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Introduction [to: Cybernetics : state of the art]

INTRODUCTION

Liss C. Werner

Cybernetics: state of the art' is the first volume of the book series 'CON-VERSATIONS'. 'CON-VERSATIONS' is based on and driven by cybernetic principles. It engages with pressing questions for architecture, urban planning, design and infrastructure; in an age of increasing connectivity, AI and robotization; in an evolutionary state of the Anthropocene, perpetuating anxiety as well as excitement and joy of a future, that we will be able to predict with less and less certainty. The editors acknowledge cybernetics as a contemporary, effective and efficient way of dealing with current and future challenges for humankind. We understand cybernetics as the art of interacting, listening, learning and conversing with environmental – internal and external—impulses and perturbations. It allows for comprehending the best part of our world as infrastructure and as system and to leave an object-oriented understanding behind. Although CON-VERSATIONS does not explore in detail the inter-, cross- and trans-disciplinary nature of cybernetics, nor its inter-sectoral and international approach, those characteristics are naturally deeply embedded in cybernetics. This first volume invites the reader to enjoy a glimpse into the past and to imagine a cybernetic future. At this stage the reader may ask the question:

> *What is this 'Cybernetics-Thing'?*
> *Isn't this all digital?*
> *Isn't this all about robots, and the Internet – and not about humans – about Cyberspace and virtual reality. About Cyber-hacking and machines that do what they want because of some smart-ass intelligent computer program?*

The answer to the first question is no, if we differentiate between natural systems and machines, and those that are man-made, and if we claim that a conversation between humans is different in scope, meaning and complexity than a conversation between machines or a human and a machine. The answer to the second question is yes, if we consider all systems as being digital, if we consider all systems as binary working agents, and, if we consider those agents to be connected in a complex fashion—independent of being 'natural' or 'artificial', man or machine. And surely—the answer to the third question—cybernetics includes all systems from natural organic, including humans, to artificial intelligence, immaterial conversations, learning algorithms and of course hybrids of the two or more of the above mentioned. The field has started through information exchange, reaches via design to ethical questions within second-order cybernetics (von Foerster 2003) as well as teleological approaches triggered by e.g., cyber-hacking. I will refrain from venturing a more detailed discussion of the definition of the term machine at this stage, since it would open up topics related to trivial and non-trivial machines, natural machines, man-made machines, the machinic and last but not least the human-machine relationship. For ease of understanding, let's define any organization as a machine that processes something, from energy generation via knowledge transfer to metabolism. Machines can be natural, artificial or hybrid. A natural machine—generally understood as a living organism—for filtering water could be a naturally grown coral reef, a man-made machine —generally understood as a non-living apparatus—for filtering water could be an filtration plant utilizing biomimetic technology. A mushroom colony, for instance, is a natural machine made of an intricate network passing nutrition through its 'veins'; a natural brain is an intricate network, transmitting impulses from which meaning can be constructed; a city functions similarly. So does the natural Internet: our intricately woven web of data-autobahns that spans and merges between intelligent physical and virtual sub-systems equipped with artificial intelligence —or, to paraphrase the previous paragraph, 'with some intelligent computer program'. The fact that the artificially grown coral reef is composed of living organisms that operate like the natural structure on which it is modelled, and that the Internet is defined as a naturally-grown network triggers a debate on what absolute distinction or boundary, if any, can be drawn between the artificial and the natural. Following this line of thought, the question of whether cybernetics only relates to computers becomes obsolete. Human and machine feedback are equally relevant to cybernetics and for the topics covered in CONVERSATIONS. The subject matter becomes rather difficult and ungraspable once not only objects, humans or machines are part of the equation, but also relationships, systems, infrastructure and interaction. The term cybernetics was first coined by Norbert Wiener in 1948 in his treatise *'Cybernetics: Or Control in the Animal and the Machine'* (Wiener 1948). It stems from the Greek word Κυβερνήτης (kubernetes) and means steering, governing, regulating or managing. Cybernetics is concerned with systems. Cybernetics had existed for centuries before being articulated explicitly to the world by Norbert Wiener. In the late 1940s, cybernetics was largely regarded as dealing primarily with information transfer as represented by the Shannon-Weaver model, described in *'A Mathematical Theory of Communication'* (Shannon 1948) and *'Communication Theory of Secrecy Systems'* (Shannon 1949); the latter at that time unknown and classified. The model proposes that information that is transferred from one place to another, is subjected to noise (small perturbations) when traveling from a sender (encipherer) to a receiver (decipherer). Research on control systems of navigation and communication carried out between the World Wars, e.g., by *Bell Telephone Laboratories*, established a first phase of cybernetics – mainly focusing on war-related applications. The Evolutionary Biologist David A. Mindell describes this in his book *'Between Human and Machine: Feedback, Control and Computing before Cybernetics'* (Mindell 2002). The Shannon-Weaver model mentioned above, a model of first order cybernetics did not allow for and did not desire feedback. Models of and for second-order cybernetics developed shortly after were built on feedback. Cybernetics, the art of governing and steering was soon defined by Margaret Mead as

