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MUSIC-MAS: Modeling a harmonic composition system with virtual organizations to assist novice composers

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ABSTRACT

Many music students today experience difficulties in composing melodies without a prior harmonical guide. While harmony can be helpful in creating a melody the generation of harmony is challenging due to the many factors that must be taken into account, such as style, harmonic functions, musical consonance or aesthetics. Although various solutions have been proposed in the past, our study employs a different expert solution based on virtual organizations to make musical harmonies, which can assist novice improvisers and/or composers. The virtual organizations are implemented with Multi-Agent System (MAS) using PANGEA (Platform for Automatic coNstruction of orGanizations of intElligent Agents), a platform to develop different multiagent systems. The main goal is to simulate an expert multiagent system that can compose harmony following specific rules. To do so, the Harmony Search Algorithm is implemented as the main behavior of the composer agent, and adapted to a Belief-Desire-Intention architecture. The application of a VO has not been previously used in the development of this kind of expert system in music. We measured the quality of the music obtained, by minimizing a mathematical function. Additionally, we developed an evaluation test that positively validates the musical results from the perspective of consonance and usefulness of the composers.

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1. Introduction

Interest in computational creativity is on the rise in the scientific community. Although this interest is recent, there are many algorithms, schemas and procedures to develop such an intelligent machine, capable of creating new ideas or new artistic compositions.

In the musical field, there are also many music students, and even musicians, who experience difficulties in composing melodies with their own instrument, and the may find it difficult to practice by themselves. For this reason, the system presented in this paper is designed to assist music students in improving their abilities without any external help.

The main contribution of this paper is to demonstrate how a new approach based on an agent framework can build a proper music generation system to assist novice composers. This will be accomplished by building an expert approach of harmonization useful for novice students of composition. A multiagent system based on virtual organizations is proposed in order to make a scalable and flexible expert system. This permits making changes in the problem specification, such as changing music style or adding new rules, without changing the structural composition. Only the agent behavior is modified, which is why the Belief-Desire-Intention (BDI) agent architecture was specifically chosen. It is also presented here a brief review of reviews several algorithms and methods used in harmony composition to highlight the contributions made by this system.

According with Delgado, Fajardo, and Molina-Solana (2009), due to the difficulty to evaluate music generation, a listening test may be needed to validate our results. At the same time, López-Ortega and López-Popa (2012) consider the evaluation must be a mathematical evaluation. Thus, we will evaluate the results by considering two types of criteria. To begin, we will consider mathematical criteria, which involve an optimization function. This function encloses constraint rules that are evaluated in the chord proposed as a candidate for our composition. A small value of this function for one chord studied means a good chord to incorporate to our composition. In fact, a threshold is established, so that if the chord exceeds this value when it is measured with the optimization function, it is dismissed, and the process starts again with a

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new chord that replaces the rejected chord. These rules will be detailed in Section 3.

Additionally, the concept of consonance is studied as a musical concept necessary to evaluate the system. This evaluation is made by musical experts as well as non-expert listeners.

A memory to store the different chords obtained is designed, imitating the memory used when a musician is composing. This Harmony Memory (HM) has a limited size due to the constraints of human memory and memory space. The new harmony will be included in the HM if it is better than the worst chord stored.

It will also be interesting to determine whether this system helps composers make their melodies or to improvise a melody by simply listening to the harmonies. As the user determines the number of bars or chords, the algorithm will create a fixed number of chords; however, the algorithm will be active in a loop until the stopping criterion (maximum number of improvisations) is reached, and will choose the best harmony among the possibilities.

The paper is structured as follows. Section 2 contains a brief review about the concept and definition of creativity, algorithms in music composition and artifacts made with these algorithms. The use of multiagent systems in computational creativity is also discussed and several examples are proposed. We will also introduce basic concepts of a Multi-Agent System (MAS) with a BDI architecture, and based on virtual organizations.

Section 3 presents our model with our particular solution, which attempts to solve the problem of harmony composition with an unknown melody, and demonstrate how Virtual Organizations (VO) can help to improve this system. Section 4 shows some results of the system, and proposes new lines of improvement.

