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Technological Prospecting On The Use Of Artificial Intelligence In Image Recognition

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Abstract

Technological prospecting is a tool used to map technological development. Artificial Intelligence (AI) aims to simulate or reproduce human intelligence in machines. This technology has systematically revolutionized several sectors, with emphasis on image recognition, an area that refers to the identification of patterns in an image and constitutes one of the most dynamic fields of AI. The present study aims to verify the technological development of AI applications in image recognition. The methodology used was patent-based technological prospecting through the Orbit platform, combined with a literature review on the subject in a qualitative approach. The results indicate significant advances in image recognition. A total of 5,154 patents were identified, with a peak in filings occurring in 2022, when 1,109 patents were published. The country with the most filings was China, with 3,713 patents. Most of the deposits were classified in the G-Physical section, code G06F, with 1,923 documents. As for the legal situation, 17.08% of patents are not in force. Image recognition is a transforming factor in contemporary society, even though it brings ethical challenges and challenges related to the privacy of individuals.

Keywords: *Ethics; Innovation; Patent; Privacy; Technology.*

INTRODUCTION

The popularization of social media and the development of cell phones equipped with built-in cameras have contributed to increasing the traffic of information through images, which have become an important information vehicle. However, unlike written texts, images do not allow direct processing, which can generate different interpretations due to their static and freely perceptible nature. Therefore, it is necessary to use computers and Artificial Intelligence (AI) to classify and recognize the data contained in the images [1], [2], [3], [4].

In recent years, AI-related research has advanced significantly, promoting global changes and revolutionizing human life. This technology simulates human actions that require cognitive capacity, aiming to solve problems, perform repetitive tasks or tasks that demand physical effort, as well as execute complex activities requiring skills, dexterity and precision. Its main uses include robotics, expert systems, speech and image recognition, among others [5], [6], [7], [8].

In the past, AI was mostly depicted in the cinematic arts, particularly those related to science fiction. Later, it migrated to the experimental phase in the laboratories and currently performs real operations. Its application covers several fields, such as health - in intensive care units and in medical diagnosis -; in finance - in solving financial market problems (*financial trading*), extracting large volumes of data and detecting fraud -; and in the automotive industry - in autonomous cars and autonomous driving -;, facial recognition, among others. Among its advantages, the reduction of time in post- and pre-processing steps stands out [5], [6], [7], [8], [9]. AI is related to several areas of knowledge, such as psychology, computing, philosophy, sociology, communication, education, biology, engineering, among others [10].

Image recognition refers to the analysis performed by AI systems to identify and interpret objects and patterns in an image. This process aims, for example, to enable the accurate detection of diseases, overcoming the limitations

of naked-eye observation – which, in certain cases, can be inaccurate and lead to incorrect diagnoses [11]. It is usually associated with the development of neural networks, algorithms, and machine learning, through computational models that are essential for disruptive innovation. It is a field that has evolved in parallel with advances in AI. Three types of resources can be used in recognition: for objects, Scale-Invariant Feature Transform (SIFT) resources are used; for faces, Local Binary Patterns (LBP) are used; and, for pedestrian detection, the Histogram of Oriented Gradients (HOG) [12].

The evolutionary trend of image recognition is related to the high market demand for applications in surveillance and property security, as well as the widespread availability of technologies such as smartphones, digital cameras, among others; in addition to the maturity achieved by machine learning techniques [13].

The main technologies associated with image recognition include: neural networks residual neural networks (ResNets); real-time detection neural networks; models of care; adverbial generative networks (GANs); image segmentation algorithms; deep learning neural networks; and multimodal analysis systems [12], [13], [14], [15].

The socioeconomic development of a nation can be measured by several mechanisms, one of which is Intellectual Property (IP). It is a public policy instrument aimed at fostering and encouraging the creative process, also ensuring its protection to avoid misuse without the consent of the rights holder or the creator. IP is related to the transfer of technology and constitutes one of the branches of law that, through specific legislation, guarantees the possession of material or immaterial goods generated by the human intellect in the areas of scientific, literary or artistic domain. It is divided into three categories: Copyright, Intellectual Property and *Sui Generis Protection*. Its distinctive elements are: originality, novelty and distinguishability [16], [17], [18], [19] as illustrated in Figure 1.

Figure 1 *– Differential elements of IP*

Source: Authorship (2024)

Originality refers to the differentiation of intellectual creations in relation to the author; novelty means differentiation in relation to time, in the case of technical creations; and distinguishability is the differentiation in relation to the object, functioning as a distinctive sign [16], [18], [19].

A patent is a provisional title of ownership granted by a public entity to an inventor or owner, valid only in the territory where it is granted. To be considered a patent, an invention must meet the following requirements: industrial application, novelty, and inventive step [17], [20].

Technological prospecting is one of the instruments used in the search for innovation, allowing the differentiation of existing technologies and their respective fields of application, in addition to identifying market trends and the most promising sectors for exploration and creation of niches, thus preventing commercial or unauthorized use by third parties [9], [17].

The technological advancement of facial recognition raises issues related to privacy, since there is not always the consent of the person being identified. In some cases, misidentification may lead individuals to situations of

embarrassment or even to prison, as occurred in Rio de Janeiro, where a woman was mistakenly identified as a fugitive, and it was later found that the person sought was another [21], [22].

Another implication of technology refers to the safety, health, and daily life of individuals. Therefore, its implementation must be carried out in order to mitigate possible negative effects, the consequence of which could be the discredit of the system - which would affect its importance and use, especially by public entities responsible for citizen security, making accuracy essential to avoid errors [23], [24], [25], [26].

The study of facial recognition is very important to understand its capabilities and limitations, in order to guide future research and technological development, such as that provided by technological prospecting carried out on patent bases.

The present work aims to verify, through technological prospecting, the patents of image recognition based on AI.

METHODOLOGY

The classification of the research is of the academic type, as it is carried out in the university environment, with pedagogical activity that inspires the intellectual spirit and the search for knowledge, in addition to offering answers to society's concerns [27], [28].

Regarding the technique used, it is of the indirect documentation type, as it collects from primary and secondary sources with the objective of interpreting and analyzing the data obtained [29].

