Creating Life-like Autonomous Agents for Real-time Interactive Installations

Nathan S. Lachenmyer
nathan@sitara.systems
Sitara Systems
Las Vegas, Nevada, USA

Sadiya Akasha
sadiya@sitara.systems
Sitara Systems
Las Vegas, Nevada, USA

ABSTRACT

This talk briefly describes the implementation of a complex virtual ecosystem of autonomous agents for the purpose of an art installation. The autonomous agents, called Aerobes, are inspired by the lifecycle of the *Aurelia* sp. jellyfish, and use artificial life techniques to simulate the behavior of two distinct types of organisms. We describe the process of using ethological research of organisms to design an artificial life system in a way that both creates a cohesive simulacrum of life-like behavior and allows for compelling interactions with audiences. We created complex behaviors for the Aerobes using low-level schemata that encapsulate individual goal-directed behaviors, and combined schemata to build behaviors that appear biomimetic. In order to give each agent the appearance of individuation, we mapped the underlying parameters of individual schemata and behaviors to personality traits to create a cohesive psychographic resource for autonomous agents that allowed for variance in decision-making and behaviors without additional computational complexity. The final artificial life system was then used to control the Aerobes in *In Love With The World*, a public art installation hosted at the Tate Modern's Turbine Hall for four months.

Figure 1: Multiple members of two species of Aerobe, controlled by an artificial life simulation, fly above visitors inside of the Turbine Hall at the Tate Modern. (Photo by Will Burrard-Lucas. © Tate)

CCS CONCEPTS

• **Applied computing** → **Media arts**; **Fine arts**; • **Computing methodologies** → **Artificial life**; • **Human-centered computing** → *Human computer interaction (HCI).*

KEYWORDS

Autonomous Agents, Behavioral Animation, Interactive Robotics, Interactive Installation

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1 INTRODUCTION

This talk describes an artificial life simulation used to control a fleet of biomimetic robots for the art installation *In Love With The World*, originally shown at the Tate Modern. *In Love With The World*, conceived by conceptual artist Anicka Yi, begins with a central question: what would it be like to live with new, emergent forms of intelligence? To explore this question, we created life-like robots that would roam the Tate Modern's Turbine Hall for four months, each with their own motivations, behaviors, and personalities.

Artificial Life techniques have been used to create life-like behaviors in computer animation for decades[Reynolds 1987]. The majority of these models have been based on ethological studies[Tu and Terzopoulos 1994], creating simplified models that could efficiently mimic complex biological systems. However, most models assume a homogenous population of simulated organisms, where all agents essentially act the same from a computational standpoint. In our work, we sought to create synthetic organisms that could be identified as individuals within the ecosystem. To accomplish this, we used the OCEAN personality model as a basis for agent psychology, creating unique psychographic resources for each individual organism that could extend the behavioral model with unique variations on decision-making.

Our final artificial life system was based loosely on the behaviors of the *Aurelia sp.* jellyfish, otherwise known as the moon jelly; the aquatic nature of this specimen, along with the expansive nature of the Turbine Hall, created a unique feeling of being immersed inside of an aquarium of machines. The conceptual framework for this project is covered in greater depth in [Lachenmyer and Akasha 2022]; in this talk we summarize the implementation of

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this artificial life system, the creation of individual psychographic resources, and opportunities for improvements to the framework.

2 ARTIFICIAL LIFE SYSTEM

We chose to model our virtual ecosystem on the lifecycle of the *Aurelia* sp. jellyfish, commonly known as Moon Jellies. Recent research has shown that the polyp and medusa forms of the jellyfish are not temporally separated; that is to say, neither form is considered an "adult" or "larval" form, but rather, two dimorphic presentations that the *Aurelia* sp. may present depending on environmental conditions[Ceh et al. 2015]. This multi-modal lifecycle was the inspiration for our two species of Aerobe, shown in Figure 1. The Xenojelly is the more active and animalistic of the two species, directly seeking interactions with visitors and having a form that has more range of motion. The Planula, being more plant-like, is less active than the Xenojelly and largely only interacts with other species and visitors indirectly through their environment.

For our artificial life simulation, we designed a system based on the cognitive architecture developed by Burke et al. for C4 [Burke et al. 2001] and further refined by Stephens et al. in [Stephens et al. 2003]. At a high-level, our artificial intelligence is divided into three modules: *perception*, *mind*, and *body*; these three modules correspond to sensing, thinking, and acting, respectively. The *perception* module encompasses the sensors and hardware that gather data about the environment, as well as the software post-processing and filtering of the data to give each Aerobe its individual representation of the world. The *mind* module contains each Aerobe's internal motivations (represented as internal state variables), as well as an action selection model that produces behavioral choices based on motivations and perception data. Finally, the *body* module contains all of the hardware and software necessary for the Aerobe to move in the physical world based on the output of its mind module.

We used the Five-Factor Personality Model (also known as OCEAN) as a framework to develop a system for creating behavioral variation across individuals in the virtual ecosystem. In the field of cognitive psychology, the Five-Factor Model has proven to be the predominant model of general personality structure[Widiger and Crego 2019]. The five factors, which are orthogonal dimensions of the personality space, are openness, conscientiousness, extroversion, agreeableness, and neuroticism. Each individual was assigned a five-dimensional vector, with each dimension representing a factor in the Five-Factor Model, based on the real-life clustering of human personalities in the five-factor personality space[Gerlach et al. 2018]. This clustering resulted in the grouping of our Aerobes into four distinct personality archetypes. Using the descriptive adjectives in Table 1, we qualitively decided which behavioral parameters to map onto each of the five factors, and used this mapping to give each individual a unique spectrum of observed behaviors.

Table 1: Descriptive adjectives that are associated with each of the five factors of the OCEAN personality model.

Trait	Descriptive Adjectives
Openness	curious, risk-taking, responsive
Conscientiousness	focused, diligent, persistent
Extraversion	social, energetic, assertive
Agreeableness	communal, tolerant, patient
Neuroticism	avoidant, defensive, cautious

3 FUTURE WORK

The Aerobes represent a multispecies virtual ecosystem that uses artificial life techniques to guide their interactions with their environment, visitors, and each other. While creating visually distinct motions and a tranquil atmosphere in the Turbine Hall, using scyphozoa as the basis of our artificial life system possessed its own distinct limitations and challenges. The limited degrees of freedom in Aerobe motion, as well as their overall slow and meditative pace, led to a relatively small pool of plausible behaviors.

In future work, we hope to represent a more complex species where we can portray a greater range of personality archetypes that influence not just decision-making, but also high-level behaviors. We hope that adding this level of individual complexity to virtual organisms could create a richer experience than is possible with only variations in individual decision-making.

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