
TECHNOLOGY AND DIGITAL RIGHTS: AUTHORSHIP OF AI-GENERATED CONTENT, COPYRIGHT IN THE METAVERSE, AND LEGAL PROTECTION OF ALGORITHMS

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ABSTRACT

Intellectual property law is now under pressure due to the fast development of such phenomena as machine learning, blockchain-based assets, artificial intelligence, and metaverse. Non-Fungible Tokens (NFTs), digital exhaustion, avatar branding and digital identity, copyright in the metaverse, copyrightability and authorship of AI-generated works, and protection of AI algorithms and machine learning models are discussed in this paper.

The question of human authorship and determining whether prompting, selection, organization, editing, or altering qualifies as an adequate human creative contribution receives particular attention. Moreover, the dichotomy of digital asset ownership and IP ownership of those assets is analysed throughout the article, in relation to NFTs and virtual goods particularly.

The approaches of different countries regarding human authorship, copyright exceptions, digital ownership, liability, and technological protection of IP are exemplified through the discussion of the policies of the US, EU, UK, and India. Emerging policies in relation to AI training, transparency, licensing, platform liability, and international enforcement of IP rights are also touched upon in this paper.

It provides arguments on how new technologies do not necessarily mean new intellectual property laws, but that the current framework needs to become more technologically sophisticated and clearly defined. The paper proposes certain measures and interpretative guidelines in terms of human authorship, AI training, licensing, transparency, digital assets, and algorithmic protection in India.

Finally, the paper promotes an adaptive and technology-neutral framework for intellectual property laws, which could find a balance between innovation, author protection, digital ownership, and accessibility.

Keywords: Artificial Intelligence; Copyright; Metaverse; Non-Fungible Tokens; Digital Identity; Intellectual Property

INTRODUCTION

The process of creating, owning, and using creative works, digital assets, and technological innovations has changed significantly because of the rapid evolution of artificial intelligence, immersive virtual environments, blockchain technology, and machine learning. Technologies such as non-fungible tokens, algorithmic systems, generative artificial intelligence, and the metaverse have created a new form of digital ownership and creativity that does not fall within traditional intellectual property frameworks. Technological innovations have progressively challenged traditional understandings of concepts such as authorship, originality, ownership, exhaustion, and infringement.

Because AI technology can create text, photos, songs, software, and other kinds of creations with varying levels of human input, they create particular problems for copyright law, since the nature and extent of creative human contribution become important factors when assessing copyright eligibility of such creations. Similarly, the creation of the metaverse has resulted in the creation of virtual goods, environments, avatars, and digital brands whose legal status is very much unclear. The difference between ownership of a digital token and ownership of the underlying intellectual property rights becomes evident through the ownership of an NFT.

In addition, issues like digital fatigue, avatar branding, digital identity, and protection of AI algorithms and machine learning models have been raised in relation to these innovations. While existing copyright, patent, and trade secret laws provide some degree of protection, they can be difficult to apply in the context of rapidly evolving technological systems in terms of both practical and legal aspects. Given that digital assets and platforms function in various jurisdictions, cross-border digital transactions add an additional layer of difficulty.

Focusing on AI-generated content, the metaverse, NFTs, digital identity, exhaustion of rights, and algorithmic protection, this paper discusses the interplay between developing technologies and intellectual property law. By comparing legal systems of the United States, the European Union, the United Kingdom, and India, this paper attempts to identify specific areas in which legal clarification could be useful. Finally, the paper will examine how the intellectual property law could continue to be technology-adaptable while maintaining a proper balance between the relevant interests.

COPYRIGHTABILITY OF AI-GENERATED CONTENT: AUTHORSHIP

The creation of literary, artistic, musical, and audiovisual content has been transformed by generative artificial intelligence (AI). The fact that generative AI can create results without any considerable human input, unlike traditional computer-assisted creations, has raised the question regarding the protection of such AI-generated works and the issue of attribution of their authorship. Autonomous or semi-autonomous creation presents difficulties to be implemented into the existing legislation as the copyright system is mainly designed for human creativity¹.

Human intellectual and creative involvement has always been connected with copyright protection. Hence, the main problem with the AI-generated content is not only to determine whether the result is unique, but also to figure out who made the creative contribution connected to the output. It may be possible for the user to be considered the author in case of the selection, arrangement, editing, or alteration when AI works as a complex tool under substantial human guidance. However, the determination of the human contribution becomes more difficult when the output is mostly determined by the AI system².

It becomes especially problematic in case of the prompts. Even though the prompt may imply a lot of intellectual effort, the question here is whether this effort qualifies as the authorship of the resulting output. Giving a prompt does not automatically guarantee that there was sufficient creative control of the final product from the side of the user. In contrast, more connection between human creativity and the final product may be proven through multiple outputs, more prompting, editing, and organizing. Thus, the degree of human assistance may turn out to be more crucial than the human operator of the AI system.

The comparative approaches show that the different jurisdictions have failed to find a consensus on the issue. While the UK has a unique legal regime for some computer-generated works, the US has maintained the rule of the human authorship traditionally. Thus, the comparative approaches emphasize the contradiction between the maintenance of traditional

¹ Ruihan Sun & Shuhuan Zhou, How Much Human Contribution Is Needed for “Ownership” of AI-Generated Content: A Comparison of Copyright Determination for Generative AI in China and the United States, 29 J. World Intell. Prop. 257 (2026), <https://doi.org/10.1111/jwip.70011>.

