May 2022 · Philippe Lorenz

Analyzing Global AI Dependencies through Intellectual Property Rights

Understanding trade secrets, patents, and copyrights for artificial intelligence

Stiftung
Neue
Verantwortung

Think Tank at the Intersection of Technology and Society

Executive Summary

Artificial intelligence (AI) has become an important strategic asset in foreign policy. As a general-purpose technology, AI can increase a state's economic power and enhance its political influence. It has also become an element of protecting states' national security and defense interests. Therefore, access to AI technologies and the ability to participate in AI innovation is key to increasing the economic competitiveness and sovereignty of states. Where companies gain importance within a country or region by virtue of their innovative capacity, technological dependencies can arise. At first, such dependencies on foreign AI technologies become visible in the private sector, but eventually they can develop into political ones. Ultimately, this can lead to shifts in the global balance of power and result in geopolitical tensions.

To uncover strategic dependencies on foreign companies, countries, or regions in the field of AI, European policy makers need to examine whether European industries are highly dependent on foreign AI technologies. Only if the European Union (EU) knows its position in the global AI innovation ecosystem, it can develop sound technology foreign policy. It needs to identify leading AI innovators, but also reflect on its dependencies and weaknesses that prevent it from achieving a higher degree of autonomy, especially when it comes to national security or digital transformation.

This paper provides European foreign policy makers with in-depth information on how to uncover the EU's strategic dependencies in AI. It applies a particularly revealing technique of identifying dependencies in AI: It maps the AI ecosystem with respect to innovative capacity. This can be measured by examining different intellectual property (IP) rights that allow for the protection of inventions in AI. The distribution of **AI patents**, for example, is not only a strong indicator for the innovative capacity of companies, but also more generally for the inventiveness of states and regions. Currently, companies from the US and Asia dominate European patent applications in the field of computer and digital communication technologies, to which AI technologies are of fundamental importance.

However, it is not enough to count patent applications. Rather, as a first step in mapping Europe's AI landscape, this paper suggests examining the distribution of IP rights along the core industrial inputs of AI. This allows an understanding of the innovative capacity of AI companies and the general structure of AI ecosystems; it also helps to identify locational (dis)advantages that arise from the lack of international harmonization of IP rights protection.

In addition to patents, **trade secrets** and **copyrights** are important indicators for measuring innovation in AI. Moreover, European foreign policy makers need to understand what AI is and which individual elements make up this technology. This

requires a breakdown of AI into its key industrial inputs: **algorithms**, **hardware**, and **data**. These categories—patents, trade secrets, and copyrights, as well as algorithms, hardware, and data—form the analytical matrix this paper applies to identify the ways in which innovation in AI can be protected by IP rights and how this, in turn, can contribute to technological dependencies.

This paper has identified three main challenges related to the IP rights protection of AI's core industrial inputs.

- U.S. patent law offers more room than European provisions in terms of opportunities to patent AI algorithms. This could represent a locational disadvantage for the EU, especially considering that algorithms form the core of AI innovation.
- The project of mapping Europe's AI ecosystem is further complicated by pending court cases. In the EU as well as in the US, there is legal uncertainty as to whether private sector companies may train their AI models on copyrighted data. The situation might tilt towards AI developers and weaken the legal position of copyright owners. If at all, this seems more likely to happen in the US, if US courts should rule analogous to the Google Books decision, which allowed the company to scan millions of books that had previously been under copyright protection.
- In the case of AI hardware, the challenge does not lie in the different application of IP rights, but rather in the lack of a European hardware infrastructure in the form of hyperscale cloud platforms or supercomputing clusters. Therefore, European AI companies and increasingly European cutting-edge research are already dependent on foreign, especially U.S. cloud computing infrastructures.

In sum, examining different IP regimes along AI's core industrial inputs highlights the need for the EU to engage in a systematic mapping of this complex space to identify its strengths, weaknesses, and strategic dependencies. This constitutes a first step towards building long-term strategic capacities in European AI technology.

The SNV's Artificial Intelligence and Foreign Policy project was made possible by the generous support of the German Federal Foreign Office and the Mercator Foundation. The views expressed in this paper do not necessarily represent the official positions of the German Federal Foreign Office or the Mercator Foundation.

The author would like to thank Helena Winiger for her excellent research assistance, Dr. Wolfgang Bomba, LL.M. and Jan-Peter Kleinhans for their very valuable feedback, Luisa Seeling and Sebastian Rieger for providing substantial help with finding a narrative and their editing of the paper, Dr. Stefan Heumann for backing the idea to explore this research avenue, and last but not least, all workshop participants for sharing their perspectives on intellectual property rights protection of inventions in artificial intelligence and possible foreign policy implications.

Table of Contents

1. Introduction

Artificial intelligence (AI) has developed into a key strategic asset in foreign affairs. As a general-purpose technology, AI can increase a state's economic power and raise its political influence. It has also become an element in the protection of states' national security and defense interests. As a result, access to AI technologies and the capacity to be part of AI innovation is key to raise states' economic competitiveness and sovereignty.

Conversely, restricting others from gaining access to AI technologies or their technological resources can raise a state's relative economic and political power. AI technologies have therefore been added to export control lists[1], are part of foreign direct investment screening, and visa control. These foreign policy tools have seen a renaissance in foreign economic and trade policies, as part of the bigger picture of technology foreign policy.[2]

A policy area where the EU finds itself increasingly under pressure from China and the United States (US) are national digitization or tech policies that successfully combine elements of industrial policy with public research and development spending. This is a whole of government approach to tech policy. In the US, leading national security and tech think tanks[3] have long been advocating such an approach, and this advice is now increasingly being absorbed by Congress[4], the executive branches, and even to be found in recent legislation[5].

In China, official government strategies on technology policies[6] follow a top-down approach requiring all relevant stakeholders—political and academic institutions, as well as industry—to work together to achieve their primary goals. For AI, this means "making China the world's primary AI innovation center" by 2030—as described in China's AI strategy, published in 2017.[7]

Since the Obama Administration's critical pivot to Asia, that was radically steered towards containing the economic and political rise of the People's Republic of China under U.S. President Donald Trump, European foreign policy makers find themselves challenged to redefine their position between the EU's most important ally, the US, and China—an economic competitor and systemic rival. In AI policy, the EU has chosen a regulatory approach to regain global influence and to get a grip on the technology's developmental trajectory. The EU Commission's draft proposal for a regulation on AI (the AI Act) puts forward a risk-based assessment of AI applications, based on their possibility for causing harm to individuals' rights.[8]

The EU is risking technological dependencies in AI

Dependencies of European governments on foreign technology such as semiconductors, and on pharmaceutical companies for vaccines and chemical pre-products—exposed by supply-side shocks during the Covid-pandemic—provided a wake-up call to pay closer attention to emerging technologies likely to affect a government's foreign policy. These concerns extend to foundational and emerging technologies such as semiconductors, quantum computing, and AI. This has given rise to the European concept of open strategic autonomy, that has become Europe's answer to regain self-reliance in matters of economic, defense, energy,[9] but also in tech policy issues (see Annex 1). This vision will guide European foreign policy and help to further position the region in the international political arena.

If companies in a country or region of the world gain in importance due to their innovative capacity, technological dependencies can reduce the economic performance of the dependent country which in turn may negatively affect its political importance. Hence, issues of private sector dependencies may well develop into political dependencies at a later point in time. Ultimately, this can lead to shifts in the global balance of power and result in geopolitical tensions, especially when the access to general-purpose technologies, such as AI, is concerned.

To uncover strategic dependencies from foreign companies, countries, or regions in AI, European foreign policy makers need to closely examine whether European industries—especially nascent startups and SMEs—are relying heavily on foreign AI technologies. To design reasonable foreign technology policies (for example foreign direct investment screening, export and visa control, and the evaluation of international research collaborations), the EU must know its position in the global AI innovation ecosystem. It must identify the top innovators and leaders in AI, but also reflect on its dependencies and weaknesses which prevent it from achieving strategic autonomy.

Uncovering dependencies in AI by looking at intellectual property rights

If European firms were less innovative in AI than their foreign peers, this could reduce their global market shares, and further reduce the overall importance of the EU's AI innovation ecosystem. A way to detect these dependencies is to consider intellectual property (IP) rights, required for the protection of inventions in AI. For example, if fewer AI high-quality patents were filed by EU companies, this could result in strong dependencies of said companies from non-EU AI patent holders.

This might already be the case. For example, when considering the World Intellectual Property Organization's (WIPO) data on Patent Cooperation Treaty (PCT) applications by top technical fields,[10] companies from the US and Asia account for most patent applications in the categories of *computer technology* and *digital communication*.

According to the European Patent Office's (EPO) recently published patent index, the same is true for European patent applications.[11] Companies from the US and Asia are dominating European patent applications in computer and digital communication technologies, for which AI technologies are foundational. Thus, not only are patents a strong indicator for the innovative ability of firms, but also more generally for states and global regions.

IP rights are a competence of sovereign states. This is based on the legal principle of territoriality. Consequently, states differ in their provisions on IP rights protection for software-based inventions. As a result, there might be a strong variation in the global distribution of AI patents. But when measuring AI innovation, it is not enough to measure the distribution of patents. The task is more complex. Apart from **patents**, other indicators important to tracing innovation in AI are **trade secrets**, and **copyrights.** European foreign policy makers must acquaint themselves with these instruments to understand how securing AI innovation is achieved in the private sector. But this is only the first step.

Innovation measured by the distribution of IP rights along AI's core industrial inputs
The second step involves European foreign policy makers to understand what AI is. Above all, this paper focuses on inventions in machine learning (ML). Not only is ML the most dominant technique in the field of AI innovation when measured by technology disclosed in patents,[12] patent families related to ML are also the most litigated ones.[13] This indicates the significance of ML—both for academic research and for industry application.

Additionally, it is crucial to understand what AI products and services are made from. This requires a breakdown of the technology into its core technology resources. AI systems are built from distinct industrial inputs. AI's central building blocks are **algorithms**, special purpose **hardware**, and **data.** Consequently, in AI, IP rights protect inventions along these core industrial inputs. Thus, an important indicator for innovative capacity in AI is the distribution of IP rights along AI's core industrial inputs.

It is therefore important that European foreign policy makers know that private sector companies chose from different IP rights to protect their inventions in AI's core industrial inputs, and that they have some knowledge about how different IP regimes function and are applied in practice. This is essential to be able to evaluate the EU's dependencies in AI.

This paper describes different ways in which AI technologies can receive IP rights protection through **trade secrets**, **patents**, and **copyrights** by looking at AI's essential technological resources **algorithms**, **hardware**, and **data**. In the case of AI hardware, the analysis is restricted to patents. To identify and reduce current but also future dependencies of the European Union on foreign AI technologies, the paper concludes by encouraging European foreign policy makers to monitor the AI innovation ecosystem as measured by the global distribution of IP rights along AI's core industrial inputs.

2. Intellectual Property Rights Protection of Inventions in AI along its Core Industrial Inputs: Algorithms, Hardware, Data

In software-based inventions, patenting is only one option among many to receive IP rights protection. Other important instruments are trade secrets, utility models, industrial designs, trademarks, and database rights—each offering different options of protection. For inventions in AI, **trade secrets**, **patents**, and **copyrights** are the IP rights in widest use. This is based upon the specific legal requirements that states assign to software-based inventions—in which they can differ—, the specific features of AI technologies, and the motivation of companies that seek protection of their inventions.

