

## Uncovering the Complexities of Intellectual Property Management in the era of AI: Insights from a Bibliometric Analysis

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### Abstract

Intellectual property (IP) management has posed continuous problems in the digital world, so understanding its associated concepts and the particularities they present is crucial. Within artificial intelligence (AI), machine learning (ML) and natural language processing (NLP) have enabled the intelligent processing and analysis of large volumes of data, making them widely used tools. In order to help fill the research gap that exists due to the novelty of the concepts, a bibliometric analysis is proposed of 404 scientific documents linked to AI, ML, NLP and IP, extracted from the Web of Science (WoS) core collection repository. The results demonstrate a current trend in research on the management of IP, related to digital tools and highlight the issues that arise from the management of IP stemming from their use. This research also identifies how these tools have been used to facilitate the management and identification of IP. In this sense, this study brings originality to the field of intellectual property management by examining previous studies and proposing new avenues for future research, thus broadening the current understanding of the subject. Entrepreneurs and business leaders can benefit from this study as it uncovers the complexities of IP management and thus enhances understanding of the opportunities and challenges in the AI era.

**Keywords:** Intellectual Property, Artificial Intelligence, Natural Language Processing, Machine Learning.

**JEL Classification:** O32, O34, D23, P14

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### 1 INTRODUCTION

As new technologies proliferate and new functionalities emerge, society becomes more familiar with their use, and the number of connected users increases due to the apparent advantages offered by their application. The Internet, according to technological advancements, leads people to incorporate and use it, making tools such as social networks part of the daily routine for the majority of individuals (Ata et al., 2022). Digitalisation is crucial for the economy and is important for both large and small businesses and the public sector (Kő et al., 2022). Moreover, with Covid-19, digitisation has had a significant impact on society (Gavrilă & de Lucas, 2021a), and in particular in the business environment, where digital transformation has led to a break with the past and to new sustainable growth models (Gavrilă & de Lucas, 2021b). Thus, considering the content and usefulness of technological tools, it becomes necessary to protect the intellectual property (IP) of the programmes and tools used and the content generated. Indeed, laws that protect IP are essential for a company's competitiveness (Chen, 2021). IP goes back centuries, and has received much academic attention in recent decades (Reichman & Samuelson, 1997; Ali & Tang, 2023). In particular, IP linked to the nature of knowledge, and the rules and assets it presents, remain a focus of attention (Teece, 2018). However, nations in the early stages of development often adopt an equivocal attitude towards regulation and enforcement of intellectual property rights (IPR) (Lin & Wu, 2022).

Collaboration on IP, therefore, represents an important avenue for corporate entities wishing to increase the utility of their IP resources and foster knowledge innovation (Teece, 2000). It is therefore important to analyse the concept of IP thoroughly, considering the challenges posed by emerging technologies. Given the relevance of the concept and the implications arising from it, the issue of IP protection has, unsurprisingly, been a matter of international policy (Park & Ginarte, 1997). Due to the similarities between IP and a public good, it becomes necessary to protect IPR (Falvey et al., 2006). Authors such as Kang et al. (2022) highlight that in today's knowledge era, IP requires dynamic cooperative behaviour that enables the promotion of knowledge innovation. Traditionally, IPRs have supported commercialisation services (Bustamante, 2019), including patents and other forms of IP protection as incentives for entrepreneurs (Heller & Eisenberg, 1998). The patenting process is considered an important area for companies that wish to capture the strategic value of IP (Darroch et al., 2005). Fujii et al. (2007) highlight patents as elements of IP, as they have been key elements for industry, business and legal communities.

