EVODES: An Evolutionary Poster Design Environment

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1 Introduction

Human mind is currently considered as the only device that can "create", be creative, produce ideas that are never thought before. To mimic the human mind, we have to understand its creative processes. One theory on this matter is proposed by a present-day philosopher Daniel C. Dennett. According to Dennett [2], the human mind is a battleground of ideas competing each other to gain access to the higher levels of the brain. Along with their the struggle, they get replicated and mutated into other ideas. And sometimes they die out trapped in an inactive part of the brain to never come back again.

Assuming that this theory, which is supported also by other important academicians such as Richard Dawkins [1], the inventor of the concept of memes, is a fact or at least close to be a fact, one can model the creative processes of the brain by emulating the corresponding evolutionary processes. The brain, which is currently inaccessible to our understanding, becomes understandable through the theory of evolution. Therefore, if we can create an external environment where the ideas are get replicated, mutated and selected, then we can build machines that "create".

In this project, my aim was to try to create such an environment. I chose the poster designs to be the subjects of the creative/evolutionary process. This is partly because it is relatively easy to generate posters on a computer and also because the poster designs have well-defined purposes so that their "beauty" can be evaluated more objectively than other visuals. Also, to make the project feasible, I had to focus on the emulation of the replication and the mutation and leave the sophisticated process of selection on the brain: The fitness of a design is defined to be human taste. After implementing such model, I went one step further, and loosely modeled the collaboration process by including migration of designs as a genetic operator. All in all, the project is now can be described as an online collaborative interactive evolutionary poster design environment[1]. The details on the implementation and the evaluation of EVODES are explained in the following sections.

[1]EVODES is currently accessible on http://160.75.26.175/evodes/

2 Methodology

2.1 Components of EVODES

EVODES can be summarized by the entities that compose it. There are several such entities and they are covered in the respective subsections.

2.1.1 System

Systems are entities that represent different design tasks. For example, "Advertisement of Atari 800 XL computers" and "Judas Priest's show in Istanbul on July 18th, 2009" are two different design tasks that may be included as a system in EVODES. A system contains information about many details of the evolutionary process. It specifies the modules –and the parameters that will be passed to the modules– that handles genotype-phenotype mapping, initialization, recombination, mutation and migration. Systems are created by administrators. Other users do not have the privilege of creating new systems.

2.1.2 Island

Islands are partially isolated environments where populations emerge, regenerate and disappear. Each island is owned by an elector, which guides the regeneration of the populations by its inputs.

2.1.3 Population

A population is a group of individuals that live on the same island and share the same generation number. An elector always sees one population on an island at time. Currently every population contains exactly 10 individuals.

2.1.4 Individual

Individuals are the entities that are subject to the evolutionary process. Each individual stores a genetic code that is used to generate its phenotype, which is a poster design in the case of EVODES. Individuals regenerates to create new individuals with similar genetic codes. The elector decides which individual has more chance of regeneration and which one has less by examining their phenotypes.

2.1.5 Administrator

Administrator is a user which has a full control over all entities of the EVODES.

2.1.6 Elector

Electors are the users of EVODES that have the ability to create and manage islands. An elector may have as many islands as he/she wants.

2.1.7 Voter

Voters are the users that participate polls organized for performance evaluation. Voters do not interfere with the evolutionary process; they only evaluate the outputs of the process.

2.2 Genetics of EVODES

We *see* the posters. We *print* them and *look at* them. Therefore, phenotype of an individual should be an *image*. In my case, I represented posters by raster images. Rasterization is done by executing a list of drawing operations on a stack machine. The stack machine reads the list of operations from beginning to end and executes the items one by one. It also keeps a state stack that stores previous states of the context (i.e. transformation matrix, aspect ratio, font face, font size and text alignment) and restores them when instructed to do so. Each drawing operation consists of two parts: Operator and operands. The operator part specifies which specific action will be taken at the time the operation is encountered. Currently, there are 2 operators for state stack management, 3 operators for coordinate system transformation, 2 operators for drawing primitives, 6 operators for drawing texts and 1 operator for drawing images. A list of all these 14 operators can be found in Table 1. The operands part consists of a list of operation parameters. Expected parameters for each operator is also shown in the table.

