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## Taking the Lid off the *Utah Teapot*

### Towards a Material Analysis of Computer Graphics\*

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IN HIS 1974 MANIFESTO *Computer Lib / Dream Machines* the eminent advocate of computer culture Ted Nelson argued against the notion of the computer as mere mechanical device: »the idea is [...] that computer activities are somehow uncreative as compared to say rotating clay against your fingers until it becomes a pot. This is categorically false, computers involve imagination and creation at the highest level.«<sup>1</sup> In order to highlight the gap between the common perception of creativity and computing, Nelson contrasted the cool, technical activity to the direct interaction with warm, sticky matter.

This article argues that the material process of throwing clay at the potter's wheel does actually not differ so much from the material process of creating artefacts with the computer and that it is precisely because the materiality of computing has long been ignored, that we are missing insights into how exactly computer generated artefacts function in technical, cultural and social contexts. The parallels in material creation are emphasized by the object under investigation here. In the same year that *Computer Lib* was published, the computer's creative potential was greatly increased through the exact same object Nelson contrasted with computational activities: a pot.

This pot, a teapot to be precise (see p. 170), was the first 3D computer graphic model that represented a real-world object. Within a few months it became the test bed and not long after the icon of the then emerging computer graphics community, to which scientists, programmers, artists and designers would equally belong.

Together with its story, this article presents a material analysis of the teapot in order to understand its popularity and ubiquity as well as the material condition of computer graphics artefacts. Five material layers are distinguished, each devel-

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\* I would like to thank Marianne van den Boomen for the many inspiring discussions about the materiality of the digital.

<sup>1</sup> Theodore H. Nelson: *Computer Lib. You can and must understand Computers now/ Dream Machines. New Freedoms through Computer Screens – a Minority Report*, South Bend <sup>1</sup>1974, under: <http://www.digibarn.com/collections/books/computer-lib/index.html> (all links in this article have been accessed on 10.01.2011).



Fig. 1: Hendrik Wann Jensen, *Utah Teapot* rendered with BSSRDF, 2002.

oped in relation to different theoretical concepts of materiality. Before approaching the matter however, the stigma of immateriality still clinging to computer generated imagery, needs to be explored briefly.

## 1. De-materializations

In their seminal article *The Status of the Object* (2002), Dick Pels, Kevin Hetherington and Frédéric Vandenberghe address the neglect of things and objects in critical and postmodern theory, which »generically favoured the view that material entities primarily existed as envelopes of meaning«<sup>2</sup> rather than being generative of meaning themselves. Since then, the material turn in the social sciences and more recently, the humanities, has shifted attention towards all things material, their lives, histories, and agencies. But what we actually mean by materiality remains quite vague: »a gap exists between the promise of concreteness that makes the turn to ›things‹ and the notion of ›materiality‹ appear so attractive, on the one hand, and our still rather meagre understanding of and lack of agreement about what we mean by ›matter‹ and ›materiality‹«,<sup>3</sup> as Birgit Meyer and Dick Houtman summarize. Voicing a comparable concern, Timothy Ingold wonders why the general interest in materiality has hitherto generated little research about actual materials and why most scholars still cling to a hylomorphic model, in which ideas and theories form passive matter so as to become meaningful.<sup>4</sup>

<sup>2</sup> Dick Pels et al.: *The Status of the Object. Performance, Mediations, and Techniques*, in: *Theory, Culture & Society* 19, 5/6, (2002), pp. 1–21, here p. 5.

<sup>3</sup> Birgit Meyer and Dick Houtman: *How Things Matter*, in: id. (eds.): *Things. Religion and the Question of Materiality*, New York 2012 (forthcoming).

<sup>4</sup> Timothy Ingold: *Materials against Materiality*, in: *Archeological Dialogues* 14/1 (2007), pp. 1–16; id.: *The Textility of Making*, in: *Cambridge Journal of Economics* 34 (2010),

The gap between a general interest in materiality and thorough theoretical knowledge of things and materials is especially palpable in art theory and media studies, where images are still primarily regarded as essentially immaterial appearances, which are translated into material artefacts through manual or technical processes.<sup>5</sup> The traditional opposition between an immaterial and material side of images has been enforced in visual studies by influential critics such as James Elkins and William J. T. Mitchell, who have associated the immaterial with *image* and its materializations with *picture*.<sup>6</sup> While Gottfried Boehm and Hans Belting have argued that the German *Bild* overcomes this opposition, their concepts of, respectively, *Ikonische Differenz* (iconic difference) and *Bild-Anthropologie* (image anthropology) still situate the immaterial *Bild* (ideas, memories, concepts, etc.) prior to its materialization into actual artefacts, thereby incorporating the opposition, rather than resolving it.<sup>7</sup> The notion of an essential twofoldedness of the image – oscillating between representation and material – through relevant, seems to impede a theoretical study of materials because scholars tend to align the immaterial with theory, setting material aside as belonging to the realm of (non-theoretical) practice.<sup>8</sup> While hierarchic oppositions cannot be dissolved easily and an inversion of hierarchies only enforces dichotomies, they can – as Bruno Latour has suggested – be sidestepped.<sup>9</sup> In order to allow for a theoretical analysis of images as material, we can assume that images have no a-priori immaterial form, but only exist from the moment that they are *in* material. From a radical *materialist* position, it may even be argued that images assigned to the realm of the immaterial in the hylomorphic paradigm – ideas, fantasies, concepts, memories, dreams, visions etc.

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pp. 91–102; id.: *Being Alive. Essays on Movement, Knowledge and Description*, London 2011.

