A Methodology and Paradigm to Build Social Creative Systems

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Abstract. The development of creative systems has traditionally been carried out independently and there is a number of pending questions which remain to be solved at present. The goal of this paper focuses on the creation of "social creative beings". A methodology for developing creative artificial beings is proposed for this purpose, facilitating the collaboration and comparison among various systems developed by several research teams, including experts from various branches, and using different computational paradigms. Besides, a generalisation of Turing's Test called "Hybrid Society" is developed. This allows the validation of computational models for social and creative tasks using a virtual egalitarian society composed of humans and computer systems. Finally, the application of both contributions to the world of music is presented.

1 INTRODUCTION

Creativity constitutes one of the key elements in Artificial Intelligence, something which is patent since the first works appeared in this field. Thus, Alan Turing describes among the characteristics of an "intelligent being": "(…) have as much diversity of behaviour as man, do something new" (sic) in the famous paper where the basic test for an intelligent system appears, Turing's Test [TURI-50]. In this regard, Juan Pazos comments as one of the features which characterise human intelligence "to be able to derive knowledge from information, to consider the relations among the world's phenomena, to create and appreciate aesthetic forms" [PAZO-95].

The possibility of creating machines which perform creative processes beyond human understanding is both interesting and disturbing, and it entails a necessary step towards a real AI, providing solutions to problems of a creative nature.

Creativity is one of the few terms which has as many and diverse definitions as "intelligence". Among those definitions, we could quote the "capacity to create something new" or the "capacity to solve a new problem". Peter Bentley links creativity to the following words: "aesthetic, lovely, poetic, beautiful, skilled, proficient, inventive, elegant" (sic) [BENT-99]. Nadal Batle defines creative process in one of his articles "when two or more knowledge items are united for the first time in order to produce a new idea, hypothesis or solution to a problem" [BATL-89].

A series of terms related to creativity will be used throughout this work. It is important to define these terms properly. Thus, the term "creative product" will be used in order to characterise an idea, concept or solution which shows creativity.

A creative product must be a valid element within a culture, and it must be "built" with elements from that culture. So that a work of art or a scientific theory may be defined as creative, it must be understood in relation to the thing which existed previously within a given culture. Therefore, a creative product must be new but it must have been built with the elements from the culture where it is created. That is why the Nobel Prize Albert Szent-Gyorgy defined the creative act the following way: "it consists of seeing what everybody has seen and thinking what nobody has thought." [SZEN-64]

Apart from all this, a creative product must be new and original: "the more unlikely and unexpected the new combination is, the more original or creative". [BATL-89]

Once a series of features of a creative product have been defined, we should analyse which capabilities are expected from a creative being. In principle, it may be argued that in order to be creative it is necessary to create or to make a creative product. In this regard, a random solution generator could be creative, given that some of the multiple solutions provided by it might be creative. However, as may be understood from H Poincaré's previous quote, the creative being recognises the good and aesthetic solutions, that is, the creative ones. Therefore, if this being is creative, it must be able to identify these products as creative (interesting, new…).

Finally, we should say that, despite the fact that every human action can be performed creatively, there is a series of fields of a creative nature, such as art and scientific research. These fields cannot be isolated from their environmental, cultural and social context. Some kind of link or interface with the environment, culture and society is required. Besides, these fields are particularly interesting and representative when tackling "computational creativity".

2 COMPUTATIONAL CREATIVITY

Computational creativity systems [MECH-76] [HAMM-84] [SHAN-87], specially artistic creation systems, [TODD-98] [ROME-00] [BENT-99] [SODD-00] [TODD-92] [BURT- 97] [PAZO-99] show a moment of maturity which is reflected on the diversity, quantity and quality of the existing works. However, there is a series of lacks which hinder the construction of global systems capable of constituting computational models in complex social tasks performed by human beings. Some of these lacks are general, existing or having existed in other fields, while others are specific.

