HAPTIC FEEDBACK FOR DIFFERENT STROKES USING DIMPLE

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ABSTRACT

This paper describes the addition of haptic feedback to the Different Strokes performance software environment via the DIMPLE haptics framework and a force feedback manipulator. We have experimented with several haptic effects, and we present our qualitative observations of their influence on the user's performance gestures.

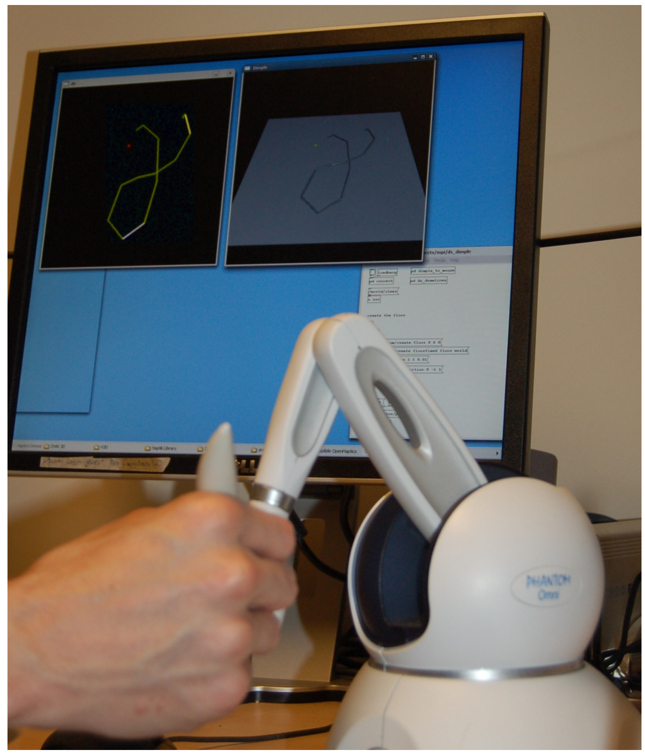

Figure 1. The prototype's physical setup.

1. INTRODUCTION

Different Strokes (DS) is an experimental software interface for computer music performance based on drawing gestures [4, 5]. It is intended for use in a solo "laptop performance" context, where the performer plays music by operating a graphic user interface. The main impetus behind the system's design was to explore interfaces amenable to solo improvisation and that provide a demystifying visualization to present to the audience.

In DS, the performer draws strokes on a full-screen window, typically using a graphic tablet or mouse. These strokes serve as tracks along which animated *particles* can move. By drawing networks of strokes, the performer creates cascading and looping patterns of animated particles. The movements of these particles are in turn mapped to sound sample playback. The motion of the particles, and thus the corresponding patterns of sounds, is controlled by creating and modifying stroke topologies in real time. The intersections between the strokes are meaningful: when a moving particle arrives at an intersection, it is duplicated and the two particles continue outward along the two outgoing tracks. This mechanism allows particles to orbit continuously around closed stroke loops, bringing about periodic motion. This novel, visual approach to sequencing is intended to be non-analytical and intuitive to the performer, as well as appreciable by the audience.

DS takes advantage of the typical user's long experience with stylus tools for creating directed markings on paper. It allows the performer to transfer this deeply ingrained expertise to the control of a sound-making process by having these markings relate directly to parameters of sound. The use of drawing gestures to drive the system also leads to some other attractive properties. For example, the natural variability of hand movement induces organic, non-quantized timing in the sound patterns.

However, aspects of this visual control medium introduce new semantics into the drawing task with which the user is likely not familiar: that the speed of drawing a line should affect the sound, and that crossing another line should have an effect upon the control structure of the musical process. Since these new semantics do not necessarily relate in a familiar way to the act of drawing, new perceptual cues may be necessary to inform the user of what is happening. In this work, we demonstrate the use of haptic feedback in a pen-based force feedback device to enhance the use of DS by providing information that is not available in the visual display.

