SPIRALLING SLOPE AS A REAL LIFE CO-DESIGN LABORATORY

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ABSTRACT:
The paper and its presentation is to discuss a family house Spiraling Slope (sophia) that is co-designed, inhabited, tested and developed prototype by the second and third author of this submission, the clients. The eco-systemically performing house, literally twisted as a helix into the sloping terrain, gaining its thermal energy, is also covered by extensive greenery to gain this property on its top. Algae, grown on the glass roof, is to moderate its atrium clime. Through its sloping disposition, the house employs natural ventilation for its airing. Though the first author is conducting research that this performance is operated by nature of material properties (Davidová 2016c), in the time of the house's design stage, this research was not developed enough to meet the building practice. Therefore, the house's eco-systemic performance that could not have been reached by biology is achieved through the technology of autonomous environment control (sysloop). Sysloop is a real-time knowledge processing software cowering physical computing, where the clients are the main developer, co-designing with all the other professions involved in the house design and construction, including its architects and systemic designer. Since the house's design is based on natural performance, both its environmental, social, cultural and practical performance is operated through a computer based system AI that relates to BIG Data, the paper therefore presents one of the first attempts of fusion of abiotic and biotic agency with artificial intelligence in architectural practice. Testing such prototype by life co-living experience brings true insights into its design in time. This approach has been defined by Sevaldson as Time-Based Design at the start of this millennium (Sevaldson 2004; Sevaldson 2005). However, at that time the crucial leading design team member was not at the same time the subject of testing. This brings the Shön's discussion on 'reflective practitioner' (Schön 1983) few steps further. It is not the case when her/his designing and lecturing is enriched by tacit knowledge of i.e. building practice experience, but furthermore, the co-designer's experience is gained through living within the system s/he is co-designing and co-prototyping in real life and for real life. Therefore, through such case studies, as the approach fuses the life performance with its design and eco-systemic design and living processes, the first author defends to ratify a new design field, Systemic Approach to Architectural Performance that fights for the shift from Anthropocene.

INTRODUCTION:
The paper is to present the ongoing development and growth of the performance of the family house Sophia. The paper's first author, architect and researcher from Collaborative Collective, was the project lead from sketch to the building allowance, while she is still active on the site. The second and third author are the AI and Physical Computing developer and researcher from sysloop and NUVIT

and culturologist from Open House Prague, that later on joined the team of Collaborative Collective, respectively. Therefore, the paper represents, and witnesses the true *'reflection in action'* (Schön 1983) of both the first person practitioner and the first person user, all co-designing together in real time. Similar approach was discussed by Sevaldson in the context of *'Time-Besed Design'* and *'Research by Design'*(Sevaldson 2005). However, this work extends such approach into the means of co-design. In addition, this co-design does not cover only the clients.

The local authorities did still not confirm the built project, while it is inhabited and developed through this inhabitation; therefore continually co-designed by its clients, the overall eco-system and its ambient artificial intelligence. The mission of the building intervention aims to perform in synergy with the local environment, using analogue and digital tools for it. While the first author is leading the research on environmental co-designed responsiveness without use of energy, the second author leads the research in artificial intelligence of so called 'autonomous dwellings control' and the third author adds the cultural, social and sustainable dimension to it. However, this division of terminology will be questioned latter in the paper. As opposed to the leading environmental research of the first author, the today practice application has to lower down of its direct, primary resource based performative ambitions. Therefore, this trans-disciplinary research by design project involves and fuses three major cases of time-based co-design development: a) the initial and real time co-design with an ambient eco-system; b) the initial and real time co-design with clients; c) real time co-design with artificial intelligence.

Figure 1: The geological formations of Cappadocian landscape, giving the opportunity of building both, human and pigeon dwellings for co-living situation in real need to survive. The culture was in eager for agricultural fertilization in the semi-arid and arid climate of the city of Göreme (Photo: Davidová 2016)

The co-design and co-living with environmental settings is common throughout the architectural history (Hensel and Sunguroğlu Hensel 2015), specifically in extreme climates (Davidová 2009; Davidová 2016b; Davidová and Raková in press). I.e. Hensel and Turko investigate the relation to ground and envelopes, arguing for its intense embeddedness in its local specific settings, its non-discreteness (Hensel and Turko 2015). The first author has performed a hands on traditional architecture study to investigate such relations to ground and other biotic and abiotic agency across the bio-climactic layers, discussing their synergy that is performing across the species in and on the cave buildings in Cappadocia, Turkey (see **Error! Reference source not found.**) and Southern Moravia, Czechia (Davidová and Uygan 2017). Similar discussion she mapped on semi-interior spaces of

Norwegian traditional architectures, 'svalgangs and skuts' (see Figure 2), arguing for such co-living situation (Davidová 2016a; Davidová and Raková 2018). This project brings such historical synergic context into today practice.

