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Of PhDs, Pirates and the Public: Three-Dimensional Printing Technology and the Arts

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ABSTRACT

The confluence of three-dimensional printing, three-dimensional scanning, and the Internet will erode the dividing line between the physical and the digital worlds and will bring millions of laypeople into intimate contact with the full spectrum of intellectual property laws. One of the areas most affected by 3D printers will be three-dimensional art. This Article analyzes several ways in which 3D printing technology will affect the creation, delivery, and consumption of art. Not only does 3D printing offer great promise for creative works, but it also presents a problem of piracy that may accompany the digitization of three-dimensional works. As 3D printing technology's relationship to intellectual property law is largely unexplored, this Article explores foundational issues regarding how copyright law applies to 3D printing technology, laying the groundwork upon which further analysis of 3D printing's effects on copyright law may be built.

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I. INTRODUCTION

Three-Dimensional printing (sometimes called "additive manufacturing"[1] or "rapid prototyping"[2]) will transform our economy and culture in dramatic ways. 3D printers can already make a wide variety of things: shoes, clothes, car parts, toys, guns, human body parts, and much more.[3] Their capabilities will only continue to improve.

Traditionally, most sculptures and other three-dimensional art started with a block of solid material from which the artist removed unwanted pieces until she formed the sculpture. 3D printing turns this idea on its head: complex shapes and sculptures will no longer require removal of material from a unitary block; rather, the printer will build the object up layer-by-layer. All you need to print almost anything is a printer, "ink," and computer files detailing the item being printed.

The confluence of 3D printing, 3D scanning, and the Internet will commingle the physical world and the digital world and will bring millions of laypeople into intimate contact with the full spectrum of intellectual property laws.[4] One of the areas most affected by 3D printers will be three-dimensional art. This Article begins the work of identifying and responding to the effects of 3D printing technology on copyright law.

After introducing the technology in Section II, this Article analyzes three ways in which 3D printing (together with 3D scanning and the Internet) will affect the creation, delivery, and consumption of art. First, Section III discusses how 3D printing will bring the fields of art, science, and technology into more intimate contact. 3D printing will make for some strange bedfellows. Stereotypically (though often unfairly), artists and scientists are considered polar opposites. 3D printing will further erode this myth. Already artists rely on scientists in the areas of nanotechnology, genetics, and biology, just to name a few, to

1. "Additive manufacturing" is a more accurate but less-used term for the machines. Before 3D printing, most machines made objects through "subtractive" manufacturing: they removed pieces from a large block of material until they formed the desired shape. 3D printers create objects additively: by depositing the bottom layer of material and building up layer-by-layer.

2. Rapid prototyping refers to the fact that 3D printers can usually build custom prototypes much more quickly and cheaply than traditional machine techniques.

3. *See generally* CHRIS ANDERSON, MAKERS: THE NEW INDUSTRIAL REVOLUTION (2012); HOD LIPSON & MELBA KURMAN, FABRICATED: THE NEW WORLD OF 3D PRINTING (2013); *Special Report: Manufacturing and Innovation: A Third Industrial Revolution*, THE ECONOMIST (Apr. 19, 2012), http://www.economist.com/node/21552901.

4. Lucas Osborn, *Regulating Three-Dimensional Printing: The Converging Worlds of Bits and Atoms*, 51 SAN DIEGO L. REV. ___ (forthcoming 2014).

help them use 3D printers to generate new forms of art. Technologists, including the makers of printers and the creators of the .stl computer files, will also work hand-in-hand with artists to expand the boundaries of art.

Second, Section IV describes how 3D printing and 3D scanning will increase access to three-dimensional art. Any object can be scanned in three dimensions, and the resulting file can be uploaded to the Internet. Anyone in the world will have instant access to it and can print it. This has broad implications for everyday decorative art, but it also has tremendous implications for rare art. Objects too delicate for people to view or handle can be scanned and reproduced in exact detail, allowing users the world over to experience (see, touch, use) invaluable works of art. Want to drink water from a Greek vase? Print it!

Third, Section V analyzes the piracy problem that 3D printing poses for creators of three-dimensional art. Much like authors and musical performers have struggled with digital piracy, the Internet will allow for widespread piracy of three-dimensional art. Some of this piracy results in lost sales for the artists. But it is conceivable that a fair amount of "stolen" sculptures are ones that the "thief" would never have purchased in the first place. Rather, technology may lead many people who would otherwise be uninterested in three-dimensional art to become interested in it and build off it. The law will need to strike a balance that protects artists and yet promotes the arts. Part of striking this balance involves determining whether copyright law protects CAD files of creative objects, as opposed to the physical objects themselves. A large portion of Section V analyzes this issue.

3D printing will herald a burst of creativity and access: many new "tech-sculptors" will emerge, as will many new consumers of three-dimensional art. In addition, piracy will (literally) reach the third dimension. Congress and the courts will need to strike a balance. If they get it right, a new era can flourish. If they get it wrong, they will stifle progress.

II. THREE-DIMENSIONAL PRINTING TECHNOLOGY

3D "printers" are only superficially related to current 2D printers. Rather than printing "ink," they "print" (expel) solid or molten material. Further, they print not just in two dimensions, but also move in a third direction: the printer head moves up (or the base moves down) to stack layer upon layer of expelled material until a three-dimensional object is formed.[5]

3D printers can print in a remarkable range of materials, including extruded or powdered plastic, metal, ceramic, food, cement, wood,

5. Numerous sources supply more in depth technology summaries. *See, e.g.*, LIPSON & KURMAN, *supra* note 3, at 68–84.

and even human cells.[6] Though the various types of 3D printers work in different ways, the results are the same: solid objects printed in one pass. While 3D printers can create all the simple shapes one would expect, part of their tremendous potential comes from the ability to print remarkably complex shapes, some of which would be impossible using traditional techniques.

Before one can print an object with a 3D printer, the object must first be created in a computer model. Various Computer-Aided Design ("CAD") programs (Google Sketchup, AutoCAD, etc.) allow users to design and modify three-dimensional objects on a computer. Depending on the CAD program used, the CAD file might need to be translated into a format that a 3D printer can understand. The most common such file format is the ".stl" file,[7] which directs a 3D printer how to create the object layer-by-layer. Throughout this Article, I will refer to a "CAD file" to mean any computer file that can instruct a 3D printer to print an object.[8]

Besides creating a CAD file from scratch, users can use a 3D scanner to scan an object and translate that scan into a CAD file. For example, someone could scan a famous sculpture or piece of ancient pottery with a high-resolution 3D scanner to capture a near-perfect digital file of the object. Though high-end scanners cost tens of thousands of dollars, home-based scanners are getting less expensive,[9] and there are ways to build them very cheaply using household digital cameras or optical lasers.[10]

Once a user makes a CAD file, either from scratch or by scanning, the user can send the file to others via email or post it on the Internet. From there, others can access the file and print it, modify it, or forward it along. Various websites act as hosts for 3D CAD files, and some offer to print the files on behalf of customers who do not own a

6. *See* LIPSON & KURMAN, *supra* note 3, at 68–75; *Biofabrication—Fit to Print*, THE ECONOMIST (Apr. 6, 2013), http://www.economist.com/news/science-and-technology/21575745-new-ways-make-living-tissue-artificially-fit-print.

7. The letters "stl" are short for STereoLithography. *See 30 Years of Innovation*, 3D SYSTEMS, http://www.3dsystems.com/30-years-innovation (last visited Aug. 12, 2013). Industry participants also refer to .stl as "Standard Tessellation Language." LIPSON & KURMAN, *supra* note 3, at 101. Other more sophisticated file formats, such as .amf, may soon replace the .stl format. *Id.*

8. The file might be an .stl file or any other relevant type. I do not mean files solely for two-dimensional printouts or files that are incapable of directly being used to print three-dimensional objects.

