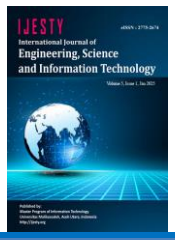
International Journal of Engineering, Science and Information Technology
Volume 5 No. 1 (2025) pp. 446-454
ISSN 2775-2674 (online)
Website: http://ijesty.org/index.php/ijesty
DOI: https://doi.org/10.52088/ijesty.v5i1.1095
Research Paper, Short Communication, Review, Technical Paper



Advancing Startup Ecosystems Through AI-Driven Matchmaking: A Comprehensive Bibliometric Analysis

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The manuscript was received on 11 June 2024, revised on 10 September 2024, and accepted on 24 January 2025, date of publication 2 May 2025

Abstract

This study investigates the integration of AI in streamlining the alignment process between startups and potential collaborators and partners, particularly in the Indonesian startup ecosystem. The motivation behind this research lies in the gaps and challenges startups face in efficiently connecting with suitable partners or investors. We employed a bibliometric analysis approach. This study sourced data from Scopus, analysing 515 articles and 59,412 citations published from 2018 to 2023. Key findings provide insights into the predominant role of AI technologies, notably machine learning methods like deep learning and data mining, and the significance of recommendation systems that incorporate collaborative filtering. Furthermore, the results underscore the increasing importance of AI as an indispensable tool in the startup landscape, enhancing the efficiency and productivity of collaborations. We assessed publications from several countries, authors, and citations through the bibliometric measures to comprehensively understand the current trends and trajectories. The study concludes by recognising the transformative potential of AI in fostering tighter and more efficient alliances within the startup ecosystem, laying the groundwork for future research into refining AI-driven collaborative processes.

Keywords: *Startup, Matchmaking, Artificial Intelligence, Machine Learning, AI-Driven.*

1. Introduction

Indonesia's startup ecosystem has experienced a significant growth spurt in the last decade. This growth has captured national and international attention, positioning Indonesia as the most vibrant startup hub in the Southeast Asian region [1]. Such a thriving environment is driven by several factors, including a rapidly expanding middle-class population, heightened internet penetration, and government initiatives that support startups [2]. Figure 1 delineates how Indonesia, with approximately 2,483 startups, outpaces other Southeast Asian countries, housing more than double the startups of its closest competitor, Singapore.

Despite Indonesia's dominance in the startup scene, startups need help finding the right partners or collaborators. This challenge is magnified by information asymmetry, limited accessibility to relevant data, and a dearth of effective platforms to encourage collaboration.[3] While startups have significantly influenced the shift toward sustainable development, there is an evident research gap concerning their growth patterns, particularly impact-oriented ones. These impact startups play a pivotal role in ushering in and promoting sustainability innovations and stand as not mere businesses but forces for beneficial transformation. Nevertheless, the ways these startups project their market innovations toward sustainability and impact markets still need to be studied [4].

Artificial intelligence (AI)has emerged as a transformative tool across a multitude of sectors [5], [6]. In the startup matchmaking arena, AI presents a variety of benefits. It can analyse vast data sets, identifying potential partners based on various criteria such as industry orientation, business goals, and geographical placement [7]. These algorithms constantly refine their suggestions through machine learning, ensuring startups align with partners, catering to their ever-evolving requirements [8].