Figure 2: The penetration the semi-interior space of the 'Loft', so-called svalgang, offering and generating co-living situation with other species. The 'Loft', or habitable store house originates from Nes, Hallingdal from 1700-1797, now located in the Oslo Open Air Museum (Photo: Raková 2017, with the courtesy of Raková)

This approach of the trans-disciplinary research through practice, that has been always natural to architecture and regains its attention due to recent world's complexity increase (Hensel and Nilsson 2016), preferably investigates the bio-climatic and psychological layers performing across the discussed bounding and/or its extensions. In this case, it also means an investigation of local specific species and/or artificial intelligence for co-living and co-performing across the grounded, the semi-interior and the interior spaces, performing as non-discrete. The biotic and abiotic agency in build environment has been investigated and discussed by Mostafavi and Leatherbarrow as weathering (Mostafavi and Leatherbarrow 1993). Extensive and very impressive research by design as well as historical referencing on grown architecture called Baubotanik is performed by Ludwig, his colleagues (Ludwig, Schwertfreger, and Storz 2012) and others.

This practice based research attempts to merge such environmental performance with computing. Many autonomous operational systems for buildings are recently present on the market. However, these all are done and approached purely from anthropocentric perspective. Co-design, in the means of co-creation was explained by Sanders and Stappers as an active agency within the design process (Sanders and Stappers 2008). We would add that this co-creative design process is best performed as the *'first person practitioner research'* (Sevaldson 2005) through co-living and co-performing across the biotic and abiotic agency. Thus this research is perceived as a *'real life co-design laboratory'*. The discussion on the contradiction of the building autonomy and local specific adaptation was

investigated by Argues (Aragüez 2016). We claim, that the buildings were always 'allopoietic systems', keeping their autonomy (autopoiesis) while being in necessary exchange with their environments (Dekkers 2015). A lot of research of merging biology with computing has been performed by Francois Roche (Roche 2010). However, this research has not yet been implemented enough to architectural practice.

Performance in architecture (therefore Performance Oriented Architecture) was reformulated by Hensel in 2010 as a *'reconsolidation of form and function into synergy of dynamics of natural, cultural and social environments'* (Hensel 2010). We wish to bring this discussion into real life process of cultural and social architectural practice that offers to the eco-systemic agents both dwelling and nutrients. This cross-agency, time-based, co-performative, eco-systemic co-design was ratified by the first author in her PhD thesis as a new design field: *'Systemic Approach to Architectural Performance'* (Davidová 2017).

THE THREE TYPES OF CO-DESIGN

The discussed co-performance is generated by biotic and abiotic agency across multi-layered spatial and climatic concepts of living built environment. Therefore, the research seeks to establish the notion of *'real life laboratory'* as a part of full-scale prototyping concept of smaller scale bio-climatic eco-tops and their relations to support bio-corridors across the city. We are aware that the term is an oxymoron as the concept of labs is to isolate the researched items observation and experimentation from real life. However afterwards, such experiments often fail to meet the appropriate interaction with the complexity of real life. Such reductionist approach is criticized in urban context i.e. by Hemmersam and Morrison whose methodology involves transect walks with the purpose of mapping the peculiarities of cultural landscapes (Hemmersam and Morrison 2016). In 2017 the Journal of Design and Science (JoDS) published its third issue called *'Resisting Reduction'* (MIT Media Lab and MIT Press 2017). The issue is introduced by a manifesto of the same name by Joichi Ito in context of second order cybernetics, the context where the designer participates within the system. Ito explains such approach as the only viable technique to design within the complexity of today world (Ito 2017). Similar discussion is covered by Ben Sweeting from the perspective on how could cybernetics benefit from design (Sweeting 2016). The interaction with the complexity of the *'real life'* is my main researched item to observe and experiment on. Therefore, I consider the site as a laboratory for real life interaction.