² Ulaş Göker Bektaş, The Algorithmic Authorship Threshold: Identifying Human Contribution in AI-Assisted Creativity, 21 J. Intell. Prop. L. & Prac. 610 (2026), <https://doi.org/10.1093/jiplp/jpag078>.

human basis of the copyright and the need to modify it according to the technological progress. Therefore, the question is not only whether AI is capable of generating the content, but also what should be done to take the human involvement into account within the copyright law.

The Copyright Act of 1957³ in India does not include the special provisions to identify the author of the works created solely with the use of artificial intelligence. Since the current laws leave some room for interpretation in cases of creative expressions generated by artificial intelligence because they are based on the traditional concepts of authorship and ownership, it becomes evident that recent researches have emphasized the necessity to prove whether the current principles are able to cover AI-generated creativity or the special legislation or regulation is needed⁴.

Thus, the AI-generated content requires the distinction of works with the minimum human creative input from those assisted by AI. Although the denial of copyright protection to the AI-assisted works may ignore human creativity, the copyright system oriented only on the mechanical creation may undermine the traditional concept of the copyright. The search of the reasonable degree of human contribution that will provide authors with security and preserve the human-oriented nature of the copyright system becomes a new legal issue.

COPYRIGHT IN THE METAVERSE: EMERGING CHALLENGES AND LEGAL UNCERTAINTIES

The metaverse is an emerging digital ecosystem that facilitates exchanges of digital products and services, creation of virtual places, and interaction of users through avatars. The idea behind it is to create more permanent and immersive forms of digital connection compared to traditional internet platforms. Since virtual worlds contain copyrighted artworks, music, designs, software, virtual goods, and user-generated content, these technologies raise a number of important issues regarding intellectual property. Thus, it is important to consider the nature of ownership, reproduction, and communication in electronically-mediated spaces when applying current copyright notions to such contexts⁵.

³ Copyright Act, 1957, No. 14 of 1957 (India)

⁴ Shinu Vig, Intersection of Generative Artificial Intelligence and Copyright: An Indian Perspective, 17 J. Sci. & Tech. Pol'y Mgmt. 118 (2026), <https://doi.org/10.1108/JSTPM-08-2023-0145>.

⁵ Shinu Vig, Intellectual Property Rights and the Metaverse: An Indian Perspective, 25 J. World Intell. Prop. 753 (2022), <https://doi.org/10.1111/jwip.12249>.

The legal status of digital objects created or acquired in the metaverse is one of the major concerns. Even though virtual clothing, buildings, artworks, accessories, and other digital objects can be of considerable economic value, the ownership of a digital object does not necessarily imply ownership of intellectual property embodied in it. Therefore, when virtual goods copy or incorporate protected works, it becomes essential to distinguish the ownership of a digital object from the ownership of copyright. In this respect, purchasing a virtual item provides for a contractual/licensing rather than outright copyright interest⁶.

Unauthorized reproduction, display, distribution, or communication of protected works can lead to copyright infringement in the metaverse. For example, users might use protected artworks in virtual environments, post copyrighted photos or reproduce branded designs on avatars. Identifying whether these digital uses qualify for legally relevant acts of infringement and the liability for such infringements—the platform operator, the user, or some other intermediary—is a complicated issue. According to recent research, the issue of copyright and trademark enforcement in relation to user-generated content and digital wearables can be very serious in metaverse gaming platforms⁷.

Copyright limitations and exceptions is another vital issue. Traditional exceptions such as fair dealing and fair use were primarily designed in view of traditional methods of dissemination and reproduction. Their application to immersive virtual environments in the context of displaying, modifying, or incorporating protected works into interactive experiences might become difficult. With frequent creation and participation in three-dimensional digital environments, the issues of incidental inclusion, transformation, and freedom of panorama become increasingly important⁸.

Since the existing intellectual property laws were primarily drafted with traditional types of creative and commercial activities in mind, there is an additional level of uncertainty in the Indian context. While the Copyright Act of 1957 might protect original digital works, the issues

⁶ Philippe Jougoux, Intellectual Property in the Metaverse: When a Virtual Force Meets an Intangible Object, in *Real Rights in the Virtual World* 52, 52–69 (Riku Neuvonen & Jukka Viljanen eds., Edward Elgar Publ'g 2026), <https://doi.org/10.4337/9781035338856.00009>

⁷ Zoi Krokida & Ioanna Lapatoura, Enforcing Intellectual Property Rights in Metaverse Gaming Platforms: The Next Steps for the EU's Metaverse Agenda, *J. World Intell. Prop.* 1 (2026), <https://doi.org/10.1111/jwip.70022>

⁸ Dinusha Mendis & Tatsuhiro Ueno, “Mind the (Virtual) Gap”: A Critical Analysis of UK and Japanese Copyright Exceptions Relating to Immersive Environments and the Metaverse, 56 *IIC—Int'l Rev. Intell. Prop. & Competition L.* 1704 (2025), <https://doi.org/10.1007/s40319-025-01645-x>.

related to virtual property, platform-based ownership, avatars, and cross-border infringement are not sufficiently addressed. Therefore, it is important to analyse the ability of current principles to adequately regulate the novel forms of digital creation and exploitation at the rapidly developing pace of metaverse technologies.