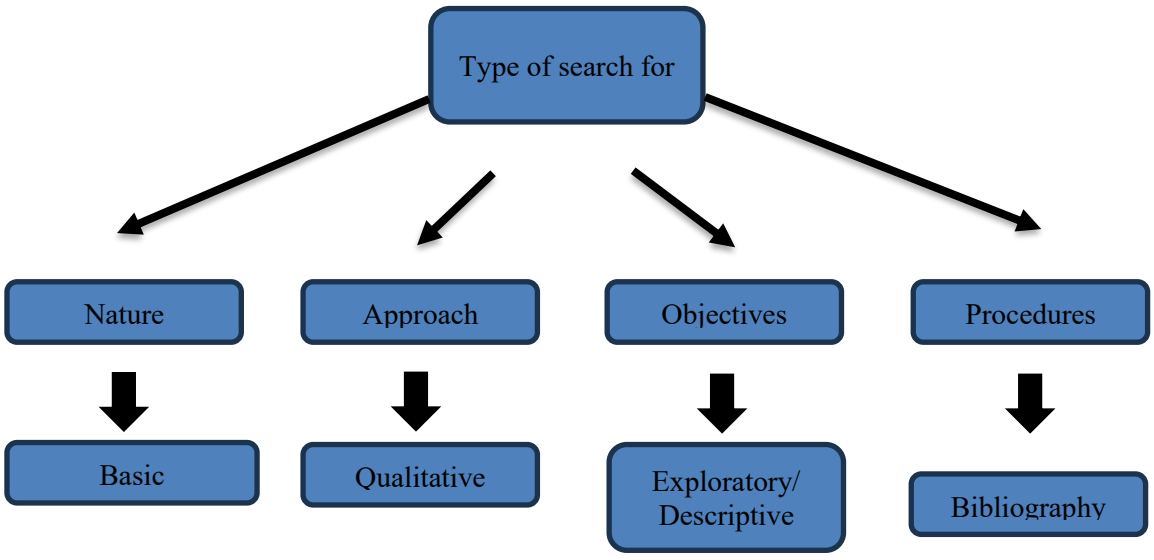
The nature of research is basic or pure, as it seeks theoretical results on the subject, valuing theoretical knowledge and without experiencing the results in practice. Its objective is to generate new knowledge on the subject, without having as its goal the solution of problems or the creation of a product directly applied to meet a certain demand [27], [28].

As for the objectives, the research is classified as both exploratory and descriptive. Exploratory research is the initial one, as it seeks to know and understand the problem, create familiarity with the problem to explain it or build hypotheses, in addition to exploring new trends and disruptive technologies or not. It is primarily based on a bibliographic survey [27], [28]. Descriptive research, on the other hand, aims to describe facts or phenomena through observation or collected data, such as the characteristics of a population, the nature of a phenomenon or the establishment of relationships between variables, in addition to describing the characteristics and applications of the researched technologies [27], [28].

A bibliographic research was also carried out, a technical procedure that aims to support the theoretical part of the study. The process involved the review of published literature, including scientific articles, books, term papers (monograph, dissertation, and thesis), audiovisual media and other specialized sources related to the fundamentals of AI, image recognition, and the methods used in this area [27], [28].

Regarding the approach to the problem, the research is called qualitative, because it does not quantify the investigated phenomenon. It is based on the analysis of the existing literature to understand and explore the problem, analyzing the subjectivity present in the written part of the materials that have already been published [27], [28]. Figure 2 shows the typology of the research used in the present study.

Figure 2 *- Typology of the research methodology*



Source: *Authorship (2024)*

Aiming at theoretical referencing, the Capes Portal, *Web of Science (WoS), Google Scholar, Scientific Electronic Library Online (SciELO), Scopus* and the Brazilian Digital Library of Theses and Dissertations (BBTD) were used as a basis. Regarding temporality, the documents were collected from 2014 onwards, and 11,904 documents were found in WoS.

In the search for documents related to patents, the system retrieved 14 articles, consisting of two review articles, six procedural articles, and six scientific articles. These works were authored by 60 researches, four of whom contributed to two articles each. Seven of the papers belong to the field of Computer Science/Artificial Intelligence. Chart 1 shows the result obtained.

Table 1 *- Patent _Bibliometria*

Author	Title	Year	Document Type
Lin, WG; Yu, WQ; Xiao, RB	Learning Efficient Representations for Image-Based Patent Retrieval	2024	Procedure Article
Wang, HS; Zhang, YQ	Measuring Patent Similarity Based on Text Mining and Image Recognition	2023	Article
Lee, HJ; Oh, H	Assessment of Pharmaceutical Patent Novelty with Siamese Neural Networks	2023	Procedure Article
Cheung, CY; Tang, FY; Ting, DSW; Tan, GSW; Wong, TY	The efficiency of a Machine learning approach based on Spatio-Temporal information in the detection of patent foramen ovale from contrast transthoracic echocardiography Images: A primary study	2023	Article
Barnell, M; Raymond, C; Isereau, D; Capraro, C; Cote, E	Digit Recognition Using Composite Features With Decision Tree Strategy	2023	Article
Fatima, SA; Kumar, A; Pratap, A; Raoof, SS	Tomato Production Prediction Based on Deep Learning Algorithm-Cascade-PSPNET and Bayes	2023	Article
El-Shimy, H; Zantout, H; Hassen, HR	A multi-spectral palmprint fuzzy commitment based on deep hashing code with discriminative bit selection	2023	Article
Yang, J; Zhang, SQ; Zhou, YX; Yu, HY; Zhang, HQ; Lan, TY; Zhang, M; Huang, WY; Zhang, W; Cheng, LG; Li, YJ; Tian, JW; Yuan, JJ; Ran, HT; Guo, YL; Zhang, RF; Zhang, HX; Wang, AX; Du, LJ; He, W	A Study on the Deduction and Diffusion of Promising Artificial Intelligence Technology for Sustainable Industrial Development	2020	Article
Chen, CH; Huang, KW	Object Recognition and Detection in Remote Sensing Images: A Comparative Study	2020	Procedure Article
Zhao, RY; Li, XL; Li, DY	Artificial Intelligence in Diabetic Eye Disease Screening	2019	Review Article
Barnell, M; Raymond, C; Capraro, C; Isereau, D; Cicotta, C; Stokes, N	Research of Competition Pattern and Technology Development Trend based on Patentometrics-a Case Study of AI-field	2019	Procedure Article
Qi, CC; Liu, WZ	High-Performance Computing (HPC) and Machine Learning Demonstrated in Flight Using Agile Condor® Upstream Machine Learning (ML) for Anomaly/Object Detection and Target Classification	2018	Procedure Article
Wu, TF; Leng, L; Khan, MK	Machine Learning in Computer-Aided Synthesis Planning	2018	Review Article
Coley, CW; Green, WH; Jensen, KF	Utilizing High-Performance Embedded Computing, Agile Condor, for Intelligent Processing An Artificial Intelligence Platform for Remotely Piloted Aircraft	2017	Procedure Article

Source: Authorship based on WoS (2024)

In the process of inclusion and exclusion of articles, the most relevant ones on the topic studied were selected, excluding those prior to 2014 or not related to the theme.

