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Motion Space Reduction in a Haptic Model of Violin and Viola Bowing

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Introduction

String instruments such as the violin and viola are hard to play. One of the main challenges is bowing: the position, velocity, and force on the bow are all three-dimensional, and control of the bow is complex and difficult. Good bowing technique requires an understanding of the required motion at every point of the stroke, as well as practice in order to develop the ability to produce the motion and control the bow. To focus on specific aspects of bowing or a problem area, it is helpful to abstract away from those that are not currently at issue. This is impossible to do with a real instrument, but a haptic model of a virtual system offers a solution.

Other researchers have developed haptic tools that are related to bowing string instruments[1, 2]. There is also research in robotics which describes 'virtual fixtures' that allow a user controlling the robot to feel the environment with some aspects of motion restricted artificially[3]. Haptic guidance has been defined as a paradigm in which the user is physically guided through the ideal motion, giving a kinaesthetic understanding of what is required, and has been shown to be effective in training[4]. We present a haptic model for bowing that uses a combination of these ideas: the model allows the user to feel the contact with the strings as a string player would (haptic guidance), while limiting movement of the bow (virtual fixtures) so that it cannot drift out of position.

A Haptic Model for Bowing

Design A virtual environment based on a bowing model has been implemented using a PHANToM force-feedback device (SensAble Technologies). The system includes a virtual platform representing the contact between the bow and a string. This object can be thought of as a flat surface viewed from the side, which slants from the top left to the bottom right of the virtual environment and screen. The user sits in front of the PHANToM and holds the stylus attachment (Figure 1), as if it were the handle of the bow, and moves it across the virtual platform while following the action on the monitor.

Figure 1. A player holds a plastic 'bow' and the pen attachment to the PHANToM haptic device and practices bowing on the violin E string or viola A string.

An initial prototype was developed that allows a string player to bow on a platform representing one string, the violin E string or viola A string, bowing at an angle of 67°, although this angle could be adjusted to represent other strings. The model was developed in consultation with experts with the aim of providing haptic feedback to the user similar to the bow passing over a string, representing the inherent constraints of the system. Additionally, the system would provide artificial constraints to help the player to practice one aspect of the bowing motion.

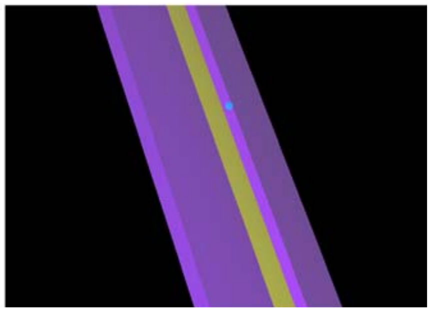

Figure 2. The playing platform: the middle section (yellow) represents the desired path for the bow. The action is constrained within this path by the raised platforms on either side (blue).

One such artificial constraint has been implemented which limits motion parallel to the strings, that is between the bridge and finger board. There is a narrow central rectangular playing platform, with two other rectangles on either side that have been slightly raised to help constrain or guide the bowing within the playing platform (Figure 2). The student selects the middle, sunken, platform and practices the correct bowing motion. If the bow deviates from the desired path the player will encounter the edges of the confining rectangles and therefore can practice secure in the knowledge that these errors will be corrected.

Preliminary Evaluation We ran an study in which seven experienced string players tested a version of the model developed to identify the haptic property values that determine the realism of the system. The results indicated that a realistic feel of bowing could be achieved. We also discussed with the participants their views on the usefulness of providing computer assisted guidance in a simulated environment, in particular the use of artificial constraints in focusing on a key skill. Some of the players had already tried various techniques for teaching students to open and close the elbow when bowing and they agreed that the haptic model could provide support for this activity.

Conclusions

We have developed and implemented a haptic model of bowing for the violin and viola. This model allows motion to be limited artificially in certain dimensions, which can be used to give the user feedback when the bow motion is incorrect. This approach helps the performer to focus on one specific problem, which can make the learning process more efficient.

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