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## ARTICLE

# STREET AND GRAFFITI ART BETWEEN AUGMENTED REALITY AND ARTIFICIAL INTELLIGENCE: A COPYRIGHT PERSPECTIVE

ENRICO BONADIO\* & SIRI-HELEN EGELAND

### I. INTRODUCTION

The street art and graffiti scenes are under the influence of constantly developing technologies such as augmented reality (AR) and artificial intelligence (AI). This interaction between AR and AI on the one hand and street art and graffiti on the other can materialize in several ways. Section 1 evaluates how artists themselves can use these technologies to enhance or modify their works, but more often the interaction happens because others find street art and graffiti to be interesting forms of input data or backdrops for digital creations. Section 2 investigates the developments in AR and AI and their intersection with street and graffiti art, and Section 3 includes current examples of such technologies being applied to street and graffiti art. The examples are selected based on their relevance to the street art and graffiti scene so that the reader can have the necessary background. These

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His current research agenda focuses on copyright protection of non-conventional forms of creativity, amongst other areas. He recently edited the “Cambridge Handbook of Copyright in Street Art and Graffiti” (Cambridge University Press, 2019) and “Non-Conventional Copyright – Do New and Atypical Works Deserve Protection?” (Elgar, 2018). He is currently finalising his monograph “Copyright in the Street: An Oral History of Creative Processes in the Street Art and Graffiti Sub-Cultures” (CUP forthcoming, 2023). Enrico is a Member of the Editorial Board of the NUART Journal, which publishes provocative and critical writings on a range of topics relating to street art practice and urban art cultures.

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two sections set the stage for the discussions that follow but are not meant to give an exhaustive description of AR or AI technologies. There are indeed numerous other examples of them, but for the sake of brevity, they have not been highlighted here. Sections 4 and 5 then deal with general copyright and moral rights issues arising from the encounter between these forms of art and AR and AI, while Section 6 focuses on whether works derived from street and graffiti pieces by using AR and AI may be protected by copyright. Section 7 describes the conclusions for what this means going forward. As the subject covered in this article has not been well researched thus far and, to the best of our knowledge, no case has been decided that touches on these aspects, there is some speculation on how judges may face such issues. In addition, as the technologies are still developing, there is also speculation on how AR and AI could impact the development of street art and graffiti.

The terms street art and graffiti are sometimes used in this paper interchangeably, even though they are different creative subcultures. *Graffiti* is the name used to define a technique of painting names and letters on various urban surfaces,<sup>1</sup> such as tube and railway trains as well as walls. The term *street art* is instead used to refer to more elaborate forms of art, which have evolved from the early graffiti movement and focus on images rather than letters.<sup>2</sup> Street artists may nowadays use a variety of tools to paint and draw: not only spray cans, but also traditional instruments such as brushes, rollers, and palettes as well as marker pens, chalks, and charcoal. Ways of placing art in the street may also take forms different from painting, such as urban knitting, attaching mosaic tiles, stickers, posters, and cutouts, as well as abandoning artworks.

## II. AUGMENTED REALITY AND ARTIFICIAL INTELLIGENCE AND THEIR RELEVANCE TO STREET ART

AR and AI are technologies that rely on data processing, where existing data is used to either adapt or create output. Data processing can be defined as: “manipulation of data by a computer. It includes the conversion of raw data to machine-readable form, flow of data through the CPU and memory to output devices, and formatting or transformation of output.”<sup>3</sup>

Augmented reality is a form of data processing technology that uses different applications to add virtual information or digital layers to the real

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1. The word “graffiti” comes from the Italian verb *graffiare*, which means *to scratch* (the Italian word deriving in turn from the ancient Greek verb *grafein*, which means *to write*).

2. Enrico Bonadio, *Street Art, Graffiti and Copyright: A US Perspective*, in *THE CAMBRIDGE HANDBOOK OF COPYRIGHT IN STREET ART AND GRAFFITI* 105, 106 (Enrico Bonadio ed., Cambridge Univ. Press 2019).

3. The Editors of Encyclopedia Britannica, *Data Processing*, in *ENCYCLOPEDIA BRITANNICA*, <https://www.britannica.com/technology/data-processing>.

physical world in real-time.<sup>4</sup> In a commonly accepted definition,<sup>5</sup> Ron T. Azuma, a renowned American computer scientist and expert on AR technology, describes the characteristics of an AR system as “1. Combines real and virtual; 2. Is interactive in real time; 3. Is registered in three dimensions.”<sup>6</sup> Azuma’s definition is not limited to a specific type of technology or medium. AR technology is applied across different mediums, apps, and sectors. The most common form of accessing augmented reality is through apps on handheld smartphones, but other gadgets also exist, such as smartglasses, where the augment is visible directly through the eyeglass. Google, for example, has a range of smartglasses aimed at enterprises.<sup>7</sup> In September 2021, the social media giant Facebook also launched smartglasses that seem to be aimed at consumers.<sup>8</sup> One common feature of all augmented reality software available through apps, etc. is that the software uses the smartphone’s or the smartglasses’s camera to mix reality with virtual content. This also means that visual representations are being made by users’ cameras in real-time.

Augmentation of reality through adding virtual layers of digital information can be tied to a specific geographical site by geotagging<sup>9</sup> or other forms of geographical information, but AR technology can also be used without such site-specific ties.<sup>10</sup> The site-specific tie can also be a form of cue that activates a response from the AR platform—for example, where holding a smartphone over a specific mural activates a digital layer in users’ AR app. Both site- and non-site-specific versions of AR are relevant when discussing street art and graffiti. The site-specific version is relevant because these art forms, in their original form, are tied to specific geographical locations, namely the streets. Virtual graffiti is also created with specific

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4. According to a EUIPO Tech Watch discussion paper, augmented reality is “[d]ata processing technology that applies different gadgets to add virtual elements to the physical world.” THE EURO. OBSERVATORY ON INFRINGEMENTS OF INTEL. PROP. RTS., EUIPO, INTELLECTUAL PROPERTY INFRINGEMENT AND ENFORCEMENT TECH WATCH DISCUSSION PAPER, 10 (2020), [https://euiipo.europa.eu/tunnel-web/secure/webdav/guest/document\\_library/observatory/documents/reports/2020\\_Tech\\_Watch\\_paper/2020\\_IP\\_Infringement\\_and\\_Enforcement\\_Tech\\_Watch\\_Discussion\\_Paper\\_Full\\_EN.pdf](https://euiipo.europa.eu/tunnel-web/secure/webdav/guest/document_library/observatory/documents/reports/2020_Tech_Watch_paper/2020_IP_Infringement_and_Enforcement_Tech_Watch_Discussion_Paper_Full_EN.pdf).

