Hertzian, Disruptive, Experimental Text Physicalizations

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Abstract

A series of creative text physicalizations are accounted for herein, with reference to research literature and, most importantly, to an experimental algorithmic system designed and implemented by the author. The latter concerns a series of experimental pipelines that 'understand' the input text generating keywords, that utilize them to query 3D data from WWW, and, finally, that transfigure and merge the latter so that new original artefacts are synthesized. The various physical, digital, and post-digital material affordancies of the resulting physicalizations are scrutinized in some depth and in an analytic fashion. Objects of sorts are shown to be ascribed a certain kind of emergent neo-materiality, in that they are themselves hybrid manifestations of interwoven physical and digital affairs. As such, they constitute situated inquiries of the very same (technological) paradigms that brought them forth, as well as of their cultural and ideological offshoots. Physicalizations of sorts are shown to be 'Herzian', post-optimal, and disruptive, being both the creative means towards an exploration of new kinds of materiality/objecthood, and an implicit critique of the canonical functional design schemata that largely pertain digital fabrication nowadays.

Keywords

Physicalization, Post-digital, 3D printing, Solid modeling, Digital fabrication, Natural Language Understanding, 3D Data.

Introduction

Digital fabrication has been hitherto researched in various contexts, *inter alia*: FabLabs [1, 28], DIY personal fabrication [6], 'maker' culture [32, 21], and architecture [15, 5]. The last few decades, the proliferation of assorted technologies has accelerated an ongoing trend calling for the 'datafication' of physical objects [29, 2, 7, 17], and has resulted in the formulation of various relevant communities [3, 33, 24]. Despite their disparity, however, such communities/endeavors are rather orientated towards functional, maker-oriented, decorative, or otherwise 'useful' designs. This project, instead, is rather concerned with methodologies aiming at the production of objects that are post-optimal, disruptive/critical to the capitalist user-oriented design paradigm, or simply 'weird'.

In this respect, it is more relevant to all those hybrid artistic endeavors that concern the production of non-canonical (in some respect) artefacts and in ways that may speculate non-standardized, and not necessarily functional, production paradigms. *Oiko-nomic Threads* [18], for instance, speculates the nature of labor by virtue of a hybrid system producing a textile in a self-generative fashion and employing numerical data, digitized motifs, bespoke software running on iMac computers, a hardware hacked knitting machine from the 1980s, and an individual physically operating it. Another example is *Crafted Logic*, concerning operative electronic logic gates produced by means of textile-crafting techniques and being intended as a way to "*imagine alternatives to existing realities of computational technologies*" [27]. Insofar as approaches employing natural language are concerned, of particular relevance is *Spam Architecture*, revolving around a bespoke (albeit not yet documented) algorithm that produces 3D forms from junk email [34]. The resulting forms do sustain an architectural sense of rectilinearity, yet they defy pragmatics appearing rather unconventional and somehow corrupted—if not altogether 'uncanny'. (For more approaches employing textual data in some nonlinear fashion see, for instance, [22]).

The endeavor accounted for herein pivots on a series of experiments that concern the algorithmic production of physical objects from arbitrary text, employing Natural Language Understanding (NLU) and 3D data. Physicalizations of the sort are illustrated in the following pages, as well as in [20]. Their production relies on a series of experimental pipelines. The first parses and processes the input, collapsing it to a series of keywords, or phrases that are subsequently used as queries in order to retrieve 3D-printable models from Thingiverse[1]. This is achieved by means of algorithmically manipulating the input, so that it collapses into a bag of associated words, phrases, and concepts (not necessarily just the ones that appear in the text) that may, in principle, exemplify its meaning. This is a rather involved task that employs bespoke NLU techniques so that (a) words of possible interest are identified and extracted, (b) possible semantic associations between them are resolved employing co-reference resolution tactics that depend on online databases for lexical/semantic associations, (c) occurrences among the latter are quantified and ranked, and (d) just the highest ranked ones are kept. This resulting bag of concepts can be then used to perform online

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[1] https://www.thingiverse.com Accessed December 18, 2018

queries so that 3D data are accordingly retrieved. Following this transliteration stage, the following pipeline is rather straightforward and concerns the geometrical transfiguration and eventual synthesis of the retrieved 3D data into new original mergers. These may be, later on, fabricated using standard 3D printing technologies.

