Artificial Computational Creativity based on Collaborative Intelligence in Music

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Abstract. In this paper, I will propose a series of Artificial Computer Creativity (ACC) techniques based on Collaborative Intelligence from a multidisciplinary approach. The common thread here are some reflections on the Turing Test (TT) that will inspire alternative metrics of validation. I will propose Collaborative Intelligence (CI) techniques as an expansion of anthropocentric ACC by: replacing the idea of imitation in its basis with playing a game, using self-referentiality and circularity between the generative and the validation processes; having hybrid man-machine networks; incorporating algorithms that function as mediators of the nodes in hybrid networks avoiding centralities and by integrating self-referential metrics in the works themselves. Finally, I will show how these techniques have been used in a set of works.

Keywords: Artificial Computational Creativity, Non-anthropomorphic AI, Collaborative Intelligence.

1 Introduction

Since Turing proposed a metric of Artificial Intelligence (AI) by evaluating the Intelligence of a machine through its ability to imitate human intelligence (Turing Test (TT)) (Turing, 1950), AI techniques have been developed (not all) whose result is measured by a human metric (by comparison in its similarity to what is human). The modelling of human intelligence is one of the great challenges of Computer Science so there is no harm in trying to imitate the human mind computationally. How to formalise the human mind and use this model to solve a great variety of problems difficult to treat by other methods, led to a series of anthropomorphic methods with which problems are solved by modelling the human brain (neural networks) or human learning (Machine Learning).

We can consider that an AI system is anthropomorphic when it imitates a human characteristic and the result is validated by a subjective human metric, such as the TT[1]. Millar (1973) described the TT as anthropocentrism.

It is useful for some AI techniques to be evaluated according to anthropomorphic metrics. For example, if we want a system that predicts emotions on human faces in a similar way as how a human infers emotions, we will need a human evaluation metric. We can consider that such a computational system will evaluate the success of its operation by its successes in comparison with human response.

[1] The fact that intelligence is qualified as anthropocentric is neither good nor bad, but only descriptive. It is about experimenting with the creative possibilities that non-anthropocentrality brings. In fact, in most fields of application of AI, this distinction is irrelevant, including many associated with creativity.

Is it possible for Computational Creativity to be evaluated according to non-anthropocentric metrics?. My answer is yes. If we consider that human creativity is a manifestation of a type of Intelligence, we can affirm that other forms of intelligence like animals (still biocentric) or those resulting from the interactive aggregation of humans or robots (Collaborative Intelligence), or others different to human intelligence that may have particular forms of creativity other than human associated.

Certain authors such as Karelis (1986) and Shannon (1989), criticise the fact that the TT does not show that intelligence has a largely social component. From an evolutionary perspective, Barresi (1987) proposes a *Cyberiad Test* instead of the TT which defines intelligent behaviour as what is necessary for survival in society. Although there is no anthropocentrism in most problems in which AI intervenes and they are neutral according to a human evaluation, it regains its relevance in the field of AC, since in Anthropomorphic Artificial Intelligence (AAI) human metrics are required for its evaluation. The result cannot be verified but against a subjective human metric.

Anthropocentric systems start from an a priori consensus of a community of creators regarding a model to be imitated that will be imitated and that defines the judgment metric. There is a circularity between the selection of an imitated model and the metric that validates it.

We will use the idea of circularity to create forms of AC that will replace the circularity between the model to be imitated and its validation by self-referential circular systems that do not stem from an a priori nor do they validate the result by the adequacy to that apriorism.

Furthermore, some currents of Cognitive Science such as Embodied Cognition or Enactive Neuroscience claim that the process of cognition associated with intelligence is complex and requires the intervention of many factors. Embodied Cognition studies take into account the cognitive process as something that occurs in a medium (which is a body) that influences that process. For example, Tom Froese (Froese, 2009) defines the cognitive process as mind-body continuity. We can find similar approaches in (Gaggioli et al., 2016), (Shapiro, 2011) or (Francisco et al., 1992).

In the context of this paper, I follow the definition of Computer Creativity given by Boden, (2010).