Among the general lacks we could quote the lack of definition within each of the creative fields, of a meeting point from which to start tackling the construction of creative beings, together with a common and reasonable path which could be followed by all researchers. All leads to the clear need for a methodology which facilitates the establishment and organisation of co-operation among researchers. One of the main problems in this field is the lack of collaboration and the isolation of the existing works.

Another need linked to the previous one is the implementation of devices which allow the comparison and collaboration among different computer systems performing creative tasks with the purpose of facilitating its perfection and the comparison among various techniques and approaches.

With regard to the specific questions about creative problems, the first one is the lack of a clear quality criterion such as those which exist in many other fields. Thus, in many instances, the quality of a computational system may be rated by means of a mathematical function or a qualitative criterion. In the case of many creative systems, the quality of the product is dictated by society or by part of society, being dynamic to the extent that a given product may be rated differently by several individuals in a given culture or by the same individual at different moments. Think about how difficult it is to assess a work of art or the existing method for evaluating scientific research, based on the opinion of other scientists.

The other specific question is the definition of the role of the various types of experts with regard to the definition and development of creative beings, given the multidisciplinary character of creative tasks.

This paper intends to provide an answer to these questions by means of facilitating the development of social artificial beings which develop and assess creative products in complex human tasks.

Two complementary techniques are proposed for this purpose. On the one hand, a methodology which allows the organisation of the step-by-step common development of creative beings by experts from different areas and different research teams is proposed.

On the other hand, we propose a paradigm which allows the comparison and collaboration of various artificial beings developed by these experts independently from the computational platform, language or technique used for their implementation. Besides, this paradigm integrates a quality criterion and an adequate learning procedure for social and creative tasks by means of the incorporation of human elements in a social environment.

The next section analyses the evolutionary modelling methodology. Then the developed paradigm ,called "Hybrid Society" will be explained. Finally, the application of these elements to musical composition and the achieved results will be explained.

3 METHODOLOGY

The first problem with computational creativity systems is the lack of a methodology. As Asunción Gómez explains, "among the lacks suffered by any new methodology, maybe the most notorious one is the existence of a commonly accepted methodology". [GOME-97]

This methodology should provide answers to the following questions:

- Determination of a starting point and a reasonable common path to develop creative systems.
- Non-limitation of the tools or techniques to be used. As an old Spanish saying goes, "when the only tool you have is a hammer, all the problems start looking like a nail".
- Facilitation of collaboration among researchers, taking into account the role of the various experts who may take part in the definition and development of creative beings.

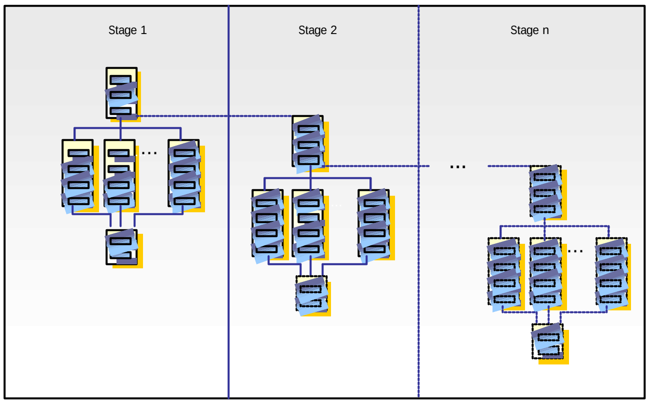

Figure 1: General organisation of the methodology in stages and phases.

Given the lack of specific methodologies for developing creative beings, [ROME-01] analyses the adaptation of several methodologies existing in the computational field, artificial intelligence and simulation, observing that this adaptation posed numerous problems.

The Software Engineering Methodologies [BOEH-81] [PRES-01] and the Knowledge Engineering ones [GOME-97] which were analysed possess a technological approach, therefore both their goals and the techniques used are not adequate enough for creative tasks.

With regard to simulation methodologies [ZEIG-76], although they have some interesting points, they suffer from a series of lacks when applied to creative problems, given that they do not allow the creation of increasingly difficult models and they are not designed for comparing multiple alternative solutions: "these conventional techniques break down, however, when a representation model is difficult to obtain due to uncertain or sheer complexity or when the model thus produced violates the underlying assumptions of the control law techniques" (sic) [GUPT-94].