The research by design follows Ulanowicz's holistic approach of the field of *'Eco-Systemic Phenomenology'* (Ulanowicz 1988). Only through researching in real life, we can meet strategies for interacting with eco-systemic complexity through prototypical interventions, and therefore co- and re-designing it. This *'praxiological'* perspective with *'designerly ways of knowing'* (Cross 1999) is therefore truly grounded in *'development of theory through practical investigations'* (Sevaldson 1999). Though cross-related, we divided the co-design and co-living in this real life co-design laboratory into three types: a) the initial and real time eco-system's co-design; b) the co-design with clients; c) the co-design the- and with the- artificial intelligence. Though divided into these sub-sections in this paper in eager of clearer explanation, these types of co-design are if not already fused, than performing in synergy. This explains the cross-relation of these sections that have often not clear boundaries.

The Initial and Real Time Eco-Systemic Co-Design

The villa was co-designed through its environmental settings. This means namely the ground and geological and topological parameters (see Figure 3), world axis orientation, micro-climate, local fauna and flora (see Figure 4 and Figure 5), including the social pre-sets. It is spiralling into the ground's topological nature that generates its design. Its design is also formed through its social environment – being on the edge of the lower class flat housing and the villa like area, with the respect to the terrain. Therefore, its entry on the plateau is low level and non-representative, to equalise the social settings (see Figure 5) while the development of the house into the terrain with the view over the Vltava river's south oriented slope valley has a character of opening itself into the major Prague's bio-corridor and higher class build up area.

The terrain's topology is addressed on the inside, where rooms are following the ground. These all are organized around central atrium build of staircase generating semi-interior living room that can fully open to both south and north side of the house on its both levels (see Figure 6). The south oriented side uses physically generated shading and is fully extended by terrace, connecting the spiralling interior spaces through the exterior. As the disposition is sloping up towards north, it is benefitting from an excellent opportunity of natural ventilation. This one is operated by sysloop AI discussed latter. The atrium's glass fan is to be inhabited by algae to regulate the sun and humidity concentration on its central part that opens to the sky.

Figure 3: Upper part: The relationship of the ground; and the lower part: the villa during the building time when the mass and spaces are topo- and typo- logically integrating into the present terrain (Collaborative Collective 2014)

As the body of the house infiltrates to the ground, the roofing (see Figure 4), pool and other built environment of it is offering the surface for the original and local species see, adjusted to the topology of the plot, means south slope or the habitation on its northern side (see Figure 5). These species have also performative capacity, generating extended climate comfort - pleasant clime, smell and colour atmosphere, on the exterior, semi-interior and interior, offering *'edible landscape'* (Creasy 2004; Adams and Lindsey 2016; Davidová, Zatloukal, and Zímová 2017) for local insects and birds. The same is generated by composting of the biological waste by the users and their collection of rain and waste water. Therefore, the building's performance is co-designed by its ambient eco-system, clients included.

The new plan for willow grown semi-interior living extension is on the table at the moment to meet needs of new users member, the daughter. This *'garden pavilion'* will be co-designed so it grows with the little new user over her life, while offering food for pollinators and therefore the birds from nearby

birds' reservoir, as a result of food chain. This shows that the time-basis of the actors' work is present and generative in many ways and meanings.

The presented eco-systemic co-design is to address the today eager for cities' eco-systemic services that are argued as being deadly existential for human life (Sandhu and Wratten 2013). However, this is approached from non-anthropocentric perspective. When discussing such, we understand the meaning of the term eco-system as it was described by Allen and Roberts, an ecological system inside the system that includes the geophysical part (Allen and Roberts 1993).

Figure 4: The upper floor excess on the green roof with local species (photo: Birke 2018)

Figure 5: The Northern façade, its relation to ground and inhabitation of pool by algae (photo: Birke 2018)

Figure 6: The sloping atrium integrated in- and respecting the- terrain that is to naturally ventilate all the interior spaces. (photo: Birke 2018)

The Initial and Real Time Co-Design with Clients

The clients participated in co-design on the project from sketch and their envisioned technological, environmental, use and aesthetics preferences were implemented within the building design already when submitting to the authorities. However, the building is constantly developed, while inhabited by its users, the clients (see Figure 7). Though the dwelling has not been approved by authorities yet, it is in use and therefore constantly re-designed due to enacted needs, food and other stuff consumption and biological compostation or opportunistic use of the clients, the users' family growth and the visitors, including the architects from Collaborative Collective. This part also takes part of co-designing and re-designing the initial eco-system, first by its building intervention, second through its support. We argue, that humans are full part of the eco-system, therefore they have right to take role in its active agency. However, this agency must be very careful and wise, therefore not anthropocentric,

urging for co-living with and within the overall eco-system. However, the first author concluded through performative architecture's mapping, that this large spectre of performative agency is anyway also the most beneficial to humans. I.e. without ground, tree and pollinators, we cannot have fruits and if the eco-system is healthy, we have healthy fruits. Therefore the clients' motivation of the co-designing of the healthy eco-systemic environment is existential.