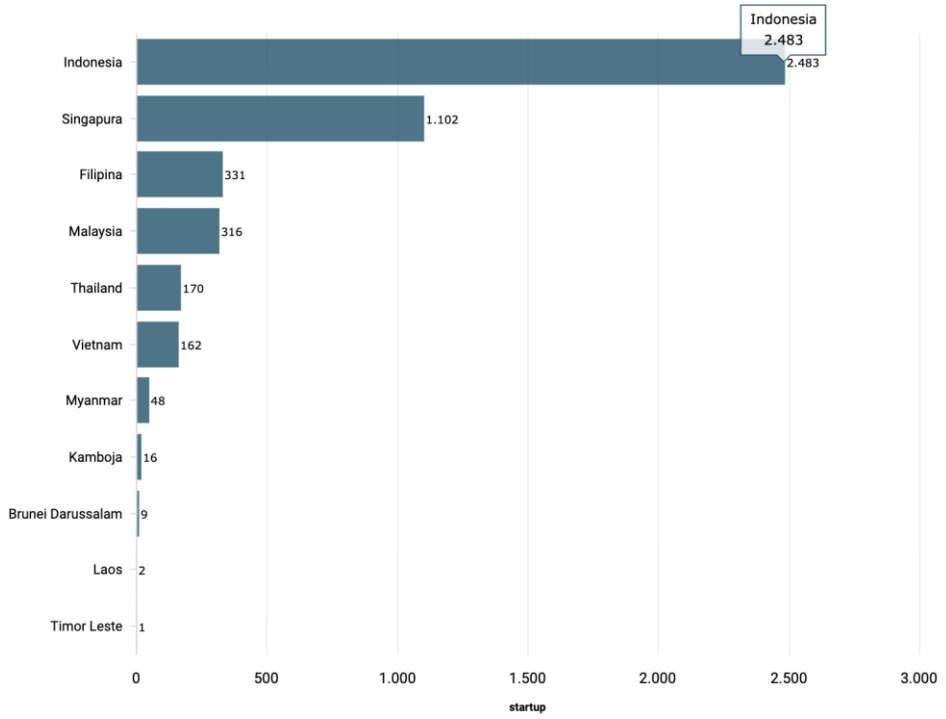

Fig 1. Number of Startups in the Southeast Asia Region (14 June 2023)
Source: databoks.katadata.co.id

In light of AI's potential, this study explores AI's role in augmenting collaboration and partnership avenues for startups. Probe into the transformative trajectory of impact startups and their contribution to navigating markets toward sustainable trajectories. Our research is structured around the following three Research questions:

1. RQ1: What prevalent trends and obstacles exist when matching startups with potential partners or laboratories within the startup ecosystem?
2. RQ2 - tem?
3. RQ3: What does the current landscape of research and knowledge in AI-driven startup matchmaking entail?

This research can potentially address Indonesian startups' pivotal challenge, further advancing the country's burgeoning startup ecosystem. Enhanced matchmaking can quicken the pace of startup growth and spur innovation, job generation, and economic progression. Moreover, as this study aligns with global techno-logical shifts, its implications could resonate beyond the Indonesian context [9].

Bibliometric Analysis is the chosen methodology for its numerous benefits [10]. It provides a holistic perspective of the extant knowledge on AI-driven startup matchmaking, pinpoints existing research voids, employs a data-centric method to chart the research terrain, and helps evaluate research influence and dissemination. Such insights can guide policymakers, entrepreneurs, and researchers in making well-informed decisions [11].

The primary goal of this study is to bridge the discernible gap in startup matchmaking in Indonesia by leveraging the prowess of AI. By addressing the challenges startups face and employing bibliometric Analysis, we hope to proffer valuable insights, advancing Indonesian and global startup ecosystems [12]. The subsequent sections of the paper are structured as follows: Section 2 reviews related works and details our data collection method. Section 3 showcases findings from primary Scopus and Web of Science datasets. Section 4 comprehensively discusses the contemporary state of AI-driven startup matchmaking. Section 5 concludes and provides directions for impending research.

2. Methods

This section provides a comprehensive exploration of the subject matter. The section delves into the intricacies of startup matchmaking, charting its evolution from traditional networking practices to technologically driven methodologies. The section offers an in-depth examination of the role and potential of Artificial Intelligence (AI) in reshaping the startup ecosystem. The section focuses on Machine Learning (ML), illuminating its foundational concepts and relevance in refining matchmaking. Section shifts the focus to recommendation systems, elucidating how they operate and their transformative impact on startup matchmaking. The section introduces a bibliometric analysis to provide a rigorous academic grounding, offering a panoramic view of research patterns, influential works, and emerging trends in this domain.

