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PICBREEDER: COLLABORATIVE INTERACTIVE EVOLUTION OF IMAGES

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Picbreeder [1] is a new website that is open to the public for collaborative interactive evolution of images. A unique feature of Picbreeder is that users can continue evolving other users' images by *branching*. The continual process of evolving and branching means that images can continue to improve and increase in complexity indefinitely, yielding a proliferation of artistic novelty that requires no explicit artistic talent to produce.

Interactive Evolutionary Computation

Picbreeder borrows ideas from Evolutionary Computation (EC), which allows computers to produce a myriad of digital artifacts, from circuit designs to neural networks, by emulating the process of natural selection. In EC, a population of individuals is evaluated for fitness and mutated and/or mated, to produce the next generation. This cycle continues until evolution produces an individual considered significant. Interactive Evolutionary Computation (IEC), originally explored by Dawkins [2], is a type of EC in which a *human* evaluates the fitness of individuals (see Takagi [3] for a review). This technique is particularly effective at evolving artifacts that are too subjective for the computer to evaluate itself, including artwork, music, and designs.

Picbreeder uses a specialized evolutionary algorithm called Compositional Pattern Producing Networks-based NeuroEvolution of Augmenting Topologies (CPPN-NEAT) [4], which is extended from the original NEAT algorithm [5]. A property unique to NEAT is its ability to *complexify*, which means that as evolution progresses, the individuals become more complex. Therefore, the potential complexity and sophistication of images evolved in Picbreeder is unbounded. The *genetic art* created by this process thus tends to look organic and often resembles familiar objects (figure 1).

The Picbreeder client program presents the user with several grayscale images (figure 2a). The user selects which images to reproduce. The program then performs crossover and mutation on the chosen images to produce the next generation. As this process iterates, images increasingly satisfy the users' desires. Interactive evolution finally terminates when the user is satisfied.

Picbreeder Principles

A primary aim of Picbreeder is to allow a large group of unskilled individuals to collaborate to produce interesting output. Good taste, rather than explicit artistic talent, powers the process.

This goal faces several challenges. For example, in some other online, interactive evolution communities (e.g. in [6]), input from a large number of users produces an averaging effect, wherein the votes of individual users are washed out by the masses. In addition, in IEC, producing a significant output can take a long time, in many cases longer than the user is willing to continue the process. If, for example, 1,000 one-minute generations are required to produce an interesting image, it would take a single user almost 17 hours to complete. While the output may be significant, such an investment is typically impractical.

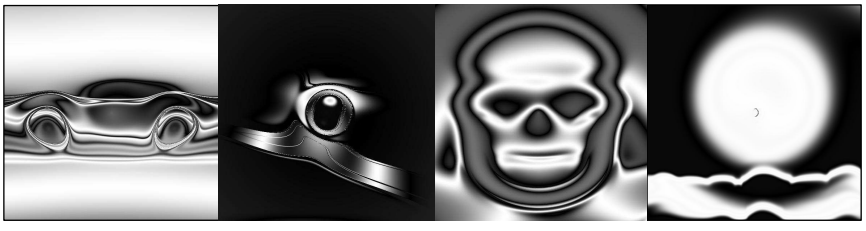
Picbreeder solves these problems by allowing users to *branch* from the works of other users. Once a user has created an interesting image through the IEC client, he or she then *publishes* the image, making it visible to the rest of the community. Any other user that discovers this image on the website can subsequently branch from it, thereby continuing evolution with his or her own copy of the image. Because of this mechanism, a chain of successive branches can be evolved by many users through thousands of generations, potentially producing otherwise unreachable images. While branching allows many users to contribute to the final image, each can take artistic liberty in the part of the series that they own. Furthermore, branching can produce a diversity of lineages originating from a single source.

While branching is an effective mechanism for IEC, it cannot work properly unless users can find appropriate images from other users. To make finding good images easy, users can rate the images of other users and thereby promote images that are generally interesting. However, Picbreeder protects nascent images by showing the newest in addition to the most highly rated (figure 2b). This policy gives the newest images a chance to be seen and rated by users who might be interested. Finally, because often "beauty is in the eye of the beholder," users can search or browse for images by text *tags* given to images by their respective owners. Tags allow small groups of users to jointly create images that specifically interest them.

The Picbreeder Online Experiment

The Picbreeder website [1], recently opened to the public, allows users across the Internet to participate in Collaborative Interactive Evolution (CIE) to produce images. We anticipate exciting benefits from this system. The images produced, because of unique properties of the CPPN-NEAT algorithm, can be rendered at infinitely high resolution, making them ideal for prints. Thus, interesting images may end up in a variety of places, from websites to t-shirts. Furthermore, we plan to examine data from Picbreeder to learn more about evolving art. This information will help produce more effective CIE systems that can better harness the power of unskilled groups to produce significant works. For example, figure 2c exhibits an evolutionary tree produced by five separate users collaborating. It is evident that children tend to resemble their parents, yet with increasing variation. This phylogenetic tree shows how users actually collaborated to produce artistic concepts that expand in both breadth and depth.