5. See Mark Billinghurst, Adrian Clark & Gun Lee, *A Survey of Augmented Reality*, 8 FOUNDATIONS AND TRENDS® IN HUMAN-COMPUTER INTERACTION, No. 2-3, 73, 77 (2015).

6. See Ronald T. Azuma, *A Survey of Augmented Reality*, 6 PRESENCE: TELEOPERATORS & VIRTUAL ENVIRONMENTS 355, 356 (1997).

7. See Google Glass Homepage, GOOGLE, <https://www.google.com/glass/start> (last visited Dec. 2, 2021).

8. See Elizabeth Culliford, *Facebook Unveils its First Smart Glasses*, REUTERS (Sept. 10, 2021, 1:51 AM), <https://www.reuters.com/technology/facebook-unveils-its-first-smart-glasses-2021-09-09>.

9. “Geotagging is the process of adding metadata that contains geographical information about a location to a digital map.” Justin Stoltzfus, *Geotagging*, TECHOPEDIA.COM, <https://www.techopedia.com/definition/86/geotagging> (last updated July 7, 2021).

10. The distinction between site-specific and non-site-specific AR is adopted from Declan T. Conroy, *Property Rights in Augmented Reality*, 24 MICH. TELECOMM. & TECH. L. REV. 17, 18 (2017), <https://repository.law.umich.edu/mttlr/vol24/iss1/2>.

geographical information added to the image to allow others to find it: for instance, using the Mark App.<sup>11</sup> In this app, users can create virtual graffiti added to a real physical wall of their choice as a digital layer existing within the software. The graffiti can then be found by others through the app.<sup>12</sup> The non-site-specific version of augmented reality, i.e., the version existing separate from any specific physical location, has been widely used in education.<sup>13</sup> This form of AR may become ever more relevant for street artists who can use it to create derivative digital art that is not connected to a specific location. Many street artists already sell prints of their street pieces, and AR might be another way street artists can reimagine and make use of their art if they so wish. Examples include the creation and sale of digital pieces in the specific graffiti art style of the artist, or of derivative works based on their existing murals, that users can display in their own homes through augmented reality software.

What about AI? This technology is defined as: “the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.”<sup>14</sup> One of its forms is machine learning. Here, the machine is enabled to learn, and algorithms are trained through existing data to make progress.<sup>15</sup> One subtype of machine learning technology is neural networks.<sup>16</sup> These networks are inspired by how biological neurons in the human brain function with hierarchical layers of cells.<sup>17</sup> Deep learning is another subtype of machine learning. “Deep” refers to multilayers of cells in neural networks being involved,<sup>18</sup> allowing such machines to be able to process large datasets with progressive complexity. Deep learning algorithms have been used to create art, one notable example being the project known as “The Next Rembrandt.”<sup>19</sup> Here, the algorithms were used to achieve a new masterpiece in the exact style of the Dutch maestro, based

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11. See MARK App Homepage, MARK – THE AR SOCIAL NETWORK, <https://www.mark.app/pc/index.html> (last visited Dec. 2, 2021).

12. See *id.*

13. One example of this is the Spanish company Arloon. This company creates AR for educational purposes across a wide range of disciplines. ARLOON, <http://www.arloon.com> (last visited Dec. 2, 2021).

14. See B.J. Copeland, *Artificial Intelligence*, in ENCYCLOPEDIA BRITANNICA, <https://www.britannica.com/technology/artificial-intelligence> (last visited Mar. 17, 2022).

15. See TOM MITCHELL, MACHINE LEARNING (1997).

16. The first artificial neuron was proposed in 1943 by Warren S. McCulloch and Walter Pitts. See Warren S. McCulloch & Walter Pitts, *A Logical Calculus of the Ideas Immanent in Nervous Activity*, 52 THE BULL. OF MATHEMATICAL BIOPHYSICS 99, 99 (1990).

17. See STEVEN L. BRUNTON & J. NATHAN KUTZ, *Neural Networks and Deep Learning*, in DATA-DRIVEN SCIENCE AND ENGINEERING 226, 227 (Cambridge Univ. Press 2019), <https://www.researchgate.net/publication/331229703>.

18. See *id.* at 228, 246–47.

19. ING Group, a Dutch financial institution, is the presenting partner for the project. See more on how deep learning algorithms and facial recognition technology were used in the video on the homepage for the Next Rembrandt Project. THE NEXT REMBRANDT, <https://www.nextrembrandt.com> (last visited Dec. 2, 2021).

upon data from his original works. The new AI-created painting was 3D printed using paint onto canvas to create a realistic physical version. It is not hard to imagine the same technology being used to create new street art pieces and murals in the artist's exact style.

Another type of machine learning technology that uses neural networks and deep learning is the generative adversarial network (GAN).<sup>20</sup> GANs consist of two networks working together to create novel outputs. In the training process, the two networks are trained simultaneously, and "one network generates candidates and the other evaluates them."<sup>21</sup> This cooperation or competition between the networks gives rise to an ever-evolving complexity of the output. One subtype of GAN is StyleGAN, which can generate convincing novel images based on existing styles.<sup>22</sup> It was originally introduced in 2018, and generated new high-quality images based on a dataset of existing human faces.<sup>23</sup> StyleGAN can also be used for creating new artworks and has already been applied to street art. The StyleGAN network GANKsy has been trained on the portfolio of renowned street artist Banksy and creates Banksy-style images based on this dataset that are then sold in an online gallery.<sup>24</sup>

In the rapidly changing world of AI art, new tools and combinations emerge constantly. For example, in January 2021, Open AI, a research and deployment company, introduced a new neural network named CLIP ("Contrastive Language-Image Pre-Training").<sup>25</sup> This neural network "learns visual concepts from natural language supervision"<sup>26</sup> and is trained on a "dataset of 400 million image and text pairs collected from the internet."<sup>27</sup> In March 2021, CLIP was connected with another AI network named VQ-GAN,<sup>28</sup> and a new image generator was created.<sup>29</sup> VQ-GAN is

20. See Ian J. Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville & Yoshua Bengio, *Generative Adversarial Nets*, ADVANCES IN NEURAL INFO. PROCESSING SYS. 27 (2014), <https://papers.nips.cc/paper/2014/file/5ca3e9b122f61f8f06494c97b1afccf3-Paper.pdf>.