This paper focuses on instruments of IP rights protection in the EU and the US. Not only is the US home to influential multinational technology companies (and universities) responsible for breakthrough innovations in AI, but these companies are also heavily invested into providing AI services to their customers in the EU. This is only possible because they have access to the key industrial inputs of AI and skillfully integrate them into their hyperscale cloud platforms. These services range from providing customized AI software-as-a-service to end-to-end cloud solutions that combine many different elements, of which data hosting and cloud computing are only the best-known examples. Second, there are important differences between the US and the EU in terms of their intellectual property frameworks that enable AI innovation, which makes it worthwhile to examine the key aspects in which they differ.

The focus here is on innovation in AI technologies which is to this day predominantly occurring at the levels of **algorithms**, the ways in which the model (i.e., a neural network) processes **data** during training (training data) and inference (live data), and how special purpose **hardware** provides the compute required to process very large data sets. This is where innovation in AI can be traced to. And IP rights cater to these different layers that make up AI, more specifically, that make up advanced ML technologies.

2.1. Algorithms

The first place of interest with regards to IP rights protection of AI technologies lies with the algorithmic level. Can inventions at the algorithmic, or software level, receive IP rights protection?

2.1.1. Trade Secrets Applied to AI Algorithms

Following the definition of the WIPO, trade secrets are "IP rights on confidential information which may be sold or licensed[14]".

The information needs to meet three conditions to qualify as a trade secret:

- it must be of **commercial value** because the information is secret,
- only a **limited group of people** know about the information,
- the rights owner must have taken **reasonable effort** to keep the information secret, for instance by holding employees and third parties accountable by using confidentiality agreements and similar procedures.[15]

If the information that is protected by the trade secret is acquired without authorization, used, or otherwise disclosed, this constitutes a violation thereof.[16]

Trade secrets provide an effective way to shield innovation in AI, that the company deems important, from outside competition. Because they are so tightly related to abstract thoughts and mathematical concepts, AI inventions at the algorithmic level can be of tremendous commercial value if they, for example, improve prediction levels of the model over the ones used by the competition. Consequently, AI inventions at the algorithmic level can be appropriately protected through trade secrets.

As ML technologies are multilayered in the sense that they involve engineering, data science and data analytics skills, especially with regards to preparing training and re-training processes, trade secrets apply mostly to algorithms and data handling.[17]

Trade secrets are ensured through contractual and/or statutory law obligations and enforced by contractual penalties, and other subcomponents such as access provisions to the ML-model, or password protection. In some jurisdictions, e. g. Germany, trade secrets are protected by criminal law as well. It involves a plethora of different adjustments that may require detailed legal counseling. On the upside, the protection of the AI software-based application theoretically lasts "forever" rather than "only" 20 years as it is the case with patents (counted by the filing date).

But there are also important downside costs, apart from legal fees. Nothing prevents competitors from independently inventing similar technologies as the ones a firm has protected under trade secrets.[18] The competitor might even decide to file a patent application to receive patent protection for the AI software-based application it considers to be of its own creation. Secondly, no matter how high the hurdles are for keeping trade secrets, the information on the invention might eventually leak out and therefore loose its secrecy character.[19] Thirdly, trade secrets might act as a strong disincentive to attract top-tier AI talent to the firm, especially top researchers from academia that have a strong incentive to publish their work.[20]

Lastly, viewed from an AI ethics perspective on the trustworthiness or explainability of AI systems, AI models that are kept trade secrets but have real-world applications can correspond to proprietary black box models. While a published patent provides insight into the functioning of the AI system and therefore only leaves open the possibility of being a black box due the technical complexity of the model, the set-up of AI models that are protected by trade secrets cannot even be assessed, much less understood. So, in the worst case, AI models protected by trade secrets can involve a double black box: non-disclosure and complexity. While IP rights are supposed to increase social well-being, trade secrets, on the contrary, can significantly restrict it.[21]

2.1.2. Patentability of AI Algorithms

IP rights are granted by states to reward the innovative capability of the inventor. In the case of a patent, a state awards the inventor with the exclusive right to exclude others (for the duration of 20 years) from using the invention without the inventor's authorization, in exchange for the detailed description of the invention. On the one hand, this bargain guarantees effective rights protection to the inventor within the country's legal system. On the other hand, it is raising the state's overall level of innovation through providing others the possibility to access the invention by way of paying licensing fees to the inventor.

Another advantage of pursuing patents for inventions in AI, is it is indicative of a firm's innovative potential. Because AI talent is scarce, and top talent seeks to publish their work in journals or at conferences, formal patent application formats provide an elegant way for companies to incentivize their AI research engineers to show their work to their community. Patent applications are indeed an important publication channel.

To determine the world's leading regions in the field of AI, it is useful to consider patent filings at intellectual property offices (IPOs). However, caution is advised here. The quantity of patents filed does not say anything about the quality of the technology on which the patent is based.[22] When patent applications for AI technologies of European companies are compared with those of American and Chinese ones, they are significantly below their numbers.[23] Because the United States Patent and Trademark Office (USPTO) accounts for most filings, a regional bias in terms of disproportionate filing may occur.[24] Therefore, it is useful to consider additional indicators that can infer regional strength: IP-strong companies, acquisitions of AI companies, IP-strong universities, universities leading in AI publications, and R&D

spending related to AI.[25] In summary, the US and China hold strong to dominant positions in all the above mentioned categories, while the EU mostly ranks behind these countries.[26]

China is increasing its share in AI innovation
Startling, Chinese AI innovation seems to have overtaken the US in the recent years when measured in patent filings for ML[27]. This can be derived from the number of patents filed at key patent offices, with the National Intellectual Property Administration of the People's Republic of China (CNIPA) having more than doubled its share of world-wide patent applications from 19.6% in 2010 to 45.7% in 2020; with resident Chinese companies accounting for the highest share of patent applications.[28]

Not surprisingly, when measured by their share of patented AI technologies at the CNIPA[29], Chinese companies are leading the ranking. However, as mentioned before, the number of patent applications is not indicative of the quality of the underlying technology. Secondly, by far the greatest share of patent applications are filed by and granted to Chinese companies by the CNIPA.[30] Therefore, both indicators are heavily skewed towards Chinese companies and might be indicative only for the innovative potential of Chinese companies that are focused on the domestic Chinese market. In contrast to the CNIPA, both the USPTO and EPO receive higher shares of patent filings from and equally grant more patents to international companies than the CNIPA. Hence, their statistics are more indicative of transformative AI capabilities manifested in patents that allow for the penetration of global markets. And certainly, patent applications are not the sole meaningful measurement to determine innovative capacity—patents granted, patent applications per GDP, and patent quality assessments, among other, are also important indicators to consider.

How AI algorithms can receive patent protection
ML-algorithms are based on mathematical rules articulated in software code. In the same way as mere discoveries, scientific theories, or computer programs, mere mathematical models are generally not a patentable subject matter. Nonetheless, in many jurisdictions, AI inventions at the algorithmic or software level can receive patent protection.

AI is dependent upon the underlying software code base.[31] Software-based applications are generally patentable. But, as mentioned before, patentability is dependent upon the jurisdiction and patent office of the target country (territoriality). Depending on the jurisdiction and IPO in question, AI software-based applications can receive patent protection, as well as AI software-based applications that improve compute-operations in AI hardware. Large agreement between different national jurisdictions and IPOs is attributed to three distinct properties that AI software-based applications must demonstrate to be considered for patent protection (see for example Art. 52 (1) European Patent Convention – EPC): **novelty, inventive step, (susceptibility of) industrial application.**[32]

Disagreement between important IPOs and therefore room for interpretation regarding the patentability of inventions in AI remain whether specific features of AI software-based applications can be considered a **patentable subject matter**[33].

Patentability of inventions at the algorithmic level in the EU
For the EPO, the distinctive feature is whether the software-based applications contribute to the technical character of the invention (technicality) (see Art. 52 (1) EPC: "in all fields of technology"). If the claimed invention is based on a mathematical method, the EPO raises the bar for granting patent protection. It is then examined whether the mathematical method contributes to the **technical character** of the invention (eligibility hurdle).[34] There are two situations where the mathematical method can contribute to producing a technical effect that serves a technical purpose in the context of the invention (patentability hurdle), thus providing the necessary inventive step:[35]

1. by its application to a field of technology [**technical application**] and/or
2. by being adapted to a **specific technical implementation**[36].

In both cases, the claimed subject matter must contribute **a technical solution to a technical problem (technicality)**.[37]

In the case of the technical application, the claimed mathematical method must be **functionally limited** to a **specific technical purpose**[38]**.** This is assured if "the mathematical method is causally linked to a technical effect".[39] The EPO "Guidelines for Examination" ("EPO Guidelines"), which specify the EPC, list the following examples where the mathematical purpose serves the technical purpose:

- controlling a specific technical system or process, e.g., an X-ray apparatus
- speech recognition, e.g., mapping a speech input to a text output
- providing a genotype estimate based on an analysis of DNA samples
- providing a medical diagnosis by an automated system processing physiological measurements.[40]

Another interesting example is a patent that was granted to Google DeepMind by the EPO solely after technicality was proven by the applicant in the patenting process: Illustrating the close interconnection between the algorithmic level and the specific technical application, the claimed mathematical method is here functionally limited to a specific technical purpose. The patent claims a reinforcement learning technique that is *tied* to a specific robotics application.[41]

The technical implementation claim is even more relevant for patent protection of inventions in AI hardware and will therefore be described in detail in the next chapter.

Patentability of inventions at the algorithmic level in the US
In the US, the patentable subject matter needs to be significantly more than just an abstract idea (Alice Corp. vs. CLS Bank International[42]). Whether software-based AI inventions are indeed a patentable subject matter, is determined by patent examiners but ultimately by US courts in a steadily evolving body of case law. To determine whether software-based inventions qualify as an eligible subject matter for patent protection, patent examiners (and courts) rely on a two-step procedure, referred to as the **Alice/Mayo test**[43] (for details, see Annex 2).

Please see Annex 2 for a detailed account on the differences between the EU and the US on the patentability of AI inventions at the algorithmic level.

Core differences between the EU and the US on the patentability of software-based AI inventions
The EPO does not consider AI a technology sufficient to be a patentable subject matter. The EPO Guidelines of the EPO require patent applications for inventions in AI to meet the technicality criterion. This constitutes a very high hurdle for inventions in AI that claim solutions outside of a specific technical context, i.e., linked to a technical apparatus. Consequently, inventions that limit their claims to so called **core AI** are unlikely to receive patent protection in the EU. In contrast, the U.S. patent system is more flexible with regards to granting patent protection for core AI.

Here it can be observed that the U.S. patent system leaves more room for maneuver than the European one. The EPO outright excludes the patentability of stand-alone ML algorithms. In contrast, in the US, AI software-based inventions can receive patent protection if the patent application claims to recite **significantly more than an abstract idea**. Given the dynamic nature of U.S. case law, additional precedent on the question when a software-based (AI) application amounts to significantly more than an abstract idea will further complement the status quo in the future.