In business and innovation, startup matchmaking has emerged as a pivotal process. It connects budding startups with potential investors, mentors, partners, or customers [13]. While the traditional approach to achieving this has been rooted in networking events, personal connections, and direct investor meetings, the landscape is shifting [14]. The global surge in entrepreneurial activities has underscored the need for more streamlined and efficient methods. Various platforms and services have come to the fore [15]. These platforms intricately evaluate startups on several fronts. They consider the domain, which pertains to the industry or field the startup operates

within, ensuring a match with investors with a keen interest in that particular area. Another critical parameter is the startup's development stage, be it ideation, seed, growth, or expansion, which can influence the investment or mentorship they require [16]. The geographical preferences of investors, who might be biased towards tech hubs or global opportunities, are also factored in.

Furthermore, the specific needs of a startup, ranging from funding requirements to the type of mentorship sought, play a decisive role in the matchmaking process. The essence of effective matchmaking is undeniably transformative [17], [18]. By fostering the right connections, startups can witness an accelerated growth trajectory, unlocking invaluable resources, mentorship, and opportunities. This evolution from traditional media to a more technologically driven approach is graphically depicted in Figure 2.1, showcasing the paradigm shift ushered in by advancements like artificial intelligence and machine learning. The transformative prowess of Artificial Intelligence (AI) is not just a buzzword; its implications are deeply felt across diverse industries [19],[20].

In healthcare, AI has become instrumental in diagnosing diseases with unprecedented accuracy. Simultaneously, in the financial realm, it has proved invaluable in predicting stock market trends. When applied to startup matchmaking, the potential of AI remains untapped, mainly, but the prospects are tantalisingly promising [21]. AI's core strength in this context lies in its unparalleled ability to recognise patterns. By meticulously analysing vast datasets encompassing startup attributes and investor preferences, AI can discern intricate patterns and emergent trends that might remain elusive to manual scrutiny. Sophisticated algorithms like Decision Trees or Random Forests, powered by AI, categorise startups according to investor preferences [22] [23]. However, the journey with AI also has its challenges. In addition to the existing data privacy issues, there are also possible model interpretation issues. Deciphering how AI models navigate decision-making is critical, especially when significant financial interests are involved [24]. Additionally, the computational weight required by complex AI models requires a robust infrastructure backbone [25].

Machine Learning (ML), often seen as a subset of AI, is a beacon of hope for industries that thrive on data. The allure of ML is its intrinsic ability to learn and evolve [26]. Instead of adhering to rigidly defined parameters, ML models are trained on vast datasets, enabling them to refine their predictions over time [27],[28]. This characteristic has been harnessed in diverse applications, from the realm of image recognition to the nuances of financial forecasting. ML shines in refining and optimising the process when channelled for startup matchmaking. By delving into historical data, ML models can identify patterns that characterise successful matches, providing a foundation to enhance future predictions [29]. The world of ML is vast, encompassing supervised learning, where models are trained on past successful matches to predict future partnerships, and unsupervised learning, where clustering algorithms like K-Means might be employed to group similar startups or investors[30]. However, the path with ML is strewn with challenges. One notable obstacle is overfitting, where a model's quest for accuracy becomes overly tailored to its training data, potentially faltering when exposed to new, real-world data.

The dawn of the digital age has brought recommendation systems to the forefront, especially in the e-commerce and media streaming sectors [31]. These systems, primarily powered by AI and ML, promise personalisation. At their core, recommendation systems operate on two foundational pillars: Collaborative Filtering and Content-Based Filtering. While the former hinges on past user behaviours and decisions to make recommendations, the latter matches items based on their inherent properties and user preferences [32],[33]. In the startup matchmaking arena, this translates to a revolutionary approach. By assimilating the multifaceted needs of startups and juxtaposing them against investor preferences, recommendation systems can suggest matches with a high probability of success. By adopting a hybrid model that synergises collaborative and content-based filtering strengths, recommendation systems are full of challenges. A notable limitation is the cold start problem, where the system, without sufficient data, needs to provide accurate recommendations for new entrants [34].