21. BRUNTON & KUTZ, *supra* note 17, at 262.

22. See Tero Karras, Samuli Laine & Timo Aila, *A Style-Based Generator Architecture for Generative Adversarial Networks*, 2019 IEEE/CVF CONF. ON COMPUT. VISION AND PATTERN RECOGNITION (CVPR) 4396, 4403 (2019), <https://arxiv.org/abs/1812.04948>.

23. See *id.* at 4401, 4408.

24. See GANKsy Homepage, VOLEWTF, <https://vole.wtf/ganksy> (last visited Dec. 2, 2021).

25. See Alec Radford, Jong Wook Kim, Chris Hallacy, Aditya Ramesh, Gabriel Goh, Sandhini Agarwal, Girish Sastry, Amanda Askell, Pamela Mishkin, Jack Clark, Gretchen Krueger & Ilya Sutskever, *Learning Transferable Visual Models From Natural Language Supervision*, PROC. OF THE 38TH INT'L CONF. ON MACH. LEARNING, PMLR 8748 (2021), <https://arxiv.org/abs/2103.00020>.

26. See Alec Radford, Ilya Sutskever, Jong Wook Kim, Gretchen Krueger & Sandhini Agarwal, *CLIP: Connecting Text and Images*, OPENAI (Jan. 5, 2021), <https://openai.com/blog/clip> (describing the properties of CLIP).

27. *Id.*

28. This is a strong generative model. See Patrick Esser, Robin Rombach & Björn Ommer, *Taming Transformers for High-Resolution Image Synthesis*, PROC. OF THE IEEE/CVF CONF. ON COMPUT. VISION AND PATTERN RECOGNITION (CVPR) 12873, 12875 (2021), <https://openaccess>

a type of GAN network that synthesizes high-resolution images.<sup>30</sup> The combination of CLIP and VQ-GAN enables the user to easily generate images based on text input. The images the combination produces are highly expressive, and their quality is also such that they can be mistaken for images made by a human artist.

### III. EXAMPLES OF AR AND AI BEING APPLIED TO STREET ART

The most famous example of AR affecting street art is the app “Pokémon GO.” This game uses AR to add digital Pokémon (cartoon monsters) to real-world locations. Some of the game’s locations are called “PokéStops,” and serve as hotspots where players can find items needed in the game. The users see the Pokémon characters displayed with real-world backgrounds in real-time through an app on their smartphones.<sup>31</sup> According to Niantic Inc., the developer of Pokémon GO, the app has been downloaded over one billion times.<sup>32</sup> In many of the PokéStops, street art pieces, murals, and graffiti serve as the background or geographical location. The PokéStops are nominated by users and evaluated by Niantic’s player community.<sup>33</sup> Some of the street art is credited in the game with information on the artist; however, many works only seem to have a description of how the work looks, attached to an image of the PokéStop.<sup>34</sup> Niantic Inc. also has a comprehensive copyright policy that covers user-generated content.<sup>35</sup>

Moreover, apps that add digital works of art to physical surroundings are becoming a more common fixture of the art scene itself. There are many examples of such apps, for instance, Acute Art.<sup>36</sup> This app allows users to access digital works of art through their smartphones from a gallery within

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.thecvf.com/content/CVPR2021/papers/Esser\_Taming\_Transformers\_for\_High-Resolution\_Image\_Synthesis\_CVPR\_2021\_paper.pdf.

29. See Mordechai Rorvig, *AI-Generated Art Scene Explodes as Hackers Create Groundbreaking New Tools*, VICE (July 11, 2021, 3:37 PM), <https://www.vice.com/en/article/n7bj7/ai-generated-art-scene-explodes-as-hackers-create-groundbreaking-new-tools> (crediting Ryan Murdoch with creating the combination, however other sources, including Alexa Steinbrück, *VQ-GAN+CLIP — How Does it Work?* MEDIUM (Aug. 3, 2021), <https://alexasteinbruck.medium.com/vqgan-clip-how-does-it-work-210a5dca5e52>, credit Katherine Crowson as the writer of the Google Colab Notebook that combined VQGAN + CLIP under inspiration from Murdoch’s earlier work).

30. See Esser, Rombach & Ommer, *supra* note 28.

31. See POKÉMON GO, <https://pokemongolive.com/en/#learn> (last visited Mar. 17, 2022).

32. *Products*, NIANTIC INC., <https://nianticlabs.com/en/products> (last visited Oct. 6, 2021).

33. *Submitting a PokéStop Nomination*, NIANTIC INC., <https://niantic.helpshift.com/a/pokemon-go/?p=All&s=in-game-locations&f=submitting-a-pokestop-nomination> (last visited Oct. 15, 2021).

34. See *Pokémon Go Introduces New Fans to Street Art*, THEODORUS GALLERY, <http://thedorusgallery.com/news/pokemon-go-introduces-new-fans-to-street-art> (last visited Dec. 2, 2021).

35. See *Niantic, Inc. Copyright Policy*, NIANTIC INC., <https://nianticlabs.com/copyright/en> (last visited Oct. 15, 2021).

36. See *generally* ACUTE ART, <https://acuteart.com> (last visited Dec. 2, 2021).

the app.<sup>37</sup> The digital work appears as a filter overlaying the representation of the physical world on the screen of the smartphone, and the location where the augment is placed can be chosen by the user.<sup>38</sup> The user can get digital sculptures by renowned contemporary artists, such as KAWS, in their own living room through the augmented reality software in the app.<sup>39</sup> This will then exist within the software but will also be fixed to a geographical spot in the living room. When the user holds the smartphone over the spot where the sculpture has been placed, the sculpture will appear. This has strong similarities to how Pokémon GO works. Acute Art is directed and curated by Daniel Birnbaum, a former director at Moderna Museet in Stockholm, and is an example of AR technology giving people access to curated works of contemporary artists.<sup>40</sup> Another example is Artivive, an app with AR tools that enables artists to create digital artworks connected to physical art.<sup>41</sup>

Art-focused AR apps can use existing street art to serve as backdrops for new contemporary digital pieces, allowing users to create derivative works and to connect digital street art located in the AR space with the physical streets. The idea of digital street art being available through apps on smartphones is brought to life in apps like the MARK App.<sup>42</sup> This is an AR social app that, amongst other features, allows users to write or paint digitally on physical walls.<sup>43</sup> The virtual graffiti exists within the bounds of the MARK App; however, screenshots and photos of the wall with the augmentation (i.e., the virtual graffiti) can be made by users and uploaded to the internet.