Finally, the entirely new legal framework is not necessarily required for copyright protection in the metaverse. Regulation of virtual environment might rely on established principles of authorship, reproduction, communication, and licensing. However, their application has to take into account peculiarities of digital objects, user-generated content, and immersive technologies. Therefore, the coherent framework should clarify ownership, liability, licensing, and enforcement while providing appropriate balance between the freedoms of creation and participation in virtual environments and protection of rights owners.

NON-FUNGIBLE TOKENS (NFTs) AND INTELLECTUAL PROPERTY RIGHTS

With the use of blockchain technology, Non-Fungible Tokens (NFTs) created a novel way of transferring digital assets and attaching them to a particular token. In the case of digital artworks, music, collectibles, virtual items, and any other creative content, NFTs might be used. Nevertheless, it is essential to consider the legal relevance of the token itself and distinguish it from intellectual property rights of the underlying work. Thus, understanding the relationship between NFTs and IP law implies the consideration of this difference⁹.

The common assumption about purchasing NFT being equal to buying copyright of the underlying work represents a significant legal problem. Ownership of the token and copyright are, in theory, two different legal rights. The buyer of the token may receive only the token itself and not get the right to reproduce, distribute, change, and commercially exploit the underlying work, unless it was specially specified in the agreement. Thus, the determination of the transferred rights may depend on the wording of the marketplace agreement and smart contract¹⁰.

⁹ Jussi Kaisto, Timo Juutilainen & Joonas Kauranen, Non-Fungible Tokens, Tokenization, and Ownership, 54 *Comput. L. & Sec. Rev.* 105996 (2024), <https://doi.org/10.1016/j.clsr.2024.105996>

¹⁰ Corinne Tan, Rights in NFTs and the Flourishing of NFT Marketplaces, 32 *Int'l J.L. & Info. Tech.* eaae018 (2024), <https://doi.org/10.1093/ijlit/eaee018>

Another legal problem related to NFTs is the unauthorized minting of NFTs representing copyrighted materials. An NFT attached to an artwork might be created and sold despite the lack of the consent from the copyright holder. This behavior undermines the reproduction, public communication, licensing and accountability of NFT marketplaces. The analysis of the procedure may depend on whether it includes copying the work, distributing it publicly, or misusing rights reserved for the copyright holder. Thus, the use of the decentralized system does not eliminate the existing limitations of copyright law with regard to blockchain technology¹¹.

NFTs also create problems regarding the interaction between smart contracts and management of intellectual property rights. Despite the fact that smart contracts are capable of setting up the terms of transfer, royalties, licensing, or any other transactions, the technical nature of the process may sometimes fail to comply with copyright law. The blockchain record may serve as evidence of the transaction without the need to prove the transfer of copyright. Therefore, the rights of the buyer and the ongoing rights of the original copyright holder should be clearly defined in all contracts regarding the particular NFT¹².

The same kind of ambiguity is seen in the Indian legal system. Despite the fact that the qualified creative works are protected under the Copyright Act of 1957, there are no special provisions related to NFTs, tokenized assets, and blockchain intellectual property exchanges. The issues of NFT ownership, license, unauthorised minting, and buyer's rights are raised in recent Indian research. These questions become especially relevant when NFTs are applied to the sale of artistic creations and digital treasures.

Thus, NFTs should not be used as the substitute of the intellectual property rights. While the underlying copyright will depend on conventional rules of authorship, ownership, and licensing, its legal relevance lies in the possibility to record, authenticate, and facilitate transactions with digital assets. Thus, the logical approach will require greater transparency of intellectual property rights transferred through NFTs and clear separation of ownership of the token from the ownership of the underlying work.

¹¹ Andres Guadamuz, *The Treachery of Images: Non-Fungible Tokens and Copyright*, 16 J. Intell. Prop. L. & Prac. 1367 (2021), <https://doi.org/10.1093/jiplp/jpab152>.

¹² Amith Sriram K. S. & Valarmathi R., *Offering Copyright Protection for Non-Fungible Tokens in India: Legal Frameworks and Strategies*, 28 J. World Intell. Prop. 830 (2025), <https://doi.org/10.1111/jwip.12356>.

THE THEORY OF EXHAUSTION OF RIGHTS

The principle of exhaustion, which can also be known as first sale, constrains the power of an intellectual property rights holder after the authorized initial sale of a particular copy. After the lawful transaction, the purchaser often does not require any further permission from the copyright holder to use, sell, lend, or dispose of the physical copy. Thus, the idea of exhaustion tries to create a proper balance between the interests of the purchasers and those of copyright owners¹³.

However, in the digital environment, the application of the principle of exhaustion becomes much more complicated. Digital works can be easily transferred and perfectly replicated, unlike physical goods. Therefore, instead of simply transferring an existing copy, a digital resale might include the creation of a new one. The differences have led to the deterioration of traditional principles of first sale in the digital sphere where the copyright holders distribute the content through licenses, subscriptions, and technological means¹⁴.

In general, the US continues to make a distinction between digital replication and traditional first sale. The resale of a legally obtained digital music file on the internet platform was discussed in *Capitol Records, LLC v. ReDigi Inc.*¹⁵. The approach taken by the court has shown how difficult it becomes to use first sale doctrine in case of transferring a digital file because of reproduction. The question of whether technical reproduction prohibits the exercise of secondary market freedoms by consumers as in the case of physical copies is, therefore, basically raised in the digital world¹⁶.