As the economy becomes increasingly based on knowledge and technological advances, it has become even more important for companies to incorporate service innovation in order to maintain a competitive edge (Tsou & Chen, 2022). The evolution of technologies influences organisations, as many of them can be integrated into the internal processes of the company. The digitalisation of companies in business innovation has become a key research topic (Li et al., 2023). Gaining competitive advantages through technology is becoming increasingly vital for companies (Saura et al., 2022). Their implementation can be challenging, but their correct use, strategy and integration can impact economic growth. Digital disruption has forced digital businesses to seek value creation (Nyagadza, 2022). Technological innovations can bring a differential value to the organisation. Due to globalisation and competition in the current market, it is essential to register innovations in order to avoid possible misuse or plagiarism and to protect the integrity of content and thus protect the rights of both organisations and developers. Despite the importance of property certification, however, illegal copying leading to considerable monetary losses continues to cause controversy and concern in society (Hartung & Ramme, 2020). Digitisation is a key element of business development (Peng & Tao, 2022), and academic interest in it has grown considerably in recent years. Digital convergence and the positioning of digital tools have made it imperative to understand the ownership and nature of the knowledge derived from them. Thus, the boundaries between organisations are often blurred, and the exchange of knowledge is increasing, making it challenging to protect it (Ilvonen et al., 2018). The current digital era is bringing about certain problems related to the ownership of rights, and authors such as Menell (2011) have analysed the disintegration of IP in the digital era. Much information and knowledge is generated and shared through digital platforms, which raises important questions about who has rights to that knowledge and how it can be used fairly and equitably. In addition, given the amount of information available online, it is important to understand how to distinguish between what is verifiable and reliable information and what is not.

This paper considers the impact of IP on different digital tools such as artificial intelligence (AI), natural language processing (NLP) and machine learning (ML). Given the importance of AI, NLP and ML as facilitators for obtaining and processing information, those involved in their development or invention must obtain protection. Although other researchers such as Torre et al. (2019) have carried out reviews highlighting the value of IP, it is still a relatively unknown topic that needs to be expanded upon. Therefore, to address these issues, this study adopted a systematic literature review (SLR) methodology in order to examine 406 documents collected up to January 2023. This research is significant as it allows us to explore the field of IP, which has been researched less than other areas. It reviews the evolution of the concept up

to the present day and highlights the relevance of the concept today, linked to new technologies and the influence they have on the protection and promotion of innovation in an increasingly digitalised and globalised world.

The paper is organised as follows. Section 2 sets out the literature review of the three key words that remain linked to IP. Thus, the concepts of AI, ML and NLP are further developed. Section 3 sets out the methodology used to address the research questions. Section 4 then refers to the data analysis and the main results obtained. Section 5 provides the conclusions. Subsequently, limitations and potential avenues for future research are addressed.

## 2 THEORETICAL BACKGROUND

Intellectual capital (IC) is currently a decisive element with the potential to determine the success of any organisation. In particular, IC refers to intangible assets such as expertise, data, IP and skills that can be leveraged to generate wealth (Kannan & Aulbur, 2004). Moreover, the company must understand the importance of obtaining validation and recognition at an individual level to achieve legitimacy (Kusuma & Almahendra, 2022). IC should therefore be considered an important business asset. In the form of patents, trademarks and copyrights, it can improve the efficiency and economic performance of a corporation (Coleman et al., 2013). IP, particularly the protection of copyrights, is therefore essential in any field of activity. IP is thus an increasingly important, cross-cutting concept, crucial in many areas, including medicine and chemistry (Griffen et al., 2018).

Considering the growth of digital content and the development of new products derived from the use of technologies, it is essential to consider the vulnerability presented by IP. Moreover, digitalisation poses the challenges of an uncertain and finite world (De Lucas & Gavrilu, 2023), and encryption and authentication techniques have been developed (Stamm et al., 2013) as ways of protecting IP; that is, preventing unauthorised access to information. Many incidents are reported in the media related to the management of IPR (Fossaceca et al., 2015), so it is essential to provide greater awareness of what IP entails and the implications derived from its use. When dealing with new technologies and, more specifically, with techniques based on computational intelligence, Davies (2011) discussed IPR linked to computer-generated works, and authors such as Nedjah et al. (2022) have suggested that the need for human knowledge will decline since these tools make it possible to extract information patterns and identify critical elements. The technologies analysed allow the processing of deep neural networks through algorithms to manage real-world tasks (Cichy & Kaiser, 2019). To tackle the mentioned range of topics, a systematic literature review is proposed in order to answer the following research questions:

RQ1. What has been the evolution of the application of the IP concept up to 2022?

RQ2. Who are the main references in the area, and how are they related?

RQ3. How is this evolution characterised in terms of the co-occurrence of terms?

