

# Synchronized artificial natures: *The Secret Life of Trees* connecting York, Delft and Alicante

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## Abstract:

This paper presents an experiment that explored teaching limits in architecture and computational arts. Three universities (York, Tu-Delft and Alicante) collaborated, commissioning and producing three Interactive scenographic spaces. These were formed by visitors, artificial trees as well as reactive technologies and emulated the way in which fungi communicate by connecting their roots underground.

Over the four months of duration of the experiment, students learnt about programming resources in contemporary musical scenographic creation; graphic resources and digital manufacturing for 3D printing; component design; Arduino programming; and interfaces such as the "Game of Life" to explain the project in terms of cooperating particles.

Theoretical backgrounds such as the architecture of contingency, readings such as "the secret life of the trees" by Wohlleben and performance practices such as "A-volve" by Mignonneau and Sommerer or "Hylozoic series" by Philip Beesley were approached in the workshop. The ultimate goals of this teaching practice described more explicitly in the paper include: understanding the ways in which communities cooperate; synchronous communication between scenic spaces as well as transparent design processes; and efforts to reduce excessive subject learning encapsulation in new Degrees based on the Bologna model.

**Keywords:** experience architecture, modal interfaces, design by agents, computer interaction.

## 1. Introduction

"When a tree is sick, or some unscrupulous woodcutter has cut it down, its surrounding great community of peers helps it, keeps it alive through that vibrating network beneath the earth. Even when a woodcutter leaves just the base of its trunk, a minute portion of what the tree had once been, the community can keep the stump alive for decades ..."(Solé, 2017) In the example in Figure 1, the fungus in the central part of the image is created thanks to the roots of both species linking together: it will have more chances of survival than from what can be seen in the left margin. According to Wohlleben, author of the bestseller "The secret life of trees", trees communicate, share nutrients and protect themselves, all by means of electrical signals and complex symbiotic interactions in the subsoil (Figure 1a, Wohlleben, 2016).

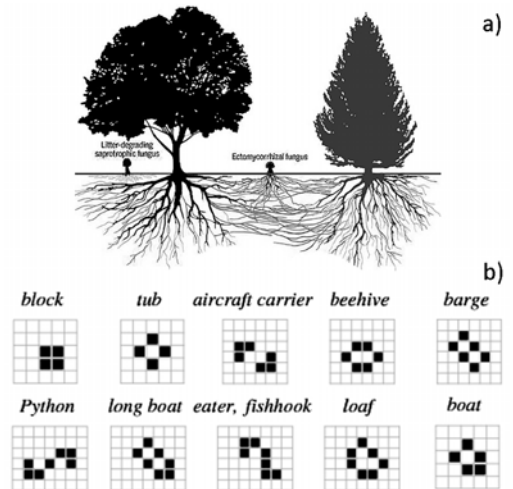


Fig 1. Drawing of carbon transfer through the mycorrhiza network (Hartmann 2016) (a); Game of Life. Cell aggregations: block, tube, hive ..... b) (Schiff 2011).

In terms of biological complexity, both individuals and the community can be taken into consideration. For example, ants cannot explain the anthill on their own (Solé, 2011). In this sense, the mycorrhizae and fungi that connect roots of tree species constituted the conceptual metaphor and inspiring component (in its multiple expressions) of a simulation and sensory immersion space, described in this paper. The behaviour of mycorrhizae also illustrates a view of architecture based on the necessary interaction of basic elements. Thus, we explain how digital data travelled across scenic spaces in Alicante and Toronto, monitored by teams from both universities; we describe how pixels/cells emulated real visitors and virtual mushrooms in the Max/MSP programming environment; and we report how interactions between the previous particles translated into electrical impulses in led wiring, resembling a digital sap belonging to artificial parametric trees.

This project was implemented in the context of a workshop at the University of Alicante (UA), called "The Secret Life of Trees" in recognition of Wohlleben's book. It ran over several phases during the second semester of the 2016-2017 academic year and led to a collaboration between students in the 5th year of their Architecture Degree at the UA, students of "Technology" at TU-Delft and students of "Designing Interactive Objects" at Toronto's York University in Canada.

