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ORIGINAL PAPER

# Vagueness in Artificial Intelligence: The 'Fuzzy Logic' of AI-Related Patent Claims

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## Abstract

Artificial intelligence is an emerging technology with an average growth rate of 64.70% in patent filings worldwide and 39.71% in Europe between 2015 and 2019, according to Espacenet queries. This trend has raised several concerns regarding the implications for Intellectual Property rights, including disclosure, which is one of the main components justifying the existence of the patent system. Despite its importance, this requirement has been disputed due to certain tendencies that distort the functions that the act of disclosure fulfils, such as promoting innovation, research or teaching. With artificial intelligence–related patents being granted, the disclosure requirement is once again compromised, and perhaps even more due to the particularities that this branch of technology entails. In this sense, one main concern lies in the question of how artificial intelligence–related patents should be disclosed, as well as the fulfilment with this requirement. To this aim, two case studies are conducted to show the heterogeneity of compliance with this requirement, focusing on patents filed at the European Patent Office. The methodology used in the case studies consists in the analysis of a core-AI patent and an AI application patent which allow to assess the differences in the disclosure of both inventions. The heterogeneity between both case studies highlights the relevance of the topic and allows to propose three recommendations to improve sufficiency of disclosure in AI-related patent claims: metrics and benchmark analysis, standardisation of patent claim construction by introducing a 'claim chart' and introducing a peer review patent programme.

**Keywords** Sufficiency of disclosure · Artificial Intelligence · Patent claims · Vagueness · Heterogeneity · EPO

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## 1 Introduction

Artificial intelligence (AI) is one of the fundamental technologies brought about by the Fourth Industrial Revolution. This technology is present in different fields and has been credited with several ground-breaking products and services that have the potential to change many aspects of society at large (Bengi & Heath, 2020). However, even if there is extended academic research on AI, as well as great interest from industry, governments and individuals, there is not a universal definition of it (JRC, 2018).

AI is a general-purpose technology with widespread applications that are generating important concerns around aspects such as ethics, data protection or Intellectual Property (IP). Regarding the latter, IP policy represents a key aspect for innovation and creativity since it stimulates economic and cultural systems. AI interplays with IP in several ways and has resulted in interesting discussions in recent years. However, most of the attention has been addressed to the questions of authorship and inventorship, leaving aside other relevant IP questions.

This paper aims to focus on the disclosure requirement in the patent realm. Sufficiency of disclosure is one of the fundamental pillars that justify the patent system. It ensures certain transparency of human inventiveness in exchange for which the inventor is granted a time-limited patent right. With AI-related inventions entering the patent system, disclosure may be affected due to its 'black-box' character (Früh, 2021), i.e. the algorithmic decision-making of the inventions may be opaque, resulting in reproducibility issues (Waltl & Vogl, 2018), and affecting the validity of sufficiency of disclosure. This leads us to pose the following research question: How could sufficiency of disclosure be improved in the field of AI?

To answer the research question, a combination of research methods has been used, composed of a systematic literature review and empirical analyses consisting of a patent landscape and two case studies of AI-related patents from the EPO. Due to the extended analysis of each case study, it was decided to limit the selection of AI-related patents to a core-AI patent and an AI-application. The selection of the case studies was performed using the database Espacenet.

Regarding the structure, this paper begins by explaining the field of AI together with a patent landscape, focusing on the evolution of AI-related patent applications through time and the areas in which AI is more present and gaining relevance. Secondly, the patentability of AI-related inventions is briefly explained highlighting its particularities and the relevance of the person skilled in the art. Thirdly, the sufficiency of disclosure requirement is addressed from a legal, philosophical and economic perspective showing its relevance for innovation and society but also underlying the challenges that it entails, especially in the field of AI. Fourthly, two case studies of AI-related patents are presented, assessing how the inventions are disclosed and highlighting the heterogeneity of disclosure between both patents. Lastly, conclusions are developed together with three proposals that could help avoid vagueness and heterogeneity while disclosing AI-related inventions.

## 2 Artificial Intelligence

AI is considered as an emerging technology, due to the important developments that are being done within it (EPO, 2020). Even if AI is attracting attention from different disciplines —e.g., engineering, medicine, economics or law— due to its wide application possibilities, this technology is not new.

AI finds its roots back in the 1940s when it consisted in programs that executed specific instructions by the programmer (Bathaee, 2018), but it was not until the 1950s that AI was introduced as an academic discipline and defined as 'machines behaving in ways that would be called intelligent if a human were so behaving' (McCarthy et al., 1955). Since then, AI has evolved largely thanks to other technology developments, such as computer power, and it has moved, for instance, to machine learning (ML) algorithms that 'can learn, adapt to changes in a problem's environment, establish patterns in situations where rules are not known, and deal with fuzzy or incomplete information' (Negnevitsky, 2005).

As abovementioned, even if there is an important interest from different sectors of society in the potential of AI, there is not a universal definition of it (Waltl & Vogl, 2018). Nevertheless, there have been attempts to find a proper legal definition (AI HLEG, 2018; Proposal for the Artificial intelligence Act, 2021). According to WIPO, AI can be understood as a computer science discipline aiming to develop machines and systems that can execute tasks considered to require human intelligence, with minimal or no human intervention (WIPO, 2020). The discipline of AI is in fact a catch-all term that covers a fast-evolving family of technologies including ML,[1] machine reasoning[2] and robotics[3] (Drexl et al., 2019; AI HLEG, 2018).

AI can contribute to a wide array of industries and social activities by providing competitive advantages —such as optimising operations or improving predictions— that can result in economic and social benefits (Proposal for the Artificial Intelligence Act, 2021).[4] In this sense, inventors dealing with AI-related inventions are interested in getting patents since, even if AI is based on computational models and mathematical algorithms which are of an abstract nature, AI-related inventions may not be excluded from patentability if they possess technical purposes and they are claimed as such (Art. 52(3) EPC; EPO Guidelines for Examination, section G-II, 3.3.1; Decisions T154/04, T1173/97, T935/97). To show the interest in patenting AI-related inventions, this paper exposes an AI-related patent landscape.

[1] As specific examples of ML, deep learning and reinforcement learning can be highlighted.

[2] Including planning, scheduling, knowledge representation and reasoning, search and optimisation.

[3] Including control, perception, sensors and actuators, and the integration of all other techniques into cyber-physical systems.

[4] The European Commission points out different areas that could benefit from AI, for instance: 'healthcare, farming, education and training, infrastructure management, energy, transport and logistics, public services, security, justice, resource and energy efficiency, and climate change mitigation and adaptation' (Proposal for the Artificial Intelligence Act, 2021).

### 2.1 AI-Related Patent Landscape

To conduct the patent landscaping of AI-related patents, the online available patent database Espacenet[5] is used. AI-related patents can be identified by the presence of AI-relevant keywords —such as machine learning (ML), AI or fuzzy logic, among others[6] (Baruffaldi, et al., 2020). Those relevant keywords are related to the AI technique that is used in the patent,[7] and its functional application.[8] Therefore, a search query[9] using 18 AI-relevant keywords[10] extracted from the WIPO's AI patent landscape is conducted. For the purpose of this patent landscape, only patents filed until 31 December 2019[11] are included, due to data reliability. As shown in Fig. 1, AI is already present across all CPC classes and therefore several technological fields, including 'green technologies' (Y02 and Y04S).

Regarding the time development of AI-related patent filings, Fig. 2 shows that both, worldwide and European patents, have been on the patent scene for some time, but it is only since 2015 that they have seen an unprecedented increase. This may be due to several aspects that have been highlighted above, such as computer power, but also because of technological advances and research interest in the field of AI (JRC, 2018).

