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DESIGN FOR ENGAGEMENT: THE CASE FOR MATERIAL USER INTERFACES

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Abstract
Under the theme *Radical Atoms*, the 2016 edition of Ars Electronica Festival referenced the MIT's Tangible Media Group research project to present a strong focus on new materials, which owe to the fast development of nanotechnologies in recent years. The present paper proposes to further discuss the *Radical Atoms* vision and the relevance of the Ars Electronica curatorial intent. By highlighting the possibilities opened by material user interfaces, the exhibit opens debate on the relation between materiality and information in the design of engaging experiences of technological artifacts.

Keywords
Ars Electronica Festival
Radical Atoms
Material User Interfaces
Computational Composites
Cognition
Design
Engagement
Virtual Worlds

1. INTRODUCTION

The 2016 edition of Ars Electronica Festival (Linz, September 8 to 12) introduced itself with one question: "Radical Atoms and the alchemists of our time… and what comes after self-driving cars and the internet of things?" The curators draw on the many possible futures of technological artifacts, with a strong focus on *smart materials*, which are the product of intersecting research on nanotechnology, computer science, mechatronics, neurosciences or biotechnology. By seamlessly weaving hardware and software, these materials exhibit an adaptive behavior to their environment, allowing the design of organism-like ubiquitous interfaces that will fundamentally change our relation to everyday objects, as soon as in the next 5 to 10 years. As Daniel Leithinger from MIT states in an interview to Ars Electronica:

> (…) on the one hand there will be objects that we'll design by ourselves, that will be individually done. That means there will be the professional designer, but also input from the consumer. And therefore we need computers. And on the other hand there will be changeable objects that will grow with us. These objects, let's say a table, will have the possibility to communicate with me, like a living thing. This is only one of many possible futures that we're thinking about at the moment. (Ars Electronica, 2016)

Therefore, the curatorial intent of the festival underlines the need to ponder the new ways technological artifacts are designed and experienced within this possible future paradigm. To this point, the collaboration between Ars Electronica and the MIT Tangible Media Group becomes relevant if considered the shift the research group made between two different projects, usually referred as *Tangible Bits* and *Radical Atoms*. The present paper proposes to further discuss the Radical Atoms vision, focusing on how these technological artifacts make relevant the need to reassess materiality and information in design processes.

2. FROM TANGIBLE BITS TO RADICAL ATOMS

2.1. Tangible Bits and the Tangible User Interface

The decisive moment for the MIT Tangible Media Group is traced back to CHI'97, in which Ishii and Ullmer (1997) presented the *Tangible Bits* vision, drawn from the specialized scientific artifacts that allowed cognition of phenomena with their rich affordances, before computers and digital simulation became standard procedure. This paper would pioneer research on tangible human interaction, translated as the possibility of seamlessly coupling physical space and digital space into palpable technological artifacts that could provide an alternative to the flatness of the Graphical User Interface:[1]

> Current GUI-based HCI displays all information as "painted bits" on rectangular screens in the foreground, thus restricting itself to very limited communication channels. GUIs fall short of embracing the richness of human senses and skills people have developed through a lifetime of interaction with the physical world. (Ishii and Ullmer 1997, 7)

1 It is worth noting that while the GUI had been introduced to the consumer market with Apple's Macintosh in 1984 and achieved mass access with Windows 95. By 1997, the GUI was becoming the standard interaction experience for users that were able to own their desktop computers either in the domestic or professional space.
By then, the idea that tangible interaction could eventually overcome the already established paradigm of keyboard, mouse and monitor was quite groundbreaking.

Tangible Bits relies on three key concepts: 1) activation of physical surfaces as interfaces, 2) the coupling of digital information (bits) and everyday known graspable objects (atoms) and 3) the use of ambient media so that interaction isn't reduced to the foreground, is extended to the periphery of human senses (Ishii and Ullmer 1997, 2). Most of the early prototypes fit into the category of tabletop tangible user interfaces, in which discrete objects are positioned and manipulated across the illuminated surface of a workbench. Physical actions are then sensed by a scanning device and once differential positioning of objects is detected, the system will project visual feedback onto the surface and the objects. Because these systems require different input and output mechanisms, synchronization of perceptual cues poses a great challenge, as instantaneous feedback is crucial to maintain a coherent interaction.