Fig. 1. Example images evolved in the Picbreeder system



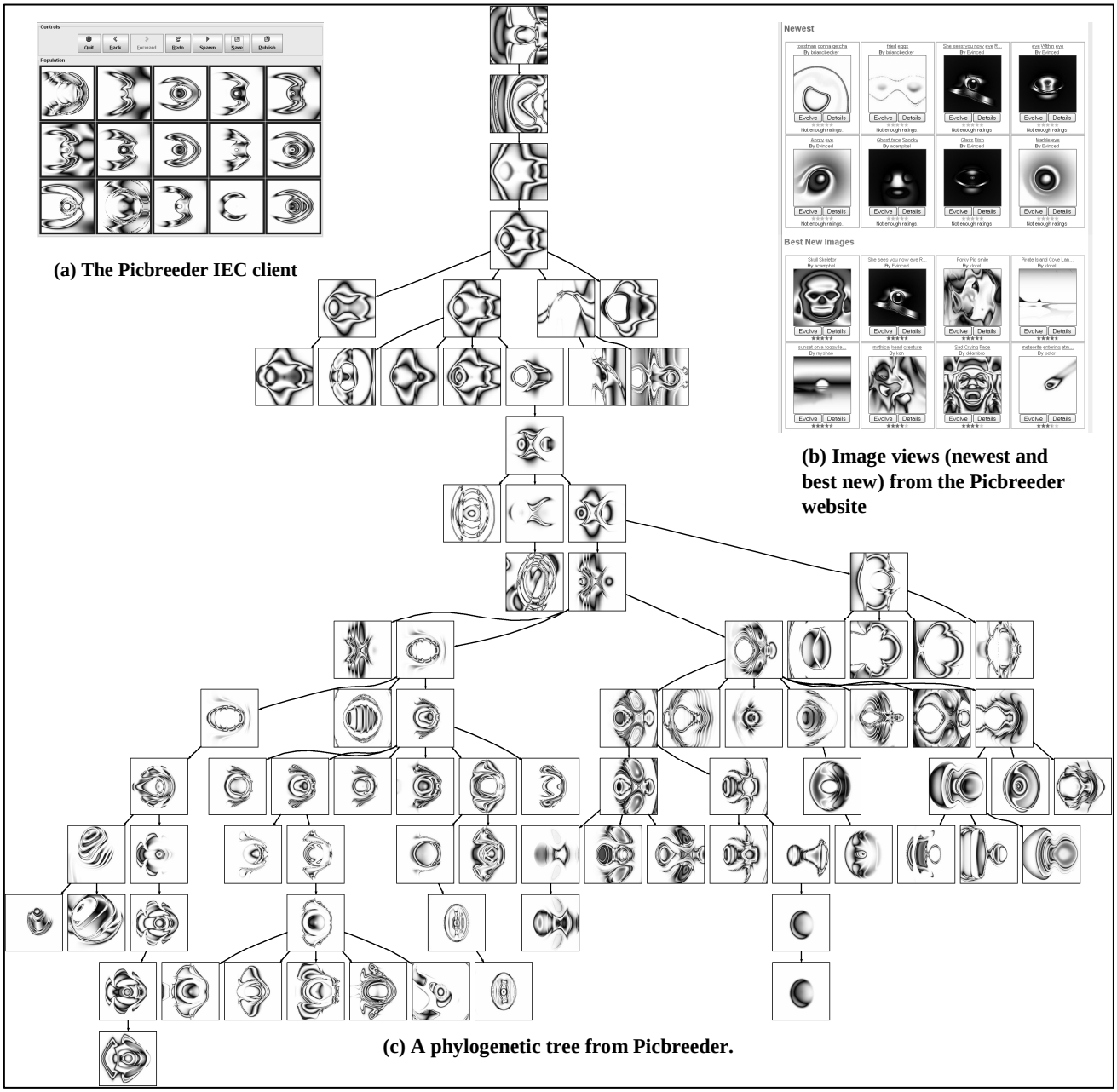


Fig. 2. Picbreeder views: (a) The Picbreeder IEC client lets users evolve images. (b) Front page views from Picbreeder show newest and best new images. (c) This actual phylogenetic tree produced through CIE on Picbreeder was created by five different users branching and evolving.

Future Applications of CIE

Images are only the beginning of what Picbreeder-like services can evolve. CPPN-NEAT is currently being tested in evolving digital artifacts such as music, particle systems [7], and three-dimensional designs. All can potentially be adapted to a CIE system like Picbreeder. We envision a future in which companies deploy systems like Picbreeder to evolve new designs, images, and songs through a population of users. For example, in the future, a car company may open such a website to users, and perhaps even manufacture the top designs that users evolve. Large user communities may evolve two-dimensional and three-dimensional artwork that others download to obtain a full sized portrait or three-dimensional representation for output through a personal rapid prototyping machine. Eventually, such systems could even one day evolve intelligent agents, speech synthesizers, or other computational intelligence products that are difficult to explicitly design, yet easy to evaluate.

References and Notes

1. Picbreeder (2007), <http://www.picbreeder.org>, accessed 6 August, 2007.

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