

# Permacomputing Aesthetics: Potential and Limits of Design Constraints in Computational Culture

Aymeric Mansoux  
a.l.mansoux@hr.nl  
Willem de Kooning Academy  
Rotterdam, Netherlands

Dušan Barok  
db@societyofalgorithm.org  
Multiplace  
Bratislava, Slovakia

Brendan Howell  
brendan@howell-ersatz.com  
The Howell-Ersatz Co.  
Berlin, Germany

Ville-Matias Heikkilä  
viznut@low.fi  
low.fi  
Turku, Finland

## ABSTRACT

Permacomputing is a nascent concept and a community of practice oriented around issues of resilience and regenerativity in digital technology. At the heart of permacomputing are design principles that embrace limits and constraints as a positive thing, as well as being creative with available computational resources. As a result, permacomputing aesthetics provides a transformative countervoice to digital aesthetics that promote maximisation, hyperconsumerism, and waste. In terms of implications for design, this means that next to a more formal understanding of aesthetics—how things look—there is also an urgency for permacomputing to critically engage with how things work, how they are created, how they are situated, the conditions of their creation and their component materials.

In this paper, we argue for the potential of permacomputing as a rich framework for exploring creative design constraints building on a long history applying constraints in art, design and cultural practices. This lineage highlights that the use of self-imposed constraints or the repurposing of obsolete devices in permacomputing cannot be conflated with restorative nostalgia, but is instead substantiated and post-digital in nature. However, we also argue that the greatest challenge for permacomputing is the potential lack of immanent critique and situatedness in the use of these design constraints. In times when intersectional approaches are increasingly needed to meaningfully engage with contemporary issues, the failure to contextualise the conditions of permacomputing could be at odds with its transformative agenda and limit its practice to a form of cultural appropriation, an aestheticisation of poverty, an artistic genre, a hobby or a privileged subcultural style.

## KEYWORDS

permacomputing, aesthetics, computational culture, art, design, cultural production, constraints, environmentalism, electronic waste, re-use

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## 1 INTRODUCTION

Permacomputing, a blend of the words permaculture and computing,[29] is a potential field of convergence between technology, cultural work, environmental research and activism. It is both a nascent concept and a community of practices that aim to promote and experiment with more sustainable relationships with computer and network technology. At a time when computational culture seems to be increasingly characterised by electronic and energy waste, permacomputing instead encourages a more sustainable approach by maximising the life of hardware, minimising energy consumption and focusing on the use of already available computing devices and components. As a long-term utopian project, permacomputing aims to “give computers a meaningful and sustainable place in a human civilization that has a meaningful and sustainable place in the planetary biosphere”.[29] In addition to environmental issues, permacomputing also challenges the negative impact of the computer industry. It does so not only in terms of the environment, but also in terms of the kind of socially harmful systems it enables. For this reason, the link with permaculture is used to emphasise the cultural ambitions of the proposal, and also as a provocation to the extractive and exploitative nature of the computer tech industry. In making this connection, permacomputing practitioners are in effect asking whether there can be a place for computer and network technology in a world where people contribute to the well-being of the biosphere through systems of care and mutual aid.[8]

Permacomputing grew out of online subcultures of practitioners working creatively with computers and network technology. As a result, artists, designers and cultural workers are very present in the community and are part of a wider reflection on ecological issues and the role of infrastructures in the cultural sector.[53] Given this cultural specificity and

the constraints of working within the computational limits of use and reuse, the question of aesthetics cannot be ignored.[30] However, moving beyond a formal understanding of aesthetics, and in light of the community's transformative agenda, in this paper we draw on a definition of aesthetics as the relational and distributed capacity to register, perceive and make sense of the world.[23] For us, this means that aesthetics also leads to questions of responsibility, particularly when working with materials, tools and techniques whose very nature actively leaves traces of extraction and exploitation in their making, use and disposal. Therefore, perhaps paradoxically given our choice of definition of aesthetics, permacomputing wants to be a counter-voice to a digital aesthetics that encourages maximisation, e.g. high bandwidth, high resolution, more computing power at any cost, for anything, sensing and capturing more, while making less and less sense, ultimately rendering us insensitive to the harms and damages we legitimise.

So in this article, we begin by introducing the aesthetics of permacomputing as something that is deeply partisan in its practice. Something in which the aesthetics of sensing and making sense do not lead to mesmerizing or ambivalence, but instead transforms design constraints into a way of practically countering the maximalist techno-aesthetics of the dominant computer tech industry, at the risk of being understood as archaic or reactionary. Consequently, in providing a brief overview of the history of constraints in art, design and cultural works, we also argue that the introduction of constraints that make sense leads to a conundrum that highlights the tension between constraints as self-imposed creative strategies and constraints induced by external conditions. We present several works that demonstrate this capacity, and explain how they negotiate and contextualise this engagement in their own ways, in an aesthetic that reveals and uses constraints as a sensitive protest.

