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Initial Remarks on Analyzing Acousmatic Music from the Perspective of Multi-agents
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Agency and Agents

The notion of agency can be traced back to the age of Enlightenment within the philosophical discussions of whether instrumental rationality or moral norm-based action is the truest expression of human freedom [Emirbayer & Mische 1998]. The terminology of agency and agents appeared later across disciplines such as Social Sciences, Cognitive Sciences, Applied Sciences, Computer Science. Although there is no consensus on the definition of agency in Social Sciences and Philosophy, an agent is a well-defined term in Computer Sciences, specifically in the fields of Artificial Intelligence and Multi-agent Systems. In their book on Artificial Intelligence (AI), Russell and Norvig [2010] define an agent as "anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators."

An agent perceives its environment using sensors while a percept is the sensory data input at any given time. A percept sequence is a histogram of

what an agent perceives for a period, and an action is a set of actuators. An agent is a function that associates a percept sequence to an action [Wooldridge 2009], in a perception-action duality.

Agents situate in an environment where they perceive the stimuli and carry out actions within the environment in response to the stimuli. The notion of perception-action has also been brought up in the literature of acousmatic music. Horacio Vaggione [2001] proposed the action-perception relationship in the acousmatic composition process, concentrating on the agency of composers and their relationship with the composition. In Vaggione's perspective, the composer is the agent that acts in the sonic environment by adding, removing, or altering the sonic objects.

Musical Agents

Artistic contexts often involve interactivity between agents; hence, agent-based approaches for artistic applications greatly benefit from establishing a typology of agent behaviors. My doctoral studies focused on audio-based musical agents using unsupervised machine learning. The idea behind these studies was to come up with an agent-based framework where the learning utilized a set of audio recordings so that the musical aesthetics of the agent could be conveniently changed by using different sets of audio recordings. The first step towards developing this flexible musical agent framework, was to to propose a typology of musical agents emerging from the current literature. To do so, Philippe Pasquier and I [2018] surveyed seventy-eight agent-based systems for music to discover a typology of musical agents, which implement the technologies of Machine Learning, AI, and Multiagent systems (MAS) for musical applications. The resulting typology categorizes musical agents though the dimensions of: agent architectures, musical tasks, environment types, number of agents, number of agent roles, communication types, corpus types, input/output types, and human interaction modality.

Our typology identifies six levels of musical agent behaviors:

1) Reactivity: Agents respond to the changes in the environment in a timely fashion.

2) Proactivity: Agents can perceive their environment and plan future actions.

3) Interactivity: Agent can interact with other agents (human, artificial, or biological).

4) Adaptability: Agents learn from their environment to improve competence or efficiency.

5) Versatility: Agents are domain-inde-pendent.

6) Volition and framing: Agents can explain why they choose certain actions when asked by other agents.

Temporality

In comparison to the agency of the composer within the sonic environment of a composition, we can analyze temporal sonic events in the composition using the theory of agents. Temporality is a fundamental aspect of both acousmatic music compositions and the perception-action duality of agents. The temporality within fixed-media works of acousmatic music allows us to apply agent theory to the analysis of acousmatic compositions. We can decompose a composition to its sonic events, and approach sonic gestures as agent behaviors.

If we approach the sonic gestures in the environment of an acousmatic composition as actions of a set of agent behaviors, how do we group sonic gestures as actions of a single agent? The relationship between consciousness, will, and action within the notion of agency has been previously approached by psychologist Daniel Wegner [2003]:

"When a thought appears in consciousness just before an action (priority), is consistent with the action (consistency) and is not accompanied by conspicuous alternative causes of the action (exclusivity), we experience conscious will and ascribe authorship to ourselves for the action." Wegner here summarizes the "mental apparent causation" theory in Social Psychology. This relationship between the thought and action of signifies self-agency with an implication of a body, because thoughts and actions occur within the body of an agent. In the case of acousmatic music, the disembodiment of sonic actions breaks the connection between the body and the action of an agent, which makes it difficult to correlate sonic actions to non-observable bodies of agents within a composition. Although the correlation between the body and the sonic action is missing, the sonority and sound similarity still function to perceptually group sonic gestures and appear as if they are actions of an unknown agent.

Thus, the agency of the listener decides the level of perceived similarity in the grouping of multiple gestures into actions of a single agent.

Incorporating the agent literature to the analysis of acousmatic music, we can analyze fixed-media artworks as if they are occurring in real-time. This approach is similar to the way we experience animations in Computer-Generated Imagery (CGI), which like music compositions, are also often temporal works of pre-rendered fixed-media. When the audience views a sequence of actions in CGI animation, a character may appear to have a sense of agency, like a character in a movie. The observer views the character's actions in real-time, and perceives the occurrence as if the decision-making is also happening in real-time, even though the artist has prepared the actions in advance. While the preparation and fixed-media aspects of CGI animations and acousmatic music are similar, the perception of causality in acousmatic music differs from CGI in terms of the embodied representation of actions. We visually observe the body of a character in animations, and perceive a sense of causality between action and effect, and may infer a sense of agency and temperament based on the character's interactions with its environment. In acousmatic music, the visual embodiment aspects of the sonic actions are missing, and so in most cases the causality of a sonic event is not directly observable, which in turn obscures the agent behind the actions.

Situation

Agents exist in the environment where they carry out actions. Thus, the properties of sonic environments of acousmatic musical agents can be examined in relation with the technology and acoustical spaces they exist within. In some cases, the acousmatic composer creates a real-world sonic environment and spatializes sounds in real-world locations using a multi-channel speaker setup. For example, in the twelfth concert at the ICMC 2019, Natasha Barret's "Dusk Gait" spatialized sonic gestures in the real-world sonic environment using a ring of 16 speakers. In other cases, composers utilize psychoacoustics to create a virtual sonic environment. For example, using virtual reverberation and binaural spatialization techniques, composers can imitate a virtual room that is different from the room of the listener. The balance of the absence and presence of sound

constitutes to a perception of a virtual space, which covered in depth by Barry Truax in the book of Acoustic Ecology [2001].

Agents with agents: towards an analytical framework

Using our typology of agent behaviors such as reactivity, proactivity, interactivity, adaptability, coordination, and communication drawn from the literature on multi-agent theory [Weiss 2013, Wooldridge 2009, Tatar & Pasquier 2018], an analytical framework could be developed to provide insights on behavioral qualities of sonic actions within acousmatic compositions.

For example, looking at the agency of the listener in grouping sonic gestures to form a perceptual connection between a non-observable agent body and its sonic actions, we can recall that the process of grouping sound gestures is related to the principle of sound similarity. It should then be possible to apply computational approaches to identify perceptual agents through studying the similarity between sonic materials.

Our previous work on preset generation using OP-1 synthesizer by Teenage Engineering [Tatar, Macret & Pasquier 2016], is an example of one approach to the analysis of sound similarity. In this work, we developed a Multi-objective Genetic Algorithm to find an OP-1 preset that matches a given target sound, by calculating the sound similarity based on the Euclidian distance of envelope, spectrum, and spectral envelope from the target sound. This three-dimensional approach allowed us to work with a non-deterministic synthesizer such as the OP-1. A similar approach could be used to algorithmically cluster sound gestures in an acousmatic composition, and computationally identify the potential perceptual connections between sonic actions and non-observable agent bodies.

The correlation of sound gestures and sonic agents could then form the basis of new kinds of analytical frameworks, agent behaviors as outlined above, could be automatically identified and used to understand the complex relationships between sound gestures and action-perception linkage in temporal multi-agent interactions.

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