Genetically, poster designs are represented by variable-length strings of *residues*. Residues are the basic elements of the genetic material and they take values from the residue set R, which is defined by the system. Formally, the genotype space is equal to the set R^*. Mapping the genotype space to the phenotype space is done by mapping each residue to a list of drawing operations using a mapping M and running the rasterizing stack machine on the left-to-right concatenation of these lists. The residue-operation list mapping M is also defined by the system and it is the most crucial ingredient as it actually specifies the constraints of the design task.

2.2.1 Mutation

Mutation is the most basic component of an evolutionary process. The only type of mutation that has been tested is the point mutation. In a point mutation, a single residue is affected at a time. A residue can be deleted or substituted by a random residue or a new residue can be inserted in a random position. The number of deletions, substitutions and insertions are determined by three random variables, D, S and I, obeying Poisson distributions. The lambda parameters of the distributions are calculated according to the equation

$$\lambda_X = r_X \sqrt{|G|},$$

where X is either D, S or I and $|G|$ is the initial length of the genome. The rate constants r_D, r_S and r_I are specified by the system. These rates are multiplied

Table 1: Drawing operators and their parameters.

Operator	Parameters	Description
push	-	Stores the current context.
pop	-	Restores the last stored context.
translate	x, y	Translates the coordinate system by (x, y).
scale	s	Scales the coordinate system uniformly by s.
rotate	α	Rotates the coordinate system by α degrees.
aspect_ratio	f	Multiplies the rectangle aspect-ratio by f.
rect	-	Draws a rectangle with stored aspect ratio, which is initially 1.
load_font	i, n	Loads a true-type font (TTF) from file n and assigns it to the identifier i.
font_face	i	Sets the font face to i.
font_size	k	Sets the font size to k.
halign	h	Sets the horizontal text alignment. h should be -1 for left, 0 for center, 1 for right.
valign	v	Sets the vertical text alignment. v should be -1 for top, 0 for middle, 1 for bottom.
text	t	Draws the text t using current font and alignment settings.
image	n	Draws Portable Networks Graphics (PNG) image stored in file n.

by the square root of the genome length in order to keep a balance between the mutation strength and the genome length. The actual values of the rates are determined empirically.

2.2.2 Recombination

During regeneration, it is desirable that the individuals are occasionally recombined by pairs to allow the transfer of genetic information within the population. Two different methods for recombination are tested. The first one is a modification of the well-known one-point crossover. In the standard one-point crossover, recombiner chooses a random cut-point and exchanges the chromosomal parts that are on the same side. This behavior is slightly modified in EVODES to make it work with variable-length chromosomes. As it is not possible to align variable-length chromosomes in a trivial way, one cannot assume that a randomly chosen cut-point will be shared between chromosomes. Therefore, one-point crossover recombiner of EVODES chooses one random cut-point *for each chromosome* instead of a single one. An important property of the one-point crossover method is that it preserves the local relationship of the residues throughout the parts that are transferred. This helps in generating more robust individuals.

The second recombination method that has been tested is the two-point crossover, which is very similar to the one-point crossover. In this case, recombiner chooses two random cut-points for each chromosome and exchanges the parts that are in between. As a result, this method allows non-terminal genetic codes to be copied from one chromosome and inserted into the other. This property is not as pleasant as it seems for a procedural encoding like in the case of EVODES, because the effect of a residue is often defined by its neighborhood. Also empirical comparisons support the fact that one-point crossover is a better alternative for this particular application.

2.2.3 Migration

A different kind of evolutionary process introduced in EVODES is the migration process. In contrast to the mutation and recombination processes, which take place inside a single population, migration works *across* the populations. When it is triggered during a regeneration routine, an elite individual from a proper population, which may or may not be on the current island, is copied directly into the new population that is being generated. A proper population is defined to be a present or past population whose generation number is between $\lfloor g/2 \rfloor$ and g, where g is the generation number of the new population. The limit on the generation number ensures that neither too much nor too less information is transferred to the island. In that way, the migration process keeps the general complexity of the individuals roughly intact still providing a remarkable diversity.