AI as applied to street art is also increasingly used. As mentioned, one such example is GANKsy.<sup>44</sup> This StyleGAN-network currently creates images that seem alien, with the style and feel of the images closely resembling the art of Banksy. Yet, the pieces made by GANKsy seem to be of a more abstract nature and are easily distinguishable from the original artist. The deep learning technology used in “The Next Rembrandt” project, as well as in other forms of AI tools as described in Section 2, seem to be of a more complex nature than that of GANKsy—and could be used to produce

37. See, e.g., *Curate your own Unreal City from home*, ACUTE ART, <https://acuteart.com/curate-your-own-unreal-city-from-home> (last visited Mar. 17, 2022); see also “Start the Experience” to Access the Gallery, ACUTE ART APP (last used Mar. 17, 2022).

38. See, e.g., *KAWS: New Fiction*, ACUTE ART, <https://acuteart.com/artist/kaws-new-fiction> (last visited Mar. 17, 2022).

39. See KAWS, <https://kawsone.com> (last visited Dec. 2, 2021); KAWS, STREET ART BIO, <https://www.streetartbio.com/artists/kaws> (last visited Dec. 2, 2021).

40. See generally ACUTE ART, <https://acuteart.com/about> (last visited Mar. 17, 2022).

41. See ARTIVIVE, <https://artivive.com> (last visited Dec. 2, 2021).

42. See MARK App Homepage, *supra* note 11.

43. See Google Play’s MARK App Description, GOOGLE PLAY, <https://play.google.com/store/apps/details?id=com.psst.app&hl=en&gl=US> (last visited Mar. 17, 2022).

44. See GANKsy Homepage, *supra* note 24.



images indistinguishable from the works of the original artist.<sup>45</sup> A possible use of AI-created street art could be to decorate private and public spaces at a low cost on commission from homeowners, businesses, or local authorities. The application of the image could be done through 3D-printing techniques, as was done in “The Next Rembrandt” project.

#### IV. COPYRIGHT ISSUES

Both AR and AI technologies are still evolving and have not yet reached their full potential.<sup>46</sup> It is true that these technologies have been present in the context of art for some time,<sup>47</sup> but the refinement of their creative outputs in recent years has been of such quality and accessibility that both AR and AI art have now entered the mainstream. Games such as Pokémon GO have enabled many people to access AR technology, thus contributing to its development. As mentioned, to our knowledge there are no cases decided by courts focusing on the unauthorized exploitation of street and graffiti art via AI or AR. However, this may likely change, as these technologies are now in widespread use and are being applied to street art and graffiti.

Indeed, most street and graffiti artworks are eligible for copyright, and as long as the requirements for obtaining copyright set forth in the relevant jurisdiction are met, especially originality and fixation, such pieces are protected.<sup>48</sup> Yet, when the artwork has been created and placed in the street illegally (which still happens frequently), whether the art can be protected by copyright and the extent of enforceability of rights before the courts still remains unclear in several jurisdictions, including the United States.<sup>49</sup>

##### A. Infringement

A work, in being protected by copyright, means that its author, here the street artist, has a set of exclusive rights over the piece. These include the right of reproduction, adaptation, and communication of the work to the public.<sup>50</sup> These rights are important legal tools in the hands of graffiti artists to fend off attempts to appropriate and exploit their art, especially for com-

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45. As we will see under the discussion on infringement of artists’ rights of reproduction under copyright law, infringement may arise if the art created by the AI-entity is substantially similar to that of the original work.

46. See THE EUR. OBSERVATORY ON INFRINGEMENTS OF INTEL. PROP. RTS., EUIPO, *supra* note 4, at 9.

47. An example of this is AARON, a computer program developed by Harold Cohen in 1973 that creates art. See Harold Cohen’s Homepage, AARON’S HOME, <http://aaronshome.com/aaron/index.html> (last visited Dec. 2, 2021).

48. There is a discussion on issues of originality for different forms of street art, such as tags, throw-ups, words, and phrases. These forms of graffiti may sometimes not meet this requirement and thus not be protected by copyright. See Bonadio, *supra* note 2, at 107–09.

49. See *id.* at 118.

50. See, e.g., 17 U.S.C. § 106(1)–(3) (2020).

mercial purposes. Indeed, the fact that these forms of art are created or placed in the public environment facilitates misappropriation, as they are readily available to anyone seeking them out. Street pieces are more vulnerable to such phenomena than traditional forms of visual arts confined to galleries or museums. In addition, both forms of art appeal to digital consumers, as street culture has a wide segment of fans, especially those who are exposed to social media where images of street artworks are constantly uploaded and shared.<sup>51</sup> The use of humor in street art to create conversations and views of our society from a different angle also adds to the appeal. Such appeal makes it tempting to misappropriate and exploit street art, and there have been several copyright cases, especially in the US, focusing on misappropriation of graffiti by fashion brands and other corporations.<sup>52</sup>

What about cooptation of graffiti via AR and AI technologies? It is objectively difficult for street artists to discover and react to such misappropriation, as the digital landscape is so diverse. When it comes to AR, misappropriation happens within the boundaries of the specific software, and it is therefore difficult for artists to even find out about the infringements of their rights.<sup>53</sup> The hidden nature of AR, combined with the easy accessibility of street art and graffiti, makes it easy to appropriate and take advantage of street artists' pieces. As far as AI is concerned, the potential for misappropriation is equally abundant. Again, it is the inherent features of these art forms—especially their immediate availability and subcultural appeal—that makes them easy to reproduce and exploit as input data to train machines and algorithms. On the other hand, it could also be argued that many graffiti works are created without being signed or marked with a pseudonym, making it harder for anyone wishing to find the artist to clear rights for use.

