On the Socialization of Evolutionary Art

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Abstract. The lack of a social context is a drawback in current Interactive Evolutionary Computation systems. In application areas where cultural characteristics are particularly important, such as visual arts and music, this problem becomes more pressing. To address this issue, we analyze variants of the traditional Interactive Evolutionary Art approach – such as multi-user, parallel and partially interactive approaches – and present an extension of the traditional Interactive Evolutionary Computation paradigm. This extension incorporates users and systems in a Hybrid Society model, that allows the interaction between multiple users and systems, establishing $n-m$ relations among them, and promotes cooperation.

1 Introduction

Interactive Evolutionary Computation (IEC) is a variation of Evolutionary Computation in which the fitness of the individuals is determined, at least to some extent, by a subjective evaluation carried out by a human user. In recent years, this paradigm has been applied to various fields. Some of these domains possess a high social component, for instance, those related to aesthetics such as art, music, design, architecture, fashion, etc [1–3]. We will call these domains *social domains*, and these systems, *interactive evolutionary art (IEA) systems*.

In social domains we may distinguish two roles: the *creator* and the *critic* or audience. The canonical IEA system integrates only two participants: an Evolutionary Computation (EC) system and a human user. The role of the creator is played by the EC system, while the role of the critic is played by the human who assigns fitness to the generated *products*. Products stand for any kind of artifacts (ideas, approaches, artworks, information, solutions, etc.). Fig. 1 illustrates the relationships established in canonical systems.

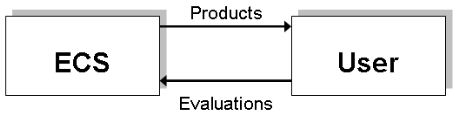


Fig. 1. Canonical IEA system

The fitness of the creators depends on the user's taste. Moreover, the user does not always wish to find an "optimal" product. Usually he/she wants one or more products that satisfy his/hers subjective preferences.

Due to their nature, social domains, present a series of characteristics [4] that complicate IEC systems' design:

- The existence of several different fitness functions. Each user assigns fitness according to their individual criteria and taste.
- The dynamic character of the fitness.
- The difficulty to define fitness in a formal way [5].

Additionally, canonical IEC systems have several shortcomings that hinder their applicability to social domains:

1. They lack a cultural environment, such as the one existing in human societies; "The value of an artwork depends on its surrounding cultural context (or contexts)" [5].
2. The lack of cooperation among users. The results attained by certain users are not shared with other ones.
3. The lack of evaluation abilities. Canonical IEC systems are unable to evaluate their products, which forces the user to evaluate the whole population. As a consequence, population size and length of the evolutionary runs tends to be small.
4. Related to the previous issue, user fatigue caused by the need to evaluate a large number of individuals raises a wide variety of problems.

The aforementioned problems are related with the $1-1$ relation between user and system established in canonical IEC systems and can be alleviated by establishing an n-m relationship model.

This $1-1$ relation also makes difficult the integration of IEC in other systems, and the creation of complex systems that incorporates IEC systems. Several authors [1, 2, 4, 3] have remarked the need for fostering common environments which allow the interaction and validation of several IEC systems. A model that allows the integration of multiple IEC systems and users, establishing an $n-m$ relation, can be of great value to the research community providing a way to validate and compare several IEC systems, and promoting the cooperation among researchers by providing a common framework.

We propose a paradigm, called Hybrid Society (HS), which extends the capabilities of current IEC allowing the establishment of $n-m$ relationships between evolutionary computation systems and users, as well as the incorporation of human creators and artificial critics [6]. We start by making an analysis of the existing variations of the IEC paradigm. Afterwards, we make a brief conceptual description of the HS architecture and of its main mechanisms. Finally we draw some overall conclusions.

2 IEC Paradigm

In this section, we analyze the current extensions of the canonical IEA system.

2.1 Multi User

One of the most common variations of IEA is the multi user approach, in which the evaluation of the products is performed by a set of users instead of a single one. Typically (see e.g. [7]) the fitness of each product is determined by the average of the evaluations made by the users. This approach has one severe shortcoming: when the users have different preferences the results will hardly be satisfactory.

In social domains that involve highly subjective criteria this problem is accentuated. The lack of consistency in the evaluations can jeopardize the evolutionary process, due to the existence of contradictory assessments resulting from the different preferences of the users. Considering the average assessment can lead to the evolution of products that, although relatively well sanctioned by the community, are not entirely pleasing to any of the individual users. In addition, it might lead to a "dictatorship of the majority" where the interests and preferences of minority groups are never satisfied.