- <sup>5</sup> For a more nuanced discussion see Ann-Sophie Lehmann: *Das Medium als Mediator. Eine Materialtheorie für (Öl-)Bilder*, in: *Zeitschrift für Ästhetik und Allgemeine Kunstwissenschaften* 12 (2012) (forthcoming).
- <sup>6</sup> James Elkins: *On Some Limits of Materiality in Art History*, in: 31: *Das Magazin des Instituts für Theorie* [Zürich] 12 (2008), pp. 25–30, here p. 28 (Special issue: *Taktilität. Sinneserfahrung als Grenzerfahrung*, edited by Stefan Neuner and Julia Gelshorn); William J. T. Mitchell: *Four Fundamental Concepts of Image Science*, in: James Elkins (ed.): *Visual Literacy*, New York 2008, pp. 16–18.
- <sup>7</sup> Hans Belting: *Image, Medium, Body. A New Approach to Iconology*, in: *Critical Inquiry* 31 (2005), pp. 302–19; id.: *An Anthropology of Images. Picture, Medium, Body*, Princeton 2011. Though Boehm's most recent elucidation of iconic difference criticizes the separation of representation and material, it does not offer an alternative model, Gottfried Boehm: *Ikonische Differenz*, in: *Rheinsprung 11 – Zeitschrift für Bildkritik* 1 (2011), pp. 170–76, here p. 175.
- <sup>8</sup> See for instance Elkins: *Limits* (as note 6).
- <sup>9</sup> Bruno Latour: *Reassembling the Social. An Introduction to Actor-Network-Theory*, Oxford 2005, p. 76.

– have a material basis in our bodies and brains, different than paper, charcoal, oil, celluloid or pixels maybe, but nonetheless material in essence.<sup>10</sup>

But to leap beyond the image-picture divide and approach images as material entities only gets us half way, because not only the image, but also the digital has been persistently framed as immaterial. To pull artefacts which are both – digital *and* image – back into the domain of their material existence, takes twice the effort.

Tropes of immateriality have dominated popular and academic discourse since the 1990s, which presented new media as possessing new and amazing qualities, marked by a transformation of atoms into bits and of matter into mind.<sup>11</sup> Paradigmatic is a quote by Jean-François Lyotard from the catalogue to his exhibition *Les immatérieux* (1985): »A colour, a sound, a material, a pain or a star are coming to us as digits on numeric charts of great accuracy [...] good old matter reaches us as something that has been dissolved into complicated formulae.«<sup>12</sup> The plural *im-materials* already hints at a materiality of the digital, yet it would take some time before it would be scrutinized by scholars like N. Katherine Hayles, Joanna Drucker or Matthew Kirschenbaum, whose ideas will be considered in more detail further down. The first to criticize the supposed immateriality of digital images in particular were artists, curators and archivists. Being on the producing, conserving and collecting end of digital visual culture they were confronted with the vulnerable and complex nature of media artefacts.<sup>13</sup> Still, due to what one might call their ›double immaterial weight,‹ art and media theory continue to characterize digital images as processual, nomadic, liquid, spectral, fleeting, transient, ephemeral and so forth.<sup>14</sup> Though digital images certainly can be all of this, these characteristics should not be granted to an immaterial but a material existence, which is such that it affords these qualities but also many others, as the analysis of the *Utah teapot* will show.

<sup>10</sup> Ingold: *Materials* (as note 4), p. 12. John Dewey consequently described these images as »inner material«. John Dewey: *Art as Experience*, New York 1934, p. 74. See also Susanne Küchler: *Technological Materiality. Beyond the Dualist Paradigm*, in: *Theory, Culture & Society* 25 (2008), pp. 101–20.

<sup>11</sup> Marianne van den Boomen et al.: Introduction. From the Virtual to Matters of Fact and Concern, in: id. (ed.): *Digital Material. Tracing New Media in Everyday Life and Technology*, Amsterdam 2009, pp. 7–17.

<sup>12</sup> Dietmar Rübél et al. (ed.): *Materialästhetik. Quellentexte zu Kunst, Design und Architektur*, Berlin 2005, p. 336, trans. A.-S. L.

<sup>13</sup> E. g. Christiane Paul: *The Myth of Immateriality. Presenting and Preserving New Media*, in: Olivier Grau (ed.): *MediaArtHistories*, Cambridge, MA 2006, pp. 251–273; Marlene Manoff: *The Materiality of Digital Collections. Theoretical and Historical Perspectives*, in: *Libraries and the Academy* 6/3 (2006), pp. 311–25.

<sup>14</sup> See for instance Martina Hessler and Dieter Mersch (eds.): *Logik des Bildlichen. Zur Kritik der ikonischen Vernunft*, Bielefeld 2009, p. 12.