The pipelines are further discussed in [16], where the method, technical implications, and implementation specifics are elaborated upon in great detail. As explained there, the proposed algorithm, in its final contingency, is characterized by important design decisions insofar as the particular ways in which the input text would be processed, and, accordingly, regarding repercussions that would propagate through the subsequent data-retrieval and synthesis phases. To give an example of the complexities at play, consider that when verbs/verb-phrases are also taken into account by the NLU-related parts of the algorithm, the resulting bag of concept does, indeed, better summarize the original narrative, yet, at the cost of an increasing number of queries resulting to haphazard 3D data (since most available models are typically named using noun-based descriptors alone). At the very same time, it is still unclear whether constructing longer, and thus more descriptive, noun phrases would result in more, or less, relevant results. Arguably, and up to some certain extend, design decisions also adhere to an aesthetic appreciation of how objects should not look like—that is, it is both presupposed and desired that they should not resemble ordinary functional/canonical objects.

It should be noted that in its final incarnation the suggested system is already contingent and can be extensively parameterized. To boot, it has been preceded by several other experimental set-ups that are not discussed in the above mentioned article. All together they lay out an array of assorted paradigms to physicalize text in creative, non-descriptive, and non-utilitarian, fashions. This treatise zeroes in on the kinds of physicalizations these systems may result into, irrespective of the technical particularities governing their production. Such artefacts are examined herein in an analytical fashion, and are found to attain a series of interesting physical, digital, and post-digital properties, as well as to constitute themselves crystallized inquiries of the very same technologies that brought them forth in the first place.

Having introduced the article and its primary foci, the next section outlines related work, and the one after that presents several example physicalizations. A discussion section follows, where the latter are analyzed in all physical, digital, and post-digital respects. Concluding remarks follow.

Related Work

Research literature accounts for several 'datalogical' approaches to digital fabrication. Several papers elaborate on systems for the physicalization of data representing human physical activity [14, 31, 11], others compare physical—e.g. 3D bar charts and 'data sculptures'—to traditional visualizations [13], and others discuss data physicalization in general [12, 30]. Zhao and Moere elaborate on "*data-based physical artifacts*" [*sic*] that possess both artistic and functional qualities, and that aim "*to augment a nearby audience's understanding of data insights and any socially relevant issues*

that underlie it" [35]. To boot, at least two notable cases of workshops that pivot on the physicalization of information have taken place in InfoVis/CHI contexts [12, 10].

The most straightforward trend in information physicalization is to simply map data directly into objects of varying dimensions. Consider, for instance, Hogan's *Vessels of Ireland's Past* series, where wooden circles of varying radii along a spit represent Ireland's emigration, immigration and murder rate over selected periods of time[2]. This is a largely chart-inspired approach that can be particularly informative and intuitive in functional contexts, as illustrated in [12]. Direct comprehensibility should not be thought of as requisite to functional physicalizations, however, as there are many cases of a largely functional scope that, nevertheless, adhere to more liberal mapping schemata.

As a matter of fact, certain traits within 'personal informatics' and the so-called 'self-tracking culture' [23] rather prioritize individuated readings of data defined by their own making, or by one's personal experiences of it. Their actual quantitative significance, then, may, or may not, be of any importance. Physicalizations of sorts suggest an abstract and primarily qualitative approach, resulting in artefacts the signification of which remains largely individual-specific and the comprehensibility of which is not necessarily a desired trait—at least not in the traditional quantitative sense associated with InfoVis related research. Consider, *e.g.*,"*Activity Sculptures*" of running activity. Quoting the authors:

> "[. . .] we decided to focus on sculptures of an abstract nature and which support self-reflection. [. . .] Comprehensibility and direct readability of the exact data at the first glance was secondary since participants used the sculptures for a longer time." [31]