2.2 Parallel

The parallel IEA variant is characterized by the use of a set of IEA systems whose EC System interchange individuals of the population. Fig. 2 shows the parallel IEA model.

This approach poses a problem in fields where fitness is assigned in accordance with subjective criteria such as individual taste. In this type of domains, it would be necessary to integrate a mechanism that maximizes the migration of products among the IEA systems of users with similar preferences, and that minimizes the transfers among the ones that have dissimilar or opposite tastes.

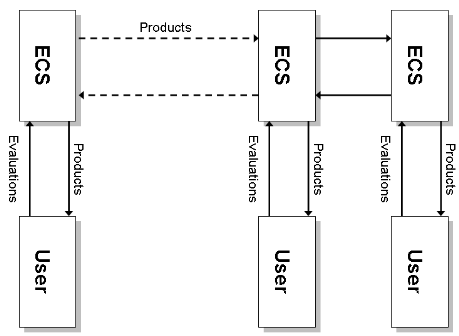


Fig. 2. Parallel IEA.

This approach has another important shortcoming, it is only useful when the IEA systems use the same representation for the individuals. To use different IEA systems, one would need to devise a way of translating the products from one system to the other.

This can become a huge problem, especially if one wishes to incorporate a set of heterogeneous IEA systems. The problem, once again, is linked with the way that preferences and taste are communicated from one system to the other, which, in this case, happens indirectly by the migration of highly fit individuals.

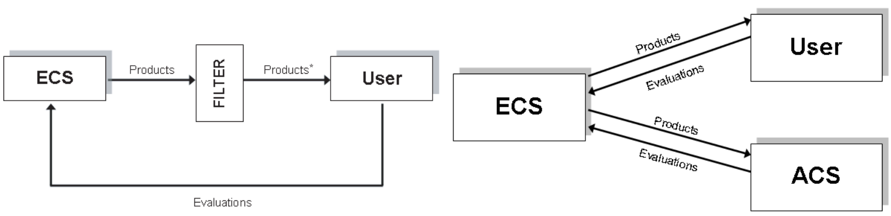
Probably due to the previously mentioned shortcoming, we were unable to find examples of parallel IEA systems applied to social domains.

2.3 Partially Interactive

Another extension of the IEA paradigm consists in the integration of evaluation mechanisms. These can have two different goals: performing some sort of evaluation task that simplifies the job of the user, for instance, eliminating products that are invalid; predicting the evaluations of the user, thus enabling the system to run in standalone mode, even if it is just during short periods of time. In both cases the integration of automatic evaluation mechanisms may contribute to the decrease of user fatigue and to an increase of quality of the overall result[3]

Fig. 3a illustrates the functioning of a partially interactive EC system applied to art, with a filtering layer, while figure 3b presents a system where the evaluations of the products are performed either by an Artificial Critic (AC) or by a human user.

In [8] the authors describe a partially interactive evolutionary system, which integrates both components. A filtering layer eliminates images "too simple or too complex, e.g. completely blank or noise (i.e. completely random)"[8]. The AC assigns fitness to the remaining images. The user can interfere in any point of the evolutionary process, by giving its own assessment of the population images, thus overriding the evaluations of the AC.



a) b)

Fig. 3. Partially IEA systems with a filtering layer (a) and an AC (b).

[3] Since less user evaluations are needed longer runs can be performed and consequently better products attained.

Another active research line concerns the independent development of ACs. For instance, [9, 10, 8, 11] describe ACs for visual art and music domains, that carry out tasks of author and style identification, attaining accuracy rates

These systems are based on a pre-processing of the artworks, extracting a series of measurements, which are then used as input to Artificial Neural Networks.

The use of these independently developed ACs in the context of IEA may prove interesting and useful, both for increasing performance and for testing purposes. The development of a generic architecture which allows the effortless integration of several ACs and ECs can be of great interest for the development of complex systems, enabling the comparison of different approaches, and promoting the collaboration among research groups.

3 Hybrid Society

Bearing in mind the problems existing in the different IEA variants, this section describes HS, as an extension of the IEC paradigm applied to art domains.

The design of this extension is based on a set of goals:

1. Allowing each user to interact simultaneously with several EC systems.
2. Allowing each EC system to interact with different users.
3. Allowing the participation of generic ACs which evaluate the products created by different EC systems.
4. Providing a way to evaluate the performance of the EC systems in accordance to its capacity to satisfy the preferences of a set of users and of its ability to adapt to changes in these preferences.
5. Allowing a greater degree of interaction between participants with similar preferences, fostering the development of groups with common interests and tastes.
6. Simulating some aspects of the behavior of human society.