## 2. From Melitta to Utah

In 1974, Martin Newell, a young PhD researcher at the computer science department of the University of Utah, was looking for an object that would move emerging 3D computer graphics from spheres and cubes into the domain of recognizable, real-life things. It was not in the lab, but at home that he came across such an object, where his wife Sandra Newell suggested to use their newly acquired teapot. Because this teapot by the German brand *Melitta* was a relatively simple, convex object with interesting details such as spout, lid, and handle, it was ideal for the task. From the teapot, Newell developed the first 3D CG object that was rendered as sculptured surface with Bezier curves, rather than as a set of polygons.<sup>15</sup> Together with James Blinn, Newell presented the first application of texture mapping to the teapot in a lecture at one of the first annual meetings of SIGGRAPH (Special Interest Group of Computer Graphics, a subdivision of the Association of Computing Machinery) in 1976.<sup>16</sup> Blinn, who described this publication as the »original teapot paper«, was to become one of the most well known researchers in the field of graphics and recently retired as Microsoft research fellow. Ivan Sutherland is reported to have said that »there are about a dozen great computer graphics people, and Jim Blinn is six of them«. <sup>17</sup> Blinn's work on texture and reflection rendering initiated what is often referred to as the *holy grail* in the Graphics scientific community: the quest for ultimate visual realism.<sup>18</sup> Shortly after 1976, Blinn slightly squashed the teapot to demonstrate the abilities of graphics in a funding application to the department of defense. The joke – implying that defense would like simulations of squashing things – was too subtle and no funding was obtained, yet the change in form gave the teapot its characteristic, slightly more

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<sup>15</sup> See Frank Crow: *The Origins of the Teapot*. IEEE Computer Graphics and Applications 7/1 (Jan. 1987), pp. 8–19; Steve Baker, *The History of the Teapot*, under: [http://www.sjbaker.org/wiki/index.php?title=The\\_History\\_of\\_The\\_Teapot](http://www.sjbaker.org/wiki/index.php?title=The_History_of_The_Teapot); Wayne Carlson: *A Critical History of Computer Graphics and Animation*, under: <http://design.osu.edu/carlson/history/lesson20.html>. In 2003, a Wikipedia entry was started, under: [http://en.wikipedia.org/wiki/Utah\\_teapot](http://en.wikipedia.org/wiki/Utah_teapot); see also the Museum of Computer History, under: <http://www.computerhistory.org/revolution/computer-graphics-music-and-art/15/206> and the infographics animation *UTANALOG. HONORING AN ICON* (Belgium 2009, Unfold), under: <http://unfold.be/pages/projects/items/utanalogue>.

<sup>16</sup> James Blinn and Martin Newell: *Texture and Reflection*, in: *Communications of the ACM* 19/10 (1975), pp. 542–47. See also id.: *What, Teapots Again?*, in: *Computer Graphics* 7/9 (1987), pp. 61–63.

<sup>17</sup> Carlson: *Critical History* (as note 15).

<sup>18</sup> See Barbara Flückiger: *Visual Effects. Filmbilder aus dem Computer*, Marburg 2008; which is one of the most comprehensive studies on the topic.

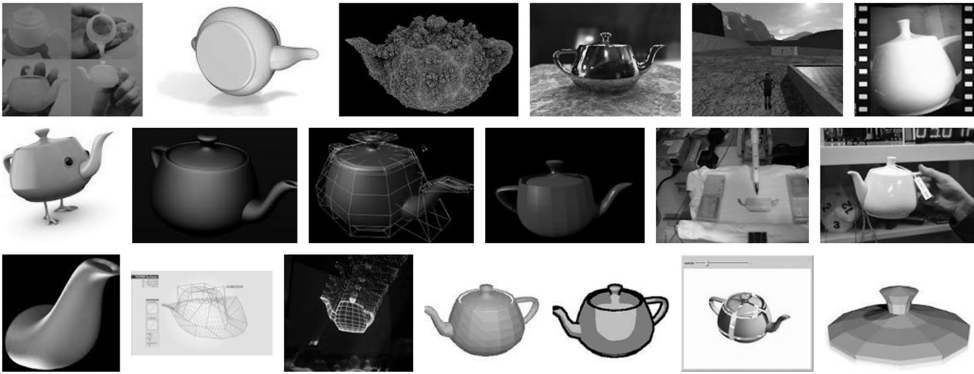


Fig. 2: Google image search for »Utah teapot« (Screenshot), January 2012.

cartoonish appearance, which it was going to keep.<sup>19</sup> Because the dataset for the pot was small and freely available, and because there were no comparable models available, it became the logical test bed for new rendering algorithms from various textures to shading and luminosity.<sup>20</sup> At the SIGGRAPH meetings, teapot rendering contests were held, demonstrating the state of the art in texture and reflection rendering and aiming to fulfil the promise of visual realism with the teapot as its grail. Today, endless variations of teapots swarm the Internet, golden or transparent, Lego or brick, with spikes or rendered from thousands of other teapots.

The rich iconography of the teapot initially rooted in the fact that it was one of the few interesting shapes to work with; as an insider summed up its attractions for the CG community: »It's instantly recognisable, it has complex topology, it self-shadows, there are hidden surface issues, it has both convex and concave surfaces [...] It doesn't take much storage space.«<sup>21</sup> But the teapot acquired the status of icon because through these practical aspects, it embodied the young history of graphics. To use the teapot was to keep creating and adding to this history, as well as demonstrating personal affinity with the field. It is an anthropological constant that people form attachments with things by decorating them and computer scientists have decorated the teapot quite literally with new textures all the time.<sup>22</sup>

<sup>19</sup> Jen Grey: *The Teapot as Object and Icon*. Siggraph Exhibition Review 2006, under: <http://la.siggraph.org/?q=node/25>.

<sup>20</sup> Computer scientist Steve Baker writes that people could type the dataset from memory, Baker: *Story of the Teapot* (as note 15). For a demonstration see the documentary *THE STORY OF COMPUTER GRAPHICS* (USA 1999, Siggraph Studios), which features James Blinn explaining the teapot.

<sup>21</sup> Baker: *History* (as note 15).

<sup>22</sup> Alfred Gell: *Art and Agency. An Anthropological Theory*, London 1998, p. 78 ff.

