Uncovering Global Trends in Internet of Behaviors (IoB) Research through Bibliometric Analysis

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Article Info	ABSTRACT
	The Internet of Behaviors (IoB) represents an emerging multidisciplinary field that integrates technology, data analytics, and behavioral science to influence and understand human actions through digital interactions. This study conducts a bibliometric analysis to uncover global research trends in IoB, highlighting its evolution, key themes, and emerging areas of interest. The analysis, based on publications from 2001 to 2024, reveals the central role of technological advancements such as artificial intelligence and IoT in driving IoB research. Key applications include personalized marketing, healthcare optimization, and smart city development, while ethical and privacy concerns remain critical challenges. India is identified as a leading contributor and global hub for IoB research, with significant international collaborations. Despite its rapid growth, gaps exist in understanding the long-term societal impacts of IoB and its applicability in underrepresented regions. This study emphasizes the need for interdisciplinary research, ethical governance, and inclusive collaboration to maximize IoB's potential for innovation and societal benefit.

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1. INTRODUCTION

The Internet of Behaviors (IoB) represents a cutting-edge intersection of technology, data analytics, and behavioral psychology, offering unprecedented insights into human behaviors through the lens of digital interactions. Originating from Gartner's prediction as one of the top tech trends of the 2020s, IoB leverages data collected from various sources including social media, location tracking, and Internet of Things (IoT) devices to influence behavior in targeted ways [1]. This convergence facilitates a deeper understanding of how individual and collective actions align with digital habits, potentially transforming numerous sectors including marketing, healthcare, and urban planning.

The potential of IoB is vast, ranging from enhancing customer experiences to optimizing health interventions based on

personal behavior patterns. For instance, companies can tailor marketing strategies with unprecedented precision, while healthcare providers can nudge patients towards healthier lifestyle choices through personalized feedback loops [2]. Such applications underscore IoB's capacity to bridge the gap between digital footprints and real-world outcomes, making it a focal point for stakeholders seeking to harness data-driven insights.

However, the proliferation of IoB also raises significant ethical and privacy concerns. The manipulation of behavior through data can lead to scenarios where user consent and data security are compromised [3]. This is particularly sensitive in regions with stringent data protection laws, such as the European Union's GDPR framework, which mandates strict guidelines on personal data usage. The ethical implications of deploying IoB solutions without robust privacy safeguards are a major consideration for researchers and practitioners alike.

Despite these challenges, the academic interest in IoB has surged, as evidenced by the growing number of publications and research projects focused on this domain. A bibliometric analysis of existing literature can provide a structured overview of the field's development, key themes, and gaps in research. This analysis is crucial not only for mapping the trajectory of IoB research but also for identifying influential studies and emerging trends that could shape future directions in the field.

While IoB's potential is widely acknowledged, there is a lack of comprehensive synthesis of the global research trends within this domain. The existing literature is dispersed across multiple disciplines, making it challenging to grasp the full scope and depth of IoB studies. Additionally, the rapid evolution of digital technologies outpaces the scholarly understanding of the implications of IoB, resulting in a gap between current practices and academic insights. There is a need for a systematic examination of the literature to consolidate knowledge, identify prevalent research methodologies, and highlight the ethical considerations that govern the field.

This study aims to conduct a comprehensive bibliometric analysis of the global research trends in Internet of Behaviors (IoB). The objective is to map the intellectual structure of the field, identify the most influential studies, and delineate the thematic evolution of the research. This analysis will provide a consolidated view of the academic landscape of IoB, offering insights into how it has developed over time and highlighting potential directions for future research.