## 2. Background

The emerging behaviour of particles has been under development for several decades. It takes shape and is simulated by digital interfaces of biomathematical origin called "Game of Life" in which one can observe how cells (pixels) are born, grow, move, reproduce or die (Figure 1b) by means of parametric algorithms. These algorithms simulate the sporadic or indeterminate properties of communities formed by individuals (de-hierarchized species such as flocks, shoals, colonies, etc.). The game works with basic biological rules (live, die, reproduce) and social rules-things occur depending on the position and number of neighbouring cells (Gardner, 1970). In the first years, some cybernetic facilities had already dared to connect robots to live plants. For example, Tom Shannon's "Squat": "when visitors touched the plant, the electric potential of the human body was reinforced and transmitted to

the robot, which began to move and make noises" (Witzgall, 2011, 34).

What type of architecture is made easier to approach thanks to these practices? Probably, one for which events can be forecast and in which the haptic predominates over the geometric, superficial and formal (Contingent theory, Addington 2010); one that is interested in the ambiguity of transient states of matter in living and non-living substances; one which helps to cross ontologically discrete domains such as subject versus object, culture versus nature, human versus animal, organic versus mechanical (systems theory); and that imbricates bodies, machines, code, discourses and space (posthumanist theory, Beesley et al., 2010, 58). Originally from Toronto, Philip Beesley has been researching these concepts for years through facilities called "hylozoic". The name comes from a metaphysical doctrine of the Ionian and Stoic school of ancient Greece, which considered matter not only as active but also as living, that is, endowed with spontaneity and sensitivity (Figure 2). They have taxonomies (pores, peristaltic waves, air pumps, mould ...) that are coupled to nature (e.g. in "grounds from articulated parts systems"), exploring sensoriality such as the echolocation of dolphins or bats to detect the presence of obstacles and dams.

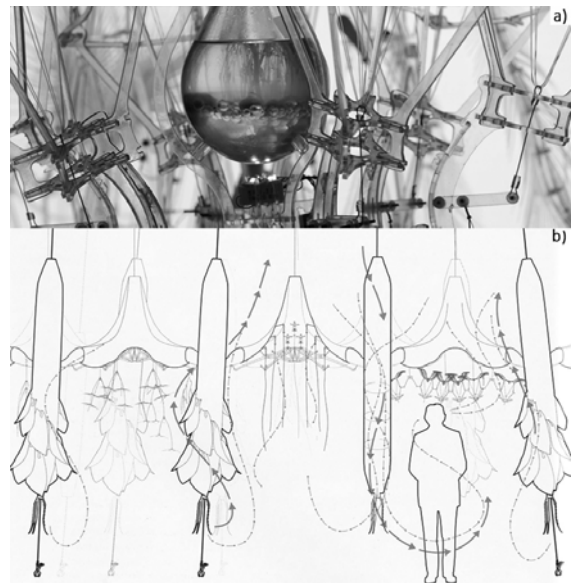


Fig. 2. Philip Beesley: "Breathing Pore Cluster" (a); breathing cycle of the "hylozoic ground" project (b).

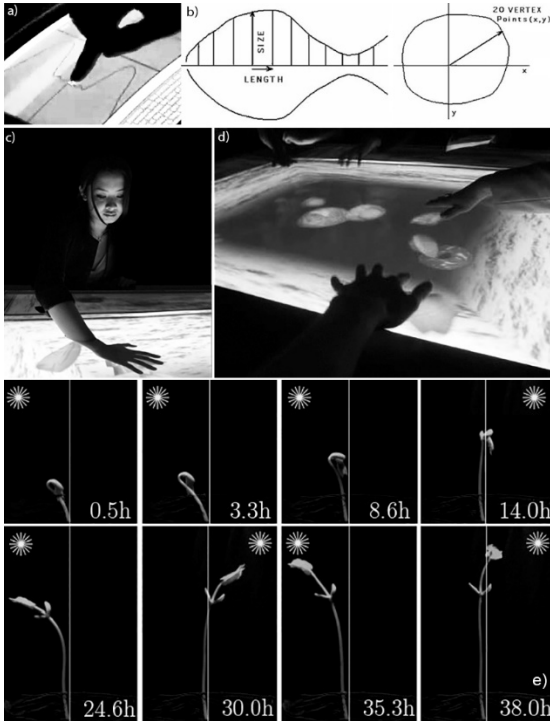


Fig 3. "A-Volve". Graphic processes to create each creature (a,b); digital haptic space (c,d) (Sommerer y Mignonneau, 1994-1997); Eight instants in a bean's growth ("Flora Robotica") (e) (Hamann, 2015).