As CG grew into a commercially available medium, the teapot became one of the first *Easter eggs* of visual digital culture, appearing in rendering software like 3D Studio Max alongside standard cubes and spheres or in the Windows screen-saver *Tubes*, if one only kept looking long enough.<sup>23</sup> Pixar, founded in the early 1980's by Ed Catmull, a fellow PhD student of Newell at Utah<sup>24</sup>, eventually turned the teapot into an analogue gadget. Since 2003, Pixar issues a small plastic teapot at every SIGGRAPH conference to promote their rendering software *Renderman* and their most recent animated movie.<sup>25</sup> The tangible manifestation of the icon is a much sought for collectible at the conferences. Aficionados have walked the line queuing up of the teapot with a camera in hand, which took four whole minutes at Siggraph 2010.<sup>26</sup> The popularization has not prevented the teapot from remaining a serious scientific object, as it appeared together with the five Platonic Solids on the ACM communications cover of a special issue on scientific visualizations and the Utah computer science department has a newsletter called »the teapot«. In 2006, SIGGRAPH honoured the *Utah teapot* with a day of presentations and an exhibition, titled *The Teapot as Object and Icon*, stressing its existence as thing and image.

The original Melitta model for the teapot is kept at the *Computer History Museum* in Mountain View, California, where it has been moved from the *Boston Computer Museum*, to which Sandra Newell donated it initially.<sup>27</sup> The Melitta teapot is also cherished in material culture and design history for its unmistakable 1950's charm and the advancement of efficient and functional design. As such it is archived at the collections of the *Deutsches Historisches Museum* in Berlin and the *Museum der Dinge/Werkbundarchiv* in Berlin.<sup>28</sup> Given this other history, Martin and Sandra Newell's choice in 1974 was certainly not arbitrary but directed by the distinct appearance of the object in question, and today it is hard to say whether the originals are collector's items because they are German design-icons or American CG-icons, or both.

Together with its aptness as a graphics model and its design status, one also has to take into account the teapot's broader cultural connotations in order to explain

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<sup>23</sup> Under: [http://en.wikipedia.org/wiki/Utah\\_teapot](http://en.wikipedia.org/wiki/Utah_teapot).

<sup>24</sup> David A. Price: *The Pixar Touch. The Making of a Company*, New York 2009.

<sup>25</sup> under: <http://www.siggraph.org/programs/archive/reports/conference/2006/articles/swag-attack-renderman-walking-teapots> and <https://renderman.pixar.com/products/tools/renderman-teapots.html>.

<sup>26</sup> Under: <http://www.youtube.com/watch?v=My-ZWxkuP14&feature=related>.

<sup>27</sup> Computer History Museum in Mountain View, California, »Teapot used for Computer Graphics rendering«, cat. nr. X00398. 1984.

<sup>28</sup> Deutsches Historisches Museum, GOS-Nr. 200056094, Inventarnr. AK 2005/18 and Museum der Dinge/Werkbund Archiv, O 10827.

its success. In the white, male, and mostly bearded scientific community that produced the first computer graphics in the 1970's, it was an object not from the lab but from the home, a different, yet familiar thing, blending the efficiency of mathematics with the cosiness of a warm cup of tea. The teapot thus crossed boundaries between genders and cultures, but also between art and science, as it served to develop and express visual creativity in a scientific environment, or joined the left and right side of the brain, as James Blinn once put it.<sup>29</sup> Other standard graphic models were developed later on, more complicated in structure and form, like for instance the Stanford Bunny and Buddha at the Stanford Department for Computer Science.<sup>30</sup> But none of these were able to establish an iconographical tradition like that of the teapot. In fact, the teapot is one of those rare motifs completely congruent with Erwin Panofsky's theory of disguised symbolism, that he developed to explain the shift from a symbolic to a realist visual language in early Netherlandish painting shortly after 1400: the seemingly everyday objects in the paintings by Jan van Eyck and his contemporaries, Panofsky contended, were richly laden with symbolic content, obvious to the devout contemporary who contemplated the religious scenes depicted, but hidden to the eyes of the modern viewer.<sup>31</sup> In the first feature length computer animation by Pixar, *TOY STORY* (USA 1995, John Lasseter), the *Utah teapot* appears in a scene where the little sister of the horrible neighbour boy plays *tea party* with Buzz Lightyear and her dolls. To the ignorant viewer, it blends in naturally with the computer generated environment. The CG connoisseur however will recognize it as self-referential hint to the origins of the medium, serving its makers to situate themselves in a distinct technical, scientific, and cultural tradition.

Clearly, the *Utah teapot* acquired its prominent position in scientific as well as popular culture due to the manifold attractions of the thing it originated from. But what kind of object is this teapot exactly, from which no tea can be poured and that unfolds itself in such an astonishing variety of appearances and contexts?

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<sup>29</sup> Grey: Teapot as Object (as note 19).

<sup>30</sup> Stanford 3D Scanning Repository, under: <http://graphics.stanford.edu/data/3Dscanrep/> and a list of standard D3 models under: [http://en.wikipedia.org/wiki/List\\_of\\_common\\_3D\\_test\\_models](http://en.wikipedia.org/wiki/List_of_common_3D_test_models).

<sup>31</sup> Erwin Panofsky: *Early Netherlandish Painting*, Oxford 1953.