The EU has taken a different position, especially concerning computer programs. In *Used Soft GmbH v. Oracle International Corp.*, the Court of Justice of the European Union recognised exhaustion where the copyright holder issued a license to use the software for an indefinite period in return for the price equal to the economic value of the copy. This judgment proved

¹³ Kanchana Kariyawasam & Royal Raj Subburaj, Importance of the Doctrine of Digital Exhaustion in Copyright Law, 33 Int'l J.L. & Info. Tech. eaaf009 (2025), <https://doi.org/10.1093/ijlit/eaaf009>.

¹⁴ Bronwyn E. Howell & Petrus H. Potgieter, The Exhaustion Principle in Copyright and Modern Digital Markets, 50 Telecommunications Pol'y 103276 (2026), <https://doi.org/10.1016/j.telpol.2026.103276>.

¹⁵ *Capitol Records, LLC v. ReDigi Inc.*, 910 F.3d 649 (2d Cir. 2018)

¹⁶ Luohaoran Zhu, The Vanishing Ownership: Reconstructing the First Sale Doctrine and Digital Exhaustion in the Age of Cloud Computing and NFTs, 1 Law, Econ. & Soc'y p58 (2025), <https://doi.org/10.30560/les.v1n2p58>.

that digital exhaustion could be possible in cases where the transaction is substantially similar to the sale¹⁷.

In terms of the Indian situation, there is additional ambiguity regarding digitally distributed software and other intangible works. The Copyright Act of 1957 does not provide a comprehensive legal framework for the issue of digital exhaustion, although including ideas about the ownership and distribution of copyrighted works. Due to the fact that many digital products are distributed under license agreements that do not allow resale and subsequent transfer, the distinction between ownership and licensing becomes extremely important¹⁸.

Thus, the idea of exhaustion remains important for determining the extent to which copyright is applicable to a work after its legal acquisition. The problem of reconciling the rights of copyright owners with the legitimate interests of consumers of ownership, resale, and perpetual usage becomes the main challenge in the digital economy. Differentiation between digital purchases and limited-term or subscription-based access may become necessary in order to solve technological difficulties and address secondary usage. The discussion shows that digital exhaustion impacts the issue of ownership, consumer freedom, and secondary markets operations in addition to copyright doctrine.

AVATAR BRANDING, DIGITAL IDENTITY, AND INTELLECTUAL PROPERTY

In virtual worlds, there has emerged a new aspect of the intellectual property in relation to identities and brands thanks to avatars. In the metaverse, the avatar becomes the digital representation of the individual and evolves into an important social and commercial identity. Although the company may use branded avatars to market the products and services, the users can customise the avatar with distinctive visual look, clothes, accessories and other virtual elements. This brings up the issue of how the names, pictures, designs, trademarks and other intellectual property in relation to digital identities can be protected¹⁹.

Avatar branding also creates a very strong connection between virtual commerce and trademark laws. Companies have been increasingly using trademarks in relation to the virtual

¹⁷ Simon Geiregat, Digital Exhaustion of Copyright After CJEU Judgment in Ranks and Vasiļevičs, 33 Comput. L. & Sec. Rev. 521 (2017), <https://doi.org/10.1016/j.clsr.2017.03.005>. □

¹⁸ Sayed Qudrat Hashimy, The Doctrine of Copyright Exhaustion in Software Under Indian Copyright Act: A cursory Glance, 4 Indian J.L. & Legal Rsch. 1 (2022), <https://doi.org/10.2139/ssrn.4138871>.

¹⁹ Ben Chester Cheong, Avatars in the Metaverse: Potential Legal Issues and Remedies, 3 Int'l Cybersecurity L. Rev. 467 (2022), <https://doi.org/10.1365/s43439-022-00056-9>.

accessories, avatar clothes, virtual objects and immersive commercial experiences. Therefore, the brand could be used simultaneously in real life and digital marketplaces. Determining if the current trademark laws can regulate the unauthorised use of the marks in the virtual environment has become complicated because the virtual object is distinct from the physical product, yet performs the same function²⁰.

Copyrights and design rights could also apply to the avatar design. The unauthorized use of the content may be important for intellectual property laws because the avatar may include distinct artistic elements, clothing designs, images and other types of protected material. However, the collaborative creation of the avatar by the users through the platform technology may create the issue of ownership and authorship. Therefore, the contributions of the users, the designers, the developers and the platform creators should all be considered when dealing with this type of content legally²¹.

Since the avatar might become closely associated with the user's identity and personality, digital identity becomes another layer of complexity. The unauthorized reproduction, impersonation or manipulation of the avatar may affect both intellectual property incorporated in the avatar and identity interests of the user. Nevertheless, sometimes the current legal system fails to recognize the avatar as a legal extension of the individual. It brings up the question of whether the avatar has the substantial market value or is strongly related to the user's identity.

The enforcement of the intellectual property rights becomes even more complicated because the virtual environment is often global and platform-based. The user who resides in one jurisdiction, the platform that operates in another and intellectual property located in the third jurisdiction may all be involved in the case of the infringement. Therefore, the determination of the applicable law, jurisdiction and platform liability becomes complicated. The challenges related to the protection of copyrights and trademarks from user-generated content and virtual products have recently been discussed in relation to metaverse platforms.