> *"…[T]he set of cross-disciplinary ideas which we first called 'feed-back' and then called 'teleological mechanisms' and then called … 'cybernetics' – a form of cross-disciplinary thought which made it possible for members of many disciplines to communicate with each other easily in a language which all could understand."*
>
> Mead, 1968

Cybernetics is a tool, a strategic weapon, a way to understand the world as a constantly changing network constructed of communicating objects designing ways and instruments of communication and information delivery and exchange – living, non-living, organic, non-organic, artificial and natural. It is not a model for linearity and feed forward. Cybernetics is a mindset orchestrated by feedback.

Volume 1

'Cybernetics: state of the art' was conceived as an anthology of chapters following a conference with the same title. The event was held at the Institute of Architecture at Technical University Berlin between 09th and 10th June 2016 and extended into a complimenting exhibition during the ‘Long Night of Sciences’ a day later. The exhibition was shown in the Forum of the Institute of Architecture. It orchestrated a journey from first writings on cybernetics, architecture and urban design via project work investigating data driven design processes, interactive/reactive architectural structures, and provided an insight into the Brainbox, a design negotiation and planning tool renamed to ‘CCL—Conscious City Lab’ in 2016. The idea of the event was, to (re)start and continue the conversation about cybernetics as an active and living mindset. We intended, curated and achieved a conference to review and preview cybernetics as design strategy in computational architecture, urban design and socio-ecological habitats—natural and artificial—if there can be registered a difference at all. The book is largely influenced by the great cybernetician Andrew Gordon Speedie Pask, who developed Conversation Theory, comprising influential concepts of Second-order cybernetics relevant to architecture and design. In 1969, Pask introduced cybernetics as

> *“[...] a discipline which fills the bill insofar as the abstract concepts of cybernetics can be interpreted in architectural terms (and where appropriate, identified with real architectural systems), to form a theory (architectural cybernetics, the cybernetic theory of architecture).”*
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> Pask, 1969