A patentometric search was conducted on the technological development of AI-based image recognition. The technological prospecting was carried out on July 2, 2024, to seek patents related to the use of AI in image recognition, considering a time frame beginning in January 2014. The Orbit tool was used, a business software aimed at researching, selecting, analyzing and exporting information contained in patents documents.

The search strategy used the keywords "*artificial intelligence*" *AND* "*image recognition*". All documents that presented both expressions together in the title and in the abstract were considered valid. The language of the survey was English, which is considered universal and understood by most of the global population. The time frame covered from the first publication of a patent on the subject until 2024.5,154 patents and 19,181 reference documents were found in the *WoS database*.

The methodological steps followed were: (i) definition of the research strategy and keywords; (ii) verification of the information contained in the patent documents; (iii) processing of the data obtained; (iv) analysis of information; and (v) generation of a document with the results. Based on the results, Microsoft Excel was used to assist in the analysis of the data, as well as in the generation of spreadsheets and graphs, such as those presented in this work.

RESULTS AND DISCUSSION

The research made it possible to identify the technological development in the use of AI in image recognition. A significant advance in algorithms related to recognition has been observed, especially after the advent of neural networks, which has contributed to improving the accuracy of systems and, consequently, increasing technological efficiency.

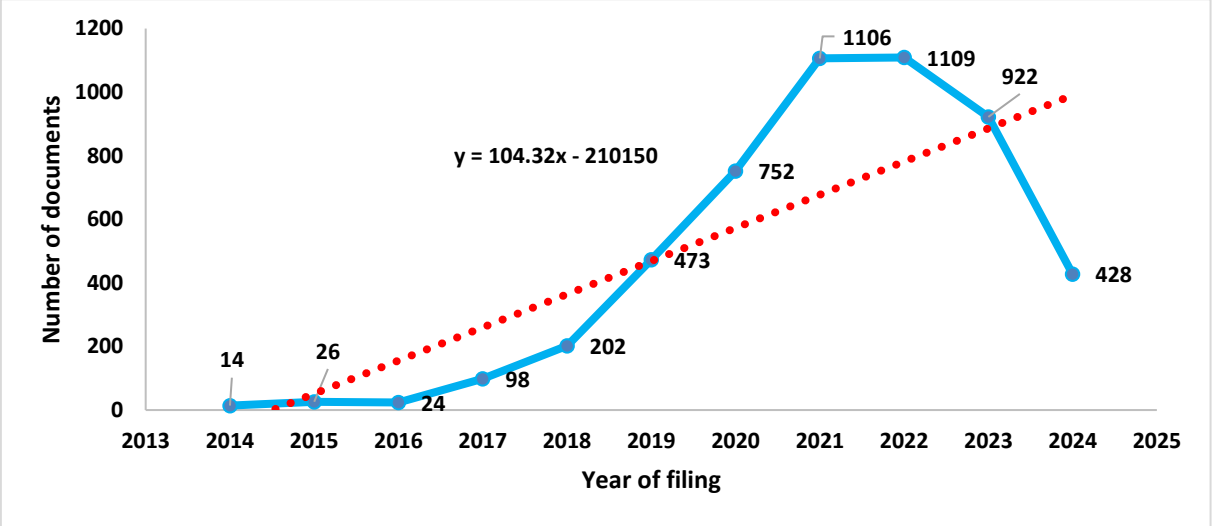
The granting of patents have evolved over time, a trend that is also seen in image recognition, especially in conjunction with advances in AI, which is progressively integrated with other emerging technologies, such as the Internet of Things (IoT), further accelerating innovation in this domain.

The first patent for AI-based facial recognition was filed in 1989, titled "*Neural network based automated cytological specimen classification system and method*", number AU628342B2. It is an automated screening system and method for the classification of cytological specimens, in which a neural network is used to perform the classification function. The invention also includes an automated microscope and an associated image processing circuit.

TEMPORAL DISTRIBUTION

The temporal distribution of the number of patents filed between 2014 and 2024 is shown in Figure 3.

Figure 3 *– Temporality of patent filings between 2014 and 2024*



Source: Authorship based on ORBIT (2024)

Figure 3 presents the temporal evolution of patents published between 2014 and 2024, evidencing the inventive behavior of the technology over the period analyzed. There has been a consistent growth since 2016, possibly associated with the expansion of the use of connected devices in networks and the widespread diffusion of digital platforms. The linear growth recorded between 2015 and 2016 suggests an initial consolidation phase, characterized by the stabilization of Research and Development (R&D) efforts, compatible with the technological validation process described in the early stages of the innovation life cycle.

Taking into account only the period between 2014 and 2024, the following interpretation is given:

Early phase of low activity (2014-2016 = discovery/niche stage): the numbers are low and typical of embryonic or niche stages of the technology or research area. During this period, the topic was still little explored or began to gain attention. Emerging technologies tend to present an initial period of low inventive activity, followed by a rapid phase of expansion after the definition of a dominant project [30]. The consolidation of a technological paradigm guides the trajectory of innovation, reducing uncertainty and stimulating concentrated investments [31], as can be proven in this period between 2014 and 2016.

Inflection point and rapid growth (2017-2019 = acceleration phase): it is observed that, in 2017 – identified as the inflection point - the number of published patents quadrupled (from 24 to 98), configuring a critical point of acceleration, in which the technology gained traction, attracted investments, and expanded the application base. This movement intensified between 2018 and 2019, when the exponential growth culminated in 473 documents in 2019, reflecting a period of consolidation of technological knowledge and intense technological discovery, maturation, and diffusion. This condition is consistent with the thinking of Soete & Freeman [32], who cites that innovation spreads rapidly and starts to be explored by a growing number of economic actors.

Period of maximum productivity and consolidation (2020-2022 = maturity and dominance phase): in this interval, the annual values are the highest in the series (752, 1,106, 1,109), configuring the peak maturity of the cycle of interest. The maximum plateau occurs in 2022, suggesting the stabilization of the pace of innovation, with technology assuming a central and dominant role in its area of activity, while gains become mostly incremental.

Signs of saturation or deceleration (2023-2024 = possible maturity/advancement to specializations phase): there is a significant drop in 2023 (from 1,109 to 922), which may indicate that the field is beginning to reach a point of theoretical saturation or that the focus of research is shifting to more specific subareas. The amount for 2024 was obtained based on data collected up to the middle of the year and, therefore, should be considered partial, mainly due to the 18-month secrecy period. Thus, it should not be interpreted as a real drop in activity, but as a technical characteristic of data collection.

