# Neosentient Architecture Generator

n_arch.gen

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*Abstract*— This paper outlines an approach to a series of "open" purpose "architecture" generators and related systems. The word "architecture" is here defined in the broadest of linguistic manners. This paper outlines the long-term goals for the facilitation of the functional components of this 'system of systems', although the system will be designed to be extensible as a large-scale open source project. Three major components make up the system: 1) one or more databases; 2) a means to generate intelligent queries; and 3) a virtual media space to display media elements and processes as derived from the queries/interaction. I will begin by discussing precursors and historical problems related to computational creativity and symbiotic creative systems. Given the non-linear nature of the subject matter, the following text will progress in a modular manner, where much of the paper could we read in differing orders. Thus, it will not unfold in the linear manner of other more traditional IEEE papers, and should be explored with this intentionality by the reader. The project takes a multi-perspective approach to the subject matter in which no overarching hierarchy can be given, suggesting the need for such a form. Thus I will draw on the IEEE formatting related to "Component Heads"— "components of your paper and are not topically subordinate to each other." This structure also mirrors the functionality of the system itself which seeks to explore dynamic heterarchical combinatorics as its overarching methodology as an intelligent system. Thus the reader may need to work harder at making the creative jumps that enable this analogue "system" to function by reading each of these different component heads in relation to each other and articulating their own connections between the components. This is a Koestler-like bisociational approach[1]. Thus the paper itself becomes an analogue combinatoric "architecture" used to discuss this project.

***Keywords— Generative Architecture, Generative Art, Recombinant Poetics, Recombinant Informatics, Generative Systems, Cybernetics, Systems Approach***

## I. INTELLIGENT COMBINATORICS

Central to the Neosentient Architecture Generator — n_arch.gen, is the employment of intelligent combinatorics as they are potentially applied to multiple fields of production across the arts, the humanities and the sciences. This is achieved through using meta-tags, meta-meta tags, key words, the analysis of text bodies, as well as pattern-related searches and image recognition tools. Additionally, Seaman seeks to extend study into context analysis and generation through new forms of multi-modal sensing that would work in tandem with this system of systems — Polysensing[2]. The overarching goal is in creating new forms of intelligent generative virtual environments via symbiotic forms of human and computational creativity.

## ARCHITECTURE GENERATING SYSTEMS

In terms of architecture generating in the more traditional use of the term, a series of related precursor projects stand out: Christopher Alexander's *A Timeless Way of Building*, an analogue generative system [3] as well as his earlier text about generative systems[4]; *The Architecture Machine* and *Soft Architecture Machines*[5], by Negroponte [6] with texts by Gordon Pask; and *An Evolutionary Architecture* by John Frasier[7].

Alexander in his text Systems Generating Systems presented four salient points related to generative architecture systems:

1. There are two ideas hidden in the word system: the idea of a system as a whole and the idea of a generating system.
2. A system as a whole is not an object but a way of looking at an object. It focuses on some holistic property which can only be understood as a product of interaction among parts.
3. A generating system is not a view of a single thing. It is a kit of parts, with rules about the way these parts may be combined.
4. Almost every 'system as a whole' is generated by a 'generating system'. If we wish to make things which function as 'wholes' we shall have to invent generating systems to create them[8].

Seaman seeks to use multiple generative levels and approaches to make a "switchable" or "repurposable" combinatoric system out of multiple extensible systems in n_arch.gen, each different modality housing a different set of functionalities. One key to the human brain as it compares to computers is that is that it can quickly shift, compare, and combine contexts in creative, associative ways.

A related interest in a system of systems is viewed in the work of Gordon Pask, Nicholas Negroponte, and The Architecture Machine Group. After over 40 years since the original books were initially published, *The Architecture*

*Machine*[9] and *Soft Architecture Machines*[10], one still sees many of the original goals going unanswered. Negroponte states the following in relation to creating "intelligent" generative systems: "what makes this [intelligent] behavior unique and particularly difficult to emulate in machines is its extreme dependence on context." A central goal of the n_arch.gen system is understanding context from multiple perspectives. It is interesting to note that Negroponte goes on to talk about giving the system senses (eyes in particular) [11]p29 to extend the potential for computers to come to better understand context. This points back to Turing's ideas of "input" and "output" organs[12]. Seaman seeks to extend this idea through multi-modal sensing or what he calls Polysensing[13].

Most importantly Negroponte talks about the goal of "humanism though machines"[14]. Architect-Machine Symbiosis is a goal, to be potentially achieved via "Architect Machine Dialogue" [15]. This enfolds Pask's work related to Conversation Theory[16] as applied to architectural ideas. Pask talks about each generative system as needing to become an experiential learning system[17]. These humanist, symbiotic goals arrived at in part through conversation, "natural" language employment and learning, are taken up by my current project.