Patent claims for ML techniques
To add another important difference between the two jurisdictions, there are certain examples of patents filed in the US that illustrate that companies like Google have successfully filed patent applications that attempt to protect central ML techniques.

Prominent examples are the deep learning techniques: *DQN*, *Batch Normalization*, and *Dropout*[44]. The Dropout technique, for example, assures the model's capability to generalize.[45] This was met with strong criticism, especially from the open source and ML developer community.[46]

But in this example, there is, again, a geoeconomic dimension involved. If innovations that target ML techniques can be obtained with U.S. patents, this could provide another decisive locational advantage to the U.S. innovation ecosystem. While every startup around the world applies the Dropout technique to their ML models, it is up to Google to enforce it (and make the global AI industry pay licensing fees). Although Google might never enforce its patent on Dropout or similar foundational deep learning techniques in its patent portfolio—the mere possibility thereof has certainly disquieted the international AI developer community[47]. For details on the patentability of ML techniques, see also annex 2.

If innovations at the algorithmic level—core AI—are easier to be obtained with U.S. patents, this could provide a locational advantage to the U.S. innovation ecosystem. Consequently, the USPTO will account for more (granted) patent applications aimed at the protection of inventions in AI algorithms or core ML techniques than its European counterpart, the EPO. This subtle legal difference might constitute a strong advantage to U.S.-based companies and research entities invested in the advancement of core algorithmic advances in ML.

Countries differ in their treatment of inventions in AI
While Japan determines AI software patentability similarly to the US, China's approach is similar to the EU's technicality, in requiring the software-based AI application to providing a technical solution for a technical problem. Furthermore, in the EU, ML and other AI subfields are considered mere abstract mathematical models and not fields of technology.[48] This interpretation is particular to the EPO and not shared by other patent offices, for instance the USPTO and the Japan Patent Office (JPO) and might thus change in the future.

These differing interpretations among key national IPOs constitute important thresholds that determine the patentability of the AI invention in question. Inventors of AI applications must be aware of these distinguishing features, that national IPOs apply to determine the patentability of AI software-based inventions. Countries differ in their treatment of inventions in AI. This becomes especially obvious in the case of patent applications that claim software-based AI inventions at the algorithmic level, in which the EPO and USPTO differ from each other.

2.1.3. Copyrights Applied to AI Algorithms

Various types of works fall within the realm of copyright protection. Related to AI, computer programs, and databases are of interest, but so are artistic works such as photographs, films, and musical compositions.[49] When viewing copyrights in the light of AI algorithms, it must be noted that copyright protection is limited to so called *expressions*.[50] Hence, mere ideas, as well as mathematical and technical concepts lie outside the scope of copyright protection.[51] Copyrights award the author of the expression with economic and moral rights.[52] Whereas economic rights are the basis to claim a financial compensation when others use the author's work, moral rights go beyond the mere commercial interest of the author. They seek to protect the author's personality which is expressed in the work.[53]

Patenting inventions at the algorithmic level of AI technologies can be challenging or impossible. Therefore, copyrights might be an option to protect at least aspects of the AI software, for instance its source code.[54] Moreover, the copyright protection of the source code does also last longer than mere patent protection (in many states, such as Germany, 70 years following the decease of the author, vs. 20 years). Thus, aspects of the software under copyrights award the author with the possibility to control the source code longer than it would be possible by relying on a patent.[55] Although the Berne Convention for the Protection of Literary and Artistic Works holds that copyright protection is automatically obtained without the need for registration,[56] registering the works at copyright registers can be helpful for example to prevent disputes and to facilitate remuneration or the management of rights.[57]

The most important copyright registers for the AI industry are the copyright registers at the U.S. Copyright Office[58] and at the Copyright Protection Center of China (CPCC)[59]. Although often lamented by policy makers, academics, representatives from industry, and the legal professions, the EU has no copyright register to call its own.[60] Especially the reliance of European companies on the U.S. copyright register for software-code might constitute a dependency of strategic relevance if it were to allow an U.S. administration to use the copyright register to exert pressure on the EU in matters of foreign economic and trade policies.

Similar muscles were flexed towards trade partners, when the U.S. Department of Commerce explored ways of listing features of AI technologies of great relevance for the international AI ecosystem (components of AI put so general as "*neural networks and deep learning*", or "*AI chipsets*" [61]) on the export control list under the Trump Administration. Although these attempts were connected to the U.S. entity list and were rather steered towards Chinese (state)companies that might have posed threats to the national security of the US and were suspected to be part of the technological ecosystem that supplied Chinese state surveillance capabilities,[62] these instruments (export control, foreign direct investment screening, visa control) could, theoretically, also be targeted at other states and economic regions, including the EU.

However, geopolitical disputes set aside, if patent protection of software-based AI applications should not be possible because the claim is not subject-matter eligible for patent protection, it can still be possible to pursue copyright protection for certain aspects of it—namely its source code.[63]

2.2. Hardware

Current day ML capabilities would not have been possible without the application of special purpose hardware to both training[64] and inference[65] of ML models.[66] Despite all skepticism towards deep learning that is probabilistic and by no way establishing causal understanding,[67] its practical application to many sectors of the economy has not even peaked yet. The technology is still scaling. So much to the point that multinational tech platforms from the US and China have engaged in a fierce competition to increase their hardware infrastructure and hardware design capabilities.[68] This is necessary to further grow their already compute-heavy deep learning capabilities.

MetaAI has only recently announced that its *AI Research SuperCluster Phase 1* will be using 6080 units of Nvidia's A100 GPUs (with a manufacturer's suggested retail price (MSRP) of 30,568.00 US dollars *each*[69]).[70] The company doubled down on this announcement by adding that it would increase this number to 16,000 GPUs throughout 2022.[71] A quick calculation—without including volume discount, material, or staff costs—puts a stunning price tag of roughly half a billion US dollars to the GPU's that will power MetaAI's hardware super cluster.

Skeptics can only hope that deep learning will indeed succumb to the problem of *causal understanding*. Otherwise, should it scale-up nonetheless, it will be tremendously challenging financially for competitors of tech multinationals to compete with their hardware infrastructures that are responsible for advancing the boundaries of ML. Thus, specialized AI hardware constitutes a very important AI resource[72] that will likely be a key determinator of the EU's strategic dependencies in AI towards US tech multinational companies. Now, with increased competition among companies that consider AI capabilities at the very core of their business models[73], market entry barriers for compute seem to have been raised once again.

Increasing the available compute allows the model to *learn* from more data. This will result in overall better performance of the model—without changing a single line of code. Because of the lesser importance of trade secrets and copyrights for the protection of inventions in AI hardware, and because of the importance of big compute for the overall progress and application of deep learning, this chapter describes the possibilities that are at the disposal of patent specialists to secure patent protection for inventions in AI hardware. In doing so, this chapter deviates from the general structure this paper applies to analyzing AI's core industrial inputs along the different available IP rights. Thus, the focus of this chapter not only shifts to patents, but it also shifts to the significance of the industrial input itself. Because the availability of compute, as a basic infrastructure, is a decisive feature of highly competitive AI ecosystems.

2.2.1. Patentability of Special Purpose AI Hardware

Algorithmic inventions that improve hardware operation can be claimed from either the software side (process claim), or the hardware side (product claim).[74]

Patent protection of AI hardware in the EU—technical implementation
In the EU, the patentability of a mathematical method is also possible—independently of any technical application—when the claim "is directed to a **specific technical implementation**". In this case, the algorithm design must "(...) be motivated by technical considerations of the **internal functioning of the computer**". The technical considerations "must go beyond merely finding a computer algorithm to carry out some procedure"[75]. This must go beyond mere programming. In its decision T 0697/17, the EPO's Boards of Appeal lists examples that refer to such circumstances:

- a compression algorithm used for the purpose of reducing the amount of data to be stored or transmitted[76]
- a RAM-based hash table of fingerprints of stored URLs, in the context of web crawling[77]
- search indexes used to provide access to stored data.[78]

The technical implementation requirement provides a high hurdle to mathematical methods where the algorithm design is not specifically directed at the adaption to special purpose hardware. In the EU, it might thus be difficult to claim a technical implementation of a mathematical method to anything other than special purpose AI hardware.

Patent protection of AI hardware in the US

In the US, inventions at the algorithmic level have been found eligible subject matters when: 1) the software-based application **improves computer operation** (Enfish, LLC v. Microsoft, Inc.[79]); 2) if the software invention causes **improvements to the functioning of a computer** (DDR Holdings v. Hotels.com).[80] This applies to special purpose hardware specifically, so called "accelerators", essential for training neural networks and for inference from live-data. In their article "Patent Protection on AI Inventions", Weiguo Chen and Yunlai Zha[81] provide concrete examples for this AI patent category:

- "specially designed hardware to improve training efficiency by working with GPU/TPU/NPU/xPU[82] (e.g., by reducing data migrations among different components/units)
- memory layout changes to improve the computational efficiency of computing-intensive steps
- arrangement of processing units for easy data sharing
- and efficient parallel training (by segmenting tensors to evenly distribute workloads to processors)
- an architecture that fully exploits the sparsity of tensors to improve computation efficiency".

The EPO and the USPTO come to similar results concerning the protection of AI inventions that enable special purpose AI hardware. Either through requiring the claimed mathematical method being directed to a specific technical implementation to cause a technical effect that serves a specific technical purpose (EU), or by requiring the software-based invention to improve computer operation, or else to cause improvements to the functioning of a computer (US). Hence, patenting special purpose AI hardware is more straightforward in the EU and in the US than patenting software-based AI innovations at the algorithmic level.

More important than the question on securing inventions in AI hardware, is the capability of states to ensure that their nascent AI ecosystems are equipped with compute infrastructures that ensure their industries (and academic institutions) to train very large ML-models, which in turn requires access to data and big compute for processing these data, especially during the compute-heavy training phase. Because tech multinationals pursue business cases that bank on AI—for instance search, ad tech, social media, cloud computing, or ML-as-a-service—they have a strong incentive to prevent compute from being a bottleneck for their ability to innovate and to providing services on their respective cloud platforms. This explains, in part at least, why many of the largest hyperscale cloud providers, for instance Amazon Web Services, Microsoft Azure, Google Cloud Platform, have engaged (for varying reasons—i.e., reducing dependencies on Nvidia, lowering energy consumption, being more application specific) in designing their own special purpose AI hardware that power their compute clusters and enable their end-user products.