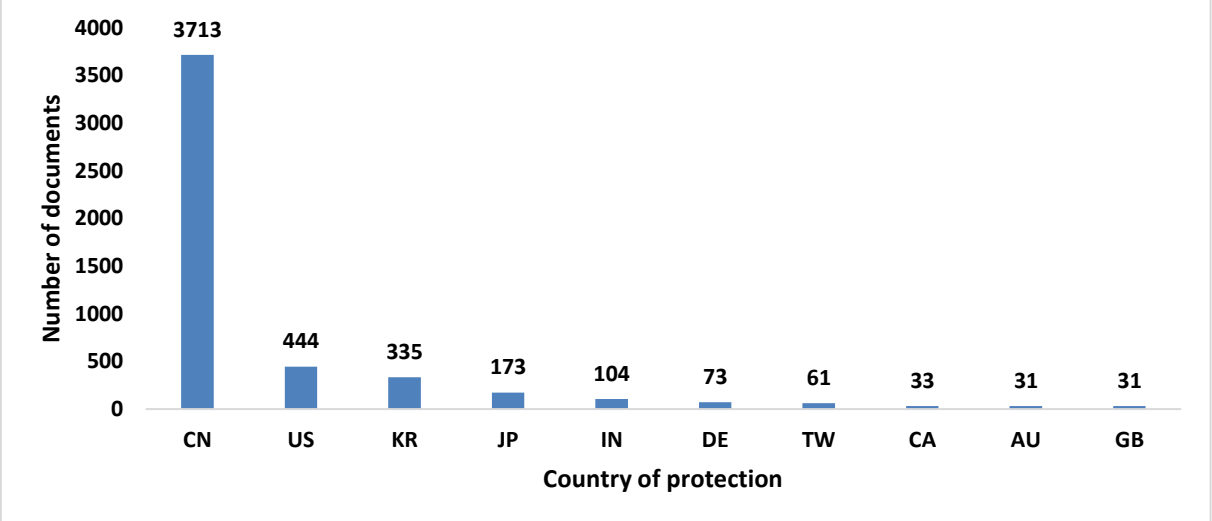
The analysis of growth rates reinforces this interpretation: the highest percentage increase occurred in 2017 (308.33%), typical of rapidly rising technologies, while the lowest rate was recorded in 2022 (0.27%), compatible with the maturity phase of the cycle. From 2019 onwards, a deceleration in the percentage growth rate, although the absolute number of patents increased by 58.99% in 2020, 47.07% in 2021, and 0.27% in 2022. This condition suggests limits to the extensive expansion of the technological field, possibly influenced, among other factors, by the reduction in the growth of global investments in R&D, which went from 15% in 2021 to about 7.4% in 2022 (WIPO, 2020).

COUNTRIES OF PROTECTION

Although the protection conferred by a patent is territorial, it can be extended beyond the country of initial filing, covering other markets in which the technology is intended to be commercialized. To do so, the patent holder must apply for protection with the office of each country of interest, in compliance with the respective rules and legislation in force, which requires an internationalization strategy and the ability to operate in different jurisdictions.

The main markets for patent protection are shown in Figure 4.

Figure 4 *– Countries of protection*



Source: *Authorship based on ORBIT (2024)*

The largest market for patent protection is China, with 3,713 patents, followed by the United States of America (USA), with 444, and the Republic of Korea, with 335. China has more than 8 times the number of patents of the USA, the second place, which demonstrates its strategic and planned dominance, indicating that the country is the main battlefield and application of this technology, there is an aggressive national policy of encouraging innovation and patent protection, and Chinese companies are seeking to obtain a global competitive advantage and consequently, make it difficult for foreign competitors to enter.

This result highlights the potential of these markets for the protection of technology, representing about 89.88% of the total among the ten most relevant. These countries have programs to encourage research and product development, aiming, among other objectives, to retain and master the technology, generate market niches, obtain gains in scale and receive royalties through licensing. Such a condition also favors a global strategy of economic growth. Brazil is not among the ten largest markets in this technology, with only seven patents, occupying the nineteenth position.

There is an axis of Asian domination, which in addition to China, stands out the Republic of Korea (335), Japan (173), India (104) and Taiwan (61), which together account for more than 87.86% of the patents listed, demonstrating that the global R&D center for this technology is in this continent. Countries with strong innovation ecosystems, such as Canada (33), Australia (31) and the United Kingdom (31), have relatively low numbers, indicating that they are not primary markets for protecting this technology and probably their corporations prefer to protect their inventions in larger markets such as China and the USA.

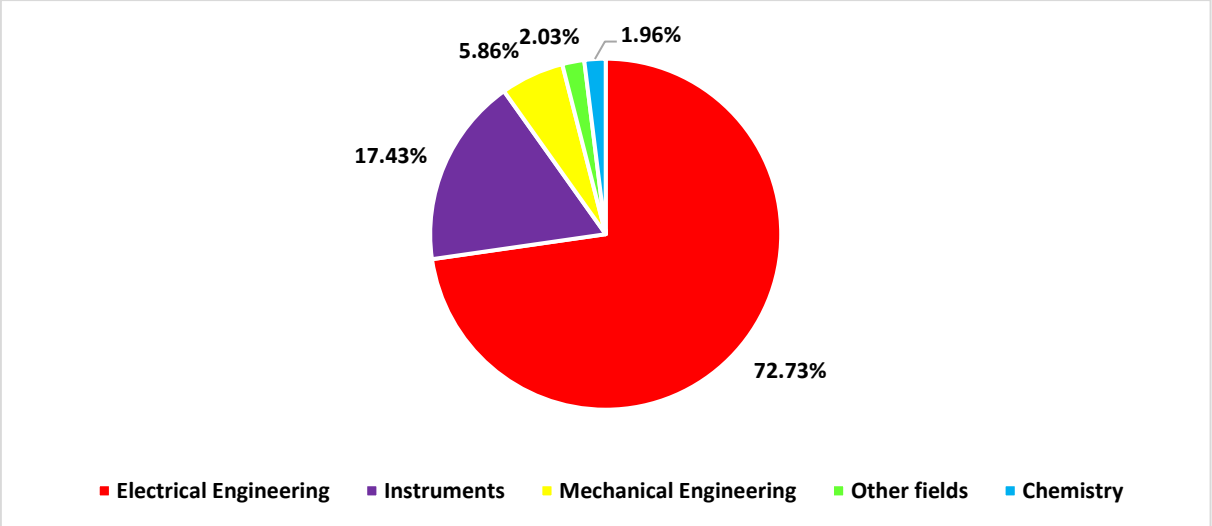
Competition in image recognition technology is intense, both between countries and between companies, which seek to consolidate themselves in a highly competitive market. This dispute creates opportunities to capture market share and, consequently, generate economic gains. For this reason, there is a large volume of investments by the agents involved to maintain or achieve leadership and obtain competitive advantages, as occurs with Asian, European and American countries. This movement inevitably influences geopolitical relations and allows global access to technology by its holders to be controlled.