HS was designed specifically for social domains and is, therefore, based on a "social conception". According to this view only those products which are found to be interesting by a given *cultural surrounding* are valued. A cultural surrounding may be defined as a set of agents with a high degree of cultural affinity.

This conception does not discard minority trends, as one might infer. If a particular work of art raises the interest of a small community, it will be valued. For instance, Jazz does not have mass appeal. However, in HS the participants that like jazz, and the creators and artificial critics who have adapted to that style, are grouped together in a, possibly thriving, subgroup.

Next we will describe the architecture of HS and its main mechanisms.

3.1 Architecture

The HS architecture consists of a central element called *scenario*, together with a set of participants who communicate with it. Participants may be either artificial or human, and they may play the roles of creator or critic.

Conceptually, a scenario is the common ground of the beings participating in a society. It includes the rules of the game and defines the principles of communication among those beings. Formally, it is the set of applications (databases, communication protocols and interfaces) with which creators, critics and products interact.

In HS the artificial creators are instances of an EC system similar to the one used in standard IEC. The artificial critics are instances of an AC system, similar to those described in section 2.3. Creators, humans or artificial, send products to the scenario. Critics perform evaluations of the products belonging to the scenario, communicating these evaluations by means of bets. The human or artificial nature of a participant is hidden from the rest. Fig.4 shows the relations among the different types of participants and the scenario.

Since there is no longer a direct communication between one user and one EC system, a series of mechanisms must be put in place in order to regulate and monitor the integration of all of them. These mechanisms are: energy exchange, affinity, and offspring generation. The upcoming sections briefly explain these mechanisms, as well as the main variables related to them.

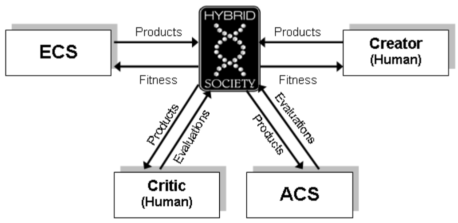


Fig. 4. Hybrid Society Model.

3.2 Energy Exchange

The HS energy exchange mechanism makes it possible to determine the adaptation of the participants to the cultural context. Each participant possesses an energy which is, in this context, the measure of its success. This can be seen as an expansion of the fitness concept, in order to evaluate the adaptation of artificial creators and critics.

One of the HS parameters is the initial energy value of each participant. If the energy of a participant becomes less or equal than 0, it is virtually dead and it can no longer participate in the society.

Humans and artificial participants gain and lose energy accordingly to the same rules. Depending on being a creator or a critic, different rules apply.

Each time a creator sends a product to the scenario, a certain amount of energy is subtracted. The creator receives energy when other participants place bets on its products.

The critics can evaluate products and place bets on the creators of the ones they find interesting. A bet is an energy transfer from a critic to a creator. The value of the bet must always be positive and less than the current energy of the critic placing the bet. Once placed, all bets are irrevocable.

When a critic bets on a creator, it gets in return a *possession percentage* of that creator. Possession percentage is defined as the ratio between the value of the bet and the energy of the creator when the bet was placed.

$$possesion\, percentage = \frac{value\, of\, bet}{energy\, of\, creator} \tag{1}$$

Each time a bet is placed the following actions take place:

1. The value of the bet is subtracted from the energy of the critic placing it.
2. A percentage of the value of the bet is distributed among the previous punters (if there are any) in proportion to their possession percentages. Each of these critics receives energy according to the following formula:

$$profit_i(t) = \frac{possesion\, percentage_i}{\sum\limits_{j=1..m} possesion\, percentage_j} * E(t) * C, \tag{2}$$

   where $E(t)$ is the value of the bet placed on the creator at instant t and C an adjustable parameter.
3. The remaining value of the bet is summed to the energy of the creator.

A bet placed on a creator with a small amount of energy can be more profitable to the critic than a bet placed on a creator with a vast amount of energy.

The creators which are valued by the participants of HS obtain great amounts of energy, since they receive many bets. The creators that do not fulfill the demands of the society do not receive energy.

The success of the critics depends on their ability to place bets on interesting products that other members of the society find attractive. If the critic bets on “uninteresting” creators, it will never recover the energy used for the bet. If the critic bets on very “interesting” creators, these creators will later receive a vast number of bets. Since the critic acquired a possession percentage, he will receive part of these bets and thus eventually increase its energy.