For this reason, this work proposes a new methodology called "Evolutionary Modelling Methodology". The proposed methodology, as shown in Figure 1, has a two-dimensional structure composed of stages and phases, while the latter can be divided into blocks.

The stages are the most general dimension, reflecting a moment in the performance of the capability in question, from the human point of view.

A series of phases are defined within each stage, which can be in turn grouped into three main blocks, which are the following:

- Conceptualisation: the stage characteristics are defined, creating a common computational environment.
- Design and creation of models: the computational beings performing the actions defined in the previous block are developed.
- Validation: the developed beings are integrated into the common environment together with human beings in order to be validated.

Both the first and third blocks are carried out in common, while the design and creation of creative beings one is carried out independently by each group involved.

3.1 Stages

The methodology proposes a time analysis of the task to be performed defining a set of stages through which the capability has gone at a given time in the history of humankind, a specific culture or an individual. Two main criteria are suggested from this point of view:

- The historical or philogenical criterion, which considers the story of humankind or of a human society with regard to the performance of a task.

- The individual or ontogenetic criterion, which considers the story of each human being from the point of view of learning.

The different approaches of both criteria may be seen by means of the example of natural language. From the philogenical point of view, this approach would take into account the origins of language in humankind. The ontogenetic point of view would analyse the devices which allow any human being to acquire the abilities related to language from his/her conception to adulthood.

3.2 Blocks and phases

Within each stage, the "Conceptualisation", "design and creation of models" and "Validation" blocks take place.

Within the "Conceptualisation" block, everything which is necessary is given to the various groups for the later elaboration of creative beings, including:

- The definition, analysis and characterisation of the stage.

- The implementation of all the necessary common elements.

This block contains the following phases:
First of all, at the stage delimitation phase the historical human growth moment is defined. Next, at the characterisation phase several questions related to the stage are thoroughly defined, such as creative products (including their possible representations), and the various roles which may be played. Experts in the field take part in these two phases, together with experts in the history of learning. Finally, the last phase develops a common computational environment which will allow the creation of independent creative beings. In order to facilitate this task, a paradigm supporting the computational framework called Hybrid Society has been developed. This paradigm will be analysed later on. It avoids the need to analyse, design and implement a specific computational environment for each problem.

Once all the necessary common aspects have been defined, each research team in the second block develops creative beings which correspond to the characteristics of each stage and which can be integrated in the previously defined computational framework.

The various phases carried out in this block are the development of hypotheses for building individuals (where the technique or set of techniques to be used for the construction of creative beings are selected), and their design, implementation and preliminary validation.

Finally, the various beings developed in the previous block are checked in the third one. For this purpose, these beings are incorporated together with human individuals to the common computational environment, analysing the results of this incorporation with the purpose of obtaining better computational models. Starting from the results achieved, the creation of new computational beings may be tackled, going through the phases of the second block once again.

4 HYBRID SOCIETY

Just as the proposed methodology allows the organisation and collaboration among human experts, it is necessary to have a device (a common framework) which allows the validation and co-ordination of the various computational systems.
A new paradigm called "Hybrid Society" has been defined in order to develop this common framework. [ROME-02]

As explained in the abstract, creative artificial systems pose a series of specific problems, one of them being the difficulty to find an adequate quality criterion. In human societies, this assessment is done by means of the interrelation among members of a given culture. Therefore, one way to tackle the problem would be modelling a human society or culture. This "society model" must maintain a relationship with human beings and their cultures and societies, with the purpose of fostering interaction between the developed artificial beings and the human ones. Undoubtedly, the use of any kind of computational technique or a combination of them is still necessary. Finally, we have to define how different computer systems are going to collaborate, apart from competing.

The Hybrid Society (HS) presents itself as an alternative to solve these questions. It constitutes a development framework where different computational models for tasks requiring creativity and social behaviour may be validated at the same time (regardless of the techniques used).

