The Condition
Towards Hybrid Agency

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Abstract

This exposition paper presents the background for and central themes of *The Condition* (2015-2016), an artwork by the authors. The cultural and scientific values underlying research in the cloned Christmas trees that are part of the installation are discussed. So are historical microgravity studies on plants and recent insights of plant science into the sentient, agential and social aspects of plant life. The artwork is contextualized historically as a continuation of a decades long artistic interest in combining robots with plants. Through this, the hybrid agency inherent in its specific merger of cloned plant life, robotic technology and a self-organizing algorithm is articulated.

Introduction

Recent decades have witnessed an acceleration of developments taking place at the intersection of the technological and the biological. Things we have hitherto associated with the adjective *natural* have by now become malleable and thoroughly imbricated with technological devices. [1] *The Condition* (2015-2016) looks into questions concerning organisms in hybrid conditions that result from the contemporary entwinement of technological, economic, biological and cultural factors. The artwork consists of twelve rotation boxes each housing a small cloned Christmas tree. The rotation speed and direction of the trees is governed by a self-organizing map algorithm driven by input data from space weather measurements. The tree species in question, Nordmann fir (*Abies nordmanniana),* has become a representative of the perfect Christmas tree for Danes and has gained success through its suitability for growing in the Danish climate conditions. It has also become the economically most important tree species in Danish forestry. [2] Currently, this species is being tested and developed for cloning with an aim for improved profit through efficient mass production of high-quality Christmas trees.

The Christmas tree has been selected as a focus of attention for the work due to the fact that it is at the same time a biological organism and a cultural artifact. The interest has been in probing genetic selection and cloning of Christmas trees as a cultural, economic and technological practice. The work equally seeks to explore the adaptability of an organism to changed living conditions and the messy web of hybrid agencies that emerge when a culturally defined biological organism merges with robotic elements and information and communications technology.

Postnatural Christmas Trees

The artistic research underlying the project started with a realization that Denmark, where the authors are based, is one of the major producers of Christmas trees in Europe. Approximately 90% of the Danish Christmas trees are exported to other parts of Europe – Germany, Britain, France among others. The remaining 10%, equaling approximately one million trees, stay in the small country of 5.6 million inhabitants. [3] Typically a large percentage of the trees produced with traditional methods would not qualify as ‘elite’ and would be sold cheaper, or used only in part as decorative branches, or categorized as waste. [4] This problem, however, is currently being addressed by the development of cloned Christmas trees, an active research and development area at Copenhagen University. [5]

Fig 1. Cloned Nordmann firs with the same genetics but different ages. Photo: Laura Beloff 2015.

The developed cloning process of the trees not only produces large numbers of trees that aesthetically please the customers, but also enables better control over the different phases of the growth season. But this also has a flip side – if a selected tree is prone to attracting a pest such as a specific fungus, all the clones will be vulnerable to it as well, and in the worst scenario this may cause the whole harvest to be decimated.

Fig 2. Cloned seedlings at an early stage. Photo: Laura Beloff 2015.

Notwithstanding this risk, it is predicted that the cloning process of the trees will greatly improve the amount of 'elite' trees in the production, resulting in a rise in the economic profit of the branch. [6]

Fig 3. Small clones at Copenhagen University's Tissue Culture Laboratory. Photo: Laura Beloff 2015.

One of the first questions emerging while investigating the ongoing development of the cloning process in Denmark was: How does one define criteria for a perfect Christmas tree? This crux of the cloning attempts is obviously a point where the cultural aspects start taking over the technological and biological ones. It has become explicitly clear in the discussions with Christmas tree cloning experts, that the normative criterion is mainly an aesthetic one: the selection of a perfect Christmas tree is based on visual appearance and whether or not the tree complies with the customers' wishes in this regard. In other words, one can argue that cultural tradition and aesthetics determine the controlled existence of this biological organism in the fields of Denmark. Nordmann fir is also strongly connected to an economic value chain in a Danish context. The species is thus an exemplar of the complex situation involving culture, economics and biological nature that also underlies domestication.

Richard Pell and Lauren Allen have recently coined the term *postnatural* in reference to anthropogenic interventions into evolution that are both intentional and heritable, regardless of their potential subsequent unintentional consequences. In their definition, postnatural is an adjective used to describe the purposeful and permanent modification of living species by humans through domestication, genetic engineering and synthetic biology. [7] Pell and Allen's definition of postnatural refers specifically to organisms that are carbon-based and belong to the category of things, which we are used to perceiving as 'natural' but which today - to an increasing extent - are designed by us. An often-cited example of such a long-term human postnatural modification is the domestication of dogs, which cast these non-human animals as a companion species to humans. As the example of the Danish Christmas trees show, Pell and Allen's term, however, has a much wider application in our current situation.