> Creativity can be defined as the ability to generate novel, and valuable, ideas. Valuable, here, has many meanings: interesting, useful, beautiful, simple, richly complex, and so on. Ideas covers many meanings too: not only ideas as such (…), As for novel, that has two importantly different meanings: psychological and historical. A psychological novelty, or P-creative idea, is one that's new to the person who generated it. It doesn't matter how many times, if any, other people have had that idea before. A historical novelty, or H-creative idea, is one that is P-creative and has never occurred in history before. (Boden, 2010, p. 24)

2 Artificial Non-anthropomorphic Creativity

The forms of AC[2] whose result cannot be measured using a specific pre-existing anthropocentric metric, and that do not part from an a priori consensus are non-anthropomorphic. These forms do not consider that the Computer Creativity is

[2] Same concepts used in this paper such as Creativity, Intelligence, Artificial Creativity and Computer Creativity are in a process of evolution and change. The implicit definition given is considered only under the perspective of the author. There are other different meanings.

necessarily, the imitation of an a priori model or that the validation metric is human. Velardo defines non-anthropocentric intelligence as: "Non-anthropocentric creativity transcends anthropocentric creativity in that the evaluation process of artefacts is carried out by non-human systems such as animals and machines, which employ non-human-based evaluation criteria. A nonanthropocentrically creative artefact cannot be judged as creative by human evaluators". (Velardo, 2017, p. 96)

Reflections on the TT (Pinar et al., 2000) pose the possibility of idealising forms of AC that include a social aspect of Intelligence and incorporate different objective validation metrics, producing a result that is enjoyable or makes sense for a third party who has not participated in the creative process, or that imply a new concept of aesthetic enjoyment as a result of integrated participation in that process.

There is a *petitio principii* in the anthropocentric computer creation in which the model considered to be imitated acts simultaneously as premise and conclusion. That creates a circularity between what is considered to be imitated and the model to verify the success of such imitation. When the Computational Creative process is good, the result is similar to the model imitated. But in this way, we are in a P-creativity as defined by Boden. H-creative ideas are easiest to achieve if we use non-anthropocentric techniques. What I am trying to suggest is that there is an inverse relation between the proximity of the model to be imitated and the model of evaluation and the proximity with H-creativity. The less anthropomorphic resemblance, the closer to H-creativity we are. Integrating non anthropocentric validations inside the work itself makes easy being closer to H-creativity.

From my point of view, in a Computer Creative process, the creative model is as important as the validation model. We can find in recent literature a growing interest in the objective models of validating the computer creative models. for example, Velardo (2017) uses the evaluation framework SPEC (Jordanous, 2013) to evaluate the creativity of his S(S(S)) system and the amount of stylistic change occurring in the agents of the system. In Pearce & Wiggins (2007) we can find an interesting stochastic approach to this topic.

Human intelligence is not the only form of intelligence that exists. Certain species such as dolphins or whales have been attributed with even higher intelligence than humans (Weiskrantz, 1985). There are also multiple descriptions of forms of Collaborative Intelligence in the biological environment (Miller, 2007).

Climate change (Wuebbles et al., 2017) and environmental disasters that the human species has created and that threaten its survival make us wonder if human intelligence in its embodiment as a species is truly Intelligent. This criticism facilitates the imagination of different forms of intelligence, not necessarily biocentric. Stanislav Len's (Case, 2009) literary work is a clear example of imaginary creation of non-anthropocentric and non-biocentric forms of intelligence.

2.1 Game and Circularity

I propose the concept of cooperative game[3] as a substitute for anthropomorphic imitation, since it includes the social dimension of Intelligence as a social body, and focuses on solving the objective of the game that requires a certain type of optimal intelligence to solve it. We create a game and launch an algorithmic creative procedure to solve it, which results in the work. Moreover, the problem is solved by collaborating

[3] This implicit definition of game does not exhaust all the elements that can be part of a game. Imitation itself is an important element of a lot of games as well as invention.

agents who use objective metrics to evaluate whether their contribution is adequate, replacing subjective anthropocentric metrics.

The characteristic of a non-anthropocentric AC is to overcome these limitations by creating systems that can create new aesthetic paradigms, or concepts, or works outside the model considered a priori. Including the possibility to change the model itself and not only imitate it. Non-anthropocentric ACs allow the reintroduction of historicity and change as intrinsic to H-creativity. There are a multitude of different ways to create non-anthropocentric AC forms. Only a few are listed in this paper. One way of introducing historicity and intentionality (Dennett, 1996), for example, is to create networks of social agents who collaborate by playing to create a work in which the agents objectively validate their intervention and are able to modify their own beliefs through the evaluation of achieving their own goal. In *Transcognition* (2018)[4], The metrics of validation are integrated in the work itself, creating a feedback between the generative algorithm and the validation process. The generative algorithm changes according to the validation process.