Bibliometric Analysis is a systematic method to evaluate and interpret publication patterns within a field or subject [35]. Through this Analysis, researchers can glean insights into the most influential works, authors, and trends shaping a domain [36], [37]. In the context of startup matchmaking and its technological underpinnings, a bibliometric analysis can offer a panoramic view of the evolving research landscape. By assessing citation patterns, collaboration networks, and keyword co-occurrence, one can trace the trajectory of research developments, identify knowledge gaps, and predict future research directions [38]. Bibliometric Analysis using VosViewer primarily involves visualising and analysing networks of items such as journals, researchers, or individual papers based on co-citation, bibliographic coupling, co-authorship, or term co-occurrence. Collect bibliometric data from databases Scopus and Web of Science. This dataset includes details like authors, titles, abstracts, keywords, references, and other essential metadata [39]. VosViewer offers a map-based visualisation where items are represented as circles and their relationships as lines. The distance between items indicates their relatedness. Colours can represent clusters of closely related items [40].

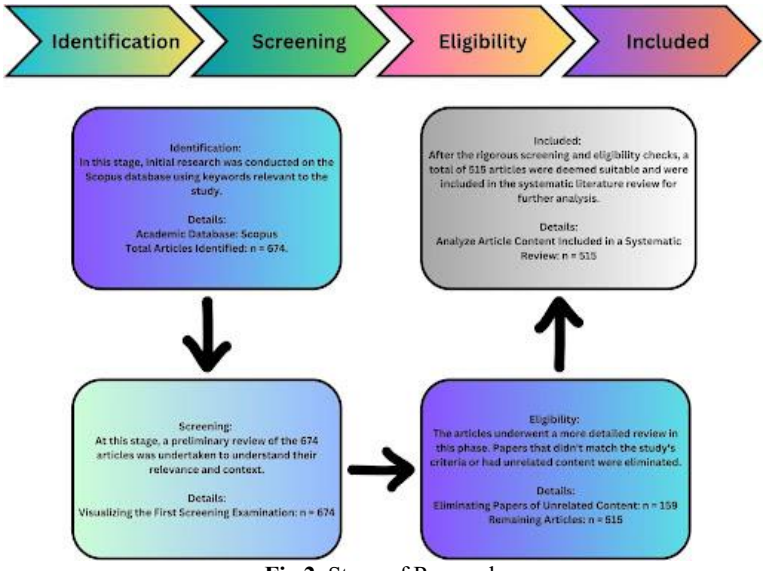

Fig 2. Stage of Research

As depicted in Figure 2, the systematic literature review followed a structured multistage approach to ensure a thorough and systematic exploration of the relevant literature. The process commenced with the Identification phase, during which an initial search was executed on the Scopus database using pertinent keywords related to the study. This search yielded a total of 674 articles. Following this, the Screening stage was undertaken. In this phase, all the 674 articles were subjected to a preliminary review to discern their relevance and context. Each article was meticulously visualised to ensure the initial screening was exhaustive. The subsequent phase was Eligibility, wherein the articles underwent a more intensive assessment. Criteria were established to ensure the relevance and quality of the articles to the study's objectives. Papers that did not align with the study's focus or contained unrelated content were excluded. This rigorous assessment eliminated 159 articles, leaving 515 and 59,412 citations published from 2018 to 2023 for further consideration. Concluding the process was the included phase. After the detailed evaluations in the preceding stages, 515 articles were found to be most fitting and were selected for the systematic review. These articles provided the foundation for the comprehensive Analysis and insights drawn from the research.

3. Results and Discussion

This study emphasises how AI can significantly enhance and optimise aligning startups with potential collaborators and partners. With the extensive literature review undertaken, our focus remains on understanding the transformative potential of AI in facilitating and nurturing startup ecosystems. In this research, we harness the analytical prowess of bibliometric Analysis to delve deep into the evolving landscape of AI-driven startup matchmaking, particularly within the Indonesian context [41]. Bibliometric Analysis, by nature, is a quantitative approach that allows us to assess the breadth and depth of scholarly publications in a specific domain, identifying prevalent trends, seminal works, and notable gaps. Given AI's dynamic and rapidly evolving domain in startup ecosystems, understanding the intellectual landscape becomes pivotal. Our primary goal is to illuminate how AI has been leveraged to foster collaboration among startups and how this can revolutionise the Indonesian startup arena.