9. *See* Rachel Feltman & Christopher Mims, *3D Scanners Are Getting Cheap So Fast, the Age of 3D Piracy Could Soon Be Upon Us*, QUARTZ (Aug. 15, 2013), http://qz.com/115824/3d-scanners-are-getting-cheap-so-fast-the-age-of-3d-piracy-could-soon-be-upon-us/.

10. *See, e.g.*, Adam P. Spring, *David Laser Scanner Offers DIY, Low-Cost 3D Recording Solution*, GIZMAG (Aug. 12, 2012), http://www.gizmag.com/laser-3d-recording-david-laser/23676/.

3D printer.[11] Users can manipulate a CAD file much as people can edit photographs or music on a computer. (Would you like to superimpose your face on Rodin's *The Thinker*?). The ability to transfer and manipulate CAD files opens up an entire new world of sharing and creativity: sharing of rare art data, 3D mash-ups, 3D parodies, and follow-on works.

III. Commingling Art and Science

The stereotypes of scientists and artists are familiar, but often inaccurate. Scientists have thick eyeglasses; artists have thick nose rings. Scientists are comfortable with math and computers; artists with paintbrushes and guitars. Scientists can't wait to get the newest gadget; artists can't wait to get the newest tattoo. Though these stereotypes were never fully accurate,[12] 3D printing technology will further demonstrate their error. To illustrate the possibilities, this Section presents three examples of 3D printing projects that include significant artistic and scientific components.

A. *DNA*

Artist Heather Dewey-Hagborg demonstrates one way in which 3D printing technology opens avenues for artists and scientists to cross boundaries. Dewey-Hagborg is an artist with a degree in information arts and some experience with computer science.[13] You might not expect her to know much about how deoxyribonucleaic acid (DNA) works, but after viewing her *Stranger Visions* project, you might think she held a PhD. in genetics.

Dewey-Hagborg's *Stranger Visions* project started when she contemplated a random strand of hair from a stranger.[14] Although she did not have a strong background in life sciences,[15] she knew that stray hairs, gum, saliva, etc., can leave traces of a person's DNA. Based on that knowledge, she began collecting samples from public spaces and searching them for DNA.[16] When she found DNA, she had a labora-

11. *See, e.g.*, I.Materialize, http://i.materialise.com (last visited Sept. 10, 2013); Shapeways, http://www.shapeways.com (last visited Sept. 10, 2013).

12. The fields of art and science have always mixed to some extent, and this trend accelerated with the advent of the internet and robust two-dimensional computer art. Artists with a technical bent found opportunities designing webpages, contributing to computer graphics, and creating and disseminating art via the internet (just to name a few examples).

13. Christina Hernandez Sherwood, *Q&A: Heather Dewey-Hagborg, Information Artist, on the Intersection of Art and Science*, smartplanet (Aug. 2, 2013, 3:00 AM), http://www.smartplanet.com/blog/pure-genius/qa-heather-dewey-hagborg-information-artist-on-the-intersection-of-art-and-science/.

14. Amanda Kooser, *Artist 3D-Prints Portraits From DNA Left in Public Places*, CNET (May 8, 2013 8:31 AM), http://news.cnet.com/8301-17938_105-57583442-1/artist-3d-prints-portraits-from-dna-left-in-public-places.

15. Sherwood, *supra* note 13.

16. *Id*.

tory extract information from the DNA to ascertain the depositor's physical traits such as ethnicity, eye color, and the like.[17] She fed the lab results into a custom-designed computer program that crunched the information to generate a three-dimensional model of the anonymous depositor's face. She then printed the model on a 3D printer, creating an amazingly (and perhaps spookily) life-like model of the face.[18]

Due in part to the limits of our understanding of DNA and how it is expressed in individuals, the face printouts are not exact replicas of the depositor's face, but rather what Dewey-Hagborg describes as a "family resemblance."[19] Nevertheless, seeing the multiple faces hanging on a wall silently staring at their onlookers brings about awe at the science, fear for privacy, and appreciation for the artistic accomplishment. Without 3D printing, Dewey-Hagborg's art would have been largely trapped in a more banal two-dimensional setting.

B. *Fractal Art and Biomimicry*

3D printing is also creating opportunities for creators of aesthetically pleasing furniture and housewares. Artists have long had creative ideas for lamps, silverware, furniture, and the like. Many of those ideas could not be produced by traditional manufacturing techniques,[20] and so they stayed trapped in the minds or drawing sheets of artists. But 3D printing technology frees these designs and their creators because geometrically complex shapes are virtually no more difficult to print than solid cubes.

Because 3D printing technology delivers complex objects at a relatively low cost, it allows scientists and artists to collaborate to create ornate useable objects based on living organisms (biomimicry) or mathematical equations.[21] For example, designers Gernot Oberfell, Jan Wertel, and Matthias Bar utilized biomimicry and mathematical equations to create *The Fractal-T*, a 3D-printed coffee table whose base consists of several columns that branch upwards in a mathematical pattern mimicking the growth of trees.[22] The smooth and flat top of the table is created when the branches become so divided and thick that they combine to create a continuous surface. The striking table is thus a combination of a mathematical equation applied to a concept from nature, a computer adaptation of that equation and concept, and a 3D printer. Before 3D printers, such exotic and unique works would have been trapped in the realm of the mind, but now they are just a click away from physical instantiation.

17. *Id*.
18. *See id*.
19. Kooser, *supra* note 14.
20. LIPSON & KURMAN, *supra* note 3, at 175.
21. *See, e.g*., *id.* at 176–95.
22. *Id.* at 177.

C. *Molecular Nanotechnology*

Shane Hope uses his artwork to prepare people for the future of nano-scale manufacturing.[23] He 3D prints enlarged versions of real and imaginative nano-structures and combines them on a canvas to create complex, barnacle-like works of art.[24] To create his nano-structures, he mines research repositories containing computer files of nano-scale objects, such as the biological molecules found in the Protein Data Bank.[25] He then uses various software programs to manipulate the original files iteratively to generate artificial nano-structures.[26] He keeps the interesting files, converts them to 3D printable files, and prints them out.[27] To add more creativity and complexity, he changes the speed of the 3D printer mid-way through a print job, yielding even more unpredictable shapes.[28]

The result is thousands of variegated, small 3D structures that Hope collages together into complex compositions that "straddle[ ] the worlds of art, science and technology, while slyly comparing the utopian promises of 3D printing and molecular manufacturing."[29] Hope believes that his work "foreshadows a forthcoming age of programmable matter,"[30] which is an age where objects will be built atom-by-atom.

Creators such as Dewey-Hagborg, Hope, and others who mix technology and art represent modern-day Leonardo da Vincis, helping to integrate disparate worlds and conceptualize a future where technology allows things barely imaginable today. One unfortunate aspect of these works of art is that they reach a relatively narrow audience—many will only be noticed by those who frequent museums or premium furniture stores. But 3D printing technology offers other opportunities in the world of artistic expression, and as discussed in the next Section, these opportunities are likely to reach millions of people.

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23. *See* Joseph Flaherty, *3-D Printed Paintings Make Jackson Pollock Look Plain*, WIRED (Oct. 10, 2013, 9:30 AM), http://www.wired.com/design/2013/10/3-d-printed-abstract-expressionism. The term "nano-scale" refers to objects measured in billionths of a meter, such as molecules and atoms.

24. *Id.*

25. RCSB PROTEIN DATA BANK, http://www.rcsb.org/pdb/home/home.do (last visited Jan. 3, 2014).

26. SHANE HOPE, http://shanehope.info/?page_id=1357 (last visited Mar. 5, 2014) (answering the fourth question).

27. *Id.*

28. Flaherty, *supra* note 23.

29. Michelle Lhooq, *Map-like Collages Made with Thousands of 3D-Printed Plastic Models*, CREATORS PROJECT (May 21, 2013), http://thecreatorsproject.vice.com/blog/shane-hope-collages.