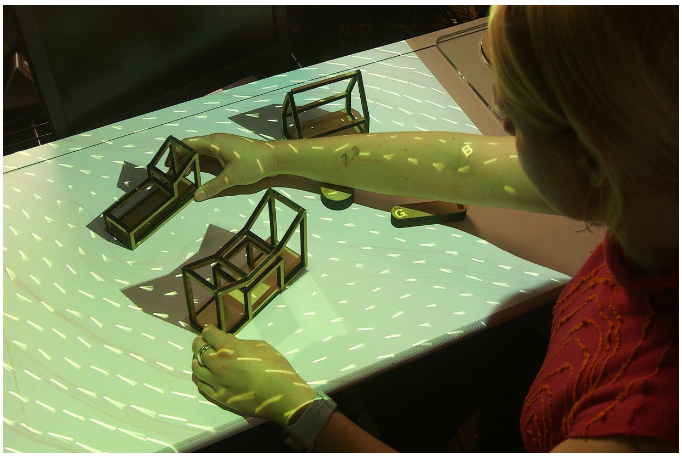

Fig. 1
Urp: A workbench for urban planning and design.
© 2012 Tangible Media Group / MIT Media Lab

2.2. Radical Atoms and the Material User Interface

As we saw *Tangible Bits* relies mostly on prototyping systems that would consider "rigid" objects as containers or action triggers for digital information. However, unlike pixels, these objects do not allow to easily change the form, position and properties in real time. (Hiroshi, et al. 2012, 40) There remains a certain substantialism to this view, as it relies on the necessary link between objects as particular manifestations in the physical world of digital immaterial instances. Therefore, *Radical Atoms* is presented as the next logical step from *Tangible Bits*: a possible future for human-computer interaction that envisions a new class of high-tech materials capable of the same kind of reconfiguration and malleability that pixels on a display do. Within Radical Atoms there is no duality between physical and digital realms, as interface design and product design become the very same process of form-giving:

> Radical Atoms is our vision for human interactions with dynamic physical materials that are computationally transformable and reconfigurable. Radical Atoms is based on a hypothetical, extremely malleable, and dynamic physical material that is bidirectionally coupled with an underlying digital model (bits) so that dynamic changes of the physical form can be reflected in the digital states in real time, and vice-versa. (Ishii et al. 2012, 45)

These hypothetical objects would rely on a new class of materials to fulfill three requirements: 1) *transform*, as the interface should allow direct input by the means of manual manipulation and gesture; 2) *conform* to a set of programmable constraints according to the physical properties of each material; and 3) *inform* the user of its transformational capabilities and the current state of the interface by the means of dynamic affordances. When envisioning the possibilities of *Radical Atoms*, researchers at the MIT Tangible Media Group projected an object that would reflect the three requirements above: *Perfect Red* is sketched as a storyboard of a hypothetical shape-changing interface that allowed for the same degree of malleability as objects in Computer-Aided Design software (CAD).

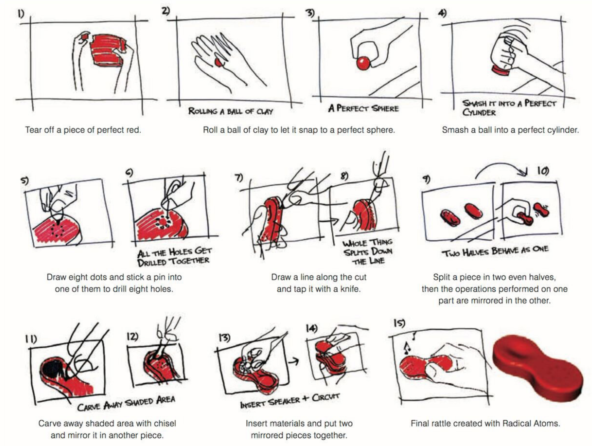

Fig. 2
Storyboard of *Perfect Red* by Leonardo Bonanni © 2012 Tangible Media Group / MIT Media Lab

Throughout the research project, many techniques for sensing and display were applied to prototyping in attempting to come closer to *Perfect Red*. These include pneumatic and hydraulic jamming, layer jamming for flexible displays, shape-memory alloys, pin displays, bio-hybrid film, among others. At Ars Electronica Festival there were exhibited a few remarkable examples of this effort, from which *PneUI* and *jamSheets* offer good examples:

PneUI

PneUI is a shape-changing interface driven by pneumatically actuated soft composite materials. Its multi-layered structure uses materials with different properties and enables input and output through dynamically controllable texture patterns.