Another precursor is that of Shape Grammars originated by George Stiny[18]. March provides a rich history to shape grammars in his paper *Forty Years of Shape and Shape Grammars*, 1971 – 2011[19]. This history is advanced in one sub-system of n_arch.gen through the employment of architectural primitives with meta-tags and meta-meta tags (defining a network of high-level relationalities/adjacencies), working in conjunction with text analysis (syntactic, semantic, and statistical) and with pattern-oriented approaches as well as the employment of learning algorithms. This enables one to build and explore the sketching of a building in a symbiotic manner with the "intelligence" of this particular sub-system. Central is the development of new mixed/multi-modal approaches to computational "understanding" of context used to articulate relevant juxtapositions.

*Evolutionary Architecture* by Frazer is another precursor: "The book investigates the fundamental form-generating processes in architecture, considering architecture as a form of artificial life, and proposing a genetic representation in a form of DNA-like code-script, which can then be subject to developmental and evolutionary processes in response to the user and the environment."[20] I see the potential of having some sub-systems running such genetic algorithms, and a-life functionalities, working in tandem with the interaction of an interactant, yet my focus deals with intelligent ways of making "informed" media-element juxtapositions in concert with user input and intelligent machine symbiotic interaction. In each of the overarching functionalities inherent to n_arch.gen, generative sub-systems will enable one to make elaborate media-element juxtapositions in virtual space — constructions on the fly, closely aligned with my *World Generator* system[21] as 'married' to my *Insight Engine*[22][23] project. This combination of functionalities from these two different works lie at the heart of n_arch.gen, and additionally enfolds multiple foci from my *Neosentience* research with Otto E. Rössler.[24] More recently Seaman has been undertaking the creation of generative stand-alone systems. This form of generativity will also be central as a sub-system choice in the n_arch.gen system of systems.

Along with generative architecture history, we can consider the "architecture" of creating an image (in this case extended into the production of virtual environments) via the employment of an intelligent system. The early AI concepts of Howard Cohen in terms of computational creativity[25] are also germain. He discusses perception and it's role in creative processes early on. In relation to seeking to make a generative series of works of art Cohen states: "…it would seem to follow that some of the machine's functions will need to parallel, at least in a primitive way, some aspects of the human perceptual process[26]. Cohen also discusses the ability to adapt: "It seems likely that the machine's feedback system as a whole will need to possess a comparable adaptiveness [to that of the human] to permit the fluently changing pattern of decision-making which characterizes the practice of art."[27] Here again, n.arch.gen will include adaptive learning sub-systems.

## A PUN ON ARCHITECTURE

The n_arch.gen project is unique in that it seeks to outline a multi-functional system that explores the notion of "architecture" as a kind of pun or series of different functionalities that intentionally become enfolded, each forming one conceptual perspective that can be called upon interactively within this intentionally derived, multi-perspective approach to visualization, sonification, generative media of a multi-modal variety, and multiple forms of generative production. The system seeks to be modular in nature and can be driven to explore many different "Architectures" through the interaction of a user: of computation; of language; of buildings; of thought; of non-standard approaches to knowing; of physical properties; of art and music; of sharing concepts; of media-elements and processes; of human and machinic sensing.

Each of these foci will have relevant components that can be interacted with. There will be many different overarching uses for the system. The following represents the initial set of overarching modalities: Architecture Generator; Insight generation — the Insight Engine[28]; Intelligent 'artistic' World Generator exploring generative image, music and text; and CyberArchelogical World Generator / Emergent Relationality System[29] - exploring intelligent juxtapositions of a variety of differing archeological media. The system will be open source and new functionalities will potentially be defined by others than the originator of the concept.

## CYBERNETIC LOOP

The human as interactant becomes part of the cybernetic loop. This will be central to the focusing of the shifting functionality of the n_arch.gen system.

## FUNCTIONALITY OF SEAMAN'S SYSTEM OF SYSTEMS

Seaman's n_arch.gen is an open source project. Each sub-system related to "architecture" generation can be participated with given the multi-functional nature of this mechanism. Each generative set of functionalities seeks to be emergent in nature and thus become examples of anticipatory systems [30][31][32]. The "architecture" of the system must be designed to be open in nature, such that it can be "built upon" based on the needs of differing participant foci, in an accretive manner. Some initial functionalities include the following: being an intelligent "architectural" sketching system; a system to facilitate the intelligent juxtaposition of media objects and processes — this might be employed in CyberArcheology [33](footnote Forte); a system to generate virtual installations that include image, music and text elements (See Seaman's historical artworks[34]; and a systems to search for relevant transdisciplinary research media [The Insight Engine][35] Since it is open in function it might be focused in ways that are unimagined at this time. It thus must be designed with the intension of accessing multiple differing databases (or one overarching database with differing kinds of media-elements stored in it, which can be drawn on given the intentionality of the interactant and/or chance related processes. Thus, the overarching system 'architecture' must be specifically designed given this directive of open intentions, with a focus on the different needs and goals of the participant. One can also imagine drawing on the functionality of one sub-system and applying it to one of the alternate "architectures", thus extending the combinatoric generative possibilities of use and embodying radical notions of bisociaiton[36] and what Seaman calls polysociation [his coin] — multiple linked ideas.