MetaAI's compute cluster is exemplary for the costs required to equip AI researchers with the compute required to push the boundaries of the discipline. Only recently, different German academic research universities have rung the alarm bell on the fact that even their most excellent departments were struggling to ensuring the amount of compute necessary to engage in cutting-edge ML research. Training models the size of GPT-3 is currently out of reach for European academic research centers.[83] Thus, dependencies on U.S. hyperscale cloud providers are a reality for European universities and the EU's nascent AI industry. Although the compute is available on U.S. cloud platforms, payable by the hour, this nonetheless constitutes an increasingly important dependency that requires mitigation. It comes to no surprise that the LEAM initiative (Large European AI Models) calls for the provision of hyperscale infrastructures that enable European AI models to be trained on very large data sets.[84]

2.3. Data

The uptake of deep learning would not have been possible without very large quantities of data made available by the Internet. Increasingly, these data will be complemented by connected goods additionally producing very large quantities of data. As an industrial input for ML technologies, data is essential. But the downside to deep learning is its hunger for huge quantities of training data which also helps to explain the requirement for big compute. Current ML models scale in performance (in terms of accuracy and utility) with every additional data point ingested.[85] Apart from the quantity of data, other data traits important to consider are data quality, diversity, variance, and history of the data.[86]

The importance of these data traits for the performance of ML models, has led academic and applied AI researchers to come up with various methods to increase the quantity and overall quality of training data. These techniques are referred to as *data augmentation*. These data manipulating techniques (for instance in photo and video, adding or reducing noise, changing the contrast, adding another angle to the same picture, and many more[87]) prove clever ways to enhance the training data. Such pre-processing techniques can be in the realm of receiving patent protection.[88]

But data—especially training data because it is industry and use case specific—can also receive IP rights protection by other means than relying on patenting only. Important instruments are yet again: trade secrets and copyrights. Contrary to algorithms, of which most are available to developers via open source, the availability of data to train deep learning models constitutes a serious bottleneck, especially for startups that lack domain specific data that larger companies can consider their own. Although compute is made available as-a-service, data are considered crown jewels, unlikely to be shared with potential economic competitors.

This chapter takes a closer look at the problems associated with proprietary data. Differences in the availability of data between different countries or economic regions can very well determine the innovative capability of their nascent AI industries. Therefore, the differences in IP rights regimes concerning (training)data are a decisive function of the overall innovative capabilities of AI ecosystems.

2.3.1. Trade Secrets Applied to Data

Trade secrets are an appropriate tool not only to protect an AI invention but also to protect the creative process that may lead to an invention which, once attained, can then also be protected by other IP rights able to claim exclusivity (patents or copyrights).[89] In the context of data, some requirements of trade secrets are particularly challenging: secrecy and commercial value of the data. Once the data has been transferred, it might be possible for it to remain secret only if confidentiality clauses had been agreed upon by the entities involved in the transfer of the data. And because data under a trade secret is indeed *secret*, it is difficult to argue the commercial value of the individual data without putting it into the open.[90]

Trade secrets are legally protected only if the information has been obtained illegitimately[91]. For ML practitioners, that have access to data their firm considers valid for trade secret protection, once the dataset is published by whichever means, protection under trade secrets can no longer be claimed.[92] Similarly, sharing datasets with third parties, for instance for data analysis or feature engineering, should always include a prior assessment whether the respective data sets comprise information protected by trade secrets.

Hence, trade secrets are a way of protecting (training) data, but this approach involves some important caveats to be aware of. Other, more exclusive rights, namely patents and copyrights, therefore, may be more appropriate to protecting (training) data.

2.3.2. Patentability of Practices Applied to Processing Data

Where data is concerned as an industrial input to AI systems, patent protection might be an option if the way in which the data is prepared (pre-processing) or otherwise manipulated once the model has produced an output (post processing) represents a novel approach.[93]

ML practitioners work in teams that include data scientists, data engineers, and software coders. While ML researchers program ML architectures in deep learning software frameworks, they also consider the specific data set that will be used for training and choose the appropriate model and classifier. Data scientists design prediction models and data-engineers help with the architecture to reach the projected prediction levels. Software coders finally help to code the final software application. This pyramid structure,[94] with few ML specialists at the top, data scientists and data-engineers in the middle, and many more software coders at the base, is the signature workforce structure of advanced tech clusters that develop AI.

Now, ML researchers, data scientists, and data-engineers often go great lengths to prepare the data in a way that optimally serves the model to produce accurate results.[95] And these manifold approaches of normalizing, transforming or otherwise preparing the input data so that it is “more easily approachable” by the model[96], might themselves represent viable methods to claim patent protection.[97]

Similarly, but at a different step of the way, processes by which the model’s raw output data can be altered may also be worth of laying a claim to a patent (post-processing). There are numerous reasons for why it is worth to alter the output data, for instance, when trying to explain why the model has come to produce the output it has produced.[98]

Hence, if the practices by which ML practitioners engineer the data throughout the ML process[99] may provide something additional to prior art, these techniques may be worth of claiming patent protection.

2.3.3. Copyright Protection of Data

In ML, the model learns from data it is exposed to during training. For example, in image recognition, during training, the model (i.e., a convolutional neural network) is exposed to many example data (i.e., pictures of cyclists) as well as target data (pictures of cyclists specifically labeled as such; *supervised learning*). After having been exposed to many example data, the model discovers stochastic patterns in the data that allows it to map pictures of cyclists according to the specified category—with high levels of confidence.[100] When the model is confronted with new data, it can now apply these rules and accurately classify cyclists.[101] The model can assess the probability that the new data points fit the learned pattern (inference)—and thus generalize to new data.

But patterns only emerge after the model has consumed massive quantities of training data.[102] This is often portrayed as one of the major pitfalls of deep learning.[103] For example, OpenAI's third generation natural language processing (NLP) model, *GPT-3,* was trained on unstructured data (*unsupervised learning*[104]), among other,[105] on "45 TB [terabyte] of compressed plaintext before filtering and 570GB [gigabyte] after filtering (...)" gathered from "41 shards of monthly CommonCrawl" that were created between 2016 to 2019.[106] The Common Crawl corpus contains "raw web page data, metadata extracts and text extracts" that was collected over 12 years of crawling the Internet.[107] The Common Crawl database is in essence an indexing of the Internet. Thus, the Common Crawl dataset is one of the most important resources used as input to train NLP models.[108]

Three problems can be derived from deep learning's huge appetite for data: First, very large ML models can only be trained on gigantic amounts of training data.[109] Therefore, **data access** provides a first bottleneck.[110] The second problem is concerned with data-engineering and involves the compute pipeline: how can it be assured that there is enough compute that allows for training the model? This represents another bottleneck and increasingly also a market-entry barrier worth exploring in more detail, although it lies outside the scope of this paper. Thirdly, individual data collected in the corpora can be subject to copyrights. Hence, the question whether it is permitted to train ML models on copyrighted data[111] (**data usage**) is causing tremendous legal uncertainty to the AI industry.

Data Access

The prerequisite to train ML models is data. Simplified, data is either proprietary and not accessible or in the public domain and accessible (although individual works within the corpora may be protected by copyrights). Additionally, there is special law for personal data and privacy, for instance the EU's General Data Protection Regulation that provides special provisions to the processing of personal data.[112] Where can large datasets be retrieved to train ML models?

Apart from proprietary data, data in the public domain is an important resource for training ML models, especially in NLP. Automated web crawlers used to create corpora such as Common Crawl or such as WebText (emphasizing document quality[113]) essentially extract text from URLs through text and data mining[114] (TDM) techniques. Web crawlers are accessing websites' *robots.txt* files, a machine-readable file format, that includes relevant information on sections of the web domain which can or cannot be accessed by such bots[115]. Data retrieved by TDM techniques are copied and stored in databases that can then be pre-processed and used for training ML models.

But individual works contained in such datasets can be protected by copyrights. This can pose serious problems to AI developers and might even provide a locational disadvantage towards AI ecosystems less rigid on allowing copyrighted data to being used for training ML models.

Please see Annex 3 for a detailed account on the differences between the EU and the US regarding text and data mining of copyrighted data and its application to training ML-models.

Data Usage
Can copyrighted data be used as an input for training ML models, without prior permission of the copyright owner? To achieve a better understanding of the issues related to this question (legal uncertainty, compliance costs, barriers to innovation, and many more), it is necessary to consider the respective legal provisions in the EU and the US on the usage of copyrighted works—resulting from TDM—for the training of ML models.

Data Usage in the EU—the Directive on Copyright in the Digital Single Market (EU) 2019/790
To assess the situation in the EU, it is important to consider the Directive on Copyright in the Digital Single Market (DSM Directive) because it introduces exceptions for research organizations[116] to employ TDM techniques[117] "for the purpose of scientific research", Article 3 (1) DSM Directive.[118]

Commercial entities and the application of TDM techniques
Article 4 (1) DSM Directive gives Member States the option to allow TDM techniques for any other user than just research organizations.[119] Which, in principle, would allow commercial entities to employ TDM techniques on copyrighted data. However, it is important to note that Article 4 (3) DSM Directive contains an **opt-out provision** that allows rights-owners to exclude commercial entities from TDM of their copyrighted works.[120] The only prerequisite is that rights owners have "expressly reserved their rights in an appropriate manner". The article goes on to specify that "machine-readable means" represent such an "appropriate manner".

Hence, copyright owners in the EU can very easily exclude commercial entities from TDM of their copyrighted works, for example by making use of machine-readable robots.txt files that define which parts of the domain can and cannot be accessed by bots. As a result, Article 4 (3) DSM Directive perpetuates the legal position of copyright owners that exclusively commercialize TDM of their works, especially large print, and other media publishers[121].

The DSM Directive has enabled academic research institutions to employ TDM techniques, but the opt-out provision in Article 4 (3) will effectively shut-out commercial application of TDM on copyrighted data by private companies, including AI companies. Although the opt-out provision may be aimed at tech multinationals to prevent them from further harvesting data and adding them to their already enormous data bases stemming from their consumer facing business models, this provision may cause collateral damage to the nascent European AI startup ecosystem that is effectively prohibited by the opt-out provision from web scraping copyrighted works and from using these data to train their proprietary ML models. This could constitute another tidal wave for the European AI industry in addition to the inability to train very large models (lack of data and lack of compute) already impeding European AI innovation capabilities in deep learning.

Data Usage in the US—the legal doctrine of fair use

In the US, the baseline situation is the same as in the EU: whether commercial entities can train ML models on copyrighted works, is an open and contested question.

In the US, there is legal uncertainty as to whether commercial entities are indeed entitled to copy expressive works through TDM and whether they can then proceed by using the copied data for training ML models (without remunerating the rights owner). In a legal system that relies on case law, this situation is further convoluted in the absence of judicial precedent. To this date, no US court has yet tested digitization through web crawling and TDM for purposes of ML training, or the training of ML models with "already-digitized works".[122]

The exception to the reproduction right of copyright owners—fair use

To decide whether this would infringe copyright, US courts will need to determine whether a most important limitation on the exclusive right of copyright owners,[123] known as **fair use**, is applicable or not. "Fair use is a legal doctrine that promotes freedom of expression by permitting the unlicensed use of copyright-protected works in certain circumstances."[124] It requires courts to weigh four explicit statutory factors, specified in section 107 of the Copyright Act, 17 U.S.C. § 107.[125]

In the US, the issue of training AI systems on copyrighted works was stated in a USPTO issued request for comments (RFC) on the patentability of AI inventions.[126] In its report, that analyzed a multitude of differing comments to its RFC, the USPTO first establishes the ground truth: *"Copying substantial portions of expressive (copyrighted) works, even for non-expressive purposes implicates the reproduction right and, absent an applicable exception, is an act of copyright infringement".*[127] But TDM might be a scenario "*eligible for an exception to the reproduction right* [of copyright owners]".[128]

Participants contributing to the RFC largely opposed each other in their statements—depending on their status regarding copyright ownership[129]. Both fractions based their reasoning on hypothetically applicable legal precedent from well-known court cases such as *Authors Guild Inc. v. Google, Inc.* ("Google Books" case) where the digital scanning of "tens of millions of books" without explicit permission of the authors' constituted non-infringing fair use.

