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On patent searching: the case of 3D bioprinting

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Abstract: This study offers a commentary on the retrieval of patents related to 3D bioprinting. Patents contain technical information that can't be retried from other sources. However, it is challenging to obtain this information precisely and comprehensively. A patent search strategy that focuses exclusively on the title and abstract may yield incomplete results, as patent documents possess a distinct intrinsic nature that differentiates them from those found in academic publications. A patent search, limited to the title and abstract, whether in isolation or in combination, may offer only a preliminary, general perspective on a technology and its underlying inventions. For a comprehensive understanding, it is imperative to consider additional elements, such as bibliographic data, including patent classification codes, and claims. The classification symbols are independent of the language used and have the capacity to enhance a patent landscape or patent prior art to a considerable degree.

Keywords: patents; patent search; 3D-bioprinting; international patent classification; WIPO

1. Introduction

Patent searching is a specialized skill that requires a high degree of expertise. This task is entrusted to patent professionals who possess the necessary qualifications and experience to ensure the integrity and accuracy of the results. This is an intellectual activity that cannot be improvised. It requires specific knowledge of patent databases, including how the data are organized and how to extract it to perform patent landscape or prior art analyses.

Assuming that all databases are incomplete, a comprehensive search strategy is required that incorporates multiple databases. In many cases, reviews and scientific articles are written with the use of only keywords, and the Boolean search is limited to the title and abstract. This methodological shortcoming results in an inadequate retrieval of patent information.

In the interest of providing an example of improper patent searching, the present report draws upon the article entitled "3D bioprinting: current status and trends - a guide to the literature and industrial practice" (Santoni et al. 2022), which was read with great interest. The authors carried out a patent search on Espacenet in July 2020, employing solely keywords in the Title/Abstract (TA)search fields. This yielded a total of 309 patent families. In a previous publication (Rodriguez-Salvador et al. 2017), other researchers carried out a more precise search, identifying 345 patent families that were filed from 2000 to mid-2016. In that case, PatSeer was used as the reference database, a more complex search query was constructed, and the search was carried out in the Title/Abstract/Claims (TAC) search fields.

2. Methods

For current analysis, Espacenet (a free of charge patent database managed by the EPO) was utilized as a reference database, thereby facilitating a comparison of the data found by the authors of the article (Santoni et al. 2022). An exhaustive search was conducted using Octimine, a professional patent database that was made available for a trial period. The Octimine database provides the functionality of executing semantic searches, followed by the subsequent analysis of the results, in a manner that is both thorough and comprehensive.

3. Results

3.1.Searching with Espacenet: Comparison results

The patent query listed in the supplementary file (Santoni et al. 2022) was replicated with slight modifications to account for the July 2020 data range, as illustrated below:

Citation: Massimo Barbieri, Domenico Golzio. 2025. On patent searching: the case of 3D bioprinting. *Trends in Intellectual Property Research* 3(2), 9-16. https://doi.org/10.69971/tipr.3.2.2025.48

((((ta = "tissue" OR ta = "organ") AND ta = "3d" AND ((ta = "print*" AND ta = "cell*") OR ta = "bioprint*")) OR ta = "bioink*") NOT (ta = "metal*" OR ta = "alloy")) AND pd <= "202007" [Query 1]

Query 1 yielded 341 results. The observed discrepancy between the data obtained in the cited reference and the actual number of published applications retrieved with Query 1 can be attributed to the incomplete nature of the published applications at the time of searching.

As illustrated in Figure 1, results obtained from keyword searches in different search fields (TA, CLAIMS only, TAC) are presented. It is evident that the number of results varies slightly.

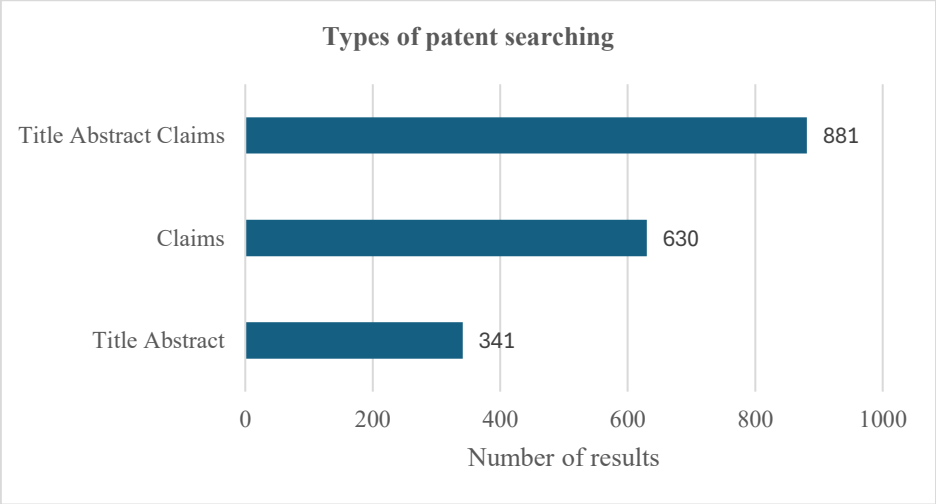


Figure 1. Number of results obtained with different KWs searching.