With that being said, how can misappropriation of graffiti materialize in a digital environment such as the one created through AR and AI? In AR platforms, digital copies of street art placed in the real world can be made and stored. Also, when images are used as input data for training AI, the machines may need to reproduce these images in the training process. In both scenarios, content copying happens whenever a file is uploaded or sent from one digital location to another and may infringe the artists' rights of reproduction. As copies are fixed in the digital medium, the fact that they often can be stored within the software—which enables sharing amongst users or stored as screenshots—likely amounts to a violation of the artists' rights to make their work available to the public. The right to adaptation is

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51. This can be seen in the way some street artists have become globally famous outside of the street art scene, such as Banksy and Shepard Fairey.

52. *See, e.g.,* Williams v. Cavalli, No. CV 14-06659-AB, 2015 U.S. Dist. LEXIS 34722 (C.D. Cal. Feb. 12, 2015).

53. *See* Mma Afoaku, *The Reality of Augmented Reality and Copyright Law*, 15 Nw. J. TECH. & INTELL. PROP. 111, 112 (2017), <https://scholarlycommons.law.northwestern.edu/njtip/vol15/iss2/4>.

equally vulnerable to infringement due to the very nature of both AR and AI technology. In AR, adaptation is one of the main features. If no adaptation occurs, then the work or the real world has not really been augmented.<sup>54</sup> Similarly, AI platforms that use street art and graffiti for creative purposes may end up adapting the input data. For both types of technology, the adaptation may not constitute an infringement if the mutation has been so extensive that only marginal similarities remain between the original and the derivative works.<sup>55</sup>

If infringement does occur, the next question is who the copyright infringer is. Is it the developer of the AR or AI platforms? The user? Or the person or entity who has invested in the technology? These are not easy questions. One may also note that the company that runs the AR or AI platform—which allows its users to create, upload, and view images based on existing murals—may be at risk of being condemned for copyright infringement. Yet, such risk would be minimized in countries where the so-called “safe harbor” exemption is made available to Internet Service Providers (ISPs) (this exemption is subject to certain conditions, i.e., that the ISP does not have actual knowledge of illegal activity on its platform and is not aware of facts from which the illegal activity or information is apparent or, upon obtaining knowledge or awareness, acts expeditiously to remove or to disable access to the information).<sup>56</sup> This kind of exemption is available in several jurisdictions, including the US<sup>57</sup> and the EU,<sup>58</sup> and protects ISPs from the consequences of their users’ actions, e.g., creation, uploading, and viewing of an image. Such an approach is also reflected in some apps’ copyright policies, including the policy for Pokémon GO.<sup>59</sup> If the “safe harbor” exemption does apply in these scenarios (this also depends on whether the AR or AI platforms can be considered ISPs), the user of such platforms turns out to be the infringer. But even when this exemption does not apply, users might still be infringing the copyright of street artists if they actively carry out selections of input images.

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54. See also Olivia Jean-Baptiste, *Augmented and virtual reality art: A new frontier of legal protection*, 4 INTERACTIVE ENT. L. REV. 102 (2021) (noting that “it would appear there is no derogatory treatment where a digital work exists alongside a physical one, for example as an AR addition”).

55. See Enrico Bonadio & Luke McDonagh, *A.I. as Producer and Consumer of Copyright Works: Evaluating the Consequences of Algorithmic Creativity*, 2 INTELL. PROP. Q. 112 (June 2, 2020).

56. See also KEVIN J. HICKEY, CONG. RSCH. SERV., DIGIT. MILLENNIUM COPYRIGHT ACT (DMCA) SAFE HARBOR PROVISIONS FOR ONLINE SERV. PROVIDERS: A LEGAL OVERVIEW (Mar. 30, 2020), <https://crsreports.congress.gov/product/pdf/IF/IF11478>.

57. 17 U.S.C. § 512 (2020), amended by Digital Millennium Copyright Act of 1998, Pub. L. No. 105–304, 112 Stat. 2860.

58. Directive 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/EC, 2019 O.J. (L 130) 62, art. 17.

59. NIANTIC, *supra* note 35.

## B. Exceptions

There are also substantive defenses that may be relied on to exclude any violations of artists' rights through AR and AI platforms. The grounds upon which such defenses operate include fair use, *de minimis*, and the freedom of panorama exception.

In the US, the most common defense is that the use of the protected work constitutes "fair use."<sup>60</sup> A similar defense is also available in the UK ("fair dealing")<sup>61</sup> and the EU,<sup>62</sup> although the scope of the exception is notoriously broader in the US. Are these exceptions available when street art is used by AR and AI platforms? Take the US "fair use" doctrine for example. The analysis here focuses on whether the use of the copyrighted work is purely mechanical or expressive, with the former being more likely to constitute fair use.<sup>63</sup> It would be difficult to show that uses of graffiti in AR and AI scenarios are just mechanical and non-expressive, as these forms of art are often reproduced and adapted for creative purposes. Indeed, their use frequently has an artistic or aesthetic purpose. In this case, in order to be "fair," the use of street art in these platforms would have to be transformative. This may happen in countries such as the US where transformative fair use has often been affirmed by courts (in Europe the chances of winning a transformative use case would be lower). In *Cariou v. Prince*, for example, the United States Court of Appeals for the Second Circuit held that artist Richard Prince's blatant appropriation (and slight digital modification) of Patrick Cariou's photographs of Jamaican Rastafarians was fair use and that a number of his works were transformative fair uses of Cariou's pictures.<sup>64</sup>

From the examples mentioned in Section 3, it could be argued that for both AR and AI technologies, the use of street art and graffiti by the technologies may be to a lesser or greater extent transformative. Take, for example, an AR technology such as Pokémon Go that incorporates the real world and uses it as background for the characters in the game; or the app Artivive that lets users connect digital works to physical ones, with such works being enhanced with digital layers; or the GANksy and Next Rembrandt projects that use artworks as data input and building blocks for

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60. 17 U.S.C. § 107 (2010).

61. See Copyright, Designs and Patents Act, (1988) §§ 29–30 (UK) [hereinafter CDPA].

62. In the EU, member states can implement several limitations that, in sum, cover much of the same ground; however, the EU legislation does not contain a doctrinal equivalent of the US "fair use" or the UK "fair dealing." Some of the limitations that can be implemented by member states are found in Directive 2001/29/EC, of the European Parliament and the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society 2001 O.J. (L 167) 44, art. 5(2)–(3)(n).