Additionally, DS may be used as one instrument of many in a studio configuration. We have found through experience

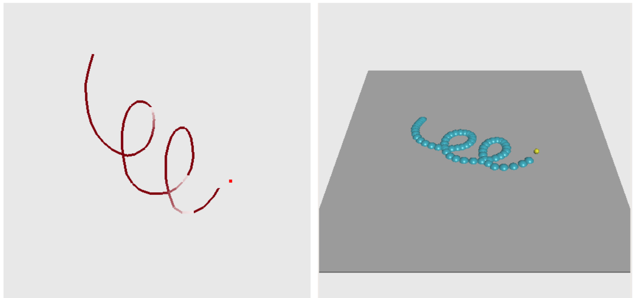

Figure 2. The synchronized Different Strokes (left) and DIMPLE (right) applications.

that DS's requirement of constant visual attention can be challenging in such situations [5]. By duplicating some of the visual cues in the haptic modality we hope to allow the user to free his or her visual attention for other tasks, and to get a more intuitive feel for controlling sound in DS that does not require constant conscious monitoring.

For prototyping this system, we made use of DIMPLE [3], a haptic simulation environment that can be controlled by external applications through Open Sound Control (OSC) messaging. We created a Pure Data patch to interface between DS and DIMPLE, constructing virtual objects on the fly to correspond with pen strokes. This created lines which could be felt haptically on a virtual drawing surface with programmable friction coefficients and other modifiable properties.

We used a SensAble Phantom Omni (Fig. 1) for haptic display. The Phantom and other similar haptic devices have been used previously in musical contexts. For instance, O'Modhrain [1] showed that the presence of force feedback can improve performance in electronic musical interaction, using a 2-DOF haptic device to interact with a virtual Theremin and violin model. Most relevant to the current work, Rodet et al. [2] implemented a musical 'game' using a 6-DOF haptic device simulating a virtual drawing surface. During development they performed an informal comparison between the use of a graphic tablet and the haptic device, allowing users to draw freeform representations of presented stimuli. This study made some interesting observations on the relationship between curvature and drawing speed during expressive unconstrained gestures: in particular, that, for expressive purposes, subjects would sometimes perform gestures that were contrary to the laws governing the relationship between velocity and curvature that the authors expected. In general they found agreement between usage of the graphic tablet and the haptic device, though not many details in this regard were presented.

The ultimate goal of integrating force feedback into Different Strokes is to determine whether particular types of haptic feedback can affect the experience of performing. Could certain forces and textures promote expressive, musical playing? This project provides us with a platform for examining these questions as related to DS. In this paper we will describe the interaction between DS and DIMPLE, and discuss some different haptic properties we have tried and their effect on the experience of using DS.

2. SYNCHRONIZING THE WORKSPACES

DIMPLE provides a scene graph which consists of simple 3D objects of different shapes and sizes, and provides a spherical cursor which represents the location of the haptic device. It takes care of haptic rendering, the calculations of collisions and penalty forces that occur at rate of 1 kHz. It also provides a rigid body dynamics system so that these objects can interact, but since the DS workspace is static we decided to disable this feature. The task then was to create a DIMPLE environment that matched the DS workspace, and to use the haptic cursor as the DS pen. This implied bidirectional real-time communication between the two programs, which we mediated using a simple Pure Data patch.

2.1. DIMPLE to DS

In DIMPLE, a large, thin prism object was created to represent the drawing plane. The haptic cursor position was requested at regular intervals, and this 3D position information was converted to messages for DS representing pen movements, with positions converted to a normalized 2D coordinate system. The vertical axis was used to determine pen up/down status. DS was configured to receive the following messages:

```
/pen/up
/pen/down <float:x> <float:y>
/pen/move <float:x> <float:y>
```

DS then interpreted these messages exactly as though they originated from a mouse or graphic tablet.

