In June 2011 Leon Amiel Jr. was sentenced to two years imprisonment by a U.S. District court for his part in a ring that sold fake prints of Salvador Dalí and other high profile artists. Amiel Jr. is the grandson of New York art book publisher Leon Amiel (“Amiel Sr.”) who was a major producer of fake prints in the 1980s. Amiel Sr. was able to utilize new developments in photomechanical reproduction of the late 1970s to make thousands of fakes that were nearly identical to the original prints. Although he died before federal investigators could catch up with him, Amiel Sr.’s business was continued by family members who were ultimately caught and convicted for their activities. Nearly 70,000 fakes were destroyed by the authorities, but a collection of his grandfather’s prints remained intact and available for Amiel Jr. to resume selling to unwitting buyers on eBay until he too was caught and convicted.

The legacy of the Amiel family illustrates how advances in technology have made the forgery and sale of artwork easier and its detection harder. Today, this has progressed to the point where it is possible to manufacture copies of paintings with virtually identical 3D brushwork as the original, such as the five Vincent van Gogh masterpieces being reproduced for sale by the Van Gogh Museum in Holland through advanced Fujifilm technology (FIGS. 1-3).

The rapid development of 3D printing technology has also made it possible to reproduce three-dimensional artworks themselves. The forgery of sculpture and the material arts will no longer be confined to skilled craftsmen, but will be accessible to a new class of “technician” forgers adept at manipulating and even advancing new technologies. Because 3D printing has the potential to achieve an exact likeness of the original artwork, the detection of fraudulent works will become more difficult, requiring more emphasis on techniques of authentication.

IMITATION AND FORGERY

The copying and imitation of great art has long been a part of the art world. In the Western tradition, young apprentices would imitate their masters in order to learn technique as part of the process of artistic growth. In the Chinese painting tradition, precise imitation was a form of flattery and considered to be both a demonstration of the artist’s own skill and a tribute to the greatness of prior masters. However, as the art industry has developed, and the value of the works of established artists has increased, imitation not as flattery but as forgery has introduced an undesirable element of risk into art collecting.
Forgery, in this sense, denotes the deliberate imitation of style and technique to pass off a work of art as having been created by another artist usually of greater fame and market value. Many infamous forgers have produced fakes by passing off their work as newly discovered works or pastiches of existing works by popular masters. The Dutch forger, Han van Meegeren, is a well-known example of this. He produced works that were attributed to Johannes Vermeer and sold them as such before confessing to his fraud. More recently, Wolfgang Beltracchi was convicted by a German court for thousands of forgeries that he described as the “unpainted pictures of other artists.”

The extreme manifestation of imitation is the identical copy. Copying an artwork created by the free hand of an artist (as painting often is) has historically required a high level of skill and craftsmanship. It is more difficult to make a replica of a known artwork than to pass off a stylistically consistent forgery as being previously unknown when it is subject to the scrutiny of experts who are intimately familiar with an artist’s work and career. Advancing technologies have made valuable works increasingly prone to forgery through unauthorized reproduction by a new class of forgers. Just as Amiel Sr. took advantage of technology in his day, it will not be long before other opportunists will learn to employ cutting-edge 3D printing technology to make convincing forgeries of sculptures, ceramics, antiques and other valuable 3D objects such as jewelry.

**3D SCANNING: MAKING THE BLUEPRINT**

3D printers operate according to the data stored in a digital file, so the first step in the process is to use computer-assisted design (“CAD”) software to produce an accurate 3D image that will serve as a digital “blueprint.” Scanning technology is capable of generating such blueprints, and recent advances have made it possible to produce high quality results inexpensively and with relative ease.

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6 The exact number of his forgeries is not known, but Beltracchi claims to have forged work by more than 50 artists including Max Ernst, Fernand Léger, Heinrich Campendonk, André Derain, and Max Pechstein: See “Interview with Wolfgang Beltracchi: Confessions of a Genius Art Forger,” *Spiegel* (9 March 2012) online, Spiegel Online International <http://www.spiegel.de/international/germany/spiegel-interview-with-wolfgang-beltracchiconfessions-of-a-genius-art-forger-a-819934.html>.
3D scanners are already employed in the research and preservation of art. Researchers at the University of Leuven, Belgium, have used 3D scanning as a forensic tool to analyze and verify the brushstrokes of a disputed painting attributed to Peter Paul Rubens. In another example, conservators at the Institute of Information Science and Technologies in Pisa, Italy, used 3D scanning as a modeling tool to virtually reassemble the statue La Madonna di Pietranico (shattered in the 2009 earthquake in the Abruzzo region) before commencing the physical restoration process.