Therefore, avatar branding and digital identity demonstrate how the traditional concept of

²⁰ Woojung Jon & Sung-Pil Park, Comparative Analysis of Trademark Protection in the Metaverse and Registration of Virtual Goods and NFTs, 57 Comput. L. & Sec. Rev. 106137 (2025), <https://doi.org/10.1016/j.clsr.2025.106137>.

²¹ Karun Sanjaya & P.R.L. Rajavenkatesan, Intellectual Property Protection for Virtual Assets and Brands in the Metaverse: Issues and Challenges, 14 Int'l J. Intell. Prop. Mgmt. 527 (2024), <https://doi.org/10.1504/IJIPM.2024.142411>.

intellectual property gets extended into the more immersive digital spaces. The particularities of the avatars, virtual products and digital identities need to be considered when applying the current copyright, trademark and other relevant intellectual property laws. Therefore, protection of the avatar as a creative work, protection of the brand and protection of the person's digital identity need to be distinguished.

COMPARATIVE APPROACHES: UNITED STATES, EUROPEAN UNION, UNITED KINGDOM, AND INDIA

There have been different responses from major copyright jurisdictions to the fast development of digital assets, virtual environments, and artificial intelligence. Different approaches to regulating developing technology have been applied in the US, the EU, UK, and India based on their respective legal traditions. The EU has increasingly been relying on legislative acts, the UK has unique statutory provisions regarding computer-generated works, India has been relying on the technology-neutral copyright regime, and the US has been heavily relying on judicial interpretation and flexible copyright doctrines. Such differences demonstrate that copyright law does not possess a well-established approach to adaptation to technological developments²².

Copyright protection in the United States still relies on human authorship. The US approach uses judicial interpretation alongside constitutional and statutory criteria to determine the adequacy of reflection of human creativity in technologically-assisted works. Moreover, the US uses the flexible fair-use doctrine described in 17 U.S.C. § 107, which may be applied in relation to technological application of copyrighted material, for example, artificial intelligence training. The combination of human-authorship criteria and judicial flexibility allows the courts to solve new technology-related cases²³.

The EU has relied on a more organised legislative approach. With respect to Directive (EU) 2019/790, the EU copyright system has particular exemptions for text and data mining, and

²² Francesca Vessia, Cinema, AI and Copyright: Reflexion on the Copyrightability of AI-Assisted Works in the US, EU and Italy, and the Role of Terms of Use, 75 GRUR Int'l 622 (2026), <https://doi.org/10.1093/grurint/ikag050>.

²³ K. S. Amith Sriram, Copyright Facing the Challenges of Generative Artificial Intelligence: Judicial Practice and Legislative Strategies in India, the United States and the European Union, 3 J. Digit. Techs. & L. 598 (2025), <https://doi.org/10.21202/jdtl.2025.24>.

new regulations in the sphere of artificial intelligence impose additional requirements regarding transparency and copyright compliance. Thus, the EU approach to adaptation to technological development involves particular legal procedures and tries to balance technological innovation with copyright protection. At the same time, difficulties in regulating AI-generated outputs and new digital spaces are discussed²⁴.

The UK possesses a unique statutory approach because the Copyright, Designs and Patents Act of 1988 contains specific recognition of the notion of a computer-generated work. In accordance with Section 9(3), a person who made the arrangements for creation of the computer-generated literary, dramatic, musical, or artistic work is considered an author. The statutory approach in comparison to the human-authorship approach, which is more common for the US, provides a particular legal solution to a specific type of computer-generated content²⁵.

In India, there are no legal provisions that provide specific protection of generative AI, AI-generated works, and virtual assets. As a result, current copyright provisions still may be applied in connection with originality, authorship, infringement, and exceptions, but their adaptation to new technologies is ongoing. Difficulties with definition of AI-generated authorship and the lack of adaptability of the current fair-dealing provision in relation to new technologies such as generative AI and blockchain are discussed in Indian scholarship²⁶.

Comparison of the approaches demonstrates the use of various combinations of current copyright principles, judicial interpretation, and legislation to solve problems related to technological development. Whereas the US prioritizes judicial flexibility, the EU emphasizes comprehensive statutory regulation, the UK has a particular statutory provision regarding computer-generated works, and India relies mainly on the current copyright provisions in connection with new technologies. Such approaches demonstrate the necessity of further development of more specific legal principles in connection with rapidly evolving types of digital creation.

²⁴ Katharina de la Durantaye, Control and Compensation: A Comparative Analysis of Copyright Exceptions for Training Generative AI, 56 IIC—Int'l Rev. Intell. Prop. & Competition L. 737 (2025), <https://doi.org/10.1007/s40319-025-01569-6>.

²⁵ *Id*

²⁶ *Id*

PROTECTION OF AI ALGORITHMS AND MACHINE LEARNING MODELS

In the digital economy, machine learning (ML) models and artificial intelligence (AI) algorithms are important technological assets. A substantial investment of datasets, computing power, model architecture, training, and expertise is required for their development. However, algorithms perform mostly computational and functional tasks which makes the application of copyright law problematic as compared to traditional creative works. Therefore, it is important to analyse the legal protection of AI systems using intellectual property tools, namely trade secrets, patents, and copyright²⁷.