Sensing modalities include gestures on the surface, hovering over the surface, gestures that deform the surface and air deformation of the surface — the first ones used for input and the latter for output. *PneUI* is composed of two structural layers: the first one responds isotropically to stress and it's usually made of an elastomer such as rubber; the second layer enables anisotropic deformation in response to air pressure and it may be made of paper, fabric, wood, yarn or string, plastic, metal sheet or wire. A third layer enables the sensing of hand input and output trough liquid metal, conductive thread, metal wire, foil or tape, conductive fabrics or conductive ink. Finally, one additional layer can be used to control other material properties, either haptic or visual, such as surface stiffness or color. *PneUI* was initially presented through four different applications: height changing tangible *phicons* (the term for *physical icons*), a morphing bar-shaped changing mobile, transformable tablet cases and a shape shifting lamp. (Yao et al. 2013, 14)

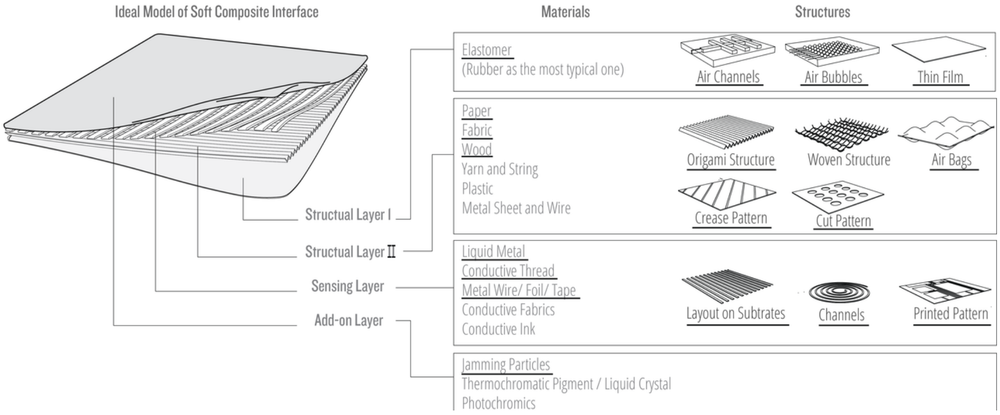

Fig. 3
Diagram of the composite structure technology of PneUI © 2012 Tangible Media Group / MIT Media Lab

jamSheets

jamSheets uses similar technology as the one presented in *PneUI* to enable thin lightweight interfaces for tunable stiffness. One of the most interesting applications of *jamSheets* concerns shape-changing furniture as portable objects that allow deformation into different shapes of variable stiffness with different affordances. In its unjammed state, the object resembles a carpet that can easily be folded and carried around. If the user changes its shape into the one of a chair, by creating two folds in the place where sensors are embedded, then the system will activate stiffness to fix the shape of a chair with the capacity to carry up to a 55 kg load. Two additional air bladders can then be attached to the surface to switch to a coffee-table. (Ou et al. 2014, 69)

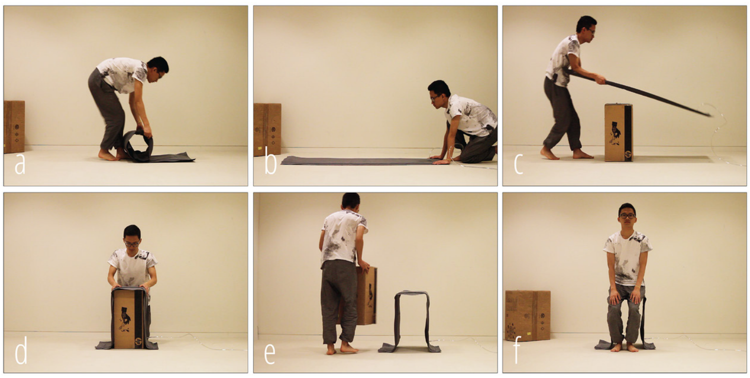

Fig. 4
Deformable furniture storyboard © 2012 Tangible Media Group / MIT Media Lab