3 Collaborative Intelligence

Even now, the concept of intelligence if highly controversial. There is no closed definition (Ritchie, 2015). The concept of Collaborative Intelligence (CI) has gained relevance in recent years to the point that MIT itself has developed a large-scale programme dedicated to it (Malone et al., 2015). The emergence of the Internet is linked to the concept of CI. There is also no closed definition of CI. Many of the definitions are anthropomorphic, for example: "A group of human beings [carrying] out a task as if the group, itself, were a coherent, intelligent organism working with one mind, rather than a collection of independent agents" (Smith, 1994, p. 1). We can also find non-anthropomorphic definitions: "A form of *universally distributed intelligence*, constantly enhanced, coordinated in real time, and resulting in the effective mobilization of skills." (Levy, 1994, p. 29).

Basically, the idea of CI is the resolution of a problem by a system made up of a series of elements that collaborate in this task. The advantage of this approach is that complex problems can be solved from unintelligent units that cannot solve them individually.

There is a long tradition of collaborative creations in non-computational creation such as surrealist collective poetry developed using the exquisite corpse method. We can find examples of collective musical compositions in musical literature. As this is the Beethoven year, I cannot think of another work as an example other than *About Beethoven* (1989). Work created collectively by (Rzewski, del Cerro, Barwin, Gibson, Henriquez, Trawick, Cohen, Sharman, Thomas, Johnson). Each week a composer completed a page on a Beethoven symphony, based on an early Rzewski manuscript.

3.1 Computational Modelling of Cooperative Games with Cognitive Agents.

We can find an example of CI work in the work Transcognition (2018)[5] for 32 Multi-mode Cognitive Agents. The aesthetic objective of the work is to create a

[4] Https://busevin.art/transcognition

[5] This work is explained in detail in (Egido, 2018)

disruptive narrative that, when viewed closely, does not have any logic or any type of recognisable musical material. But when seen in perspective, it reveals a process with implacable logic. Instead of creating a musical work based on a model form. An Interaction process is developed between the agents that creates a procedural narrative. The narrative of the process is intelligible through the former way in which the collaborative interaction of the agents takes place.

The work is conceived as a collaborative game between the agents. Each cognitive agent is modelled as a virtual musician. The game consists of each agent simulating a musician who improvises to create a collective work. The collaborative goal of the game is to make the resulting music as interesting as possible. At the beginning of the game the agents are in competitive mode. In this mode they believe that the way to make the best music is to find the most significant note to allow them to stand out from the rest. The agents use an informational metric Based on (Shannon,1948) to analyse the database where the other agents' music is recorded. Before singing competitively, the agent listens to everything the others have done, calculates what the most significant note will be (using an objective non-human metric) and sings it.

The paradox is that if all the agents follow the same competitive logic, none stands out from the others. When the agents realise that by singing competitively the material doesn't move nor do they attract attention, they decide to switch to collaborative mode to prevent the music from becoming monotonous. In this mode they try to imitate what the others have sung, attempting to repeat the notes that have appeared the most. The fact that the agents change their strategy during the work produces a musical process in which the material gradually evolves, enabling us to understand this process despite the fact that on a microscopic scale each agent interrupts the others' singing.

The result of the work is a procedural narrative, not modelled on the agents, which can only be understood as a collective process in which none of the agents plays a central role.

There is a process of aesthetic change underway related to a social process of change based on an objective metric instead of an anthropocentric one.

We arrive at two key points in non-anthropocentric Intelligence processes. The elimination of any type of centrality and the fact that the works function as a process that is not defined by the intrinsic properties of their materials or their initial models, but by the interaction of the network nodes. Musical tension derives from cognitive tasks and not from material properties.

Self-referential circularity is expressed through a database-score in which the notes composed by said agents are written, and which is also used as a source of information about reality. The fact that the metrics are not human allows the function of the score in the composition to be changed, thus ceasing to be the final product and become the means for the agents to communicate and obtain information from a simulated reality to decide whether to continue in cooperative or collaborative mode. The score becomes the medium where the expanded perception of Collaborative Intelligence occurs.

Historicity is added with a self-referential circularity controlled by a metric. The agents improvise through the calculation of a metric that they write in a score-database that is used circularly by the others to calculate their note. The change that occurs when moving to collaborative unveils the process of the work as a story caused by a change in the beliefs of the agents that gives orientation to that story. The agents themselves change their beliefs as they perform the work to create a result outside the model.

4 Hybrid Human-machine Networks of Non-homogeneous Nodes.

We have seen how to build a process not dependent on the development of materials through a network of 32 cognitive agents that communicate through a database. In this case, all the nodes that interact in the network are homogeneous, but this does not necessarily have to be the case. The existence of processes created with networks whose nodes are not homogeneous adds great unpredictability to the AC process.