Generally, inventors first request the protection of their inventions in the country of origin and, later, in markets with high commercial potential, mainly to avoid counterfeiting or undue economic use of the technology. The choice also falls on markets where direct competitors operate, as a way to prevent unauthorized use.

CATEGORY OF DOMINANT TECHNOLOGIES

The categories of dominant technologies are distributed in five groups: Chemistry (1.96%), Instruments (17.43%), Electrical Engineering (72.73%), Mechanical Engineering (5.86%) and Other Fields (2.03%), The predominant group is Electrical Engineering, with emphasis on computer technology, as illustrated in Figure 5.

Figure 5 *– Category of dominant technologies*



Source: *Authorship based on Orbit (2024)*

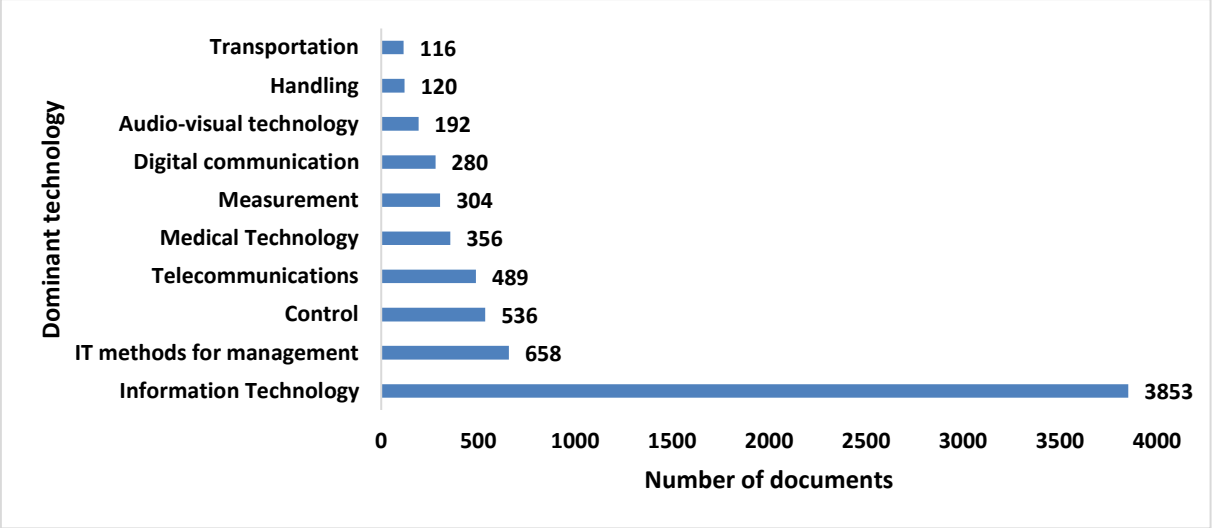
Electrical Engineering (5,349 patents = digital core) is overwhelmingly dominant, as it is the backbone of this technology, which includes computing, telecommunications, semiconductors, electronics, signal processing, computer vision, and AI technologies. This condition confirms that the core of innovation is digital and based on electronic software/hardware. It is the brain part of the innovation system and where intelligence is created.

The second largest group is instruments (1,282 patents = sensing and interface layer), which includes medical technology, measurement equipment, optics, sensors, and control instruments. They represent a vital component of the system in the vision part (sensors and cameras) and in the tactile part (measurement and control devices) that are integral to AI solutions in relation to the physical world. This condition demonstrates that innovation is not purely theoretical, but aims at the creation of functional devices and systems. It is the layer that collects data in the real world, performs the actions determined by the core, becoming the bridge in and out of the system.

DOMINANT TECHNOLOGY

The dominant technology can be seen in Figure 6.

Figure 6 *- Dominant technology based on CPI*



Source: *Authorship based on ORBIT (2024)*

Figure 6 shows the predominance of computer technology, identifying the main player in the technological portfolio, which demonstrates that the central theme of the research is fundamentally a software and data processing technology, rooted in computer science. This does not preclude, however, the less representative areas, which serve to indicate other fields of application of the technology. Computer technology includes the advances inherent in hardware (the physical part of the computer) and software (computer programs), essential elements for the progress of AI.

In second position is IT Methods for Management, which reflects the application of the solutions in business management, logistics and decision-making systems.

The development of AI-powered image recognition is driven by computer science, but its relevance and business value are amplified by its transversality and integration into mature and critical economic sectors such as healthcare, management, telecommunications, and automation.

The dominant technology is defined based on the code of the Cooperative Patent Classification (CPC), a variant of the International Patent Classification (IPC), which groups inventions in various technological fields. Generally, the dominant technologies are those that receive the greatest volume of resources and, in some cases, are the most academically studied, generate more patents and have greater market potential. This dominance also tends to attract new entrants, who perceive the field as fertile for research and development.

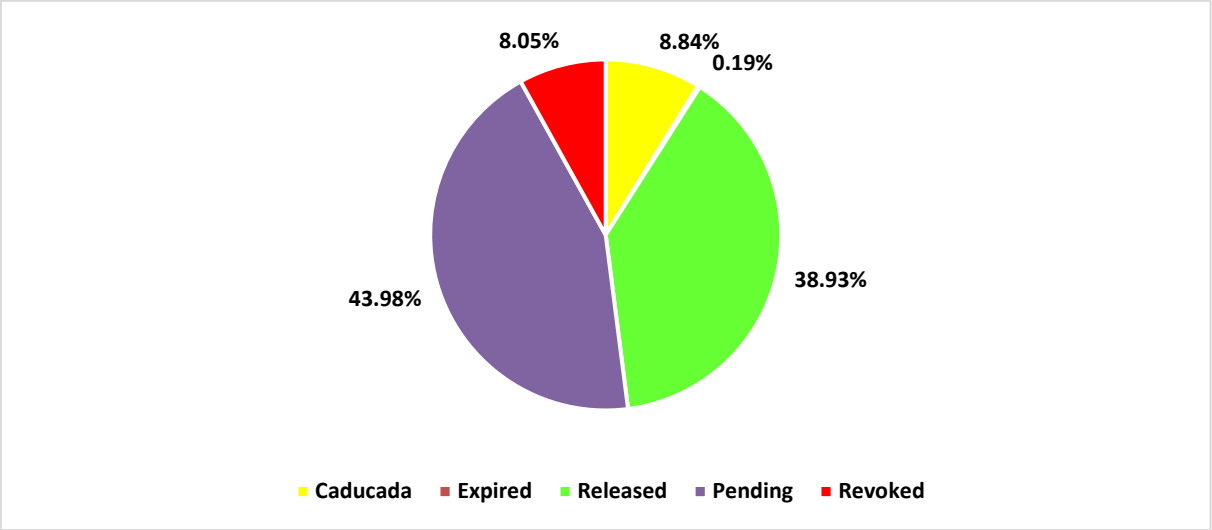
Among the observed impacts of image recognition technology, we can mention the applications in security and surveillance, used to monitor and protect public and private places. There are also uses in the medical field, such as support for diagnoses, treatments, and the analysis of radiographic and magnetic resonance images, contributing to the detection of diseases with greater accuracy.