We argue that the weakness and strength of permacomputing design principles lay in this highly interpretive consideration of material conditions and environmental responses that, while attempting to offer a different artistic, design and cultural perspective on degrowth and other concepts orthogonal to capitalist growth and market organisation, still struggle to address its situatedness in times where it is increasingly difficult to articulate common causes.[56] We discuss this in relation to post-digital aesthetics and nostalgia, and conclude with open questions about the limits of permacomputing practices, particularly in relation to issues of privilege, aestheticisation and cultural appropriation.

## 2 DECEPTIVE MAXIMALIST TECHNO-AESTHETICS

We live in a time of maximalist techno-aesthetics driven by the myth of perpetual growth and infinite resources, an aesthetic based on the ever-increasing complexity and resource consumption of digital devices that seeks to justify their growth through self-referential legitimisation. Its most visible feature is the increasing density of information for its

own sake: more pixels, more detail, more 'fidelity'. Negative social and environmental effects of this constant increase can be seen, e.g., in 'bandwidth imperialism'[43] as well as in the high resource demands of AI art.[36] In an unfinished letter to Jacques Derrida, Gilbert Simondon describes a techno-aesthetic work as "perfectly functional, successful, and beautiful,"[54] where contemplation and joy arise from the fusion of aesthetics and technique. Simondon also points out that aesthetics cannot be reduced to the sensations felt by the consumer of a work. It also encompasses the sensations of the person who crafts, makes and creates the artifact, as well as the relationships with the instruments used in the process.

We find that contemporary maximalist aesthetics show that this fusion can also be joyless and dysfunctional.

In the context of art, design and cultural production in general, this often translates to a constant rush to adopt new tools and techniques, while simultaneously accelerating the creation of new discourses around novel aesthetics that entirely avoid critique around these very new tools and techniques. This phenomenon is not limited to cultural production, but extends to all fields and sectors that have embraced the digital revolution with little questioning. Leaders in the computer tech industries often remind us that we live in times of computational miracles,[14] yet our experience of these miracles tells a different story of mundane, uninspiring and bleak anecdotal failures: always taking photos but never having time to look at them, files that can't be found or contextualised on devices or in cloud storage, losing the password for the password manager, stifling productivity apps, electronic document explosion while paper documents are still required, invalid usernames, everything becoming a website, baroque chains of dependencies, software updates required to keep using the same software, terms of service for pointlessly networked home appliances, customer support that can only be reached on social media, laptop leg burns, glued and soldered batteries, no service manuals or technical documentation to facilitate repair of trivial hardware failures, internet connectivity mandatory for offline use, AI telling lies with unscrupulous conviction, restaurant menus with QR codes, etc., the list goes on endlessly.[40] These observations need not be driven by nostalgic generational issues—a point that we will develop in a later section of this paper—nor by an anti computer and network-technological resentment, as in anarcho-primitivist critiques of industrialisation. They are banal reflections on the failed fusion of the technical and the aesthetic in the techno-aesthetics of contemporary computational culture.

However, this severe dysfunction is obfuscated by the computer tech industry and its supporters in the form of an aspirational, accelerationist, techno-progressive discourse that essentially redirects consumers and manufacturers towards a growing space of possibility, towards unleashed potentials at our fingertips, towards a brighter future. Bell and Dourish refer to this phenomenon where "motivations and frames are often written not merely in the future tense, describing

events and settings to come, but portray a proximate future, one just around the corner.”[18] In fact, this field of possibility acts like a hypnotic distraction that prevents one from dealing with what is essentially more of a world view guided by an undemocratic niche of longtermist visions[12] and consumerism.

The maximalist techno-aesthetics of contemporary computational culture is profoundly deceptive. The so-called seamless and transparent design, plastic virtual worlds, the Cloud, consciousness uploading, transhumanism, cryonics, democratisation of access to domestic workers via app-based anonymous delivery servants, Mars colonies, frictionless interfaces and digital workflows, virtual reality, lifecasting, composite conflation of Gaia, Cyberspace and the Noosphere, hybrid and blended learning, avatars, omniscient AI, cashless societies, online shopping, people staring at black mirrors in empty spaces with shiny floors while being surrounded by gorgeous wild nature behind glasses. It seems to represent this proximate future as a space that is almost completely artificial, devoid of any trace of biology. Welcome to *digitality*, a nineties idea [47] of an immaterial digital future that decades later is still an unfulfilled promise, a digital revolution whose online life is painted with a “massive palette of irrelevance and pointlessness to be explored,”[22] a hyperaesthesia of mediating sensors,[23] and mostly full of crap. [11] But it takes little effort though to peek behind the curtain and see what feeds the digital dream. Surrounding the sleek, futuristic design of Apple’s headquarters is an endless view of the bland, suburban, copy+paste, car-based, precarious, extractive worker-consumer culture that fuels a promise that is essentially based on white, upper-middle-class normativity and the privilege of a few in the global north. In other words, this maximalist aesthetic is also deceptive. Like Apple’s UFO building, it may appear to be a hermetically sealed object from outer space, but its origins are far more terrestrial and sordid. It is profoundly extractive and lacking in any kind of social justice, and yet it precludes any response other than boarding the spaceship at the end of a new product launch and diving further into the abyss of late capitalism.