30. *Id.*

IV. Disseminating Three-Dimensional Art to the Public

The previous Section explored how specialists are testing the boundaries of art and technology. 3D printing, scanning, and computer design programs will allow not only specialists, but also millions of amateurs to create, reproduce, and modify three-dimensional art. By digitizing three-dimensional art, both ancient and modern, people can use the Internet to disseminate the files across the globe to be printed out. Further, a multiplicity of derivative works, parodies, etc., will result when others download the files and use computer programs to add their own artistic twists to existing CAD files.

A. *Digitizing People*

Portraits have existed for thousands of years, though creating them was time consuming and expensive. Photography dramatically lowered the cost of two-dimensional representations of people, and digitization of photography has made them almost costless. 3D printing technology allows the printing and digitization of three-dimensional portraits, which people can instantly share around the world through the Internet and email. Just as amateur photographers and videographers can share their life experiences on sites like Facebook and YouTube, amateur (and professional) artists can share their creations as CAD files.

New popular-culture and artistic forms will emerge from the ability to digitize and print self-representations. For example, companies have already added a third dimension to the well-known photo booth.[31] These companies take a detailed 3D scan of an individual (which can include multiple color photographs that are converted into a three-dimensional image).[32] The resulting 3D file can be shared, modified, or printed in full color. Printed statues already in existence include sentimental moments such as pregnancy, young babies, and—perhaps the pinnacle of wedding narcissism—replicas of couples atop their own wedding cakes.[33]

Companies are using the personal scans in even more creative ways that foreshadow new cultural memes. At least one company helps you put your head on the body of something else, such as an action fig-

31. *World's First 3D Printing Photo Booth to Open*, 3D Focus (Nov. 12, 2012), http://www.3dfocus.co.uk/3d-news-2/3d-printing-3d-news-2/worlds-first-3d-printing-photo-booth-to-open/11105; *see also* Ian Tucker, *Could the Mini-me Make 3D-printing Mainstream?*, The Observer (Sept. 14, 2013), http://www.theguardian.com/technology/2013/sep/15/imakr-3d-mini-me-models.

32. Tucker, *supra* note 31.

33. Helen Collis, *The Ultimate Selfie: 3D Printing Service Creates Photo Real Replicas*, Daily Mail (Aug. 13, 2013, 5:43 PM), http://www.dailymail.co.uk/news/article-2391216/Captured-Dimensions-Texas-offers-ultimate-3d-printing-service-creates-life-like-photo-replicas.html.

ure[34] (raising infringement concerns for action figures protected by copyright or trademark[35]). Videogame makers can use the 3D CAD files as a basis for personalized videogame avatars.[36] While we cannot presently envision all the uses of personal 3D scans and prints, it is clear that an exciting moment of cultural innovation is at hand.

B. *Digitizing Ancient Art*

Have you ever wondered what it would be like to drink from an ancient Grecian kylix (drinking cup)? Or perhaps you have thought about decorating your home with statues and artwork from millennia past? 3D printing technology will bring the average person one step closer to such experiences, because it allows exact digital replicas of ancient three-dimensional art to be shared and printed around the world.

Some of the world's best museums are digitizing their collections so that they may be shared and printed. For instance, the Smithsonian began to three-dimensionally digitize its collection of 137 million objects in 2009.[37] In fact, the two people leading the Smithsonian's effort capture perfectly the art-meets-science theme from Section III of this Article. Vince Rossi and Adam Metallo have fine arts backgrounds, and before starting the digitization project, they used to make props for theater productions.[38] They now are known as the "laser cowboys" for their use of laser-based, three-dimensional scanners to scan a variety of the museum's priceless works of art.[39] They have scanned an ancient Cosmic Buddha sculpture, a rare orchid, and modern art installations.[40]

In part their work is about safely preserving and reproducing fine art. Museums would love to have a replica of a work in case a disaster ruins the original.[41] But previous reproduction methods involved risky physical contact with the original, perhaps with plaster. The three-di-

34. Mark Fleming, *3D Printing Can Turn You Into Superhero*, 3D PRINTER.NET (May 10, 2012), http://www.3dprinter.net/3d-printing-can-turn-you-into-a-superhero.

35. *See infra* Section V.

36. Jane R. LeBlanc, *Captured Dimensions and Its 3D People-Scanning Bring Out the Almost Real You*, THE DALLAS OBSERVER (Sept. 6, 2013, 10:05 AM), http://blogs.dallasobserver.com/mixmaster/2013/09/captured_dimensions_and_its_3d.php; Mike Jackson, *Xbox One Video Shows Off Kinect Facial Scanning*, CVG (Aug. 23, 2013, 11:32 AM), http://www.computerandvideogames.com/426386/xbox-one-video-shows-off-kinect-facial-scanning.

37. Jane J. Lee, *5 Ways Smithsonian Uses 3-D Scanning to Open Up History*, NAT'L GEOGRAPHIC (Sept. 4, 2013), http://news.nationalgeographic.com/news/2013/09/130904-3d-printing-smithsonian-whale-skeleton-technology-science.

38. *Id.*

39. *Id.*

40. *Id.*

41. *See, e.g.*, Ying Yiyuan, *3D Printer Makes Traditional Art*, CCTV (May 31, 2013, 5:42 PM), http://english.cntv.cn/program/newsupdate/20130531/104929.shtml (discussing scans of ancient Chinese art).

mensional scans do not require contact with the original piece, relieving museum curators of a source of anxiety.[42] Moreover, the scans are highly precise, leading to a more faithful replica.

Museums can 3D print the scans to create extra copies for expert study, such as the Smithsonian's replica of a 1,300-year-old Cosmic Buddha statue.[43] The statue is almost six-feet tall, making it difficult to study even putting aside risks of deterioration.[44] But the Smithsonian created a printed copy of the statue that allowed researchers to study it intimately.[45] The result was a revision of the date of the original piece to about 550 to 557 A.D., whereas previous estimates placed it in the range of 581 to 618 A.D.[46]

The 3D printed reproductions need not be limited to use by experts. Because only two percent of the Smithsonian's 137 million-piece collection is publicly available at any one time, the museum is also printing high-quality copies of its works so that many more people can enjoy them.[47] One impressive example is the full-sized replica of a Thomas Jefferson statue that it recently installed for the "Slavery at Jefferson's Monticello: Paradox of Liberty" exhibit at the National Museum of African American History and Culture.[48] The original statue is on display at Monticello, the Thomas Jefferson museum in Virginia, but to increase viewership and protect the original from the perils of transit, the museum created what was at the time the largest 3D-printed, museum-quality historical replica on earth.[49] Such high-quality replicas have the potential to increase significantly the number of people who can intimately experience priceless works of art.