Copyright may provide protection of the expressional features related to an AI system, such as documentation, source code, and other distinctive literary works. However, the mere implementation of algorithm or mathematical approach through computer software does not mean that it is protected by copyright. The difference provides a boundary between the protection of expressional features and functional logic of an AI system. Hence, relying solely on copyright may make essential components of an AI model unprotected by traditional means.

Patent protection is another tool for protecting an invention when it meets the relevant requirements. However, considering that patent law usually distinguishes technical inventions from abstract concepts and mathematical approaches, algorithms and computing techniques may face restrictions. The character of the claimed invention and its contribution to the technological advancement are what matter. This distinction is particularly important in the jurisdictions where the eligibility for patent protection and inventorship requires human intervention²⁸.

Trade Secrets One of the most important ways of protecting ML models and AI algorithms is keeping them as a secret. Since they are not publicly disclosed, proprietary algorithms, model parameters, training methodologies, and private technical information retain their value. Unlike patents, trade secret protection does not require disclosing the protected information. However, for being effective, the owner should take the measures to ensure confidentiality and prevent

²⁷ Katarina Foss-Solbrekk, Three Routes to Protecting AI Systems and Their Algorithms Under IP Law: The Good, the Bad and the Ugly, 16 J. Intell. Prop. L. & Prac. 247 (2021), <https://doi.org/10.1093/jiplp/jpab033>.

²⁸ Tiyyaba Furqan, Hamda M. Aleissae, Nadirah Ghenimi & Alya A. Arabi, Global Laws Governing Intellectual Property Rights for AI-Generated Works, 6 Discover Artif. Intell. 449 (2026), <https://doi.org/10.1007/s44163-026-01165-8>.

unauthorized usage and disclosure²⁹.

Security becomes much more complex after training the ML model. The parameters of a trained model may include valuable commercial information and represent a significant investment into the data, architecture, and computation power. To prove the ownership and detect any infringement, recent research examines the technology-based solutions like watermarking, fingerprinting, and access control of the model. These solutions do not replace the traditional legal protection but complement it.

At present, AI algorithms and ML models are insufficiently protected in India by the contract and intellectual property law. The confidentiality of information can be ensured by contractual and trade secret principles, the patents may be eligible when the necessary legal conditions are fulfilled, and the expression of the qualified software may be protected by copyright. Also, recent research highlights the fact that the framework of trade secret protection in India continues to evolve in light of the threats posed by artificial intelligence³⁰.

An AI algorithm or ML model cannot be protected by a single instrument of intellectual property. The copyright for expressional features, patents for qualifying technical inventions, and trade secret or contractual methods for private technological information are required for comprehensive protection. A technology-neutral and flexible enough framework may ensure the protection of investments into AI without imposing unjustified monopolization of mathematical approaches, functional ideas, and underlying knowledge.

COMPARATIVE LEGAL ANALYSIS

As shown above, despite the different legal foundations, the USA, EU, UK, and India have the same intellectual property issues caused by artificial intelligence, digital assets, and virtual environments. The human authorship, copyright exceptions, digital ownership, accountability, and protection of technology developments are the key points in question. Thus, it is necessary to conduct a comparative analysis to understand how the current legal principles adjust to

²⁹ Jamshid Kazimi, *AI Algorithms and Trade Secrets: A Legal Exploration of Intellectual Property Rights*, 6 *Legal Issues in the Digital Age* 25 (2025), <https://doi.org/10.17323/2713-2749.2025.4.25.38>.

³⁰ Fathima Rena Abdulla & Niyati Nilesh Prabhu, *Balancing Trade Secret Protection and Public Interest in the Age of Artificial Intelligence: A Critique of India's Protection of Trade Secrets Bill, 2024*, 1 *J. World Intell. Prop.* 1 (2026), <https://doi.org/10.1111/jwip.70034>

technological developments without disregarding the key aims of copyright³¹.

In general, the United States applies judicial solutions to address technological challenges, paying a lot of attention to human creativity. Within its flexible fair use concept, courts are able to consider the aspects like the purpose, nature, quantity, and market effect of the technological application. Although the issues of the AI training and generated outputs are associated with unanswered questions of replication, transformation, and market replacement, this flexibility has allowed copyright law to address the developing technology in litigation³².

The legislative approach in the European Union is structured to some extent. The copyright framework contains specific text-and data-mining exceptions, and the additional transparency and compliance measures are introduced with the help of the bigger artificial intelligence legal framework. Although compared to the judicial paradigm, it provides more legislative guidance, it reveals the problem of defining the exceptions which could cover quickly developing technological practices. As a result, the EU framework uses specific legislative solutions to strike the balance between technology development and copyright protection³³.

Due to the specific clause relating to the computer-generated works in its Copyright, Designs and Patents Act 1988, the United Kingdom has the unique position. At the same time, the modern issues of the AI training, infringement, and the generated outputs should be addressed by the UK copyright legislation. It creates the interesting combination of the well-developed framework for the computer-generated works and the unclear issues of applying traditional copyright to the contemporary generative AI systems.