2. LITERATURE REVIEW

2.1 Evolution and Scope of Internet of Behaviors (IoB)

The Internet of Behaviors (IoB) extends the concepts underpinning the Internet of Things (IoT) by integrating data analytics into behavioral science, creating a comprehensive framework that informs user interactions with technology [4]. According to Gartner, IoB is an evolutionary step beyond IoT, where not only are devices interconnected, but the data they generate is used to influence behavior in a targeted and context-aware manner [5]. This evolution marks a significant leap in how data can be utilized, emphasizing predictive analytics and personalized user experiences. Studies such as those by [6] highlight the dual utility of IoB in both commercial and public sectors, showcasing its broad applicability from smart city deployments to personalized marketing campaigns. These implementations demonstrate the versatility of IoB in leveraging behavioral data for diverse applications, including health promotion, environmental sustainability, and consumer behavior management.

2.2 Key Technologies Driving IoB

IoB's operational backbone is supported by a range of technologies

including artificial intelligence (AI), machine learning (ML), and big data analytics. AI and ML play pivotal roles in processing and making sense of large datasets that IoB applications generate, providing insights that are not discernible through traditional data analysis methods [5]. For instance, big data analytics can identify patterns in user behavior that predict future actions, thus allowing organizations to tailor their strategies accordingly. Blockchain technology also contributes significantly to IoB by ensuring data integrity and security, critical aspects given the sensitive nature of behavioral data [7]. With blockchain, data transactions are transparent and tamper-proof, which is essential for maintaining user trust, a crucial component in the widespread adoption of IoB solutions.

2.3 Applications and Impact of IoB

The applications of IoB are manifold, with significant impacts observed across various domains. In marketing, companies like Amazon and Netflix use IoB strategies to recommend products or content based on user behavior patterns, enhancing customer satisfaction and engagement [8]. In healthcare, IoB is used to monitor patient behaviors and improve treatment adherence, which is particularly useful in chronic disease management [6]. Furthermore, the implementation of IoB in smart cities for traffic management and energy use optimization demonstrates its potential to contribute to sustainable urban development [9]. These applications not only show the practical uses of IoB but also underscore its potential to drive significant societal and economic benefits.

2.4 Ethical, Legal, and Social Implications

The pervasive nature of IoB raises substantial ethical, legal, and social concerns, particularly related to privacy and surveillance. The balance between behavioral insight and consumer privacy is a contentious issue, as the potential for misuse of sensitive personal data is high [6]. The ethical considerations involve ensuring that IoB deployments are transparent and that individuals are aware of and can control the data they generate. Legal frameworks like the General Data Protection Regulation (GDPR) in the EU provide guidelines and obligations for data protection that are particularly relevant to IoB implementations. These regulations mandate that data collectors maintain transparency about how behavioral data is used and provide users with the option to opt-out of data collection, ensuring a level of user control over their information.

3. METHOD

This study employs a bibliometric analysis to systematically review and synthesize existing research on the Internet of Behaviors (IoB). We will extract data from Scopus database, using specific search terms related to IoB such as "Internet of Behaviors," "IoT and behavior," "digital behavior analytics," and "behavioral data applications." The selected publications will span from the inception of the term up until the present to capture the full scope of the literature. VOSviewer software will be used for citation analysis and to visualize the network of research collaborations and keyword occurrences. This approach will allow us to map the intellectual landscape of IoB research, identify major themes, trends, and gaps in the literature, and understand the evolution of the field over time.

4. RESULT AND DISCUSSION

4.1 Results

a. **Bibliometric Overview**

Table 1. Bibliometric Overview

Metrics Data	Information
Publication years	2001-2024
Citation years	23
Papers	96
Citations	541
Cites/year	22.35
Cites/paper	5.35
Cites/author	208.62
Papers/author	38.57
Authors/paper	3.27
h-index	3.57
g-index	14
hI,norm	20
hI,annual	7
hA, index	0.30
Paper with ACC >=	1,2,5,10,20:53,39,17,12,1