HS is based on the idea of machines and humans co-existing in a virtual "egalitarian" society. It is opposed to approaches similar to artificial life and to those societies based on co-evolution which constitute purely artificial society models.

In order to illustrate the concept of HS, we may start by the classic Turing's Test, also called Imitation Test. This test decided a machine's intelligence according to its capacity to imitate a human being. Therefore, if a given human being was unable to distinguish between another human's behaviour and that of the machine, the machine was considered as "intelligent", since it was "one of us".

HS can be understood as a generalisation of Turing's Test (TT), composed of a series of steps, the most important of which is the addition of a fourth role adaptable to creative tasks. Thus, there are three roles in the TT adapted to creative tasks: the human critic, the human producer and the artificial producer. An artificial being acting as a critic is also added, given that this is one of the qualities which a being muss possess to be considered as creative. These extensions lead to a model in which sets of artificial and human beings evaluate the answers given by other beings (both artificial and human). It must be taken into account that none of the beings has to play both the role of critic and producer, it may well play just one of them.

4.1 Computational Autonomy and Learning in Hybrid Society

Turing uses a pedagogical figure in order to explain how a computer works. This example, contained in the same article in which the Imitation Test is presented, is called “human computer”. This human computer is an isolated human being who may only read one book with instructions and carry out operations. If we substitute the TT computer by this “human computer”, the result would be that a human being with potential creative capabilities would not e able to perform many creative actions in that state.

The basic difference between this human computer and a human being is the fact of belonging to a culture or society and also autonomy. These conditions prove to be necessary for elaborating creative computational systems.

If autonomy is the capacity to act, two types of autonomy may be distinguished:

- Internal autonomy, which refers to how things are done (which mechanisms are used).
- External autonomy, which defines which things can be done.

Now we will analyse autonomy in humans and artificial systems which perform the task used for experimenting this work, that is, music creation.

From a creative point of view, a human composer is whole (at least, that is the reference to be followed). His/her internal autonomy is whole, only being limited by his/her senses and conceptual apparatus. From the external point of view, he/she is influenced by his/her society or culture, therefore it is not whole. In fact, “too much autonomy” makes a composer inappropriate for a human society, given that his/her works would not be aesthetic for the other members of society.

In this field we may talk about a first generation of computational systems which were at the edges with regard to computational autonomy: either they were based on a deterministic algorithm, thus lacking autonomy, or they were based on random use without human guidance, being totally independent.

With regard to adaptive artificial composers, which use evolutionary and connectionist techniques, a higher degree of internal autonomy is achieved, since the behaviour of these techniques allows adaptation forms. Externally, acceptable levels of autonomy are also achieved, given that these systems interact with humans, adjusting their results to the user’s aesthetics. However, this external autonomy is relative, given that the system is a “slave” to the human user, by means of feedback. Using the simile of the human computer, the composer would develop music works receiving a prize or punishment in return.

There are systems within this context [TODD-98] which build societies of artificial composers and critics by means of devices such as co-evolution. However, these systems are independent from human tastes.

Finally, HS achieves an external autonomy similar to that of the human composer, that is, influenced by a society integrated in this case by artificial and natural individuals, while each artificial individual’s internal autonomy depends on the technique used.

From the point of view of learning, the characterisation of HS should take into account the degree of supervision. Ryszard Michalski [MICH-83] establishes a classification according to the degree of supervision required for learning. These are the categories defined: learning through direct incorporation, learning through instruction, by analogy, by examples and by observation and discovery. The categories which possess more autonomy and adaptation are the last ones, given that they require less supervision, being more autonomous.

HS can be situated at a middle position between the last two categories. On the one hand, it could be classified as a learning system through examples, actually as a paradigm of learning by means of reinforcement, since the messages sent by each individual in the system are reinforced. On the other hand, HS may be seen as a learning system by discovery and observation, given that information about the assessment of each element is not absolute and dependable, but reflects the “opinion” of another element in the system.

4.2 Components

Once the HS has been presented as a model at the conceptual level, this section describes a suggested implementation which collects the previously expressed concepts and analyses its components and the relations among them.

