethics," "Decision-Making," and "Research Ethics" also appear with significant frequency, with "link strength" values reflecting strong relationships in

the literature. The cluster appears to deal with issues such as medical ethics, bioethics, decision-making, research ethics, as well as topics in mental health, psychiatry, and psychology. Overall, these data provide an overview of the important topics in this cluster, with an emphasis on medical ethics and related topics.

Tabel 1. 10 top Keywords each cluster

	no	10 keyword teratas	Total occurrences	link strength
1st Cluster 155 Keyword	1	artificial intelligence	1608	3964
	2	ethics	1223	3180
	3	machine learning	313	973
	4	ai ethics	243	506
	5	ai	124	446
	6	privacy	105	428
	7	big data	75	260
	8	fairness	63	246
	9	machine ethics	105	245
	10	robotics	67	236
2nd Cluster 28 Keyword	1	machine ethics	105	245
	2	robots	53	172
	3	philosophy	20	73
	4	consciousness	21	69
	5	autonomous systems	20	68
	6	robot ethics	28	66
	7	moral responsibility	17	51
	8	morality	16	51
	9	human-robot interaction	14	50
	10	moral agency	15	49
3rd Cluster 19 Keyword	1	chatgpt	49	157
	2	justice	18	67
	3	chatbot	17	65
	4	natural language processing	21	61
	5	health care	18	56
	6	society	18	55
	7	research	14	46
	8	chatbots	12	42
	9	computer science	18	37
	10	gender	9	34
4th Cluster 19 Keyword	1	medical ethics	47	130
	2	bioethics	25	77
	3	decision-making	25	74
	4	research ethics	26	63
	5	mental health	17	53
	6	information technology	28	50
	7	decision making	18	48
	8	psychiatry	13	46
	9	neuroethics	17	45
	10	psychology	8	40

It can be seen in Table 1 above that the top 10 keywords are in each cluster, where total occurrence refers to the frequency of occurrence of a keyword in the literature or dataset analyzed. It gives an idea of how often the keyword is used in general in research or literature. The higher the total occurrence of a keyword, the more important or general the keyword is in the field of study concerned (Ding et al., 2001), While the link strength measures the degree to which two terms are related in a research setting. This value indicates the frequency with which two keywords appear in the same document or piece of literature. The greater the strength of the connection between two keywords, the closer their association in literature or study. Link strength analysis identifies correlations and connections between concepts or themes in the analyzed field of study, which can show significant academic trends, possible collaborations, or knowledge networks (Guo et al., 2017).



Gambar 2. Co-Accurance by Overly Visualisation

Figure 2 depicts co-accuracy when viewed from above, as well as the uniqueness of research from 2019 to 2022. The dark blue area suggests that the study topic or phrase has been around since 2019, whilst the lightening towards bright yellow shows that the topic or keyword has only recently begun to be utilized in the final years. Since 2019, ethical challenges in technology have been the subject of discussion, as seen in Figure 6. Even if the term "machine ethics" or "computer ethics" is still used in conjunction with the development of artificial intelligence, the terms "artificial intelligence" and "ethics" began to be used extensively beginning in 2021, and by 2022, the term "AI ethics" was coined.

Word Cloud and Tree Map

After doing an analysis with VosViewer, the researcher attempted to study the sorted metadata with Biblioshiny, a web browser-based program from Bibliomatrix, a package from Program R designed for bibliometric, infometrics or scientometrics.

Gambar 3. Word Cloud

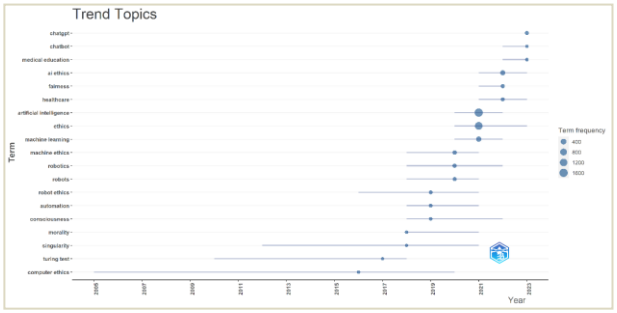
The word cloud in the image above is made based on an analysis of keywords contained in metadata that has been processed before. The size of each word indicates how often it appears in a particular article. It can be seen that the words artificial intelligence and ethics are still the main sentences that most often appear among other keywords.