2. Domain of knowledge

Two disciplines interact in this paper: artificial agents and music. We will begin by presenting a general and brief review about creative development, ideas and artifacts made. The first subsection introduces a brief background about computational creativity. The second subsection presents general information about composition algorithms, in which Harmony Search (HS) is discussed in greater detail, as it is the algorithm that was selected to solve the problem. The third subsection explains concepts about MAS and VO, whereas the last section includes a brief explanation about the background of agents, emphasizing the relationship between MAS and Creativity.

2.1. Computational creativity

Creativity is considered to be an essential component of human intelligence. Consequently, in attempting to answer the question of whether computers can think, it is only natural to ask whether computers can think creatively.

Some Artificial Intelligence researchers have tried to simulate creativity with computers. Among the most impressive programs developed are AARON (Cohen, 1995), a painting program that produces both abstract and lifelike works using a small robotic turtle, combined with several drawing strategies, or the Ebcioglus CHORAL system (Ebcioglu, 1988), which was able to produce chorale harmonizations rather similar to those of J.S. Bach. After these experiments, and partially due to the lack of conceptual and theoretical consensus, there have been scientists interested in exposing new theories about creativity and concepts related to it. One of the most important is Boden, who proposed a framework and a creativity view (Boden, 1987) which continues to have philosophical impact in computational creativity (Colton, Wiggins et al., 2012).

Boden defines creativity as an ability to conceive new, surprising and valuable ideas and artifacts. These three elements must exist in all creative phenomena. Another remarkable theorist, Csikszentmihalyi (1997), defends the argument that creativity consists of three main parts: the domain (a set of symbolic rules and procedures); the field, which includes all the individuals acting in the domain; and the individual.

Creativity concepts in AI, such as imagination, surprise, novelty or emergence, make it possible to conceive psychology in a new way, in order to build and test hypotheses about structures and processes involved in the mind. Some of these concepts have been considered controversial due to their abstract nature. In particular, emergence is a concept that has multiple definitions depending on the field studied, the theory in which it appears, or the author (Deguet, Demazeau, & Magnin, 2006). Despite this, emergence is a concept used to value complex systems; in our particular case, creative systems are considered as complex systems (Deguet et al., 2006).

With regards to the mental process that machines can simulate to be creative, Boden is interested in running tests to determine whether computers can conceive ideas that are considered or appear to be creative. In “AI and natural man”, Boden (1987) considers AI to be the science of thinking and action, which suggests that computers are tools that provide themselves with a “human-like” intelligence. Along these lines, Lösch, Dugdale, and Demazeau (2009) identify aspects about creativity in individuals, as motivation, externalization, inspiration, etc., to define requirements and functionalities of a model capable of enhancing the creative abilities of the user in design tasks.

2.2. Musical composition algorithms

Music is considered to be an interesting research area in a variety of research fields because it deals with a human activity that is both intellectual and emotional. It is a universal language quite different from spoken language.

For example, telecommunications researchers are interested in music software because since music is considered a form of information and they need to know general characteristics of information and how it can be manipulated for its broader dissemination. Philosophers are interested in music software because the ability to specify musical compositions (i.e. “to compose”) at a higher level than note-by-note would bring them one step closer to reaching a direct expression of musical ideas.

Software engineers also find formidable challenges in areas such as music composition; the simulation of this complex activity requires expertise in algorithm design, expert systems, optimization, and other related software engineering disciplines. Designing an algorithm to compose music has no simple, mechanical test for success.

Initially, grammar-based systems were widely used in composition tasks. By thinking that music follows grammatical rules, many computer composers modeled music relationships as grammatical structures, representing musical structures (Roads & Wieneke, 1979). In fact, Holtzman (1981) creates a musical grammar that generates harp solos based on the physical limitations imposed on harp performers. Cope (1987) derives grammar from the linguistic principles of haiku to generate music in a particular style. Although grammar can produce a natural sound, the tasks corresponding to deciding the aspects of a musical structure that should be represented are often difficult and ad-hoc (Marsden, 2000). Nowadays, there are many other algorithms that attempt to compose music, some of which are called live algorithms (Bown, 2011).

One of the most successful algorithms is the Markov Models (Eigenfeldt & Pasquier, 2013). There are also algorithms that use lyrics as a variable in their compositions, as for example Monteith, Martinez, and Ventura (2012) or genetic algorithms (Pereira, Machado, & Cardoso, 1998). In this sense, one interesting

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