India provides quite a new framework. Despite the provision of the Copyright Act of 1957, which is able to cover the technologically assisted or computer-generated works, the legislative framework specifically designed for generative AI, NFTs, metaverse assets, and AI training is not provided. Additionally, the Indian fair dealing framework is more developed than the flexible fair use concept in the United States. Therefore, both AI-generated outputs and the use of copyrighted material for the AI training are questionable according to the recent comparative

³¹ *Id*

³² *Id*

³³ Eleonora Rosati, *Infringing AI: Liability for AI-Generated Outputs Under International, EU, and UK Copyright Law*, 16 Eur. J. Risk Regul. 603 (2025), <https://doi.org/10.1017/err.2024.72>.

analysis³⁴.

The relationship between copyright and developing technologies has not been sufficiently addressed by any jurisdiction in the more comprehensive comparison. While the United Kingdom has its unique statutory solution for the computer-generated works, the EU relies on the legislative exceptions and regulatory obligations, the United States provides the flexibility in judicial solutions, and India is currently developing its reaction within the existing copyright framework. All these differences indicate that instead of addressing AI, digital assets, and virtual environments as separate legal challenges, the future regulation should cover the entire technical life cycle of the technology including the invention, training, distribution, ownership, and economic exploitation.

EMERGING POLICY CHALLENGES

Significant gaps in the current intellectual property regimes have emerged in light of the rapid growth of virtual worlds, blockchain-based digital assets, and artificial intelligence. Copyright regimes' key characteristics included identifiable human authors, traditional means of distribution, and relatively stable artistic expressions. However, the metaverse and NFTs introduce novel ways of digital ownership and exploitation, while generative AI generates content on large scales. As a result, the concepts of authorship, ownership, infringement, liability, and enforcement remain unclear due to these advancements.

The use of copyrighted works for the training purposes represents one of the core policy concerns. Generative AI models might require tremendous amounts of textual, visual, musical, and other creative contents during their training phase. In this way, the interests of copyright holders collide with the necessity of access to big datasets from the side of technology. Consequently, policymakers must decide whether the current copyright exceptions are sufficient, whether new licensing regimes must be developed, and how authors can exercise control over the usage of their works. Due to the size of training datasets, recent studies emphasize the practical and financial difficulties associated with the necessity to conduct individual negotiations between AI developers and copyright holders.

³⁴ Anna Bashir, Prospects and Challenges of Artificial Intelligence Protection in Indian IPR Regime Vis-à-Vis EU, China and the US, 30 J. Intell. Prop. Rts. 65 (2025), <https://doi.org/10.56042/jipr.v30i1.7403>.

The division of liability along the AI value chain represents another issue. Developers, model providers, users, data generators, and platforms represent some of the actors who participate in the process of working with generative AI. Thus, copyright disputes can arise on the different stages, including the training, storing and distributing the models, and producing and distributing the outputs. When complex interactions between training data, design of the model, and user instructions result in the generation of the infringed work, it becomes particularly complicated to attribute the liability to the relevant actor. In this way, these stages represent the distinct zones of emerging copyright liability, according to the recent European research.

Transparency represents another important policy issue. Users and copyright holders face the difficulties in comprehending the inner work of many generative AI systems, which makes it problematic to identify what content has been used during the training or why a certain output resembles an existing work. The ability of the creators to prove the infringement and obtain the corresponding remedies may be impacted by the lack of transparency. Transparency requirements should be balanced with the justified concerns about the protection of proprietary technological data and valuable AI models.

Moreover, additional policy issues related to the digital ownership and enforcement arise in light of the metaverse and NFTs. Although the transfer of an NFT is usually not accompanied by the transfer of copyright in the underlying work, virtual assets can incorporate copyrighted works, trademarks, designs, and other types of protected objects. Cross-border transactions and platform-based virtual environments complicate the jurisdiction, applicable law, and enforcement of copyrights. These issues demonstrate that the ownership of a token, ownership of a digital asset, and ownership of the underlying intellectual property must be better differentiated in digital ownership.

These questions are particularly important for India since the topics of generative AI, AI training, NFTs, and virtual environments are currently underregulated by the existing copyright regime. While pointing out the need for legislation that protects the interests of creators without hindering technological innovations, recent academic analysis of the Indian context reveals the open questions regarding the AI-generated works and adequacy of the current copyright regime.

Thus, the development of a legal framework that will facilitate technological innovation while

ensuring the protection of genuine intellectual property rights has become an increasingly pressing policy issue. Human authorship, AI training, transparency, credit, liability, digital ownership, and cross-border enforcement should be considered in an integrated way within such a framework. Intellectual property laws should cover the whole lifecycle of digital innovations and exploitation, rather than treating every particular technology separately. This approach will allow keeping the proper balance of intellectual property law, including innovation, protection of creators, and public accessibility.

RECOMMENDATIONS

The emergence of machine learning systems, metaverse platforms, generative AI, and NFTs highlights the fact that the law of intellectual property needs to adapt but not at the expense of undermining its core principles. It is necessary that the current regime does not develop an entire distinct copyright regime for each of the emerging technologies. On the contrary, it should modify and define the current principles in order to address issues related to authorship, ownership, infringement, licensing, and enforcement. A technology-neutral regime will bring more legal clarity and will be flexible enough to accommodate future innovations³⁵.