### 2.1. Artificial Intelligence

The volume of information handled nowadays is growing, so the use of artificial intelligence (AI), a technology that enables the processing of large amounts of information automatically, is becoming necessary (Popkova & Sergi, 2020). When handling such a large volume of data, it is essential to safeguard data privacy and ensure sovereignty over input data and algorithms. This means companies being accountable for the AI process and its results and providing reliable and transparent technical implementations (Kaissis et al., 2020). Place et al. (1995) pointed out that AI is a collective form of IP. Thus, when developing new models based on this

technology, IP registration must be taken into account in order to achieve transparency and symmetry in the input information. Sniecinski and Seghatchian (2018) highlight the ethics of IP processes when considering AI technologies, since IP has traditionally been linked to humans and their intelligence, which machines can now emulate.

Authors such as Zhang et al. (2018) have highlighted the need to protect the IPR of deep learning models that develop AI-based technologies. Others, such as Aristodemou and Tietze (2018), have considered the linkage of AI techniques in order to analyse IP-related data. Gurkaynak et al. (2017) contend that the difficulty of AI lies in the fact that there is no direct human responsible for the work created by AI, which makes it difficult to determine the author and the assignment of rights. In order to explore further the problematic concept of IP management in AI, ML and NLP have been selected for the current study because they are two of the most widely used techniques.

## **2.2. Machine Learning**

The development of computational algorithms that favour machine learning (ML) is motivated by the proliferation of technologies. These tools have highly valuable functionalities as they are capable of finding behavioural patterns in the massive datasets that are currently handled and generated. Accordingly, ML can uncover and extract valuable insights from data stored in a data warehouse (Lin et al., 2022), and techniques based on this learning have been considered in different disciplines (Naqa & Murphy, 2015). They have also been widely used to increase the effectiveness of intrusion and cyber-attack detection platforms (Fossaceca et al., 2015). Therefore, their management is essential to preserve IP. Another area is the responsible, ethical and fair use of ML technologies, protecting privacy and data rights. Considering data ownership and control can help ensure that these technologies are used appropriately. This includes the idea that IP management is therefore necessary to promote the free flow of knowledge and ideas.

## **2.3. Natural Language Processing**

The vast volume of text in the world makes it possible through natural language to obtain a large amount of knowledge content. NLP techniques make it possible to obtain relevant information efficiently and accurately through extraction processes (Chowdhary, 2020). They use computational techniques that allow understanding and learning from human language through the automation of the analysis of linguistic structure (Hirschberg & Manning, 2015). One of the main applications of NLP is based on the automatic extraction of relevant information (Lauriola et al., 2022). Lupu (2017) highlights the influence of NLP tools in obtaining information linked to IP techniques. These techniques, which draw from diverse fields (Nadkarni et al., 2011), have also been used for the intelligent classification of patent documents (Trappey et al., 2020). Jochim (2014) discussed the link between information retrieval techniques and NLP techniques, as there is a need to manage and improve access to this IP-related information. Technologies can be patented if they meet the requirements of novelty, non-obviousness and utility. In this sense, works generated by NLP, such as text or images, are also eligible for copyright protection. Thus, IP protection for NLP technologies may be important for companies wishing to protect their competitive advantage and monetise their NLP technology. Therefore, it is essential to analyse the linkages that arise from the technologies and the management of their IP. In conclusion, it is crucial to consider the interrelationships between the previously presented concepts and IP. NLP should be regarded as a specialized application of AI that relies heavily on ML techniques to process and comprehend human language. Thus, these three concepts are interconnected and often work together to create intelligent systems capable of interacting with and understanding humans in

a natural language context. This, therefore, gives rise to challenges and issues related to the IP of the generated content and knowledge.

### 3 RESEARCH OBJECTIVE, METHODOLOGY AND DATA:

The proposed analysis begins with a systematic search in the Web of Science (WoS) core collection database. This research aims to present an updated theoretical framework of the analysed topic and the relevance of IP in the digital domain and to provide new lines of research. In order to study the existing contributions related to IP and digital tools such as AI, ML or NLP, a systematic literature review (SLR) has been used. The overall procedure adopted is illustrated in Figure 1.

