Fluid Processor Design for Ecological Computing - a new Techno-Ecological Computing Paradigm for Sustainability

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Abstract

This paper proposes ways of designing processor like devices operating with nothing else than natural flow of water to execute basic physical computing. Such types of fluid processors carry the potential to form the fundament of future fluid computing devices allowing for complex forms of ecological computing integrated directly into our environment. The proposed design works on natural principles of physics, uses no electricity at all, lasts almost forever and can literally be thrown around. That might sound like a radical, game- as well as life changing form of computing. And it will be. If we up-engineer the many and proven designs of old mechanical, analogue and physical ways of doing computing. So, what is the solution? Future and emerging computers will be carved out of and into stone. Their ornamental design will be more than environmental aesthetics, it will enable physical principles known from fluid and liquid dynamics to interface and interact with our world in multiple and -for now- speculative ways.

Keywords

Fluid processor design, ecological computing, Informed Matter, discursive Design, Environmental Aesthetics, Sustainability.

Introduction

Why construct ecological computing devices? There is an urgent, ontological and existential need for new computing paradigms. Current computers and chip architectures are built on highly un-ecological designs that super-consumes global resources such as electricity and non-renewable resources like rare-earth metals and minerals. How can we change this non-sustainable, high impact and senseless use of natural resources? How to develop alternative, low impact, environmentally friendly, eco-sensing and purposeful ways of computing? Our world needs new forms of computing that use renewable energy as its power source and that aims at improving both the human condition and our environment. The increasing concern for the well being of the human race in the age of the Anthropocene is a major push towards a responsible onto(logical)-ecological politics.

Techno-Ethically Unsustainability

The current production methods of electronic and digital technologies present us with serious ethical challenges. The Techno Ethics surrounding digital technology is not just the concern for the individual, but it is rapidly becoming an ‘ethics of the globe’ or the globosphere. We need a global ethics to become a synonym for environmental ethics. From this techno ethical point of view, contemporary chip designs are completely unecological. Even if the digital domain appears clean and green, it is far from so.

“The Internet seems clean because its ecological footprint is elsewhere”.

- Jane Anne Morris (Morris, 2016)

Current use and developments in computing appears increasingly unsustainable both from an ethical and ecological point of views. The term *ecology* stems from the Greek *oikos*, meaning home. Consequently the techno-ecological world should provide a situation where we are at home as humans, safe and sound, and healthy. It does not appear to be so. Google alone uses 2,3 billion kWh per year (2013). That is enough to power up to 200,000 US homes for a year. One Google search costs about 10 Calories per search. That is less than a cookie, but the enormous number of searches adds up, not to mentions up- and down-loading of files. Just the sheer daily manufacturing of millions of computers and smartphones for a seeming insatiable world market chips away the world’s resources, slowly and surely. Their production is an extremely material- and energy-intensive manufacturing process.

The enormous global computing infrastructure supports many technologies; from the many mobile phone networks to the all-pervasive internet consisting of countless server farms, routers, switches, optical equipment and the like. This creates a "monster footprint of digital technology". (Lowtechmagazine, 2009) Estimates of the current 2016 power consumption of the computing industry and Internet are up to 10% of global power production. It is expected to at least triple over the next decade, putting an enormous strain to our power consumption and infrastructure. (Independent.co.uk, 2016) Even if all the power should come from renewable resources it will take an enormous effort to build the necessary future infrastructure, not to mention the catastrophic environmental impact it will cause. We need not follow down this path. There are other and much more sustainable ways of doing computing, even without electricity.

A Brief History of Mechanical and Analogue Computing

The origin of computing could be as old as human have been counting. Our earliest documented example come in the form of Tally sticks that are (still) used to both count and record numbers in relation to everyday life, such as number of livestock, debts etc. The tally stick known as the Ishango bone, dates most likely at least 20.000 years back. (Pickover, p. 26, 2009) The world's oldest known mechanical analogue computer is the Antikythera mechanism from approx. 100 BC. It was most probably used to calculate astronomical positions and calendric data. Another famous example is the Difference Engine made by Charles Bab-bage in 1822. It was used as a mechanical device to calculate polynomials. After the invention of the transistor that led to the construction of the computer chip in the 50ies, analogue computing and problem solving has been more or less completely replaced by digital technologies. Surprisingly there remains one much used analogue computer today. That is the flight computer, also known as the 'whiz wheel' used by many pilots for flight planning.