This section has shown the growing relevance of AI-related patents in Europe and worldwide, as well as the variety of fields that AI has reached, including diverse and heterogeneous areas such as chemistry, transporting, textiles, mechanical engineering and/or green technologies. The increasing importance, as well as the prevalence across technology fields, of AI-related patents underlines the need to research issues related to this type of patent. Moreover, the scant literature regarding disclosure justifies and motivates the scope of this paper, and therefore its focus on disclosure in AI-related patents.

[5] Espacenet is an online free available database that contains over 120 million documents including European and worldwide patents. It is considered as one of the best online available tools (Jürgens & Herrero-Solana, 2015). In Espacenet, it is possible to filter patents' searches by keywords, publication numbers or by countries where the technology is patented, among others. Likewise, it is possible to filter patent results using the 'International Patent Classification' (IPC) or the 'Cooperative Patent Classification' (CPC).

[6] There are several AI-related patent taxonomies; some rely on keywords other than CPC or IPC, and depending on the strategy and databases used, the identified patents and results can be different.

[7] Neural network (NN), fuzzy logic, support vector machine, etc.

[8] Natural language processing (NLP), computer vision, speech recognition, etc.

[9] The timeframe selected is until 31 December 2019, since it can only be guaranteed until this date that all relevant patents have already been published, as it takes approximately 18 months after filing for patents to be publicly available.

[10] ML, fuzzy logic, AI, convolutional neural network, genetic algorithm, deep learning, support vector machine, Markov model. Espacenet has a limitation of search criteria, and therefore, the selected keywords are the ones that result in the higher amount of identified AI-related patents.

[11] Query done in Espacenet: https://worldwide.espacenet.com/patent/search?f=publications.pd%3Ain%3D19690101-20191231&q=ctxt%20%3D%20%22machine%20learning%22%20OR%20ctxt%20%3D%20%22genetic%20algorithm%2A%22%20OR%20ctxt%20%3D%20%22convolutional%20neural%20network%2A%22%20OR%20ctxt%20%3D%20%22deep%20learning%22%20OR%20ctxt%20%3D%20%22support%20vector%20machine%2A%22%20OR%20ctxt%20%3D%20%22markov%20model%2A%22%20OR%20ctxt%20%3D%20%22artificial%20intelligence%22%20OR%20ctxt%20%3D%20%22fuzzy%20logic%22.

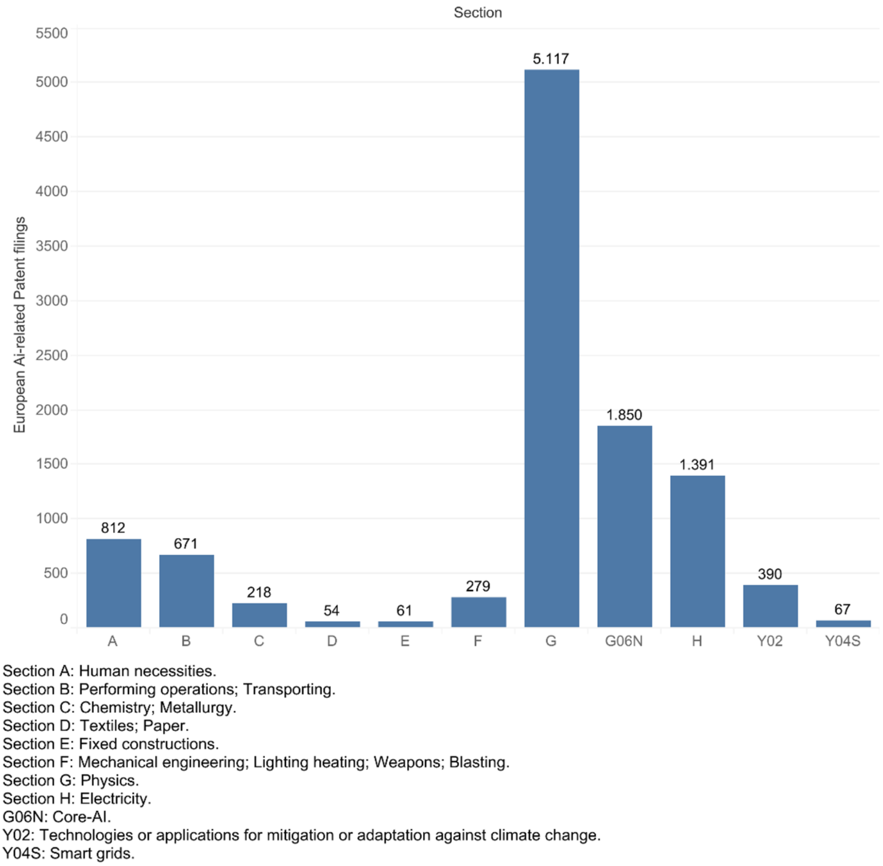


**Fig. 1** Distribution of AI-related patents across CPC sections and some relevant technology fields (generated with Tableau)

## 3 Artificial Intelligence and Patent Law

AI has triggered interesting debates and literature on several aspects of patent law. Discussions among experts have particularly focused on inventorship, patentability and non-obviousness issues (Abbot, 2016; Fraser, 2016; Ramalho, 2018; Bengi & Heath, 2020; Balos, 2021; Slowinski, 2021). Based on those matters, it has been questioned whether the current patent system is optimal and up to date to meet the challenges posed by AI.

However, before thinking about amending laws or creating new ones to consider AI developments —which would not consist of either a technology-neutral solution or a realistic one (Ramalho, 2018; Hartmann et al., 2020; Balos, 2021)— it is relevant to assess the current patent system, which already includes specific guidelines to assess AI-related inventions in IP offices (e.g. EPO Guidelines for Examination G-II, 3.3.1) and has been able to deal with AI-related issues (Decision J0008/20

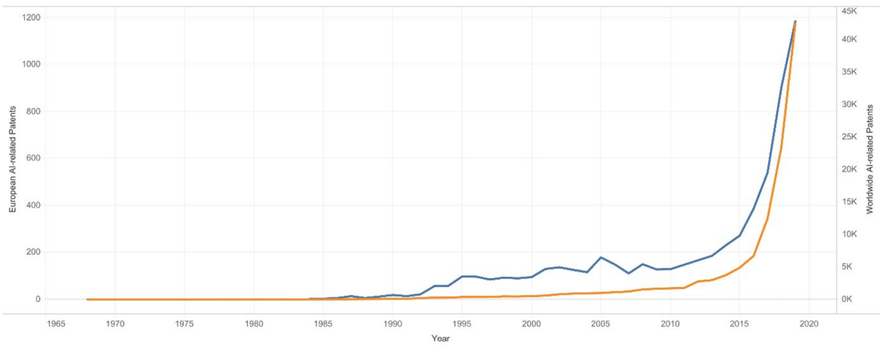


**Fig. 2** Time development of AI-related patents worldwide (orange) and in Europe (blue) (generated with Tableau)

DABUS). In this paper, we focus on the EPC definitions and EPO procedure, even if other patent systems may be mentioned.

### 3.1 Patentability of AI-Related Inventions at the EPO

A patent is a territorial exclusive right granted for an invention, in all fields of technology, which consists of a product or process that is new, involves an inventive step and is capable of industrial application (Art. 27 TRIPS). To benefit from a patent right, the inventor must disclose technical information to the public through the patent application (Art. 29 TRIPS).