There are important similarities between such approaches and the one accounted for herein, in that they are both not particularly concerned with immediate comprehensibility, and in that the resulting objects can be somewhat weird-looking. Still, while *direct* readability is not, indeed, inherent to such an endeavor's foci, *individuated*, and/or *longer-term*, readability appears to be—as the above excerpt implies. Most importantly, and comprehensibility affairs aside, that kind of physicalizations are still meant as somehow 'useful', and thus functional, artefacts that do satisfy some particular need related to self-tracking and the projection of personal information. While it is arguable to what extent the resulting artefacts constitute themselves commodities of some sort, they are typically dealt with as prototypes that may, eventually, become somehow commercialized—be them for physical products or services. As such, the canonical norms governing functional design are, to some varying extent, both in effect and of relevance in this and in other similar cases. The herein presented research, however, rather concerns physicalizations that pose questions regarding their very own hybrid materiality and the technologies that govern their own making—in a sound materialist fashion. As explained in [16], the underlying algorithms are designed not in order to facilitate the generation of objects that are descriptive, or otherwise exemplificatory,

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[2]`http://tactiledata.net` Accessed December 18, 2018

Figure 1: 3D text physicalization; largest dimension is 6cm

Figure 2: 3D text physicalization; largest dimension is 16cm
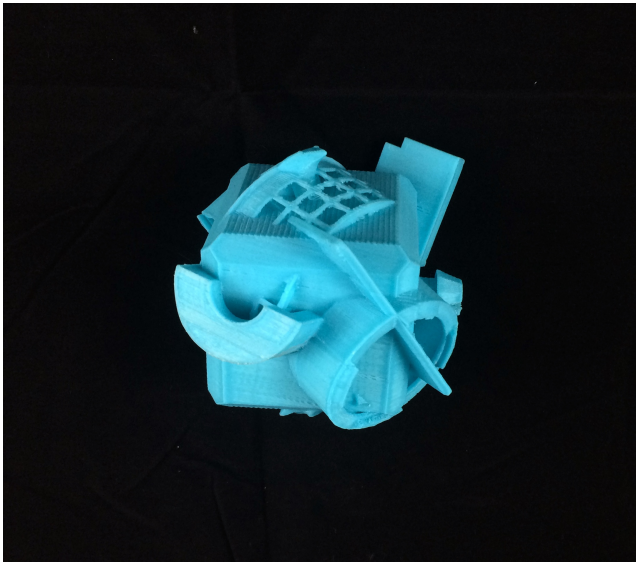

Figure 3: 3D text physicalization; largest dimension is 27cm

of the input text, but, instead, to generate ambiguous and disruptive artefacts that may fuel an interrogation of the technologies, and the data repositories, that are involved in their making. In this respect, and as to be later on discussed, such artefacts celebrate a certain kind of materialist structural introspection.

Much closer in spirit to such an approach are Nissen and Bowers' participatory data physicalization experiments [25]. One of those experiments concerns the physicalization of data representing the hand movements of crochet practitioners on a series of different occasions. Since participants cannot easily interact with the specifics of fabrication—that is, to experience the consequences of their modified behavior in the resulting artefacts—the resulting objects are rather abstract and illegible. They have observed, nevertheless, that after some certain period of time, the participants have become increasingly more interested in how their practice may inform the produced shapes, and have been even reported to change their crocheting behaviors in order to either interactively control the physicalization process at will, or to ameliorate the way they crochet with respect to the feedback physicalizations provide them with. In this research context, the authors have also become themselves reciprocally interested in crochet practice. All in all, their approach suggests, up to a certain extend, a community-driven and non functional attitude towards data physicalization. The resulting artefacts are primarily dealt with as the means to explore post-digital materiality in a situated real-life context here, rather than as 'products' to be eventually commercialized somehow.