First, the current copyright law should introduce some additional clarity related to human intervention in AI-assisted works.. Protection should no longer rely solely on the presence of human input in terms of suggesting a certain topic to the AI system. It is possible to retain the requirement of significant human innovation but in situations where the end product reflects human innovation, significant human selection, arrangement, modification, or creation, then copyright protection can also be justified. This way one can distinguish outputs generated without any human involvement and those generated through AI assistance.

Second, there should be some clear structure of AI training licensing introduced. Given the fact that it is not always possible to acquire individual consent from each of the copyright owners, the wide-spread use of copyrighted works for training purposes creates many practical difficulties. Through structured licensing, which includes collective licensing and appropriate remuneration mechanisms, the works used in training can become legally accessible to the

³⁵ Orit Fischman-Afori, *Generative AI Art and Copyright Governance: Rethinking the Adaptation Right and Its Limits*, 13 *Humanities & Soc. Scis. Commc'ns* 1469 (2026), <https://doi.org/10.1057/s41599-026-07311-y>

public and authors can be compensated. In addition to that, such a structure should guarantee that licensing requirements will not unduly hamper research and innovation and acknowledge legitimate exceptions³⁶.

Third, transparency obligations should be one of the fundamental aspects of any AI regulation. Taking into account reasonable confidentiality and security considerations, developers of AI technologies should maintain proper documentation of training datasets and provide copyright owners with sufficient information on how their works were used. Machine-readable tools for expressing copyright reservations or opting out would simplify managing permissions at large scale for authors and AI developers. Recently openness and machine readability have been pointed out in comparative policy discussions as means for facilitating licensing.

Fourth, the boundary between ownership of digital assets and intellectual property should be clearly defined by the law. Purchasing or transferring an NFT does not automatically mean that the copyright of the underlying work was transferred. Therefore, NFT marketplaces and digital platforms should clarify what specific rights, including reproduction, commercial exploitation, modification and reselling rights were transferred to the buyer. This would eliminate the ambiguity and prevent customers from mistakenly assuming that having a token means owning the underlying copyright.

Fifth, the accountability along the AI value chain should be shared depending on roles and power of different participants. Differentially developers, model providers, users, and platforms influence the generation or distribution of potentially infringing content. That is why instead of giving equal obligations to all the parties involved, it is important to apply a differentiated liability approach. Recent research demonstrates that output generation, model storage and distribution and training are separate steps that create separate copyright issues³⁷.

Lastly, the layered approach should be applied to protect AI algorithms and machine learning models. Algorithms, model parameters, and training methodologies should be adequately protected through trade secret and contractual provisions,; qualifying expressive elements

³⁶ Saliltorn Thongmeensuk, Rethinking Copyright Exceptions in the Era of Generative AI: Balancing Innovation and Intellectual Property Protection, 27 J. World Intell. Prop. 278 (2024), <https://doi.org/10.1111/jwip.12301>.

³⁷ Antoni Rubí-Puig, Generative AI and Liability for Copyright Infringement Under EU Law: State of Play and Emerging Issues, 2 Cambridge F. on AI: L. & Governance e11 (2026), <https://doi.org/10.1017/cfl.2026.10059>.

should be protected by copyright and patent protection should remain available for inventions satisfying statutory requirements of technical inventions. Such an approach will allow protecting technical investments without unduly creating monopolies over abstract ideas and mathematical formulas³⁸.

Therefore, instead of adopting a completely new AI copyright law, it is worth considering the adoption of specific amendments or interpretive guidance within the existing intellectual property regime of India. The objective is to provide certainty related to human authorship, AI training, licensing, transparency, digital assets and algorithmic protection while preserving technical innovation and public access. The Indian copyright law will be able to adapt to the new digital technologies and preserve core principles of IP protection through a balanced approach³⁹.

CONCLUSION

Ambiguities of the standard intellectual property rights framework have been uncovered as a result of the emergence of machine learning, NFTs, artificial intelligence, and the metaverse. Those new technologies cast doubt upon established notions of human authorship, originality, ownership, infringement, exhaustion, and protection of innovations and technological breakthroughs. Especially, AI-generated works reveal how complicated it is to use traditional copyright principles in case there are various levels of human and machine involvement leading to the creation of something creative.

Digital asset ownership does not necessarily mean intellectual property rights to whatever is stored in that asset, which is confirmed once again by the legal issues associated with the metaverse and NFTs. Along with that, there should be given much consideration to the relationships between personality, trademarks, copyright, and virtual commercial activity in relation to avatar branding and digital persona. Comprehensive knowledge of copyright, patents, trade secrets, and contractual approaches is required to protect AI algorithms and machine learning models.

³⁸ *Id*

³⁹ *Id*

Comparison of the United States, the European Union, the United Kingdom, and India reveals that different jurisdictions are using different approaches to solve those problems arising from the evolution of emerging technologies, but none of them have managed to cope with the challenges caused by rapidly developing technologies. While the existing framework of intellectual property rights might serve as a good foundation for India, it lacks clarity in human input, AI training, digital assets' ownership, licensing, platform liability, and algorithm protection.

In conclusion, while different regimes need to be constructed for each new technology, the future development of intellectual property law should focus on developing flexible and technology-neutral approaches that can be adapted to time. Both technological innovation and interests of creators, businesses, consumers, and the society at large can be combined with the help of better legislation, interpretation rules, licensing processes, and international cooperation. Hence, the flexibility and balance of intellectual property law in the constantly growing digital economy will need to be ensured.