Source: Output Publish or Perish, 2024

The bibliometric overview provides a quantitative summary of the Internet of Behaviors (IoB) research landscape from 2001 to 2024, encompassing 23 years of citation data. During this period, 96 papers were published, collectively accruing 541 citations, with an average of 22.35 citations per year and 5.35 citations per paper. The data reveals active collaboration, with an average of 3.27 authors per paper and individual authors contributing an average of 38.57 papers. Key bibliometric indicators include an h-index of 3.57, reflecting that at least 3 papers have received 3 or more citations, and a g-index of 14, indicating that the top 14 papers received a cumulative 196 citations. Normalized metrics, such as the hI,norm (20) and hI,annual (7), suggest steady citation performance over time. The hA index, a measure of authorship impact, is relatively low at 0.30, indicating limited high-impact authorship concentration. Furthermore, the distribution of highly cited papers shows 53 papers with at least 1 citation, 39 with 2 citations, 17 with 5 citations, 12 with 10 citations, and only 1 paper exceeding 20 citations, suggesting a research field in its growth stage with few seminal works achieving high impact.

b. **Citation Analysis**

Table 2. Most Cited Article

Citations	Author and Year	Title
43	[10]	Internet of Behaviours (IoB) and its role in customer services
39	[11]	The Personal Health Applications of Machine Learning Techniques in the Internet of Behaviors
38	[12]	Machine Learning-Enabled Internet of Things (IoT): Data, Applications, and Industry Perspective
37	[13]	Digital twin generation: Re-conceptualizing agent systems for behavior-centered cyber-physical system development
32	[14]	A MEC Offloading Strategy Based on Improved DQN and Simulated Annealing for Internet of Behavior

Citations	Author and Year	Title
31	[3]	Internet of Behaviour (IoB)-based AI models for personalized smart education systems
21	[6]	Towards an Advanced Deep Learning for the Internet of Behaviors: Application to Connected Vehicles
21	[15]	Designing Internet of Behaviors Systems
21	[16]	The Internet-of-Behavior as Organizational Transformation Space with Choreographic Intelligence
19	[7]	A Tutorial on Internet of Behaviors: Concept, Architecture, Technology, Applications, and Challenges

Source: Output Publish or Perish, 2024
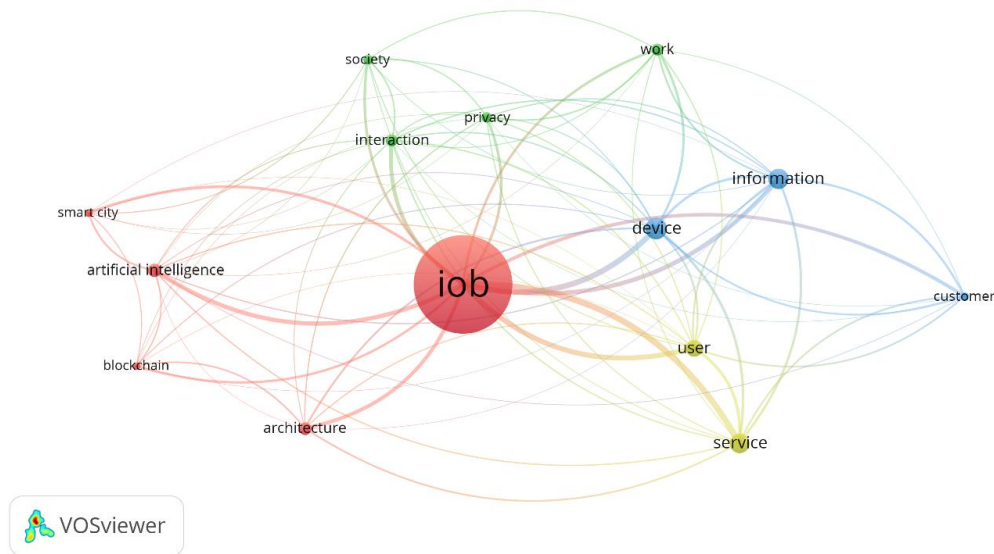
c. Keyword Co-Occurrence Network

Figure 1. Network Visualization
Source: Data Analysis, 2024

The visualization highlights "IoB" (Internet of Behaviors) as the central node in the network, indicating its dominant role as the primary research focus in this field. The size of the "IoB" node signifies its significant weight, reflecting frequent occurrence and strong connections with various subthemes. This central positioning shows that IoB serves as the conceptual hub around which all other related topics revolve. The dense network of links radiating outward from "IoB" indicates its multidisciplinary nature, with studies drawing upon diverse areas such as technology, user behavior, and data management.