Results

The physicalization system outlined in the Introduction has been employed on many occasions, spawning dozens of models several of which have been fabricated employing 3D printers. Figures 1–9 present a small sample of such physicalization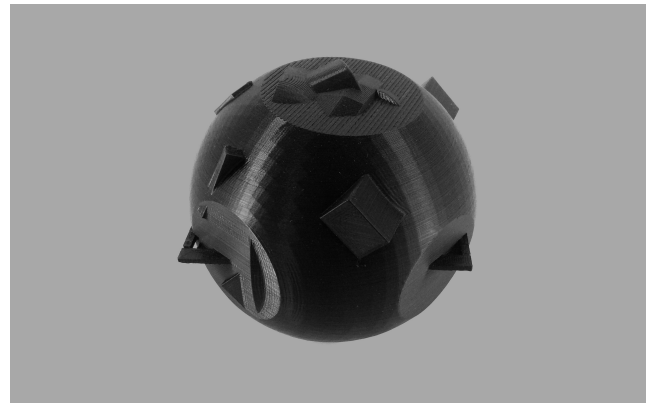s. The question of whether, and if so how exactly, such artefacts may relate to their input text is examined in some detail in [16]. As discussed there, while in a few exceptional cases individuals did indeed come up with stories, or described moods that are rather evocative of the original input narrative, such physicalizations do not, in principle, exemplify the former in some significant semantic or phenomenological fashion. That said, they have been reported to trigger imagination in interesting ways and to result in particular moods, impressions, and even related clear-cut narratives that are occasionally shared across different viewers. As discussed in the above mentioned treatise, this can be attributed to the fact that they typically comprise recognizable shapes and (parts of) other objects. That is, they *are* themselves eclectic syntheses of more or less ambiguous entities with respect to the particular kinds of associations forged by their generating algorithm. The former may range from literal to non-intended, and from too-implicit to altogether dysfunctional ones.
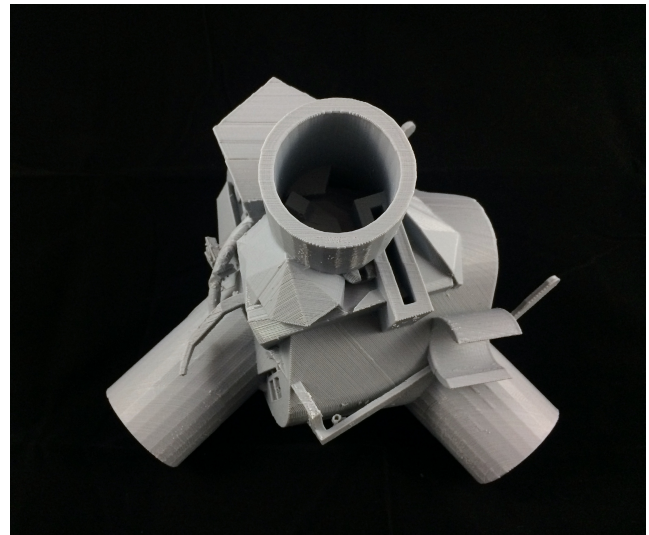
In this way, individuated readings of such artefacts are laid out by virtue of 'connecting the dots' between arbitrary signs
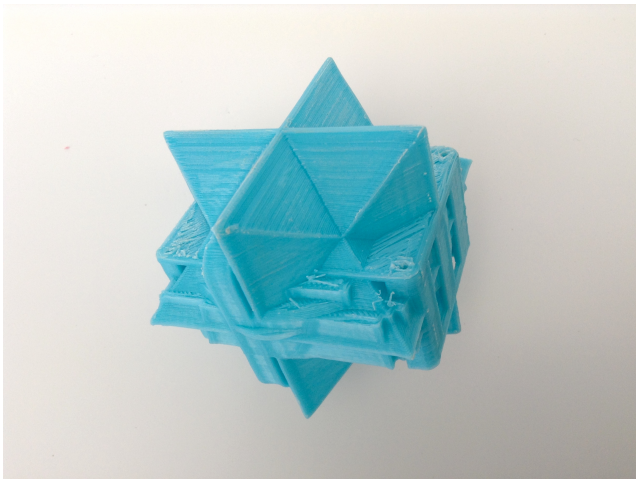
Figure 4: 3D text physicalization; largest dimension is 6cm