There are two main components: the scenario and the individuals: The scenario is the equivalent to the environment or society, which constitutes a substratum through which the participating individuals communicate. In this regard, it is different from an Artificial Life scenario in which the individuals exchange, apart from “material” elements, “spiritual” ones, such as plans, ideas, creative products. These spiritual transfers constitute the support to culture. The scenario may or may not use the concept of space, depending on the characteristics of the field. With regard to individuals, they are classified into human and artificial ones. Both types of individuals possess the same set of possibilities and roles, being treated equally by the scenario. The only exception has to do with descent mechanisms.

Artificial individuals belong to a type or species, and possess a genetic code. The type or species is determined by the programme managing the individual. The descendants of an individual will belong to the same species. The variations within the genetic code which take place in descendants, together with the use of the same genetic code, are also determined by the programme responsible for a species. Thus, a single computer system may be simultaneously reflected on several individuals whose behaviour may differ according to their genetic code.

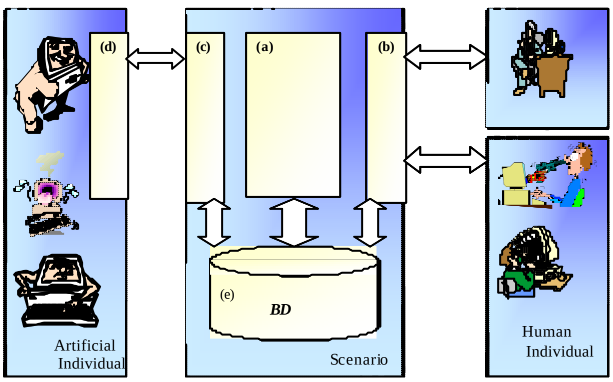

Figure 2: Hybrid Society Architecture.

The individuals obtain or spend energy depending on a series of activities they may carry out and on some factors which characterise HS. Age and offspring are included among those factors, but those related to economic activities will be explained in this paper due to their relevance for HS.

The concept of bet is key to HS. A bet constitutes an energy expenditure which is sent to another individual in exchange for a percentage of possession. Possession allows the individual upon which a bet has been placed to receive energy in any form, sending some of it to the previous bet makers according to the importance of the bet. The importance of a bet depends on its amount and on the energy possessed by the receiving individual at that time. This entails some kind of feedback to the critics which have placed bets on successful creators.

4.3 Architecture

The S architecture is composed of the following elements, shown in Figure 2:
Both the participating humans and the artificial individuals are connected to the scenario via interfaces (c) and (b). Besides, there is a generic module for monitoring artificial individuals (d) which is in charge of managing communication with the scenario and other actions, allowing them to be transparent to the specific individual.

The DB is also in the scenario (e), together with the scenario server (a). The DB centralises all the information, providing integrity and consistency, and facilitating later research.

The DB stores the internal information required by the scenario and all the messages sent from and to the scenario.

These messages have different status, depending on whether they are:

- Awaiting processing
- Processed
- Rejected.

Creative products, bets, and even individuals are treated as messages, given that the individuals belonging to the system are those entry application messages accepted by the scenario.

The scenario server carries out the following tasks:

- It runs the individuals' actions. The scenario checks the validity of every action, together with the conditions for implementation, it causes changes on the status of the affected individuals, and it reports to the applying individual that the action has been performed.

- It manages the HS rules. The functioning rules of the scenarios themselves are also found in the scenario. For instance, when an individual has exhausted its energy, when it is able to perform a specific action, and how these actions are materialised.

- It manages message transmission among individuals. Messages are only transmitted between scenario and individuals. Those messages coming from an individual and addressed to another are managed by the scenario.

This architecture allows a great distribution capacity at various levels, so that each component may be at a different and heterogeneous computer set, since communication is established via the DB. Besides, this enables the use of several computers in each module, even the establishment of different criteria for distribution in different components.