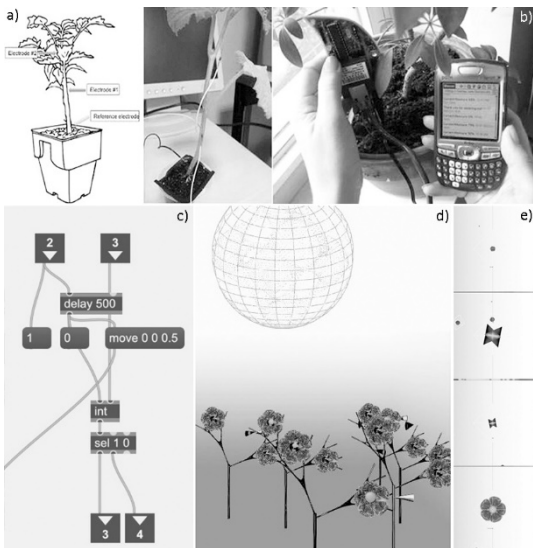


Fig 4. Internet of Things: monitoring plants (a); the plant "responds and calls" the caregiver (b); Programming in Max/msp: the agent is paralyzed when finding food (c); general display (d); phases of seed, flower, fruit (e).

This contingent architecture considers that technology is assembled very naturally in human lives, such as how the anthropologist Ingold refers to the chair he sits in or the pen he writes with as follows: "... I concentrate on my writing, not on my pen; I look at the time, not at my watch ... I can use these and other very close devices without difficulty, just at the point where they disappear as objects ..." (Ingold 2000, 406); it also favours the codification and monitoring of human and non-human entities and objects in networked systems ("internet of things", see Figure 4 a-b); and it helps to explore so-called boundary conditions, which in the physical sciences refers to spaces in which changes occur, surface pressures are balanced or molecules are combined.

First example: in the mid-90s, Mignonneau and Sommerer, professors at the Interface Culture Lab in Linz, designed installations to be understood as virtual ecosystems populated by apparently living creatures whose growth and evolution depended on decisions made by visitors in real time (Altaió et al 2011). In the "A-Volve" installation (1994-1997), a water reservoir projected onto a horizontal and large sized touch screen generated a very credible experience of generating the birth, growth and reproduction of creatures. They swam in a sort of odd-natured digital water (Figure 3, cd). A tactile interface first helped the visitor to draw two flat contours, one elevation and one section (figure 3, a-b). Next, algorithms established the initial form of the creature, its behaviour and different types of soft and natural movements. The creatures had a genetic code that was transmitted to new organisms. These had missions (e.g. combat, mutate, feed, adapt or survive) proper to evolutionary biology, applying a large number of rules of guardianship, care or rejection. The bottom scene of the reservoir, resembling a quadrangular well, was comparable to the virtual universes that twenty years later would be established as spaces of play in the Max-MSP. Other works of his such as "Eau de Jardin", "Interactive plant growing" or "Mobile feelings" also helped to understand the reality-virtuality binomial and extend experience to more sensory domains (Mignonneau & Sommerer, 2005).

Second example: "Robotic Flora", a contemporary project financed by European funds that integrates robots and vegetation to improve both domains (some researchers call them "mixed societies"), producing hybrids in search of adaptive behaviours such as the automation of care, pest control or the incorporation of

phyto-sensors in architectural designs. For these researchers, the question was: what is the use of monitoring the growth of a bean (*Phaseolus vulgaris*) under alternate sources of light? (Figure 3e). Among other things, to train the researcher in complex multi-scale representations, those that combine time scales and behaviour scales, by compressing extensive natural cycles.