Several prominent subtopics are closely linked to IoB, such as "artificial intelligence," "device," "privacy," "smart city," and "service." These nodes represent the major domains where IoB research is actively applied or studied. For instance, "artificial intelligence" and "smart city" highlight the technological and urban development aspects of IoB, emphasizing how data from interconnected devices and systems is leveraged for decision-making and optimization. Similarly, the connection between "privacy" and "user" underscores critical ethical considerations in IoB research,

particularly concerning user data protection and behavior tracking.

The network shows strong relationships between key nodes, such as "device," "information," and "user," forming a tightly interconnected cluster. This suggests that much of the IoB research focuses on understanding how devices collect, process, and transmit information to influence user behavior. Additionally, links to "architecture" and "blockchain" indicate a focus on the structural and security frameworks that underpin IoB systems. The diverse connections suggest a holistic approach in IoB studies, combining technical, behavioral, and social perspectives.

The nodes "society," "interaction," and "work" are smaller but well-connected, pointing to emerging trends in IoB research. These themes suggest increasing interest in the societal implications of IoB, such as how it affects workplace dynamics and human interaction. The inclusion of "customer" and "service" further indicates applications in consumer behavior and service personalization. The network also reveals significant interdisciplinary collaboration, as IoB research spans fields such as artificial intelligence, blockchain, smart city design, and behavioral sciences.
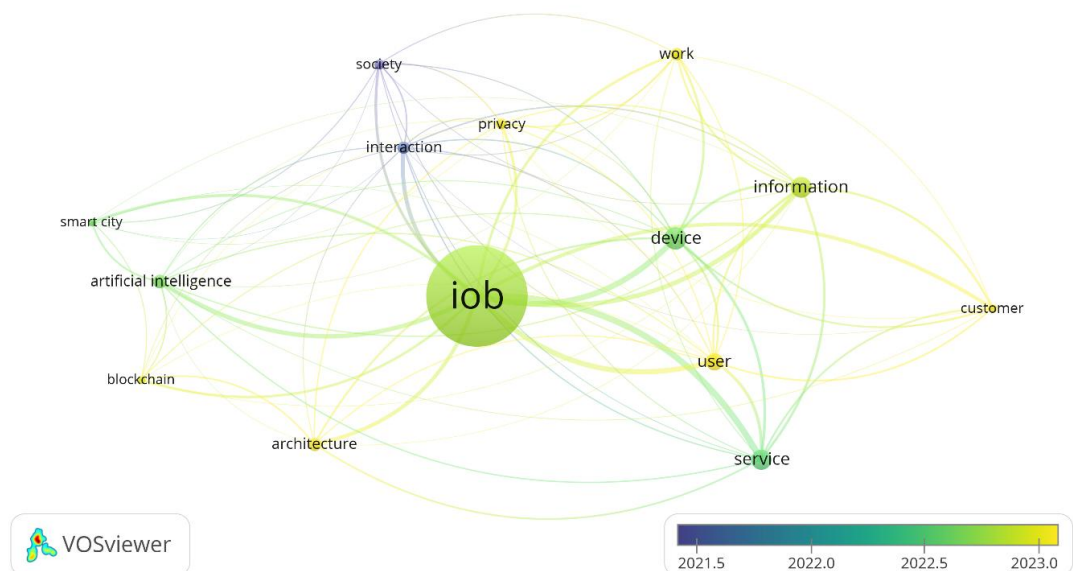

Figure 2. Overlay Visualization
Source: Data Analysis, 2024

This visualization adds a temporal dimension to the bibliometric network, showcasing the evolution of research on the Internet of Behaviors (IoB) from 2021 to 2023. The gradient coloring of nodes and links indicates the recency of focus, with lighter colors representing more recent studies. Core topics like "IoB," "device," and "user" remain central throughout the timeline, reflecting sustained interest in these foundational themes. Emerging nodes such as "work," "society," and "interaction" are lighter in color, suggesting a growing focus on societal and workplace applications of IoB research in recent years.