### 3. The Materials of the *Utah Teapot*

Object-theories usually locate agency in the interaction between humans and things that already exist.<sup>32</sup> What tends to drift out of view in this approach is the making of things from material, as it is here where the life of things and, we might add, the life of images, really starts.<sup>33</sup> Therefore, the teapot is approached here as an image and object that possesses a surface and a material depth or thickness.<sup>34</sup> This depth, which constitutes the objecthood of the image, holds the skilled procedures and complex interactions between makers, materials, tools and technologies involved in the teapot's production. To fathom these depths, I attempt what Karin Knorr Cetina and Klaus Amman have called »image-dissection« in a ground-breaking article on the interpretation of scientific images.<sup>35</sup> Coming from the social sciences, Knorr Cetina and Klaus Amman did not share in the legacy of the material/immaterial divide in the humanities and propose to approach images like scientists do their objects in the laboratory. Image-dissection »involves pursuing the threads that lead from bits and pieces of the surface of the display to developments and occurrences underneath«<sup>36</sup> and allows us to get inside the image, in our case to lift the lid off the teapot. Though the idea of depth and dissection suggests a body with a physical structure, the distinct but not separate material layers that can be encountered in the following image-dissection are not neatly organized in an anatomical or topographical manner, if there is an order at all, its mostly temporal.

#### Code

Code is generally considered the basis for CG. Digital images are often characterized as consisting of *just* code, of algorithms or ones and zeros. This existence in numbers is often contrasted with the representational aspect of images in popular descriptions but also in academic analysis. Vilém Flusser in his early theorization of digital images, created a strong opposition between traditional and techno-images, attesting the latter opacity because technical processes and code fall out-

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<sup>32</sup> See Latour: Reassembling (as note 9).

<sup>33</sup> Ingold: Materials (as note 4); Ann-Sophie Lehmann: Showing Making. On Creativity and Representation, in: *Journal of Modern Craft* 1/5 (2012), pp. 9–24.

<sup>34</sup> Bruno Latour: Can We Have Our Materialism Back, Please?, in: *Isis, Focus Thick Things* 98 (2007), pp. 138–42.

<sup>35</sup> Karin Knorr-Cetina and Klaus Amann: Image Dissection in Natural Scientific Inquiry, in: *Science, Technology & Human Values* 15/3 (1990), pp. 259–83.

<sup>36</sup> *Ibid.* p. 263.

side human understanding »they are out of reach for hands, eyes, and fingers«. <sup>37</sup> Also Lev Manovich opposed representation and code in the structure of computer images, relating the first to human culture, the latter to the machine. <sup>38</sup> The artificial separation turns code into something abstract, existing outside of human experience in the machine, where it leads an independent, immaterial life. Johanna Drucker has argued against such an »imagined ideality of code« and for a »real materiality of code«. <sup>39</sup> She described the material translation of code into image, (involving human action), as *graphesis* as opposed to *mathesis*, (the process of calculating code), which either should not be idealized as a pure machine activity. In fact, code is the result of the human-machine interaction of programming, which again can only take place after a framework for a programme has been written. Drucker's argument is reminiscent of one by Bruno Latour, who stated that technical visualization processes are far too often granted to the scientific mind and apparatus alone while the role of hands and eyes are ignored (as Flusser indeed did). <sup>40</sup> Recently, also researchers from within the field have started to emphasise the highly material aspects of their work and speak of programming as craft, firmly rooting it in material activity. <sup>41</sup> The dataset of the teapot therefore is not the image nor a genetic blue-print from which a machine generates an image all by itself. As the result of a code, which was obtained through calculation, it is part of a complex series of events, which eventually leads to an image.

## Making

In the beginning however, Martin Newell had to draw the teapot on paper. He then plotted a number of dots to describe the different parts of the pot. So before there was code, there was direct engagement with analogue materials. This kind of engagement is difficult to study. If we are not there to witness it ourselves, we

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<sup>37</sup> Vilém Flusser: *Ins Universum der technischen Bilder* (1985), Göttingen 2000, cited in: Alberto J.L. Carrillo Canán: Deception and the »Magic« of »Technical Images«, in: *Flusser Studies* 04, under: [www.flusserstudies.net/pag/04/carrillo\\_deception.pdf](http://www.flusserstudies.net/pag/04/carrillo_deception.pdf).

<sup>38</sup> Lev Manovich: *The Language of New Media*, Cambridge, MA 2001, p. 45.

<sup>39</sup> Johanna Drucker: *Digital Ontologies. The Ideality of Form in/and Code Storage. Or: Can Graphesis Challenge Mathesis?*, in: *Leonardo* 34/2 (2001), pp. 141–45.

<sup>40</sup> Bruno Latour: *Visualization and Cognition. Thinking with Eyes and Hands, Knowledge and Society*, in: *Studies in the Sociology of Culture Past and Present* 6 (1986), pp. 1–40, here p. 26.

<sup>41</sup> Peter Seibel: *Coders at Work, Reflections on the Craft of Programming*, New York 2009. On the notion of computing as craft, see Malcolm McCollough: *Abstracting Craft. The Practiced Digital Hand*, Cambridge, MA 1996; Jane Harris: *Crafting Computer Graphics*, in: *Textile* 3/1 (2005), pp. 20–35.