Rotation Within Plant Science – Producing Microgravity Conditions

The Condition, sees cloned Nordmann fir trees embedded in an installation comprised of plant rotation boxes, which are hung on the wall in a 3 by 4 matrix structure (see fig. 6). Within the study of plant physiology, rotating plants have a long history notably in connection with the seminal instrument known as a *clinostat*. One of the many findings obtained through use of this device is that rotational movement can actually be beneficial for plants, as it helps distribute the growth hormone Auxin throughout the plant's structure resulting in faster growth rates and greater strength. [8]

The basic principle of the clinostat is to use continuous rotation to negate the effects of gravitational pull on plant growth and development. Commonly the device is constructed to have a plant attached with its stem positioned horizontally during the rotation.

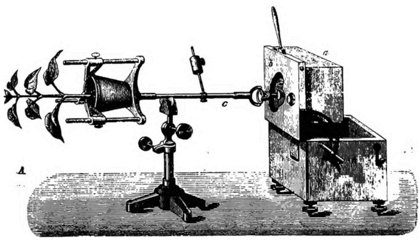

Fig. 4. Illustration showing the simple clinostat. Used under creative commons license. [9]

Several historical scientists have experimented with plant physiology and gravitation by using rotational devices. The British botanist Thomas Andrew, for example, described in a letter to the Royal Society in 1806 how he eliminated the force of gravity while germinating seeds by rotating them with a vertically positioned wheel and later with a horizontally positioned wheel. [10] A similar kind of instrument was also used by the German botanist Julius von Sachs in 1873, who coined the term "clinostat" [11]. Von Sachs used slower rotation speeds than Knight. When the clinostat is rotating slowly – about one to three minutes per revolution – the rotating plant experiences a gravitational pull that is averaged over 360 degrees, but only negligible rotational forces, thus approximating a weightless environment more closely. [12]

The further development of instruments for studying the effect of gravitation in organisms is visible in a three-dimensional version of the clinostat. Also known as a *random positioning machine* (*RPM*), this device was invented by Japanese researchers Hoson et al in 1986. The more recent version of the RPM was developed in 2000 by Dutch Airbus Defence and Space technology agency. [13] The use of the RPM has been very much in line with the original aims of the clinostat – to achieve a simulation of microgravity environments. The contemporary RPM is constructed with two axes and a container with samples connected to these axes, which is rotated by the machine at random speeds in all directions. The RPM's rotation minimizes the influence of Earth's gravity on samples inside the container. [14]

Contemporary rotational experiments involving plants do, however, not only focus on gravity nullification. An additional interest has been in growing fresh vegetables in stuffed urban spaces where space and light are scarce. [15]

Within the arts, scientific rotational instruments have been put to use by a few contemporary projects, which address the idea of changing conditions for living organisms. The RPM was appropriated by Zbigniew Oksiuta in his *Cosmic Garden* (2007), in which the artist used it for germinating seeds on agar inside a polymer sphere under microgravity conditions. [16] The simple clinostat has been a part of *The Moon Goose Analogue* (2011/2012) project by Agnes Meyer-Brandis for speculating on Dandelion growth under non-directional gravity. [17]

Most of the scientific and artistic experiments involving plant rotation, cited above, are related to observing the effects of non-terrestrial conditions on organisms. While space suits and space stations are designed for human survival in space environments, typically by aiming to bring the terrestrial environment with us, rotational instruments are used to observe the physiological growth and survival of non-human organisms in simulated space-like environments on Earth. They are devices, whose construction relates to a long-term human foresight about possibly living on other planets or under radically different conditions. In our era of the Anthropocene, such speculations still abound, as the conditions on planet Earth could change even more drastically over the course of time than what we currently anticipate. [18] Some of the questions emerging from this envisaging include: What kind of life forms will survive with us or without us in other kinds of conditions than the ones we currently have on planet Earth? What ecology is forming at the intersection of technological and biological evolution and human intentionality?

To engage these speculative issues, a novel rotational device was constructed from scratch. The rotational boxes used in the installation thus displaces the standard rotational axis commonly used with the simple clinostat and adds elements that might facilitate a more independent existence for the rotating trees, namely a watering container and grow lights for each plant.

Fig. 5. One of the plant rotation boxes used in the installation. Photo: Jonas Jørgensen 2016.

Robotic Plant Systems in the Arts

A central conceptual move underlying *The Condition* has been to consider the group of twelve rotating cloned Christmas trees as a collective organism, a kind of coherent artificial forest, instead of treating the trees as individuals. This thinking is in part inspired by recent insights of plant science that have emphasized the interconnectedness and communicative links between forest trees in their local ecologies. Plant scientists have also recently shown how certain plant species are able to recognize their own genes and enter into a mutually beneficial, rather than competitive, relationship with plants have the same heredity as themselves. And it has been demonstrated, that plants are able to hear, see and move to a degree previously unthought-of. [19]

Fig 6. *The Condition*. Installation view, Kunsthall Grenland. Photo: Laura Beloff 2016.