Other examples of analogue ways to solve physical computing related tasks are found in ancient irrigation techniques. For example clay pot irrigation has been used for millennia to water plants precisely and sufficiently over longer periods through the use of osmotic pressure. (Bain-bridge, p. 79, 2001). Surface irrigation through controlled flooding by contour laterals and channels also represents a form of practice-based computation through hands-on problem solving with fluid pathways cut along and shaping the surface of soil.

More examples are found in historic garden designs. The garden of Villa d'Este, Tivoli, can be likened with gigantic water computer with all its layers, pipelines, meanders resulting in spectacular flow of water and fountains (Trevi, 2013).

These mentioned analogue ways of doing physical computing remain little if at all used today. The reason for this can be many and lack of speed is one. Another reason can simply be that our culture has unlearned the analogue and often tacit knowledge of the past as the invention of the transistor blinded us with the promise of digital perfection. The knowledge to build fluid processors is around. What we need to do is to piece together the various knowledge and resample them into new devices.

Principles for Future Fluid Computing

In 1964 Stanley W. Angrist describes Fluid Control Devices and how they perform various amplification and switching operations in a mechanically rather than electrically manner, see Figure 1. For some purposes they are more reliable than their electronic counterparts (Angerist 1964). This is nothing less than a description of a simple water based computer whose functionality is solely based on the design of carved channels in combination with the flow and force of liquids. This represents the first principle of how to make liquid processors.

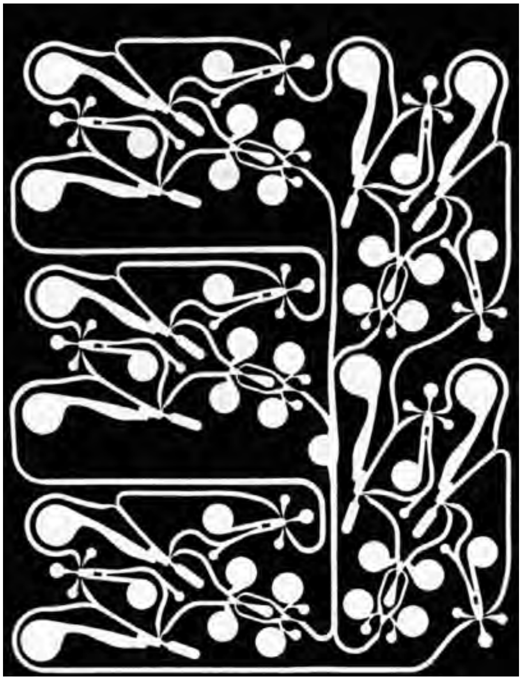

Figure 1. The image shows a fluid circuit that "performs the operation of dividing by 10 in an all-fluid digital computer: for every 10 input pulses circuit delivers one output pulse" (Angrist 1964). ©William Vandivert

Angerist also describes the fluid amplifier consisting "of a solid block of material in which shallow channels have been cut to allow the passage of a fluid", see Figure 2. When a high-energy power stream hits the splitter directly, this will divide the stream in two. However, the slightest introduction by a control jet from either side will deflect the power stream in the opposite direction. Such fluid amplifier designs represent a second principle of how to precisely control and steer liquid processors.

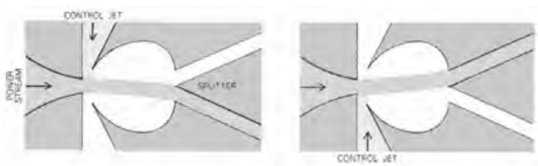

Figure 2. Basic layout of a fluid amplifier (Angrist 1964). © Angrist

Basic Fluid Processor Design

As Angrist describes above, the way of making a functional, precise and lasting processor is principally as simple as carving pathways and channels into solid material. This basically means we can upcycle into a new Stone Age where processors can be literally carved into stone -or any other hard material- to accomplish physical computing tasks.