Figure 7: Clients dwelling in the house (photo: Birke 2018)

Figure 8: GIGA-Map of the sysloop AI house 'autonomous system' co-design (photo: Davidová 2017)

The critical part of the house's co-design through inhabitation is its, so called, 'autonomous system' of its *'agency'*, a sysloop AI. Sysloop was designed as an artificial intelligence to co-design this healthy

eco-systemic environment. The first set of its transdisciplinary co-design input, lead by the human users, was achieved among all through super extensive visual complexity mapping, so called *'GIGA-Mapping'* (Sevaldson 2011; Sevaldson 2015) (see Figure 8). Therefore, this house and its ambient environment also serves as a prototype for AI system, that is both, developed and updated by and through its users – means them as designers that test the prototype as well as them as observed *'laboratory rats'* for machine learning. Here the world environment is perceived as defined by Oxford Dictionary:

'Environment is physical and biological surroundings of an organism. The environment covers non-living (abiotic) factors such as temperature, soil, atmosphere and radiation, and also living (biotic) organisms such as plants, microorganisms and animals.' (Oxford University Press, 2004)

However, in this case, the *'organism'* is rather perceived in an extended meaning for the reason that the agency often merges. Therefore, it can also include the artificial intelligence sysloop that is discussed below.
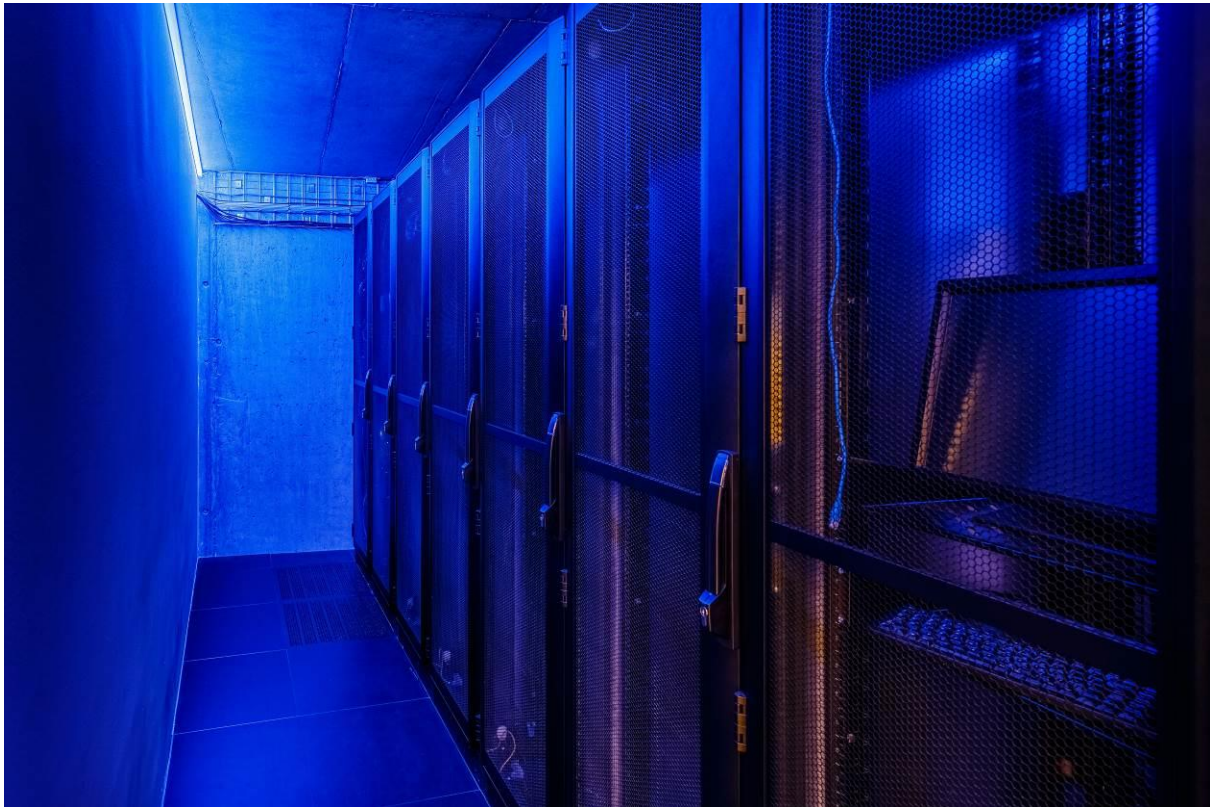
Co-Design with Artificial Intelligence