### 3. Development

#### 3.1 Phase 1, February 2017. Alicante.

The first workshop was directed to students in Alicante. They learnt how the Max/MSP programming language worked using sound, chromatic values or data series to condition agents (particles in terms of artificial intelligence) of virtual spaces, producing visible and audible end materials. The Max/msp is a multimedia environment created in 1986 by the IRCAM, the centre for electroacoustic creation in Paris, aimed at stage productions requiring sound (MSP) and video (Jitter) synchronization.

Objectives of the workshop included to bring parametric Rhino or Grasshopper objects to the Max space and to design a virtual life cycle (object-fruits that are born, mature and wither) whose phases were conditioned by variables and complex data.

Another goal was to teach students a way of handling the virtual programmable space by controlling small definitions in Cartesian 3D space (displacement and changes in position) subject to temporary intervals. For example, in the first learning version, the "agent" (a digital creature that seems to fly) moves in an ascent loop, a descent loop and stops until it finds its "food" (attractor). The growth and life limits of this fruit depend on the agents' proximity and interaction. The definitions of Max/MSP, in a vertical format comparable to a Grasshopper, solved these topological conditions (Figure 4, c-e).

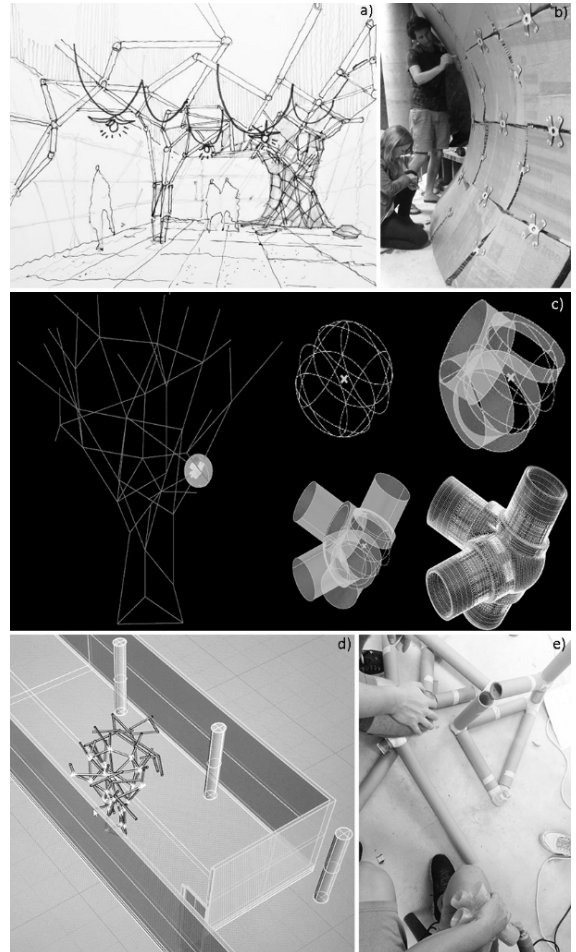


Fig 5. project scheme (a); panels (b); Wireframe and definition for 3D printing of a four-branch node (c); room and tree scheme (d); start of pipe assembly (e).

#### 3.2 Phase 2, April 2017. Alicante, Delft and Toronto.

The purpose of this workshop was to build in few days, the primary elements (a tree made of cardboard tubes and a curved wall of honeycomb cardboard panels) for an artificial version of a sensory immersion space. This was the second step in working on digital interactions in collaboration with an equivalent laboratory located several thousand kilometres away, in the transmedia classroom of the School of Media Arts at the University of York, Toronto. This phase was carried out by thirty students from the TU-Delft school, both at that school and in Alicante, collaborating with local teachers and students.



This workshop enabled to experiment with basic and cutting-edge connections between parametric and other 3D production drawings linked to a 3D printer for the knots, as well as a flex-mould table for the double curvature honeycomb panels; a striking technological contrast came about when small household appliances were used as irons to heat and undo the surface glue in the honeycomb panels (see Figure 5).