The implementation of a further search that incorporated an additional relevant keyword, "*organ on a chip*", enhanced the number of results to 913.

Query 2 is a s follows:

((((ctxt = "tissue" OR ctxt = "organ") AND ctxt = "3d" AND ((ctxt = "print*" AND ctxt = "cell*") OR ctxt = "bioprint*")) OR (ctxt = "bioink*" OR ctxt = "organ_on_a_chip")) NOT (ctxt = "metal*" OR ctxt = "alloy")) AND pd <= "202007" [Query 2]

Specific and relevant classification codes were added, producing 1,174 results, thereby yielding a fourfold increase in the number of results obtained. The final search query is as follows:

(((((ctxt = "tissue" OR ctxt = "organ") AND ctxt = "3d" AND ((ctxt = "print*" AND ctxt = "cell*") OR ctxt = "bioprint*")) OR (ctxt = "bioink*" OR ctxt = "organ_on_a_chip")) NOT (ctxt = "metal*" OR ctxt = "alloy")) OR ((cl any "A61L27" OR cl any "A61F2" OR cl any "A61L2430" OR cl any "C12M" OR cl any "C12N") AND (cl any "B33Y" OR cl any "B29C64") AND (ftxt = "bio_printing" OR ftxt = "3D bioprinting" OR ftxt = "biofabrication"))) AND pd <= "202007" [Query 3]

The definitions associated with the various IPC symbols used in Query 3 are enumerated in Table 1.

Table 1. List of classification symbol used and their corresponding definitions

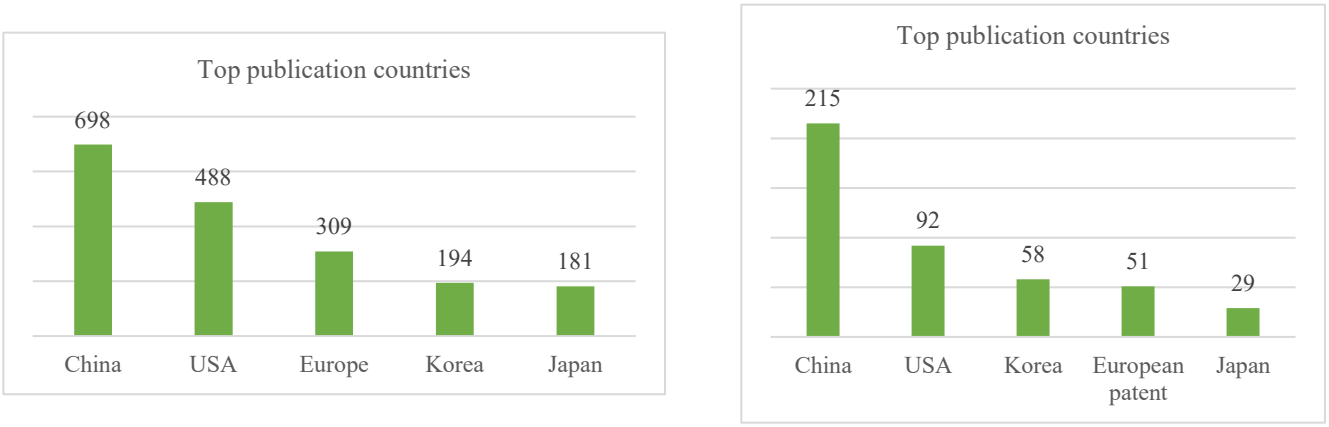
Classification symbol	Definition
A61L27	Materials for prostheses or for coating
A61F2	Filters implantable into blood vessels; Prostheses
A61L2430	Materials or treatment for tissue regeneration
C12M	Apparatus for enzymology or microbiology
C12N	Microorganisms or enzymes
B33Y	Additive manufacturing
B28C64	Manufacturing of three-dimensional objects by additive deposition

A specific and relevant code may be retrieved by using the keywords or by identifying a patent document that sufficiently matches the subject of the search using multiple keywords. The resulting classification symbol serves as a foundational element in the subsequent analysis. Utilizing this classification symbol as a basis, it is possible to identify the nearest groups or to navigate up the hierarchy to select the most suitable group (Blokhina, Ilin 2021).