Born in 1928 in Derby, UK, Pask studied engineering and was awarded a PhD in Psychology from University College London, UCL in 1964. He joined the Architectural Association in London where he taught until 1996, partly with Raoul Bunschoten, partly with John and Julia Frazer. He acted as cybernetic consultant for the *Fun Palace* designed by Cedric Price, commissioned by Joan Littlewood in 1964, and exhibited his cybernetic machine *A Colloquy of Mobiles* at the exhibition *Cybernetic Serendipity* in 1968, curated by Jasia Reichardt. In this volume, we discuss cybernetic principles and devices developed in the late 20th century, to learn from for the current state of the art. The book juxtaposes cybernetic-architectural theories with applications and case studies. We were rather modest and did not engage biological computers or humanoid deep learning systems that might disrupt current human existence and condition eventually. I also refrained from discussing the ‘hacked body or the extended phenotype’ as introduced in my lecture at the Digital Bauhaus in 2015, which—inspired by Ríchard Dawkins' book 'The extended Phenotype' (Dawkins 1980)—suggests a novel, alien iteration of the mechanically intelligized human being living mutually with the biologically humanized machine. Instead I intended a humble juxtaposition of selected historical events and current streams of cybernetic applications ranging from cybernetic machines via participative design processes to policy-making. The first include Stafford Beer's Cybersyn (1971-1973) (see Espejo ch. 2), Ross Ashby's notion of 'Design for a Brain', (Ashby 1954) and the legendary legacy of Gordon Pask, the latter including cybernetic approaches to urban design in China and design strategies for land-use in the US. All chapters in this book tackle the underlying question of whether there is a difference between hardware and software, between human communication and machinic communication. Thus, the chapter also invites to a philosophical approach towards the definition of matter in an era that embraces the bit-based virtual as well as the atom-based material and encourages a multiple, almost avataresque, existence in a multitude of time-zones and geographical locations.

Contributions and chapter structure

The book comprises nine contributions written by an international group of authors from four academic generations: (in alphabetic order) Raoul Bunschoten, Raul Espejo, Delfina Fantini van Ditmar, Michael Hohl, Tim Jachna, Arun Jain, Kristian Kloeckl, Paul Pangaro and Liss C. Werner; with a foreword by Omar Khan. In order to follow our plan to 'review and preview cybernetics' we decided to structure the book into two complimenting parts. Part one 'A Concept and a Shape' focuses on the history and theory of cybernetics, its disappearance and future impact. It comprises chapters 1-4. Part two 'System 5' focuses on applications—with people, the individual and human feedback in mind. It comprises chapters 5-9. All chapters embrace the relevance of uncertainty, unmanageability and surprise as drivers for a governing improvisation; an unplanned and highly appreciated phenomenon. Kristian Kloeckl (ch. 8) specifically engages with the interdependency and synergy of improvisation and public life in cities. Our aim is to steer towards an interdependency-considering systemic design approach with the goal to develop resilient, sustainable, iterative and happy projects. The reader may decide to read the book back-to-back, which certainly is beneficial for a complete understanding. Chapters, however, do not build up upon each other, and can be read independently. The title for part one

'A Concept *and a Shape'* derives from Gordon Pask's paper *'The Conception of a Shape and the Evolution of a Design'* (Pask 1963). In the entry paragraph, he states:

> *"In this paper we consider a Cybernetic view of the designing process. To restrict the field we shall discuss only those systems which can (in principle) be physically realized. Thus, although we are chiefly concerned with design as it occurs in man, most of our arguments apply also to mechanisms that design."*
>
> Pask, 1963

Pask describes the concept of Musicolour, his interactive music-color-machine as an example for "a Cybernetic view of the designing process". In Musicolour, communication between a 'light organ', musicians, an amplifier and sensors created a communication system, which equally was an ongoing design process of a conversation between musicians and a light-organ. The system was driven by the reaction of the musicians and in return the reactions of the machine. Pask introduces the notion of 'perception'. The design principles Pask presents in 'The Conception of a Shape and the Evolution of a Design' are exemplary for the chapters in part one. The title for part two 'System 5' finds its origin in the Viable System Model developed by Stafford Beer in 1979. The VSM is a model of an organization in which five distinct subsystems, with distinct functions, are coherently sitting next to each other. By feeding back to each other, the subsystems together keep the whole system alive, running and sustainable. The model was initially designed for managing and regulating markets and partly applied in the project Cybersyn in Chile 1971-1973 (see ch. 2, Espejo). System 5 in Beer's VSM is responsible for policy decision making within the organization. Its function is to regulate and steer the system. According to Stafford Beer, system 5 is 'the people'. We have chosen 'System 5' as the title for part two, since all chapters engage with the people, the human, as governor for the system as a whole. Part two encourages further thoughts and projects towards human-centered computer-aided design, a strand on which we are planning to focus in future volumes. In the remaining paragraphs, I will briefly summarize the individual chapters:

1. In the first chapter, **Paul Pangaro** introduces the subject matter of the book with his chapter *'Cybernetics as Pheonix: Why Ashes, What new life?'*. **The**

chapter reflects on questions and answers why cybernetics dissipated in the 1980s. One of the reasons, Pangaro states, is that (second-order) cybernetics is anti-objective, an attribute not embraced by the traditional sciences. Pangaro leads us through a journey that allows glimpses into some of the key-projects / -developments / -events of cybernetics in the last half of the 20th century, including Heinz von Foerster's BCL (Biological Computer Laboratory), Marvin Minsky's development of the perceptron at MIT and Rittel and Webbers notion of 'wicked problems'. Pangaro leads us further into the year 2017 to discussing cybernetics in the context of design. The chapter concludes with an edited transcript of a conversation between Paul Pangaro, Kristian Kloeckl, Omar Khan and myself, recorded on June 9th 2016 during the conference 'Cybernetics: state of the art'.

2. **Raúl Espejo** provides the reader with a colorful and critical (re)view of the project Cybersyn (1970-1973) in Chile by combining historic and personal with an insight into the system behind Cybersyn. In his contribution *'Cybernetic Argument for Democratic Governance: Cybersyn and Cyberfolk'* he highlights Cybersyn's conceptual strengths and vision: Beer's Viable System Model. **At the core of Espejo's chapter stands a model that has the desire to enable democracy on all levels of organizations of different kinds. He emphasizes on the strength of a Matrioshka-like formal organization, in which numerous subsystems are sitting within higher-level systems.** Graphic illustrations describe the VSM's seemingly autonomous units coalescing in cohesion of their individual functions. Information transfer and feedback were the drivers for a self-organizing resilient system, conceived and born out of a Utopian vision. Espejo further introduces Cyberfolk, a mechanism, a tool, a method for the people (on Chile) to communicate with politicians and policy-makers. The idea, which reminds at today's 'openly spoken word' using social media channels, was to enable real time responses of the people by activating Cyberfolk's algedonic loop, stating satisfaction or dissatisfaction. In the context of this publication, Raul Espejo's chapter acts as an incubator from the past for a cybernetic future.

3. '*Cybernetification I: Cybernetics Feedback Netgraft in Architecture'* by **Liss C. Werner** suggests that the possibilities for design increase through digitization and digitalization given, that cybernetic principles are taken into account.

Werner's theory of cybernetification presents an extended ecology where nature and technology seem interchangeable and not differentiable. **She argues that the act of netgrafting—a networked ‚graftsmanship', a collaboration between humans and algorithms enabled by the infrastructure of the Internet—enjoys similar underlying rules of feedback that colonies in open systems found in nature are governed by, which eventually lead to physical unforeseen forms of the environment.** Werner further suggests that emergence is inherently to the process of design once opened up to an unknown but akin group of connected agents and devices. Werner underpins her argument through foundations in the theory of feedback (Ludwig von Bertalanffy), systems theory and cybernetics—by the cyberneticians Ross Ashby, Norbert Wiener and Gordon Pask—and ecology (Simondon). The author draws the relationship to evolutionary algorithms and computational architecture between the first digital turn to now. Her chapter is accompanied by the underlying debate about how digitally driven design strategies **"eventually can govern and feed back into practice and the art of architecture"**.