Other museums are opening themselves up to 3D scanning, printing, and archiving. The Skulpturhalle Basel museum in Basel, Switzerland, will allow a 3D printing expert to digitize the museum's extensive collection of high-quality plaster casts of ancient Greek and Roman sculptures.[50] Although these are eighteenth- and nineteenth-century plaster casts of the originals (the originals are spread throughout the world), the casts are very high quality, and the digital files will be made available for free on the Internet for anyone to view, print, and build upon.[51]

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42. *See* Lee, *supra* note 37.
43. *Id.*
44. *Id.*
45. *Id.*
46. *Id.*
47. Daniel Terdiman, *Smithsonian Turns to 3D to Bring Collection to the World*, CNET NEWS (Feb. 24, 2012, 4:00 AM), http://news.cnet.com/8301-13772_3-57384166-52/smithsonian-turns-to-3d-to-bring-collection-to-the-world.
48. *Id.*
49. *Id.*
50. Olin Coles, *Cosmo Wenman Announces 3D-Scans of Ancient Greek and Roman Sculptures*, BENCHMARK REVIEWS (June 17, 2013), http://benchmarkreviews.com/331/cosmo-wenman-announces-3d-scans-of-ancient-greek-and-roman-sculptures.
51. *Id.*

Already technology is progressing such that even laypeople can inexpensively digitize and 3D print reproductions of fine art. For example, in late 2012 the San Francisco Asian Art Museum opened its doors to experts and hobbyists to photograph and scan its works to create a digital archive.[52] Using things as simple as consumer-level digital cameras and iPhones, people photographed objects from multiple angles and fed the photos into 123D Catch, a computer program available for PCs and smartphones, which created a digital three-dimensional copy of the object.[53] Some printed their scans at a nearby tech shop that has high-quality 3D printers and is open to the public.[54] All the scans will be available for free on the Internet.[55]

Events like the Skulpturhalle Basel Museum's and the San Francisco Asian Art Museum's "scanathons" herald an era where fine art is digitized, reproduced, reinterpreted, and experienced in ways previously unimaginable. Cosmo Wenman, the 3D printing enthusiast heading up the project at the Skulpturhalle Basel Museum, foresees a generation whose "aesthetic sensibility [is] informed by direct, hands-on access to the world's sculptural masterworks," and whose "cultural landscape and visual vocabulary will be richer, more complex, and more varied than ours."[56]

Not only can people touch and feel inexpensive reproductions, but they can also remix them to use them in new ways. One of the people from the San Francisco Asian Art Museum's event created an iPhone case based on an ancient work titled *Scene From the Epic Ramayana: Kumbhakarna Battles the Monkeys*.[57] Programs and apps are already appearing that make three-dimensional scanning and remixing accessible to laypeople.[58] Thus, we see the beginning of a time when ancient three-dimensional art can be preserved, disseminated, experienced, and remixed as easily as two-dimensional photographs and paintings.

C. *Digitizing Everyday Things*

Besides the three-dimensional digitization of fine art, 3D printing technology also promises to overhaul three-dimensional jewelry, crafts, and cultural forms.

52. Nathan Hurst, *3D-Print Your Own Ancient Art at Museum Scanathon*, WIRED (Oct. 2, 2012, 6:30 AM), http://www.wired.com/design/2012/10/scanathon/all/1?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+wired%2Findex+%28Wired%3A+Top+Stories%29.

53. *Id.*

54. *Id.*

55. *Id.*

56. Coles, *supra* note 50.

57. Hurst, *supra* note 52.

58. *See, e.g.*, Michael Molitch-Hou, *Matter Remix Remixes Itself with Updates and Business Plan*, 3D PRINTING INDUSTRY (Nov. 20, 2013), http://3dprintingindustry.com/2013/11/20/matter-remix-remixes-updates-business-plan (describing a simple program for manipulating 3D files).

1. Arts and Crafts

For modern creators of arts and crafts, 3D printing technology is an exciting and empowering tool, lowering the costs of production and opening doors to previously impossible geometries. As discussed in Section III,[59] traditional manufacturing techniques can produce only limited geometries. A sculptor described his frustrations before 3D printing was available, stating, "I wanted to develop the drawings I was doing three-dimensionally and there was absolutely no way to do it."[60] 3D printing enables artists to unleash the ideas that have been stuck in their imaginations or on pieces of paper.

Geometric complexity has not been the only thing restraining arts and crafts makers; the high costs of creating manufacturing molds and configuring machinery act as a barrier to many would-be creators.[61] Rather than having to gather the tens of thousands of dollars needed to manufacture arts and crafts on a large scale, 3D printing allows hobbyists and professionals to print only what is needed when it is needed, reducing risk and encouraging participation. One jewelry designer who relies on 3D printing to make her jewelry reported that in one year she spent $25,000 to print numerous pieces, a sum of money that would have only been enough to make about thirty pieces using traditional manufacturing methods.[62] Now that 3D printing has largely removed the twin barriers of geometric complexity and manufacturing start-up costs, a hundred (or in this case, a million) flowers of creativity can blossom.[63]

2. Culture

3D printing fosters creativity throughout the cultural arena. Programs and apps already permit the editing and sharing of three-dimensional files (think Instagram for 3D files).[64] While many of the millions of resulting files will be mundane and inconsequential, collectively they represent a tidal wave of cultural innovation and participation in the new "semiotic democracy."[65] We will live in a world that

59. *See supra* note 20 and accompanying text.

60. *How 3D Printing is Changing the Arts and Crafts World*, NDTV GADGETS (May 16, 2013), http://gadgets.ndtv.com/laptops/news/how-3d-printing-is-changing-the-arts-and-crafts-world-367601 (quoting Joshua Harker).

61. *See, e.g.*, *id.*

62. *Id.*

63. Mao Zedong used the slogan "let a hundred flowers blossom" (often misquoted as a "thousand") ostensibly to encourage diverse approaches to scientific development. *See* MAO ZEDONG, 3 COLLECTED WRITINGS OF CHAIRMAN MAO 216 (Shawn Conners ed., Foreign Language Press trans., El Paso Norte Press 2009).

64. Molitch-Hou, *supra* note 58.

65. "Semiotic democracy" refers to "the ability of 'consumers' to reshape cultural artifacts and thus to participate more actively in the creation of the cloud of cultural meanings through which they move." Peter K. Yu, *Moral Rights 2.0*, 1 TEX. A&M L. REV. 873, 881 (2014) (quoting WILLIAM W. FISHER III, PROMISES TO KEEP: TECHNOLOGY, LAW, AND THE FUTURE OF ENTERTAINMENT 184 (2004)).

will increasingly blur the line between digital representations of objects and the real objects themselves.

An example of the technology's dynamism can be witnessed through the various three-dimensional remix contests that have popped up since 2012. One contest challenged participants to remix design files from furniture designer Tom Dixon's latest creations, offering a prize to the person who made the most creative functional objects based on the original design files.[66] Another contest invited participants to remix a 3D file of a basic gnome (an imaginary creature popular in certain cultural circles).[67] Participants mixed in pop culture to create notable entries such as the Lego Gnome and the alien-popping-out-of-the-chest gnome.[68]

While remix competitions are fun, they are often relatively lighthearted. At the same time, 3D printing technology has already helped to produce more pointed social commentary. Artist Nickolay Lamm used a 3D modeling program and the Centers for Disease Control's measurements of the average nineteen-year-old woman to remix the iconic Barbie doll into a doll having average measurements.[69] After editing his doll to have average measurements, Lamm added Barbie-style clothes, hair, and facial features.[70] He 3D printed his resulting creation and photographed it next to the taller, slimmer Barbie doll as a commentary that "average is beautiful."[71]

The Barbie doll has long been the subject of criticism, in part for her unrealistic body proportions that allegedly contribute to self-image issues in adolescent girls.[72] 3D printing empowers commentators such as Lamm to criticize cultural icons in a third dimension. Whereas previous criticism was confined to words or perhaps drawings, this technology permits commentary to meet Barbie on her home turf, so to speak.

D. *Summary*

As this Section has made clear, 3D printing and related technology will have dramatic effects on the creation, dissemination, study, and preservation of three-dimensional art. The ease with which people can

66. *Disrupt Tom Dixon—A New Design Competition*, STRATASYS (Apr. 16, 2013), http://blog.stratasys.com/2013/04/16/tom-dixon-design-competition-3d-printing.

67. Evan Chavez, *Thingiverse Gnome Remix Challenge Showcased Artistic Influences*, 3D PRINTING INDUSTRY (Oct. 7, 2013), http://3dprintingindustry.com/2013/10/07/thingiverse-gnome-remix-challenge-showcased-artistic-influences.