In the work *Horror Vacui* for two sopranos and electronics in real time. A collaborative hybrid node network made up of singers and bots is used. The movement of the sopranos on stage is picked up by various sensors and sent to a computer in which two other bots use a parametric algorithm to generate the notes to be sung by the sopranos and those to be produced by a synthesis system of electronic sounds in real time. The parametric algorithm guarantees that none of the 4 elements that collaborate is central. A self-referential circularity is created between the movement of the sopranos and how this movement is returned to them in the form of notes. Sopranos react to notes with their movement, and the algorithm reacts to movement by creating the notes. This self-referential circularity replaces the circularity of anthropomorphic AIs between judgment and aesthetic community apriorism.

4.1 Algorithms that Mediate between Nodes Avoiding Centralities.

The parametric algorithm used (Egido, 2011) collects the data from the motion sensor of the sopranos as its input and returns the notes to be sung to them, creating a circularity through which the sopranos react to the notes with their movement and the computer reacts to the movement by giving the notes. Each of the two bots works as a pattern whose repetition time depends on the sensor of the sopranos. Each of these two movement patterns uses the phase with respect to the other cyclical movement of the other pattern to generate the notes to sing, so that neither can be considered central. This creates a feedback system such as the reflexivity of singing the movement itself that replaces the imitation of circularity. Circularity and reflexivity fulfil their self-referential role.

The self-referentiality among the sopranos who sing their own movement makes the work self-referential without the need for anything external to merge with it, the bots react to the movement of the sopranos who try to find the best way to move according to the notes that bots send them using WIFI.

4.2 Public Participation in Collaborative Hybrid Networks.

Participation of the public in the works enables compositional strategies to be elaborated in which a non-musical human agent contributes a special type of interaction. Participation in a musical work conceived as a network of hybrid nodes integrates the audience as a type of node with its special characteristics. Interaction between human nodes without musical training, but with the capacity to listen and react to computational nodes, allow the total dissolution of the roles on the stage.

In the work *Public Music* (2017)[6] a set of *n* participants and *n* bots interact through a hybrid node network made up of bots and participants. Participants interact with the

[6] This work is available at https://busevin.art/public-music/

system through a mobile application in which they select the repetition time of the associated bot pattern. The bots process this information through a parametric algorithm that prevents some node or parameter of the music from becoming central. The bots send the performance data to the participant through a WIFI network, which he can connect to himself or use a mobile device.

In the same way that in *Transcognition* we saw that the function of the score was transformed by the concept of the work, in this work we can see how all the roles involved in a staging of a conventional work are fully integrated. The audience becomes a composer by participating as a collaborative node. The symbiotic incarnation of computational and human nodes enables unusual forms of creativity. The metric of the result depends on the sensations that the experience provides to the participants, and it is not a question of measuring the validity as an imitation of what is known but of valuing the intensity of an aesthetic experience fostered by being the creator of the work himself.

5 Collaborative Metrics.

The fixed metrics of the a priori models can be replaced by changing metrics that allow results outside the model. The work *Collaborametrun* (2018) uses the measurement of the collaboration between two musicians as input to the parametric algorithm. A Machine Learning algorithm recognises collaborative movement patterns of musicians on stage. If they collaborate, it returns a high value, if not a low one. This value is used to set the rate of change of the parametric algorithm. If in *Horror Vacui* the sensors fed the generative score engine. The collaborative metric is responsible for establishing the repetition speed of the patterns. We can then establish a new self-referential circularity. Musicians must learn by ear how to collaborate. Being reactive to the music, while bots will be reactive to the collaboration. The collaborative metric acts as the validating strategy of the generative algorithms of the bots.

6. Conclusions

We can expand the AC Techniques by using and creating different forms of Intelligence. The non-anthropomorphic AC forms provide creative opportunities and are a source of inspiration for new works. Allowing integrative experiences and new aesthetic categories.

Integrating the validation system of the generative process in a circular way into the work itself permits the initial generative model to change according to the feedback provided by the verification process.

The imitation of Collaborative Intelligences allows the generation of new compositional and aesthetic strategies, and allows the creation of works whose results are gestated outside the initial model. To imaging forms of Intelligence other than human or transformed by human will open doors to new models of Artificial Creativity associated with these forms of Intelligence and will allow us to better understand what human creativity is. In Non-anthropocentric ACs, the creation of new forms of intelligence is an aesthetic fact in itself.

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