63. See *Sega Enters. Ltd. v. Accolade Inc.*, 977 F.2d 1510 (9th Cir. 2007) (on non-expressive fair use).

64. *Cariou v. Prince*, 714 F.3d 694 (2d Cir. 2013).

downstream digital creations.<sup>65</sup> And there may be other ways street art and graffiti can be transformed through these technologies: it is not a stretch, as mentioned in Section 3, to think of an AI platform connected to a printer that can spray paint on walls—where input data from pre-existing graffiti is used to create new physical street bound pieces. With that, the decision of whether the use and adaptation of street artworks by AR and AI platforms amounts to copyright infringement depends not only on the jurisdiction where the legal action is taken but also on the facts of each case and the subjective analysis carried out by judges. Indeed, it is well-known that “fair use” and “fair dealing” cases are often unpredictable, fact-specific, and frequently produce conflicting decisions.

Another copyright defense that may apply when street art is reproduced in AR and AI platforms is the *de minimis* exception. This defense can be invoked where the alleged use of the copyrighted work (e.g., a mural) is so insignificant that it can be deemed trivial.<sup>66</sup> The exception has been applied by a US court in a copyright case focusing on graffiti. In *Ittoffee R. Gayle v. Home Box Office Inc.*, a street artist named Ittoffee R. Gayle claimed infringement of copyright and trademark because his graffiti-style words “Art we all” painted on a New York City wall were used for a few seconds as background for a shot in the TV series “Vinyl.”<sup>67</sup> The Court found that the use was *de minimis* and ruled in favor of the defendant. The judge, Jesse M. Furman, clarified, citing *Ringgold v. Black Ent. Television, Inc.*<sup>68</sup> to demonstrate that “*de minimis*” means “what it means in most legal contexts: a technical violation of a right so trivial that the law will not impose legal consequences,” and that “copying has occurred to such a trivial extent as to fall below the quantitative threshold of substantial similarity, which is always a required element of actionable copying.”<sup>69</sup>

This exception may also be relevant where street art is being digitally augmented without being in the spotlight. One such example is where the augment in the form of a digital piece of art is placed in the virtual representation of the street within the AR technology and where the graffiti work happens to be painted or written on a wall or other urban surface on the real street that serves as part of the backdrop for the augment. In this case, the virtual augment will be the focus, and the backdrop it is displayed against will change with the angle the user chooses to hold their smartphone. In such a situation, the street art piece may or may not be displayed as part of the backdrop, and the use can be argued to be trivial. However, if the aug-

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65. See NEXT REMBRANDT PROJECT, *supra* note 19; see also GANKSY, *supra* note 24; see also POKÉMON GO, *supra* note 32; see also ARTIVIVE, *supra* note 41.

66. See *Ringgold v. Black Ent. Television, Inc.*, 126 F.3d 70, 74 (2d Cir. 1997).

67. *Gayle v. Home Box Office, Inc.*, No. 17-CV-5867 (JMF), 2018 WL 2059657 (S.D.N.Y. 2018).

68. See *Ringgold*, 126 F.3d at 74.

69. See *Gayle*, 2018 WL 2059657, at \*3.

ment is site-specific, and the site is chosen with a particular backdrop to set off the augmented piece, then the use will likely be non-trivial. As AI, similarly, where the input data is only one amongst millions of other images, it may again be argued that this is a *de minimis* use. Yet, here one may counterargue that the artistic work might be used to a greater extent than what traditionally is thought of as trivial, as it is a use for training purposes, which may entail that the machine has access to reproduce and store the image for longer than just a short amount of time. Analogous arguments and counterarguments could be put forward with regards to another defense, i.e., the transient copy exception under the EU Info-Society Directive,<sup>70</sup> which exempts from copyright infringement temporary acts of reproduction of the protected work.

The freedom of panorama exception may also be relevant here. This defense limits the right of the owner of the copyright in certain artistic works placed in the public environment (such as sculptures and buildings) to take an infringement action.<sup>71</sup> Examples of such exceptions can be found in US<sup>72</sup> and UK<sup>73</sup> copyright laws, where the use of copyrighted material can also be for commercial purposes. Yet those laws restrict the use of the defense, with paintings on walls being ineligible to take advantage of it—meaning that muralists and other artists who paint walls and other urban surfaces may be able to enforce their copyright to stop the exploitation of their art in these platforms (unless other defenses such as “fair use,” “fair dealing,” or “*de minimis*” apply).<sup>74</sup> On the contrary, in countries where this exception is not limited to sculptures or works of architecture, such as Germany,<sup>75</sup> this defense is likely to justify the use of all types of street art in the context of AR and AI technologies and even for commercial purposes.

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70. See Directive 2001/29/EC, *supra* note 62, at art. 5(1).

71. See, e.g., Bonadio, *supra* note 2, at 171.

72. 17 U.S.C. § 120(a) (2020), amended by Architectural Works Copyright Protection Act (AWPCA) of 1990, Pub. L. No. 101-650, §§ 701-06, 104 Stat. 5089. The freedom of panorama exception in the US is indeed limited to architectural works.

73. CDPA, *supra* note 61, at §§ 62(1)-(3).

74. As far as US case law is concerned, two recent cases discussed the extent to which murals can be considered as incorporated into the buildings on which they are painted and therefore deemed to be part of the whole architectural work. See *Mercedes Benz, USA v. Lewis*, No. 19-10948, 2019 WL 4302769 (E.D. Mich. Sept. 11, 2019) (Mercedes had alleged “a plausible claim” that the company has the right to photograph publicly visible buildings with murals on the walls, thus suggesting that the above incorporation may take place); see also *Falkner v. Gen. Motors*, 393 F. Supp. 3d 927 (C.D. Cal. 2018) (the artwork was viewed separately from the building). The Falkner case was settled out of court.

75. See Marc Mimler, *Street Art, Graffiti and Copyright: A German Perspective*, in *THE CAMBRIDGE HANDBOOK OF COPYRIGHT IN STREET ART AND GRAFFITI* 188, 204-06 (Enrico Bonadio ed., Cambridge Univ. Press 2019).