## NEOSENTIENT RESEARCH OF SEAMAN AND ROSSLER

Seaman and Rössler consider a Neosentient robotic entity to be a learning system that could exhibit well-defined functionalities: It learns; it intelligently navigates; it interacts via natural language; it generates simulations of behavior (it "thinks" about potential behaviors) before acting in physical space; it is creative in some manner; it comes to have a deep situated knowledge of context through multimodal sensing; it exhibits a sense of play; it will be mirror competent and will in this sense show self-awareness; It will be competent to go through the personogenetic bifurcation (thereby acquiring the ability to articulate meta-levels and metapatterns). We have entitled this robotic entity The Benevolence Engine. In this case the neosentient_arch.gen system will include some but not all of the pragmatic attributes of Neosentience. As this iterative system progresses over time it may take on more and more of the criteria discussed above[37]. Thus it extends historical study of intelligent systems including intelligent buildings.

## META-TAGS, META-META TAGS, AND DIFFERING ASSOCIATIONAL METHODOLOGIES

The potentials of textual search methodologies (semantic, syntactic and statistical) will be dynamically "associated with" differing media-elements, functioning in part as a driver for media-element recombination displayed in differing qualities of virtual environment, as displayed through different kinds of "ordering" of media elements that are "derived" through use within differing "associated" virtual environments. Each media-element constellation is brought about through differing sets of user chosen and/or chance functionalities. Interfaces will include: multi-modal sensing systems, virtual menu systems, touch interaction, physical objects/interface tables, and forms of natural language interface (speaking to the system is to later be implemented) as well as standardized interfaces used over the internet (keyboard and mouse / touchpad, GUI). These will be just some of the ways participants will be able to interact with the system. In that the system is open source, others may also add new forms of interface/interaction.

It is interesting to quote Einstein here related to thinking, creativity and combinatorics: "The physical entities that seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined." [38] The media elements and processes that can be combined and recombined here point at mind, as media elements become associationally ordered through meta-tags, meta-meta tags and pattern-related processes and in the future multi-modal sensing. Functionalities include intelligent combinatoric exploration of language/text as well and multiple forms of media-elements… not everyone thinks like Einstein! Imagine bringing two media objects into juxtaposition. The system then looks for all relevant media objects and orders them in relation to the two, as driven by an interactant, or part of the intelligent system functioning as an interactant, through some form of "conversation".

## MULTI-MODAL SENSING POTENTIALS

Computers are currently not as good at discerning context as humans. One area of development to augment both textual and image search/pattern recognition methodologies concerns new forms of multi-modal sensing or what Seaman calls Polysensing[39]. The body understands environment through pattern-flows of differing sense modalities[40]. The notion is to bring together new sensor modalities and arrays that function in tandem over time to create "time-based" parallel flows of sensed data. These can then be "understood" as multi-modal media-objects. One imagines that this might be a

multi-modal machinic sensing module that is developed and plugged into an iphone (or other smart phone), leveraging the multiple sensors and transmission mechanisms already included in the device. Here the idea of defining a set of relationalites between a physical space and a virtual space becomes central. e.g. imagine the set of relations between an archeological dig and an intelligent system enabling new computational juxtaposition of relevant media –elements in a virtual space. Here the system could potentially provide symbiotic insight to defining their relationality.

A long-term new goal is to implement polysensing[41]. Polysensing is multimodal sensing that can be focused to pay attention to particular foci. Initial research discussed the notion of creating an "Emergent Intention Matrix" – an object based programming environment that would enable the user to define the focus and relationality of the sensors. One imagines intelligent cross talk between physical space and virtual space, as tied to a dynamic database. One concept is related to the parallel pattern flows of the human senses. We come to know context through multi-modal human sensing, now functioning in conjunction with machinic senses. The notion is to make time-based streams of multi-modal 'sense' data that come to gives us new knowledge of context— where parallel (conglomerate) code-objects begin to tell us about when differing qualities that are noted, giving us an idea of what actually builds context in the human, and perhaps enabling a much higher level knowledge of context to come into the system as part of the embodied / embedded school of AI. Seaman's notion is that a deep understanding of context can only come out of polysensing as it discerns patterns of flow over time (pattern flows). Here the system builds up knowledge of environment, functioning through bio-mimetics and bioabstraction as applied via in learning systems[42]. This is in keeping with Pask's original ideas of making the system an experiential learning system[43].