4. **Michael Hohl**'s chapter *'Designing designing: Ecology, System Thinking, Designing and Second-Order Cybernetics'* continues the design theoretical approach given by Liss C. Werner (ch. 3). The author is concerned with the issue of learning through applying a Second-order cybernetics approach as seen in nature. **Hohl supports his argument of learning from living systems by linking "systems thinking, Second-order cybernetics and designing with a dimension of ethics and values"**; he examines Linda Booth-Sweeney's 12 habits of mind of a system thinker. He starts with a quote by Terry Irwin, Head of the School of Design at Carnegie Mellon University, in which she asks the question:
"Are we failing to take into consideration the inter-connectedness and interdependencies that are present everywhere?"
Looking through the lens of second-order cybernetics Hohl leads the reader through a journey of biomimicry, second-order cybernetics, Horst Rittel's notion of Wicked Problems—as they occur constantly in every design context – and Terry Irvin's '10 living systems principles'; by doing so he constructs an ecology of possibilities for cybernetic learning, whereby the learning process is a design process. At this stage Hohl refers to Ranulph Glanvilles influential statement "[C]ybernetics is the theory of design and design is the action of

cybernetics." (Glanville, 2007). Michael Hohl's contribution concludes part one of and hence the theoretical framing of the subject matter. Part two of the book focuses on applied cybernetics beginning with the chapter 'The Second Skin – from Cybernetics to Conscious City' by Raoul Bunschoten that bridges the underlying and guiding principles, discussed in part one and part two.

5. In chapter five, *'The Second Skin – from Cybernetics to Conscious City'*, **Raoul Bunschoten** imagines that the intelligence of urban systems, emerging through a smart network fed by a mix of data, **"in an ideal case scenario enables humans to increase their health, comfort and wealth as well as design plans and processes for an efficient use of natural resources."** The second skin acts as an extension to the first skin of the earth, namely the natural crust. Bunschoten grounds his vision of an increase of living quality on the strong believe in intelligent and 'conscious' communication between objects and processes in an urban environment; he finds the foundations for communication and conversation between devices in cybernetics. Bunschoten suggests that Industry 4.0—the use of networked design processes and digital manufacturing processes in combination with automated construction—"can improve the living conditions of billions of people". His projection is strong in its intentions – quantitative proves of concept and scientific references from collegial Smart City labs, such as the ETH's Future Cities Lab in Singapore or MIT's Department of Urban Studies and Planning are still to come. Raoul Bunschoten introduces the digital negotiation tools 'Urban Gallery' and 'Conscious City Lab'; the latter developed as Brainbox by Holger Prang, Arne Siebenmorgen, Dietmar Köring and others at TU Berlin—fostering participative and democratic urban planning.

6. *'Managing (with) the Unmanageable City'* by **Tim Jachna** tackles a number of real-world issues in urban design and planning, through a case study on the Pearl River Delta (PRD) in China, which he and his students examined in a workshop. He guides the reader towards the core subject of his chapter by setting a conceptual background based on understandings of risk and resilience. Jachna introduces the notion of "unmanageable" systems written about by Ranulph Glanville in 2000 in order to then engage with key steps in the development of 'Cybernetics and the City", including Forrester and Brown's cybernetic descriptions of urban dynamics in 1969, Reyner Bahnham's Four Ecologies' of Los Angeles in 1971, 'S, M, L, XL' by Koolhaas & Mau in 1997, and Mostafavi

& Doherty's 2010 understanding of "cities as complex heterogeneous systems, that are in constant interaction with natural ecosystems". **Tim Jachna constructs a picture of the challenges global societies face to (re)create urban ecologies / ecological urbanism in the Anthropocene era. He suggests a "shift in the way of thinking about the built environment, shifting away from a focus on monuments and objects, towards a focus on environments, 'performativity' and social construction."**