Figure 2 (a, b) presents a comparison of the top five countries in terms of publication frequency, as categorized by patent families. The data presented in Figure 2a were retrieved using Query 3, while the data illustrated in Figure 2b were obtained through the implementation of Query 1.

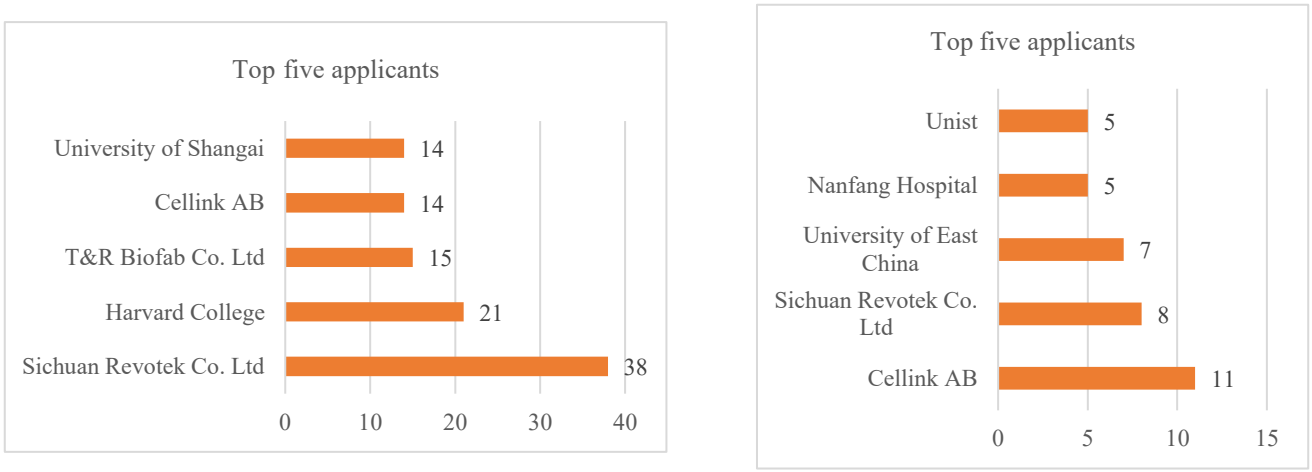
An analysis of the geography of patents reveals subtle variations in the patent landscape, with China and the United States occupying the top two positions.

Figure 3 (a, b) presents a comparison of the top five applicants per number of filed patent applications in the field of 3D bioprinting. The data presented in Figure 3a were retrieved using Query 3, while the data illustrated in Figure 3b were obtained through the implementation of Query 1.



(a) **(b)**

Figure 2. (a) List of the top five publication countries using Query 3; (b) List of the list of the top publication countries using Query 1.



(a) **(b)**

Figure 3. (a) List of the top applicants using Query 3; (b) List of the list of the top five applicants using Query 1.

The ranking of applicants on the top five list has undergone significant alterations. From a business intelligence perspective, this change carries significant implications, as prior art searches can also be utilized to ascertain the value of a prospective investment. It is of paramount importance to be acquainted with the proprietors of potential valuable patents.

3.2. Searching with octimine database

The Octimine patent database was searched by a combination of semantic and Boolean searches. The initial semantic search yielded 533 patent families, the subsequent search yielded 618, and the Boolean search yielded 1,436. The system aggregated all results, yielding a total of 1,713. The semantic search results were screened using the international patent classification (IPC) symbols B33Y and B29C64. In the Boolean search, a combination of specific keywords and IPC symbols was utilized. The IPC codes were related to the concepts of additive manufacturing, biology, and material science.

Patent classification systems are a language-independent search tool that is arguably of particular significance in a multilingual environment (List 2015). This tool may be very effective in patent landscaping, thereby avoiding trouble with keywords. The combination of keywords (along with their synonyms) and classification codes has been demonstrated to be a highly effective strategy (Clarke 2018), yielding results that are not retrievable using only keywords. In the context of keyword searches, it is generally advisable to employ a broad search strategy, including claims.

The query used in the Boolean search is as follows:

(TAC=bioprinting OR TAC=bioink OR TAC=organ on a chip OR TAC=tissue engineering OR IPC=C12N OR IPC=C12M OR IPC=A61L27) AND (IPC=(B33Y*) OR IPC=(B29C64*)) [Query 4]

The total number of results obtained was 1,713, which corresponds to 5,879 publications.

The main classification symbols were retrieved from Espacenet by entering the search terms "3D bioprinting" into the "Classification search" field, as illustrated in Figure 4.