In this phase, efforts on digital design and manufacturing were concentrated on the tree. For this, cardboard tubes in equal sections and variable length as well as a sort of 3D printed hollow knot were chosen to allow the passage of multimedia cabling (see Figure 6a).

In a first version, the tree would be generated by an evolutionary design process called DLA (Diffusion-Limited Aggregation), thanks to which a topological structure develops into branches (defining growth by levels) due to the encounter with particles on a trajectory and at a speed in a surrounding universe (Serrano et al., 2017). In the final version, the Grasshopper software helped to control the whole process and to select matches between bars, discard angles that would be incompatible with digital production or bars that were too short with junctions impossible to solve geometrically, among other issues. The LED cabling lines and other electro-acoustic dimensions were designed, programmed and manufactured by students in York, Toronto supervised by the engineer and musician Mark-David Hosale

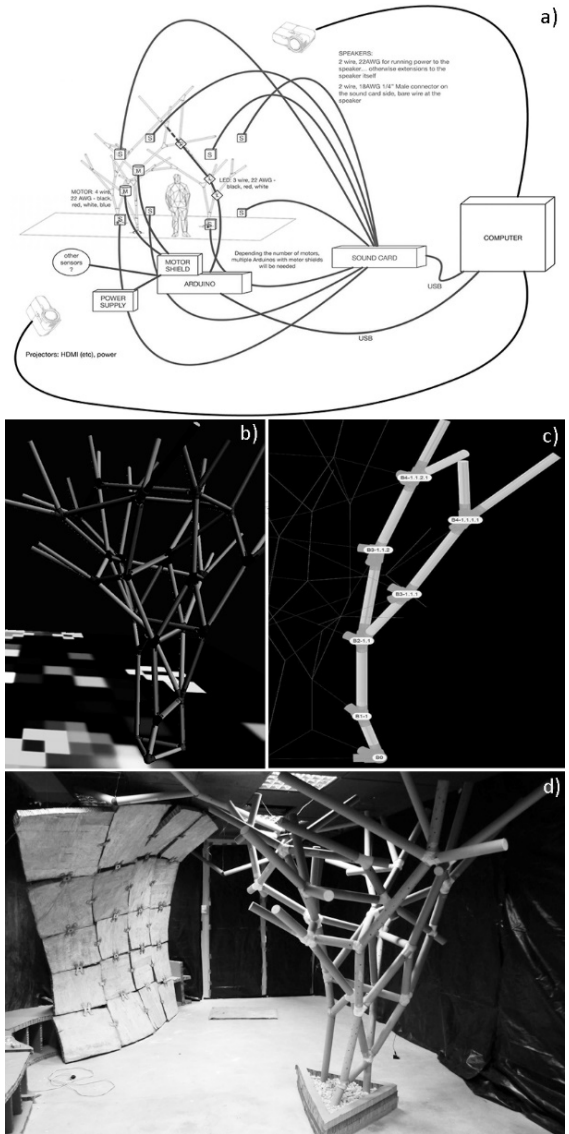


Fig 6. multimedia components (projectors, sound card, Arduino and engines) (a); virtual space Max-MSP (b); vector graph for knot numbering and making (c); real space built in a room in Alicante, phase 2 (d).

### 3.3 Phase 3, May 2017. Alicante and Toronto.

This phase concluded by chance on the International Museum Day whose motto in 2017 was "Saying the unspeakable". Based on this, students oriented the experiment towards feeling the presence of distant others and, in particular, to explore interactions of visitors in the synchronized facilities of Alicante and Toronto, without using popular audiovisual resources

such as Skype or Messenger.

The great structure of this artificial-natural landscape was completed with grafts and technologies designed and made by Architecture students in Alicante (see figures 7 and 8).