68. *Id.*

69. Scott Stump, *'Normal' Barbie Uses Real Women's Measurements*, TODAY (July 3, 2013, 4:56 PM), http://www.today.com/news/normal-barbie-uses-real-womens-measurements-6C10533511.

70. *Id.*

71. *Id.*

72. Sarah Kershaw, *Ruth Handler, Whose Barbie Gave Dolls Curves, Dies at 85*, N.Y. TIMES (Apr. 29, 2002), http://www.nytimes.com/2002/04/29/arts/ruth-handler-whose-barbie-gave-dolls-curves-dies-at-85.html?ref=barbiedoll.

scan three-dimensional objects and manipulate and share the resulting CAD files promises a new era of creativity and artistic flourishing. Yet anyone familiar with copyright law will realize that the same features that make 3D printing technology exciting also make it a tool for violating copyright law. The next Section explores this concern.

V. The Problem of Piracy

Enthusiasm about 3D printing's great potential for fostering creative works is tempered by concerns over piracy. As the copyright battles over musical recordings taught us, any protected work that can be digitized can be infringed repeatedly with ease.[73] Even top government officials have noted both the promise of 3D printing technology and its potential to facilitate piracy.[74]

The potential for massive piracy could disrupt the incentives to produce creative works. Whether the creative work is a unique statue or a mass-produced ornamental trinket, a would-be infringer can scan the object and print as many copies as he wants. Likewise, the person can share the file on the Internet, allowing many more people to print the object. Clearly, if someone 3D prints an object identical to one that is copyrighted, a claim for copyright infringement exists.[75] But because many 3D printers will be used inside of peoples' homes, detecting the actual prints will often be difficult or impossible. What the original author would like to protect, therefore, is both the object itself and the CAD file for making it.

Thus, to understand the full extent of the piracy risks that 3D printing technology will bring, one must first determine which CAD files, if any, are protected by copyright. Copyright law protects "original works of authorship," which can include, among other things, "literary works" and "pictorial, graphic, and sculptural works" ("PGS works").[76] After discussing how to characterize CAD files under the

73. *See generally* Peter K. Yu, *P2P and the Future of Private Copying*, 76 U. Colo. L. Rev. 653 (2005).

74. U.S. Intellectual Property Enforcement Coordinator, 2013 Joint Strategic Plan on Intellectual Property Enforcement 6 (June 2013), *available at* http://www.whitehouse.gov/sites/default/files/omb/IPEC/2013-us-ipec-joint-strategic-plan.pdf ("[J]ust as 3D printing offers the opportunity to make meaningful contributions to our society, there also exists the opportunity for individuals who look to exploit others' hard work to abuse this technology by trading in counterfeit and pirated goods, of which we must be cognizant and diligent in our efforts to prevent.").

75. This assumes the absence of a fair use argument or other defense. The bulk of this Section V will not consider the traditional infringement question of whether one physical object infringes another copyrighted physical object; that issue is largely the same whether the device is 3D printed or made in some other manner. For an excellent exploration of when 3D printed items (as opposed to the CAD files) fall within copyrightable subject matter. *See* Edward Lee, *Digital Originality*, 14 Vand. J. Ent. & Tech. L. 919, 948–50 (2012). Note also that some of the infringement in three-dimensional works would probably not displace sales to the original creator. People may be willing to print something for free that they would never pay full price for.

76. 17 U.S.C. § 102(a) (2012).

copyright statute, the bulk of this Section will consider which kinds of CAD files might constitute "original works of authorship" under the statute.

A. *CAD Files Should Be Categorized as PGS Works*

One might conceive of a CAD file[77] as either a "literary work," or as a "PGS work" under Section 102(a) of the copyright statute. At first it might seem strange to characterize a CAD file as a literary work, but it makes sense when one considers that the creative aspects of computer programs are considered protectable as literary works under the statute.[78] Further, copyright law defines a computer program as "a set of statements or instructions to be used directly or indirectly in a computer in order to bring about a certain result."[79] A CAD file (as I use the term) contains all the information (i.e., "instructions") to be used by a printer (i.e., a "computer") to print a three-dimensional object (i.e., "bring about a certain result"). Hence, a CAD file falls within the definition of a computer program under the copyright statute.

Yet computer programs are not protectable in total; rather, they are protectable only "to the extent that they incorporate authorship in the programmer's expression of original ideas, as distinguished from the ideas themselves."[80] Thus, the idea of a program that will print an object or make a spreadsheet is not protectable. Only those parts of the software code, if any, that represent nonessential, creative expression receive protection.[81] Generally, most software code exists for utilitarian purposes, e.g., to achieve a certain result in a fast and trouble-free manner, and only contains a kernel of creative expression.[82] With CAD files, however, the code/text of the file itself would not appear to contain *any* creative expression, because unlike computer programs for applications, there is only one (or very few) ways to achieve the result.[83] That is, for a CAD file to print a coffee cup of certain dimen-

77. The reader should recall that I am using the term "CAD file" here to refer generically to any computer file that can instruct a 3D printer to print an object. The file might be an .stl file or any other relevant type. Although the 3D CAD file can also be shown two-dimensionally on a computer screen, I do not use "CAD file" herein to mean files used solely for two-dimensional printouts or files that are incapable of directly being used to print three-dimensional objects.

78. *See, e.g.*, Apple Computer, Inc. v. Franklin Computer Corp., 714 F.2d 1240, 1247–48 (3d Cir. 1983) (discussing statute and legislative history with respect to protection for programs); *see also* 17 U.S.C. § 117.

79. 17 U.S.C. § 101.

80. H.R. Rep. No. 1476, 94th Cong., 2d Sess. 54 (1976); *see id.* (stating that "literary works . . . includes computer programs to the extent that they incorporate authorship . . . .").

81. *See, e.g.*, Computer Assocs. Int'l v. Altai, Inc., 982 F.2d 693, 706 (2d Cir. 1992).

82. *Id.* at 706–12.

83. This is not to say that the underlying object is not creative—it may very well be. But the code/contents of the CAD file will only include the necessary information

sions, the CAD file must contain instructions exactly corresponding to those dimensions.

If CAD files are not protectable as literary works, they may still in some instances qualify as PGS works. The statute defines PGS works in part as "two-dimensional and three-dimensional works of fine, graphic, and applied art, photographs, prints and art reproductions, maps, globes, charts, diagrams, models, and technical drawings, including architectural plans."[84] Thus, a CAD file of an object (assuming the object contains the appropriate originality, as discussed later) is potentially protectable as a PGS work.[85] Of course, strictly utilitarian objects do not count as PGS works,[86] and this qualification will affect many CAD files. But before discussing limits on utilitarian objects in Section V.C, the next sub-section looks at the originality requirement.

B. *CAD Files May Contain Originality*

Because copyright law protects only "original works of authorship,"[87] originality is the touchstone of U.S. copyright law. For a work to be "original" the Supreme Court has stated that it must be (1) independently created and (2) possess a modicum of creativity.[88]

1. Independent Creation

The *Feist* Court explained that "independently" created means the author did not slavishly copy from other works.[89] Hence, simply copying a public-domain Shakespearean sonnet will not count as independent creation. On the other hand, if someone truly had no access to Shakespeare's sonnet, and yet happened by amazing coincidence to write the exact same words independently, the work could be protected.[90]

(in the form of zeroes and ones without any creative flourish) for printing that object. The object may be copyrightable, but not the instructions for printing it.

84. 17 U.S.C. § 101.