Another example that foresees fluid processors was demonstrated by Mertaniemi et al. (Mertaniemi, 2012) In 2012 they carved superhydrophobic channels in a copper plate. By letting small water droplets move down the channels they created a superhydrophobic droplet logic forming an AND/OR gate. Such logic gates arise where droplet collisions affect their output path. This forms another basis for future and alternative electricity-free computing devices. This experiment showed how the droplets can be simply controlled and converted to informed matter. In the context of ecological and speculative computing, what if future rain became exactly that: informed matter? That is 'information' as inherently embodied in the water -as well as other natural elements- itself. How could that impact and change weather control and watering of the earth?

Other principles and approaches relevant for the design of fluid processors can be found in the fields of surfactant transport (Leal, 2007, p. 493), cytoplasmic streamings (Wayne, 2009), hydroponics (Licker, 2005, p. 1110), Lagrangian and Eulerian specifications of the flow field (Kiselev et al, 2012), molecular dynamics and not to forget the foundational principle of capillary action and capillary motion where liquid flow in narrow spaces without the assistance of, or sometimes in opposition to, external forces such as gravity.

As this paper only represents an initial approach to the topic, questions that need to be explored are how to practically shape such processors through forming channels in terms of profile, depth and materials. Other issues influencing the functionality of fluid processors are choices of production such as carving, casting or 3d printing. Material choices greatly influence for example durability and duration in nature. Figure 6 shows a cube shaped fluid processor sample printed in bio- degradable corn-starch based PLA plastics. Such a cube is expected to decompose within a few months in hot and humid conditions such as the Amazon.

Discursive and Speculative Design

To explore the principles of building fluid processors and its possible uses, several designs and initial experiments have been conducted inside the Amazonian rainforest. During the Lab Verde Art Immersion program in 2016 (www.labverde.com) I was able to explore some of the principles of fluid computing described above and realize them as environmental sculptures. My approach was practice based, using the methodology of discursive and speculative design (Dunne & Raby, 2013 p.11,). The purpose of this methodology is to ask speculative questions of both how things can function and how/if we want them. Dunne and Raby are proponents of such making and thinking as the odds of achieving desirable futures increase if we open the debate and discussion of what kind of future we want – or not.

Figure 3. Leaf Connector, draft for Liquid Processor distributing water between plants using crafted capillary channels and forces. ©Stenslie 2016

In this context my open and speculative research question was how basic fluid processors could impact the growth of plants in the nutritious poor soil of the Amazon rainforest. My assumption was that they would create fertile microzones where they were placed, increasing, regulating and ensuring growth over time.

Two of my draft designs for fluid computing are he i) Leaf-connector letting different plants share and distribute liquids, securing chances of better growth, see figure 3, and ii) the Fluid Cube (figure 4) where different pathways and channels for the flow of liquids are carved into a solid cube, making up a fluid circuit channeling water in various ways related to its placement in the terrain.

The Leaf-connector is designed to distribute water flows between leaves, thus ensuring a mutually beneficent and symbiotic growth environment. The initial design and testing confirms basic flow and distribution of water, but micrometer precise shaping of channeling down to the super-hydrophobic levels as well as further tests insitu and in real-life settings are needed to improve design and applications.

The experimental Leaf-connector and the Fluid Cube represent initial approaches to emergent eco-computing based on fluid processors and fluid processing.

Future Applications

For what purposes and ends can these techno-ecological devices be used? The basics of fluid processors are not fit for running smartphone displays or ultrafast computing.These eco-computing devices function differently. They function in ways that give our thinking and action other perspectives. Eco-computing functions not by mechanically trying to reproduce the precision of digital calculations, but by adapting to natures own way of supporting living structures. Techno-ecological computing is deeply rooted in ecological consciousness, working towards a change in both the mind- and bodyset of humanity. A first line of applications could be using the fluid processors to build complex hydroponic system, collecting and diverging natural available liquids such as rainwater into various chambers and channels, each purporting a different growth and living rate within the same biotopia.

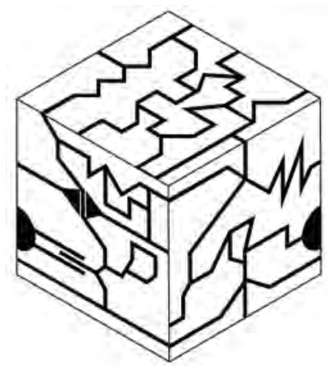

Figure 4. The Fluid Cube: layout of a cube-shaped Fluid Processor showing channels carved into solid material. ©Stenslie 2016

The Fluid Cube is designed to literally be thrown away to function, see figure 5. The flow of liquids and impact on soil is dependent upon how they fall and how the different sides orient themselves.