Employing TDM for training purposes requires making copies of expressive works.[130] It is therefore understandable that publishers argue against additional data harvesting of their copyrighted works, by tech multinationals as it is clearly expressed in the answer to the RFC by the NewsMedia Alliance[131]. On the other hand, in its answer to the RFC, OpenAI argues that the output of an NLP system might display similarities to the works in the corpus, but the ML models do not regenerate any individual work in the training corpus.[132] Consequently, the usage for training purposes, the argument goes, would not negatively reduce the value of the copyrighted expression.[133]

Ultimately, it is up to US courts to determine whether the fair use principle is applicable in the context of employing TDM of copyrighted data for training purposes of ML models. But if US courts were to follow the same reasoning as in Google Books—and allow commercial entities to train their ML models on copyrighted data obtained by TDM—this could provide a strong locational advantage for U.S.-based (AI) companies over European based ones.

3. Conclusion

This paper provides European foreign policy makers with information on how to identify the EU's strategic dependencies in AI. To do so, European foreign policy makers need a set of indicators that can measure possible dependencies. This paper suggests exploring the distribution of IP rights along AI's core industrial inputs. This leads to an understanding of the innovative capacity and competitiveness of AI companies, AI ecosystems and their locational (dis)advantages.

Counting patent applications is not enough to achieve this goal. European foreign policy makers first need to equip themselves with an understanding of the IP rights relevant for protecting innovations in AI: these are **trade secrets**, **patents**, and **copyrights**. Secondly, it is important for European foreign policy makers to know that AI innovation occurs at three distinct industrial inputs: **algorithms**, **hardware**, and **data**. This is the starting point for a systematic mapping of the various options available to states to protect innovation in AI. This information can help European foreign policy makers to effectively reduce the EU's strategic dependencies in AI.

This paper has identified three main challenges concerning the IP rights protection of AI's core industrial inputs: one of which stems from a difference in the possibilities to receiving patent protection for inventions in AI algorithms, the second being associated with the treatment of training data under copyright protection, while the third challenge is directly manifested in the industrial input hardware as a central building block of AI.

Inventions in algorithms determine AI's developmental trajectories
Innovations in AI algorithms are fundamental to the development of ML. The possibilities to protect innovations in AI algorithms are internationally not the same: In comparison, the U.S. legal framework provides for more far-reaching protection possibilities of core AI than the European one, which additionally requires a technical application that is tied to the invention at the algorithmic level. Companies that develop AI algorithms might therefore more easily obtain patent protection in the US for their inventions in AI algorithms and benefit from the less rigid U.S. patent regime. In the long term, this could result in a locational disadvantage for the EU—which in turn could lead to strategic dependencies regarding the future development of ML technologies.

Data fuels AI innovation
Very large ML models of the type of GPT-3 require high volumes of training data. TDM is a commonly used method to accumulate training data. ML models may not be trained by companies with proprietary data in both the US and the EU. Exceptions to this are research institutions (DSM Directive). In the US, many (AI) companies are

pinning their hopes on the application of the fair use principle. If US courts were to apply this doctrine, the use of copyrighted data for training ML models would no longer be considered a breach of copyright. But no high court ruling has yet been issued in either the EU or the US on whether copyright-protected data can be exploited beyond its application for academic research.

Startups on both sides of the Atlantic are therefore faced with legal uncertainty, which is also perceived as an obstacle to innovation. If the fair use principle were to apply to the exploitation of copyrighted data in the US, e.g., due to the transformative nature of AI applications, this would signify a locational advantage for companies based in the US. This would further aggravate the EU's strategic dependencies.

All is lost without big compute

In the case of hardware, the problem does not lie in the different application of IP rights. Instead, it stems from the lack of a European hardware infrastructure in the form of hyperscale cloud platforms or supercomputing clusters. European AI companies and increasingly also European cutting-edge research are therefore already dependent on foreign, in particular U.S., hyperscale cloud infrastructures. The current discussion about the EU's positioning in the global hardware supply chain should feed into efforts to increase the EU's strategic capacity in this area.

The analysis in this paper has revealed that the EU is under pressure from two sides: the first concerns the scope of its legal framework that allows for IP rights protection of inventions in AI, while the second concerns the dependencies of the EU's nascent AI innovation ecosystem on the access to AI's core industrial inputs. The exploration of different IP rights regimes along AI's industrial inputs has shown that a systematic mapping of this field is a necessary step to identify the EU's strategic dependencies and to build its strategic capacity in AI. Further research is required to provide European foreign policy makers with strategic tools to translate these insights into concrete tech foreign policy.

4. Annex

4.1. Annex 1: Deep Dive the EU's Concept of Open Strategic Autonomy

Although not yet officially defined, the best approximation to the concept of open strategic autonomy can be found in the [European] Commission staff working document *strategic capacities and dependencies*.[134] It describes open strategic autonomy as: "the ability to shape the new system of global economic governance and develop mutually beneficial bilateral relations, while protecting the EU from unfair and abusive practices, including to diversify and solidify global supply chains." This broad definition is further refined by introducing three valuable features: **strategic capacity**, **dependencies**, and **strategic dependencies.**

While **dependencies** are described as: "reliance on a limited number of actors for the supply of goods, services, data, infrastructures, skills and technologies (...)", they are not necessarily detrimental to the EU's strategic autonomy. Contrary to **strategic dependencies**, described as being of: "critical importance to the EU and its Member States' strategic interests such as security, safety, health and the green and digital transformation".

To reduce dependencies and more significantly, strategic ones, the staff working document evokes the built-up of **strategic capacity** within the EU. This is defined as: "a certain level of capabilities held within the EU allowing to produce, provide or rely on strategic goods, services, data, infrastructures, skills, industrial know-how and technologies".

4.2. Annex 2: Deep Dive Patentability of Inventions in AI Algorithms

According to the EPO Guidelines, an invention can be patented if it meets four distinct requirements described in Art. 52(1) EPC. The invention must **belong to any field of technology**, be **susceptible of industrial application**, **new**, and **involve an inventive step.** But an invention cannot be patented if it is a mere mathematical method, Art. 52 (2)(a) EPC or when claimed as such, Art. 52 (3) EPC.[135] The EPO Guidelines are very clear on the exclusion of algorithms as a patentable subject matter by arguing that: "Artificial intelligence and machine learning are based on computational models [...]. Such computational models and algorithms are per se of an abstract mathematical nature, irrespective of whether they can be "trained" based on training data."

Patent protection of software-based AI applications in the European Union
For the EPO, the distinctive feature is whether the software-based applications contribute to the technical character of the invention (technicality).

If the claimed invention is based on a mathematical method, the EPO raises the bar for granting patent protection. It is then examined whether the mathematical method contributes to the **technical character** of the invention (eligibility hurdle).[136] There are two situations where the mathematical method can contribute to producing a technical effect that serves a technical purpose in the context of the invention (patentability hurdle), thus providing the necessary inventive step:[137]

1. by its application to a field of technology [**technical application**] and/or
2. by being adapted to a **specific technical implementation**[138].

In both cases, the claimed subject matter must contribute **a technical solution to a technical problem (technicality).**[139]

Technical application
In the case of the technical application, the claimed mathematical method must be **functionally limited** to a **specific technical purpose**[140]. This is assured if "the mathematical method is causally linked to a technical effect".[141] The EPO Guidelines list the following examples where the mathematical purpose serves the technical purpose:

- controlling a specific technical system or process, e.g., an X-ray apparatus
- speech recognition, e.g., mapping a speech input to a text output
- providing a genotype estimate based on an analysis of DNA samples
- providing a medical diagnosis by an automated system processing physiological measurements.[142]

Another interesting example is a patent that was granted to Google DeepMind by the EPO solely after technicality was proven by the applicant in the patenting process: Illustrating the close interconnection between the algorithmic level and the specific technical application, the claimed mathematical method is here functionally limited to a specific technical purpose. The patent claims a reinforcement learning technique that is tied to a specific robotics application.[143]

Technical implementation
The patentability of a mathematical method is also possible—independently of any technical application—when the claim "is directed to a **specific technical implementation**". In this case, the algorithm design must "(...) be motivated by technical considerations of the **internal functioning of the computer**". The

technical considerations "must go beyond merely finding a computer algorithm to carry out some procedure"[144]. This must go beyond mere programming. In its decision T 0697/17, the EPO's Boards of Appeal lists examples that refer to such circumstances:

- a compression algorithm used for the purpose of reducing the amount of data to be stored or transmitted[145]
- a RAM-based hash table of fingerprints of stored URLs, in the context of web crawling[146]
- search indexes used to provide access to stored data[147].

The technical implementation requirement provides a high hurdle to mathematical methods where the algorithm design is not specifically directed at the adaption to special purpose hardware. In the EU, it might thus be difficult to claim a technical implementation of a mathematical method to anything other than special purpose AI hardware.

Patent protection software-based AI applications in the US

In the US, patents are granted only, if the invention is **new** (35 USC 102), **non-obvious** in the light of prior art by a person of ordinary skill in the art (35 USC 103), and the invention must be a new and useful **patentable subject matter** (35 USC 101). Whether software-based inventions are indeed a patentable subject matter, is determined by patent examiners but ultimately by U.S. courts in a steadily evolving body of case law.

A patent can be obtained for: "(...) any new and useful **process**, **machine**, **manufacture**, or **composition of matter**, or any new and useful **improvement** thereof", 35 USC 101 (statutory categories).[148] This is the case if it is self-evident from the application that the invention qualifies as eligible subject matter under 35 USC 101. If this is not the case, it is reviewed whether the claim can be amended to fall within a statutory category.

To determine whether software-based inventions qualify as an eligible subject matter for patent protection, patent examiners (and courts) rely on a two-step procedure, referred to as the **Alice/Mayo test**[149].

Step one determines whether the claim is directed to certain judicial exceptions from the statutory categories. These exceptions are a **law of nature**, a **natural phenomenon**, or an **abstract idea.** If the claim is *not* directed to one of the three judicial exceptions, it—again—qualifies as eligible subject matter under 35 USC 101. This can apply to software inventions when the software-based application improves computer operation, as it was ruled by the Federal Circuit in Enfish, LLC v. Microsoft, Inc.[150]. Hence, software methods are not always excluded categories of subject matter for patent protection.[151]

If the claim is directed to one of the three judicial exceptions, the second step determines whether the claim presents additional elements that amount to **significantly more** than the judicial exception in question. Software based inventions can also fall in the category of **abstract ideas**. Such are mental processes, mathematical concepts, or methods of organizing human activity. Revisiting judicial precedent, illustrates the categories that courts have determined for circumstances in which software inventions claimed an abstract idea but recited elements that amounted to significantly more than just an abstract idea (**inventive concept**).