The literature review allows us to obtain valuable, high-quality information about published scientific documents. Authors such as Donthu et al. (2021) have pointed out that bibliometric analysis is a useful scientific method for conducting a retrospective of a selected area, and this methodology has been widely used in undertaking literature reviews. Following the steps proposed by authors such as Xiao and Watson (2019) to conduct a literature review, the analysis is framed as follows:



Figure 1: Flowchart bibliometric analysis

- (1) Literature identification: for this purpose, a set of keywords were selected, all in English. Results collected up to January 2023 are analysed. Results were obtained for 406 documents.
- (2) Screen for inclusion: in this step, the abstracts were read and checked for the existence of the selected keywords.
- (3) Assess quality: full text of the articles was skimmed to assess the eligibility of the studies. Documents and research articles presented at conferences and indexed in the Web of Science core collection were also included in this review. Two duplicates were removed from the total number of documents, leaving 404 valid documents for the analysis.
- (4) Extract data: for each document, the title, abstract, author information, affiliations, keywords, references and DOI identifier were obtained.
- (5) Analyse and synthesise data: the R packages bibliometrix and biblioshiny were used in this step. VOSviewer was also used for the visualisation.

#### 3.1. Data Analysis

The proposed analysis begins with a systematic search in the Web of Science core collection database using the keywords “intellectual property” AND (“artificial intelligence” OR “machine learning” OR “natural language processing” OR “NLP” OR “ML” OR “AI”) from which 406 articles were extracted that matched the established search criteria and quality filters. These documents present the selected keywords in the title, abstract or in the keywords plus.



The R packages bibliometrix and biblioshiny are used for data processing and analysis. Biblioshiny has been identified as one of the key innovative methodologies in the social sciences for data visualisation (Rabbani, 2021). Bibliometrix is a widely used tool for performing comprehensive analyses of scientific literature, as noted by authors such as Aria and Cuccurullo (2017). Biblioshiny uses the shiny package to establish a web-based online data analysis platform, which allows bibliometric analysis to be performed through an interactive web interface. This enables the development of the graphs after the data from the WoS databases has been pre-processed. Then VOSViewer was used since, as Van Eck and Waltman (2010) argue, it is a useful software for visualising and interpreting large bibliometric maps easily. This methodology has been widely used in science to perform bibliometric studies by authors such as Ribeiro-Navarrete et al. (2022) and Cano-Marín et al. (2023). Specifically, VOSViewer has been valued for its text-mining functionality, since it facilitates the creation of concept maps from a corpus of documents (Van Eck & Waltman, 2011). It is therefore essential to emphasize the usefulness of VOSViewer for conducting this type of research.

#### 4 RESULTS AND DISCUSSION:

Scientific production in this field has grown significantly since 2014 (see Figure 2), with significant growth from 2018 onwards. Specifically, 2021 has the most contributions, reaching 102, followed by 2022 with 89 and 2020 with 63. Thus, in order to respond to RQ1, the growing academic interest in the subject should be highlighted; it has been remarkable in recent years due to the digital influence in all sectors and industries. Since the pandemic, interest in factors linked to digital tools has sparked scientific interest (Zimmerling & Chen, 2021).

Authors such as Tietze et al. (2020) have pointed out the relationships and collaborations established between companies that developed open-source designs and even shared specific elements of their IP during Covid-19. Relating this to digitisation, the work of Zimmerling and Chen (2021) is noteworthy. They describe a burgeoning development of digital technologies involving cooperation to promote efficiency. They emphasise, however, that apprehensions about IP could curb the effect of these transformations.

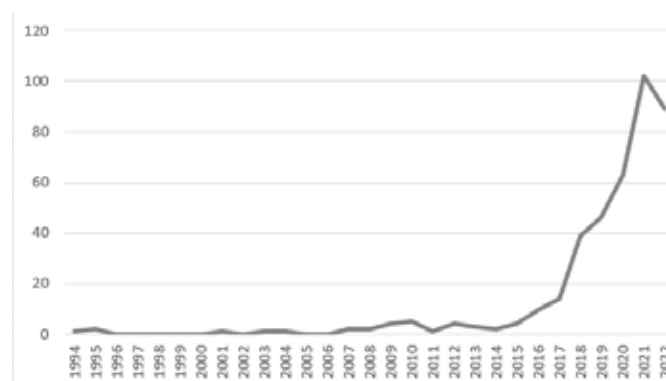


Figure 2: Annual scientific production – Biblioshiny

Regarding the journal categories from WoS, the categories of Computer/Science/Theory/Methods and Engineering/Electrical/Electronic account for the largest number of documents (18.74% of the total). Others, such as Law (12.07%) or Management (2.46%), should also be highlighted as relevant to the IP issue linked to AI technologies.