Table 1. Distribution of keywords mentioned in the article

Keyword	Occurrences	Total link strength
Machine Learning	20	58
Deep Learning	14	47
Entrepreneurship	15	41
Collaborative Filtering	15	39
Business Model	12	37
Recommendation System	20	33
Startup	13	32
Lean Startup	9	23
Digitalisation	9	23
Digital Transformation	6	21
Startup Ecosystem	3	12

Table 1 presents the distribution of specific keywords mentioned in the analysed articles, as de- rived from VOSViewer. The table categorises the keywords based on their frequency of occurrence and their total link strength. Notably, ”Machine Learning” and ”Recommendation System” appeared 20 times, with the former having the highest total link strength 58. Indicates the prominence of machine learning in the litera- ture, especially considering its interconnectedness with other topics. ”Deep Learning” and ”Entrepreneurship" followed closely with 14 and 15 occurrences, respectively, demonstrating their significance in the scholarly discourse.

Meanwhile, terms like" Collaborative Filtering" and" Business Model" also showed substantial occurrences. Despite its relevance, the term" Startup Ecosystem" had the lowest mention with just three occurrences but had a total link strength of 12, suggesting its emerging importance. In summary, the table offers a structured snapshot of the prevailing themes and their interrelationships within the body of literature, illuminating the pivotal areas of interest and the potential intersections between them.

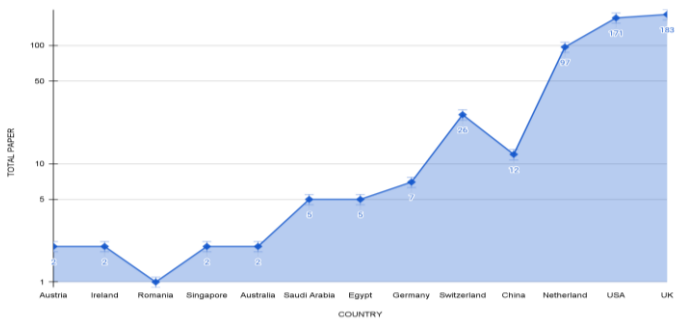

Fig 3. Article distribution by country

The chart in Figure 3 depicts the distribution of papers gathered for bibliometric Analysis, categorised by country. The United Kingdom stands out as the primary contributor, with a substantial 35.5% of the total papers, corresponding to 183. Following closely, the USA has

contributed 33.2%, with 171 papers. The Netherlands emerges as the third most prolific contributor, offering 18.8% or 97 documents to the collection. Switzerland's contribution is 5.0%, while China's is 2.3%. Germany and Saudi Arabia have smaller shares, with 1.4% and 1.0% respectively. The visualisation highlights the predominant roles of the UK and the USA in this bibliometric paper collection, with the Netherlands also making a significant impact. The contributions from other listed countries are comparatively minor.

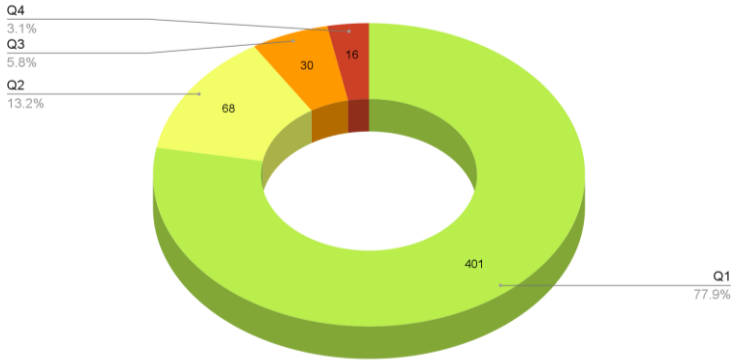

Fig 4. Article distribution based on Scopus quartile

The chart presents the distribution of Scopus-rated papers collected for bibliometric Analysis, segmented based on their repute from Q4 to Q1. Q1 papers dominate the collection with a staggering 77.9%, equating to 515 papers. They were followed by Q2, contributing 13.2% or 68 papers. The contributions of Q3 and Q4 are notably less, with Q3 accounting for 5.8% (30 papers) and Q4 holding 3.1% (16 papers). The visualisation underscores the preponderance of Q1 papers in this bibliometric paper assortment, suggesting a collection predominantly comprised of highly reputed publications. The contributions from Q2 to Q4, while present, are considerably lower in comparison.