In DDR Holdings v. Hotels.com, the Federal Circuit held that the claimed software invention must provide *improvements to the functioning of a computer*[152] if it is to qualify as significantly more than just an abstract idea.[153] In BASCOM Global Internet v. AT&T Mobility LLC., the Federal Circuit found a non-conventional and non-generic arrangement of various computer components for filtering Internet content to differ from the prior process confining the claim to a particular useful application,[154] qualifying the automated process as significantly more than just an abstract idea.

Patent claims for machine learning techniques

There are certain examples of patents filed in the US that illustrate that companies like Google have filed patent applications that attempt to protect inventions at the algorithmic level. Thus, these companies must have succeeded in claiming an **inventive concept**. Prominent examples are the deep learning techniques: *DQN*, *Batch Normalization*, and *Dropout*[155]. This was met with strong criticism, especially from the open source and machine learning developer community.[156] But there is also a geoeconomic dimension involved. If innovations at the algorithmic level, often referred to as **core AI**, are easier to be obtained with US patents, this could provide a locational advantage to the US innovation ecosystem.

How can it be assured that the patent claim for an invention on the algorithmic level recites to **significantly more** than just an abstract idea? Legal practice advises claimants to patent the string of phases that make-up the algorithm: "break down your software algorithm into a series of mathematical steps and procedures that mechanize a **process** (from the statutory categories listed in 35 USC 101), then the algorithm shifts from **abstract idea** into the patentable process category".[157]

Google was granted a patent for the dropout algorithm (either by claiming it as a process, or by successfully claiming elements that represent an inventive concept). The dropout technique assures the model's capability to generalize.[158] Without it, the model would also learn from noise in the training data which would undermine its performance on new data.[159] This claim to a central deep learning technique led to eyebrow-raising among developers in the open-source and AI community.[160] Another often cited example is the attempt of Amazon to patent their Alexa smart speaker algorithm. Its patent claim depicts the above-mentioned method of breaking down the algorithm into a string of procedures to receive patent protection for a software-based AI algorithm.[161]

While Google's patent is directed at a central deep learning technique, Amazon's patent lays claim to a procedure directly responsible for creating a revenue stream of the company. While both examples depict large multinational tech companies' activities in patenting AI software-based inventions, Google might never enforce its patent on dropout or similar foundational deep learning techniques in its patent portfolio—which is nevertheless raising strong suspicion among members of the developer community—,[162] while the enforcement of Amazon's patent specifically relating to its smart speaker Alexa (under trademark[163]) and providing a serious business case, seems more likely.

4.3. Annex 3: Deep Dive Training of ML Models on Copyrighted Data

The following sections will focus only on related EU and U.S. law.

4.3.1. The European Union—The Directive on Copyright in the Digital Single Market (EU) 2019/790

It is important to consider the Directive on Copyright in the Digital Single Market (DSM Directive) because it introduces exceptions for research organizations[164] to employ TDM techniques[165] "for the purpose of scientific research", Article 3 (1) DSM Directive.[166] Commercially funded research organizations or such that are skewed towards such entities, do not fall within the scope of this article.[167] The exception to use TDM is further extended to academic research conducted in public-private partnerships, where "(...) private partners are carrying out [TDM], including by using their technological tools.", Recital 11 DSM Directive.

Research organizations can employ text and data mining on copyrighted data
This must be interpreted in the light of Article 3 which means that the commercial partner should not be the beneficiary of the exception but the research organization in the partnership.[168] Therefore, the DSM Directive does only allow research organizations (and cultural heritage institutions) to employ TDM techniques without prior consent of the copyright owners. Private sector companies therefore are not entitled to benefit from the exception provided by Article 3 DSM Directive to employ TDM techniques.

Commercial entities and the application of TDM techniques
Article 4 (1) DSM Directive gives Member States the option to allow TDM techniques for any other user than just research organizations.[169] However, it is important to note that Article 4 (3) DSM Directive contains an **opt-out provision** that allows rights-owners to exclude commercial entities from TDM of their copyrighted works.[170] The only prerequisite is that rights owners have “expressly reserved their rights in an appropriate manner. The article goes on to specify that “machine-readable means” represent such an “appropriate manner”. Hence, copyright owners can very easily exclude commercial entities from TDM of their copyrighted works, for example by making use of machine-readable robots.txt files that define which parts of the domain can and cannot be accessed by bots.

As a result, Article 4 (3) DSM Directive perpetuates the legal position of copyright owners that exclusively commercialize TDM of their works, especially large print, and other media publishers[171].

The DSM Directive has enabled academic research institutions to employ TDM techniques, but the opt-out provision in Article 4 (3) will effectively shut-out commercial application of TDM by private sector companies. Although the opt-out provision may be aimed at tech multinationals to prevent them from further harvesting data and adding them to their already enormous data bases stemming from their consumer facing business models, this provision may cause collateral damage to the nascent European AI startup ecosystem that is effectively prohibited by the opt-out provision from web scraping copyrighted works and from using these data to train their proprietary ML models. This could constitute another tidal wave for the European AI industry in addition to the inability to train very large models because of the lack of big compute infrastructures already impeding European AI innovation capabilities in deep learning.

4.3.2. The United States—the Legal Doctrine of Fair Use

In the US, the issue of training AI systems on copyrighted works was stated in a USPTO issued request for comments (RFC) on the patentability of AI inventions.[172] Specifically, its third question was seeking comments on this exact problem.[173] The comments expressed a multitude of differing world views[174]—highly dependent, of course, on whether the commentators themselves held any copyrights. Thus, the baseline situation in the US is comparable to the one in the EU: whether commercial entities can train ML models on copyrighted works is an open and contested question.

In its report, that analyzed a multitude of differing comments to its RFC, the USPTO first establishes the ground truth: *"Copying substantial portions of expressive (copyrighted) works, even for non-expressive purposes implicates the reproduction right and, absent an applicable exception, is an act of copyright infringement".*[175] But TDM might be a scenario "*eligible for an exception to the reproduction right* [of copyright owners]".[176]

Hence, in the US, there is legal uncertainty as to whether commercial entities are indeed entitled to copy expressive works through TDM and whether they can then proceed by using the copied data for training ML models (without remunerating the rights owner). In a legal system that relies on case law, this situation is further convoluted in the absence of judicial precedent. To this date, no US court has yet tested digitization through web crawling and TDM for purposes of ML training, or the training of ML models with "already-digitized works".[177]

The exception to the reproduction right of copyright owners—fair use
To decide whether this would infringe copyright, US courts will need to determine whether a most important limitation on the exclusive right of copyright owners,[178] known as **fair use**, is applicable or not. "Fair use is a legal doctrine that promotes freedom of expression by permitting the unlicensed use of copyright-protected works in certain circumstances."[179] It requires courts to weigh four explicit statutory factors, specified in section 107 of the Copyright Act, 17 U.S.C. § 107.[180]

Participants contributing to the RFC largely opposed each other in their statements—depending on their status regarding copyright ownership[181]. Both fractions based their reasoning on hypothetically applicable legal precedent from well-known court cases such as *Authors Guild, Inc. v. Google, Inc.* ("Google Books" case) where the digital scanning of "tens of millions of books" without explicit permission of the authors' constituted non-infringing fair use or *Fox News Network, LLC v. TVEyes, Inc.*, where TVEyes used Fox's copyrighted content was not considered fair use.

It is important to differentiate between the different perspectives that argue in favor or against the application of the fair use principle. Commercial entities that have reached platform status will most likely have already gathered enormous amounts of data from their consumer facing business models that rely on the collection of user data. In the Case of Google, Google can additionally access its Google Books database for NLP purposes. It is therefore understandable that publishers argue against additional data harvesting of their copyrighted works, by tech multinationals as it is clearly expressed in the answer to the RFC by the NewsMedia Alliance[182].

Startups and their struggle for data

Although in the case of AI innovation, tech multinationals are not the only companies involved and therefore interested in data access and data usage for training purposes. Startups are an important driver of AI innovation, too. Contrary to big tech platforms, these companies do not hold vast amounts of data necessary to train their ML models. In contrast to SMEs, they do not even own industry specific data and therefore lack domain-specific knowledge.[183] Therefore, if they specialize in NLP or image recognition, deploying web scraping through TDM, or accessing large databases that hold photographs or video, is critical for being able to train their ML models. Therefore, a distinction among commercial entities should be made with regards to their access to critical AI resources, such as (training) data. Startups are commercial entities, but they operate on a vastly different economic scale than multinational tech companies.

Even more important than the argument that very large ML models that have ingested gigantic amounts of (copyrighted) data can be interpreted to be highly transformative in nature, even more transformative than the search function that is provided to the users of Google Books, is the fourth statutory feature: "*the effect of the use upon the potential market for or value of the copyrighted work*".[184] Employing TDM for training purposes requires making copies of expressive works.[185] But, training the ML model with these data does not reproduce the authors' copyright protected expression. The output that is generated by the ML model can be perceived to be a mere derivative from the individual works in the corpus. Consequently, in its answer to the RFC, OpenAI argues that the output of an NLP system might display similarities to the works in the corpus, but the ML models do not regenerate any individual work in the training corpus.[186] Therefore, their usage for training purpose do not negatively reduce the value of the copyrighted expression, the argument goes.

It is ultimately up to US courts to rule in favor or against this line of reasoning. Given the transformative capabilities of very large ML models, and given the possibility that the Google Books case might receive analogous adoption by US courts, there is more than a hypothetical chance that another locational advantage for U.S.-based companies might materialize, should US courts interpret the training of ML models by commercial entities on copyrighted data as fair use.

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81 Patent Protection on AI Inventions. Weiguo Chen & Yunlai Zha. 2021. https://www.natlawreview.com/article/patent-protection-ai-inventions.

82 Graphics processing units (GPU), tensor processing units (TPU), neural processing unit (NPU), cross-architecture processing units (xPU).

83 KI: Europa kann nicht mehr mitrechnen (translation: AI: Europe can no longer perform the calculations). Oliver Voß. 2022. https://background.tagesspiegel.de/digitalisierung/ki-europa-kann-nicht-mehr-mitrechnen. See already Philippe Lorenz and Kate Saslow: "As cutting-edge AI research is increasingly dependent on access to large amounts of compute, AI research is at a juncture–separating researchers that can access large compute infrastructures from those who cannot." in: Philippe Lorenz & Kate Saslow. 2019. Demystifying AI and AI Companies – What Foreign Policy Makers Need to Know About the Global AI Industry. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3589393, p. 16.

84 LEAM's mission statement and objectives read as follows: "To ensure that Europe stays competitive, we urgently have to invest in developing large AI models and AI supercomputers to train them. If we hesitate, we risk falling out of the fast AI innovation cycles. (...) Only with a strong AI ecosystem can we ensure the digital sovereignty of Europe." see: LEAM. 2021. LEAM - Large European AI Models. A European CERN for AI. https://leam.ai/.

85 Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. O'Keefe et al. 2021. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf, p. 7.

86 See Philippe Lorenz & Kate Saslow. 2019. Demystifying AI and AI Companies – What Foreign Policy Makers Need to Know About the Global AI Industry. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3589393, p. 9 et seq.