So when we talk about permacomputing aesthetics, it is not just about technical implementation, or about countering a broken maximalism with an equally broken minimalism. It is about re-imagining, dreaming, and experimenting with alternative ways of engaging with computer and network technology. Reflecting on the broken relationship between the technical and the aesthetic in the techno-aesthetics of maximalist computational works, it seems obvious to us that the discussion of design constraints is unavoidable and needs to become a site of activation.

### 3 ART, DESIGN AND CULTURAL WORK UNDER CONSTRAINTS

Constraints are a fundamental concept in mathematics, biology, mechanics, design, economics, to name but a few. More generally, life and our experience of it is bounded by external constraints. We are limited by our bodies, our environments,

our cultures, and all sorts of socioeconomic and material factors that, for better or worse, ground us in reality. This grounding is particularly significant for understanding and being able to confront personal alienation and the social uprooting of life and work in the context of global social, cultural, economic and political systems. However, while constraints are inevitable, they can also be perceived negatively because they are essentially a restriction. This is particularly true in liberal democracies that have adopted, adapted, or derived the model of open society which, while favouring cultural diversity and pluralism, relies on a fragile balance between laissez-faire philosophy and some form of minimal regulatory principles, as a model for solving most societal problems and preventing authoritarianism.[51]

In this context, the idea of heavily regulating, restricting, taming or limiting cultural, religious, or political activities remains controversial. However, when it comes to economic activity in these open societies, control is more than controversial because it is a fundamental freedom on which other freedoms depend. One might ask, how does this relate to art, design and culture? The answer is that in such systems, this dependence results in an inability to truly challenge the colonial, postcolonial, and neo-colonial circuits, supply chains and strategies of human and environmental extraction and exploitation that are key components of the economic fabric of such liberal democracies. It does not matter if we are discussing the production of goods, or culture, the mechanism is the same. Both activities, regardless of their framing or intentions, may end up relying on the same obfuscation schemes described in the previous section to avoid cognitive dissonance or to explicitly protect the status quo. To be sure, our position does not promote any form of techno-environmental authoritarianism. On the contrary, permacomputing simply highlights once again the old cultural industry trope, namely that cultural works that hope to exist outside of, and provide a counter-voice to, dominant harmful practices actually share the same underlying ideology, so long as they are incapable of challenging their own productive apparatus. In this sense, we believe that making design constraints visible and engaging with them is a way of exposing the friction and challenging practitioners to provide a counter-voice to maximalist techno-aesthetics. Consequently, there are very practical and material ethico-political implications to permacomputing aesthetics, in the way that it aims to produce subjectivities while allowing for the realisation of an autonomy that can go beyond the realm of professional art and design, or the field of cultural production in general.[25]

In terms of practice itself, constraints in art and design have been discussed extensively, and it is beyond the scope of this paper to provide an exhaustive overview of the critiques, discourses, and reflections that have emerged from the relationship between cultural production and freedom. However, at the risk of making an hasty generalisations, what matters for the permacomputing discussion is that constraints in art, design and culture tend to fall into two categories: self-imposed and externally imposed.

Self-imposed constraints are perhaps the most widely known and cited when it comes to demonstrating, with more or less honesty, that *less is more*. They can be formal: the literary rules of the writers of the OuLiPo collective;[50] conceptual writing in general;[19] minimalism in music and visual art;[49] any notated work to be performed, executed, installed, manifested again, such as poetry, music, graphic scores, conceptual art, performance art, installation art, software art.[9] They can also be self-imposed by the choice of technology used: early computer artists in the late 1960s and early 70s working out programs for plotters without screens;[60] the use of simple samplers, cassette tapes and basic turntables in alternative, underground and instrumental hip hop;[42] subsets of the demoscene subculture that focus on making extremely small audiovisual programs or deliberately use old and limited hardware platforms.[24] Practitioners often see self-imposed constraints as facilitators or boosters of creativity rather than as limitations, which is why alternative terms such as *fabric* have been suggested instead of *constraint*. [28] Self-imposed constraints can also arise from the choice of the materials used: arte povera in Italy in the 1960s, using materials such as wood, earth, iron, scrap, industrial waste and plastic; the making of furniture from common sizes of construction wood [41] or from found industrial materials; the making of household objects from available small trees and branches in *Slöjd*.