Image recognition has also been applied in the marketing and commerce sector, mainly to improve customer relationships and identify behavior patterns, especially purchases.

LEGAL STATUS

Legal status refers to the legal status of patents, allowing the identification of which patents have been granted or are pending (therefore, in force) in relation to those that are no longer in force – whether due to expiration, revocation or expiration. When the percentage of patents that are not in force is high, this may indicate a lower interest in continuing the development of that technology. Figure 7 presents the results of the survey.

Figure 7 *- Legal status*



Source: *Authorship based on ORBIT (2024)*

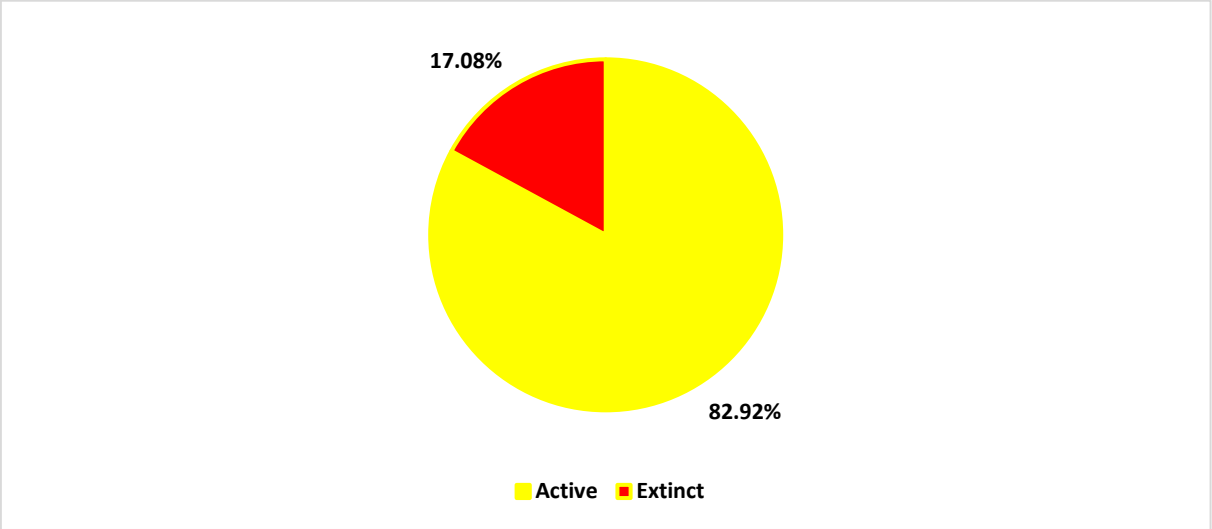
Figure 7 shows that only 17.08% of patents are not in force. Pending patents indicate that they have not yet been granted, due to various reasons, such as lack of documentation.

Expired patents (462) have lost their validity and among the reasons for this condition is the owner's lack of interest in fulfilling one of the obligations related to its continuity, such as non-payment of the annuity, which among other reasons may be related to maintenance costs that exceed the commercial or strategic value, low commercial potential, strategic changes of the holder, among other reasons. Revoked patents (421) may be related to a challenge or annulment by an authority, as it does not constitute a novelty or inventive step. Expiry shows the importance of administrative management (payment of fees), while revocations indicate that part of the patents was vulnerable to legal opposition. In turn, expired (10) means that they have reached their maximum term of protection.

The vast majority of patents in the analyzed portfolio are active or not finalized, representing 82.92%, showing a dynamic, growing and highly invested technological field, being a positive indicator of the health and value of the technological portfolio studied. The largest group is pending (2,299), representing patents whose granting process is still in progress. This indicates recent activity and a continued strong interest in the development and protection of technologies. In turn, the released/granted patents (2,035) represent the patents that have already been examined and obtained the official grant. They represent intellectual property assets in full force.

The legal status is related to the protection strategies adopted for patents, which depend on the term of validity from the filing of the application: 20 years for invention patents and 15 years for utility models. Figure 8 illustrates the distribution of the legal status of patents.

Figure 8 *– Legal status of patents*



Source: *Authorship based on ORBIT (2024)*

Figure 8 shows that, in the portfolio of this technology, the proportion of extinct patents is not very relevant. Each year, the number of registrations grows, which indicates both the interest in developing new applications and the fact that this technological field is still in the expansion phase, with great potential to be explored.