3. THE ALCHEMISTS OF OUR TIME

3.1. Form-giving for new computational composites

Design has always been a platonic-inspired discipline, as the primordial role seems to be given not to the material properties of objects, but to the ideas they embody. By revisiting the ancient greek opposition between matter and form or content and container, the main principle is that the designer imposes an eternal form—let's say, the form of a table—into a piece of wood, thus informing the material. Design as a discipline has relied on this since its early days, as it has always been about the process of informing the world by imposing a language to things: as symbols, meanings and functions.

From the industrial revolution to the present day, this notion of informing encountered fundamental changes: "In the past, it was a matter of giving formal order to the apparent world of material, but now it is a question of making a world appear that is largely encoded in figures, a world of forms that are multiplying uncontrollably." (Flusser 1999, 28). Verbeek and Kockelkoren (1998) position us back in the nineteenth-century, when means of mass production demanded that design as projection and production as execution became separated. This shift from manufacturing to industrialization gave rise to the romanticism of the Arts and Crafts Movement as response. On the other hand, the Modern Movement embraced the machine: as stated on the slogan *form follows function* products had to be functional, but form also followed the constraints of the machinery available to produce that artifact. The fifties and Contemporary Style welcomed the introduction of several new materials and commodities, many triggered by developments during WWII. From the late nineteenth century to postmodern age, Design's focus on objects as tools became secondary to objects as carriers of signification:

> **Postmodern design is trapped within another form of Platonism. It does not reduce products to heir function but to meaning. Postmodern products have become icons, symbols, or signs. They do not even need to be durable anymore, as they did for modernist design. The attachment such products evoke concerns their meaning and not themselves as material objects. They could, after all, be replaced by any other object with the same sign value. (Verbeek and Kockelkoren 1998, 33)**

This statement echoes Borgmann (1987), to whom technological artifacts of our time differ from pre-technological ones, in such a way they diminish people's engagement with each other and with the world around them. Devices, as Borgmann calls them — can be seen as consisting of two elements: a "machinery" — the product as a physical object — and the "commodity" it delivers by functioning. In the current context of ubiquitous commodity delivery, machinery tends to withdraw, so the product can come across as "user-friendly" and the less demanding as possible. Thus the Platonism of postmodern design lies precisely on the machinery withdrawal and the building up of signifiers: "the commodities of technology have surface character. They are in fact mere and opaque surfaces which permit no insight into their substructure, i.e., their machinery. Advertising remains true to this dimension and refrains by and large from breaking into the technological background and from presenting analyses and arguments which presuppose and manifest expertise." (Borgmann 1987, 127)

However, Borgmann's view is not without criticism: claiming that disengagement can only be reversed through the devotion to focal practices and things is a clear gesture of romanticization of the past. By putting the argument in these terms, Borgmann refuses any possibility of engagement in high-end technology, as he conflates it with the loss of bodily-sensory engagement. The following section will further argue on material user interfaces as a design practice that responds to this problem, not necessarily by bringing materiality to the foreground to enhance bodily engagement, but by demonstrating how symbolic and informational processes mediate materiality, incorporating themselves in the meaningfulness of things.

3.2. Designing mediality

Industrial Revolution did not only conflate with the rise of Design as a discipline, but also to new possibilities of technical control of matter. Bühlmann (2013) considers that ever since, the analytic makeup of matter is being increasingly rendered by the mathematical / symbolic formating of information.

> Electricity can affect the energetic makeup of any biological, chemical, or physical body. And the capacity to store, expand, emit, and receive information now functions as the common denominator of all things existent, a role previously ascribed to generalized materiality.
> What used to be productively conceived as a uniform substrate to all things is increasingly governed regionally, or individually, by symbolic processes. With electricity and information, materiality becomes medialized. (Bühlmann, 2013).