3.1. Network Visualisation

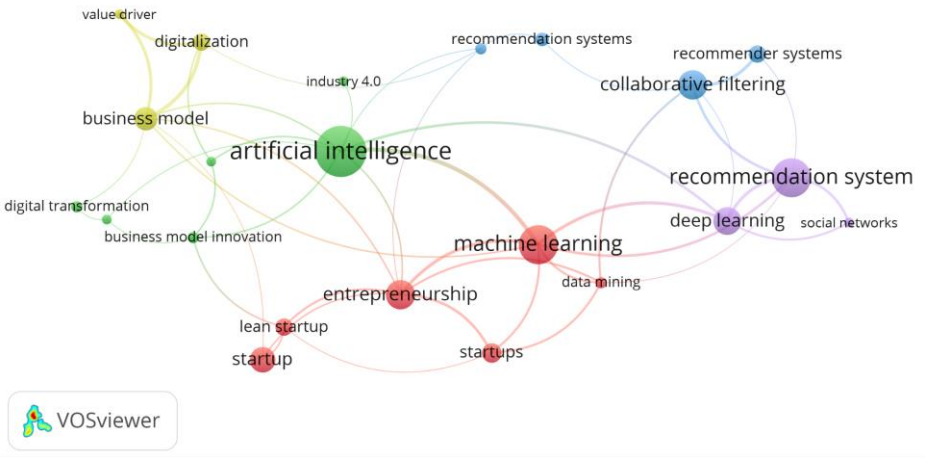

Fig 5. Network Visualisation

The visualisation delineates the interdependencies between AI and current business paradigms. Central is ”artificial intelligence,” interfacing with ”machine learning,” which further bifurcates into ”deep learning” and ”data mining.” ”Recommendation systems,” crucial in e-commerce and social platforms, utilise methodologies like ”collaborative filtering” to discern user-item relations, with ”social networks” signifying the enhancement of these systems through social data. Business adaptations to technological disruptions are represented by ”business model” and ”digital transformation,” while ”business model innovation” suggests strategic adaptations to capture digital-age value. The presence of ”entrepreneurship,” ”startup,” and ”lean startup” illustrates the iterative methodologies emerging businesses adopt.

RQ1: What prevalent trends and obstacles exist when matching startups with potential partners or collaborators within the startup ecosystem?

The startup ecosystem increasingly leverages artificial intelligence, particularly machine learning methods like deep learning and data mining. Recommendation systems, especially in e-commerce and social platforms, have become central, using collaborative filtering to determine user-item relations. Suggests that startups can benefit from integrating such systems for efficient matchmaking. Social networks further boost these systems, providing richer data and insights. However, the rapid pace of the digital landscape poses

challenges, necessitating continuous adaptation and innovation, as highlighted by ”digital transformation” and ”business model innovation [42],[43].