According to the EPO, inventions involving AI are considered 'computer-implemented inventions' (CII) which entail computers, computer networks or other programmable devices, whereby a feature is performed by means of a program (EPO Guidelines for Examination, F-IV, 3.9). Under the EPC, a CII is considered a patentable subject matter if it is not excluded from patentability (Art. 52 EPC) and fulfils the patentability requirements of novelty (Art. 54 EPC; Decisions T12/81 and T198/84), inventive step (Art. 56 EPC; Decision T154/04) and susceptibility of industrial application (Art. 57 EPC; Decision T144/83). This approach also applies to AI-related inventions (EPO Guidelines for Examination, G-II, 3.3.1).

The presence of the patentability requirements is assessed by patent examiners who are considered as persons 'skilled in the art' (Art. 56 EPC; EPO Guidelines for Examination G-VII, 3; Decision T641/00), also known as 'PHOSITA'[12] (Meara,

[12] '(a) Presumed to be a skilled practitioner in the relevant field of technology; (b) who is possessed of average knowledge and ability; (c) is aware of what was common general knowledge in the art at the relevant date; (d) is presumed to have had access to everything in the state of the art in particular the documents cited in the search report; (e) to have had at his disposal the means and capacity for routine work and experimentation which are normal for the field of technology in question; (f) if the problem prompts the person skilled in the art to seek its solution in another technical field, is the person qualified to solve the problem; (g) is in constant development in his technical field; and (h) may be expected to look for suggestions in neighboring and general technical fields or even in remote technical fields, if prompted to do so' (Hartmann et al., 2020).

2002; Fabris, 2020; Slowinski, 2021). In that sense, it is important to bear in mind that with CII, and therefore AI-related inventions, it is common to find mixed-type inventions, i.e. inventions with claims comprising technical and non-technical features[13] (EPO Guidelines for Examination G-II, 2; Decisions T26/86; T769/92; T641/00; T531/03; T154/04; T1784/06). In particular, with AI-related inventions, according to the EPO, the use of terms such as 'support vector machine' or NN may refer to abstract models and algorithms that do not imply the use of technical means but may be part of a technical solution. It has been suggested that due to this aspect, and the particularities that AI-related inventions entail, determining who is 'skilled in the art' could be brought into question. This would affect both the assessment of the inventive step and sufficiency of disclosure, since the required level of skill for both aspects is alike (Ramalho, 2018; Schellekens, 2022).

## 4 The Rationales of Sufficiency of Disclosure

### 4.1 Legal and Philosophical Rationales

With the advent of AI-related patents and their extensive and potential use in diverse fields, the social contract theory that justifies the patent system underlines its informational purpose. This theory emphasises the role that the patent system plays in achieving information uncovering since through patent disclosure, it is possible to define the scope of protection of the invention, provide society with a survey of the state-of-the-art and facilitate further developments, as well as know-how licensing (Ramalho, 2018; Beier & Straus, 1977; Kitch, 1977). Likewise, the disclosure requirement possesses important legal justifications, for enforcement and litigation purposes, since depending on how the patent is disclosed, it may be invalidated (Fromer, 2009; Decisions G2/93, G2/93, G2/98).

Disclosure is a universal precondition for the granting of a patent (Art. 29.1 TRIPS). It refers to the incentive to reveal the invention to society through the patent application, instead of keeping the invention as a trade secret (Roffe, 1974; Osborn, 2019). In return, inventors obtain exclusive rights for their inventions.

According to patent law, sufficiency of disclosure is present when a patent application allows the reproduction of the intended technical solution. In that sense, an invention may be sufficiently disclosed even if certain elements are not explicitly described by the applicant, but the examiner must be able to fill in the missing information to reach reproducibility (Art. 83 EPC; Decision T61/14; Früh, 2021). Art. 83 EPC's requirement aims to bring transparency to the description of the inventive process in the claims, thus enabling reproducibility. However, the rationale of this

[13] According to the EPO, 'when assessing the inventive step of a mixed-type invention, all technical features which contribute to the technical character of the invention are considered. These also include the features which, when taken in isolation, are non-technical, but do, in the context of the invention, contribute to producing a technical effect serving a technical purpose, thereby contributing to the technical character of the invention. However, features which do not contribute to the technical character of the invention cannot support the presence of an inventive step (T 641/00)' (EPO & JPO, 2021).

requirement has been largely discussed before AI, presenting arguments against it — such as its inefficiency or the fact that it disincentivises patent applications (Früh, 2021; Devlin, 2010; Burk & Lemley, 2002).

Sufficiency of disclosure must be assessed taking the application as a whole — including the description and claims— (Decisions T14/83, T169/83). However, the claims are a key element through which the patentee specifies the scope of the patent (Chakroun, 2020). Even if the claims should be drafted in terms of the technical features of the invention, their wording must be clear and concise (Art. 84 EPC; Decision T988/02). Accordingly, only a reasonable degree of clarity is required, since the patent language is examined by the person skilled in the art, considering the prior art and context of the invention at the time of its conception (Chakroun, 2020; Decisions T2001/12, T1180/14). As a result, insufficient disclosure will occur if the skilled person cannot rework the invention following the teaching of the patent (Decision T432/10).

The 'person skilled in the art' and the 'reasonable degree of clarity' requirement consist of two aspects that entail considerable consequences since the level of knowledge of the examiner in some cases is difficult to determine (Hartmann et al., 2020) and it may be brought into question with AI-related patents (Ramalho, 2018; Schellekens, 2022). According to the examiner's perspective, some elements may be considered obvious — and would therefore not need to be included in the patent claims— but they may constitute relevant information for users to understand the invention, avoid infringement, but also exploit it when it enters the public domain (Chakroun, 2020).

Despite the necessity of clarity, contemporary patent applications rarely are concise or disclose all the information required for the proper exploitation of the patent (Wernick, 2021). This tendency may be due to different aspects, such as technology complexity (Ebrahim, 2020), the use of specific technical jargon —so-called 'patentese' (Seymore, 2010)— but also to strategies for effective litigation (Trop, 1988; Bessen & Meuer, 2005).

In this sense, given that patent claim drafting requirements do not demand exhaustive clarity, patent examiners may grant patents entailing issues regarding claim construction or vagueness (Alison et al., 2010). This issue may be underlined by the black-box character of AI-related inventions, since it may become challenging to provide clear and sufficient disclosure for inventions and therefore be carried out by the skilled person (Hartmann et al., 2020).

As an attempt to amend the issue of vagueness, it has been suggested by scholars to introduce the requirement of a 'claim chart'[14] together with the patent application, to help patent examiners, or users that may be interested in —or in the need of— interpreting patent claims (Churnet, 2013). This type of solution would not consist of legal reform and therefore would not entail a long and tedious process but could be adopted in the form of guidelines or policy (Ramalho, 2018). This proposal could be highly beneficial for AI-related inventions and their 'explainability' and could also serve as a step towards a standard process for patent claims construction.

[14] The claim chart would prevent patentees from drafting malleable claims by defining each claim element, its limits, and provide real-world examples of the claims' limitations (Churnet, 2013; Chakroun, 2020).

### 4.2 Economics' Rationales

The economics' rationales of disclosure find their roots in the fact that through the dissemination of patent information, it may be possible to foster innovation. Access to patent information has proven to increase innovative activities and help research and development (R&D) managers execute innovative projects (Furman et al., 2021; Cohen et al., 2002). Moreover, the clarity of how the information is disclosed plays a major role, since patents with a higher quality of disclosure generate more follow-on innovation (Dyer et al., 2021) and favour competition, as they enable competitors to learn about new inventions and encourage them to create substitutes for the patented products or processes (Wernick, 2021). Therefore, higher quality of disclosure stimulates the patent system (Chakroun, 2020; Fromer, 2009).