#### 4.1. Scientific Documents

The most cited works from the list selected for this literature review are considered in response to RQ2, highlighting the contributions they make in the field of IP. Table 1 highlights the documents with the most citations in WoS. Normalised citations have been considered in order to get a true picture of the relevance of the documents over time. The standardisation of citations allows us to consider the article's potential. Authors such as Ioannidis et al. (2016) point out that old influential papers received fewer citations in their early years than more recent influential papers due to the rapid increase in scientific publications. Regarding the most cited documents at a global level, the contributions made by Kaissis et al. (2020) in the field of medicine, and Wexler (2018) linked to law, should be highlighted, given the relationship between these sciences and both IP and technological aspects.

On the other hand, Calo's research (2015) considers the cyberlaw linked to robotics, and Chen et al. (2019) address the issue of digital finance, considering patents and the digital rights they propose (Acemoglu & Akcigit, 2012). Aristodemou and Tietze (2018) discuss IP analytics as the study of data analysis methods to identify relationships, trends, and patterns within large amounts of IP data, in order to support decision-making.

<i>Documents</i>	<i>TC</i>	<i>TC per Year</i>	<i>Normalised TC</i>
Kaissis Ga, 2020, Nat Mach Intell	168	42.00	21.17
Chen Ma, 2019, Rev Financ Stud	121	24.20	14.80
Calo R, 2015, Calif Law Rev	110	12.22	2.32
Wexler R, 2018, Stanford Law Rev	97	16.17	7.06
Zhang JI, 2018, Proceedings of the 2018 ACM Asia Conference on Computer and Communications Security (Asiaccs' 18)	95	15.83	6.91
Aristodemou L, 2018, World Pat Inf	68	11.33	4.95
Fossaceca Jm, 2015, Expert Syst Appl	62	6.89	1.31

Table 1: Most cited documents – Biblioshiny

In terms of authors, 1,284 authors were considered in the analysis, with only 66 single authors in the documents. Figure 3 uses VOSviewer to illustrate the document citation network metrics. The distance between the two articles in the visualisation map represents the relationships in their citation links. In this case, connections can be observed between the articles of Cao (2021), which analyses the IP of educational resource data based on machine learning, and Zhang et al. (2020), which illustrates the concern for the intellectual protection of deep learning models. Denter et al. (2023) analyse the use of blockchain technology in the management of various types of IP and reference the work of Ragot et al. (2020), which examines how blockchain and machine learning can be used for the management of the IP lifecycle of 3D printing data files.





of a way of automatically extracting conceptual information describing the content of patent images, thus facilitating the retrieval of information from them. Considering this relationship, it can be observed that the connection between digital terms is recent, and concepts such as patents or ethics are the keywords that remain linked to IP and new technologies over the years.