The prominence of "service," "information," and "customer" in the

network, especially in lighter hues, highlights the increasing relevance of IoB in customer behavior analysis and personalized service delivery. Similarly, the rise of "privacy" and "interaction" suggests that concerns over ethical data use and user engagement strategies are becoming more prominent in IoB studies. The connection between "work" and "device" further underscores the role of IoB in shaping digital workplace environments, reflecting a shift toward real-time behavior analysis for productivity and collaboration.

Nodes such as "artificial intelligence," "smart city,"

"blockchain," and "architecture" represent technological and structural foundations supporting IoB. Although these topics are shaded darker, indicating earlier focus periods, their continued connections with the central IoB node highlight their importance in enabling IoB systems. The integration of AI and blockchain remains pivotal for data analysis and security, while the focus on "smart city" and "architecture" shows ongoing research into IoB applications in urban environments and system design.
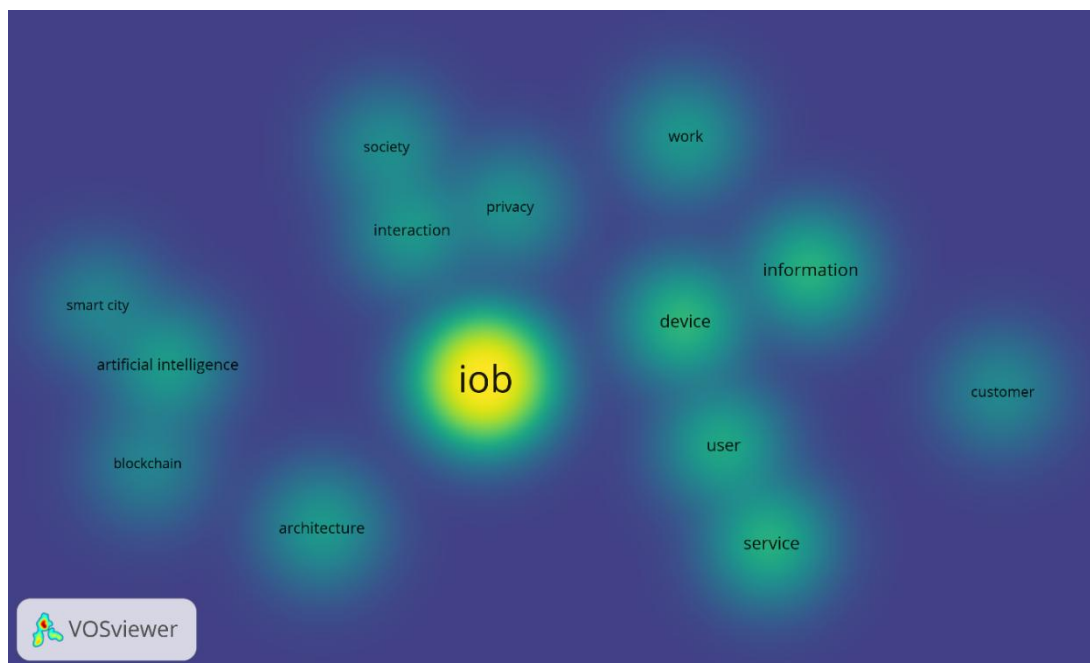

Figure 3. Density Visualization
Source: Data Analysis, 2024

This heatmap visualization provides a density-based representation of the research focus within the Internet of Behaviors (IoB). The central "IoB" node is shown with the highest intensity, signifying its dominant role and frequent occurrence across studies. The bright yellow core around "IoB" reflects its strong interconnectedness with other topics and its centrality in the

research domain. Surrounding this core, moderate-density areas such as "device," "user," "information," and "service" suggest these subtopics are closely associated with IoB, indicating that much of the research explores how IoB interacts with user behavior, data processing, and service personalization.