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Rim:
{ 102, 103, 104, 105, 4, 5, 6, 7,
  8, 9, 10, 11, 12, 13, 14, 15 }
Body:
{ 12, 13, 14, 15, 16, 17, 18, 19,
  20, 21, 22, 23, 24, 25, 26, 27 }
{ 24, 25, 26, 27, 29, 30, 31, 32,
  33, 34, 35, 36, 37, 38, 39, 40 }
Lid:
{ 96, 96, 96, 96, 97, 98, 99, 100,
  101, 101, 101, 101, 0, 1, 2, 3 }
{ 0, 1, 2, 3, 106, 107, 108, 109,
  110, 111, 112, 113, 114, 115, 116, 117 }
Handle:
{ 41, 42, 43, 44, 45, 46, 47, 48,
  49, 50, 51, 52, 53, 54, 55, 56 }
{ 53, 54, 55, 56, 57, 58, 59, 60,
  61, 62, 63, 64, 28, 65, 66, 67 }
Spout:
{ 68, 69, 70, 71, 72, 73, 74, 75,
  76, 77, 78, 79, 80, 81, 82, 83 }
{ 80, 81, 82, 83, 84, 85, 86, 87,
  88, 89, 90, 91, 92, 93, 94, 95 }
    
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Fig. 3: Dataset Utah Teapot (Screenshot).

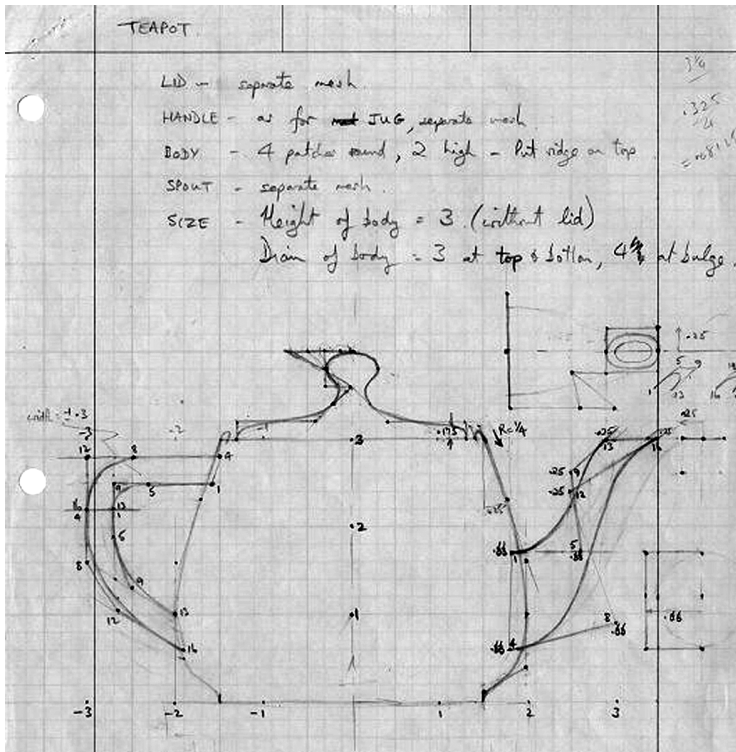


Fig. 4: Martin Newell, Drawing for the Utah Teapot 1974).

have to rely on visual or verbal descriptions, which are often anecdotic in nature, or strike us as such, because they are so straightforward.<sup>42</sup> For many computer scientists research starts by finding the right objects and materials at home, outside or in DIY stores, by observing how they are visually and physically composed, and finding ways to record their make-up.<sup>43</sup> Many texture, shading and illumination algorithms are preceded by such tinkering with the analogue. In 1998, Russ Fish, like Newell a researcher at the Utah CS department, wanted to render the inside and the bottom of the teapot, which Newell had famously omitted. Searching for an image that would demonstrate his effort in an effective manner, he came across a cleaver in his kitchen (again), which inspired him to hack the teapot in two. In order to obtain its form, he pasted the cleaver onto his screen and drew its outlines directly into the computer.<sup>44</sup> This rather comical encounter of analogue and digital practices demonstrates the continuum rather than the opposition of these domains lets us acknowledge computer graphics as artefacts and products of craft, into which tool use and authorship are inscribed.<sup>45</sup> Fish's teapot hacked in two is a literally graphic example of the inscription of making into the digital image.

### In-Material

Another very straightforward material aspect of computer graphics and all other digital images for that matter, is the necessity to be in-material. The term, coined by Mirko Tobias Schäfer to describe the properties and affordances of software<sup>46</sup>, is to be taken very literally because in order to be there and in order to be seen, a computer graphics image needs hardware equipped with a monitor, screen or projection device. In other words, it has to be *in* another material. N. Katherine Hayles has described the relation between soft- and hardware with the wonderful *Oreo* cookie metaphor: the digital as the white frothy substance which holds together or

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<sup>42</sup> Lehmann: Showing Making (as note 33).

<sup>43</sup> For our research on light diffusion and reflection of leaves, we started looking for trees that resembled the drawings by Leonardo and could be taken into the lab, ending up with three small *fic benjamini* in different shades of green, see Ann-Sophie Lehmann, Silvia C. Pont and Jan-Mark Geusebroek: Tree Textures. Modern Techniques in Art Historical Context, in: M. Chantler (ed.): Texture. The 4th International Workshop on Texture Analysis and Synthesis, ICCV Beijing 2005, pp. 43–48.

<sup>44</sup> Under: [http://www.cs.utah.edu/gdc/projects/alpha1/help/man/html/model\\_repo/model\\_teapot/model\\_teapot.html](http://www.cs.utah.edu/gdc/projects/alpha1/help/man/html/model_repo/model_teapot/model_teapot.html).

<sup>45</sup> McCollough: Abstracting Craft (as note 41), p. 166.