Figure 6: 3D text physicalization; largest dimension is 12cm

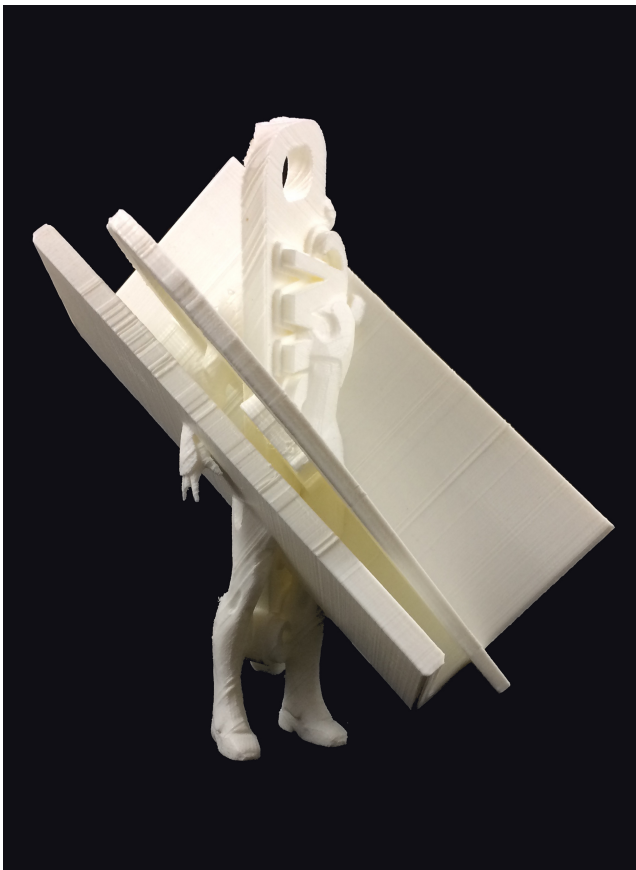Figure 7: 3D text physicalization; largest dimension is 13cm

Figure 5: 3D text physicalization; largest dimension is 21cm

and their subjective significations, so that new (symbolical) content may be generated. It should be highlighted, however, that while the methodology of production moves intentionally into ambiguity (so that the generated objects are indeed, and up to some certain extend, semantically and aesthetically ambivalent), ascribed meaning cannot be solely attributed to in-
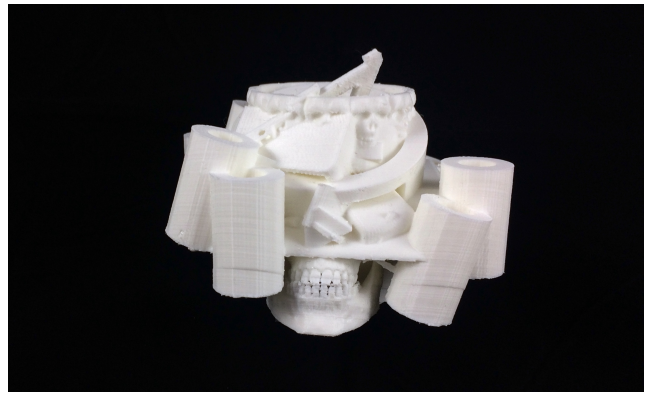
terpretation schemata that are solely intrinsic to the viewer (in a Rorschach test fashion). As explained in [16], the pipelines involved have been designed with care so that the possibility of entirely haphazard transliterations is minimized, if not altogether eliminated. Accordingly, the resulting objects typically comprise more or less related integrals that, in turn, would favor (a few) possible reading(s), or kinds of readings alone—also with respect to the specifics of the particular experimental pipeline employed and the overall technical limitations of the overall method. In other words, while a certain level of ambiguity is indeed sought for (and arguably achieved) in all aesthetic, semantic and methodological respects, the resulting artefacts are not entirely equivocal (nor are they intended as such) phenomenologically.