## V. MORAL RIGHTS ISSUES

Artists have moral rights. These include the rights of *attribution* (the right to be recognized as the creator of the artwork) and *integrity* (the right to oppose treatments of works which are prejudicial to artists' reputations or honor).<sup>76</sup> In the US, moral rights for visual artists were introduced as federal law in 1990 through the Visual Artists Rights Act (VARA).<sup>77</sup> VARA § 106A protects visual artists' moral rights of attribution and integrity. Europe also protects these rights,<sup>78</sup> with protection that is notoriously stronger than in the US and other common law jurisdictions.<sup>79</sup>

Can such rights be infringed through the use of AI and AR? As far as the right of attribution is concerned, infringement may occur where AR or AI technologies use pictures of murals or other forms of street art and graffiti (for example in the case of AR as background for the augmented digital layer) without naming the artist.<sup>80</sup> The right of attribution may turn out to be important to street artists, as their names are integral to both the artists themselves and the works they create.<sup>81</sup> It is therefore likely that many artists may object to such violation. Digital augmentation, distortion, and transformation triggered by AR and AI may also irritate practitioners of these forms of art and, in principle, amount to a violation of their integrity rights.<sup>82</sup> An example of this would be where a physical mural is used as a backdrop in AR for a digital layer containing a virtual offensive message or symbol.

One of the authors of this article, Enrico Bonadio, has conducted interviews where he could feel street artists' irritation at the above treatments and lack of acknowledgment for authorship.<sup>83</sup> For example, Anjil, a New York artist Bonadio met at the Cypher Art Community Centre in New York's Staten Island borough, found that two murals she painted were displayed as "Points of Interest" in the Pokémon Go game. She told Bonadio: "I personally never had my work on clothing, but I have a couple of walls painted in Brooklyn and I realized that they were shown on this Pokémon Go game. It's a game and I think that I'm going to reach out to them about

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76. 17 U.S.C. § 106A (2020).

77. Visual Artist Rights Act of 1990, Pub. L. No. 101-650, 104 Stat. 5130 (codified as amended at various sections of 17 U.S.C.) [hereinafter VARA]. The recent landmark decision in the 5Pointz case determined that temporary artworks could attain recognized stature under this provision and awarded twenty-one artists and writers whose pieces were illegally destroyed \$6.7 million in damages; see *Castillo v. G&M Realty L.P.*, 950 F.3d 155 (2d Cir. 2020); see also *Cohen v. G & M Realty L.P.*, 320 F. Supp. 3d 421, 435 (E.D.N.Y. 2018).

78. See e.g., CDPA, *supra* note 61, at ch. IV; see also Copyright Act § 5 (Norway).

79. See, e.g., Mimler, *supra* note 75, at 198.

80. See, e.g., POKÉMON GO, *supra* note 31.

81. See Bonadio, *supra* note 2, at 113.

82. See VARA, *supra* note 77, at (a)(2).

83. ENRICO BONADIO, COPYRIGHT IN THE STREET – AN ORAL HISTORY OF CREATIVE PROCESSES IN THE STREET ART AND GRAFFITI SUBCULTURES (Cambridge Univ. Press, forthcoming 2023).

that. . . They didn't ask for my permission and at least they could have put my name up there or my Instagram instead of just 'Graffiti Mural' because that's me and my work." New York artist Murrz, an illustrator and painter who also places art in the public environment, is aware of similar experiences. During a conversation in a Brooklyn café, she said to Bonadio, "There's an app called the 'graffiti maker app' that is using images from legend graffiti writers and I'm sure that they didn't ask them for permission."

## VI. DERIVATIVE WORKS

Another relevant issue is whether derivative works created by AR and AI technologies can attract a new and separate copyright.<sup>84</sup> Both AR and AI are data processing technologies<sup>85</sup> and can use such data to create new works. The latter pieces therefore derive to a greater or lesser extent from the works used to feed the platforms in question. As a general remark, the creator of the derived work (downstream creation) needs the authorization of the owner of the copyright over the original work (upstream work), absent which copyright infringement would happen. Derivative works, which can be fixed on a tangible medium and are original, can thus benefit from copyright without jeopardizing the rights of the original work's author.

As to derivative works made by AR and AI technologies, the fixation requirement is uncontroversial, as they are recorded in a tangible way on digital support and can be both perceived and reproduced digitally with the aid of a machine.<sup>86</sup>

What about originality? The test varies across jurisdictions. In the EU, we find the "intellectual creation" test under *Infopaq*,<sup>87</sup> in the UK the traditional "skill, labour and judgment" standard,<sup>88</sup> and in the US the "modicum of creativity" requirement (as affirmed in *Feist v. Rural*).<sup>89</sup> In the EU, the issue of "originality" was discussed in several cases, including in *Painer*,<sup>90</sup> where a photographic portrait was created using a machine. Here, the court discussed the *Infopaq* "intellectual creation" test and stated that "[a]n intellectual creation is an author's own if it reflects the author's personality. . . .

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84. It should be reminded that a derivative work is a work that is based upon a preexisting work. *See, e.g.*, the definition under 17 U.S.C. § 101 (2020): "A 'derivative work' is a work based upon one or more preexisting works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which a work may be recast, transformed, or adapted. A work consisting of editorial revisions, annotations, elaborations, or other modifications, which, as a whole, represent an original work of authorship, is a 'derivative work.'"

85. *See* The Editors of Encyclopedia Britannica, *supra* note 3.

86. *See* 17 U.S.C. § 102 for the fixation requirement.

87. *See* *Infopaq Int'l A/S v. Danske Dagblades Forening*, [2009] Case C-5/08 (Den.).

88. *See, e.g.*, *Ladbroke v. William Hill*, [1964] 1 All E.R. 465, 469 (Eng.).

89. *See* *Feist Publications, Inc. v. Rural Tel. Sev. Tel. Sev. Co.*, 499 U.S. 340 (1991) (explaining the two requirements for originality).

90. *Painer v. Standard VerlagsGmbH* (Third Chamber) [2011] Case C-145/10 (Austria).