Although evidence suggests that there are positive effects in patent disclosure, studies focusing on the effects of disclosure in Europe are to our knowledge scant, and even more, if we look for studies dealing with disclosure of AI-related patents. Nevertheless, empirical studies in other jurisdictions, such as the US, have shown that through stricter disclosure requirements or different aspects in the patent system that affect disclosure like the existence of a grace period (EPO, 2022), it may be possible to increase innovative activities and improve the scientific innovation flow (Baruffaldi & Simeth, 2020; Franzoni & Scellato, 2010; EPO, 2022).

Despite the positive effects of disclosure, its compliance faces two main challenges. Firstly, complying with disclosure is a demanding task for patent examiners, and secondly, patent applicants have incentives to be vague in their patent applications. Applicants know that their information may be useful for competitors, and this may incentivise patent applicants to draft claims clearly enough for patent offices to grant the patent application, but unclear enough from the competitors' lens (Arinas, 2012). Patent disclosures are a strategic element in firms' innovative activities (Baker & Mezze, 2005), and firms are aware that their private information is a source of market opportunities and competitive advantages (Barbaroux, 2014). In that sense, drafting vague claims can be seen as a business strategy to establish a balance between the requisites to obtain patent protection and the patentee's commercial advantage (Chakroun, 2020). The employment of deliberate vagueness in claims as a strategic use concerns the development function of the patent system, failing to inform the public of the real scope of the invention, to foster innovation and competitiveness, thus affecting the informative and teaching value and the quality of the patent system (Drexl et al., 2021; Chakroun, 2020). Apart from strategic incentives, economic policy uncertainty and changes in disclosure policies may increase the willingness of patent applicants to be vague (Kim, 2019; Amore, 2020).

Concerning patent examiners, they may confront challenges when determining appropriate prior art for patent applications dealing with mixed-type technologies (such as AI-related inventions), in contrast to 'discrete technologies', like chemistry, which are more straightforward. Moreover, in the case of mixed-inventions, it is sometimes difficult to distinguish which specific element in the complex system is in the patent scope (Tan & Roberts, 2010). Patent examiners themselves may also be a source of heterogeneity when complying with the disclosure requirement. Evidence suggests that there are 'disclosure-lenient examiners', meaning that some are less strict than others, have lower patent rejection rates and are more likely to accept less clear patents having fewer figures, worse score in disclosure metrics and NLP readability (Dyer et al., 2021). Moreover, specific circumstances like higher workloads and personal characteristics of examiners (e.g. experience) may cause heterogeneous patent examination processes, leading to granting patents that do not fulfil equally patentability requirements (Kim et al., 2017; Cockburn et al., 2002).

## 5 Disclosing Artificial Intelligence: Case Studies

Despite its importance, the concept of sufficiency of disclosure in AI has not been treated with the same attention as other aspects under the patent law prism (Früh, 2021).

However, being aware of the particularities that AI entails, the EPO has developed specific guidelines of examination for this field. According to those, AI is based on computational models and algorithms meaning that they possess an abstract mathematical nature even if they can be trained based on training data. The use of specific terms such as ‘support vector machine’ or NN may refer to abstract models and algorithms that do not imply the use of technical means but also can be part of mixed-inventions. Apart from core-AI inventions, the EPO highlights that AI finds applications in several fields that can represent technical contributions. In some cases, providing the steps of generating a training set in the patent application may contribute to the technical character of the invention (EPO Guidelines for Examination, section G-II, 3.3.1).

When an applicant files a patent, it is then subject to an examination done by a patent examiner following the guidelines for examination. As part of this procedure, a search report is issued, containing citations[15] that establish relevant prior art, which plays a role while evaluating novelty and inventive step of a patent application (Loveniers, 2018). These documents, according to the EPO Boards of Appeal (Decision T0466/09), can be considered as previous technical literature which is generally common knowledge for the person skilled in the art, and can be used to assess disclosure. Documents cited in the search report can be of any type (e.g., research papers) if they possess relevant information for the patent grant. For the analysis of disclosure, the focus lies on the following type of citations:

- X: relevant documents for inventive step and novelty
- Y: relevant documents for novelty
- A: documents giving the general state-of-the-art
- D: documents cited in the application

To show how differently sufficiency of disclosure can be executed regarding AI-related patent applications, two case studies, both granted patents by the EPO, are presented:

1. EP3432107A1: ‘Cleaning robot and controlling method thereof’, classified under CPC G05D 1/02 and G06T 7/00 application of an AI-technique to a home appliance

[15] There are several types of citations (X, Y, A, E, P, D, T, O, L).

2. WO2018094294A1: ‘Spatial Attention Model for image captioning’, classified under CPC G06N 3/04, core-AI, granted at the EPO with the publication number EP3542314B1

**Methodology** The two selected patents were found using Espacenet. For the first patent, the selected search criteria are the presence of AI-related keywords and keywords related to machines or home appliances. This enables finding patents that consist of applications of AI techniques. For the second patent, the selected search criterion was looking for patents classified under CPC G06N,[16] which according to the Cartography of the Fourth Industrial Revolution (EPO, 2017) represent patents that are classified as core-AI. Both patents are granted, and their selection is motivated by the fact that albeit both patents successfully passed the examination process, they exhibit differences in the clarity of disclosure.

The first patent (hereinafter Patent 1) is an application of an AI technique, whereas the second (hereinafter Patent 2) is a core-AI patent. The reasoning for this selection is that depending on the type of AI-related patent (whether core-AI or the application of an AI-technique), nuances regarding disclosure can be detected, which will be explained in detail in this section.

The structure of the case studies will be as follows. Both case studies start with a brief description of the invention. Secondly, an analysis of the prior art documents included in the search report is conducted, as these documents are essential to assess the quality of disclosure of a patent. Finally, considering the results of the case studies, a summary of how AI-related patents should be disclosed is proposed.

### 5.1 Case Study 1: EP3432107A1, ‘Cleaning Robot and Controlling Method Thereof’

The European patent application EP3432107A1,[17] filed by LG Electronics, for *Cleaning robot and controlling method thereof*, classified under G05D 1/02 and G06T 7/00, describes a vacuum cleaner that recognises obstacles and performs autonomous travelling.

The patent includes fifteen claims. The first three claims specify the use of training data and algorithms: ‘a controller (1800) configured to detect a difference between first (701) and second image (702) consecutively capture by the camera (130, 1400) generate a third image (704) based on the detected difference, and analyze the generated third image (704) using the preset algorithm’.

Moreover, claim 3 refers to the training data, mentioning ‘the cleaner of claim 2, wherein the memory (1700) is configured to store training data for the analysis of the image, and the controller (1800) is configured to determine a degree of similarity between a plurality of image information including the training data and third image’.

[16] See: https://www.uspto.gov/web/patents/classification/cpc/html/cpc-G06N.html.

[17] European patent EP3432107B1: https://worldwide.espacenet.com/patent/search/family/062062877/publication/EP3432107B1?q=EP3432107A1.

In the following claims, there is neither mention of the type of algorithm that is being used, nor if it is an AI-based algorithm.[18] Nevertheless, given the information in the description, it can be assumed that it is a ML algorithm. 'The controller 1800 performs a role of processing information based on an artificial intelligence technology [...] the controller 1800 may use a machine learning technology'.

The reference to AI continues with statements such as 'The controller 1800 may use training data stored in an external server or a memory, and may include a learning engine for detecting a characteristic for recognizing a predetermined object'. In patent's Fig. 6, represented by Fig. 3 in this paper, and the summary of the invention, there is mention of the fact that the analysis is done using a deep learning algorithm: 'Furthermore, an object of the present disclosure is to provide a cleaner for combining monitoring traveling with a deep learning algorithm to perform autonomous traveling'.