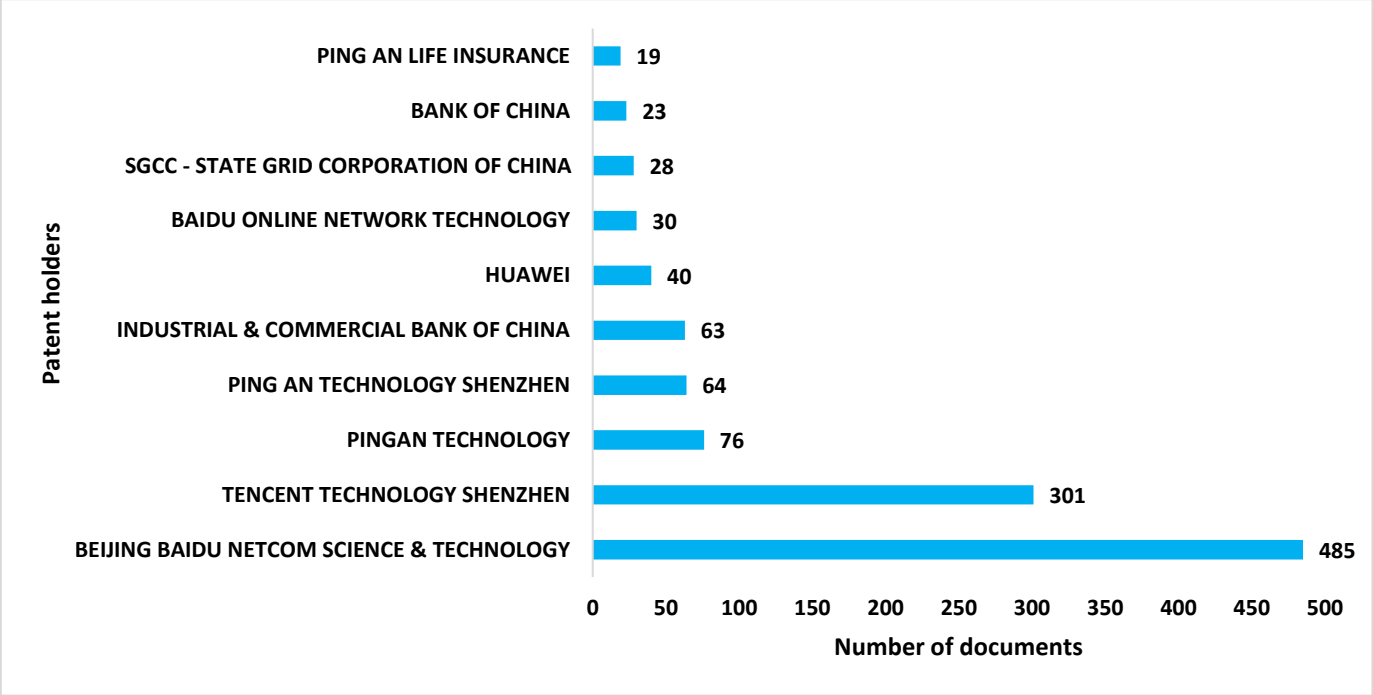
The quantitative analysis indicates that the vitality rate is 82.92%, demonstrating a robust health of the technological portfolio, constituting an extremely positive indicator, that is, the vast majority of patents are still under legal protection, generating value for the holders, in addition to showing a dynamic technological field with continuous commercial interest.

The holders of these patents consider the portfolio valuable and for this reason continue to pay the costs of its maintenance because they assess that there are conditions to obtain commercial return or strategic advantage.

PATENT HOLDERS

The main patent holders are shown in Figure 9.

Figure 9 *– Main patent holders*



Source: Authorship based on ORBIT (2024)

Figure 9 shows that, among the top ten patent holders, all are Chinese – a fact consistent with the country's relevance in protecting this technology. This is an indicator that there is a very competitive market focused on this field of innovation, in addition to being a national strategy aligned with industrial policy, which gives the country a competitive advantage.

In this group, two banks stand out, which, for security reasons, should invest in studies related to image recognition, especially for banking operations carried out by customers, usually through cell phones.

There is an absolute dominance of the Information and Communication Technology (ICT) sector, led by Beijing Baidu (485), Tencent (301) and Baidu (30), which confirms that the core of innovation in this area is digital technology. These companies are internet and AI giants, with a focus on developing cloud-based algorithms, platforms, and services.

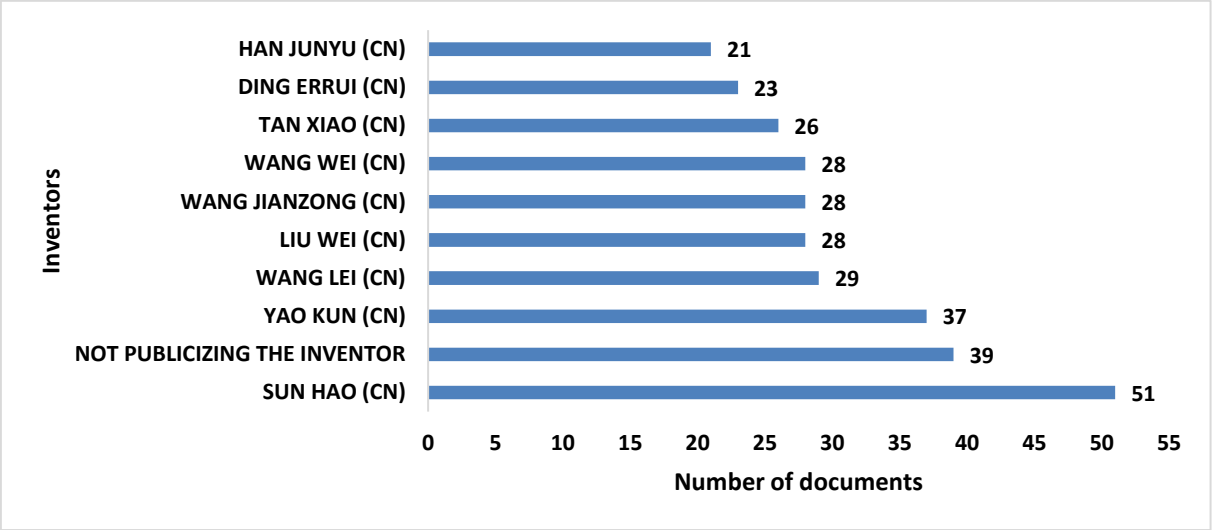
There is strong participation from the financial sector (Fintech) and insurance such as Ping An Group (76 + 64 + 19 = 159 patents), which is a financial conglomerate that appears under multiple entities, demonstrating aggressive strategic investment. This group includes the state-owned Industrial & Commercial Bank of China (63) and Bank of China (23), which demonstrates that one of the main applications of this technology is in the financial sector focused on security and authentication, fraud prevention and customer service.

There is participation from industrial and infrastructure giants such as Huawei (40), a telecommunications company, and the State Grid Corporation of China (28), a state-owned electricity company, which can use AI to perform predictive maintenance on transmission lines through drones, as well as smart grids and facility security.

INVENTORS

The main inventors are illustrated in Figure 10.

Figure 10 *– Main inventors*



Source: Authorship based on ORBIT (2024)

Figure 10 shows that, among the ten most relevant inventors, 90% are Chinese – a fact that is in line with the profile of the holders and with the predominance of China as a country of protection of this technology. This condition demonstrates that the center of development and protection of this technology is in China.