3.2. Overlay Visualisation

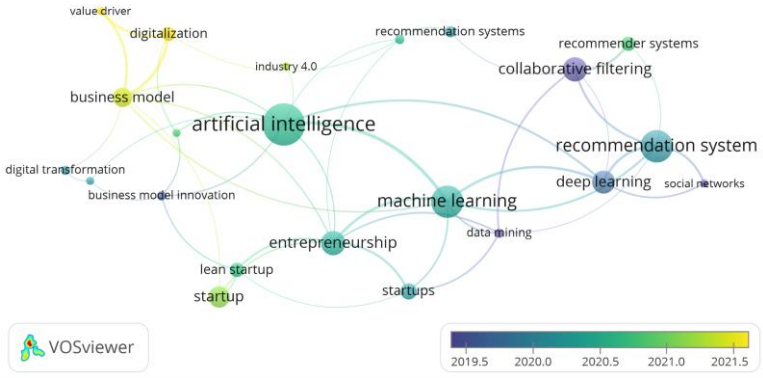

Fig 6. Overlay Visualisation

From 2019 to 2021, this visualisation portrays the evolution and interrelation of AI technologies and business innovations. ”Artificial intelligence” remains central, linking to ”machine learning” and its further branches: ”deep learning” and ”data mining [44],[45].” These technologies potentiate ”recommendation systems,” optimised via ”collaborative filtering” and integrated into ”social networks.” Concurrently, ”digital transformation” and ” digitalisation” reflect the industry's shift to digital operations. The significance of reinventing business strategies is depicted through ”business model innovation,” while the prominence of ”entrepreneurship” and ”startups” indicates a burgeoning entrepreneurial landscape.

RQ2: How can AI be harnessed to enhance the matchmaking process for startups in this dynamic ecosystem?

Through machine learning and its subsets, AI can analyse vast data to pinpoint patterns, facilitating precise matches between startups and collaborators. AI-driven recommendation systems can offer custom-tailored suggestions by analysing historical data, market trends, and individual preferences. Collaborative filtering is an effective technique in these systems for understanding user-item dynamics. Furthermore, integrating these systems within social networks can tap into social data, refining matchmaking.

3.3. Density Visualisation

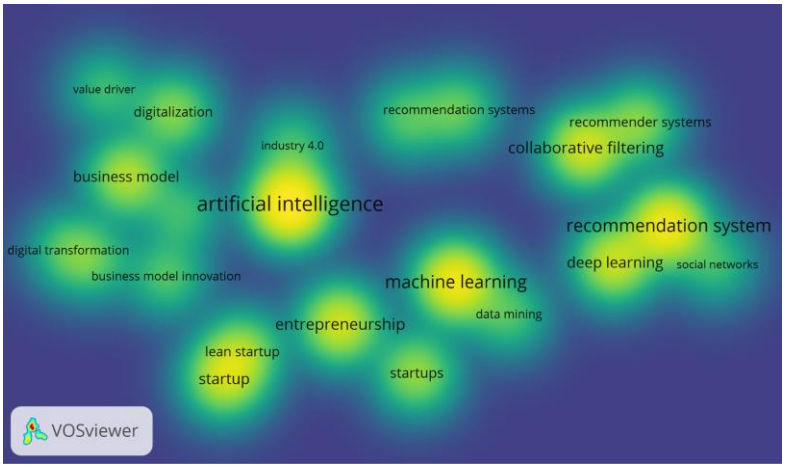

Fig 7. Density Visualisation of Keywords

This schematic provides a consolidated representation of primary tech-business concepts." Artificial intelligence" is the focal point, connected to" machine learning," which diverges into domains like ”deep learning” and ”data mining” [46]. Adjacent to this tech core is ”recommendation systems," emphasising the role of ”collaborative filtering" in enhancing user experiences within" social networks."” Digital transformation” and" digitalisation” highlight the industry's digital pivot. ”Business model" and" business model innovation" elucidate shifts in operational paradigms. Entrepreneurial lexemes" startup,"" lean startup,” and" entrepreneurship" underscore the ascent of innovative business practices in this digital epoch [47].

RQ3: What does the current landscape of research and knowledge in AI-driven startup matchmaking entail?

Research in AI-driven startup matchmaking revolves around the intersection of artificial intelligence and business. The emphasis is on using machine learning techniques to optimise recommendation systems, which are pivotal in determining potential matches.

Collaborative filtering remains a primary methodology in this domain. The evolution towards digital-centric strategies and operations is evident, emphasising the need for continuous innovation. Entrepreneurial terms focus on methods and strategies optimised for the modern digital business environment [48].
The provided visualisation represents a density map, showcasing the prominence and interlinkages of various authors within a specific field of research or topic. This type of visualisation is commonly used in bibliometric analyses to depict the interconnectedness and influence of documents or authors within a particular knowledge domain.