Also, from the patent's Fig. 9, represented by Fig. 4 in this paper, it can be concluded that the algorithm is used for object detection and image classification:

As there is no mention, nor specific description of the algorithm, the next step would be to verify if the documents cited on the search report[19] include information in this regard. The European search report includes two Y citations and two A citations, consisting of patents. Focusing on A citations (i.e., citations relevant to prior art), two US patents are cited:

- Patent US2009161911A1: 'Moving object apparatus and method' discloses a method to detect moving objects. To this aim, the patent presents a method that while capturing several images at different points in time can detect moving objects and changes in the images using temporal differencing and distance maps to obtain information regarding the moving object.
- Patent US2011243383A1, 'Image processing device method and program' discloses a method that detects changes in images, by targeting differences between pixels in the analysed images.

Despite that both patents analyse differences between several images and explain the algorithms and techniques that are used, there is no mention of AI-based algorithms.

Regarding the Y citations referred to in the European search report, there is a German patent and an international patent:

- The German patent DE10200501582A1 consists of a method comparing two images in the context of semiconductor components.
- The international patent WO2016005011A1 consists of a vacuum cleaner that also compares two images to improve travelling by using a method based on a ratio of displacement.

[18] As claims express the scope of protection of the patent, it is relevant to mention the AI-related elements in them and not only in the description, as these do not have legal implications.

[19] Patents US 2011/243383A1: https://worldwide.espacenet.com/patent/search/family/044696920/publication/US2011243383A1?q=US%202011%2F243383; and US 2009/161911A1: https://worldwide.espacenet.com/patent/search/family/040788677/publication/US2009161911A1?q=US%202009%2F161911.

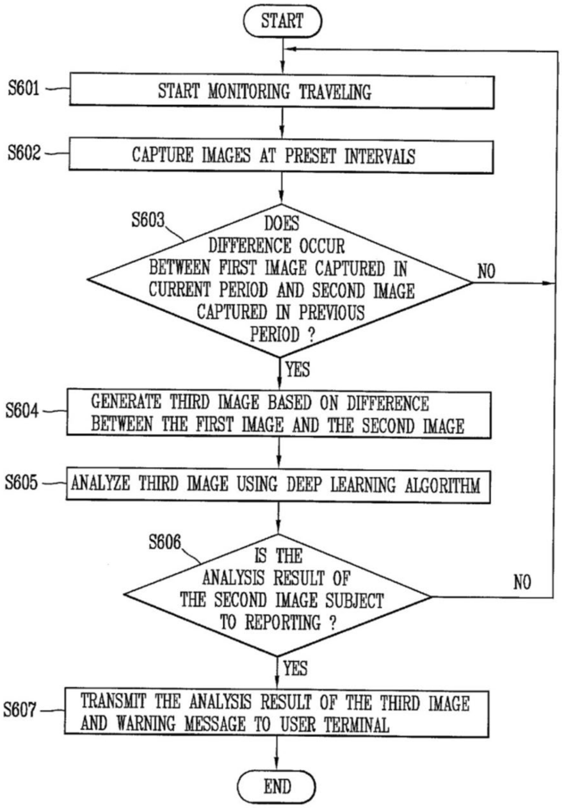


**Fig. 3** Patent's Fig. 6 describing the algorithm that the vacuum cleaner uses, mentioning the aim for which the deep learning algorithm is implemented

Similarly, to the A citations, none of these documents mentions if AI-techniques are being used.

Even if deep learning comprises several techniques and networks, like convolutional NN, and recurrent NN (Pouyanfar et al., 2018), there is no mention of which type of these techniques and networks the disclosed technology makes use of. This is relevant as in object detection and image classification, using deep learning, several techniques can be applicable[20] (Kaushal et al., 2018; Dargan et al., 2020).

### 5.2 Case Study 2: WO2018/094294A1, 'Spatial Attention Model for Image Captioning'

The international patent application WO2018/094294A1,[21] classified under G06N 3/04 and filed by Salesforce, describes a system able to generate captions for a given

[20] A survey on different AI-techniques used for object detection presents several deep learning models used for object detection including convolutional neural network (CNN), deep NN, growing competitive NN.

[21] European patent EP3542314B1: https://worldwide.espacenet.com/patent/search/family/062147067/publication/EP3542314B1?q=SPATIAL%20ATTENTION%20MODEL%20FOR%20IMAGE%20CAPTIONING.

FIG. 9

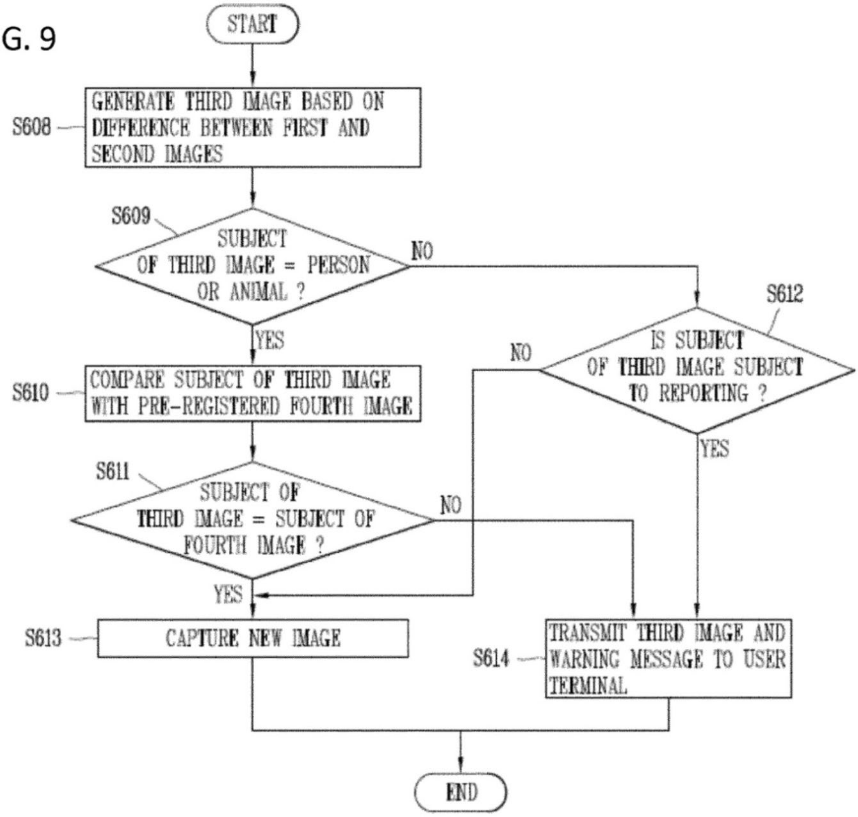


**Fig. 4** Patent's Fig. 9 describing the aim of the deep learning algorithm in object detection

image. The applicant specifies at the beginning of the document that the field of technology disclosed relates to AI, specifically to image captioning. The relevance of the invention, and its research field, lies in aiding visually impaired users and navigating through large amounts of data that are typically unstructured. This highlights the importance of generating high-quality captions for images. Hence, this type of AI-application combines both elements of computer vision and NLP.

The patent includes 22 claims, most of them devoted to explaining an image caption-generating system that leverages several AI-techniques. Moreover, the patent includes 25 figures, some of them devoted to comparing prior AI-algorithms and the disclosed algorithm as well as tables providing metrics to assess the quality of the technology disclosed. To this aim, state-of-the-art databases and metrics are used.