5 STARTING EXPERIMENT: MUSIC CREATION

Once the proposed methodology and paradigms have been analysed, we will proceed to apply them to the music field. This field was chosen due to its characteristics, given that it is social, complex, wide, typically human, and it has a purely aesthetic quality criterion. Therefore, it constitutes a paradigm of a creative task. "Music is a complex system composed of several adaptive processes, including individual behaviour, learning and biological and cultural evolution" [BILO-01].
The problem to be solved was building artificial systems with musical capabilities which can perceive and generate music. For this purpose, the methodology and paradigm presented in this research project were used. In particular, all the phases of the first stage are described. This stage corresponds to the most primeval types of music.

The methodology starts with an analysis block (top block in Figure 3) where the features of this first stage are reflected. These phases were implemented with the advisory participation of experts in music and music origins. Moreover, a computational framework is designed in the third phase which constitutes an adaptation of HS to the music field. Next two computational models are implemented, following the phases in the second block of the methodology (middle block in Figure 3). Thus, "SHTribe" was developed, which constitutes a musical composer based on genetic algorithms resulting from the adaptation of a previous computer system called "Tribe". "Ear" is introduced next, a music critic made from artificial neural networks and genetic algorithms which constitute a totally new development. "Ear" contains a population of artificial neural networks whose weights constitute the internal genetic code.

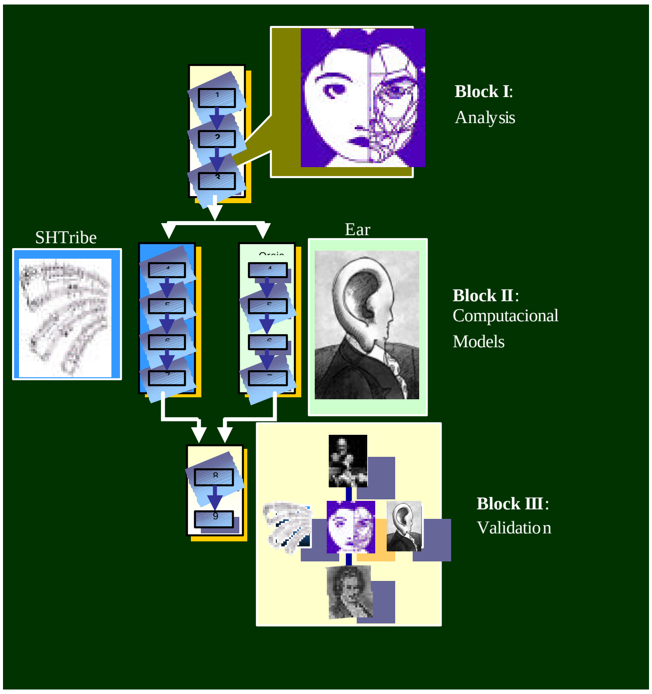

Figure 3: Blocks in the first stage of application of the methodology to music creation together with the modules developed in each block.

The two computational models which have been developed possess a control module in charge of communication with HS and the management of actions such as offspring, and also a core which is adapted to the task to be performed (music composition and criticism in this case). For that reason, these models have a double evolution level:

- The internal one, inside the population of composers or ANNs in each HS individual.
- The external one, where a new HS individual is generated.

Finally, the validation of these computational modules takes place (bottom block in Figure 3). For this purpose, both developed modules are integrated within the HS adaptation together with human users who also play the roles of composers and critics. The experiments have been carried out with two renowned piano players and teachers and an amateur musician as human participants. 10 individuals from each type also take part ("Ear" and "SHTribe"). Human participants took part during the first 200 pulses of the scenario, while artificial individuals were the only ones to take part in the remaining pulses of the experiment (a total of 2685).

Despite the short duration and the reduced number of human participants, the results of this experiment are very interesting.

"Ear" type individuals have had a very irregular performance, which basically depended on the bet threshold. Those individuals which possess a high bet threshold did not place any bet, while some individuals made excesses, losing points time after time. The two individuals which yield the best results placed a reduced number of bets (4 and 12 respectively) only during the first 200 pulses (Figure 4).