2.2.4 Fitness Evaluation

The fitness evaluation phase is the phase where the human interaction comes on the scene. Every time a new population is generated, it is exhibited to its elector. The elector then marks each individual in the population either gray, red or yellow. (The individuals are initially marked gray, so leaving an individual as it is is equivalent to marking it gray.) Then, the marks are transformed directly into fitness values according to the mapping shown in Table 2. Note that, during the selection process, yellow individuals are considered as elites too.

2.2.5 Selection

The selection is done using the trivial method of “roulette wheel”. Just after receiving the elector’s votes, each individual in the population is assigned a selection probability which is proportional to the fitness value of the individual.

Table 2: Fitness values corresponding to each of the marks.

Mark	Fitness Value
red	0
gray	1
yellow	10

Then, each time an individual is requested by the regeneration routine, the selection process passes a random individual chosen according to the selection probabilities of the individuals. In the case of EVODES, there are a couple of exceptions to this procedure. Firstly, a copy of every elite (yellow) individual is placed into the new population before any selection is done. Secondly, the regeneration routine occasionally decides to migrate an individual instead of generating a new one. In these cases, there is not any selection happening. In all of the other cases, however, new individuals are generated by either mutating or recombining *and* then mutating necessary number of selected individuals.

2.2.6 Whole Process

The whole evolutionary process going on on an island can be summarized as in Figure 1. Note that it is an infinite loop. This is because the process continues as long as the elector wants to see new individuals.

2.3 Evaluation

In one sense, seeing the posters designed on EVODES is a way to evaluate the success of this project. However, fineness of a poster design cannot be measured as objectively as, say, a distance or a color –even though I preferred poster designs over artworks because their success depend less on personal tastes. Thus, I organized a poll to be able to take the tastes of a group of people into account. To do this, first I created a system for an imaginary design task and hired 6 electors (including myself) to populate some islands with evolving designs. After each island has reached at least its 50th generation, I selected the best products of the evolution with the help of my designer colleagues and designed the poll. The poll consisted of six questions each containing six poster designs. In each question, participants (i.e. the voters) were asked to choose one the six designs that they liked most. 33 voters have completed the poll.

Each of the six questions were designed to measure a different performance criteria. First thing that one would want to know about an evolutionary system is whether the outputs are improving or not as the time passes. This is why the first and the second polls were prepared to measure such improvements. I picked a young design that is the product of a long lineage and five of its ancestors as choices in both questions. An improvement over time implies that the voters would like the youngest individuals most.