In *The Condition*, the inherent ephemeral connections that each tree naturally has with its genetic clones and the outside world is further amplified and enhanced via the technological layer. The installation receives input in the form of current space weather measurements in the solar system (from online real-time data), which serve as input for generating the overall movement pattern of the group, i.e. the rotation speed and direction for each individual tree. [20] The ensemble of technology and plants is thus endowed with the ability to sense changes that occur at a planetary scale and respond with movement patterns that have a continuous and organic distribution over the grid structure.

Robot-Plant Artworks Historically

In the pioneering artistic work on interfacing plants with robotic technology performed by Tom Shannon fifty years ago, which is evident in the artwork *Squat* (1966), a merger of a simulation of life (robotics) and an actual living organism (a plant) took place. Yet these two elements were spatially separated. Moreover, the human spectator was construed as the active agent in the setup where the plant was used as a kind of push button or haptic interface, which allowed the user to start and stop the movements of a robotic structure through touch. The much later seminal work *Telegarden* (1995-2004) by Ken Goldberg and Joseph Santarromana, instead allowed a community of users to control a robotic plant maintenance and observation system, and through telepresence establish a community garden using, at the time, still emergent Internet technology. In *Telegarden*, a distribution of agency that favored the human user was thus still basically at play, as the plants in the artwork were attributed the role of passive elements, which the user community could organize and care for as they saw fit. The focus on interactivity and control central to these two historically important works has, however, been abandoned in a number of more recent artistic plant-robotic works, which seek to grant agency and movement abilities to plants. Examples of this tendency include Masaki Fujihata and Yuji Dougane's *Orchisoid* (2001), Gilberto Esparza's *Nomadic Plants* (2008-2013), Ivan Henriques' *Jurema Action Plant* (2011) and Shannon McMullen and Fabian Winkler's *Soybots* (2015). In line with these works is also the commercial *Ga.ia* robot, which has been announced for release by the Still Human company.

The Next Step: Towards Dispersed Hybrid Agency

In the recent plant-robotic artworks listed above, the human spectator is not conceived as the sole active agent nor are plants reduced to passive entities. A similar intuition underlies *The Condition* but the focus of previous artworks on enhancing or empowering an individual plant has been left behind. Instead, the responsive behavior of the bio-hybrid installation is linked to notions of group behavior and intelligence and concepts of emergence and self-organization within Artificial Life research, swarm robotics, biological systems and cybernetic theory. [21]

The rotational patterns of the plant boxes evidences this, as they are governed by an algorithm known as a *Kohonen Feature Map* or a *self-organizing map* (*SOM*). The SOM algorithm is characterized by being able to learn how to classify information without supervision. [22] It receives input from online space weather data and maps this data set as rotation speeds onto the grid of boxes. The data is then gradually organized until each box is in a steady state at a fixed number of revolutions per minute. Some time after this equilibrium has been reached, the system will come to a halt and then restart with a new data set, which includes the most recent measurements of space weather conditions. This is then followed by a new process of self-organization.

The SOM algorithm serves as a unifying element in the work, as it makes the hybrid setup of individual plants and technological elements cohere. It allows the system as a whole to adapt intelligently through an overarching organizational scheme. But at the same time the obtained organization is continually upset by external data input in the form of fresh space weather data. The steady rotational movement of the clinostat, which could serve to even out the effects of gravity wherever the plants might be in the Universe, is thus no longer present, but has been supplanted by constantly changing rotational speeds. The setup of *The Condition* thus also in part entails a testing of how Christmas trees are able to cope with changing environments, and an exploration of an open-ended physical alteration process brought on by human intervention and technological evolution in conjunction with natural forces.

Fig. 7. Two plant boxes undergoing rotation. Photo: Jonas Jørgensen 2016.

Conclusion

The Condition makes a case for the hybrid ontology of Danish cloned Nordmann fir trees as at once biological organisms and cultural artifacts, whose mode of being is highly indicative of a contemporary situation wherein technological, economic, biological and cultural factors have become thoroughly entwined.

The installation simultaneously probes futuristic speculations on the possibility of plant societies living under radically different conditions – perhaps in a malleable symbiosis with technology, relying on alteration of the effects of gravity or enhanced sensorial connections with foreign ecologies of a vast scale.

How do we relate to non-human organisms now and in the future? If the evolution of a plant is thoroughly interwoven with Western cultural tradition and tied to contingent aesthetic preferences, what happens if this cultural basis disappears? Will the organism live on, and in what sense - what would its ontological status be without? And more broadly - what is the center or origin of agency when organic matter, cultural meaning and the technological merge – a life force inherent in all organisms, human logos or autonomous technique? Hoping to answer these questions in the abstract, is obviously an illusory notion, but preliminary attempts at posing them and interrogating their contemporary material instantiations seems more pertinent than ever.

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