2.2. DS to DIMPLE

On pen-down, DS initiates the construction of a *polyline,* a data structure consisting of several line segments appended one after the other. To represent each line segment in DIMPLE, we tried both a cylindrical mesh and a series of spheres. These were placed in the drawing surface, protruding by some variable amount. A cylinder was created for each line segment, centred between two points and with a rotation calculated to match the segment's angle, resulting in a snake-like appearance in the DIMPLE 3D view. In the case of using spheres, they were constructed to overlap at intervals along the length of the line segment. Since the objects were created dynamically while drawing, as the haptic cursor looped back on its own trajectory, it would temporarily produce a bump as it collided with previously constructed

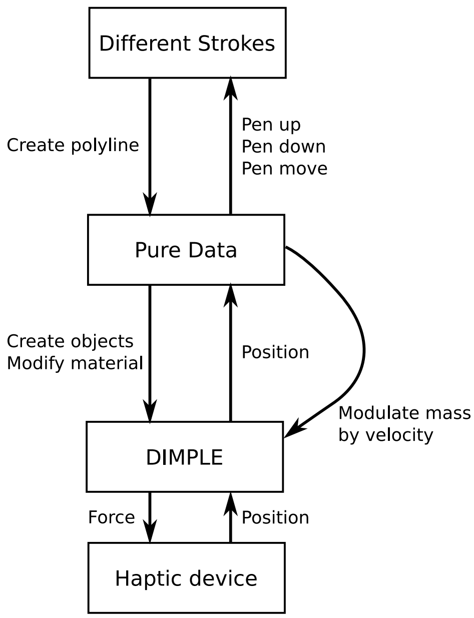

Figure 3. Information flow between the DS and DIMPLE applications.

objects. A visualization of this interaction can be seen in Figure 2.

DS was configured to send the following messages, which Pure Data used to generate instructions for DIMPLE:

```
/ds/stroke/start
/ds/stroke/end
/ds/stroke/add <float:x> <float:y>
```

3. EFFECT ON DS INTERACTION

It has been shown that force feedback can improve the control of real-time musical processes [1], and we were interested to know whether haptics can help foster more accurate hand movements to control this drawing-based interactive system. We detail here the haptic effects that we have experimented with to date, summarized in Table 1.

In our setup the DS drawing plane is modelled in DIMPLE as a virtual wall that is oriented horizontally in space, mimicking a standard graphic tablet. Being able to feel the drawing plane as a flat virtual surface was comparable to the sensation of using a normal graphic tablet, but with a completely frictionless character. Simulating this surface virtually freed us to easily alter tactile and force properties of the plane in ways that are not possible with a physical tablet.

We have experimented with haptic properties of the DIMPLE cursor and the virtual surface. Specifically, some properties and effects we experimented with were static friction, dynamic friction, cursor inertia, and viscosity. We also used virtual objects to mirror the DS line segment data structures,

Static friction	Affected beginning of stroke; easy to start at high speed.
Dynamic friction	Sharp corners; easy to stop suddenly.
Cursor inertia	Enforced large curvature.
Variable cursor mass from drawing speed	Good scribbling, but also good control at high speeds.
Viscosity	Similar to friction; increased control over drawing speed.
Virtual drawing plane	Same as physical plane, but frictionless.
Feeling intersections	Cylinders or spheres; feel the intersections as they're touched.

Table 1. Haptic effects and their gestural implications.

so that the line segments themselves could be felt.

We observed that static and dynamic friction seemed to have different effects. Dynamic friction allowed creation of sharp corners in the stroke and made it easier to stop the pen suddenly. In contrast, static friction only affected the beginning of the stroke, but made it easier to immediately start a stroke at a high speed. Recall that the speed of drawing has a direct effect on the playback frequency of a mapped sound file, so this implies a significant change in the sounds that can be produced. This will be further discussed in the next section.