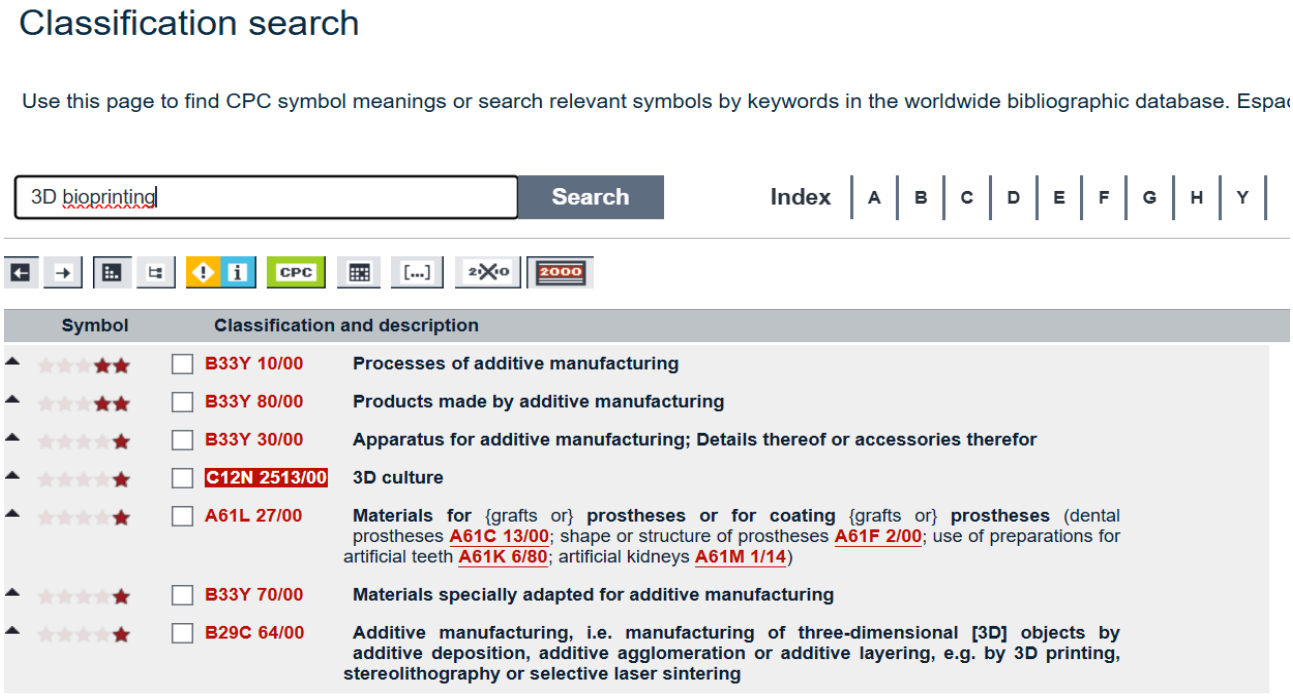


Figure 4. Classification search field of Espacenet.

The list of classification symbols obtained using keywords is presented in Table 2.

Table 2. List of classification symbols retrieved by means of keyword searching

Keyword	Classification symbols
Bioink	B33Y10/00; B33Y80/00; B33Y30/00; A61L27/00; B33Y70/00
3D bioprinting	B33Y10/00; B33Y80/00; B33Y30/00; C12N2513/00; A61L27/00; B33Y70/00
Bioprint	B33Y10/00; B33Y80/00; B33Y30/00; A61L27/00; B33Y70/00; C12N2513/00; C12M33/00

The following chart (Figure 5) illustrates the distribution of patent families from the result list according to priority year. The timeframe encompassing the years from 2002 to 2025 was considered in this study. A rising trend in the number of patent filings has been observed from 2015 to 2022/2023. The years 2024 and 2025 are not yet complete, as patent applications are filed 18 months after the filing date and are still in secrecy period. Most patent applications were generated between the years 2012 and 2023.