There are also constraints that, although they shape art, design and cultural works in fascinating ways, are not in fact the result of privileged cultural workers searching for novel creative processes. In certain circumstances, the constraints can be political: unofficial artists during 'normalisation' in Czechoslovakia (1970s-1980s) and elsewhere retreated from public space and galleries to nature and private homes, and to media such as concept, action, performance, land art and video, such as the dissident video magazine *Original Videojournal*, which was secretly edited and copied on school equipment. Limitations may arise from working within restrictive copyright or uncertain legal status: 1970s ephemeral media circulation in Cuba; low-resolution bootleg videos on ubuweb; shadow and bootleg libraries. Finally, constraints can be socio-economic: Soviet Constructivists used wood and scrap metal because other art supplies were scarce; the improvised creative solutions of *Gambiarra* in Brazil[21] or *Jugaad* in South Asia, applied to concrete problems by repurposing objects and with limited resources; artists in the 1970s using discarded materials to produce their work quickly and cheaply;[63] the 'Free Furniture' design ideas from the 1971 *Steal this Book* work by American political and social activist Abbie Hoffman.[33]

Having briefly established this rather simplified distinction between self-imposed and external constraints, we reach the point where we must admit, not without some embarrassment, that the design constraints in permacomputing exist in the grey area between these two categories. It lives in a sort of limbo, where an urgency is felt and translated into a practice, but the condition of that practice is not fully threatened or pressured to address that urgency. Is this dilettantism?

Virtue signalling? Artivism? We will try to respond to this conundrum in the final section of the paper, but for now let's discuss some examples of permacomputing design constraints.

## 4 PERMACOMPUTING AESTHETICS

In computing, constraints can be as relative as they are arbitrary; it does not take working with an 8-bit CPU to realise that the latest and greatest graphics card also imposes limits on any creative programmer. What distinguishes permacomputing from other approaches is the way in which it makes constraints visible and usable through its connection to material circumscription. The qualities of materials are also a driving force through which aesthetic choices are made, as much as how the aesthetics are produced through the selection of specific material maxima, so as to reflect environmental and cultural values. These choices might include: working with e-waste,[17] working with limited availability of hardware and energy,[52] using small files and low network bandwidths,[43] considering computing devices as heirlooms, using natural materials, repairability or designing with local, regional and subcultural aesthetics and materials in mind. Unlike Simondon's techno-aesthetics, which may eventually iteratively find a pleasing equilibrium between functional technique and aesthetics, permacomputing's techno-aesthetics are much more perilous because a third component is forced in: a situated intention in the process of making.

So coming back to the overview of constraints in art, design and cultural works, it should now be clear that as much as permacomputing values the design constraints as playful and creative,[2] these constraints also act as visible barricades, visible pickets, to express and make tangible the contemporary struggles that cannot be ignored when these works are created. For this reason, the aesthetics of permacomputing works always serve as an entry point to make visible and understandable the situated intention in the creation process.

In practice, permacomputing exists as two intertwined strands: an incentive to reuse and repurpose existing computer technology and materials to create new work; and continuously evolving design principles to guide such reuse and repurposing, but also to inform the development of new software and hardware when reuse and repurposing is not possible or relevant. At the time of writing, the permacomputing community is loosely gathered around a wiki,[8] a number of email discussion lists and IRC channels, and informal or more regular gatherings such as the permacomputing meetings at Iffy Books in Philadelphia.[7] Some works have also begun to use the term permacomputing to frame their practice. Some examples:

Computationally minimal art can be described as an algorithmic art that idealizes low computational complexity as a source of beauty.[27] A prominent example of CMA is Bytebeat, a type of computer music based on very short programs that typically generate PCM sound as a function of time using basic integer and bitwise operations.[26] The visual equivalent of Bytebeat is sometimes called Bit art.[58] In the realm of very short programs, serendipitous discovery

plays a much greater role than intentional design, and much of the aesthetic comes from the programming model and language. Since computationally minimal art can be created with any conceivable kind of computer, or even without a computer altogether, it represents the diagonal opposite of the high technological dependence of maximalist computer graphics and music.