That is the case if the author was able to express his creative abilities in the production of the work by making free and creative choices.”<sup>91</sup> In pointing this out, the court highlighted that the use of software was one among several other choices that could be made,<sup>92</sup> with the court further noting that “[w]hen selecting the snapshot, the photographer may choose from a variety of developing techniques the one he wishes to adopt or, where appropriate, use computer software.”<sup>93</sup> In the US, the originality test for derivative works focuses on the comparison between the original and the new work. This is the so-called *Gracen*<sup>94</sup> standard of “substantially different,” which *Shrock v. Learning Curve Int’l* affirmed,<sup>95</sup> “[t]he key inquiry is whether there is sufficient nontrivial expressive variation in the derivative work to make it distinguishable from the underlying work in some meaningful way.”<sup>96</sup>

With that being said, can it be argued that AR and AI works based on street and graffiti art are original enough to attract a fresh copyright? The analysis will be fact-sensitive. If we take into account Azuma’s definition of AR,<sup>97</sup> the derivative work made through these platforms combines the upstream real work with an overlaying augmenting digital filter that is interactive in real-time and three-dimensional. The derivative work can thus be described as the virtual representation of the upstream work with the digital augmenting overlay. Thus, for example, if the augmentation is a digital filter added to a mural, the upstream work can be modified in several ways, e.g., via animation of parts or of the whole upstream work as well as adding text, 3D figures, or other images. If the modification is extensive, the end result can be very different than the original. The same may occur with AI platforms. Much obviously depends on the potential for recognizing details of the graffiti or street art used in the training process, in the output created by the AI. In both scenarios, this might be enough under the *Gracen* standard in the US to the extent that the digitally augmented or AI-generated artwork is distinguishable from the real one and thus original. In Europe,

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91. *Id.* ¶¶ 88–89.

92. *Id.* ¶ 91.

93. *Id.*; see also P. Bert Hugenholtz & João Pedro Quintais, *Copyright and Artificial Creation: Does EU Copyright Law Protect AI-Assisted Output?*, 52 IIC 1190, 1190–1216 (2021) (noting under “Conclusions” that under EU law for the work to be protected by copyright a four-criteria test should apply: “the output is (1) in relation to ‘production in the literary, scientific or artistic domain’; (2) the product of human intellectual effort; and (3) the result of creative choices that are (4) ‘expressed’ in the output.”). The necessity of the human factor is also implied in the practices of the U.S. Copyright Office, see U.S. COPYRIGHT OFFICE, COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES § 101 (3d. 2021), § 313.2 (“Works That Lack Human Authorship”).

94. See *Gracen v. Bradford Exch. & MGM*, 698 F.2d 300, 305 (7th Cir. 1983) (Judge Posner used a test set forth in *L. Batlin & Son, Inc. v. Snyder*, 536 F.2d 486 (2nd Cir. 1976), namely that “a derivative work must be substantially different from the underlying work to be copyrightable.”).

95. *Schrock v. Learning Curve Int’l, Inc.*, 586 F.3d 513 (7th Cir. 2009).

96. *Id.* at 521.

97. Azuma, *supra* note 6.

courts may instead be more reluctant to let the augmented piece gain independent copyright as new work because the augmentation would need the underlying mural or other street artwork as a basis for the full image to be visible, and thus more may be needed for the work to reflect the author's personality through free and creative choices.<sup>98</sup> Yet, the CJEU's point in *Panier* that the use of a particular software can be considered a creative choice contributing to the final work<sup>99</sup> could strengthen the argument that the augmented graffiti is original enough to attract copyright. Still, one may insist that AI works generated by machines trained with graffiti may fail to obtain copyright on grounds of lack of (human) creative choices, as the AI generates output without the direct involvement of human ingenuity. The human creative element is less evident in AI than in AR as, in the former, the network often produces output that is unpredictable to the human developers of the creative machine.

It is also noteworthy to highlight the connection between derivative works in AR platforms and the freedom of panorama exception.<sup>100</sup> For example, consider smartglasses and the digital enhancement of street imagery that these platforms can trigger. This technology seems to be on the verge of revolutionizing our concept of reality through adding digital layers in a constant setting, giving the streets a virtual dimension. If this technology develops further, it will also be commonplace to use pictures taken by the smartglasses from the digitally enhanced streets in social media. In these cases, solid public policy rationale may justify the application of the freedom of panorama exception. The balancing act behind this defense, justified on the need to protect the public interest in taking pictures freely in public spaces, may become as relevant for the digitally enhanced scenario as it is for the real world. The need to use public spaces for inspiration and to fuel creativity does not disappear in the new and augmented reality. The main counterargument is naturally that the augmenting digital layer is confined to the software and app's environment (which is visible only to the people who access those platforms), and thus it is not available in a truly public setting.

However, the more available this technology becomes to the public, the more such counterargument must be scrutinized. Should the public be able to take photos of the augmented world and freely post these on social media or other places without paying any royalty to the original creator of the graffiti artwork, or should the new digitally enhanced work be commercially licensed? We believe that if this scenario becomes a reality, a "freedom of digital or virtual panorama" should be introduced so that the public will be able to take pictures of the public spaces they visit in this virtual

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98. See *Painer v. Standard VerlagsGmbH* (Third Chamber) [2011] Case C-145/10 (Austria).

99. *Id.* ¶ 91.

100. See the discussion above under Section 4, *Exceptions*.

environment, however enhanced the space might be. To protect the interests of the artists, this exception should be limited in several ways. Most importantly, it should just cover non-commercial use, so as to allow artists to be able to object to the unauthorized economic exploitation of their works by third parties. Yet, one may note that artists may also be bothered by a non-commercial use of their street pieces, especially if they do not approve of the context in which they are used (this also emerged in Bonadio's ethnographic research).<sup>101</sup> Yet, giving artists a right to oppose any use of their work may go too far, especially if they want to prohibit the use of their art for educational and research purposes. In these cases, the public interest in freely accessing art in the street may be considered as overriding the private interest of the artist in controlling her art.

## VII. CONCLUSION

There exists a potential for litigation arising from the intersection between AR and AI on the one hand and street art and graffiti on the other. The very nature of both these forms of art and technology makes the unauthorized appropriation of works placed outdoors relatively easy. Oddly enough, case law on this intersection has not emerged yet. While street artists and graffiti writers seem in a position to object to such appropriation in several circumstances by relying on both copyright and moral rights protections, in other scenarios their claims may fail, especially where the appropriator can take advantage of copyright exceptions. Artists might even benefit from new creative opportunities brought about by AR and AI, and again invoke copyright and moral rights to protect *virtual* derivative works based on their *real* outdoor art.

Thus, the future is already here, and for street and graffiti artists, it is important to be aware of both the opportunities and challenges coming from these technologies.

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101. See Bonadio, *supra* note 83.