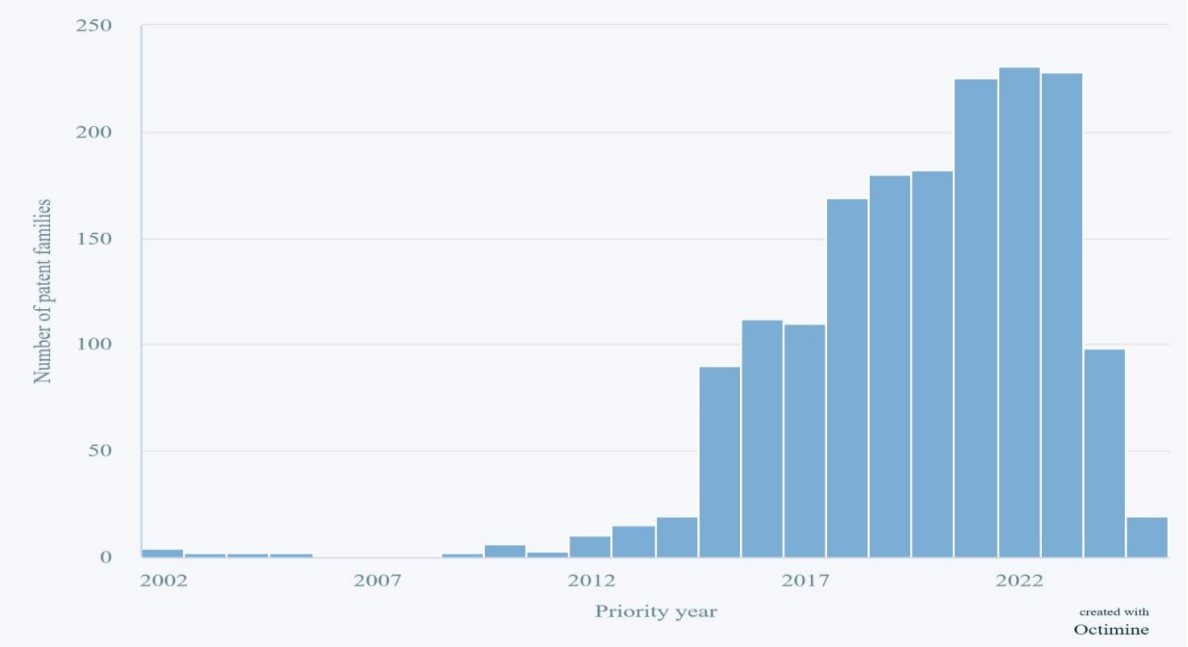


Figure 5. Distribution of patent families according to priority year.

Figure 6 illustrates the primary authorities responsible for the analysis of the patents. China is in the top position with 954 patent families, followed by the USA with 602 and the European Patent Office with 378. The PCT system is also utilized by a considerable number of applicants. According to the rules established by the Patent Cooperation Treaty (PCT), administered by the World Intellectual Property Organization (WIPO), an international patent application provides provisionally protective measures in 158 countries for a period of 30/32 months from the priority date of the application, or from the filing date of the PCT if no priority claim has been filed.

The PCT system is employed for an invention that possesses a low TRL (Technology Readiness Level) or when an applicant lacks certainty regarding the market in which they aspire to protect the invention. The PCT does not function as a granting system; rather, it serves to postpone entry into the national phases. In addition, it simplifies the process of filing and examining an application.

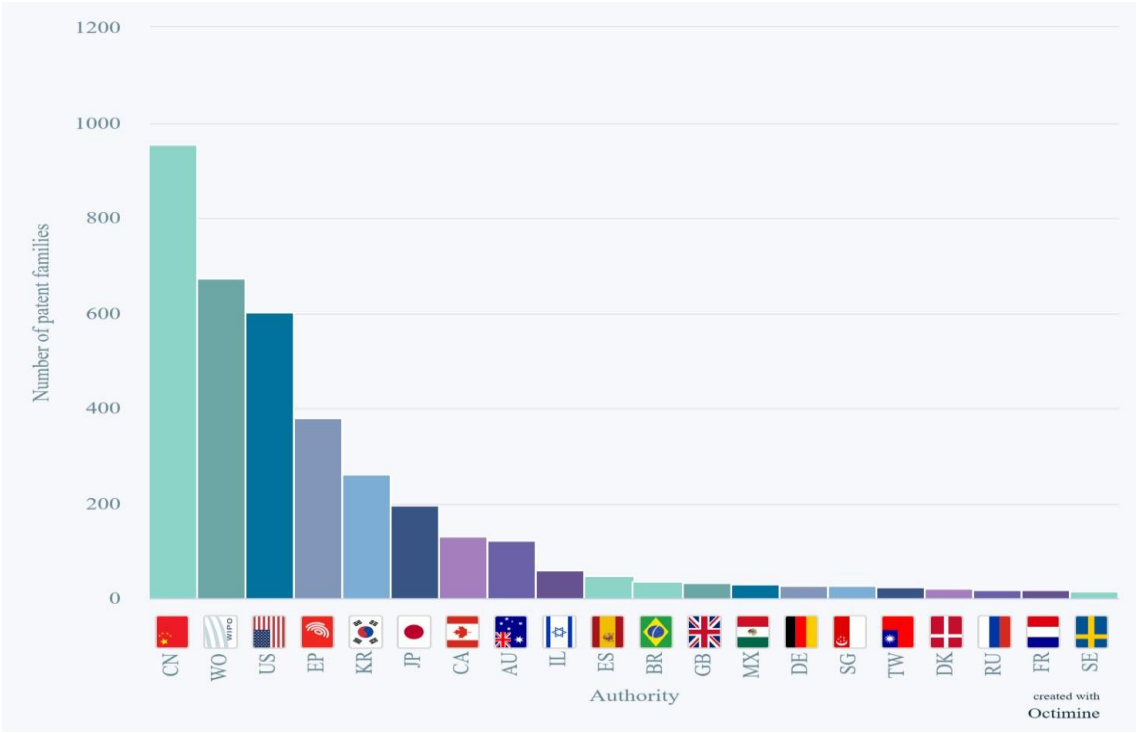


Figure 6. List of the main patent authorities.