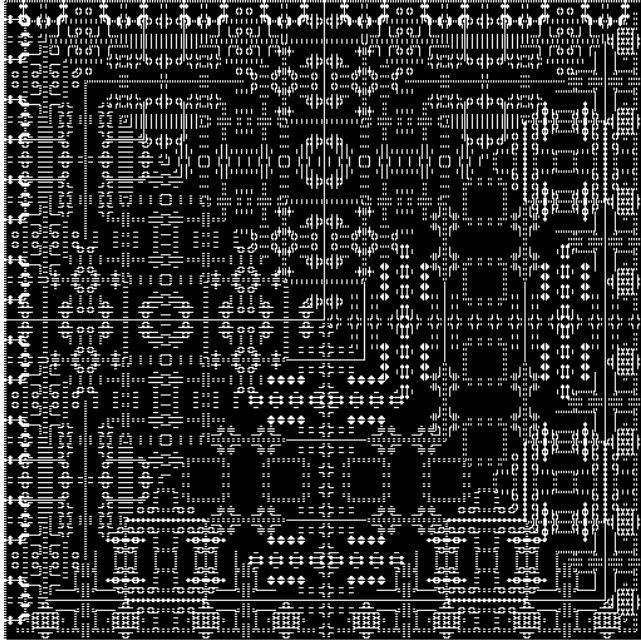


Figure 1: Twitter user @theFoldster, 2021

Gemini is a content delivery protocol created in response to the perceived complexity and wastefulness of the present-day, mainstream World Wide Web.[55] It can be seen as part of the Small Net movement, which involves small, simple and independent networking, often using self-hosted servers. Gemini is very similar to Gopher, a text-based contemporary of the earliest web browsers, but adds some modern features such as encryption. Geminispace refers to the network of Gemini sites and the community around them.

Uxn is a simple virtual machine geared towards small graphical applications, with features reminiscent of classic home computers.[35] It differs from most other *fantasy platforms* in its emphasis on simplicity of implementation, and it has already been implemented on a variety of platforms including small devices such as the Nintendo Gameboy Advance and the Raspberry Pi Pico. Uxn is being developed by Hundred Rabbits, a small artist collective living on a sailboat, as a platform for their own games and programs.

What Remains is a video game developed for the 1985 Nintendo Entertainment System (NES) console.[20] The game is the result of several years of research into the parallels between the manipulation of public opinion on environmental issues in the mid-1980s and today's climate crisis, and the role of whistleblowing in making damage visible.[13] The

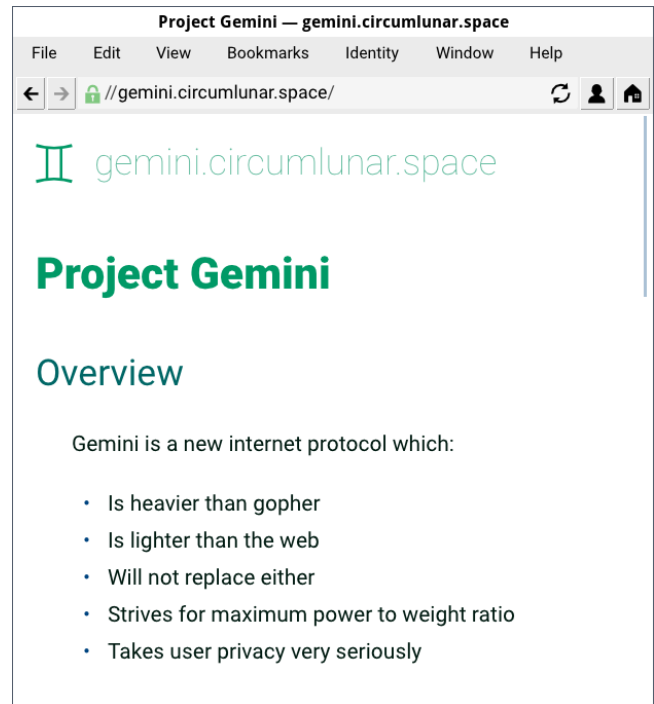


Figure 2: A screenshot of Lagrange, a graphical Gemini browser. Screenshot, Ville-Matias Heikkilä, 2023.

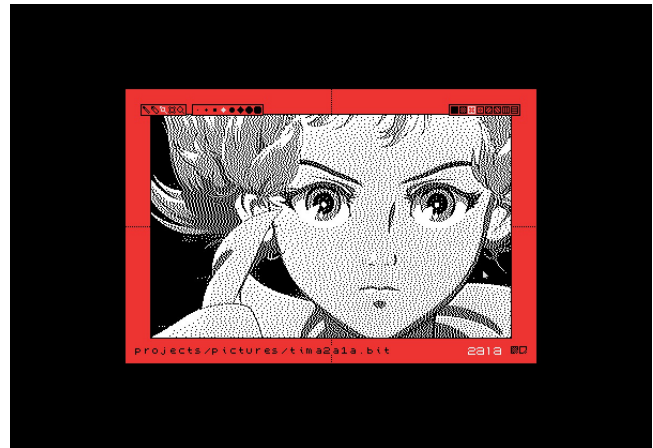


Figure 3: Noodle, a 1-bit illustration program for the Uxn virtual machine. Screenshot, Hundred Rabbits, 2021.

game subverts the nostalgic expectation of retro-gaming and is distributed by repurposing unwanted and overproduced game cartridges from the late 80s slightly modified to support the new game.

