# Ubiquitous Colonies:
# Computational Parasites, Sentiment, & the Architectural Space

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***Abstract*— This art installation consists of a computationally-enhanced architectural interior that displays capabilities for multimodal affective sensing and responsiveness. Here, the computational medium, as a *parasitic* organism, provokes and agitates the structural perfection of the built environment by amplifying the emotional awareness and assisting in proposing new conditions for empathy and co-habitation. The system of the installation uses speech recognition with sentiment analysis, and facial detection with emotion extraction that sense the individual and collective sentiment of the visitors/inhabitants. Its multimodal interface achieves real-time responses of sentimental content that is communicated through the use of media extensions (visualizations, lighting, sonification) that allow the installation in overall to become a performative agent of emotional awareness.**

## I. Introduction

In an attempt to invent machines/systems/environments that are capable of demonstrating comprehensive capacities of sentiment or affect, we quite often find ourselves in front of objects that are in a complete state of *alexithymia* [1]; a state in which emotional awareness cannot be established, demonstrating instead strong social detachment, lack of empathy, and ineffective communicational responses. Our intentions are usually quite the opposite; we do desire our creations to be responsive with anthropomorphic qualities and enhanced capabilities on establishing emotional understanding, which, essentially, follows the archetype of breathing life into the inanimate.

The project "Ubiquitous Colonies" [2] is an art installation that demonstrates an architectural interior with enhanced capabilities for multimodal affective sensing and responsiveness. The parametrically-designed structure, which appears to be emerging from a wall, attempts to resemble the moment when a parasitic organism penetrates the skin of the host; a metaphor to illustrate architecture's reform followed by the colonization of ubiquitous computing.

Fig. 1. Installation view (rendering)

A main concern for the development of this computationally-enhanced interior is to establish an environment that displays amplified noesis and emotive layers, which ultimately exhibit empathetic properties and a strong need for co-habitation and reciprocal communication. To accomplish this, a range of sensing inputs have been implemented into the system's engine: speech recognition with sentiment analysis, and face detection with facial emotion extraction. The augmented space utilizes forms of media to become expressive, and attempts to engage the inhabitants/visitors/users into a state in which sentimental content is being shared and explored from a hybrid structure that reframes the interfacing methods between humans, computational systems, and the built environment.

## II. Contextualization

Over the past few decades, architects, engineers, artists and scientists have attempted to propose and design ground-breaking works that reframe our understanding on what architecture is, or what it can ultimately become, especially with the use of computational technologies and cybernetic systems [3][4]. Archigram [5], Cedric Price [6], Nicholas Negroponte [7], and many others, have suggested architectures that are responsive, interactive, conversational, or even sentient. Kas Oosterhuis's "E-motive House" for example [8], asks us to consider a house that has its own mood, and that it is able to converse with its inhabitants on social and sentimental dimensions. The installation ADA, demonstrated an intelligent space that was able to sense and locate its visitors, communicating in turn its own emotional states through visual and auditory stimuli [9]. Amatria, an interactive artwork designed by Philip Beesley and the Living Architecture Systems Group, investigates possibilities on living and sentient architecture, one that is blended with sensors, A.I., kinetic structures, and media elements [10].

Computational technologies are to be found in an extensive array of practices within architectural environments; i.e., automations of tasks, context-aware functions, and responsive tools for the real-time needs of users, are a few applications that we can access effortlessly today. Layers of ubiquitous technologies continuously weave themselves into the structural complexity of a space, revealing "the emergence of post-digital architecture, where ubicomp and ambient intelligence dominates over spatial arrangement and design methodology" [11].

In this instance, the work "Ubiquitous Colonies" attempts to demonstrate an architectural augmentation that is driven by an affective computing system. By observing and studying the human subjects that exist in the space, the installation object attempts to calibrate itself and become emotionally

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aware and socially attached to the surrounding ecosystem that struggles for symbiotic mutualism between its dissimilar agents – human, machines, architecture.

## III. System Analysis

A main consideration for the technical development of this work has been to devise a multimodal system that registers sentiment extracted from human subjects, and to generate real-time responses of autonomous emotional expressions as media representations (visualizations, lighting, sonification).

In more detail, a speech recognition instance allows the system to continuously record and analyze spoken words of the human subjects. The recorded segments after being converted into text are processed for sentiment cues and other relevant insights with a natural language processing algorithm that includes two main methods: the first one is a sentence-level analysis that provides an indication as to the tone, emotion, social propensities, and language styles used. Its second method includes a multi-sentence linguistic analysis that uses the Big Five personality characteristics – agreeableness, conscientiousness, extraversion, emotional range, openness [12][13]. Both of the methods return categorical models of primary emotional states, with each of the identified emotions to have a returned percentage that indicates the estimation of the categorization's confidence coefficient.

In addition to the analysis of speech, the installation includes face recognition algorithms (based on a ResNet-34 architecture) that assist in extrapolating emotional statuses from facial expressions. Captured faces from the camera are scanned for emotional cues by using a facial expression recognition model that employs depthwise separable convolutions and densely connected blocks. With the help of a pre-trained dataset of ~5,000 face samples, extracted from indoor settings and organized into 6 distinct emotional categories, the system logs every facial expression captured by the computer vision as a real-time response, as well as a database entry.

According to the collective readings, the system applies a multidimensional grid that is organized based on relevant temporal associations, emotional categorizations, as well as profiling measurements. Through a mapping process, the media outputs that consist of generative visuals, lighting and sonic elements, reconfigure accordingly to reflect the anticipated conditions.

## IV. Media & Design

An important criterion for the development of this work was to create a physical structure that emerges from the architectural skin, similarly to the ones found in parasitic organisms. The form of this assembly was inspired by the works of Ernst Haeckel, and in particular the illustrations of siphonophorae, a hydro-zooid of the Cnidaria family [14]. The parametric object appears as if it emerges from the background wall, a technique often seen in the works of Henrique Oliveira [15] and Daniel Arsham [16].

Fig. 2. Parametric modelling of the structure (left), facial expression tracking (middle), real-time visualization (right).

At the centre of the installation, a real-time visualization continuously evolves and shifts according to the resulting responses of the multimodal sensing. The visual activity is displayed as a fluid dynamics simulation that utilizes an SPH method (Smoothed Particle Hydrodynamics), which is found in liquid systems. Properties of the simulation are affected in real-time by the sensing input that changes a number of parameters, such as the cell size, gravity, density, surface tension, max force, dampening. As new information becomes available from the analysis engine, the resulting fluid shifts its behaviours to accompany the sensed conditions. The visualization uses a mixture of elements into its composition; all events are sonified, using analog and granular synthesis methods, and, in addition, the visual composition extends in space through the synchronization of the lighting system's behavior that immerses the structure. In overall, this inter-disciplinary media composition attempts to reflect the multimodal affective sensing of the participants and "paint" the architectural space with a responsive sentiment.

## V. Discussion

Even though the system manages to respond and log sentiment values from speech and facial expressions satisfactorily, there are occasions where transitions from an emotional state to the other are abrupt and incoherent, as if there is an inability from the system to exhibit a realistic representation of its sentimentality; as if it is in a state of alexithymia. To ensure consistency on the way input weightings are managed, reinforcement learning, or deep learning for sentiment analysis and emotion recognition need to be further developed.

In the case of the latter, there are studies that show promising results in this area [17] using multimodal inputs fused by feature concatenation and joint latent, or in the case of Delbrouck et al. [18] a modular co-attention layer with encoded joint modalities. These approaches will be strongly considered for the future implementations of this work to ensure a sentimental agent that allows us to define emotionally-layered architectures for experiencing and living.

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