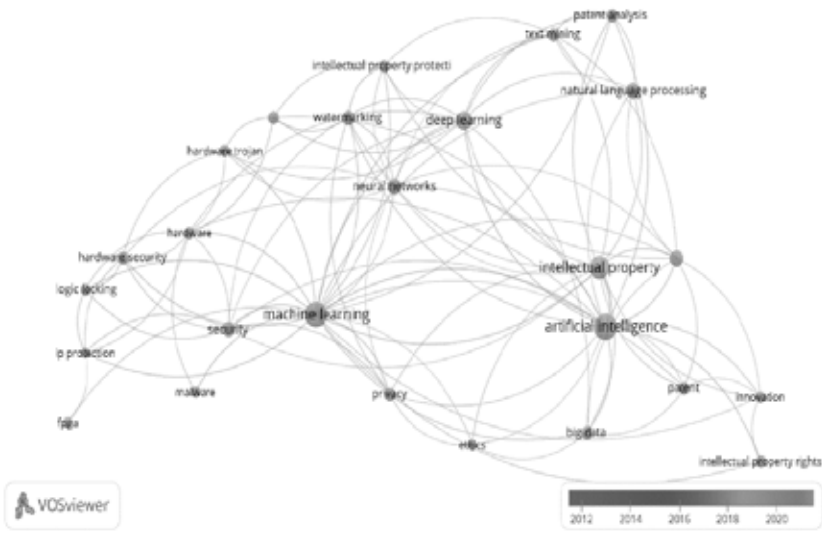


Figure 5: Author keywords co-occurrence- VOSviewer

**4.4. Keywords Plus Co-Occurrence**

Given the Keyword Plus suggested by the Clarivate database, the words or phrases frequently appear in the reference titles but not in the main title of the article. This makes clear how terms such as “information” have been present for the longest time in research and are linked in most publications. Analogously from 2012 to 2014, it emerges that terms that were used previously and have now evolved into other concepts, such as “knowledge-based system”, “expert system”, or “computer-aided”, evolved into AI and its sub-fields, in line with the research of Duan et al. (2019). The growth of technology in recent years is remarkable, and this implies exponential advances in algorithms and analysis software. This evolution is especially evident since 2018, with the terms “protection”, “artificial intelligence” and “attacks” (Figure 6). Thus, an evolution can be seen in the research from the most primitive concepts linked to technologies to the current terms, just as they have evolved in society.

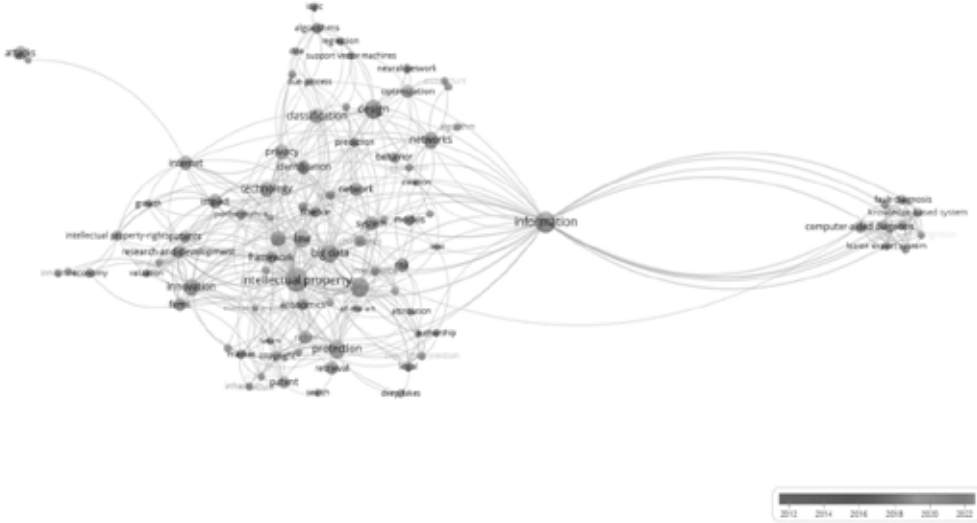


Figure 6: Co-occurrence Keywords Plus – VOSviewer

#### 4.5. Co-occurrence Bigrams in Titles

The search demonstrated that the IP set of bigrams has the greatest presence in the document titles. Clustering according to the walktrap algorithm was used to develop this data visualisation in Figure 7. Of all the keywords considered in the analysis, NLP is one of the least represented. The main cluster refers to IPR protection and regulations. The concepts related to ML associated with deep text processing are also noted. Thus, with the words highlighted, it is possible to observe the capacity provided by these tools and the uses that derive from them.