The Screenless Office is a system for working with media and networks using paper-based output from old laser and receipt printers.[34] A document camera, repurposed barcode





**Figure 4: A cartridge of the game What Remains, made by player mi213 by repurposing an old game, and following the project DIY instructions. Photography, mi213, 2021.**

scanners and simple buttons provide input. The system allows reading news, browsing, reading and replying to emails, interacting with social media and playing local or streaming music. The creator frames it as an 'artistic operating system', not intended as a universal solution, but as an expression of the needs and desires of the author. The high latency of interaction and material awareness of environmental consequences work well with obsolete, low-power hardware and afford a calmer and more reflective pattern of use.



**Figure 5: A test print on narrow receipt paper showing text and dithered images from social media. Photography, Brendan Howell, 2018.**

The Livinglab, by Michal Klodner, is a concept for off-grid facilities for artistic and scientific research in nature.[38] The

first such structure, was built in the forest of the Kras region of Czechia and has served, so far, as a site for ongoing experiments with solar power, silviculture and sound. The remoteness and low-power infrastructure necessitate and foreground permacomputing approaches for residents who wish to work with media or digital techniques.



**Figure 6: Exterior view of the Livinglab in Czechia (Barrandien / Cesky kras region), Photography, Michal Klodner, 2022.**

There is no good or bad way to make a permacomputing work; it is highly experimental and interpretative. Some projects may be very strong in some aspects while overlooking others. The idea is that, by forming a community of practice around these two strands, there will be a process of both individuation and collective learning, mutual aid and inspiration. The question of care therefore extends care for life in an ecological sense to include the importance of how we relate and talk to each other in the nascent permacomputing community. Accordingly, we want to understand conflict and disagreement as generative contributions to the discourse and practice, trying to make sense of things together through making, publishing, self-hosted platforms and communication channels, online and offline events.[24] It is a highly agonistic process.[46]

## 5 PERMACOMPUTING AND NOSTALGIA

Following these examples and given the fact that permacomputing does not hesitate to promote the reuse and repurposing of old computing devices, or often eschews high-definition sound and visuals, there is a danger of confusing permacomputing aesthetics with retro-computing aesthetics. So let's ask the question directly: are permacomputing aesthetics a form of nostalgia?

Simply put, no, there is no longing for the days when computer technology was better, since such a day never existed in the first place. If anything, the fact that permacomputing exists is symptomatic of this fundamental and perpetual disconnect between theoretical liberatory visions of computer and network technology on the one hand,[6] and

its reified brokenness.[15] It is a response to the idealised fusion of the technical and the aesthetic in the maximalist techno-aesthetics discussed above, and its absolute ugliness and disfunction, which are subservient by-products of systems of extraction and exploitation. Therefore, the best way to counter the nostalgia argument is, first, to talk about time and consumerism. In societies vastly dominated by technological novelty, economic growth, and technosolutionism, the relationship with time is difficult to dissociate from consumerism. This time, however, is of a peculiar nature. It is the time of quantified and monitored labour, the time of management, organisation and production coordination, and the time of economic cycles. Continuous updates of video games, TV/online series presented in seasons or launches of technological products – all coordinated in the context of strategic moments of increased consumption. Eras and generations are defined, analysed and symbolised by emblematic products of mass consumption. Our short lifespans, treadmill working conditions and short attention spans do not help us see these patterns, and instead support a productive apparatus that favours obsolescence, neophilia, amnesia, non-historicity, as a means to consume and produce more things. In this context, it becomes obvious that any use of so-called *outdated* computing devices that have exhausted their economic value, can only be of a nostalgic nature, because such use makes no sense from the perspective of systems of constant production, consumption, creative destruction and reproduction. In a present where consumerism, modernity and identity are all linked,[44] out-of-date things can only refer to a past self, a past time.

For this reason, activities around retro-computers and retro-aesthetics are primarily forms of restorative nostalgia,[5] in the way they allow a connection to a past home, a past self, through objects of mass consumption. This nostalgia favours the cult of simpler times; the good old days when things were less complex and often associated with a privileged childhood. Retro events often include screenings of old series, films or anime that more or less correspond to the participants' childhood; new faux memorabilia is produced for playfully decorated adult rooms; some console emulators go so far as to operate as VR simulations in which retro games can be played in a teenage bedroom that has been carefully decorated to match the era. With the well-intentioned goal of creating a safe space for the literal emulation of a lost youth, such nostalgia runs the risk of fostering deeply conservative thinking and fetishising a past that never really existed. If anything, it prevents the problematisation[57] of an already flawed computer culture and opens the doors to imagined communities.[3]

Permacomputing is much closer to computational subcultures that use so-called obsolete technology in radically different contexts.[32] It is also aligned with the creative and environmental considerations of zombie media[31]—a counterpoint to the notion of dead media—which acknowledges that “[m]edia kills nature as they remain as living deads”, and encourages the reappropriation of electronic waste, drawing an analogy with the processes of reuse found in remix culture.