<sup>46</sup> Mirko Tobias Schäfer: *Bastard Culture*, Amsterdam 2011, pp. 64–65.

is kept in place by the dark brown crunchy cookie disks on top and bottom.<sup>47</sup> That these layers interact and that the workings of software leave very material traces in hardware, has been demonstrated and described by Matthew Kirschenbaum as the »forensic materiality«<sup>48</sup> of the digital. The idea of forensic materiality unhinges one of the most dominant presumptions about software and other digital artefacts: their endless multiplication in absolute similarity. Also the pixel, the smallest picture-element is part of CG being in-material, as it constitutes the image's appearance on the screen. 3D CG, however, are not just pixels (just like they are not just code). Pixels are constrained to two dimensions and 3D CG appear as pixels on a screen as a result of material translation achieved through frame-buffering.<sup>49</sup> To study how exactly the *Utah teapot* is in-material means to include all the steps taken from rendering to displaying, not to forget additional layers of metadata and watermarks, which become accessible when the object is viewed in different programmes.<sup>50</sup>

### All-Material

A fourth layer of materiality is present in the various rendered material properties of the teapots. A central task of the computer graphics communities, as has already been mentioned, is the simulation of real world materials.<sup>51</sup> In order to do so, computer scientists need to first understand the characteristics of these materials and then develop algorithms that describe them. The teapot in Fig. 1 was rendered by Hendrik Wann Jensen and simulates the semi-translucency of materials like marble, milk, and human skin, which had posed great difficulties until then. Wann Jensen's Bidirectional Scattering Surface Reflectance Distribution Function constituted a watershed moment for CG as it gave realistic skin to synthetic human actors such as Gollum<sup>52</sup> and like many before him, Wann Jensen poured his algorithm also in the teapot. This teapot therefore may be considered an epistemic image, because it incorporates knowledge about the physical makeup

<sup>47</sup> N. Katherine Hayles: *Simulating Narratives. What Virtual Creatures Can Teach Us*, in: *Critical Inquiry* 26/1 (1999), pp. 1–26.

<sup>48</sup> Matthew Kirschenbaum: *Mechanisms*, Cambridge, MA 2008, p. 10.

<sup>49</sup> Richard F. Lyon: *A Brief History of »Pixel«*, in: *Digital Photography II, IS&T/SPIE Symposium on Electronic Imaging, Proceedings of SPIE 6069, 606901* (2006), n. p.

<sup>50</sup> Kirschenbaum: *Mechanisms* (as note 48), pp. 12–13.

<sup>51</sup> July Dorsey, Holly Rushmeier and François Sillion (eds.): *Digital Modeling of Material Appearance*, Amsterdam 2008.

<sup>52</sup> Flückiger: *Visual Effects* (as note 18), pp. 98–102; Ann-Sophie Lehmann: *Leibfarbe, Erinnerungsfarbe, Scheinfarbe. Die Darstellung der Haut als Prüfstein alter und neuer Bildmedien*, in: A. Beuerle and S. Keppler (eds.): *Haut - zwischen Innen und Außen. Organ, Fläche, Diskurs. Münster/Berlin/New York 2009*, pp. 81–99.

of a material, contributing to a better understanding of the visual world. In fact, the ACM conference proceedings in the field of CG read like an unsorted encyclopaedia of the visual-material properties of nearly everything, from specific bird's feathers, silk textiles, wet hair, damaged car-lacquer, Chinese ink brush strokes, to corroded bronze or the fuzzy surface of leaves. Every material detail calls for an individual rendering algorithm and as the material world is endless in its complexity, the goal to eventually render it all, remains unachievable. The result are models which are almost but never yet quite like the thing they simulate, a principle Lev Manovich described early on as *synthetic realism*.<sup>53</sup> Of course, computer graphics differ from the materials they know so much about: while the latter is always and only this specific material, CG generalizes its characteristics and can apply them anywhere, like the semi-translucency of skin to a teapot. Moreover, computer graphics can simulate situations which have not occurred yet, expanding material life into the future. Matthew Kirschenbaum defines this quality as a neighbouring principle to forensic materiality and calls it the »formal materiality«<sup>54</sup> of the digital. From the formal materiality a more specific material characteristic of graphics arises, which could be described as polytrophic. This property places 3D computer graphics in one line with oil paint, wax, glass, and plastic. All these materials are related through the affordance to mimic other materials, a property often neglected precisely because it tends to efface itself. Wax has been described as the ultimate material of similarity, due to its wilful malleability.<sup>55</sup> But apart from plasticity, imitation is also afforded by a certain degree of transparency. A well-known example are the extremely realistic artefacts by the Dresden glass makers Leopold and Rudolf Blaschka. The Blaschka's knowledge of crafting glass enabled them to construct scientific models of animals, like for instance jellyfish, which had evaded mimetic representation due to their transparency.<sup>56</sup> Less poetic than wax and glass, plastic – making plasticity proverbial – has rather been criticized for its imitative potential.<sup>57</sup> In its beginnings, CG was often compared to plastic to pinpoint the lingering artificiality of rendered materials.<sup>58</sup> Today, digital mate-

<sup>53</sup> Lev Manovich: *Assembling Reality. Myths of Computer Graphics*, in: *Afterimage 20/2* (1992), pp. 12–14, under <http://www.manovich.net/TEXT/assembling.html>.

<sup>54</sup> Kirschenbaum: *Mechanisms* (as note 48), p. 9, note 16.

<sup>55</sup> Georges Didi-Huberman: *Die Ordnung des Materials. Plastizität, Unbehagen, Nachleben*, in: *Vorträge aus dem Warburg Haus*, Vol. 3, Berlin 1999, pp. 1–30, here p. 12.

<sup>56</sup> Lorraine Daston: *The Glass Flowers*, in: id. (ed.): *Things that Talk. Object Lessons from Art and Science*, New York, pp. 223–56.