Gambar 4. Tree Map

Moreover, for a visual comparison of each phrase, the size of each square in the preceding Tree Map is determined by the frequency with which each keyword appears in each article's collected metadata. As in the preceding word cloud, "artificial intelligence" was ranked first with approximately 29 percent of the available keyword data, followed by the word ethics with approximately 22 percent, Machine learning with 6 percent, ai ethics with 4 percent, artificial intelligence with 2 percent, Machine ethics with 2 percent, privacy with 2 percent, and other words with less than 2 percent occurrences.

Trand Topic

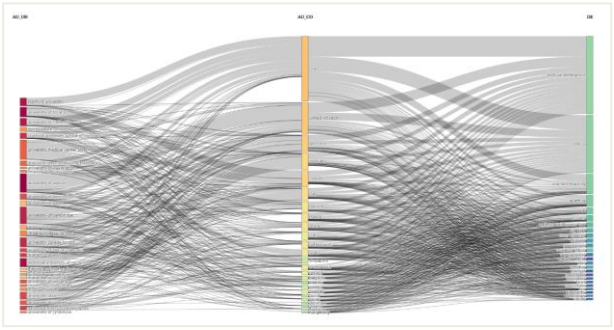
Furthermore, we can also observe topic trends that occur based on keywords in the metadata that has been obtained before.



Gambar 5. Trend Topics

The aforementioned topic trend graph is a spread chart with time on the x-axis and topic on the y-axis. Using the median distribution of events during the period analyzed, the reference year for each subject is determined. To improve the readability of graphs, only the first k subjects are reported in descending order of frequency for each year.(Aria & Cuccurullo, 2017). From mid-2021 until the end of 2022, the terms "artificial intelligence," "ethics," and "machine learning" were popular study subjects, as depicted in the graph above. Additionally, in 2022, the terms "AI ethics," "fairness," and "healthcare" saw an uptick, albeit not as significant as the previous term. In 2023, the most popular subjects will be chatgpt, chatbots, and medical education.

Three field Plots

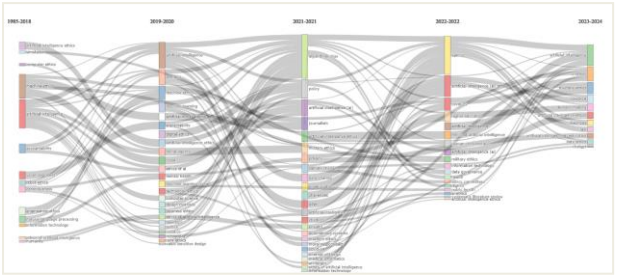


Gambar 6. Three Field Plot

Three Field Plot is one of the visualization methods used in co-word analysis to understand the relationship between keywords in meta data. This plot illustrates the interaction between institute, state, and keyword. This plot can help us understand how the relationship between institutions, countries, and keywords generated in

research relates to the dimensions of ethics and artificial intelligence in literature or research. In the picture of the Three Field Plots above, it can be seen that the US, UK, and Germany are ranked in the top 3 for carrying out research related to the dimensions of ethics and artificial intelligence, while institutions that conduct research related to similar themes are occupied by the University of Oxford, the University Medical Center Utrecht, and the University of Cambridge. The keywords generated are mostly still using the words artificial intelligence and ethics, followed by machine learning and new words that emerged from combining acronyms and the previously popular word AI ethics. By using the Three Field Plot in co-word analysis, we can understand the dynamics and relationships between institutions, countries, and keywords generated in particular research metadata. It is useful for identifying potential collaborations, research trends, and geographical influences in the academic literature.