When Jamaican music studio engineers in the 1970s began experimenting with obsolete and abandoned US audio equipment such as spring reverbs, they were not nostalgic for 60s surf music. These machines, instead, became a core component of an entirely new musical genre: dub music.[61] In truth, permacomputing sees computing devices as many different instruments waiting to be brought back to life, turned upside down and rediscovered to simply create new things. Permacomputing sees the end of a computer product's lifecycle as a moment of celebration, a moment when its socioeconomic context can be reclaimed, rather than put behind a glass and condemned to run the same old code forever as a consumerist trophy or fetish. So, if permacomputing is nostalgic, it relates more to a reflective nostalgia that questions the truth of restorative nostalgia, by exploring different possibilities, and playfully combining together shattered fragments of memory, sentiments of longing, and critical thinking.[4] Ultimately, permacomputing aesthetics could be understood as a politically driven kind of post-digital aesthetics.[10] The latter are exemplary of bringing to light the end and the new media cult of digitality, while celebrating, or simply acknowledging the combinatorial and generative conflict potential of combining new and old media. Permacomputing, in turn, attempts to develop a discursive critical practice by trying to make sense of an ever changing landscape of new and old media and computer technology.

## 6 THE LIMITS OF CONSTRAINTS

Permacomputing is a nascent concept and community of practice, and there are a number of issues that its practitioners are currently trying to work out and reflect upon.

First of all, while it is meaningful to frame permacomputing aesthetics positively as a kind of post-digital aesthetics, it is also a more problematic way to admit that permacomputing is entangled with the systems of production and consumption it seeks to critique, rather than being able to truly offer an alternative from the ground up. Put differently, the richness of combining old and new media, or the ways of working with more technological restraint with current computing devices, can also obfuscate the dependencies that such ways of working have, on the very neophilia that permacomputing seeks to address. This is not specific to permacomputing. It can be seen, for example, in software projects that are committed to minimalism or radically different ways of working and living with computer technology, but cannot escape the modern tools that can greatly facilitate this alternative. Worse, it is a real challenge to make such efforts visible and supported if their creators do not rely on social media and various cloud infrastructures, even if the latter are antithetical to their beliefs. Similarly, in the urge to develop more sustainable hardware projects, how do we deal with the fact that what appears—from a local perspective—to be alternative and fairer ways of producing still depend on a highly extractive and exploitative supply chain of globalised labour and manufacturing to which there is no alternative? More generally, in high-income countries, the democratisation of the tools

and infrastructure needed to engage in any kind of critical making in the realm of software and hardware often creates a circular problem in which the answer to a problem cannot exist without the problem itself, due to global efforts to create economic interdependence across the world. The latter situation in particular has led some to shift the reflection from the climate crisis and the means of production to address the means of climate production.[59] In more computational terms, it's as if permacomputing is trying to bootstrap a practice of constantly debootstrapping itself. This raises the question of whether permacomputing can ever be transformative, more than performative and reflective, or whether it will remain doomed to be a kind of symbolic collective late capitalist useless machine that illustrates the uselessness of the systems from which it emerges.

This brings up another limit for permacomputing. How to deal with the discrepancy between the discourse and its actual practice when it comes to issues of climate justice? How to align the ambition, the narrative and its situatedness so that it remains inclusive and more than just a few sound bites whose circulation will benefit only a few in a highly competitive race to the bottom in the cultural sector always keen to emphasize a short sighted and privileged articulation of care?[45] This problem of disconnection has been discussed extensively in related communities, for instance how the dominant narratives and ambitions of the maker movement have overshadowed other practices, as well as promoting individual heroic narratives while obscuring collective efforts, leading to a contradiction between the promises of empowerment and openness in maker culture and its other realities.[39][1]