Claim 1 summarises the elements composing the system:

1. An encoder for processing the image through a convolutional neural network (abbreviated CNN) and producing image features for regions of the image
2. A global image feature generator for generating a global image feature […]

3. An input preparer […]
4. The decoder for processing the input through a long short-term memory network (abbreviated LSTM) […]
5. An attender for accumulating at each decoder timestep, an image context as a convex combination of image features scaled by attention probability masses […]
6. A feed-forward neural network for processing the image context and the current decoder hidden state to emit a next caption word […]
7. A controller for iterating the input preparer, the decoder, the attender and the feed-forward neural network to generate the natural language caption for the image until the next caption word emitted in an end-of-caption token

In the detailed description of the patent, there are subsections and figures describing each of the elements mentioned in claim 1, and further claims. According to the disclosed technology and documents cited in the search report, image captioning systems contain an encoder-decoder and an attention-model, and the applicant mentions that 'an opportunity arises to improve the performance of attention-based models'. The inventors explain that while generating words for the caption, not all words have visual signals, e.g., 'The words "a" and "of" do not have corresponding canonical visual signals', to this aim, linguistic correlation could be used when generating so-called stop words.[22] The improvement opportunity lies in determining 'the importance that should be given to the target image during caption generation', as there are visual and non-visual words. This means that the main improvement made in this image captioning system is the attention-model.

These models determine which parts of the image are needed to focus on when generating a word and where and when to attend (Lu et al., 2017). Figure 2A, B from the patent, represented by Fig. 5, show differences in the attention decoder from the prior art and disclosed technology which is one of the elements included in the disclosed attention-model.

The patent also includes in the drawings tables that show the performance of the disclosed technology using the Flicker30k and COCO datasets[23] and the improvements when compared to the previous state-of-the-art. The metrics included are rank probabilities and NLP metrics such as *BLEU* (Bilingual Evaluation understudy),[24] *METEOR* (Metric for evaluation of evaluation with explicit ordering),[25] *CIDEr*

22 Words like preposition, articles, conjunctions.

23 To evaluate the quality of the model, there are several well-known databases in this research field — of them are Flickr8k, Flickr30k and COCO (Hossain et al., 2019). The patent only provides metrics for the last two databases; therefore, the comparison with the prior art cited in the search report will be performed considering Flickr30k and COCO.

24 This measure is normally used to evaluate the quality of a machine translation. It can be interpreted as '<10 almost useless; 10–10 hard to get the gist; 20–29 the gist is clear, but has significant grammatical errors; 30–40 high quality translation; 50–60 very high quality, adequate and fluent translations; >60 quality often better than humans'. Google's cloud translation documentation. Most image captioning documentation includes BLEU-1; BLEU-2; BLEU-3 and BLEU-4.

25 Another suggested metric to overcome weakness of the BLEU metric (Banerjee et al., 2005) https://www.cs.cmu.edu/~alavie/papers/BanerjeeLavie2005-final.pdf.

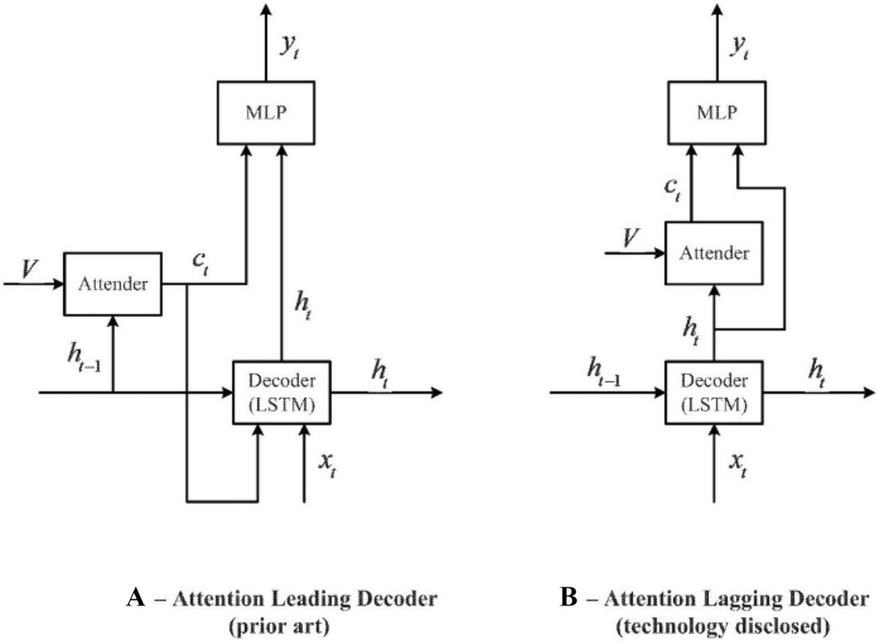


**Fig. 5** Patent's Fig. 2A, B comparing prior art with the disclosed technology

(Consensus-based image description evaluation),[26] *ROUGE-L* (Recall-oriented understudy for Gisting evaluation)[27] and *SPICE*[28] (Semantic Propositional Image Caption Evaluation).[29] Patent's Fig. 24 (represented by Fig. 6 in this paper) shows a state-of-the-art leader board that compares the disclosed technology with other image captioning generating systems:

Image captioning systems based on deep learning can have different architectures and use different approaches (Hossarin et al., 2019; Lu et al., 2017; Kiros et al., 2014). The international search report includes three A citations (consisting of two research papers and a patent from Google) and three X citations, all research papers. The research papers cited in the search report are all attention-based models with encoder-decoder frameworks. This means that the cited documents are in a specific area of research of image captioning models, making it clear in which way the disclosed technology adds value and improves this research field. The X citations consist of:

[26] CIDEr: Consensus-based Image Description Evaluation (Vedantam et al., 2015) https://www.cv-foundation.org/openaccess/content_cvpr_2015/papers/Vedantam_CIDEr_Consensus-Based_Image_2015_CVPR_paper.pdf..

[27] NPL metric adequate to evaluate short summaries (Lin) https://aclanthology.org/W04-1013.pdf.

[28] Improvement of metrics like BLEU, METEOR, CIDer and ROUGE-L enabling answering questions like 'which caption-generator best understands colors? (Leibe et al., 2016).

[29] Metrics used in image captioning models (Shaikh et al., 2021).

| Method | B-1 | | B-2 | | B-3 | | B-4 | | METEOR | | ROUGE-L | | CIDEr | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | c5 | c40 | c5 | c40 | c5 | c40 | c5 | c40 | c5 | c40 | c5 | c40 | c5 | c40 |
| Google NIC [27] | 0.713 | 0.895 | 0.542 | 0.802 | 0.407 | 0.694 | 0.309 | 0.587 | 0.254 | 0.346 | 0.530 | 0.682 | 0.943 | 0.946 |
| MS Captivator [8] | 0.715 | 0.907 | 0.543 | 0.819 | 0.407 | 0.710 | 0.308 | 0.601 | 0.248 | 0.339 | 0.526 | 0.680 | 0.931 | 0.937 |
| m-RNN [18] | 0.716 | 0.890 | 0.545 | 0.798 | 0.404 | 0.687 | 0.299 | 0.575 | 0.242 | 0.325 | 0.521 | 0.666 | 0.917 | 0.935 |
| LRCN [7] | 0.718 | 0.895 | 0.548 | 0.804 | 0.409 | 0.695 | 0.306 | 0.585 | 0.247 | 0.335 | 0.528 | 0.678 | 0.921 | 0.934 |
| Hard-Attention [30] | 0.705 | 0.881 | 0.528 | 0.779 | 0.383 | 0.658 | 0.277 | 0.537 | 0.241 | 0.322 | 0.516 | 0.654 | 0.865 | 0.893 |
| ATT-FCN [34] | 0.731 | 0.900 | 0.565 | 0.815 | 0.424 | 0.709 | 0.316 | 0.599 | 0.250 | 0.335 | 0.535 | 0.682 | 0.943 | 0.958 |
| ERD [32] | 0.720 | 0.900 | 0.550 | 0.812 | 0.414 | 0.705 | 0.313 | 0.597 | 0.256 | 0.347 | 0.533 | 0.686 | 0.965 | 0.969 |
| MSM [33] | 0.739 | 0.919 | 0.575 | 0.842 | 0.436 | 0.740 | 0.330 | 0.632 | 0.256 | 0.035 | 0.542 | 0.700 | 0.984 | 1.003 |
| **Ours-Adaptive** | **0.746** | **0.918** | **0.582** | **0.842** | **0.443** | **0.740** | **0.335** | **0.633** | **0.264** | **0.359** | **0.550** | **0.706** | **1.037** | **1.051** |

**Fig. 6** State-of-the-art leader board presented in the patent, comparing the disclosed technology with other well-known models in the field

Xu et al. (2015),[30] which describes a caption-generating system with an encoder that uses a CNN and a decoder that uses a LSTM. The authors test two attention models 'stochastic hard attention' and 'deterministic short attention'. To test the quality of these models, they also use the Flickr30k and COCO databases, which are summarized in Table 1.