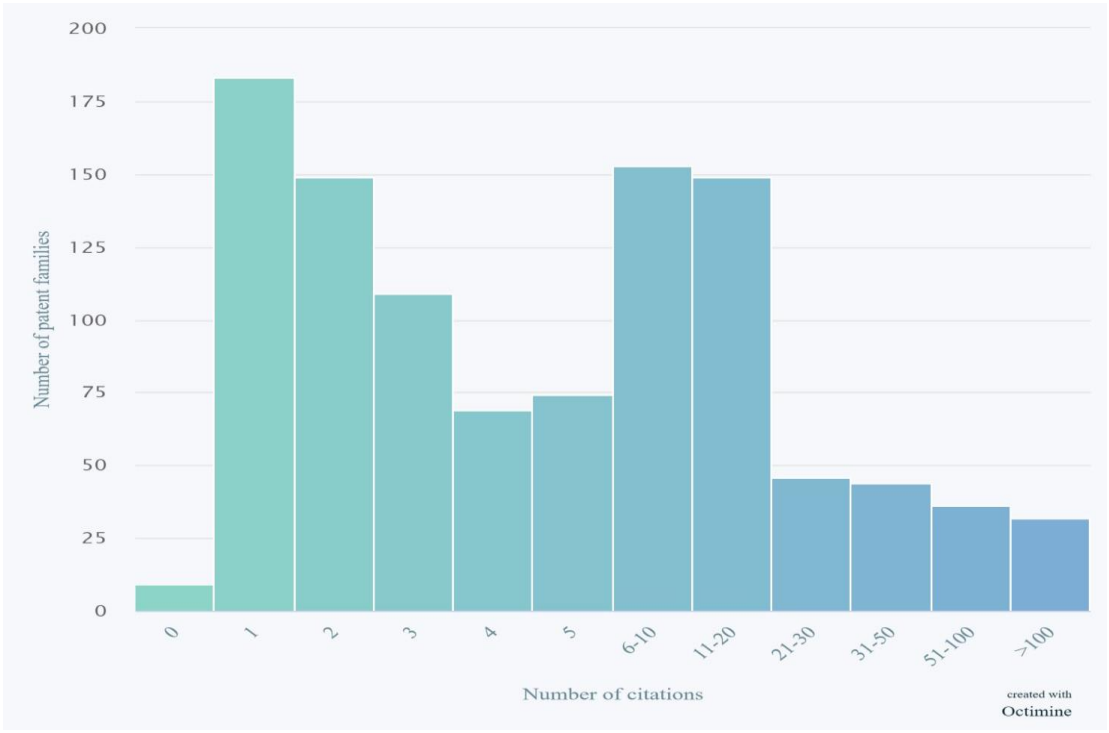


Figure 7. Frequency of citations per patent family.

Figure 7 offers insights into the frequency of citations per patent family. Patent families with a higher number of citations are likely to be influential. In this instance, 460 patent families—which have received more than six citations—should have a considerable impact within the domain of three-dimensional bioprinting.

Figure 8 provides insights into the value distribution of the patent families within the result list. The financial worth of a patent family is determined through the implementation of proprietary algorithms developed by Octimine. The calibration of these algorithms is achieved through a multifaceted approach, incorporating data from inventor surveys, auctions, licensing agreements, and renewals. The chart categorizes the patent families into different impact classes based on their likely economic significance. The 18 and 74 patent families have been determined to have a high and high-value status, respectively.