Cultural institutions have also started using 3D scanning as a tool to document their artifacts. Recently, the Smithsonian Institution announced an initiative to make some of its massive collection available to the public through 3D models. Key objects of the collection being scanned include the Wright Brothers’ first airplane, Amelia Earhart’s flight suit and a Civil War gunboat. Clearly, 3D scanning will be increasingly useful for generating databases of 3D-modelled artworks; however, as galleries, museums and collectors develop these databases, the potential for the 3D models of their sculptures, artifacts, and artwork to become widely available for potentially nefarious uses will also increase.

**DISSEMINATION OF THE “BLUEPRINT”**

There is currently at least one initiative underway to scan art objects and disseminate them over the Internet. In June 2013, the entrepreneur Cosmo Wenman announced a project to 3D scan part of the collection of the Skulpturhalle Basel, which contains plaster casts of ancient Greek and Roman sculptures. His attempt to raise money through the crowd-sourcing website Kickstarter was unsuccessful, but he maintains his intention to continue with the project and make the data available so that “anyone, anywhere” can access them for their own purposes. On the website Thingiverse, where Wenman and others release 3D printable files into the public domain, the Art category already contains 3D scans of valuable sculptures for download, including pieces made available by the Art Institute of Chicago.

Even if a 3D digital model is not released generally, it may still become a target of theft to serve as a blueprint for a forgery. This could easily be achieved by a skilled computer hacker, a dishonest technician, or the artwork may otherwise be scanned surreptitiously by forgers equipped with portable scanners.

The company Artec Group, for example, produces a portable scanner that it claims is able to quickly and accurately scan objects of various sizes without the need to move the object or place markers on the object being scanned. In the future it will not even be necessary to purchase special hardware to make high quality portable scans. Microsoft has announced that it is currently developing a mobile phone app capable of producing scans sufficient for 3D printing. With technologies like these, future forgers will easily be able to create digital models of valuable artworks without detection.

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7 3D-Coform, online: <http://3d-coform.eu>.
9 Each piece was scanned so that the statue could be virtually modeled before the actual reconstruction process commenced: Roberto Scopigno, “Sampled 3D models for Cultural Heritage: which uses beyond visualization?”, Virtual Archaeology Review (2012) vol 3, no 5 at 4, online: Virtual Archaeology Review <http://varjournal.es/doc/varj03_005_21.pdf>.
CONTEMPORARY 3D PRINTERS

3D printing is a popular term used to describe certain additive manufacturing technologies, which have been employed by industry since the mid-1980s for various uses including prototypes and small scale production. Among the methods available are fused deposition modelling ("FDM"), selective laser sintering ("SLS"), and stereolithography ("SLA"). Each method proceeds by building up layer on ultrathin layer of material until the final object has been "printed." In the case of FDM, molten plastic is extruded through the nozzle of the printer to build up each layer. SLS and SLA each employ lasers to bond the print material into form in each layer — SLS fuses fresh layers of powdered material on each pass to build up its layers, and SLA works in a similar way, using a liquefied material or resin instead of powder. Each method has advantages and limitations and suitability for different materials.

In 2007, the expiration of important patents opened the way for the development of "home" 3D printing. Since then, as various patents for 3D printing processes have expired, the market for commercial 3D printers has expanded and the technology has become more accessible and widely known. MakerBot Industries LLC, for example, now offers a "desktop 3D printer" for about USD $2,000. Although coveted by hobbyists, commercially available 3D printers are currently not likely capable of producing objects of high enough fidelity to produce convincing counterfeits — both the resolution of reproduction and the material of the output would be insufficient to fool connoisseurs. Sophisticated industrial printers, however, do produce high resolution outputs in various materials, and 3D printers are widely employed for the production of precision parts in high-tech industries.

Examples include the aviation industry where 3D printers are being used in the manufacture of components that cannot be otherwise made by traditional processes. Otherwise, the medical industry has found a variety of uses for 3D printing from routine dental applications to the production of unique medical implants, such as biotic ears and bone replacements. Scientists are even researching the potential of printing human stem cells that may in the future permit the production of organs for transplant.