87 Such as for instance: "(...) geometric transformations, color space transformations, kernel filters, mixing images, random erasing, feature space augmentation, adversarial training, GAN-based augmentation, neural style transfer, and meta-learning schemes." See Connor Shorten & Taghi Khoshgoftaar. 2019. A survey on Image Data Augmentation for Deep Learning. https://journalofbigdata.springeropen.com/articles/10.1186/s40537-019-0197-0#Sec3.

88 How to Draft Patent Claims for Machine Learning Inventions. Michael Borella. 2018. https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html.

89 Big Data & Issues & Opportunities: Intellectual Property Rights. Debussche & César. 2019. https://www.twobirds.com/en/news/articles/2019/global/big-data-and-issues-and-opportunities-ip-rights.

90 Big Data & Issues & Opportunities: Intellectual Property Rights. Debussche & César. 2019. https://www.twobirds.com/en/news/articles/2019/global/big-data-and-issues-and-opportunities-ip-rights.

91 "spying, theft, or bribery": Debussche & César refer to the European Commission, 'Frequently Asked Questions: Protection against the Unlawful Acquisition of Undisclosed Know-how and Business Information (Trade Secrets)'. European Commission. 2016. https://ec.europa.eu/growth/industry/strategy/intellectual-property/trade-secrets/faq-protection-against-unlawful-acquisition-undisclosed-know-how-and-business-information-trade_en; Big Data & Issues & Opportunities: Intellectual Property Rights. Debussche & César. 2019. https://www.twobirds.com/en/news/articles/2019/global/big-data-and-issues-and-opportunities-ip-rights.

92 Big Data & Issues & Opportunities: Intellectual Property Rights. Debussche & César. 2019. https://www.twobirds.com/en/news/articles/2019/global/big-data-and-issues-and-opportunities-ip-rights.

93 How to Draft Patent Claims for Machine Learning Inventions. Michael Borella. 2018. https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html; Patenting Artificial Intelligence in the U.S. - Considerations for AI Companies. Morrison Foerster. 2018. https://www.mofo.com/resources/insights/181108-patenting-artificial-intelligence-us.html#_ftn2.

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95 How to Draft Patent Claims for Machine Learning Inventions. Michael Borella. 2018. https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html.

96 Deep Learning with Python. François Chollet. 2018. Shelter Island: Manning, p. 318.

97 How to Draft Patent Claims for Machine Learning Inventions. Michael Borella. 2018. https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html.

98 Deep Learning with Python. François Chollet. 2018. Shelter Island: Manning, p. 175 et seq, i.e., by superimposing the original output with a visualization of class activity through using a heatmap.

How to Draft Patent Claims for Machine Learning Inventions. Michael Borella. 2018. https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html.

99 Apart from pre-processing and post-processing, mapping represents another important step in the training of a model. For details, see Philippe Lorenz & Kate Saslow. 2019. Demystifying AI and AI Companies – What Foreign Policy Makers Need to Know About the Global AI Industry. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3589393, p. 6 et seq; How to Draft Patent Claims for Machine Learning Inventions. Michael Borella. 2018. https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html.

100 Demystifying AI and AI Companies – What Foreign Policy Makers Need to Know About the Global AI Industry. Philippe Lorenz & Kate Saslow. 2019. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3589393, p. 6 et seq.

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103 Deep Learning's diminishing returns. The cost of improvement is becoming unsustainable. Neil Thompson et al.. 2021. https://spectrum.ieee.org/deep-learning-computational-cost.

104 "This branch of machine learning [unsupervised learning] consists of finding interesting transformations of the input data without the help of any targets, for the purposes of data visualization, data compression, or data denoising, or to better understand the correlations present in the data at hand." François Chollet. 2018. Shelter Island: Manning, p. 94.

105 As the data set retrieved from Common Crawl and later pre-processed, was additionally expanded by adding two high-quality data sets that included a "WebText dataset [RWC+19], collected

by scraping links over a longer period of time, and first described in [KMH+20], two internet-based books corpora (Books1 and Books2) and English-language Wikipedia.", Language Models are Few-Shot Learners. Tom Brown et al.. 2020. https://arxiv.org/pdf/2005.14165.pdf, p. 6.

106 Language Models are Few-Shot Learners. Tom Brown et al.. 2020. https://arxiv.org/pdf/2005.14165.pdf.

107 Language Models are Few-Shot Learners. Tom Brown et al.. 2020. https://arxiv.org/pdf/2005.14165.pdf.

108 Demystifying AI and AI Companies – What Foreign Policy Makers Need to Know About the Global AI Industry. Philippe Lorenz & Kate Saslow. 2019. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3589393, p. 7.

109 In the case of GPT-3 even more than "over 8 million documents of text" on which its predecessor, GPT-2, was trained, see O'Keefe et al.. 2021. Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf, p. 2.

110 Although in the case of NLP, corpora such as Common Crawl, Wikipedia or WebText provide ML researchers a formidable resource. But the availability of sufficiently large audio, film, and image datasets are also crucial for the development of ML models outside of NLP.

111 In the case of the corpora, especially literary works and newspaper articles.

112 Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement on such data, and repealing Directive 95/46/EC (General Data Protection Regulation). European Parliament & Council of the European Union. 2016. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN.

113 Only scraping websites that have been curated or filtered by humans, for instance all outbound reddit links. See Alec Radford et al.. 2018. http://www.persagen.com/files/misc/radford2019language.pdf, p. 3. Note that OpenAI did not release the WebText corpus which sparked the developer community to reproduce it under the name of OpenWebTextCorpus. This database includes "40GB of text across 8,013,769 documents", see OpenWebText2. n.d.. WebText Background. https://openwebtext2.readthedocs.io/en/latest/background/.

114 "TDM, which is commonly understood to mean an automated process of selecting and analyzing large amounts of text or data resources for purposes such as identifying patterns or finding relationships.", see United States Patent and Trademark Office. 2020. Public Views on Artificial Intelligence and Intellectual Property Policy. https://www.dwt.com/-/media/files/blogs/artificial-intelligence-law-advisor/2021/09/uspto--ai-report--10-2020.pdf, p. 23, FN. 114.

115 Robots.txt. Ryte. 2021. https://en.ryte.com/wiki/Robots.txt.

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117 Defined in Article 2 (2) DSM Directive, see European Parliament & Council of the European Union. 2019. Directive (EU) 2019/790 of the European Parliament and of the Council of 17 April 2019 on copyright and related rights in the Digital Single Market and amending Directives 96/9/EC and 2001/29. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0790&from=EN.

118 Big Data & Issues & Opportunities: Intellectual Property Rights. Debussche & César. 2019. https://www.twobirds.com/en/news/articles/2019/global/big-data-and-issues-and-opportunities-ip-rights.

119 Big Data & Issues & Opportunities: Intellectual Property Rights. Debussche & César. 2019. https://www.twobirds.com/en/news/articles/2019/global/big-data-and-issues-and-opportunities-ip-rights.

120 Mining for exceptions in the new copyright directive. Olivia Mullooly & Colm Maguire, Arthur Cox. 2020. https://www.arthurcox.com/knowledge/mining-for-exceptions-in-the-new-copyright-directive/.

121 See for instance the Springer Nature provisions on "TDM for commercial research (Industry)", Text and Data Mining at Springer Nature. n.d.. https://www.springernature.com/gp/researchers/text-and-data-mining, or Elsevier's provisions on TDM: Elsevier Text and Data Mining (TDM) License. 2022. https://www.elsevier.com/about/policies/text-and-data-mining/elsevier-tdm-license.

122 Public Views on Artificial Intelligence and Intellectual Property Policy. United States Patent and Trademark Office. 2020. https://www.dwt.com/-/media/files/blogs/artificial-intelligence-law-advisor/2021/09/uspto--ai-report--10-2020.pdf, p. 25.

123 See the HISTORICAL AND REVISION NOTES HOUSE REPORT NO. 94–1476. House of Representatives. 1976. Copyright Law Revision. https://www.govinfo.gov/content/pkg/USCODE-2010-title17/pdf/USCODE-2010-title17-chap1-sec107.pdf.

124 Public Views on Artificial Intelligence and Intellectual Property Policy. United States Patent and Trademark Office. 2020. https://www.dwt.com/-/media/files/blogs/artificial-intelligence-law-advisor/2021/09/uspto--ai-report--10-2020.pdf, p. 24, FN. 117.

125 These are: "(1) the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes; (2) the nature of the copyrighted work; (3) the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and (4) the effect of the use upon the potential market for or value of the copyrighted work.", House of Representatives. 1976. Copyright Law Revision. https://www.govinfo.gov/content/pkg/USCODE-2010-title17/pdf/USCODE-2010-title17-chap1-sec107.pdf, p. 25.

126 Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation. United States Patent and Trademark Office, Department of Commerce. 2019. https://www.federalregister.gov/documents/2019/10/30/2019-23638/request-for-comments-on-intellectual-property-protection-for-artificial-intelligence-innovation.

127 Public Views on Artificial Intelligence and Intellectual Property Policy. United States Patent and Trademark Office. 2020. https://www.dwt.com/-/media/files/blogs/artificial-intelligence-law-advisor/2021/09/uspto--ai-report--10-2020.pdf, p. 23.

128 Public Views on Artificial Intelligence and Intellectual Property Policy. United States Patent and Trademark Office. 2020. https://www.dwt.com/-/media/files/blogs/artificial-intelligence-law-advisor/2021/09/uspto--ai-report--10-2020.pdf, p. 23, and FN 114.

129 For instance, the News Media Alliance arguing against the applicability of fair use, explicitly aimed against "Tech platforms that appropriate vast quantities of news content for this purpose should pay for the privilege of doing so (...)", see News Media Alliance. 2020. Re: Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation. http://www.newsmediaalliance.org/wp-content/uploads/2020/01/News-Media-Alliance-AI-Comments-with-USPTO.pdf, p. 5; while OpenAI, a leading AI research lab and inventor of a state of the art NLP-model "GPT-3", is actively arguing in favor of the applicability of the fair use principle, relying heavily on its interpretation of the Google Books case: "Prior cases have generally supported a finding of fair use for uses of large digital corpora that were less transformative than the training of AI systems. A fortiori, training AI systems should be considered fair use." "Perhaps the most compelling case on point is Authors Guild v. Google", see O'Keefe et al.. 2021. Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf. p. 8.

130 Re: Comments in Response to Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation, 84 Fed. Reg. 58,141 (Oct. 30, 2019). Jane Ginsburg et al.. 2020. https://www.uspto.gov/sites/default/files/documents/Kernochan%20Center%20for%20Law%2C%20Media%20and%20the%20Arts_RFC-84-FR-58141.pdf, p. 4.

131 Re: Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation. News Media Alliance. 2020. http://www.newsmediaalliance.org/wp-content/uploads/2020/01/News-Media-Alliance-AI-Comments-with-USPTO.pdf, p. 5.

132 Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. O'Keefe et al.. 2021. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf. Except for when it overfits, FN. 53.

133 Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. O'Keefe et al.. 2021. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf. Except for when it overfits, FN 53.

134 Commission Staff Working Document. Strategic dependencies and capacities. Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery. European Commission. 2021. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0352&from=FR.