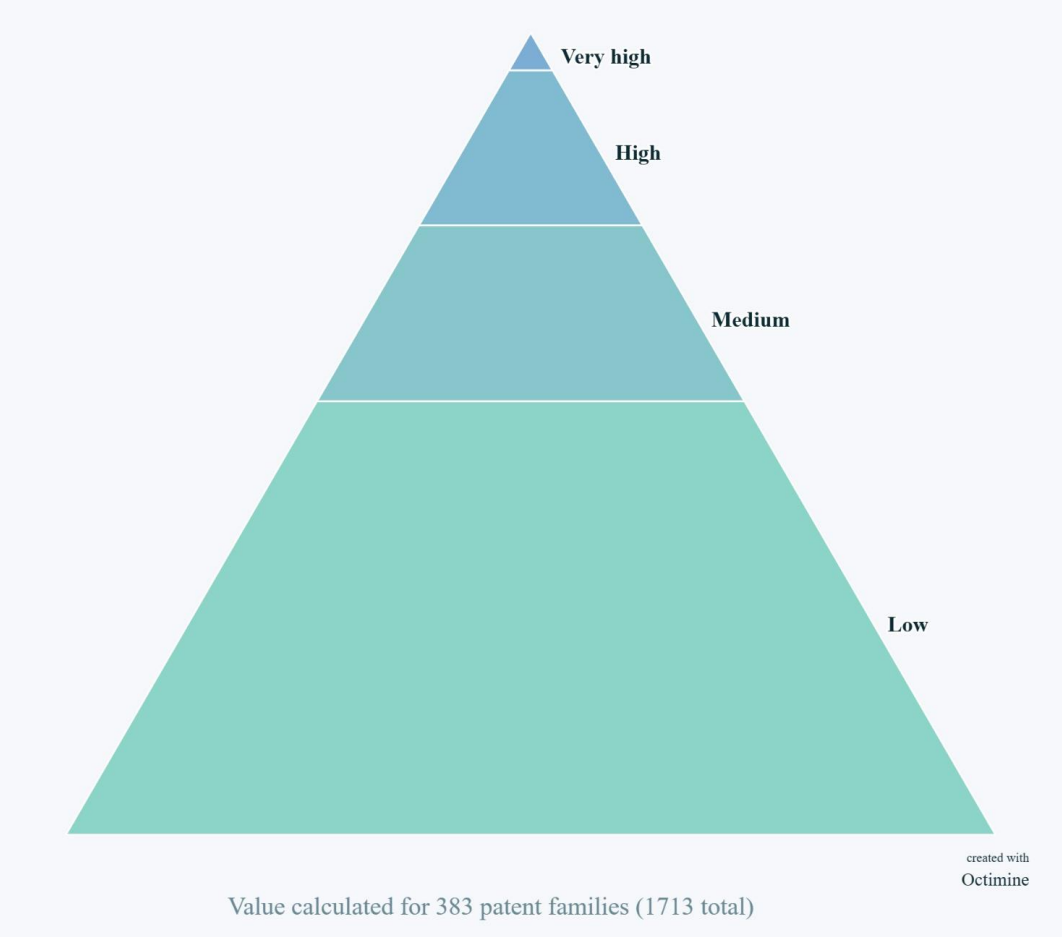


Figure 8. Value distribution of the patent families.

4. Discussion

A patent search strategy that focuses exclusively on the title and abstract may yield incomplete results, as patent documents possess a distinct intrinsic nature that differentiates them from academic publications. In the context of scientific publications, the classification of titles is typically based on three primary categories: descriptive, declarative, and interrogative.

Descriptive (or indicative) titles provide a concise summary of the study's subject matter and design, without disclosing specific findings. A descriptive title, by definition, encompasses the fundamental elements of the study, including the patients or subjects, the design, the interventions, the comparisons or control, and the outcomes. However, a descriptive title generally does not explicitly state the primary result or conclusion of the study. Declarative (or informative) titles state the study findings, while interrogative titles pose a research question. While some journals may favor declarative or interrogative titles in certain contexts, descriptive titles remain a common and often preferred style in scientific writing due to their ability to promote neutral and thorough engagement with research. The abstract is a concise summary or synopsis of the full scientific publication and possesses characteristics analogous to those of the title. The ideal publication would embody simplicity, directness, specificity, functionality, clarity, impartiality, veracity, conciseness, precision, self-sufficiency, completeness, comprehensiveness, scholarship, and balance. It should be free of any potential for misinformation or misdirection. Titles and abstracts are the only sections of the scientific publications that are often freely available to readers on journal websites, search engines, and in abstract databases.

The full publication, however, may attract a payment per view or a fee for downloading the PDF copy. The abstract is a section of the manuscript that is intended to be understood independently of the rest of the paper. It is also used by the editor to decide the fate of the article and to choose appropriate reviewers. This section is the second most frequently consulted part of the manuscript, and thus it is essential that it accurately reflects the contents of the main text of the paper and serves as a "real trailer" for the full article. Readers will only peruse a paper in its entirety if they find the abstract to be both interesting and relevant to their own professional practices. Otherwise, they may opt to bypass the paper if the abstract fails to capture their interest. The abstract's

