A Multi-finger Interface for Performance Animation of Deformable Drawings

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ABSTRACT

We present a system for manipulating drawings that lets novice users create simple, yet expressive, animations. Users move and bend the drawings by touching them with their fingers. This natural and easy to learn interface evokes the unique experience of interacting with a digital object as though it were real.

Introduction

Although most of us can easily express simple motion using gestures and props, creating computer animations today remains a tedious task achievable only by experts. The goal of our project is to make it easy for people to create simple 2D animations by relying on their natural sense of timing, and on their experience with real-world flexible objects. Users of our system move and bend drawings by touching them with their fingers as though they were physical rubber props. This interface is very easy to learn, yet it allows even novice users to create expressive animations. While traditional key-framing techniques tend to produce stilted motions in the hands of novices, our technique yields more believable results, since it inherits all of the nuances and imperfections of the user's hand motion.

Demonstrating Our System

Our system lends itself well to hands-on demonstration. Since interaction with the drawings is modeled after interaction with real-world objects, users grasp the underlying concept right away. In informal demonstrations we found that as soon as participants realized that the drawings respond to their touch, they began to move and stretch them to see how they behave. Participants could produce simple motions right away, and with a bit of practice they were able to make more complex and interesting animations.

Our system places no constraints on how users may grasp or move the drawing. This encourages exploration of different types of manipulation in order to discover what works well with a particular drawing. To create a more complex motion two people may work together and attempt to coordinate different parts of the drawing.

Setup and Implementation

Our setup consists of a digital projector mounted on a platform above a multi-finger touchpad (Figure2(a)). Images are projected onto the touchpad so that points touched by the user are registered with the corresponding points in image-space.

For multi-finger input we use Rekimoto et al.'s SmartSkin [7]. The device uses a grid of capacitive sensors to measure

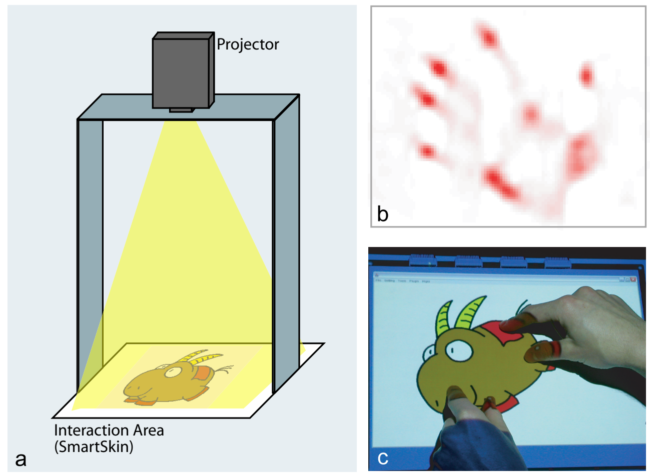

Figure 2: (a) Overview of our system setup. (b) The SmartSkin returns an image of the distance from the touchpad to the hand. (c) Close-up of interaction area.

how close a hand or finger is to each point on the touchpad (see Figure2(b)). Points where the hand is in contact with the SmartSkin show up as "hot-spots" in the distance image. To maintain the identity of each contact point, we track these points between frames using a greedy exchange algorithm [10]. The algorithm iteratively swaps the inter-frame point correspondences so as to minimize the total distance between corresponding points. While more elaborate error functions are possible, we found this technique to work sufficiently well without making further assumptions about hand motion.

The shape of a drawing in our system is represented by a triangular mesh. The touch-points are used as constraints in a 2D mesh deformation algorithm [4] which attempts to maintain the local rigidity of the mesh while meeting the given constraints. The algorithm poses the problem as the minimization of a quadratic error metric that measures the distortion associated with each triangle in the mesh. It provides a closed-form solution which gives immediate results. The effect of moving constraint points is global and instantaneous, so small local changes may affect the motion of the entire model. The object deforms as though made from a sheet of rubber, making for very lively movement that is predictable and easy to control.

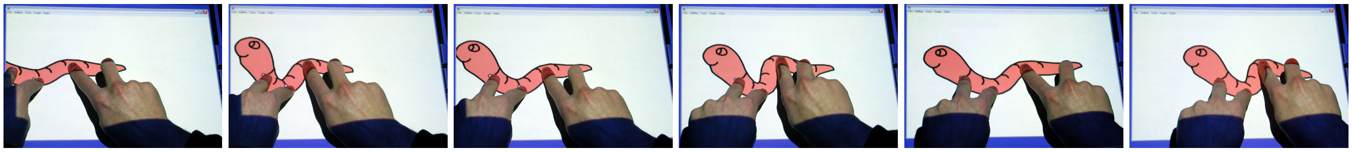

Figure 1: Animation sequence of a crawling worm. The animator moves and bends the drawing with his fingers as though manipulating a real-world flexible object.

Related work

While previous systems have used direct whole-hand manipulation to accomplish a variety tasks [11, 7], none have used the multiple degrees of freedom available from multi-point touchpads to control the many degrees of freedom of an animated character. Real-time performance animation through direct manipulation has been previously accomplished for very simple motions [2, 1]. More complex animation is possible through digital puppetry [8], in which a custom set of controls is mapped to the various parts of each character. The mapping, however, is often arbitrary and requires much practice to master. Motion capture uses a more natural mapping between the movements of the actor and the character. However, it is limited to characters that have real-world counterparts (such as people and animals) and cannot be used to animate arbitrary 2D drawings.

Other attempts at making animation more accessible have used layered recordings of motion to iteratively add motion to an animation [3]. While this approach can yield more detailed motion than our technique, it cannot be used for real-time performance, and it may be difficult to synchronize the separately recorded motions. Another way to control many degrees of freedom at once is to use pre-recorded motion [9], or pre-specified configurations [6, 5]. These approaches produce pleasing animations, but they restrict the type of motion that the user can produce to previously designed animation.

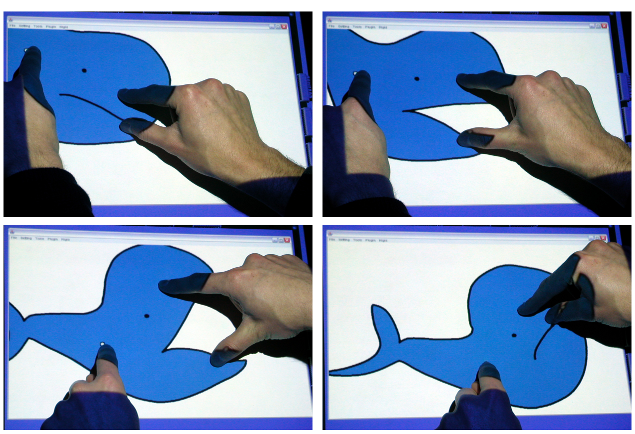

Figure 3: A user makes a whale open and close its mouth as it swims.

Conclusion

The majority of digital communication today is limited to text, photographs, and occasionally drawings. However, some ideas are best described through motion. Experience with our system demonstrates that multi-finger interfaces for performance animation are a viable way of expressing such ideas. Future applications of such interfaces may allow people to use animated explanations in their everyday communications, and provide experienced animators or puppeteers with a medium for real-time animated performances.

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