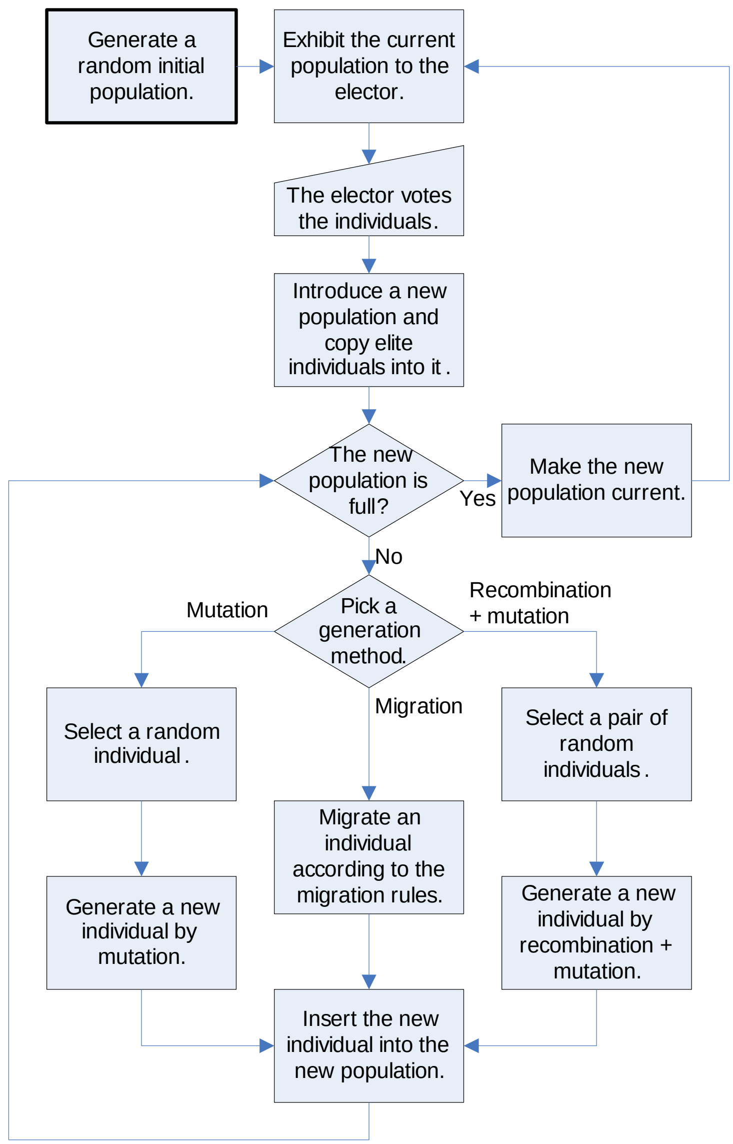

Figure 1: Complete evolutionary process going on on an island of EVODES.

In this specific application, another and a lot harder test could be done by comparing the success of the products of EVODES with the products of actual designers. The third and the fourth polls aimed this. My colleagues designed four posters for the same design task that I made up under the same constraints that EVODES has. Then, I put two of them in one question and the other two into another question along with four other designs selected from the products of EVODES. The assumption here is that the distribution of the votes should show the relative performance of EVODES with respect to actual designers.

Another question was not measuring the performance of EVODES but the performance of the electors. Half of the electors were actual designers while the other half were laypeople. I thought that it would be an interesting experiment to compare the performance of these two groups and see if good designers are also good electors. Thus, the fifth question were containing three designs elected by actual designers and three designs elected by laypeople.

One last question, which I called the sanity check, is included into the poll solely to check if the voters are sane enough to prefer feasible designs over infeasible ones.

3 Results and Discussion

The statistics for each of the questions are given in Figures 2 through 7. In the following paragraphs the results are discussed further.

First Question The vote distribution of the individuals shows a correlation between the generation and the performance. The 5th individual is an exception. This is probably because the elector created a new branch at the time 5th individual is appeared and one of the branches was an "experimental" mutation, which eventually led to the 1st individual. In fact, it is not always possible to say that ancestors are always worse than their descendants.

Second Question The results of the second question is a stronger evidence on the fact that the electors do not always keep the "boring" best but try other mutants along the way. The openness to discovery perturbs the improvement over time.

Third and Fourth Questions The numerical results of the third and fourth questions are very compatible. They both imply that EVODES has a very good share on the votes. Nevertheless, human designs are clearly more powerful in attracting people's attention.

Fifth Question The laypeople's success can be related to different factors. One of them is the statistical insignificance of a single test. One can also argue that the voters which are laypeople themselves favor the products of other laypeople. Organizing a poll specifically for designers would be a good test for this argument.

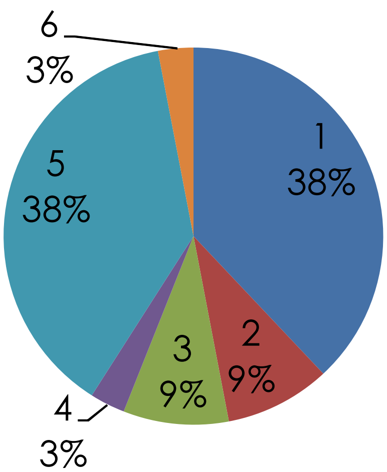

Figure 2: Results of the first question. 1 is the label of the youngest (latest) individual where 6 is the label of the oldest (earliest) one.