In the outer layers, topics such as "society," "interaction,"

"privacy," "smart city," "artificial intelligence," and "blockchain" appear with lower densities, indicating they are secondary but important areas of focus. These topics reflect specialized applications or foundational technologies supporting IoB. For example, "privacy" and "society" highlight the ethical and social implications of IoB, while "blockchain" and "artificial intelligence" suggest technological underpinnings critical for data security and processing. This heatmap illustrates the multidisciplinary nature of IoB research, with central themes maintaining strong focus while related topics expand into broader applications and ethical considerations.
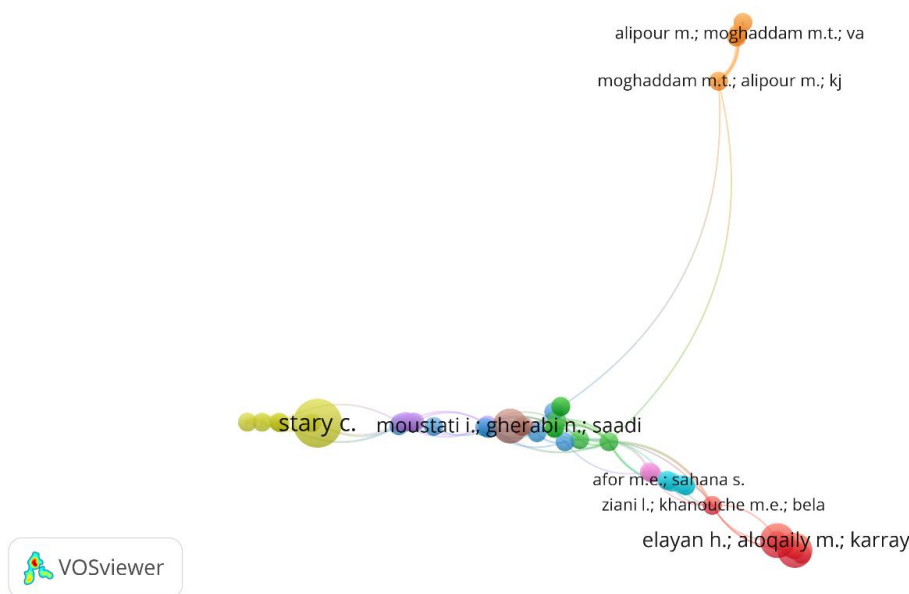
d. Co-Authorship Network

Figure 4. Author Visualization
Source: Data Analysis, 2024

This co-authorship network visualization highlights the collaboration patterns among researchers in the Internet of Behaviors (IoB) field. The nodes represent individual authors, and the connecting links indicate collaborative relationships, with the size of the nodes reflecting the influence or productivity of each author. Prominent clusters, such as the orange and red groups, reveal tightly-knit collaborative networks, suggesting a concentration of research efforts among specific teams, such as those led by authors like Alipour M. and Moghaddam M.T. Additionally, the distribution of smaller, isolated clusters, such as those near Stary C. and Saadi, indicates independent research efforts or limited collaboration between these groups and others. This network emphasizes the importance of key contributors while also revealing opportunities for greater interdisciplinary and intergroup collaboration within the IoB research community.
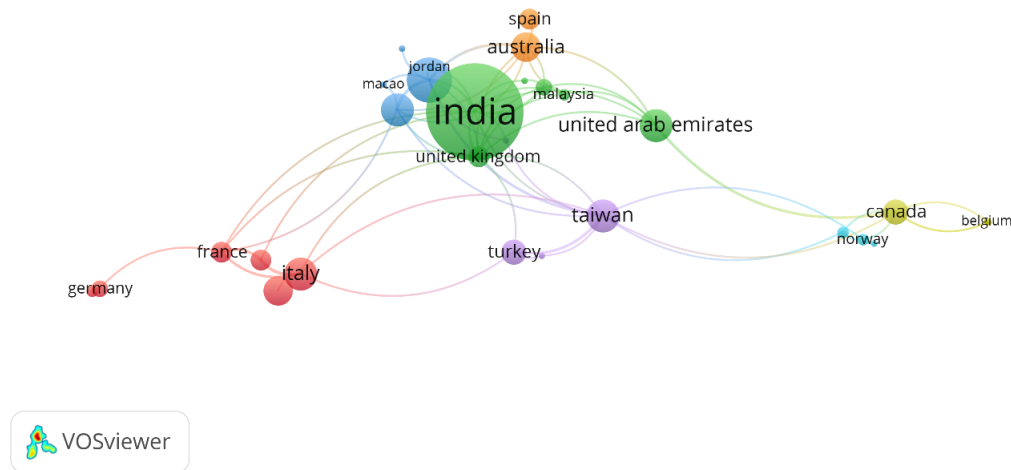
Figure 5. Country Network Visualization
Source: Data Analysis, 2024