Chen et al. (2017)[31] describes a captioning-generating system and aims at testing how different attention-models improve the quality of the generated captions. In this sense, they distinguish between semantic attention-models, which also use semantic information, and image attention-models which depend solely on visual features. The attention-models that the authors test rely on exploding several attention types. The results are also summarised in Table 1. The last paper is an A citation,[32] which also refers to an attention-based model, but as other metrics are provided, they are not included in Table 1.

Continuing with A citations:

- Kiros et al. (2014) is also a paper referring to an attention-based model, but as other metrics are provided, they are not included in Table 1.
- Merity et al. (2016) refers to the linguistic model included in the image captioning system. This linguistic model can predict the following word given the linguistic context. This is one key component of the image captioning system disclosed.
- International patent WO 2016/077797A1, filed by Google, describes an image captioning system but there is no mention of if it is attention-based.

To summarise, the improvements of the image captioning model are made in the attention-model, which is clearly explained and described. As for elements that are not part of the improvements proposed by the patent, like the CNN, the inventors

[30] Further referred to as Research Paper 1.

[31] Further referred to as research paper 2.

[32] Kiros et al. (2014), Further referred to as research paper 3.

**Table 1** Comparison between disclosed technology and prior art documents using state-of-the-art metrics and databases

| | **Flickr30k[a] (patent)** | Flickr30k[a] (research paper 1) | Flickr30k[a] (research paper 2) | **MS-COCO (patent)** | MS-COCO (research paper 1) | MS-COCO (research paper 2) |
|---|---|---|---|---|---|---|
| BLEU-1 | 67.7 | 66.9 | 66.2 | 74.2 | 71.8 | 71.9 |
| BLEU-2 | 49.4 | 43.9 | 46.8 | 58 | 50.4 | 54.8 |
| BLEU-3 | 35.4 | 29.6 | 32.5 | 43.9 | 35.7 | 41.1 |
| BLEU-4 | 25.1 | 19.9 | 22.3 | 33.2 | 25 | 31.1 |
| METEOR | 20.4 | 18.49 | 19.5 | 26.6 | 23 | 25 |
| CIDer (c40) | 53.1 | – | – | 105.1 | – | 92.1 |

[a]Presenting values for the best performing model in the research paper

mention the use of a pre-trained ResNET CNN. This enables the person skilled in the art to know which CNN should be used from the variety of CNN architectures available (e.g. AlexNet, VGG, GoogleNET). As a result, the person skilled in the art can find all the necessary information, even if it is not available in the patent.

### 5.3 Discussion: Lessons from the Case Studies

Through both case studies, it is possible to observe differences based on the way both patents are disclosed and were granted by the EPO. In that sense, these case studies serve to research to determine heterogeneity in disclosure by just showing two examples of AI-related patents.

While reading the patents, without considering documents in the search report, it can be easily noticed how differently both are disclosed. Patent 2 includes a long description of the technology, as well as quantitative metrics, which in this case are quality metrics to evaluate the image captioning system with respect to prior art. According to Dyer et al. (2021), specific pieces of information like quantities and percentages can be considered a disclosure metric that serves to assess how well a technology is disclosed. On the other hand, patent 1 has an extremely vague and short description, and it does not provide specific pieces of information.

Of the two patents presented, one is an application of an AI technique (Patent 1) and the other is a core-AI patent (Patent 2). NNs are a good example to explain the meaning of core-AI, since their contribution can consist of (1) the network itself (connections, weights, and training data); (2) the application in a specific context or (3) general concepts that can be applied to other networks (e.g. multiperceptron and back propagation algorithms; Watkin & Rau, 1996). Core-AI represents cases 1 and 3, in which improvements to the AI-technique are made.

Even if Patent 1 is not classified under G06N (core-AI), there is a mention of the use of a deep learning algorithm, but there are no further explanations regarding the architecture and type of such algorithm. In this case, as the EPO Boards of Appeal have already determined (Decision, T0161/18), it is questionable whether the person skilled in the art could be able to reproduce the disclosed technology without having any mention of how the deep learning algorithm is constructed, trained nor the type of data used. Mentioning this, for example, by citing relevant prior art, could be helpful, even if the patent does not make any improvement to the deep learning technique as such.

On the other hand, Patent 2 clearly discloses the area of AI to which it is contributing to, and the documents cited in the search report are all related to the relevant prior art of attention-models for image captioning. In this patent, the use of prior art is twofold: it serves as a benchmark to show how the patent improves the prior art, and it also serves to disclose elements relevant to the invention that are prior art. Elements that are novel and represent an improvement of an AI technique must be properly described in the patent application.

Figure 7 provides a summary of these conclusions:

These two case studies have shown how the quality of disclosure varies in both patents. This could lie in the fact that for certain technologies, it is easier to determine the prior art (Tan & Roberts, 2010), which could also justify the difference in the sufficiency of disclosure between both patents. Regarding Patent 2, there is a large amount of

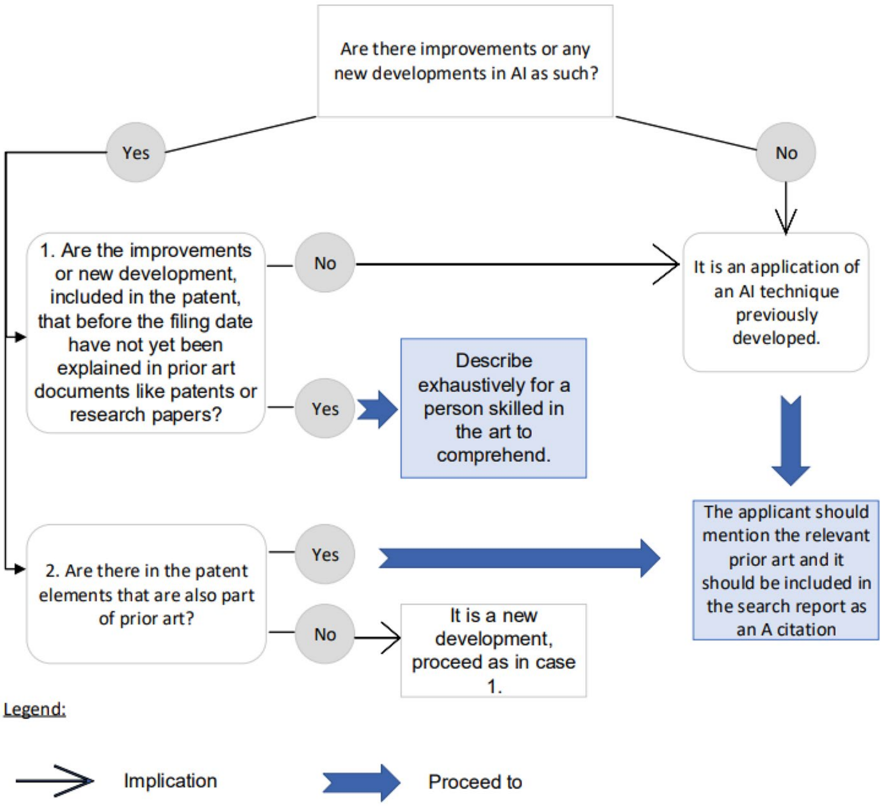


**Fig. 7** Summary of disclosure in AI-related patents (generated with Visio)

academic literature explaining image captioning models, their types and the appropriate techniques to evaluate their quality. However, this is not the case for Patent 1.