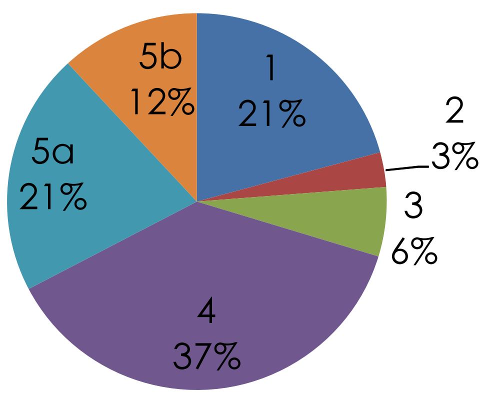

Figure 3: Results of the second question. 1 is the label of the youngest (latest) individual where 5a and 5b are the labels of the oldest (earliest) ones. (5a and 5b share the same generation.)

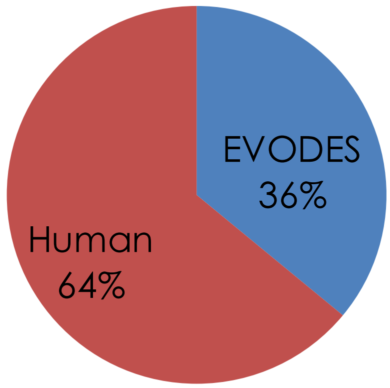

Figure 4: Results of the third question.

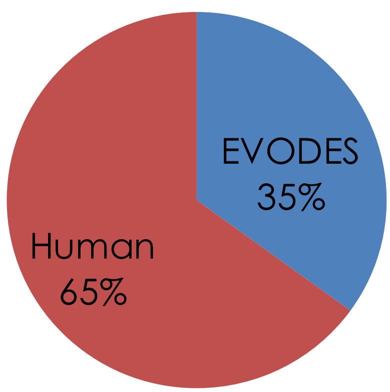

Figure 5: Results of the fourth question.

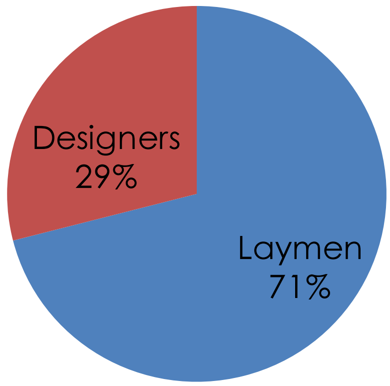

Figure 6: Results of the fifth question.

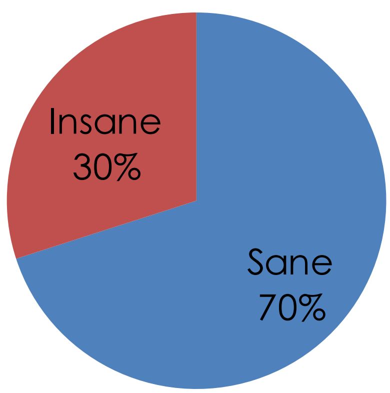

Figure 7: Results of the sixth question.

Sixth Question The sanity check succeeds with a weak clarity. It is interesting that 30% of the voters have chosen designs that in some cases do not even contain readable material. This proves that the voter profile should indeed be a concern for such experiments.

4 Conclusion

In this project I built an online evolutionary poster design environment where registered users can make the designs evolve by only electing them. With the ingredient of migrations, this application can be considered as a small model of a team of collaborating designers. This model can be extended in two ways: Firstly, by increasing the number of electors; secondly, by using more delicate mutation/recombination/migration techniques in the evolutionary process. Even on this small model, the experiments show that the performance of EVODES is not only comparable to but also –in some cases– competing with the performance of human-made designs.

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References

[1] R. Dawkins. *The selfish gene.* Oxford Univ Pr, 1976.

[2] D.C. Dennett. *Consciousness Explained.* Little Brown & Co, 1991.