This country collaboration network illustrates the geographic distribution and research collaboration patterns in the field of the Internet of Behaviors (IoB). The size of the nodes represents the research contribution or activity of each country, with India standing out as the largest and most central node, indicating its significant role in IoB research and its extensive collaborations with other countries. Countries such as the United Arab Emirates, Australia, and the United Kingdom are also prominent, reflecting their active participation and strong connections with India and other nations. Clusters like those of Italy, France, and Germany suggest regional collaboration trends within Europe, while Canada, Norway, and Belgium exhibit smaller but active connections. The visualization highlights the global nature of IoB research, with India serving as a key hub, fostering both regional and international collaboration. These patterns underscore the interdisciplinary and cross-border dynamics critical to advancing IoB research globally.

4.2 Discussion

a. Emerging Trends in Internet of Behaviors (IoB) Research

The bibliometric analysis reveals that the Internet of Behaviors (IoB) is an emerging and rapidly evolving field, characterized by multidisciplinary applications and growing academic interest. As observed in the visualization of keyword co-occurrence, IoB research spans diverse domains such as artificial intelligence, smart cities, privacy, and user behavior, highlighting its versatility. Central themes such as "device," "information," and "user" indicate a strong focus on the technological and human dimensions of IoB, reflecting its potential to bridge behavioral insights with technological advancements.

One prominent trend is the integration of IoB with artificial intelligence (AI) and big data analytics. These technologies underpin many IoB applications, from personalized marketing strategies to predictive analytics in healthcare and urban planning. This focus is consistent with prior studies emphasizing the value of AI-driven behavioral insights in optimizing

services and influencing user behavior [17]. Similarly, the prominence of "smart city" as a keyword underscores the increasing use of IoB in urban environments, where behavioral data is leveraged to improve traffic management, energy efficiency, and public services.

b. **Regional Collaboration and Research Output**

The country collaboration analysis highlights India's dominant position in IoB research, both as a leading contributor and as a hub for international collaboration. The strong ties between India and countries like the United Kingdom, the United Arab Emirates, and Australia demonstrate the global nature of IoB research and its reliance on cross-border partnerships. This finding aligns with the broader trend of globalization in science, where collaboration across geographic and disciplinary boundaries drives innovation. The visualization also highlights regional collaboration patterns, particularly within Europe, where countries like Italy, France, and Germany exhibit strong connections. These patterns suggest that regional proximity and shared research priorities play a significant role in fostering collaboration. However, the relatively smaller nodes representing countries like Canada, Norway, and Belgium indicate the potential for more active participation from these regions. Encouraging broader participation and fostering global partnerships could further enhance the diversity and impact of IoB research.