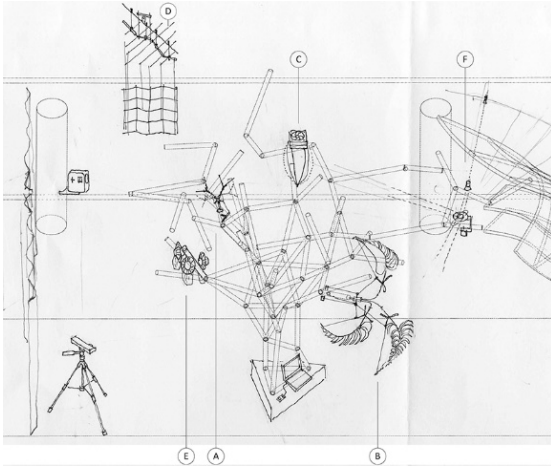


Fig 7. Components designed by UA students in phase 3, together with people detection devices (Kinect-One) and projector.

The six projects can be summarised as follows:

3.3.1 "Cuttings" (Pedro de Lera Garrido, UA). The Kinect read human presence to activate the kinetic device's movements of branches and strings at the end of one of the tubes (see Figure 7a).

3.3.2 "Ferns" (Belén Jaquero Peña, UA). Here, the agents simulated bees in search of food in fruits and flowers. When the room was empty, the transparent fern sheets swayed gently with servomotors; when people were present, the system began to gather thread until the central petiole was flexed and the lateral planes of sori were twisted, replicating the movement of the "bird of paradise" (*Strelitzia Reginae*) or of the mimosa (*mimosa pudica*) (see Figure 7b).

3.3.3 "Petals breathing" (Angela Shepherd Diaz, UA). The Arduino established a ten-second inspiration-expiration cycle with the help of two overlapping and inverted fans. In this simple modality, the petal simulated breathing. This was the minimum degree of interaction (see Figure 7c).

3.3.4 "Beat waves" (Israel Pastor Ramos, UA). Here, visitors, whose voices were collected using a microphone, modified a virtual mesh in the MAX-MSP and an analogue mesh of small articulated bars suspended from the ceiling in real time. The movement and the relative position of the vertices generated a new sound landscape: a kind of white noise that recalled the rising sound of waves (see Figure 7d).

3.3.5 "Withering fruits" (Daniel Sejas, UA). Components on a branch simulated the process of fruit ripening on orchard trees. The objective was to illustrate processes that are difficult to represent because of their duration length (the plant is born, it flowers, it is pollinated by wind or bees, becomes fruit, produces seeds and then withers) or because of intermittent human intervention (care involving sowing seeds, watering, cleaning and collecting, among others). The starting hypothesis in this work was that ripening is followed by aging through changes in texture and colour, modification of sugar, acidity and weight, etc. This led the student to produce several models using materials and knot designs on which to implement shape changes thanks to simple actions such as taking rope from a roller. Turns and rotations of the plastic skin of the vessel or bottle managed to simulate a fruit that fell, wrinkled and changed colour by means of RGB leds (green for the unripe fruit, yellow for ripening, red for aging).

Both the colour transition and the movement of the roller were regulated by an Arduino plate with a presence sensor (see Figures 8 and 7e). A stepper motor was used to obtain incremental angular movements. Different vessel or bottle forms were tested. The one that exerted least resistance to the slender plastic sheets (parallel cuts) warping on the vessels' sides was eventually selected. Future version: explained in the framework of the internet of things, this artefact would serve as an indicator of the real ripening conditions of a harvest.

3.3.6 "The seven percent light" (Daniela Paunache, UA). Starting hypothesis: on nights of full moon, it is considered that the average amount of light reflected by the moon is 7%, enough to be able to walk and perform other simple tasks. In this case, the student designed a mechanism to illuminate all her classmates' devices one after the other (see Figure 7f).