Overly large friction coefficients interfered with drawing, but we found that moderate settings enabled improved control as compared to a completely frictionless surface. Viscosity had similar effects to dynamic friction, both seeming to increase control over drawing speed. They also helped in aiming the stroke towards a target, making it easier to create an intersection at the desired location. This last point is important when manipulating drum loops, for example.

Adding inertia to the haptic cursor in a sense has the opposite effect to dynamic friction: it reduced control accuracy, enforcing large curvature of strokes. For example, it made it difficult to perform a “scribbling” action, instead promoting the creation of round shapes and making it easier to maintain a constant drawing speed. As a compromise between these two observations, we tried modulating the cursor mass to be inversely proportional to the drawing speed; moving faster would result in constant, controlled speed, but slowing down would still allow sharp corners. This seemed more successful, allowing quick scribbling but promoting accuracy at low speeds.

Finally, one consequence of the use of DIMPLE's dynamic haptic scene construction is allowing the user to feel the shape of the strokes themselves. As mentioned, creating stroke intersections is an important action in DS, so physically feeling when intersections are made could be valuable, noting our motivation to remove emphasis on visual attention. When the line intersects with itself or another line, a small vertical bump is felt since the pen tip contacts the corresponding chain of objects (cylinders or spheres) embedded in the drawing surface.

A challenge with this setup was to make the haptic sensation useful but not distracting to the performer. We found that when the cylinders protruded too high above the surface such that their walls were perpendicular, it impeded movement instead of giving a slight indication. By embedding the spheres and cylinders further down into the surface, a more subtle slope was created. This highlights the fact that it is possible for the haptic effects to detract from the drawing experience if they are not well-parametrized.

3.1. Potential Musical Consequences

While no study of the concrete musical consequences of the addition of haptics has been performed as yet, we can begin to discuss such effects informally. Certain drawing gestures seem to have been made easier, and this has a collateral impact on the sounds that the software tends to produce given the default mapping.

The inclusion of static friction allows the performer to start a stroke at high speed. The means that strokes can have a high initial pitch, something that was more difficult to achieve with a graphic tablet since it contains very little natural static friction.

Adding viscosity to the system seemed to allow steadier drawing speed, leading to a steadier associated pitch on playback. Constant pitch can be very difficult when using a standard graphic tablet. Viscosity also made it easier to target particular spatial positions, which should make it easier to target specific parts of the sample associated with a given stroke.

Dynamic friction allowed the strokes to have sharp corners, which sound like pauses when the stroke plays back. Pen inertia led to larger curvatures. While currently DS does not directly use curvature as a sound synthesis parameter, future mappings will be designed to use it. In this case, we expect sharp or rounded corners to have particular audible effects.

The haptic sensation produced on intersection is important as extra feedback to reinforce the sense that an intersection has been made. The stroke topology is the main sequencing mechanism in DS, so this is important for the musician to be aware of. For instance, to help reduce reliance on visual feedback, DS could be switched to a non-drawing mode where the user could simply feel the current drawing surface to be reminded of the system state, before switching drawing back on.

4. CONCLUSION AND FUTURE WORK

We have described a platform for experimenting with haptic effects in the Different Strokes environment, implemented using DIMPLE. The two systems are synchronized over OSC connections that are filtered through Pure Data for basic message manipulation. DIMPLE in combination with Pure Data served as a convenient platform for experimentation and rapid prototyping of a variety of strategies.

The main motivation behind integrating haptics into DS was to explore ways in which haptic information can enhance the performer's experience. While still in the early stages of the project, our initial results are encouraging, as we have been able to describe ways in which usage was affected by changing various haptic properties.

In the future, we would like to more formally evaluate how different types of haptic feedback, such as those described here, affect usage for naïve and experienced DS performers. Some effects that we have not yet explored include using various virtual surface textures (e.g., bump mapping), adding haptic noise, and using non-uniform surface maps that reflect corresponding musical controls. We would also like to compare the use of such parameters in a visuo-haptic configuration versus visual-only and haptic-only variants.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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