Mixed-Initiative Creative Interfaces for Dynamic Illustration and Generative Design

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Abstract
Modern software applications for design and drawing provide users with rich sets of features, many of which provide computational assistance or otherwise amplify the user's ability to express themselves creatively. In this paper, we present several research projects that we have undertaken in this area, with a focus on how they enable a collaboration between the user and a computational system, and thus reveal potential areas for research on mixed-initiative creative interfaces, and interaction with these kinds of system.

Author Keywords
Generative design; dynamic illustration; mixed-initiative creative interfaces

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Introduction
Software applications for creative tasks ranging from computer-aided design to sketching have moved far beyond simply emulating the analog tools that came before them. Instead, modern design software provides an environment and rich sets of features that assist the user in myriad ways. Likewise, software tools for design

and drawing enable creative minds to amplify their thoughts and express themselves in ways that were simply not possible using analog tools. In this paper, we present a number of recent and ongoing projects that we have undertaken to push the limits of these domains, with a focus on innovations that enable the user and the design software system to work in tight collaboration with one another to produce creative results.

The projects we will present suggest several models for human-machine collaboration in mixed-initiative creative interfaces that have not been explored in detail in past work. First, we explore challenges in representing complex algorithms, simulations, and dynamics to amplify a user's ability to understand and interact with those phenomena. Specifically, we discuss these ideas in the context of work we've undertaken on *dynamic drawings*. Second, we discuss the broader area of *generative design*, touching on the interaction challenges of specifying design constraints to a system, and evaluating the creative outputs generated by a computational system.

Dynamic Drawings

The goal of this line of work is to make animation easy and accessible to a wider audience, beyond professional animators. In general, crafting compelling motion graphics is a challenging task, requiring significant practice and mastery of complex skills. Artists require a deep understanding of the complex physical simulations and dynamics of the effects they are trying to recreate (e.g., the motion of hair blowing in the wind) to be able to recreate them effectively. The key challenge for these types of systems is to provide amateurs with a set of tools that allow them make use of these complex dynamics in a way that is easy to learn, apply, and experiment with.

Our approach aims to break those dynamics into simple, understandable chunks that are easy to comprehend and which amplify the user's understanding of the dynamics. Below we present two examples of this approach.

Figure 1: We devised the principles of animation as a set of seven motion amplifiers. The amplifiers are independent from each other and can be arbitrarily mixed to design motion effects of an animated object. These tools correspond to the principles of animation that address the geometric manipulation, clarity, and temporal aspects of animation.

Motion amplifiers [1] bring the exaggerated dynamics of classical 2D animation into dynamic drawings. We prototyped a sketching tool that formulates the principles of 2D animation as a set of motion amplifiers that can be combined at will. Users can sketch drawings and record motions through direct manipulation, and apply the animation principles by simply tapping on the corresponding *amplifier* icons (Figure 1). Each amplifier imposes deformations to an underlying grid, which in turn updates the corresponding strokes. The goal of our design is to increase the user's ability to modularize the fundamental concepts of 2D animation and combine them together in new and powerful ways. By representing the principles of animation in a simplified manner, our system offers users, particularly those with no prior experience in animation, the opportunity

to rapidly explore animation effects and produce expressive animated illustrations.

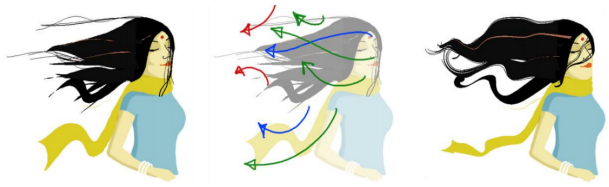

Figure 2: Example of a dynamic drawing authored with our system. Left: original user drawing. Middle: the energy brush gestures to specify the underlying forces and detail effects. Right: the resulting dynamic drawing.

Energy brushes [7]. Dynamic effects such as waves, splashes, fire, smoke, and explosions are an integral part of stylized animations. However, they are challenging to produce because they are time-varying phenomena. We developed an interactive system that enables artists to design such dynamics by sketching the underlying forces with *energy brushes* to animate drawings and textures. An energy brush creates a stable, repetitive velocity field pattern by moving flow particles along the gesture. Complex dynamics, such as splash, fire, hair, and explosion can be achieved by combining these simple energy patterns. Our approach provides artistic controls over coarse and fine scales, and preserves the fluidity of freeform sketching. Most importantly, it enables skilled artists, as well as novices, to integrate complex dynamics into their animations, by composing them out of simple energy patterns in an interactive and iterative manner.

Dynamic Drawing as a Mixed-Initiative Creative Interface

In the projects discussed above, the simulations of complex dynamics provided by the system can be viewed as the system's contribution to a collaborative creative process with the user. To enable a tight interactive loop in which both the user and the system contribute, the complex dynamics are decomposed into manageable chunks (energy brushes and motion amplifiers, respectively) which can be understood by the user and assimilated into their creative process.

There is a connection to what Seymour Papert refers to as breaking down a complex problem into "mind-size bites," which makes knowledge more communicable, more assimilable, and more simply constructible [3]. We see this as a potentially valuable model for human-machine collaboration in mixed-initiative creative interfaces. User interfaces for creative tasks that leverage these "mind-size bites" as a natural vocabulary to understand and compose complex phenomena and algorithms might have powerful influence on how creators think, learn, and explore.

Generative Design

In generative design systems, a designer provides a set of design goals and constraints to the system – these could be material parameters, manufacturing methods, or cost constraints. The system then generates a range of design alternatives, in a process that could potentially produce hundreds or thousands of solutions that meet the specified constraints. From these, the designer can select a solution, or iterate on their specified set of parameters to get a new set of design alternatives from the system.

Though generative design is not itself a new concept, it is only recently that generative design capabilities have become available in commercial 3D design software, and researchers have begun to examine the

interactions between human designers and generative design systems.

Viewed through the lens of mixed-initiative creative interfaces, the generative design process presents several interesting challenges.

First, there is the question of how to enable the human designer to communicate their goals and constraints to the generative design system. Current solutions ask the user to specify physical constraints and forces in a manner that can be rigid and is often dictated by the specific generative design algorithms used by the system. Investigating more natural ways for a user to express their goals and constraints, or ambiguities in their goals, is an interesting area for investigation. In particular, we believe there is an opportunity to learn from and adapt approaches that have been used in mixed-initiative interfaces for game-level design [2,4,6] and generating procedural 3D worlds [5].

Second, there is the question of how best to present the user with the set designs generated by the system, which could number in the hundreds or thousands. Solutions could include interfaces for filtering, ranking, and visualizing the produced designs. One interesting possibility in this space is for the system to use implicit indicators of the user's interest in produced designs (e.g., using machine learning techniques), to build a model of the user's interests. This could be used to narrow the space of generated designs, or feed back into further iterations of the generative design process.

Finally, there are unique interaction challenges raised by generative design with current technologies. For example, in 3D shape synthesis, the latency for generating designs may be on the order of minutes or hours, which can impede a tight interaction loop between the designer and the user.

Conclusions

In this paper, we have outlined how recent innovations in design and drawing are creating systems in which users collaborate actively with computational systems to produce creative results. We are interested in contributing to the workshop and helping to define a research agenda for mixed-initiative creative interfaces in this domain and more broadly.

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