7. Moving deeper into large-scale regional planning **Arun Jain**'s chapter *'Uncertainty, Complexity & Urgency: Applied Urban Design'* focuses on cybernetic thinking and acting as valuable and necessary approach towards successful urban and regional planning. **Jain begins is chapter by defining urban design as "the process of defining and shaping urban settlements", and introduces relevant points in the history and understanding of cybernetics**: a) the extension or even the shift of computer-based and AI-related cybernetics to social-systems-based cybernetics in the 1970s, and b) the complexity of 'wicked' problems for urban planning, as defined by Rittel and Webber, also in the 1970s. Arun examines the subject *Cybernetics: state of the art* through the lens of a practitioner, an urban strategist and consultant. In his chapter, he introduces the Development Management Assessment Tool (DMAT), a support tool for planning and urban development, through the case study of Montgomery County in Maryland, USA. Aim of the GIS-based DMAT is to progressively subtract the regulated lands, e.g., erodible soils, parks, agricultural reserves or forest conservation easements, to show the remaining percentage of unconstructed land. Jain concludes with a forecast into the future, where "we will continue to struggle reconciling divisive individual and collective human impulses with our need for objects and logic driven decision platforms that are easy to comprehend.". He suggests that a combination of the two disciplines, urban planning and cybernetics, may be beneficial for better and sustainable decision- and policy-making.

8. **Kristian Kloeckl**'s chapter *'Open Works for the Urban Improvise'* examines the nature of responsiveness enabled by today's networks of connected technologies in urban environments and proposes an improvisation-based design model for work in this field. Technology supported interactions in today's hybrid cities involve sophisticated techniques of sensing, processing

and actuation. They are characterized by real time feedback loops that allow for deliberate and distinct responses to unique situations that go beyond a simple action-reaction coupling. Kloeckl notes a resemblance between this dynamic and that of improvisational interactions in the performing arts. Drawing from theoretical frameworks and practice-based methods of improvisation he adopts a system perspective of improvisation as proposed by Landgraf. **The chapter discusses improvisation as a process characterized by a simultaneity of conception and action, where iterative and recursive operations lead to the emergence of dynamic structures that continue to feed into the action itself.** By identifying the interactions in and with urban responsive environments and the art of improvisation as fundamentally related topics of investigation, Kloeckl identifies four underlying positions that point toward a foundational model for urban interaction design and that can provide a framework by which interactive urban systems might be more systematically understood. Through a critical analysis of Umberto Eco's seminal text "Opera Aperta" Kloeckl examines more in-depth the first of these four positions – Design for initiative ensures openness – and illustrates its relevance in relation to a number of contemporary projects of urban interaction design.

9. Based in the context of the growing market of the smart home the finishing chapter of the boo*k 'Deconstructing the Smart Home' by* **Delfina Fantini van Ditmar** leads us back into the human scale of the people and their 'intimate' environment. The author raises a critical systemic approach to 'smartness'; the smart home's users' 'upgraded life' merely envisioned under principles such as productivity, security, efficiency, optimization, convenience and automation. **Fantini argues that it is impossible to grasp human complexity through numbers and insists that humans must not be envisioned as linearly efficient consumers.** Instead she characterizes this quantified approach inherent in current notions of 'smart' technology, as the Algorithmic Paradigm. By providing a historical account, Fantini traces back the origins of technological 'smartness' to AI, a deterministic foundational epistemology very much revived these days in Silicon Valley.

Fantini's chapter indicates that applying second-order cybernetics provides opportunities to rethink the 'smart' home. The author suggests that by a systemic understanding embracing the impact of context and experience, a second-order cybernetics epistemology leads to the acknowledgement of the limitations of smart devices. With this in mind Fantini offers awareness of how 'smart' technologies are not free from bias indicating systemic and socio-political implications that goes beyond the technical domain of efficiency. She underpins her argument with a wide spectrum of related areas, which goes from architecture via current technological socio-political authors to second-order cybernetics and design.

Final note

The nine chapters headed by a foreword by Omar Kahn are aiming at actively rediscovering, brisking up and using cybernetics in a variety of contexts. The reader may want to research further by referring to the references given in the individual chapters. This book acts as a trigger for starting to re-learn cybernetics.

Liss C. Werner,
Berlin, 31th August 2017

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