INCREASED ACCESSIBILITY

While high quality machines remain expensive and not readily accessible to the consumer market now, competition and development will inevitably make them available in the future and at less cost. The Massachusetts Institute of Technology is helping to pioneer this initiative through the establishment of an international network of "Fab Labs" where anyone can have access to digital fabrication.

In the future it is likely that similar initiatives will be undertaken by commercial operators, and it seems that it will not be long before just about anything will be reproduced with ease and at a reasonable price. While this includes the potential to create and reproduce artworks for legitimate purposes, such as is being done by the Van Gogh Museum and the Smithsonian Institute, it also presents opportunities for those with illegitimate purposes.

EXPERT OPINION

Tim Caffrey of Wohlers Associates, a leading consulting firm to the additive manufacturing industry, advised the authors that cutting edge 3D printing processes combined with state-of-the-art 3D scanning are already capable of replicating certain 3D artworks with a high degree of fidelity. A forger with access to these technologies could conceivably 3D print Auguste Rodin’s sculpture, the Thinker, in identical proportion and with every detail faithfully rendered in bronze. This might be done by employing laser metal-fusion technology, lost-wax casting, or a range of other high-end additive techniques. While the forger would still be required to skillfully apply the surface finishing, and replicating the patina would pose a challenge, such a forgery may be capable of deceiving at least some less sophisticated collectors.

However, Caffrey also noted that 3D printing faces limitations on the scale of the object being reproduced and the materials that can be printed. While a Rodin sculpture might be a candidate for forgery through 3D printing today, a large Richard Serra sculpture would not. It would also be difficult to control the accuracy of a forgery printed in ceramics because of the shrinking that occurs when the material is fired in a kiln. While technology will likely overcome these present limitations, such advances will be driven by the needs of industry.

To illustrate, Caffrey pointed out to us that while it may be possible to produce an alloy identical to the bronze used in the Thinker for use by a high-end 3D metal printer, the lack of commercial demand for such an alloy makes it highly improbable.

LEGAL IMPLICATIONS

3D printing has the potential to push the art world in new directions. At the least, it may challenge the concept of an original artwork, and the inevitable proliferation of counterfeits may also have various criminal, civil and international legal implications.

Criminal liability could be incurred if an innocent buyer is defrauded. A civil action might be brought for breach of a condition of sale or warranty, or otherwise for misrepresentation or passing-off. International law may have to be relied on to determine the legal jurisdiction that should apply to an action for a forgery created in one country but imported into and discovered or sold to an innocent buyer in another. Copyright disputes will also arise, as was recently seen when 3D model designer, Fernando Sosa, released a 3D printable mobile phone dock in the form of the Iron Throne from HBO’s popular television series Game of Thrones. Similarly, it is possible that disputes over artworks may arise in other areas of intellectual property law including patent, industrial design and trademark.

For collectors, dealers, galleries, and museums, 3D printing represents an increased risk of being defrauded. Replicas and edition works may be created for such beneficial uses as the preservation and protection of the original work or the substitution of a duplicate for traveling exhibitions, but the range of illicit uses available to criminals and opportunists is palpable.

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27 Nathan Hurst, “HBO Blocks 3-D Printed Game of Thrones iPhone Dock,” Wired (13 December 2013), online: <http://www.wired.com/design/2013/02/got-hbo-cease-and-desist/>.
A criminal organization might purchase an artwork legitimately and reproduce it for sale to unwitting buyers. A greedy collector might have a copy destroyed for insurance proceeds, while the original work is safely hidden away for future heirs. A false patron of the arts might donate a counterfeit item for the purpose of obtaining a charitable tax receipt. In addition, a replica, originally created for a legitimate purpose, might be mistaken for an original over time and find its way into the art market causing confusion, especially when the original or another copy eventually comes on the market as well.

These risks will, in turn, place new pressures on insurers to demand higher standards for authentication of the artworks they are asked to insure and may result in higher premiums. ARIS Title Insurance Corporation, for example, has recently announced an initiative to utilize cutting-edge technologies to investigate the authenticity of fine art in the global marketplace.

DETECTION AND PROTECTION

The increasing ability of the 3D printer to make identical copies may eventually confound the ability of connoisseurs and insurers to detect fakes, resulting in an increased emphasis on the role on forensic analysis and the provenance of the artwork.