primary function is to underscore the manuscript's salient features, thereby enticing the reader to peruse the complete text. The title and abstract should be constructed using keywords (key terms/important words) from all the sections of the main text. Abstracts are also employed in the context of submitting research papers to conferences for consideration as either an oral or a poster presentation. In the context of patent publications, the role of the title and abstract sections is analogous to that of scientific publications. However, the legal nature of patent documents and the patent grant process itself can significantly impact the utility of the information contained within these sections. According to the WIPO Standard ST.15, the title of an invention must be meaningful, clearly and concisely indicate the subject to which the invention relates and be as specific as possible. Furthermore, in the event that the patent document comprises claims in disparate categories (product, process, apparatus, use), this should be apparent from the title. Furthermore, it is imperative to refrain from employing terms such as "patent", "personal names", "fancy names", "trade names", "trademarks", or abbreviations, particularly those including "etc.," in the title, as these elements are intended to serve as distinct identifiers of the invention. Industrial patent offices worldwide may adhere to this standard and, similarly to the United States Patent and Trademark Office (USPTO), provide a list of words that are considered inappropriate for use in titles, such as "Improved," "Improvement(s) in/for/of", "New", "Novel", and others frequently employed in scientific publications. As indicated in the WIPO Guidelines, several industrial property offices publish the title of an invention or give access to it by way of their public registers or Gazette before the actual application itself is published around 18 months from the filing or from the earliest priority on which the patent application is based. In such instances, the title of a patent application is often generic, providing minimal indication of the specific details of the application until the complete application is published. Furthermore, the applicant may elect to withdraw the patent application prior to its publication, for instance, if the invention requires further refinement. In such cases, the use of a generic title will prevent the disclosure of crucial information pertaining to R&D and innovation activities. For instance, the filing of a patent application by a biotech company bearing the title "Bioprinting System" will not disclose any information regarding the specific invention or the technology with which the company is engaged. This information would be available to competitors only at the publication of the patent applications, when such applications are published. This phenomenon may result in industrial property offices opting not to implement the entirety of the WIPO Guidelines on title, given that titles frequently exhibit a high degree of genericity. Regarding the utilization of the title in the context of patent publications, the following conclusions and recommendations can be derived:

- Titles may be characterized by a high degree of genericity, brevity, and concision, often limited to a single word, thereby obscuring the comprehensive nature of the invention. It is imperative to note that queries composed exclusively of titles are prone to imprecision and incompleteness. Consequently, these queries must be consistently accompanied by additional bibliographic data, including the International Patent Classification (IPC) or the Cooperative Patent Classification (CPC), the names of applicants or inventors, and keywords derived from abstracts, descriptions, and claims.
- It has been observed that the titles of patents may not fully reflect the category of invention, such as device, apparatus, system, or compound, or the category of activity, such as method, process, use, or service, as presented in the patent document. In order to ensure a comprehensive search in this regard, it is imperative to use keywords that encompass both entities expressed through nouns and activities articulated through verbs.

Applicants include an abstract when filing a patent application. As articulated in WIPO Standard ST.15, WIPO Standards ST.12/A and ST.12/B, the abstract is expected to facilitate the comprehension of the reader, irrespective of their degree of familiarity with patent documents, with respect to the subject matter encompassed by the technical disclosure. The abstract should serve as an effective scanning tool for searching within the specific technical domain, especially by enabling the assessment of the necessity to consult the patent document itself. The abstract merely serves the purpose of technical information and cannot be considered for any other purpose, particularly not for the purpose of interpreting the scope of the protection sought. The sole part of a patent defining the scope of protection are the claims even though the description and drawings shall be used to interpret the claims. Moreover, according to several patent procedures, e.g., European patent, French patents, German patents, etc. the abstract is only published as part of the patent application and not as part of the granted patent and this indicate that the abstract may not be adapted to reflect the invention as defined in the final version of the claims if it was not already present in original submitted abstract. The non-legal value of the abstract, in addition to its omission from the publication of the granted patent, and other tactical considerations from the applicant—namely, the applicant's efforts to make the patent document less discoverable—do not promote the drafting of abstracts that could exhaustively represent the content of a patent document.

5. Conclusions

It can be concluded that a search limited to the title and abstract, whether in isolation or in combination, may offer only a preliminary, general perspective on technology and its underlying inventions. For a comprehensive understanding, additional elements, such as bibliographic data, including patent classification, description, claims, and drawings should be included. Conducting a patent search is often challenging and complex. The accurate outcome is seldom, if ever, readily apparent. A significant number of iterations may be necessary for an optimal outcome. The ability to execute an effective search is a skill that is developed over time and through experience. Scientists frequently lack awareness regarding the challenges associated with patent searching or with the use of CPC or IPC classification systems, which have the same hierarchical structure but a different number of subgroups and indexing codes.

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WIPO standard ST.15 – Guidelines for the wording of titles of inventions in patent documents. https://www.wipo.int/documents/d/standards/docs-en-03-15-01.pdf