## COMPENDIUM OF RELATIONALITIES

One new potential is to define a compendium of relationalites that can be drawn upon in terms of imagistic and textual pattern analysis, as well as in the ordering of different media-elements based on chosen functional parameters of each of the sub-systems[44][45]. Here imagine meta-meta tags that help the architectural generator position rooms intelligently in regard to their "relationality" to other rooms. A step-wise approach to adding intelligence to the building design /sketching aspect of the system will be explored. Initially used for combinatoric sketching from primitives stored in the database, more information will later potentially be abstracted into the system via intelligent architectural meta-meta-tags. This might enable a user to interactively explore weight, physical properties, and materials with real time feedback, or more poetic or didactic processes might be set in motion. One might later also be able to generate intelligent architectural systems --- heat, electrical, water, waste. etc. Meta-meta tags could enable powerful combinatoric tools, drawing on intelligent relationalities, e.g. which rooms need to be adjacent to other rooms. Intelligent chance systems could also generate "architecture" on the fly based on parameters that the user inputs. Imagine the functionality of different meta-meta tags with each different branch of "architectural" processes — language, media elements, historical foci, etc.

## INTERACTION WITH THE N.ARCH.GEN — MULTIPLE STATES

The user of the system will be able to explore many modalities of interaction and functionality: Entering media objects; entering meta-tags; defining intelligent meta-meta-tags (context-based); sketching with the system; potentially generating new insight/knowledge with the system; "playing" with the system; generating different varieties of virtual world with the system etc. One menu could potentially enable the intermingling of systems as well.

## MODES OF THE SYSTEM

The following modes will become operative in the system: Auto generative mode; interactive mode; interactive networked mode; levels and qualities of intelligence related to a given modality; etc.

## SOFTWARE SPECIFICATIONS

The system will draw on some works that currently exist - *The Insight Engine* or I_E already employs meta-tags with differing media elements. The I_E front end is written in HTML/CSS and Javascript, using p5.js and other open-source libraries, and the Unity Web Player plug-in. I_E is dependent on several PHP scripts to query the backend database, to retrieve and post information. The back end is run on a Mac OS X server running the AMP solution stack (Apache, MySQL, PHP). Server-side scripts are written in PHP/Ajax, and makes heavy use of the Freeling natural language processing library, and the Gensim topic modeling/latent semantic analysis library. P5.js is open source (based on a native javascript implementation of the Processing project) and is licensed under the GNU LGPL license. Freeling has a GNU GPL license. Gensim is licensed under a GNU LGPL license. It must be noted that Todd Berreth and Olivier Perriquet have collaborated in the development of the Insight Engine. Aditionally, Todd Berreth has developed an interface table to explore the system, potentially driving multiple of the subsystems through physical interaction. The software currently running on the table is a straight Unity project, with tangible/multitouch camera tracking provided via NUIGroup CCV (available under a GNU LGPL license). The Unity project will query the I_E database via a built-in Unity WWW class, and will access many of the same back-end scripts that the web application uses. The tangible touch table integrates a built-in mini pc, portable projector, infrared lamps and an IR camera.

## OBJECT-BASED GENERATIVE ARCHITECTURES OF THE FUTURE

One can imagine systems that have differing kinds of modalities and functionalities that could be presented in a virtual menu system and brought together to create new kinds of functionality— a system generator. This harkens back to Alexander's notes on Generativity.[46]

## SUMMARY

The Neosentient Architecture Generator, n_arch.gen, will become an extensible open-source system of systems. It brings together many different areas of generative and/or creative research into one overarching long-term project, with potential of use by the Humanities, The Arts, and the Sciences. The system seeks to be an intelligent learning system that can be "switched", repurposed, and focused related to different computational modalities. This engine of engines seeks to enable both literal and metaphorical "conversations" with users (in the Paskian sense) – exploring various media-elements, natural language elements, historical and technological media-elements (media archeology), differing forms of informational elements (didactic publishing – papers, diagrams, videos, data etc., and constructive elements — digital architectural primitives, 3D models etc. The work will function by employing a series of different interface strategies, "punning" on the differing meanings of "architecture". One or more databases might be accessed by the system in service of differing forms of functionality. The system will employ multiple forms of media analysis including textual analysis – semantic, syntactic, and statistical; pattern related analysis; and potential new multi-modal sensing analysis (Polysensing) to enable high-level human/machine symbiosis and contextual 'awareness'. Meta-tags and meta-meta tags will provide part of the "associational" intelligence of this system of systems. The long-term study of how to better articulate context computationally, functions as one of the central ideas of the project. The dynamic intelligent juxtaposition of media elements is here used to both point at and instigate bisociaitional and Polysociaitonal thought (Seaman's coin) in the service of focused thought and knowledge production.

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