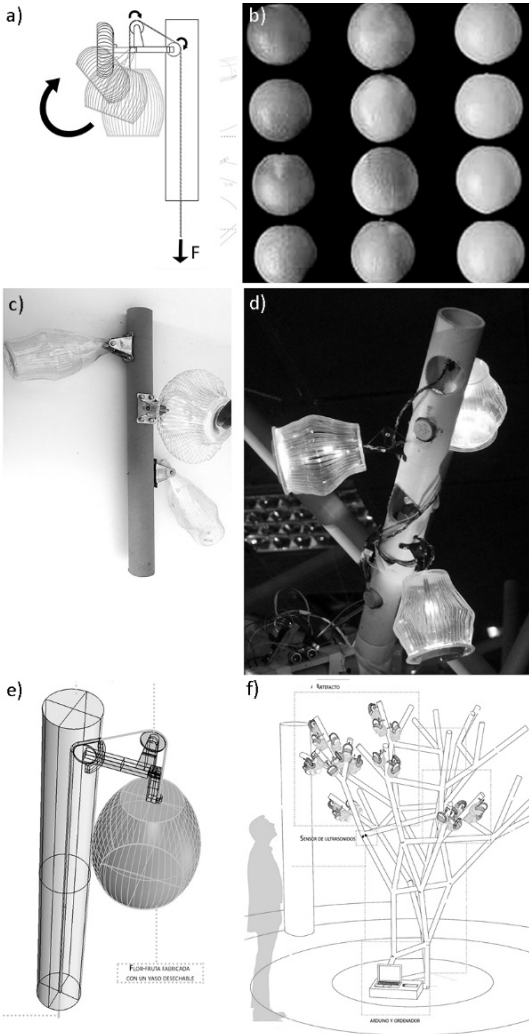


Fig 8. Branch carrying fruits: movement of extension and rotation (a); chromatic ripening (b); industrial hinge (c); 3D hinge (d); 3D graph with interior traction (e); set: sensor, artificial fruits; visitors and Arduino (f). (Daniel Sejas, architecture student).

### 3.4 Phase 4, July 2017. Alicante and Toronto.

This phase was the most enjoyable. Details had to be polished and a public venue had to be found to perform the last synchronization test between remote facilities before finishing the school year at Alicante. Elche city council agreed to hold it as a joint performance with an indie music concert. A scenic space was provided at the Escorxador's theatre warehouse, an old slaughterhouse converted into a

Centre for Contemporary Culture (see Figure 9). Meanwhile, the other installation was placed in the lobby of the Reference Library building in Toronto on the same day the Maker fair was held.

Both expected and unexpected lessons were learnt that night: as expected, we managed to improve integrating the random virtual boards space in the Max-MSP into a delimited area detected by the "Kinect-One", to activate the electroacoustic music and the rising lighting in the tree (see Figure 10top); and unexpectedly: younger attendees at both locations broke the rules by using Skype and mobile screens to communicate (communication should have been exclusively virtual, musical and visual, using light pixels in both Alicante's and Toronto's trees).

The project also worked on the sensation of physical and temporal distance: two time zones and connected physical spaces, some play spaces (Max and bounded surface for Kinect). On the whole, there was the feeling that one was part of an ecosystem that was both artificial (trees made), natural (visitors) and virtual (the game projected on the big screen).



Fig 9. Entrance and poster for July 8, 2017.

## 4. Discussion

Many questions emerge regarding creative learning exercises in architecture. For example, can artificial intelligence parameters condition programmatic or aesthetic and formal questions when designing the components of these artificial-virtual universes? For those in favour, it involves designing from particles and algorithms based on conditions of proximity. This architecture encourages and fosters fluctuation, different versions, replicability, experiences. This is

difficult to include in the Bologna framework where learning often encapsulates finished and scarcely transversal products.

On the other hand, related to latourian matters of concerns, a certain "drawing of the contingency" was experienced by students and teachers: a depiction of the event and its intermediate stages and an exhibition of agents and players (Figures 7,10). Somehow, this kind of graphics are good learning exercises in architecture, because they end up generating communicative formats to describe events full of beginnings, activators, phases, transits, etc.

Finally, taking stock, other questions emerge: can small pseudo-robotic analogue-digital grafts be used as an emotional link and capitalize the final acceptance of visitors? It seems as if the attentive design of digital and recycled components became the decisive factor to capture the visitor's attention.

In the example of the work by the student Daniel Sejas, a version among many others attempted by nature that blooms, ripens and ages ends up being installed (See Figure 8). When approaching this flowered artificial branch, one understands the ripening time translated into a few seconds of waiting, and is transported to cycles of pruning, cleaning, care, collection ... in short, one understand the seasonality and symbiotic relationship of live matter.