Despite the precision that 3D scanning and printing are able to achieve, it is still possible to detect a forgery by forensic analysis using techniques that reveal the specific identity of materials such as scanning electron microscopy and x-ray fluoroscopy. In the example of the Rodin forgery, a materials analyst would likely be able to distinguish between the bronze used to pour the original Thinker from the bronze used in the counterfeit statue. However, this is not the type of analysis employed in a normal buy/sell situation in the art world today, and it is impractical to expect forensic testing to be relied on extensively.

As Janice Passafiume, senior conservator and forensic researcher for JANA Fine Art PCL Ltd. in Toronto, explained to the authors, forensic labs are not currently set up for authentication of non-controversial artworks and will have to adjust to the increase in demand on their services that 3D printing may cause. Furthermore, to the extent that labs are able to accommodate confirmation requests, it is likely to be prohibitively expensive in common transactions. If forensic testing is to play a larger role in authentication of art objects, Passafiume suggests that a greater emphasis be placed on forensic education and training for art conservators in addition to the expansion of infrastructure.

PROVENANCE

Currently, the most accessible defense against forgeries is establishing a history of the artwork’s creation and ownership — its “provenance.” Many art specialists and auction houses already require the provenance of a work as a prerequisite to a sale. However, the culture that surrounds collector/dealer transactions does not always lead to rigorous examination. Usually it is only the experienced buyer that knows of, or requires, the background provenance on a purchase. Often the name of the consignor is never declared to the buyer with the excuse of “confidentiality.” This is something that must change as the threat of 3D printed forgeries increases.

Dealers will need to exert greater effort to keep track of the provenance of an artwork, and collectors will require documentation to support it. To the extent possible, original documents should be insisted upon. Ideally this would be a certificate of authenticity or even a statement verifying the authenticity of the artwork by the artist, the artist’s estate or a respected authority on the artist. Otherwise, an original receipt or a gallery sticker from the gallery that sold the artwork, or evidence of public exhibitions such as a pamphlet, catalogue or a review referring to the artwork would contribute to its authenticity. Even photographs of the...
artwork in authentic contexts will be helpful in establishing provenance.

It is unfortunate that a technology that has so much potential for legitimate use also brings with it such clear risks. But the reality is that the art world already attracts an abundance of fraudulent behavior, and this is likely to increase with the development of 3D printing technology that can be manipulated by almost anyone with access to it.

Greater care must be taken by dealers, collectors, galleries and insurers to ensure the authenticity of their artworks.

Just as Amiel Jr. found an opportunity to sell his grandfather’s fakes on eBay, so too will other opportunists utilize advancing technology to profit from art fraud.

So what size do you want your forgery?

...
NEWS & UPDATES

3 The Tangled Web of a Munich Art Trove
16 Ancient Gold Tablet Returned to German Museum
18 Consignor Confidentiality is Here to Stay
20 Better Late Than Never: Stolen Renoir Returns to Baltimore Museum After 60 Years
23 No Peace for the Mummy Mask—Oral Argument in SLAM Suit
24 New Lease on Life for Cassirer Claim
25 Khmer Statue Back to Cambodia
27 Recent CPAC Activity: Agreements with China, Belize and Bulgaria
28 NY State Bill May Protect Art Specialists

COME BACK IN TWO HOURS FOR YOUR FORGERY
Aaron Milrad and Christian Orton

ART FOR SALE? BANKRUPTCY AND THE DETROIT INSTITUTE OF ARTS
An IFAR Evening, October 24, 2013

38 Historical Perspective On The DIA
Samuel Sachs II

42 The Director’s Take
Graham W. J. Beal

44 The Legal Perspective: Municipal Bankruptcy
Richard Levin

46 Museums And Their Communities
Frank Robinson

49 Q&A

(Continued on next page with the ARTISTS RESALE RIGHTS program)
ARTISTS RESALE RIGHTS IN THE U.S.: OVERDUE OR SHOULDN’T DO?
An IFAR Evening, November 25, 2013

62 An Overview
Philippa S. Loengard

64 The Artists Resale Rights Bill
Jerrold L. Nadler

66 The Copyright Office Review
Karyn Temple Claggett

69 The Argument Pro
Theodore H. Feder

72 The Argument Con
Sandra L. Cobden

75 Q&A

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