The above mentioned article discusses extensively the visual aspects of such physicalizations but largely overlooks their textural and haptic qualities which, however, raise important phenomenological and post-digital affairs. Structurally, they are rough-hewn with a rather involved tactility. Unlike canonical everyday functional objects, or Info-VIS/CHI oriented data physicalizations, they tend to feature unnecessarily complex and rather uncanny 3D geometries,
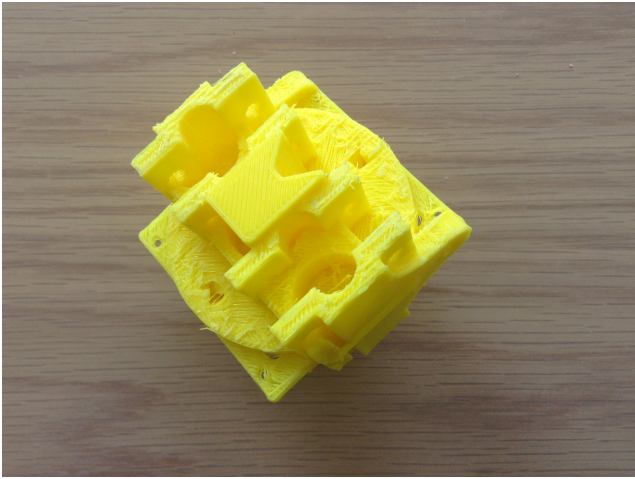
Figure 8: 3D text physicalization; largest dimension is 6cm

Figure 9: 3D text physicalization; largest dimension is 10.5cm

comprising of very eclectic props and substructures. Consider, *e.g.*, the objects in Figs. 1 and 3 that feature all sorts of haptically indefinite shapes, or the objects in Figs. 4, 8, and 9, that could be taken for as gimmicks of some sort. Indeed, they can be all 'performed'—much like fidget spinners, or rosaries—by means of holding them between one's fingertips and rotating them around various axes, of exploring their various structural cavities and haptic affordancies, or simply by holding them within one's palm. up to a certain extend this is a direct consequent of their dimensions: if they were much larger, or much smaller, that kind of affordancies would not be possible; and if the object in Fig. 2 were smaller, it would most likely afford similar performances. Still, it is also dependent on the intricacies of their geometry. Consider, *e.g.*, that even if 3D printed in different dimensions, the objects illustrated in Figs. 5 and 6 would not suggest themselves as gimmicks of sorts.

Therefore, merely with respect to their physical dimensions and structural qualities, physicalizations of the sort may suggest themselves as also attaining some kind of functionality. Such an emergent property may manifest in other ways, too. *E.g.*, the objects in Fig 5 and 7 inherently appear to suggest themselves as items to be *placed* somewhere—that is, they afford, and, in this vein, they also implicitly advertise

themselves as artefacts that *should be*, exhibited and visually appreciated. Similarly, the objects shown in Figs. 1 and 4, rather call for haptic exploration, or simply to be held within one's palm.

Discussion

The material qualities these physicalizations bring forth can be examined analytically, with respect to physical, digital, and post-digital traits. At a purely physical level, as already explained, they are already ascribed with possible meanings with respect to their constituent subparts, the more or less vague associations they lay out, and the kinds of broad narratives their synthesis may suggest. At the same time, their tactility also accelerates particular haptic affordancies and may even suggest particular ways in which they can be performed, or used. That is to say, that at a very physical level they are already operate as both items to be used/performed and signs to be read/interpreted.

Their most striking physical property, however, is their being soundly different from the canonical objects we typically share our everyday lives with. Unlike alarm clocks, cellphones, mugs, laptops, and TVs, and despite being possibly ascribed some meaning or facilitating some particular mode of interaction, they are too extravagant to collapse into some well-defined use case. While their structural affordancies may suggest some more or less proper way to engage with them, as already explained, they cannot be reduced to this mode alone so that, *e.g.* the objects in Figs 4 and 9 are not gimmicks to play with, but rather 'weird' items that can be used this way too. Likewise, the possible narratives they appear to be ascribed with are always up to a certain extend ambiguous and suggest themselves as rather implicit and somewhat vague (rather than absolute). In this vein, they can be thought of as post-optimal objects, that defy stict contextualizations and that call for an immediate exploration of what they could possibly do/mean, while, at the very same time, they seem to question—or criticize—the supposed transparency of other, canonical, objects—see [4] for more into that kind of post-optimal, that is 'Hertzian', objects.