Nevertheless, the home appliance mentioned in Patent 1 uses a deep learning algorithm for object detection and image classification, and these areas also have wide academic literature and evaluation metrics available. If possible, it may be useful to explain why this specific algorithm is used, e.g. by using object detection metrics (Karasulu, 2010), since the evaluation of object detection models on benchmark datasets plays an important role in the validation of an algorithm (Kaushal et al., 2018).

Following Ouellette (2012), patent literature should be more in line with scientific literature in the way results and inventions are disclosed. For instance, both Patent 2 and the image captioning papers serve as an example of how researchers in the field must explain prior art they built upon, as well as the procedures followed to demonstrate the improvement of the AI-based techniques.

These two case studies aim at showing that not all granted patents fulfil the disclosure requirement in the same way. Therefore, it highlights the importance of studying more in-depth the quality of compliance with this requirement. This paper has only presented two case studies but are of substantial importance since they are illustrative examples of the underlined problem and therefore worth bringing to the surface in detail. Nevertheless, even if extending this type of study to evaluate a representative number of patents is complex, it would be highly advisable for further research. Lastly, the EPO could evaluate a representative sample of granted patents to assess the quality of disclosure, to better guarantee the fulfilment of this requirement.

## 6 Conclusions and Considerations

AI-related patent filings have been growing significantly in recent years, which highlights the importance of this technological field. With the increase of such patents, certain issues regarding sufficiency of disclosure are of great importance from the perspective of IP offices, but also the users' one.

Legal, philosophical rationales and empirical economic studies justify and show the positive effects that disclosure has on innovation and society, but also the fact that patent applicants have incentives to be vague on their patent claims.

Vagueness in patent claims affects the benefits of the patent system, especially the function of sufficiency of disclosure. This issue may be highlighted by AI-related patents and their presence in several diverse fields due to their black-box character. Intentional vagueness in the wording of a patent application may be due to the strategic relevance that a claim may have. In that sense, patent claims have been described as sentences that can be worth millions and ensure a company's financial success or even its ruin (Jakobsen Osenga, 2006).

Regarding the research question posed by this paper: How could sufficiency of disclosure be improved in the field of AI? AI-related patents are already present in several technological fields and reaching a disclosure standard applicable to all technologies could be challenging, since there is no common consensus on a standard process for patent claim construction (Chakroun, 2020). Therefore, establishing disclosure standards to simplify the compliance of disclosure is not straightforward. This paper has intended to show that issue by presenting two case studies. Both showed how differently and heterogeneous the disclosure requirement can be carried out in AI-related patents at the EPO.

From the IP offices' perspective, in this case, the EPO, it could be recommended to require applicants to provide a detailed description, or a higher standard, in terms of explanation and disclosure of the logical processes involved in AI-related patents. This could help patent examiners to avoid black box cases (EPO, 2018), which represent the inability to fully understand 'an AI's decision-making process and the inability to predict the AI's decisions or outputs' (Batahee, 2018). While requiring a higher standard may benefit the quality of granted patents, it may also be more costly and time-consuming and thus discourage AI-related patent applications. Likewise, to obtain an accurate perspective of how disclosure is taking place in the AI-related patent realm, it could be advisable for the EPO to evaluate a representative sample of granted patents to assess the quality of disclosure.

As for the users' and society's perspective, it is important to bear in mind that the disclosure requirement is not just a question of getting the patent accepted, but also of enabling reproducibility and being able to enforce it in case of litigation. The technical standard of an examiner is obviously higher than the one of the ordinary public, but when it comes to enforcement, the judge must be able to understand how the patent works and proving infringement might be challenging, hence the need to avoid black box situations (EPO, 2018).

The conducted analysis does not aim at giving a final solution to the issue of disclosure of AI-related patents but intends to highlight the relevance of the topic and the need of further research on it. In that sense, to provide a proper solution, the involvement of persons skilled in the art of each AI field should be required, since they are the ones able to determine all the necessary information to be considered. However, the results of this research allow the authors to suggest some solutions that may be useful to improve the sufficiency of disclosure requirement in the field of AI-related patents.

The first solution concerns AI applications. Despite technological fields being large, functional applications are much more limited, being the most frequent ones: character recognition, computer vision, object detection and speech processing (WIPO, 2019). The specific cases of image captioning models, as well as object detection, have developed metrics to assess the quality of an algorithm. A first step and suggestion in achieving a disclosure standard would be to analyse the availability of metrics and benchmark datasets for all functional applications. In cases where core-AI is improved, a benchmark analysis could be presented. If no improvements on core-AI are made, then refer to the model being implemented and justify the selection of it.

The second solution regards patent claims drafting. As an attempt to amend the issue of vagueness in patent claims, it has been suggested by scholars to introduce the requirement of a 'claim chart' together with the patent application, to help patent examiners, but also users that may be interested —or in the need— of interpreting patent claims (Churnet, 2013; Chakroun, 2020). This solution could also serve as a step towards a standard process for patent claims construction.

Lastly, the third possible solution involves the public. Back in 2010, the USPTO developed a peer review patent program[33] in which the public was encouraged to submit relevant prior art for pending patents, using the assistance of experts in each functional application.

Those proposals could help to 'bridge the gap between the person skilled in the art' (Früh, 2021) and therefore ensure that patent offices, applicants and society have equal access to patent information and promote innovation.

**Abbreviations** AI: Artificial intelligence; BLEU: Bilingual Evaluation Understudy; CIDEr: Consensus-based Image Description Evaluation; CII: Computer implemented inventions; Citation A: Documents giving the general state of the art; Citation D: Documents cited in the application; Citation X: Relevant documents for inventive step and novelty; Citation Y: Relevant documents for novelty; CNIPA: China National Intellectual Property Administration; CNN: Convolutional neural network; CPC: Cooperative Patent Classification; EPC: European Patent Convention; EPO: European Patent Office; HLEG: High Level Expert Group; IP: Intellectual property; IPC: International Patent Classification; JRC: Joint Research Centre; JPO: Japan Patent Office; KIPO: Korean Intellectual Property Office; LSTM: Long short-term memory network; METEOR: Metric for Evaluation of Evaluation with Explicit Ordering; ML: Machine learning; NLP: Natural language processing; NN: Neural networks; OECD: Organisation for Economic Co-operation and Development; PHOSITA: Person having ordinary skill in the art; ROUGE-L: Recall-Oriented Understudy for Gisting evaluation; SPICE: Semantic Propositional Image Caption Evaluation; TRIPS: Agreement on Trade-Related Aspects of Intellectual Property Rights; USPTO: United States Patent and Trademark Office; WIPO: World Intellectual Property Organisation

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## Declarations

**Consent** Not applicable.



[33] Peer Review Pilot FY2011: https://www.uspto.gov/patents/initiatives/peer-review-pilot-fy2011.

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