Figure 9: sysloop racking space for operation (photo: Birke 2018)

The artificial intelligence system sysloop is in depth discussed in separate paper of these proceedings: 'sysloop: An Allopoietic Environment Agency' (Pánek and Davidová 2018).

Through house's environment observations, the artificial intelligence called sysloop, whose base racking space is in its underground space (see Figure 9), co-designs its performance. Therefore, the ambient intelligence is full part of the eco-system across all its interactions and as said above, we can talk about its environment. It co-operates i.e. its natural ventilation, shading, spatial accessibility, therefore spatial distribution and more generally, the heterogeneity of its micro-climates, micro-ecosystems, spaces, environments and opportunities of use based on the observed, learned, evaluated, equalized and developed preferences.

Sysloop its self is co-designed by a) its authors for machine learning; b) its environment, users included; c) BIG data through artificial intelligence. The authors of it gave the birth to the project and constantly co-design and redesign it, while the initial team grows and is altered. Therefore, it is constantly co-designed and redesigned itself. The AI is generatively co-designed and re-designed through its eco-systemic agency (including the clients), which is happening in the house's real time tracked environment. This helps to perform and/or suggest ecological performance, solutions, re-designs and interventions for the environment to flourish. However, this AI requires a link to human culture to start of, because this is the only interpretation of the world we presently know. Therefore, tracking the environmental real time data is used in machine learning and is interpretatively and generatively linked to, by its working term called, *'universal human knowledge'* based BIG Data. The, so called, *'universal human knowledge'* is based in human languages processing in order to grip generic data and while doing that, to generate a new knowledge thanks to the environmental observation, enactment and agency. Therefore, the system's extension grows as well as sysloop system is meant to feed the data of larger systems in urban and even larger scales. Please, note that we are aware of the system's ethical dangers and the need of separation of the users' data from internet. However, these issues are discussed in separate paper.

DISCUSSION AND CONCLUSIONS

The placement of the research by design prototype into *'real-life co-design laboratory'* within the present eco-system is merging the experiment process and prototype with time-based *'design result'*. This approach enables us the work's first person enactment, being first person *'rats'* in this *'real life co-design laboratory'* ourselves. We are aware that the term seems as an oxymoron, however, it is meant as a critique of the common reductionist approach that hardly ever addresses the real life.

This work represents similar approach as Francois Roche's non-discrete and non-anthropocentric architectures (Hensel 2013), often fusing living with digital into one eco-system (Roche 2010). However, this work is explicit that the generative time-based *'design result'* is an ongoing co-design and co-creation of the co-performance that is synonymous with co-living met practice. Therefore, this Research by Design fights for shift from Anthropocene and therefore for, for shift from master planned anthropocentric landscapes and urban settlements to adaptive and edible ones, appearing through the synergy of multilayered biotic and abiotic agency and interaction in real time and real life. This design-research therefore claims that if we are to survive and adapt to recent climate change and bio-diversity decrease, we have to rethink how we think of architecture, built environment and the cultural landscape in general. We can no longer design for- but we need to design with- the users, the eco-system, the planet, etc.

For starting this shift, we need to combine all present-time available agency, biotic, abiotic, and digital in the search of the most sustainable and adapted balance. Recently, many of these systems' boundaries seem to be blurred and this blur will most likely increase with the current bio-tech development. Architectural practice cannot neglect this development.

This project represents a case study in such synergy and adaptation. Therefore the fusion of these presented processes- and time- based co-designing of co-performances, involving: a) the ambient eco-systemic agency, b) the new cross-species habitants' agency, c) the artificial intelligence agency into the one performative eco-system is truly taking part in the first author's newly ratified design field: Systemic Approach to Architectural Performance that calls for such shift.

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