85. It may seem strange to call the CAD file itself a graphic work because one cannot see the "file," only the results of the file (on a computer screen on in a printed object). A CAD file is simply a collection of zeroes and ones that will cause a computer screen to display the object or a printer to print it. Nevertheless, the statute covers works "fixed in any tangible medium of expression . . . from which they can be perceived, reproduced, or otherwise communicated, either directly *or with the aid of a machine or device*." 17 U.S.C. § 102(a) (emphasis added). The CAD file can be perceived with the aid of a computer screen (two-dimensionally) and a printer (three-dimensionally).

86. *See infra* notes 115–16 and accompanying text.

87. 17 U.S.C. § 102(a).

88. Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 345 (1991).

89. *Id.*

90. *Id.* at 346 (citing Sheldon v. Metro-Goldwyn Pictures Corp., 81 F.2d 49, 54 (2d Cir. 1936)).

When dealing with PGS works, however, one must be careful not to read too much into the prohibition against copying. For centuries copyright law has protected artists' realistic depictions of real-world things, such as Cezanne's fruit. As professor Edward Lee explains, "[A]n art student who realistically draws a mountain, machine, or motorcycle has independently made the drawing, even though the artist strives to depict the mountain, machine, or motorcycle in a way that is identical to the real thing."[91] This is because the artist who draws something, unlike the plagiarist who copies mere words of a document, necessarily imparts some independent creation to the work. As Justice Holmes long ago stated,

> It is obvious also that the plaintiff's case is not affected by the fact, if it be one, that the pictures represent actual groups,—visible things. . . . But even if they had been drawn from the life, that fact would not deprive them of protection. The opposite proposition would mean that a portrait by Velasquez or Whistler was common property because others might try their hand on the same face. Others are free to copy the original. They are not free to copy the copy. The copy is the personal reaction of an individual upon nature. Personality always contains something unique. It expresses its singularity even in handwriting, and a very modest grade of art has in it something irreducible, which is one man's alone. That something he may copyright unless there is a restriction in the words of the act.[92]

The requirement of independent creation has much relevance to CAD files. CAD files can be created at least two ways: (1) someone may create a depiction of the three-dimensional object directly in a CAD program (much like one can make a two-dimensional drawing in many computer programs like Microsoft Paint), or (2) she may simply use a 3D scanner to scan the object, allowing a computer to create the CAD file. The first method, drawing the object in a CAD program, would appear to be analogous to painting a picture of the object on a canvas. As such, the drawing or CAD file would likely be "independently" created just like any other painting[93] because the person drawing the object will necessarily impart some personality to it, at least according to Justice Holmes.[94]

The second method, scanning the object, may not qualify as independent creation because the scanner rather than a person does all the

91. Lee, *supra* note 75, at 938.

92. Bleistein v. Donaldson Lithographing Co., 188 U.S. 239, 249–50 (1903) (citations omitted).

93. Note that the CAD file might lack a modicum of creativity (discussed in Section V.B.2) and might itself constitute a useful object (discussed in Section V.C).

94. *Bleistein*, 188 U.S. at 250 ("The copy is the personal reaction of an individual upon nature."); *see also* Lee, *supra* note 75 at 939–40 (describing a scientific study suggesting that "realistic depictions require skill, individual choices, and the personal reaction and experience of the creator").

work.[95] The same may largely be said of photography, yet most photographs are copyrightable (assuming all the statutory requirements are met).[96] The photographer "independently" creates the picture when she chooses to push the button on her camera. Similarly, the one who initiates the 3D scan may be said to "independently" make the scan. Thus, even three-dimensional scans may qualify as "independent" creations. Whether they meet the "modicum of creativity" requirement, however, is considered next.

2. Modicum of Creativity

The *Feist* Court also required works to have a "minimal degree of creativity" before they could be protected by copyright.[97] The Court explained that "the requisite level of creativity is extremely low; even a slight amount will suffice. The vast majority of works make the grade quite easily, as they possess some creative spark, 'no matter how crude, humble or obvious' it might be."[98] The Court provided little guidance on what might count as minimum creativity, but it did state that compilations of facts "cannot be so mechanical or routine as to require no creativity whatsoever."[99]

a. CAD Files Created from Scratch

First, consider the requirement of a modicum of creativity as applied to CAD files created from scratch by a person using a CAD program. Many such files would contain a modicum of creativity. For example, a CAD file of a creative shape would meet the test, because the artist's creativity is captured inherently in the CAD file. But what about a CAD file made to mimic an actual object, such as a hammer? One might extend Justice Holmes's reasoning in *Bleistein* and contend that just as an artist who attempts to realistically recreate an object includes his "personal reaction . . . upon nature,"[100] so too would the CAD file creator add something personal to the hammer.[101] In the painting, the creativity is manifested in the brushstrokes and colors that vary imperceptibly from the real item. Likewise, the CAD file's

95. Assuming a person does not alter the CAD file after the initial scan. Significant post-scan alterations to a CAD file would meet the "independent" requirement.

96. 17 U.S.C. § 101 (2012) (defining PGS works to include photographs).

97. Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 345 (1991).

98. *Id.* (quoting NIMMER & NIMMER, *infra* note 109, § 1.08[C][1] (1990)).

99. *Id.* at 362 (finding the alphabetical listing of names and phone numbers in the white pages to lack any creativity).

100. Bleistein v. Donaldson Lithographing Co., 188 U.S. 239, 250 (1903).

101. *See* Lee, *supra* note 75, at 940 (citing R.C. Miall & John Tchalenko, *A Painter's Eye Movements: A Study of Eye and Hand Movement During Portrait Drawing*, 34 LEONARDO 35, 39 (2001)) (describing ways in which an artist imparts creativity even when attempting to paint something as realistically as possible).

creativity can be found in the dimensions that differ slightly from the real object.[102]

Conversely, it may be that CAD programs sometimes remove the "personal touch" of the person drawing the hammer such that the depictions do not differ from reality in any creative way. Imagine, for example, a CAD program that assisted the user in creating accurate lines and angles based on measurements from the original object, or that provided the user stock shapes that needed only to be varied by the user. In that case there might not be a modicum of creativity in the CAD drawing. Hence, courts may need to assess the creativity of hand-drawn CAD files depicting real-world objects on a case-by-case basis.

A separate line of reasoning may offer support for the idea that CAD files drawn from scratch contain a modicum of creativity. One could analogize CAD files to technical drawings, which the copyright statute explicitly includes as protectable subject matter.[103] Of course, technical drawings can be copyrighted only to the extent they contain some minimal creativity. Yet technical drawings, by their very nature, are not very creative—they are used to display the uncopyrightable facts about an item. In many technical drawings, artistic decisions are removed regarding subject matter, color, lighting, shading, and perspective. How then are technical drawings ever copyrightable?

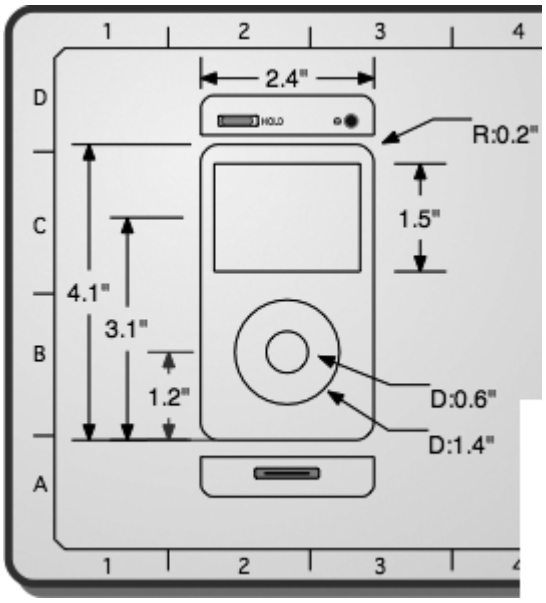
Technical drawings may have creativity in at least two ways. First, as discussed previously,[104] even basic drawings intended to replicate reality may contain some inherent, perhaps even accidental creativity. Second, even if the drawing of the object itself lacks creativity, many technical drawings may contain creativity in the way they display additional technical information, such as measurements, tolerances, etc. For illustration purposes, Figure 1 is an excerpt of a simple technical drawing containing the object's dimensions:

102. Note that copyright law in the United States does not equate creativity with effort. *See Feist Publ'ns, Inc.*, 499 U.S. at 352–59 (rejecting the "sweat of the brow" doctrine). The amount of effort or time a draftsperson expends in creating the CAD file is not what is important; it is whether any of the effort included creativity.