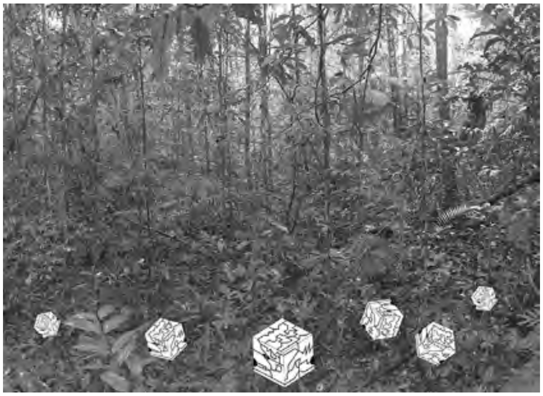

Figure 5. Example of how multiple Fluid Cubes can be tossed around on forest floor, liquid flow and functionality depending on the relative position. ©Stenslie 2016

Figure 6. A Fluid Cube: example of Fluid Processor cubes that have been CAD constructed and 3D printed in corn starch based PLA. ©Stenslie 2016

Outlook onto Sustainability and Durability of Eco-Computing

How to make a computing device that is both environmentally friendly and that lasts -if not forever- beyond current life cycles? Present-day computers have an extremely limited timespan, lasting only for a couple of years and over-consuming natural resources. Electronic components and media invariably decay over a lifespan of up to max ten years due to chemical reactions such as oxidation, magnetic fields, variations in temperature, mechanical components etc., not to mention the rapid change in incompatible software formats. Computer chips can easily be burnt for example by electromagnetic waves. Hard disks tend to become mechanically unreliable after a few years and the new SSD disks are based on electric charges to store information; lasting in best-case scenarios between two to ten years before data retention becomes a serious issue. The consequence is that data decay is increasing at an alarming speed unless continuous and electricity based updating is constantly applied. As the fluid processor design demonstrates, there are alternative ways of thinking computing and information flow. Throughout the relatively short records of art history there is one medium that particularly has resisted decay of information to such a degree that is naturally presents itself as a solution to the pursuit for a new, malleable, representative artistic medium. That medium is stone. As both the Rosetta stone and the rune stone of Harald Bluetooth – the Jelling stone- in Denmark demonstrates, data and artistic expressions inscribed in stone outlast electronic media with literally thousands of years. Similarly, a fluid processor is likely to retain its computing abilities throughout and over the millennia.

Summary

The proposed fluid processor designs represent an alternative way of thinking applied environmental aesthetic by constructing fluid computing devices that respond to everyday and emerging environmental challenges. Carving functions directly into stone and hard materials presents a basic design principle for a future computer chip like architecture that enables an analogue way of computing completely integrated into our environment and natural habitat. Furthermore, the fluid processor carries a potential of turning natural elements such as water into informed matter.

Although such processors function according to known physical principles and liquid dynamics, more practice-based research is to develop fields and application of future use.

The proposed design blueprint for fluid processors as exemplified in the Leaf-connector and Fluid Cube is a bid for a device ecology that enable novel devices to be made, devices that facilitate new, onto-ecological, symbiogenic and sustainable relationships between humans and our environment.

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Prof. Dr. Stahl Stenslie is teaching and researching as a full professor in Art and Technology at Aalborg University, Denmark.

He is an artist, curator and researcher specializing in experimental media art, interactive experiences and disruptive technologies. His aesthetic focus is on art and artistic expressions that challenge ordinary ways of perceiving the world. Through his practice he asks the questions we tend to avoid or where the answers lie in the shadows of existence. Keywords of his practice are somaesthetics, unstable media, transgression and the numinous. The technological focus in his works is on the art of the recently possible - such as i) panhaptic communication on Smartphones, ii) somatic and holophonic soundspaces, and iii) open source design and 3D print of functional art weapons.

He has been exhibiting and lecturing at major international events (ISEA, DEAF, Ars Electronica, SIGGRAPH).

His PhD is on Touch Technologies, see virtual-touch.wordpress.com