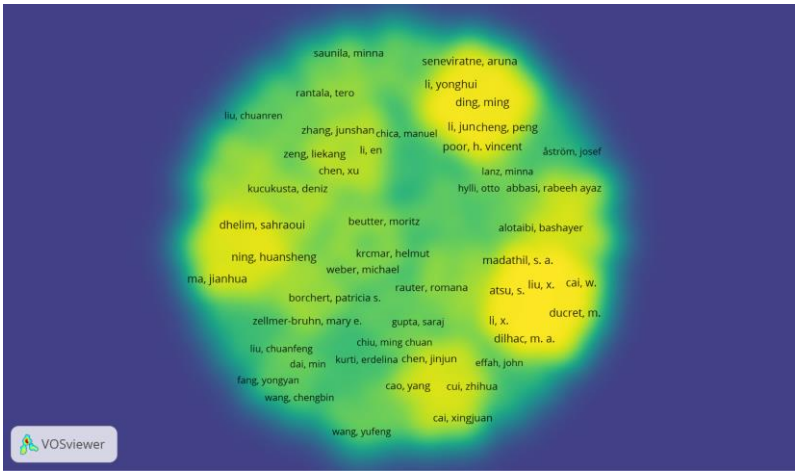

Fig 8. Density Visualisation of Authors

In Figure 8, various author names are distributed across a gradient of colours, from more astounding to warmer tones. Warmer colours, such as yellow and orange, indicate areas with higher densities of link strengths, suggesting these authors or documents have more significant influence or are frequently cited in the field. Conversely, more incredible colours, like shades of blue and green, denote lesser influence or fewer connections [49].
Central to the visualisation, authors like 'li, yonghui,'' ding, ming,' 'li, punching, Peng,' and' Poor, H. Vincent appears to be in areas with a brighter hue, indicating that their works are particularly influential and possess a high total link strength in this domain. Surrounding these central figures are other authors who, while still impactful, might have less influence than the central nodes. The tool used for this visualisation, as indicated at the bottom, is VOSviewer, a popular software for creating maps based on network data known for its utility in bibliometric analyses.
AI's transformative role, especially in the Indonesian startup ecosystem, is evident from our findings. While AI's application in business has been widely studied, the unique nuances within the startup landscape present a fresh perspective. Through bibliometric Analysis, the research underscores the dominance of machine learning techniques, with a particular emphasis on deep learning and data mining [50],[51]. The integral role of AI-powered recommendation systems in bolstering effective partnerships becomes clear. The insights also underscore startups' need to leverage AI for comprehensive due diligence, harness the synergies between AI and social platforms, and integrate AI throughout their operations to navigate dynamic market conditions effectively.

4. Conclusion

This research highlights the transformative potential of AI in optimising the alignment process between startups and potential collaborators and partners. Using bibliometric Analysis, the pivotal role of AI, especially machine learning techniques such as deep learning and data mining, in the startup ecosystem was revealed. Furthermore, recommendation systems utilising collaborative filtering are now central to enabling efficient interactions between startups and potential partners or investors.
The observed trends show that AI is fundamental in the startup ecosystem, enhancing efficiency and effectiveness. As digital transformation accelerates, startups face the challenge of continuous innovation, and AI emerges as a crucial solution. Given Indonesia's rapidly growing startup scene, the potential for AI adoption is increasing, paving the way for local startups to forge stronger collaborations with global partners and ensure sustainable growth locally.
While the literature has emphasised the potential of AI in recommendation systems and collaborative filtering, there is a need to explore further how AI can support startups during the due diligence process. The melding of AI with social networking platforms remains a promising yet under-researched area. Upcoming research should focus on pioneering AI techniques that refine the matchmaking process between startups and collaborators. It should also investigate how AI can guide startups in evolving their business models in response to dynamic market demands.

Acknowledgement

We sincerely thank the University of Raharja, Satya Wacana Christian University, and Alphabet Incubator for their unwavering support and valuable contributions throughout this research journey. The guidance, resources, and insights provided by these esteemed institutions have been instrumental in shaping the direction and depth of our study.

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