## 5. Conclusions

Questioning what was made and seeking models of reference helped, on the one hand, to understand strategies based on Artificial Intelligence, as in the case of Sommerer and Mignonneau, Philip Beesley, who speculate on what are known as "mixed societies" of natural and artificial, human and non-human, living and inert components. In addition, the project "The secret life of trees" has much to share with the transnational collective project "Robotic Flora" (Flora Robotica), which works the symbiotic relationships between vegetation- artificial ecologies by assigning weighted and equitable roles to robots and plants (Hamann 2015).

Max / MSP has been an appropriate resource for Architecture, understanding that sounds, chromatisms or spatial coordinates are likely to become lists or numerical matrices in an algorithm

that helps to configure a graphic universe with the appearance of biological rules. In a time when it is not beyond our imagination to draw music or sculpt light, it seems as if a new space of architecture has emerged to make different disciplines converge in unique works.

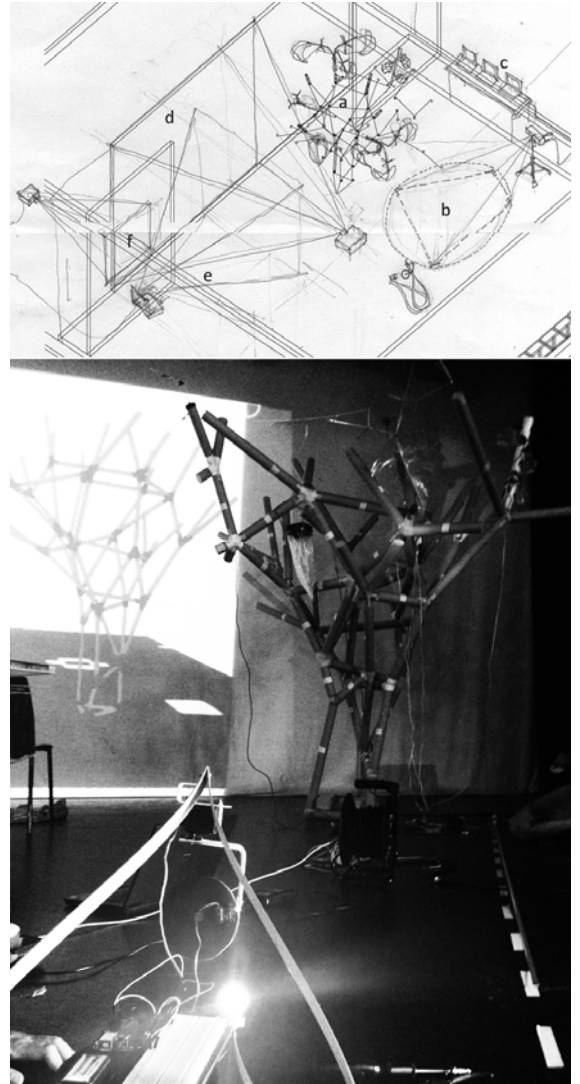


Fig 10. Interfaces in Elche: tree (a); part of the scene detected by the Kinect-one (b); processors and sound card (c); virtual box of the Max-MSP with pixilated mycorrhizae of the "game of life" and digital tree (d); spaces captured and shared in real time by Skype in Elche (e) and Toronto (f), the latter being retro-projected (top); Scenic space *L'Escorxador de Elche*, July, 8 2017 (centre and bottom).



Some future objectives for the framework of this research are: to better understand the cooperative, decentralized, self-organized systems of communities of human or non-human individuals (a); apply modes of analysis that refine these neighborhood links and characterization of behaviour patterns so that, for example, conclusions can be transferred from an analysis of the ant colonies in search of food or other transport vehicles in the middle of a jam (b); deepen in how, in this new generation of programmable environments, variables are controlled in depth so that the novel researcher can create his own version of game rules (c); maximize the ways of visualizing the invisible, in this case, the synchronous communication between facilities (d); unveil the processes (e); get simple algorithmic formulas replaced by complex and complete information of reality for the response of the system to be credible (f).

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