The illustrated physicalizations have even more interesting digital properties, in that albeit concretely physical—in the most literal sense of the word—they are simultaneously digital and embedded with the cybernetic encodings of their own making. Indeed, not only they soundly advertise their being algorithmically synthesized and digitally fabricated, they also solely exist as contingent manifestations of elsewhere stored digital information rather than as unique artefacts. In principle, they are always *copies*, meant to be re-produced and re-instantiated *in situ* with respect to localized digital technologies. They *are* digital information that can be archived, retrieved and re-produced at will, in the very same fashion that digital images [8] or digital audio [19] can.

Accordingly, being themselves digital content, they are also ascribed meaning on the account of the particular media that enable their reproduction and, most importantly, of the social and ideological repercussions the latter bring forth. In this particular case, and depending of course on the particular ways in which their exhibition may be contextualized, the digital concerns that are relevant herein involve, *inter*

alia, NLU, information retrieval, computational solid modeling, and digital fabrication technologies. Digital fabrication, in particular, is a rather charged, ideologically speaking, field of study/practice that remains relevant to a broad array of subcultures. It can be thought of, *e.g.* as drawing on, or implicitly calling for, (start-up) entrepreneurship, FabLab culture, DIY/DIWO fabrication, free/libre and open-source software/hardware, p2p sharing, hacking, and even political activism. In this vein, 3D printed physicalizations are often thought of as relating, or even advertising, such affairs. Note that the former are, in certain cases, discrepant with one another—in reality, there are severe ideological clashes between the various communities that are backing up digital fabrication technologies [9, pp. 25–44].

The extend to which such digital readings are accelerated depends, of course, on who, and in what context, interacts with the artefacts under scrutiny. In certain contexts, nevertheless, and when particular kinds of audiences are concerned, the above discussed digital traits seem to suggest legitimate ways in which one may interact with them— much like their physical counterparts. Certain kinds of audiences would be immediately drawn, *e.g.*, into sharing and fabricating themselves copies of these objects using localized 3D printed technologies, and others, when the context allows so, into generating their unique physicalizations with respect to own text input. Interaction schemata of the sort should not be understood as merely context-specific and context-related. They are rather brought forth but the very materiality of such physicalizations which already embed, in concrete physical terms, particular digital logics insofar as reproduction and performance are concerned. While arguably such objects cannot be immediately recognized as text physicalizations, they are immediately understood as algorithmically produced and digitally fabricated artefacts simply because of how they look, and feel, like.

All in all, we are dealing here with a hybrid kind of objecthood in that it is simultaneously physical, digital, and a synthesis thereof. Objects of the sort adhere to what Paul [26] refers to as 'neomateriality', that is, a certain kind of objecthood that incorporates networked digital technologies, revealing own coded materiality and the way in which digital processes may both perceive and shape physical aspects of our immediate environment. A post-digital perspective is ascribed herein exactly because of such a hybrid neomateriality and its phenomenological ramifications. An encounter with such an artefact is an encounter with a hybrid, multimodal, object that is both familiar (being made of plastic) and 'Hertzian', both ideological and open to ambiguous subjective readings, both intellectual and tactile, both poetic and algorithmic.

Conclusion

To summarize, the text physicalizations accounted for herein are shown to possess a hybrid materiality which is soundly physical, digital, and post-digital at the very same time. At a physical level, they are concrete objects one may visually and haptically engage with. At this level alone, and while already possessing more or less ambiguous meanings, they are also 'Hertzian' actors, defying strict categorization and established notions of optimality. They are surprising, simply because of their bold disregard towards the canonical product design norms of our times. This is a property they do share with many artworks and experimental design artefacts, of course; it is nevertheless not at all common in data physicalization milieus—especially insofar as functional InfoVIS circles are concerned.

These artefacts are also shown to be cybernetic. They are themselves digital information that has been produced algorithmically and by means of manipulating 3D and textual data, and that is meant to be reproduced and instantiated *in situ* with respect to localized digital fabrication technologies. That is, they are not unique original artefacts but rather *copies* or *instances* of a much broader digital hybrid that incorporates infinite contingent versions of themselves, reproduction technologies, and, of course, a broad set of ideological offshoots and debates. Therefore, the physicalizations discussed herein are also ascribed those ideological practices, trains of thought, and discourses, that are associated with the technologies that are responsible for their production.