103. 17 U.S.C. § 101 (2012) (including "technical drawings" within the definition of PGS works); *see also* Forest River, Inc. v. Heartland Recreational Vehicles, LLC, 753 F. Supp. 2d 753, 758 (N.D. Ind. 2010) (noting that technical drawings can be protected by copyright); Gusler v. Fischer, 580 F. Supp. 2d 309, 315 (S.D.N.Y. 2008) (same); Nat'l. Med. Care, Inc. v. Espiritu, 284 F. Supp. 2d 424, 433–34 (S.D. Va. 2003) (same). None of the cited cases discussed whether or to what extent the technical drawings contained creativity.

104. *See supra* notes 98–99 and accompanying text.

FIGURE 1: SIMPLE TECHNICAL DRAWING



While technical information such as dimensions consists of uncopyrightable facts, the author arguably makes creative choices regarding how to compile and portray those facts.[105] But many 3D CAD drawings differ from traditional technical drawings because many 3D CAD drawings are meant primarily for three-dimensional printing, as opposed to two-dimensional viewing. As such, CAD files may not visually display measurements and tolerances, which may make it more difficult to protect them through copyright.

b. CAD Files Created from a Three-Dimensional Scan

One must also consider whether a CAD file created by simply scanning an object contains a modicum of creativity. Taking a three-dimensional scan of an item suggests an analogy to photography. In both cases, a user essentially pushes a button and a machine does almost all the work. Yet courts almost always find that photographs include creativity because of the photographer's choices of "posing the subjects, lighting, angle, selection of film and camera, evoking the desired expression, and almost any other variant involved."[106] When taking a three-dimensional scan of an object for reproducibility pur-

105. In Figure 1, for instance, the draftsperson could have swapped the labels on the right and left. On the other hand, in some cases engineering conventions might render even this information devoid of creativity.

106. Rogers v. Koons, 960 F.2d 301, 307 (2d Cir. 1992); *see also* Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53 (1884) (seminal case recognizing copyrightability of photographs).

poses,[107] however, most if not all of these variants vanish: the goal is to get an exact and accurate scan of the object. There is no choice of posing, lighting, angling, etc.

Indeed, a utilitarian three-dimensional scan of an object is more akin to those few photographs that have been held not to be protectable. For example, in *Bridgeman Art Library v. Corel Corp.*,[108] the court held there was no originality in transparencies of paintings where the goal in photographing the works "was to reproduce the underlying works with absolute fidelity," thus minimizing or eliminating any individual expression.[109] Because the goal of a utilitarian three-dimensional scan is to reproduce the work with absolute fidelity without any creativity by the one initiating the scan, such scans would likely not be protected by copyright.[110]

The result might be different, perhaps, if a person altered the resulting CAD file to enhance or improve it. While no reported case has explored this exact issue, in *Lucky Break Wishbone Corp. v. Sears Roebuck & Co.*[111] the court suggested that changes made after three-dimensionally scanning an object can add creativity sufficient to impart originality.[112] The copyright holder in *Lucky Break Wishbone* three-dimensionally scanned a real turkey wishbone and used the scan to create graphite electrodes in the wishbone shape, which in turn were used to make a hollow mold, which ultimately was used to mass produce plastic wishbones.[113] The court held that the smoothing and subtle shaping of the graphite electrodes constituted sufficient original expression to support a copyright in the resulting plastic wishbones.[114] It follows that had the same changes been made to the CAD file and not the graphite electrodes, the CAD file itself would contain the necessary original expression to support a copyright.

107. One could intentionally distort a scan for artistic purposes, but I am assuming the scan is made with a goal of accuracy, not art.

108. The Bridgeman Art Library, Ltd. v. Corel Corp., 36 F. Supp. 2d 191 (S.D.N.Y. 1999).

109. *Id.* at 197; *see also* Schrock v. Learning Curve Int'l, Inc., 586 F.3d 513, 519 (7th Cir. 2009) (recognizing there exists a "narrow category of photographs that can be classified as 'slavish copies,' lacking any independently created expression"); 1 MELVILLE B. NIMMER & DAVID NIMMER, NIMMER ON COPYRIGHT § 2.08[E][2], n.210 (2013) (citing cases).

110. *See* Michael Weinberg, *What's the Deal with Copyright and 3D Printing?*, PUBLIC KNOWLEDGE 15 n.49 (Jan. 29, 2013), http://publicknowledge.org/Copyright-3DPrinting.

111. Lucky Break Wishbone Corp. v. Sears Roebuck & Co., 373 Fed. App'x 752 (9th Cir. 2010).

112. *Id.* at 756–57.

113. *Id.* at 756.

114. *Id.* at 755, 757.

C. *CAD Files Will Not Be Copyrightable If They Constitute Useful Articles*

Even if CAD files meet copyright's originality requirement, a portion of the statutory definition of a PGS work relating to "useful articles" may pose problems. The copyright statute limits the copyrightability of a PGS work by stating,

> Such works shall include works of artistic craftsmanship insofar as their form but not their mechanical or utilitarian aspects are concerned; the design of a *useful article*, as defined in this section, shall be considered a pictorial, graphic, or sculptural work only if, and only to the extent that, such design incorporates pictorial, graphic, or sculptural features that can be *identified separately from*, and are capable of existing independently of, the utilitarian aspects of the article.[115]

The premise behind this definitional limitation is logical: copyright protects creative expression and not useful articles; because some articles may have both creative and utilitarian aspects, the law must draw a line between what is protectable and what is not. A normal coffee cup is not copyrightable, but a work of art painted onto a coffee cup is. But what about a fancy-shaped coffee cup? Unfortunately, attempting to draw this line has proved an exercise in metaphysics. The statute has spawned a vast body of literature and case law seeking to discern when copyrightable expression is physically and conceptually "separable" from utilitarian aspects of an article.[116]

It may be, however, that one can avoid the ephemeral separability issue with CAD files. By its own terms, the definitional limitation to PGS works applies only to "useful articles."[117] The statute defines a "useful article" as "an article having an intrinsic utilitarian function that is not merely to portray the appearance of the article *or to convey information*."[118] It has been noted that technical drawings and architectural plans exist solely to "convey information," and as such are not useful articles.[119] If CAD files are sufficiently analogous to technical drawings and architectural plans, they are not useful articles and could be freely copyrighted.

In one sense, CAD files, like technical drawings, simply "convey information": when a CAD program displays the file on a computer screen, the file merely conveys information regarding what it would

115. 17 U.S.C. § 101 (2012) (emphasis added).

116. *See, e.g.*, NIMMER & NIMMER, *supra* note 109, § 2.08[B][3]; Robert C. Denicola, *Applied Art and Industrial Design: A Suggested Approach to Copyright in Useful Articles*, 67 MINN. L. REV. 707 (1983); Eric Setliff, *Copyright and Industrial Design: An "Alternative Design" Alternative*, 30 COLUM. J.L. & ARTS 49, 63 (2006).

117. 17 U.S.C. § 101.

118. *Id.* (emphasis added).