This description might lead to think that the best strategy for any critic is that of betting on a popular creator. In practice, the best strategy is to bet on emerging creators, i.e. those creators which aren’t currently valued but who will be in the future.

3.3 Affinity

This mechanism strengthens the relations between participants with high *affinity.* Two participants have high affinity if: they share the same preferences (affinity among critics); when one values the products of the other (affinity among critic and creator); when the products created by them are valued by the same participants (affinity among creators).

When two critics have a high degree of affinity, they will have access to more products which have been positively appraised by the other. For instance, if we have a community where some of the participants like Jazz and others like Rock, the affinity mechanism will foster the establishment of relations between members with similar tastes.

Two mechanisms based on a spatial representation are used in order to establish affinity relations. The first one makes it more likely for critics to receive products which are spatially close to the critic. The second one displaces products, critics and creators according to the evaluations of the products performed by the critics.

The spatial representation used may consist of two, three or more dimensions. Every participant holds a position in this representation. Initially, every participant is located at a random position. When a creator sends a product, this product is placed in a random position in the vicinity of the creator's current position. The maximum allowed initial distance between creator and product is an adjustable parameter.

To foster the establishment of affinity relations, the list of products of each critic is composed by a higher percentage of products within its vicinity than outside its vicinity. These percentages and the maximum distance defining the vicinity zone are adjustable parameters.

Participants and products with high affinity become close according to the critics' evaluations. When a critic issues a positive evaluation of a creator, three movements take place: (i) the critic moves towards the product (ii) the product becomes closer to the critic (iii) the creator of the product moves towards the critic. Each movement is independent and the distance travelled randomly chosen. The maximum distance per movement for creators, critics and products is established by independent adjustable parameters.

Conversely, there are rejection forces – of an opposite direction and lesser magnitude than the previous ones – between participants and products with low affinity.

The use of space fosters the definition of subcultures or subgroups within a scenario, given that the dynamics of HS favors the proximity of participants who have high affinity.

3.4 Offspring Generation

HS is designed so that the participants are able to meet the demands of a dynamic society. This is done following an evolutionary approach.

The offspring generation mechanism is managed by HS. When a participant exceeds a certain energy threshold, HS can create new artificial participants that are its descendants. When created, the descendent will have half of its parent energy.

By default, the creation of a new descendent is done by the mutation of the genetic code of the progenitor. This genetic information codifies a set of adjustable parameters that allow to change the behavior of the system. An example may prove useful to clarify the previous sentence. Let's consider the creation of an offspring of a creator system. The creator is a typical evolutionary system that creates pieces of art. The genetic code of the creator codifies a set of parameters of the EC algorithm, for instance: mutation rate, crossover probability, population size, etc. By mutating this genetic code, HS creates a new instance of the creator with a different behavior. In the case of critics, the genetic code can, for instance, codify the weights of the different criteria used in the evaluation.

The decision about the exact contents of the genetic code is made by the developers of the original participant. Additionally, the default descendent creation mechanism (mutation of the progenitor) can be overridden by one specifically designed for a particular system.

4 Conclusions

In this paper we presented an extension of the traditional IEC paradigm named Hybrid Society. HS was specifically designed for artistic and social domains, where the evaluation of the products depends on subjective and cultural criteria. To address some of the shortcomings of IEC systems, HS allows the interaction between a multitude of creators and critics, promoting the emergence of clusters of participants with high affinity relations.

This paradigm constitutes an evolution of IEC, providing it with a social component and giving rise to a new level of collaboration between developers and users. These are some of the advantages of our approach:

- There is a common interface shared by several IEC systems.
- The decisions of other users are taken into account in their social dimension. Users (and artificial participants) are located according to their tastes, so that the user's environment is composed of those participants which are aesthetically closer.
- General ACs are considered; these systems can perform evaluations and adapt to the general aesthetics of their vicinity.
- It is domain-independent. The conveyed product is transparent to the scenario, it is only sent between participants.

Given the maturity of the evolutionary art research area and its solid achievements, we consider that this is the correct timing for a common research effort, together with a shift of the relationship paradigm; from a $1-1$ relationship between user and IEC system to a $n-m$ relationship. We believe that the use of HS can be an important step in the development of IEC and ACs systems in social and creative domains, fostering collaboration for the creation of IEC systems, and their validation in a dynamic and complex environment.

Acknowledgments

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