<sup>57</sup> See Monika Wagner: *Vom Ende der materialgerechten Form. Kunst im Plastikzeitalter*, in: Barbara Naumann, Thomas Strässle and Caroline Torra-Mattenkloft (eds.): *Stoffe. Zur Geschichte der Materialität in Künsten und Wissenschaft*, Zürich 2006, pp. 229–46.

<sup>58</sup> William Schaffer: *The Importance of Being Plastic. The Feel of Pixar*, in: *Animation*

rial supersedes the properties of wax, glass and plastic as the ultimate mimetic material for scientific and other models; it has literally become all-material.

### Trans-Material

The last material level results from re-translations back into analogue material, which has happened a lot in the case of the teapot. There are for instance wooden teapots carved with CAD<sup>59</sup> and a *latte teapot* sprayed with caramel food coloring on top of a cappuccino.<sup>60</sup> The most stunning re-materialization of the *Utah teapot* known to me has been produced by the Japanese computer scientist and designer Tomohiro Tachi, who folded an Origami teapot from one sheet of paper for the teapot exhibit at SIGGRAPH 2006.<sup>61</sup> The intricate folding pattern for the paper teapot can only be calculated using the digital model. Tachi's work, apart from being delicate and beautiful, shows that the digital and the analogue model cannot exist without each other. Though the term *transmaterial* has been coined to describe tangible materials, which are newly engineered, include digital elements or expand familiar material properties, it can also be used to describe the relation between the digital and analogue, as the craft of coding is paired with the craft of folding, carving, cutting or painting.<sup>62</sup>

To sum up, a dissection of the teapot yields at least five material layers, from the making that leads to its encoding, to the material reality of the code itself, the CG object being in-material, the simulation of diverse material qualities and therefore being all-materials, and finally, its re-translation into the analogue. All these properties have fuelled the playful iconography of the teapot and show that the material



Fig. 5: Tomohiro Tachi, Origami Teapot (2006).

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Journal 20 (2004), pp. 72–95.

<sup>59</sup> Gershon Elber, Department of Computer Science, Haifa, under: <http://www.cs.technion.ac.il/~gershon/WoodWorking/>.

<sup>60</sup> The sprayer can be programmed for many designs but reproduced the teapot for the occasion of Siggraph 2008, under: <http://onlatte.com/blog/2008/08/20/selected-works-at-siggraph-2008/>.

<sup>61</sup> I would like to thank Tomohiro Tachi for letting me use his images. See more under: <http://www.tsg.ne.jp/TT/origami/teapot.html>.

<sup>62</sup> Blaine Brownell: *Transmaterial. A Catalogue of Materials that Redefine our Physical Environment*, Vol. 1–3, New York 2006–2010.

status of digital artefacts cannot be defined in opposition to analogue ones, but only through expanding traditional concepts of materiality to include the specificity of digital materials.<sup>63</sup>

## 9. The Material Culture of Computer Graphics

What is pouring from the teapot then is the material world of computer graphics. This world is reflected upon in another Pixar animation. *WALL-E* (USA 2008, Andrew Stanton) tells the story of a small waste robot, designed to clean up the trash of a civilization that has long left the polluted planet. Having performed his task of pressing garbage into cubic packages and stacking them skyscraper high for many years, has turned the little robot into a collector. Wall-e, a thing himself of course, takes things that strike him as interesting home to his container that he has turned into a kind of archive of human stuff, a museum of everyday culture, in which he is curator and creative recycler.<sup>64</sup> He creates mobile from old CD's, stores a videotape in a toaster and mounts a magnifying screen for an i-pod between the extendable arm of a 1950's desk lamp and an umbrella. Wall-e's affection for material culture mirrors the work of the computer graphics community: to be able to render all materials, to collect them, to understand them, to simulate their aging and weathering, to reconstruct and recombine them. The *Utah teapot* lies at the bottom of this endeavour. Like the generic pot made of clay that Ted Nelson once presented as antipode to computer artefacts, it has produced whole cultures.

Image Credits:

Fig. 1: Hendrik Wann Jensen, Utah Teapot rendered with BSSRDF, 2002, under: <http://graphics.stanford.edu/~henrik/images/subsurf.html>, reproduced with kind permission from H. W. Jensen.

Fig. 2: Screenshot Google image search for »Utah teapot«, January 2012, about 86.000 results.

Fig. 3: Screenshot Dataset Utah Teapot, under: [http://www.sjbaker.org/wiki/index.php?title=The\\_History\\_of\\_The\\_Teapot](http://www.sjbaker.org/wiki/index.php?title=The_History_of_The_Teapot).

Fig. 4: Martin Newell, Drawing for the Utah Teapot, 1974, under: <http://www.computerhistory.org/revolution/computer-graphics-music-and-art/15/206> reproduced with kind permission from the Computer History Museum, Mountain View, CA.

Fig. 5: Tomohiro Tachi, Origami Teapot, 2006, reproduced with kind permission from T. Tachi.

<sup>63</sup> See Hamid R. Ekbia: Digital Artifacts as Quasi-Objects. Qualification, Mediation, and Materiality, in: *Journal of the American Society for information Science and Technology* 60/12 (2009), pp. 2554–66, here p. 2558.

<sup>64</sup> See Colleen Montgomery: Woody's Roundup and Wall-E's Wunderkammer. Technophilia and Nostalgia in Pixar Animation, in: *Animation Studies* 6 (2011), pp. 7–13, under: <http://journal.animationstudies.org/2011/09/02/colleen-montgomery-woodys-roundup-and-walles-wunderkammer/#more-217>.