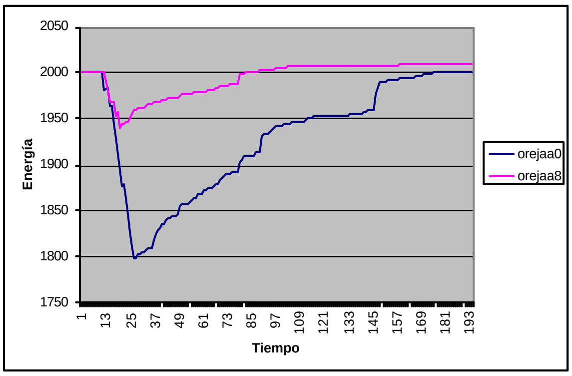

Figure 4: Chart showing the energy variation in the "Ear" individuals which produced better results during the first 200 pulses.

Figure 5 shows the energy variation of the ten "SHTribe" individuals in these first 200 pulses. In the case of "SHTribe", the response period showing how many pulses elapse before a new music theme comes out is of special relevance. Despite the fact that all the individuals increase their energy, some of them do so at a faster pace. The offspring threshold indicates at which point between 2200 and 2600 a new descendant is produced. The descendant receives one half of its father's energy.

With regard to this type of individuals ("SHTribe"), it is important to note the results obtained from the simulation of a traditional TT with the results from the experiment. The first 200 pulses are used for this purpose, together with the human bets placed on them. 84% of the bets were placed on artificial individuals, which produced only 81% of the music themes. Taking into account the high musical level of the human participants, these results are very adequate, reflecting a positive acceptance of the themes produced by "SHTribe".

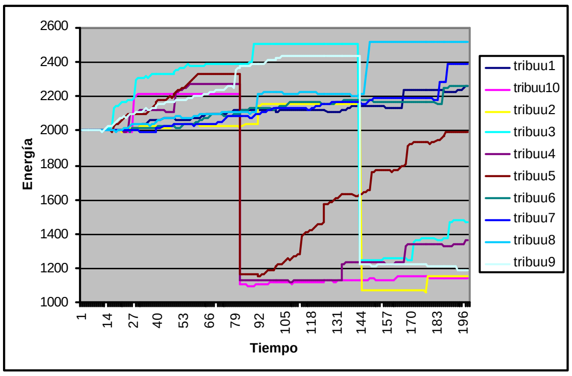

Figure 5: Chart showing the energy variation in the all "SHTribe" individuals during the first 200 pulses.

6 CONCLUSIONS AND FUTURE DEVELOPMENTS

As a conclusion to this paper, we may say that we have developed an original methodology which facilitates the creation of artificial beings, providing a solution to social and creative tasks in a co-ordinated and organised manner. This methodology provides a method for the development of a complex task in a series of progressive steps called stages, facilitating interdisciplinary collaboration as well as the collaboration and comparison among various research teams.

A new paradigm called "Hybrid Society" is developed. This paradigm complements the methodology, proposing a "conceptual world" where natural and artificial beings coexist in a virtual "egalitarian" society. It also provides a solution to the problem of the quality criterion for creative tasks both for creators and critics, specially in tasks with an aesthetic or subjective dimension. Besides, it generates an environment which allows artificial beings to learn with a minimum degree of implication or "intromission" by the creator. Moreover, it allows the integration into a single framework of computational models and other research groups developed with any computational technique or a combination of them with groups. It also enables competition, collaboration, and comparison to man in equal conditions.

Both the proposed methodology and the HS constitute proposals to try and establish techniques which allow a common step forward within this complex and wide field. However, there must be a will and effort shared by several research groups in order to co-operate making these and other alternatives useful and worthy.

Both the computational models which have been developed and their validation can be considered as preliminary, given that despite the methodology and HS are designed for the integration of multiple systems provided by several researchers with different points of view and computational techniques, in this case the models have been developed by a single group. Nevertheless, one of the purposes of these computational models is to show the use of the methodology and paradigm in the paradigmatic field of the creation of music.

At present, we are working in the creation of a tool which will facilitate the adaptation of HS to any field, and the integration of artificial individuals and research teams via the Internet with the less possible effort.

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