The volume of patents in this group is considerable, with a relative concentration for these top ten, especially in the case of a technological field where knowledge is specialized and intensive and generally centralized in large companies

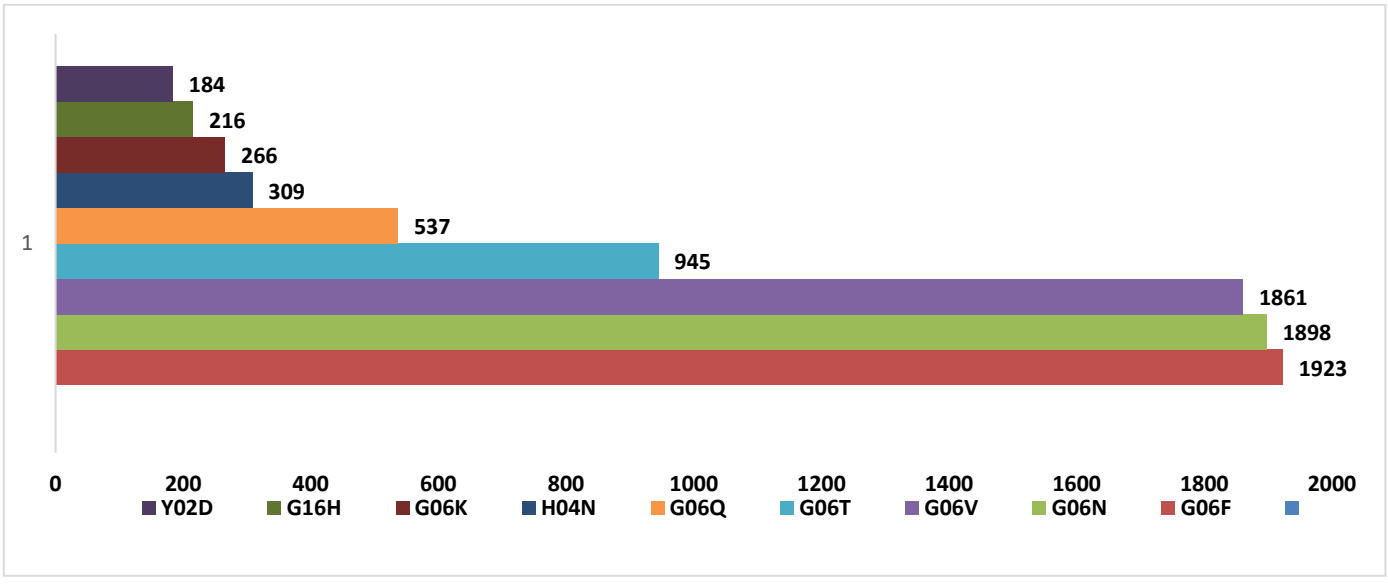
Inventor Sun Hao is the highlight, with a significant production compared to the others, being a key inventor or technical leader in this technological field.

The second place is the group that does not publish the name of the inventor, which may be a corporate strategy of the companies, with the aim of reducing the risk of losing part of the development team to competitors. By choosing not to make the inventor public, the company protects its most valuable asset, which demonstrates that the market is quite competitive for specialized AI talent.

CPC CLASSIFICATION

With regard to the CPC, it was found that class G, referring to Physics, represents 70% of the relevant patents. Within this class, the G06F subclass (electrical digital data processing) stands out, which represents about 18.3% of the top 100, followed by G06N (computing arrangements based on specific computational models), with 18.1%, and G06V (image or video recognition or understanding), with 17.7%. These data are consistent with the scope of the search undertaken, as shown in Figure 11.

Figure 11 *– Number of patents related to the development of technological innovations in image recognition, according to the CPC classification*



Caption:

G06F – Electrical Digital Data Processing

GO6N - Computer systems based on specific computer models

G06V – Image or video recognition or understanding

G06T - Processing or generation of image data, in general.

G06Q - Systems or methods of data processing, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided

H04N – Pictorial Communication

G06K - Data recognition; presentation of data; record carriers; Handling conveyors

G16H – Health informatics, i.e. information and communication technology [ICT] specially adapted for the handling or processing of medical or health data

Y02D – Climate change mitigation technologies in information and communication technologies that aim to reduce their own energy use

Y02T – Transportation-related climate change mitigation technology

Source: *Authorship based on ORBIT (2024)*

Figure 11 shows that the core of technology is computing and AI. The G06F subclass (1923) is the basis of all computing, indicating that inventions involve hardware, computer architectures, signal processing, and fundamental software.

The G06N subclass (1.898) specifically covers AI, machine learning, and neural networks. The proximity in volume to G06F indicates that AI is the dominant computational paradigm.

The G06V subclass (1.861) is the central application that defines the field of study computer vision.

The subclasses G06T (945), G06Q (537), H04N (309), G06K (266) and G16H (216) represent the areas of application and technological support.

Y-ratings indicate the objectivity of the technology and are mission-specific. The Y02D classification aims to reduce the carbon footprint of ICTs and the Y02T subclass aims to decarbonize the transport sector, therefore, they are guided by global sustainability goals, as technological advancement is aligned with the need for energy efficiency and climate change solutions.

FINAL CONSIDERATIONS

AI has revolutionized several fields of knowledge, especially image recognition – a significant advance for humanity, considering the accuracy, effectiveness, and breadth of its applications. However, its indiscriminate use generates ethical problems and violates the fundamental rights of individuals, since it often occurs without prior consent, thus hurting their dignity and privacy.

Technologically, image recognition has profound impacts on society and specific sectors, such as public safety and health. Its implementation requires large data sets and, in certain contexts, can lead to discrimination against minorities, which even serve, in some cases, as a parameter for the training of AI systems.

Technological prospecting is an essential instrument to evaluate the technological development of a product, as it allows mapping its evolution through a patent database and the use of keywords. Among its main contributions are the analysis of the evolution of time, the identification of the main inventors and holders – which can facilitate the articulation of partnerships – and the indication of countries with promising markets for the technology.

AI-based image recognition technology is present in 41 countries, with China as the main protagonist, holding 2,673 patents in various related areas. Countries such as China, Japan, Germany, France, among others, have implemented specific policies to foster this development, which has become widespread especially with the rise of social networks, in which images narrate the history of influencers and society in general.

Most of the patents belong to the Physics group, with emphasis on the code G06F (processing of electrical digital data), which is in line with the theme studied and reflects the basis of the computational models used for the manipulation and processing of data in intelligent machines.

The data indicate a continuous growth of the technology over time, especially in the last decade, evidencing the investment of public and private entities in its development.

Developed countries, with a special role in Asian nations, are the ones that stand out the most in the advancement of this technology.

This work contributes to the understanding of the current state of technology, offering researchers another subsidy for studies on image recognition through AI. In the future, it will be necessary to address ethical and privacy issues, as well as expand investigations and the possibilities of technological application.

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