135 See European Patent Office. 2021. Guidelines for Examination. https://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_ii_3_3.htm. "The exclusion applies if a claim is directed to a purely abstract mathematical method and the claim does not require any technical means". Artificial intelligence and machine learning are based on computational models (…). Such computational models and algorithms are per se of an abstract mathematical nature, irrespective of whether they can be "trained" based on training data. Hence, they are excluded from patentability according to Art. 52 (2)(a) and Art. 52(3)."

136 Cf. Guidelines for Examination. European Patent Office. 2021. https://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_ii_3_3.htm, G-VII, 5.4.

137 Cf. Guidelines for Examination. 3.3 Mathematical Methods. European Patent Office. 2021. https://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_ii_3_3.htm.

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139 For a critique of the Boards of Appeal's practice in relation to the patentability of mathematical methods, see Alexander Korenberg. 2021. Specifically ignoring efficiencies in AI?.

140 Cf. Guidelines for Examination. 3.3 Mathematical Methods. European Patent Office. 2021. https://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_ii_3_3.htm; Boards of Appeal Decisions T1227/05 (Circuit simulation I/Infineon Technologies) of 13.12.2006. European Patent Office. 2007. https://www.epo.org/law-practice/case-law-appeals/recent/t051227ep1.html, and T 1358/09 (Classification/BDGB ENTERPRISE SOFTWARE) of 21.11.2014. European Patent Office. 2015. http://www.epo.org/law-practice/case-law-appeals/recent/t091358eu1.html.

141 Guidelines for Examination. Technical applications. European Patent Office. 2021. https://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_ii_3_3.htm.

142 Guidelines for Examination. Technical applications. European Patent Office. 2021. https://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_ii_3_3.htm.

143 T 1358/09 (Classification/BDGB ENTERPRISE SOFTWARE) of 21.11.2014, 5.5. European Patent Office. 2015. https://www.epo.org/law-practice/case-law-appeals/recent/t091358eu1.html, referring to G 0003/08 (Computerprogramme) of 12.5.2010, 13.5 and 13.5.1. European Patent Office. 2018. https://www.epo.org/law-practice/case-law-appeals/recent/g080003dp1.html; Reinforcement Learning Using Pseudo-Counts. DeepMind Tech Ltd, Google Inc.. 2021. https://worldwide.espacenet.com/patent/search/family/058779356/publication/EP3459018B1?q=pn%3DEP3459018B1.

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148 35 U.S. Code § 101 - Inventions patentable. Legal Information Institute. Cornell Law School. https://www.law.cornell.edu/uscode/text/35/101.

149 Alice Corp. v. CLS Bank Int'l. 573 U.S. 208. Justia. 2014. https://supreme.justia.com/cases/federal/us/573/208/.

150 Enfish, LLC v. Microsoft Corp., No. 15-1244 (Fed. Cir. 2016). Justia. 2016. https://law.justia.com/cases/federal/appellate-courts/cafc/15-1244/15-1244-2016-05-12.html In McRO, Inc. v. Bandai Namco Games Am. Inc., 837 F.3d 1299, 1315, 120 USPQ2d 1091, 1102-03 (Fed. Cir. 2016) the claims to automatic lip synchronization and facial expression animation were directed to an improvement in computer-related technology and not directed to an abstract idea; In Visual Memory LLC v. NVIDIA Corp., 867 F.3d 1253,1259-60, 123 USPQ2d 1712, 1717 (Fed. Cir. 2017) the claims to an enhanced computer memory system were directed to an improvement in computer capabilities and not an abstract idea; Finjan Inc. v. Blue Coat Systems, Inc., 879 F.3d 1299, 125 USPQ2d 1282 (Fed. Cir. 2018) the claims to virus scanning were found to be an improvement in computer technology and not directed to an abstract idea; In SRI Int'l, Inc. v. Cisco Systems, Inc., 930 F.3d 1295, 1303 (Fed. Cir. 2019) claims to detecting suspicious activity by using network monitors and analyzing network packets were found to be an improvement in computer network technology and not directed to an abstract idea. For all, see The United States Patent and Trademark Office. 2020. 2106 Patent Subject Matter Eligibility [R-10.2019]. https://www.uspto.gov/web/offices/pac/mpep/s2106.html

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157 Can You Patent an Algorithm? Thomas Mon. n.d.. Goldstein Patent Law, https://goldsteinpatentlaw.com/can-you-patent-algorithm/.

158 "The fundamental goal of machine learning is to generalize beyond the examples in the training set.", see: Pedro Domingos. 2012. A Few Useful Things to Know about Machine Learning. https://homes.cs.washington.edu/~pedrod/papers/cacm12.pdf, p.80.

159 Overfitting and Underfitting With Machine Learning Algorithms. Jason Brownlee. 2016. https://machinelearningmastery.com/overfitting-and-underfitting-with-machine-learning-algorithms/; Deep Learning with Python. François Chollet. 2018. Shelter Island: Manning, p. 109 et seq, p. 216.

160 "Google's patent on Dropout just went active today". Discussion, 2019. https://www.reddit.com/r/MachineLearning/comments/c5mdm5/d_googles_patent_on_dropout_just_went_active_today/es352li/.

161 The claim reads as follows: "21. A computer-implemented method, comprising: receiving input audio data corresponding to a first utterance; performing speech recognition using the input audio data to determine first data; encoding the first data to generate first encoded data; receiving second encoded data corresponding to a previous utterance, the previous utterance being received prior to the first utterance; processing the first encoded data and the second encoded data using a model to determine model output data representing an understanding of the first utterance; and generating output data using the model output data." See: Amazon Technologies, Inc.. 2021. Speech Recognition Using Dialog History. https://appft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PG01&s1=amazon.AANM.&s2=conversational&OS=AANM%2Famazon+AND+conversational&RS=AANM%2Famazon+AND+conversational; Can You Patent an Algorithm? Thomas Mon. n.d.. Goldstein Patent Law, https://goldsteinpatentlaw.com/can-you-patent-algorithm/.

162 A Deal with the Devil? Insights on Google's AI Patents. Daeho Lee. 2018. https://piip.co.kr/en/blog/google-patents-open-source-software-1; and another Alphabet subsidiary, DeepMind, has similarly claimed patents on foundational deep learning techniques, see: Rose Hughes. 2018. DeepMind: First major AI patent filings revealed. https://ipkitten.blogspot.com/2018/06/deepmind-first-major-ai-patent-filings.html.

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164 Defined in Article 2 (1) DSM Directive, see European Parliament & Council of the European Union. 2019. Directive (EU) 2019/790 of the European Parliament and of the Council of 17 April 2019 on copyright and related rights in the Digital Single Market and amending Directives 96/9/EC and 2001/29. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0790&from=EN.

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171 See for instance the Springer Nature provisions on “TDM for commercial research (Industry)”, Text and Data Mining at Springer Nature. n.d.. https://www.springernature.com/gp/researchers/text-and-data-mining, or Elsevier’s provisions on TDM: Elsevier Text and Data Mining (TDM) License. 2022. https://www.elsevier.com/about/policies/text-and-data-mining/elsevier-tdm-license.

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178 See the HISTORICAL AND REVISION NOTES HOUSE REPORT NO. 94–1476. House of Representatives. 1976. Copyright Law Revision. https://www.govinfo.gov/content/pkg/USCODE-2010-title17/pdf/USCODE-2010-title17-chap1-sec107.pdf.

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180 These are: “(1) the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes; (2) the nature of the copyrighted work; (3) the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and (4) the effect of the use upon the potential market for or value of the copyrighted work.”, see: House of Representatives. 1976. Copyright Law Revision. https://www.govinfo.gov/content/pkg/USCODE-2010-title17/pdf/USCODE-2010-title17-chap1-sec107.pdf, p. 25.

181 For instance, the News Media Alliance arguing against the applicability of fair use, explicitly aimed against "Tech platforms that appropriate vast quantities of news content for this purpose should pay for the privilege of doing so (...)", see: News Media Alliance. 2020. Re: Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation. http://www.newsmediaalliance.org/wp-content/uploads/2020/01/News-Media-Alliance-AI-Comments-with-USPTO.pdf, p. 5; while OpenAI, a leading AI research lab and inventor of a state of the art NLP-model "GPT-3", is actively arguing in favor of the applicability of the fair use principle, relying heavily on its interpretation of the Google Books case: "Prior cases have generally supported a finding of fair use for uses of large digital corpora that were less transformative than the training of AI systems. A fortiori, training AI systems should be considered fair use." "Perhaps the most compelling case on point is Authors Guild v. Google", see: O'Keefe et al.. 2021. Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf. p. 8.

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183 See Philippe Lorenz & Kate Saslow. 2019. Demystifying AI and AI Companies – What Foreign Policy Makers Need to Know About the Global AI Industry. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3589393, p. 25 et seq.

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185 Re: Comments in Response to Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation, 84 Fed. Reg. 58,141 (Oct. 30, 2019). Jane Ginsburg et al.. 2020. https://www.uspto.gov/sites/default/files/documents/Kernochan%20Center%20for%20Law%2C%20Media%20and%20the%20Arts_RFC-84-FR-58141.pdf, p. 4.

186 Before the United States Patent and Trademark Office Department of Commerce. Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence. Docket No. PTO–C–2019–0038. Comment of OpenAI, LP. O'Keefe et al.. 2021. https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf. Except for when it overfits, FN. 53.

About the Stiftung Neue Verantwortung

The Stiftung Neue Verantwortung (SNV) is an independent, non-profit think tank working at the intersection of technology and society. The core method of SNV is collaborative policy development, involving experts from government, tech companies, civil society and academia to test and develop analyses with the aim of generating ideas on how governments can positively shape the technological transformation. To guarantee the independence of its work, the organization has adopted a concept of mixed funding sources that include foundations, public funds and corporate donations.

About the Author

Philippe Lorenz is Project Director of the AI Governance project at Stiftung Neue Verantwortung (SNV). In this project, he explores the development of the global regulatory framework for artificial intelligence (AI) technologies. In addition to the regulation of AI, he analyzes governance processes that are shaped by private-sector actors, and how these processes interact strongly with policymaking. These governance processes include technical standardization and patenting of AI technologies.

The AI Governance project developed out of the Artificial Intelligence and Foreign Policy project, a cooperation between the SNV, the Policy Planning Unit of the German Federal Foreign Office, and the Mercator Foundation, of which Philippe assumed responsibility in June of 2018. It focused on analyzing the geopolitical and geoeconomic implications of AI for German and European foreign policy. During the first phase of the project, Philippe's emphasis lay on contextualizing AI and how recent advances in the technology affect foreign policy, as well as explaining AI and AI companies through their access to necessary inputs (e.g. data, hardware, software and talent), and reviewing the international AI ethics debate.

Contact the Author:

Philippe Lorenz
plorenz@stiftung-nv.de
+49 (0)30 81 45 03 78 94
Twitter: @ph_lorenz

Imprint

Stiftung Neue Verantwortung e.V.
Beisheim Center
Berliner Freiheit 2
10785 Berlin

T: +49 (0) 30 81 45 03 78 80
F: +49 (0) 30 81 45 03 78 97

www.stiftung-nv.de
info@stiftung-nv.de

Design:
Make Studio
www.make-studio.net

Layout:
Alina Siebert