Following this contradiction, we enter another issue that needs to be addressed: the place of art, design and cultural works in relation to questions of class and privilege. While the permacomputing aesthetics and their call for an alternative computational lifestyle may feel affiliated with grassroots DIY activism or, for example, Brazilian cultural practices such as *gambiarra* and *mutirão*, briefly mentioned earlier, it is not. The choice of alternative lifestyles and practices, not to mention the possibility of temporarily withdrawing from productivist, extractive and exploitative systems, is a sign of privilege and remains inaccessible to the vast majority of the population, even in high-income countries. There is a danger, therefore, that permacomputing aesthetics will remain just that: formal aesthetics that rely heavily on cultural and stylistic appropriation of practices for which urgency and its constraints are necessities of life, not creative choices. This should not, in any way, be taken as an excuse to embrace extractivism and wasteful practices. But it does mean that permacomputing is walking on thin ice and needs a lot of work to understand its own situatedness to avoid it ending up as a mere hobby for the most privileged, a romanticisation and aestheticisation of poverty, like many low-tech practices in high-income countries. Understanding permacomputing's own situatedness is also necessary as groundwork for addressing harm directly where it is initiated and cultivated. In other words, how to create a space for critical practices that address urgencies such as scarcity and the limits of extraction, for

example, in situations where no regulation yet exists to make these urgencies tangible. It is a fragile proposition, and, as discussed earlier, it still remains to be seen whether the use of artificial external constraints in the form of self-imposed creative restrictions, so as to address an urgency, raise awareness, and explore other ways of making cultural works can make sense in places that constantly give the illusion that we all possess a magical cornucopia.

## 7 CONCLUSION

In this paper, we have attempted to articulate an aesthetic understanding of permacomputing that goes beyond questions of form, beauty and, more generally, the artistic mastery of emotion through the skilful use of materials and techniques. Instead, we have drawn on a more relational and distributed understanding of aesthetics to address the problem of unreasoned creative potential of what we have described as the maximalist techno-aesthetics of the contemporary computer tech industry.

Permacomputing's call to embrace constraints in this context recovers a sensitivity to and appreciation for limits in the creative process. We have argued that it is also a means of materialising an explicit resistance to computational practices that, while multiplying their capacity for sensing and opening up an ever-expanding field of possibility and granularity in the digital realm, are ultimately deceptive, exploitative, extractive and harmful. Permacomputing is a nascent concept and community of practice that is trying to figure out how best to develop meaningful approaches through common design principles. At time of writing, it is still a work in progress, but there is enough discussion, work and exchanges to begin to consolidate some aspects. In particular, we discussed how permacomputing relates to post-digital aesthetics and nostalgia, in order to address misunderstandings, but also to highlight the potential shortcomings of permacomputing's paradoxical position as a practice that is interdependent with the systems it seeks to liberate itself from. This has also allowed us to further extend the boundaries of design constraints in the context of permacomputing, specifically addressing socio-economic reservations and the risks of cultural appropriation or aestheticisation of the struggles of groups and individuals who are far less privileged, yet politically engaged in finding ways to express pressing issues, despite the somewhat artificial nature of their attempts.

If the difficulty of naming things is a popular trope of computer science lore, the difficulty of not naming critiques of computer technology is even greater. In other words, almost nothing discussed in this paper should come as a surprise or revelation. Its originality lies in its attempt to communicate as directly as possible the absurdity of legitimising and normalising the depletion of everything: energy, natural resources, ecosystems, life here and elsewhere, at our own expense and at the expense of others who have not asked for it. Why do we need a new term? While there is enthusiasm for engaging with obsolete electronics and energy waste, what about the waste of past and present ideas, concepts and



initiatives? How to forge alliances? How not to claim, define, and yet create a momentum at the cost of excluding, making invisible and wasting existing works and ideas from other times or contexts? We are not naive, and yet the way forward is not clear if it is structured according to the same patterns of heroic narratives and mechanisms—in both the cultural and academic spheres—driven by novelty, competition, individualism, precarity, and a race to the bottom. How do we deal with superficial engagement, with virtue signalling? What is a *good enough*, ecologically meaningful computing practice? What is not good enough? Who decides? How do we negotiate and explain compromises while remaining gentle and careful with each other, rather than constantly trying to assess the authenticity of one's action based on petty, trivial technological nitpicking?[16]

We cannot answer any of these questions definitively, but what is certain is that in the context of an abundance of critical theory, permacomputing exists as a critical practice. It tries to navigate this minefield through hacking, art making, design and cultural production. It makes mistakes, but at the same time tries to take a stand and defend a position. The use of the terms *barricade* and *picket* to qualify design constraints in permacomputing is not arbitrary. As we have recognised, it may be nothing more than another facet of trying to make sense of the ramblings of late capitalism.[48] Regardless, the practitioners of permacomputing reject the paralysis of pharmakon critique. A choice has to be made. What kind of present and future are we constructing?[62] Are we to leave the hypnotic comfort of witnessing disaster, are we capable of radical change? The choice is not easy, especially when we work in systems that dull our senses with mesmerising possibilities and promises. It is a choice to regain our senses and the right to try, hope and possibly fail, through aesthetic questioning, to climb out of the senseless factory world.[37]

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