Although not yet widely available, the class of materials that will enable *Perfect Red* is the next step to this energetic makeup of materiality. These new materials hold the ability to mutate their structural qualities (durability, flexibility, transparency, weight, color) according to their programmed constraints and external contextual input. Let's take one application of *PneUI* to demonstrate such capabilities, even though in a still early stage of development: a shape-shifting lamp can afford curling behavior by applying silicon with embedded liquid metal as a pulling sensor. *LED's* are soldered into flexible copper strips bonded with a paper layer, which is then bonded to the air channel layer with silicon. The end result offers a highly malleable object, triggered by a simple gestural input. This class of properties will certainly pose great challenges to design as the practice of informing the world and crafting meaningful experiences of objects.

Within such a context, computers are no longer mere tools, but become present as materials for design practice, what Vallgårda (2014) addresses as computational composites. As consequence, product design and interaction design became entangled practices, as "… interaction design in a sense becomes the practice of giving form to artifacts or environments rather like any of the other design disciplines that we have known for centuries. However, giving form to computational things is highly complex and somewhat different from most other form giving practices due to its temporal form element — its ability to change between states." (Vallgårda 2014, 577). Giving form to computational composites then means a negotiation between 1) *physical form*, accessible mainly through perception; 2) *interaction gestalt*, as the actions a user does in relation to the object; 3) *temporal form*, as intrinsic to the task of programming itself.

The first two make for the spatial consistency of the object, usually referred to as the object affordances. Temporal form, on the other hand, differentiates these computational composites from other materials: by rendering physical form and interaction gestalt temporal and allowing material properties to change across time, these objects are able to mutate and switch between states of expression depending on contextual factors and / or actions. No material is time and context independent, of course, but within material user interfaces it's possible to relate these dimensions in ways not possible before, thus emphasizing the ability of materials to *become*. By employing the notion of *becoming*, Vallgårda positions the relevance of this study within post-structuralist views in contemporary philosophy and design, views that encompass the open-ended character of realities as organisms and the indeterminacy of its potential eventualities (Vallgårda 2010, 5). Although Vallgårda's research argues for the notion of *becoming materials* to build on the temporal form of computational composites and thereby overcoming essentialism, the present paper will rather argue for an *objective* view of a flat ontology, as proposed by French philosopher Tristan Garcia. He follows the idea of a "flat ontology" shared by many contemporary philosophers, but unlike theories of pure eventuality which tend to disseminate being and keep us from understanding the world, Garcia (2014) argues that objects matter to us and to *something other than us* (the environment, other species, other ideas) in different intensities. So his proposal combines a formal ontology of equality with an objective ontology of inequity.

Common sense tends to make spatial unity precede temporal unity, as things will happen to gain an internal consistency that will remain over time. Temporal coherency, as the capacity of enduring *spatial form* and *interaction gestalt*, will only intensify the precedent spatial consistency of the thing. Within such a conception, things that are able to change their form across time appear as undefined, heteronomous, "pliable", corrupted (Garcia 2014, 35). This commonsensical view highlights the relevance of material composites, such that they oscillate be-tween the *formal* and the *objective*. Experiencing *Perfect Red* would make these articulations clear: formally, matter is that which is the thing, and form that which the thing is. *Objectively*, that which is a thing are objects, while that which the thing is the bigger plane in which this thing enters amongst other objects. (*ibid.*, 113)

To Garcia, this encompasses both signification and meaning. The former arranges things within the same plane, while the later concerns relations with things in different planes: "Significations concern things, rules and uses; meaning concerns being and comprehending, choice. Through signification, things are between each other; through meaning things are in each other" (*ibid.*, 124). Meaning is not what relates one thing to another things, but what is *in the thing* and that *in which the thing is in*, it arises from the articulation between the formal and the objective. What we are looking for is for the ability to guarantee the flux between the double sense of things. The adequate image is offered at certain point: *Signification is a continuously woven fabric; meaning is an overlapping of Russian dolls*. (*ibid.*,124).

Thereby "ghost of compactness" of the world can only disappear under the condition of rejecting all reductionism. Calling for the semiotic meaning of artifacts or their use, to our linguistic, social, or cultural practices, will be falling into the impossibility of abstracting things from the relations that we maintain with them. (*ibid.*, 13-4). However, the enhancement of materiality as a strategy to unveil artifacts from the postmodern semiotics of commodities cannot serve the purpose of the present argument, as it falls into another form of reductionism— material reductionism puts forward a schema in which things are material. In other words, it composes things with matter, and this matter with the things that matter composes. This shift in language is decisive: if atoms, particles, and forces composed matter then the universe would [also] become compact. (*ibid.*,136).

