COMPETING "INTELLIGENCES"

Considering computational design processes in the age of intelligent systems

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Abstract. In this paper, the dominant definitions of intelligence are explored in order to establish a set of working principals towards the development of higher order computational design processes in architecture. A review of intelligence as it has been understood over the last 60 years since Alan Turing (1950) first asked the question "can machines think?" shows the question of intelligence is far from clearly understood. Principals of intelligence however can be identified within the neurophysiological and artificial intelligence (AI) communities that differ significantly from the notion of intelligence as it is commonly used in architecture typically relating to the phenomena of emergence and critical point material physics. While distinct, these definitions provide a foundation for understanding intelligence specifically in computational architecture at a moment when it is necessary to develop a foundational taxonomy of systems thinking and processes. Through critiquing the principals of intelligence as it is understood in these different discipline areas, the thesis of this paper is that it is possible to frame a productive general theory of intelligent systems applicable to design processes, while simultaneously distinguishing the goals of design oriented higher order computational systems from those goals of general Artificial Intelligence research.

Keywords. Intelligence; computation; design; architecture.

Architects and designers will ultimately use both intelligent and non-intelligent systems within their work. As complex design systems are further developed however, it is arguable that the aim of design moves from the object to the organization of the systems that produce objects, necessitating the development of new design meta-models. The large majority of advanced work in architecture today is a result of systems often touted as intelligent, such as parametric modeling, BIM, CIM, evolutionary programs, agent based modeling and so on. Typically however, these processes rely on non-integrated functions of high level computational power within normative programming architectures displaying processing prowess but few of the hallmarks of intelligence as it is understood in other fields. In addition to identifying the foundations for a taxonomy of digital processes, identifying specific properties of an intelligent system in computational design processes will clearly distinguish the design ambitions and applications of intelligent systems from normative (if not complex) computationally driven work.

In architecture, intelligence is typically understood in terms illustrated by Oosterhuis (2006) who writes, "Intelligence as I use it here is not seen as human intelligence. It is regarded as emergent behavior coming up from the complex interactions of less complex actuators. It seems to be possible to apply the same definition of intelligence to the functioning of our brains, traffic systems, people gathering, and to the growth and shrinking of cities."

Oosterhuis draws on the phenomena of emergence, and recognizes an intelligence of coordinated group behavior governed by the complex interaction of many individual agents following simple rule based systems. Emergence and the larger phenomena of complexity has been widely discussed in architecture as it can be applied to a range of circumstances from town planning, traffic flow and crowd safety (Ball 2006, Batty 2005) to aggregative performance models of material and geometry (Hensel 2004). However aspects of intelligence such as goals, contextual response and awareness, judgment and multiple forms of perception or sensorial input are ignored in favor of an assumption that pattern, specifically dynamic pattern, signifies intelligence.

In other fields of intelligence research, behavior however is not universally accepted as a sign of intelligence. The massively complex interactions involved with agent based phenomena while computationally exceptional and surprisingly lifelike, remain highly constrained within a solution space that makes their qualification as intelligent only very narrowly appropriate. Similarly, autonomous response or auto-generative systems in design and manufacturing, are often equated with intelligence again based on behavior, while in effect are little more than sophisticated machinery with a pavlovian response mechanism.

However, in understanding intelligence research in the field of computational design and architecture it is important to immediately recognize the disciplinary specific goals that differ between research fields. For example, goals of an intelligent design system might include optimizing structural solutions, managing information integration processes, transcoding information towards fabrication media and specific material and machine constraints or returning partnership design capacities by generating and or limiting possible design options from a given set of parameters or contextual influences as part of the design process. These processes are currently understood as separate, sequential and typically non-integrated. Computational intelligence however will partner with us, not as a tool or device, but as a sophisticated set of compounded and parallel operations that will advise, guide, inform, suggest and empathize with our simplest tasks as well as our most complex goals as architects, designers and researchers.

Definitions of intelligence vary with every discipline. One of the most eminent researchers in the field of Artificial Intelligence, James S. Albus (1991) writes, "Even the definition of intelligence remains a subject of controversy, and so must any theory that attempts to explain what intelligence is, how it originated, or what are the fundamental processes by which it functions." The intelligence industry is very active across many different disciplines including neuroanatomy, neurophysiology, neuropharmacology, psychophysics, and behavioral psychology, while work also continues in artificial intelligence research, robotics, computer science and computer integrated manufacturing (Albus, 1991). There are several characteristics of intelligence that these separate disciplines illuminate, illustrating various opportunities for application appropriate to a general model for computational design in architecture.

Intelligence in other fields is typically scaled over various registers. Albus (1991) in his work on a *general* theory of intelligence, recognizes these levels as corresponding to *Basic Intelligence* or the ability to Sense the environment, make decisions and control actions, *Higher Intelligence* or the capacity to recognize objects, construct a world model and represent knowledge, and reason and plan for the future, and *Advanced Intelligence* which includes the capacity for perception and understanding, choosing wisely, acting successfully under numerous complex circumstances, and prospering.

Intelligence generally is assumed to encompass both biological and mechanic/artificial instances and any general theory of intelligence then should encompass both these instantiations. Indeed most discussions of intelligence move easily between biological and artificial or synthetic examples bringing the distinction itself, artificial or natural/biological/material into question. Albus, a roboticist and control systems expert, ascribes the creation of intelligence precisely to natural selection and the evolution of survival mechanisms within biology while employing theoretical structures, modules and frames to break-down intelligence into replicable computational modules.

Albus (1991) provides the most direct and elaborated exposition in his *Outline for a Theory of Intelligence*, defining intelligence as "the ability of a system to act appropriately in an uncertain environment, where appropriate action is that which increases the probability of success, and success is the achievement of behavioural sub goals that support the system's ultimate goal." Intelligence in these terms includes the integration of a range of essential components including, "behaviour generation, world modelling, sensory processing and value judgment." For the purposes of this introductory discussion, Albus' definition will suit as a benchmark to elaborate some elements of intelligent systems from the broader intelligence research community that could help define intelligence in a design system.

As computational systems evolve from expert tools to fulfill both advisory and executive roles within generative design practice, (Burke, 2007) a critical understanding of what defines intelligence in computational design systems is particularly pressing. Since the basic assumptions of intelligence remain unclear, it is timely to ask how we might begin to develop a theory of design in the age of *organized complexity* (Weaver, 1948). As the design work flow moves from image to information based models, and as architects further develop working processes with the abstractions of script, algorithm and real-time data flows, the need for frameworks to distinguish, evaluate and develop evolving forms of computational processes and partnerships will become only more urgent.

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