119. NIMMER & NIMMER, *supra* note 109, § 2.08[D][2][a]; *see also* Infodek, Inc. v. Meredith-Webb Printing Co., 830 F. Supp. 614, 623 (N.D. Ga. 1993) (technical instructions).

look like if printed. Of course, the file also tells the printer how to print the object, but this could likewise be characterized as the CAD file merely "conveying information" to the printer regarding what to print. If this view is correct, CAD files are not useful articles.

1. Analogies to Molds and Photographic Film Negatives

In another sense, however, CAD files are more like the *method* by which the article is created.[120] Viewed this way, CAD files are more akin to molds used in injection molding processes and the like. Molds do more than merely convey information, and they may not be copyrightable because they are useful articles (their utility is their ability to force other substances to conform to a predetermined shape).[121] If this view is adopted, CAD files cannot be protected by copyright if their utilitarian aspects cannot be separated from their pictorial, graphic, or sculptural features.[122]

Discerning whether molds of creative objects are useful articles under the statute demonstrates the difficulty of applying the separability tests. The physical separability test sounds easy to apply: Can the creative features be physically removed from the utilitarian object?[123] But the test is difficult to apply in practice.[124] On one hand, there is no apparent way to separate the ornate shape of the mold from the mold itself—take away the shape, and you take away the mold. This can be shown by imagining a *closed* mold and then peeling away outer layers until you peel away the artistic shape: one is left with nothing but air. On the other hand, imagine the mold is *open*: now one can peel away just the inner, ornate shape, and one is left with an unexciting mold that makes a plain, amorphous object. The conceptual separability[125] test is even more unhelpful; the answer might depend on which test one applies, and whether the object is simply "a mold" (in which case the ornate features are easily separated in the mind, leaving an amor-

120. Osborn, *supra* note 4, at ___ ("[T]he CAD creator's purpose is not . . . simply to create the image or convey information, but to create the image *as a means to* make a utilitarian article.") (emphasis in original).

121. Research revealed no case law analyzing whether molds are useful articles under the copyright statute. *But see* S.K. Potteries & Mold Co. v. Sipes, 192 U.S.P.Q. 537, 537 (N.D. Ind. 1976) (involving a copyright registration issued under the pre-1976 copyright statute for molds for Christmas ornaments; the court did not determine the validity of the registration).

122. *See* 17 U.S.C. § 101.

123. *See* Mazer v. Stein, 347 U.S. 201, 218 (1954). While *Mazer* is a pre-1976 Act case, the 1976 Act attempted to codify its result. Denicola, *supra* note 116, at 720–21.

124. Denicola, *supra* note 116, at 730.

125. If one uses a relatively broad physical separability test for molds, there may be no need to apply a conceptual test. While courts vary in the test they use for conceptual separability, the tests attempt to discern whether the object has some creative features that are distinct from and uninfluenced by its utilitarian features. *See, e.g.*, Brandir Int'l, Inc. v. Cascade Pac. Lumber Co., 834 F.2d 1142 (2d Cir. 1987); Denicola, *supra* note 116, *passim*.

phous mold) or "a mold for a particular creative object, e.g., a dragon sculpture," in which case there is no separability.[126]

One might also analogize CAD files to photographic film negatives.[127] The film negatives are useful objects because they are essentially the method by which the photograph is made. Yet negatives of photographs that are otherwise eligible for copyright protection can themselves be copyrighted.[128] A negative is like a two-dimensional mold, so perhaps three-dimensional molds for creative shapes are likewise copyrightable.

2. Should CAD Files Be Protected Through Copyright or Design Patents?

The upshot of this analysis is that there is room for disagreement regarding whether and to what extent CAD files are useful articles that copyright law will not protect. Perhaps one cannot separate any PGS aspects of a CAD file from its utilitarian purpose, because the CAD file's usefulness lies in its ability to print—in exact detail—whatever object it is designed for. Or perhaps one can separate the specific, creative shape detailed in the CAD file from the generic CAD file.

Where the statute and case law yield unclear results, policy should influence the outcome. The reality is that if the law does not directly protect CAD files for creative works, and instead protects only the printed object, the rights holder will have a very difficult time protecting her work. The unprotected CAD file will be reproduced, posted on the Internet, and shared around the world.[129] The digital music litigation demonstrated that in a world of peer-to-peer networks it is very difficult to discover who actually *uses* files from the Internet (as opposed to simply making them available).[130] Protection in the physical object will be largely meaningless when the Internet and decentralized 3D printing make it virtually impossible to detect who printed the CAD file and when.[131]

Some would argue that the difficulty of proving who prints the physical objects embodied in CAD files suggests copyright law should

126. Thanks to Professor Steven Jamar for helping to clarify this point.

127. Thanks to Professor Shubha Ghosh for this point.

128. NIMMER & NIMMER, *supra* note 109, § 2.08[E] (citing 37 C.F.R. § 202.13 (1959); Copyright Act of March 3, 1891, § 5952).

129. A recent example outside the copyright context is a CAD file for a gun that reappeared across the internet after the United States government forced its original creator to remove the file from his website. Ernesto, *Pirate Bay Takes Over Distribution of Censored 3D Printable Gun*, TORRENTFREAK (May 10, 2013), https://torrentfreak.com/pirate-bay-takes-over-distribution-of-censored-3d-printable-gun-130510/.

130. *See* Yu, *supra* note 73, at 658–60.

131. If an infringer printed multiple copies for sale, the copyright holder could learn of the infringing sales. But if only individuals printed the files, the copyright holder would essentially never learn of it.

directly protect CAD files. Others, however, would argue that it would be detrimental to society to offer CAD files the lengthy protection of the copyright term, which generally lasts for the life of the author plus seventy years.[132] The long copyright term would foreclose much follow-on creativity. Further, to the extent that CAD files represent useful objects in whole or in part, society should have access to these useful objects.

One way to shorten protection for CAD files under current law would be to exclude them from copyright protection and channel them instead to design patent protection.[133] Design patents protect the ornamental design of functional items[134] and last only fourteen years from the date of grant.[135] Design patents are often granted for molds,[136] so no changes in current law would be needed.

Limiting protection of CAD files to design patent protection would, compared to copyright, generally restrict the rights of the original creator of the work. In addition to having a shorter term than copyrights, design patents are more expensive and difficult to obtain.[137] If the law limited the creator's protection, it would tend to reduce incentives to produce creative works. But the magnitude of the reduced incentive and the desirability of it are both open for debate. Perhaps the extra incentive from protecting the CAD file is not needed, or perhaps the offsetting freedom for future authors to build off the CAD file outweighs the costs. Full answers to these questions are left for future scholarship, keeping in mind not only utilitarian perspectives, but also the natural or moral rights of the authors and follow-on creators.

VI. CONCLUSION

3D printing technology has an exciting future ahead of it. Sections III and IV of this Article demonstrated some of the remarkable benefits the technology can bring, while Section V showed some of the potential for misuse of the technology. This tension is nothing new in copyright law, but the contours of this iteration must be understood if the law is to respond to it optimally. This Article begins the work of mapping the contours of 3D printing technology's effect on copyright law.

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132. 17 U.S.C. § 302(a) (2012).

133. The law used to channel protection into one and only one form of intellectual property protection, but under current law one can protect a design with both copyright and design patent. *See In re* Yardley, 493 F.2d 1389, 1394 (CCPA 1974) ("Congress has not provided that an author-inventor must elect between securing a copyright or securing a design patent.").

134. *See* 35 U.S.C. § 171(a) (2012).

135. *Id.* § 173.

136. *See, e.g.*, Hupp v. Siroflex of Am., Inc., 122 F.3d 1456 (Fed. Cir. 1997) (design patent for a mold for producing simulated stones for a pathway). The case did not discuss whether the mold or the object made by the mold were eligible for copyright.

137. There are many differences between design patents and copyrights, but a detailed analysis is beyond the scope of this Article.