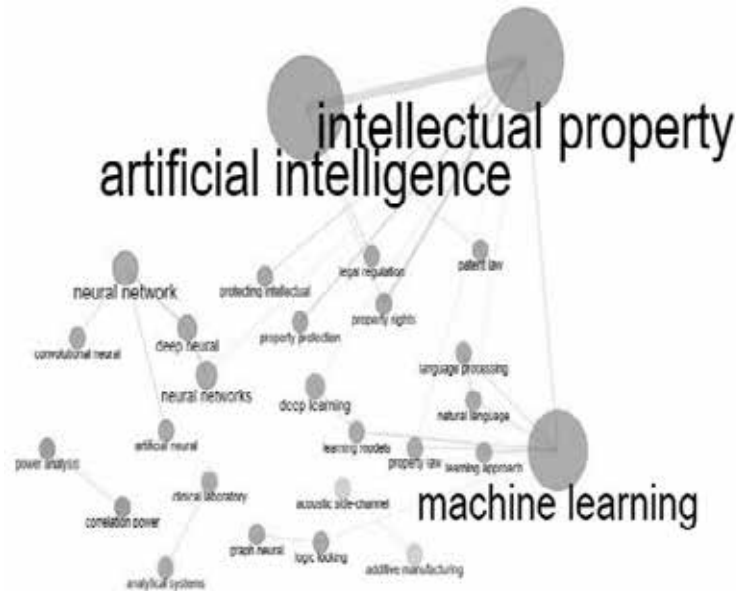


Figure 7: Co-occurrence bigrams in titles – Biblioshiny

#### 4.6. Co-Occurrence Abstract Keyword

The leading eigenvalues clustering algorithm was used to analyse the words developed in the abstracts in Figure 8. In this case, of the four groupings shown, one should be highlighted, it being linked to the management of secrets and privacy and data protection. De Laat (2022) points out that trade secrets need to be protected, as disclosing details could lead to competitors benefiting from the disclosure of information. Trained deep models, for example, are a very valuable asset for organisations that they probably want to protect as a trade secret (Domingo-Ferrer et al., 2019). The second cluster groups those bigrams related to language processing, circuits, algorithms, and data, while the other cluster is more focused on data processing through networks or models. Within this cluster, research such as that of Cao (2021) should be noted, as it reviews prior studies, emphasising the significance of the expression of IP and presenting the methods and principles of the data classification algorithm and the identification of the protection authority. Other academicians, such as Trappey et al. (2020), employ machine learning algorithms to glean crucial knowledge from patent documents in order to gauge their worth and technological superiority.





Figure 9: Collaboration world map – Biblioshiny

## 5 CONCLUSION

This study has focused on analysing the link between AI-derived digital elements, particularly ML, NLP and IP, collecting information since 1995 and analysing the evolution of the concepts up to the present day. It has explored the current challenges and the gaps in this area in order to call for future contributions in this under-explored field. The increase since 2014 in the search terms selected indicates a greater awareness of research into IP management in the technological field. The results also show how academic interest developed from 2018 onwards. There is clearly a great concern for the IP management of certain AI digital tools, and this linkage has been demonstrated over time. Information emerges as a key concept in research and is currently linked to concepts of deep learning and the management of rights and regulations. Despite the growing numbers of scientific contributions and constant technological change, so far, there is insufficient awareness of these topics, so future researchers should delve deeper into IP and its management linked to solutions derived from technologies.

This analysis highlights the importance of data and the need to manage the intellectual property of technologies and the work or innovations that may result from their use. In addition, it shows how these technologies can also assist in identifying IP. There is an ongoing debate as to whether and how current IP laws are sufficient to address the unique challenges and opportunities presented by AI. Due to the continuous changes and evolution of digital technologies, new legal frameworks will, arguably, be necessary to address AI and IP issues. IP may therefore be an important consideration in the field of digital tools such as AI, ML and NLP, as it may affect the development, use and commercialisation of these systems and the data on which they are based. This technology is often based on complex algorithms, software and other technological innovations that require IPR management. Furthermore, these results underline the growing importance of the field in terms of the academic interest developed in recent years. Therefore, companies and organisations must prioritise developing and implementing strategies and technologies based on data analysis and processing, both to manage their IP and to secure the IP of the resources and products derived from these technologies.

### 5.1. Research limitations and future research lines

This analysis has some limitations. Despite showing significant results, other repositories of scientific articles such as Scopus, Science Direct or PubMed were not used. In this case, WoS was considered because it is widely used for bibliographic reviews, but future research should extend the range of databases used to analyse whether the same trend patterns are registered. Another limitation is, arguably, inevitable: the speed of development in many parts of the field, and their cross-cutting nature, mean that any current work cannot produce a totally up-to-date picture. But it is these very characteristics that produce their impact and facilitate rapid social development, and on which future research in NLP, AI and ML should focus.

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