4.3 *Ethical and Privacy Implications*

A recurring theme in IoB research is the ethical and privacy challenges associated with behavioral data collection and analysis. Keywords such as "privacy" and "interaction" emphasize the need to address these concerns, particularly as IoB systems become more pervasive. The ethical implications of IoB are multifaceted, encompassing issues such as informed consent, data security, and the potential misuse of behavioral insights to manipulate users. The European Union's General Data Protection Regulation (GDPR) provides a framework for addressing these challenges, but the global nature of IoB research necessitates harmonized international standards. The focus on "society" as a keyword further highlights the broader societal implications of IoB. As IoB technologies increasingly influence decision-making processes, there is a growing need to ensure that these systems are transparent, equitable, and inclusive. Future research should prioritize developing ethical guidelines and technical solutions to mitigate privacy risks while maximizing the societal benefits of IoB.

4.4 *Applications and Practical Implications*

The bibliometric analysis highlights the wide-ranging applications of IoB, from personalized marketing and healthcare to smart cities and workplace optimization. The prominence of keywords such as "customer," "service," and "work" underscores the practical relevance of IoB in enhancing user experiences and improving organizational efficiency. For example, IoB systems can analyze customer behavior to deliver personalized recommendations, improving satisfaction and loyalty [8]. In the workplace, IoB technologies can monitor employee behavior to optimize workflows and enhance productivity.

The visualization also reveals emerging areas of interest, such as the

role of IoB in promoting sustainable behaviors and improving public services. For instance, IoB systems in smart cities can encourage residents to adopt environmentally friendly practices by providing real-time feedback on energy consumption or waste management. These applications demonstrate the potential of IoB to address pressing societal challenges, from climate change to public health.

4.5 Research Gaps and Future Directions

Despite the growing interest in IoB, several research gaps remain. The bibliometric analysis indicates a lack of comprehensive studies on the long-term societal impacts of IoB, particularly in terms of ethical governance and policy implications. While technological advancements have driven the development of IoB systems, there is a need for interdisciplinary research that integrates insights from behavioral science, ethics, and law to address these challenges holistically. Another gap is the limited focus on underrepresented regions and communities in IoB research. While countries like India, the United States, and the United Kingdom are prominent contributors, there is relatively little research from developing regions, where IoB could have significant societal and economic impacts. Expanding the geographic scope of IoB research could provide valuable insights into its applicability in diverse contexts and promote more equitable access to its benefits. Future research should also explore the integration of IoB with emerging technologies such as blockchain and the Internet of Things (IoT). As highlighted in the keyword visualization, these technologies are critical for ensuring the scalability, security, and efficiency of IoB systems. For example, blockchain could address privacy concerns by enabling decentralized and transparent data management, while IoT devices could enhance the granularity and accuracy of behavioral data collection.

4.6 Limitations of the Study

While this bibliometric analysis provides valuable insights into IoB research, it is not without limitations. The reliance on specific academic databases, such as Web of Science and Scopus, may exclude relevant publications from other sources, potentially limiting the comprehensiveness of the analysis. Additionally, the study focuses on quantitative metrics such as publication counts and citation frequencies, which may not fully capture the qualitative impact of IoB research. Another limitation is the lack of detailed analysis of individual studies, which could provide deeper insights into specific research contributions and methodologies. Future studies could complement bibliometric analysis with systematic literature reviews to address these limitations and provide a more nuanced understanding of IoB research.

5. CONCLUSION

The bibliometric analysis of the Internet of Behaviors (IoB) research highlights its multidisciplinary nature and rapid evolution, driven by advancements in artificial intelligence, data analytics, and IoT technologies. IoB's applications span diverse domains, including personalized marketing, healthcare, and smart cities, showcasing its transformative potential in enhancing user experiences and addressing societal challenges. However, the study also underscores critical ethical and privacy concerns, emphasizing the need for transparent governance frameworks and international collaboration. While India

emerges as a significant contributor and global hub for IoB research, the field must expand its geographic scope and address underrepresented regions to promote inclusivity. By prioritizing ethical considerations, fostering global partnerships, and integrating emerging technologies, IoB has the potential to drive innovation while ensuring equitable and sustainable development. This study lays the groundwork for future research to explore the long-term societal implications and untapped opportunities within this promising field.

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