4. ...AND WHAT COMES AFTER SELF-DRIVING CARS AND THE INTERNET OF THINGS?

Back in the second half of the 1990s, the MIT Tangible Media Group's vision was already anticipating the future of ubiquitous computing systems, with their *Tan gible Atoms* project. They envisioned the networking of digitally enhanced objects, which would be enabled by the development of smaller and more powerful processors … but what comes after self-driving cars and the Internet of Things? The shift towards *Radical Atoms* project takes the next step towards the informational possibilities of mediating matter, in a way such that the experiencing of technological artifacts in defined in terms other than the dichotomies information / material, background / foreground, or transparency / opacity.

The essentially political role of the designer has always been to impose form into matter in the world, thus organizing experience. Bühlmann sets the strategy: amongst the context of computational composites designers will need to reassess design practices to consider the integration of symbolic fluxes into the materials of their craft, in order to attain new experiences which defy the commonsensical spatio-temporal coherence of inert objects. Garcia defines the task: designing will be less about informing materials into products that will mass pro-duce, circulate and rendered obsolete, but about tailoring the coexistence and co-shaping of entities in a non-compact world, opened by the terms of a flat ontology combined with an objective differentiation.

Finally, the hypothesis above argues for the reading of Ars Electronica 2016's curatorial intent, as a commentary on the strategies to make things *matter* without the trap of nostalgia, alienation or reductionism that may threaten contemporary thinking on materiality.

REFERENCES

Ars Electronica, "Radical Atoms Exhibition". Accessed December 28, 2017. http://www.aec.at/radicalatoms/en/radical-atoms-exhibition/

Ars Electronica, "2016 Ars Electronica Festival: RADICAL ATOMS and the alchemists of our time / EN" Filmed September 2016. YouTube Video, 42:34, Posted October 25, 2016. https://www.youtube.com/watch?v=gjMdtWfCjuQ.

Bergström, Jenny et al. "Becoming materials: material forms and forms of practice", *Digital Creativity*, 21:3 (2010) 155-172.

Borgmann, Albert. *Technology and the character of contemporary life: a philosophical inquiry*. Chicago: University of Chicago Press, 1984. 1987.

Bülmann, Vera. "The Integrity of Objects: Design, Information, and the Form of Actuality" in *Add Metaphisics*. Aalto: Aalto University, 2013.

Flusser, Vilém. *The Shape of Things: A Philosophy of Design*, trans. Anthony Mathews. London: Reaktion Books, 1999.

Garcia, Tristan. *Form and Object: A Treatise of Things*, trans. Mark Allan Ohm and Jon Cogburn. Edinburgh: Edinburgh University Press, 2014.

Ishii, Hiroshii and Brygg Ullmer. "Tangible bits: towards seamless interfaces between people, bits and atoms", in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI'97 (New York, ACM, 1997), 234-241.

Ishii, Hiroshi et at. "Radical Atoms: Beyond Tangible Bits, Toward Transformable Materials" *Interactions*, 19:1 (2012), 38-51.

MIT Tangible Media Group, "Our Vision". Accessed January 14, 2017. http://tangible.media.mit.edu/vision/

Ou, Jifei et al. "jamSheets: thin interfaces with tunable stiffness enabled by layer jamming" in *Proceedings of the 8th International Conference on Tangible*, Embedded and Embodied Interaction, TEI'14 (ACM, New York, 2014) 65-72.

Underkoffler, John and Hiroshii Ishii. "Urp: a luminous-tangible workbench for urban planning and design", in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: the CHI Is the Limit*, CHI'99 (New York: ACM, 1999), 386-393.

Vallgårda, Anna. "Giving form to computational things: developing a practice of interaction design", *Personal Ubiquitous Computing* 18:3 (2014) 577-592.

Verbeek, Paul and Petran Kockelkoren. "The Things that Matter", Design Issues 14:3 (1998), 28-42.

Yao, Lining et al. "PneUI: pneumatically actuated soft composite materials for shape changing interfaces" in *Proceedings of the 26th annual ACM symposium on User interface software and technology*, UIST'13 (New York, ACM, 2013), 13-22.