Such a digital condition should not be though of as contrasting their physicality, but rather the contrary. They are not cybernetic *despite* being physical, but rather *because of*, and *in addition to*, to it. A certain kind of neomaterial, post-digital objecthood is brought forth in this fashion. These objects also celebrate a mode of reflexive inquiry insofar as their own production is concerned, in all cultural, ideological, technical, and other respects. Embedding a meaningful physical form, as well as the technological and ideological specificities of their own production, they are themselves records of their own making and explicit manifestations of broader hybrids that are responsible for similar kinds of objects. This is ascribed to their very own (neo)material properties—in the particular ways their substructural integrals are (algorithmically) synthesized, and in the unmistaken marks the 3D-printing process that has embed their bodies with.

The properties of the resulting artefacts aside, this endeavor has been also shown to celebrate an experimental approach towards the ways in which repositories of data and technologies of algorithmic manipulation may be employed. It advertises a certain trait within broader physicalization milieus that are often simply concerned with straightforward expositions, or quantifications, of data. Herein, post-digital poetics are not explored in some functional or utilitarian context, but rather as creative means zeroing in on the exploration of new kinds of materiality/objecthood and, in this way, also becoming an implicit critique of the standardized and canonical functional design schemata that largely pertain digital fabrication related affairs nowadays.

Naturally, given that the current state of affairs in digital fabrication is mostly concerned with the production of functional artefacts in some engineering, medical, 'start up', or other context, experimental 'Hertzian' approaches of sorts are often seen as (useless) curiosities by many experts. Yet, an *a priori* assumption that 3D printing (and digital fabrication in general) necessarily concern functional ends imposes significant restrictions on what is technologically feasible/easy to fabricate in those very same contexts. That is, certain kinds of

structures/forms/textures that may eventually prove 'useful' in some situated functional context would not be considered at all simply because the technical challenges their fabrication poses have never occurred pragmatically. However, the close examination of alternative experimental and 'Hertian' paradigms—such as the one accounted for herein—and of the technical, technological, and methodological quirks they bring forth can open the door to perfecting existent fabrication technologies so that it becomes possible to also consider all sorts of nonstandard and solutions to some functional (and nonfunctional) problem.

It is, accordingly, believed that experimental and 'Hertzian' approaches to digital fabrication in general, and to data physicalization in particular, should be further encouraged in various contexts, as the technological and methodological advances (or curiosities) they would resolve are expected to boost the current state of affairs not merely in digital arts related milieus, but also in all sorts of other research subareas—purely functional and applied ones included.

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Marinos Koutsomichalis is a scholar, artist and creative technologist. His practice is hybrid, nomadic, and ethnographic, involving field-work, creative coding, critical theory, making, lecturing, live performance, workshopping, artist/research residencies, 'Doing-It-With-Others', and hands-on experimentation with materials and technologies of all sorts. In this way, it draws on, and concerns, various subareas in arts, humanities, science, technology, philosophy, and design. His artistic corpus is prolific, yet persistently revolving around the same few themes: material inquiry/exploration; self-erasure (in/through performance and production tactics of all sorts); the quest for post-selfhood (through social, hybrid, and networked practices involving both human and nonhuman actors). He has hitherto publicly presented his work, pursued projects, led workshops, and held talks worldwide more than 250 times and in all sorts of milieux: from leading museums, acclaimed biennales, and concert halls, to industrial sites, churches, project spaces, academia, research institutions, underground venues, and squats. He has a PhD in Electronic Music and New Media (De Montfort University, GB) and a MA in Composition with Digital Media (University of York, GB), has held research positions at the Department of Computer Science in the Norwegian University for Science and Technology (Trondheim, NO) and at the Interdepartmental Centre for Research on Multimedia and Audiovideo in the University of Turin (IT), and has taught at the University of Wolverhampton (Birmingham, UK), the Center of Contemporary Music Research (Athens, GR), and the Technical University of Crete (Rethymnon, GR). He is a Lecturer in Multimedia Design for Arts at the Department of Multimedia and Graphic Arts at the Cyprus University of Technology (Limassol, CY).