Knowledge Evolution Analysis

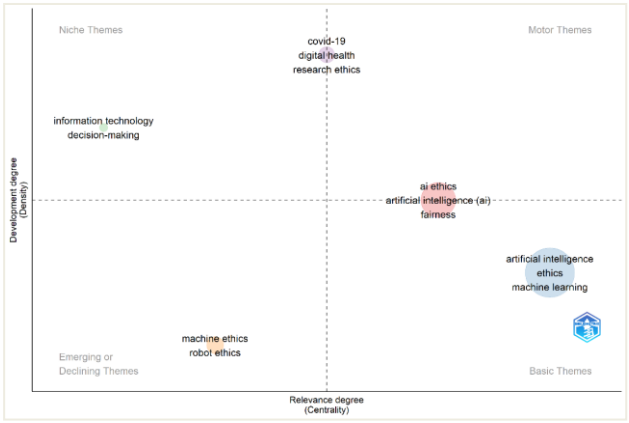


Gambar 1. Thematic Evolution

To find out how the evolution of words formed from year to year, we can look at the picture above, where each word that appears is the result of words taken based on keywords in the results of the co-accurance analysis over a certain period of years. Each segment reflects a key research topic within a given year period and describes the strongest interconnections between nodes in a co-accurance network. The height of the segment indicates how much attention is paid to the topic based on the extent to which the nodes are connected within a given period of years. Channels connecting different segments in different years reflect the amount of co-accurance between two segments and other nodes. Channel width indicates how many research topics in a segment in the previous year had similar relationships with other topics as they progressed to other research the following year. (Leydesdorff & Goldstone, 2014) In the visualization of word evolution above, we can see that word changes in the word artificial intelligence simultaneously persist in experiencing many word mentions since the initial period of the word's formation. While the ethics of artificial intelligence continue to change from time to time, Furthermore, the words ethics and artificial intelligence ultimately continue to give birth to other words or terms and continue to change from period to period.

Tematik map

When co-word analysis is used to map science, groups of keywords (and the relationships between them) are generated. These groups are considered themes (Callon et al., 1991). Each cluster or theme can be represented on a specific plot called a strategic or thematic map (Cobo et al., 2011). Each research theme obtained in this process is then characterized by two parameters: "density" and "centrality"(Cahlik, 2000).



Gambar 2. Thematic Map

In the picture above, the blue circle containing the words artificial intelligence, ethics, and machine learning is on basic themes, which means that these words are quite popular today. While the word in the red circle, namely AI ethics, artificial intelligence (AI), and fairness, is between the quadrant of basic themes and motor themes, which indicates that even the theme is quite popular and is experiencing increased research,

Furthermore, the purple circle consisting of the words COVID-19, digital health, and research ethics is between the pieces Motor Themes and Niche Themes, which means that previously these themes have increased in number but now have begun to decrease and tend to no longer be researched. Furthermore, the green circle precisely in the word information technology and decision-making is in the niche themes quadrant, which indicates that although this theme has increased before, there is still not much research that discusses related to these keywords. Finally, the orange-colored circle with the keywords machine ethics and robot ethics has been in the Emerging or Declining Themes quadrant, which means that these themes have decreased interest. From the thematic map chart above, we can track the movement of research trends over time. This allows us to identify what research themes have been extensively researched to further determine priorities and focus on what research still needs to be studied and explored in more depth.

Conclusions

Based on the Co-word analysis that has been carried out, researchers conclude that research on the ethical dimension in AI has been massive, this can be seen from the total number of occurrences of the words "artificial intelligence" and "ethics" which were mentioned 1608 and 1223 times. Apart from that, these two words have even given rise to new words related to them and have quite a few mentions, namely around 243 times with a power of around 506 mentions. This indicates the urgency and further development of research on the ethical dimension in AI. Furthermore, in this research the researchers found that there were 4 clusters spread out, the first cluster was a red cluster consisting of 155 keywords, the 2nd cluster looked green and consisted of 28 keywords, the 3rd cluster was a blue cluster consisting of 19 keywords, finally the 4th cluster is the yellow cluster and consists of 19 keywords. In first place, the biggest keyword is "artificial intelligence" which dominates the most, with 1608 total accuracy appearances, and has the highest "link strength" value of 3964, followed by the word "ethics" with 1223 total accuracy and "link" value. strength" as many as 3180, machine learning, ai ethics, ai, privacy, big data, fairness, machine ethics, robotics etc. From the word evolution graph, we can see that Artificial Intelligence and the word Ethics are still often mentioned in several literatures, and they even continue to give rise to new terms related to both. The researcher suggests that future researchers can carry out research related to the words "information technology" and "decision-making". As can be seen in the thematic map, both are in the Niche themes quadrant, which indicates that although this theme has experienced an increase previously, there is still not much research that discusses it. related to those keywords.

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