Linked-Stick: Conveying a Physical Experience using a Shape-Shifting Stick

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CHI'15 Extended Abstracts, Apr 18-23, 2015, Seoul, Republic of Korea
ACM 978-1-4503-3146-3/15/04.
http://dx.doi.org/10.1145/2702613.2732712

Abstract
We use sticks as tools for a variety of activities, everything from conducting music to playing sports or even engage in combat. However, these experiences are inherently physical and are poorly conveyed through traditional digital mediums such as video. Linked-Stick is a shape-changing stick that can mirror the movements of another person's stick-shape tool. We explore how this can be used to experience and learn music, sports and fiction in a more authentic manner. Our work attempts to expand the ways in which we interact with and learn to use tools.

Author Keywords
Tangible Interface; Stick-based-interface; Conveying experiences;

ACM Classification Keywords
H.5.m. Information interfaces and presentation: User Interface

Introduction
Humans are the world's most accomplished tool users. The simplest and perhaps the earliest of these tools is the stick. Among many other things we use sticks to conduct music, play sports or even act as a weapon. Its simple shape makes it easily graspable, but it is both a versatile

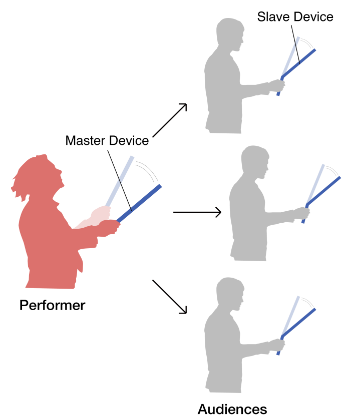

Figure 1: Conveying Experience with shape-shifting stick.

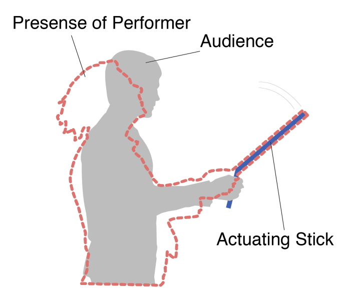

Figure 2: Feeling the presence of a performer through an actuating stick.

and nuanced tool, the motion of a stick can convey emotion and skill.

Digital tutorials or videos of stick-related tools cannot convey these detailed motions, and so are ineffective in teaching physical tasks or experiences. How can we create something that improves upon this interaction?

Linked-Stick is a handheld shape changing stick that can transmit the movements of one stick (belonging to the performer) to another (belonging to the audience) (Figure 1). By feeling a performer's movements, you are jacked-in to the original experience; big strokes convey action and passion whereas small movements show mechanics and detail (Figure 2). In this way, we convey the movements and feelings of a performer transmitted in a way that cannot be done in a purely digital medium (Figure 3).

Figure 3: Linked-Stick

In this paper, we explore how Linked-Stick can be used to convey the motion of a conductor's baton, the swing of a baseball bat or even the parry of a lightsaber in a fight.

Related Works

Currently, in order to convey one's performances to others, video is the most common medium used. Commercial wearable cameras have enabled us to record and share experiences from a first person point of view. Some work has been proposed to use Head Mounted Displays to allow users to view these experiences in a more first-hand manner[3]. In our project, we focus on creating physical interaction, by changing the shape of the stick to convey the movements of others, thus utilizing both visual and haptic feedback.

There has been some work in Tangible User Interfaces[7] to explore how we can convey one's presence or performance by controlling the shape and movement of physical interfaces[5]. inTouch[1] creates the illusion that two remote users are interacting with a shared physical shape by duplicating the shape and movements of the hands. MirrorFugue[9] enables users to listen to the music of a pianist playing by actuating piano-keys remotely and providing a visual image of the performers upper body. In our system, we propose a shape-changing interface, which users can feel the movements of by holding it in their hands, thus feeling jacked-in to the experiences, almost as if they were the performer themselves.

The stick as a form-factor for interaction devices has also been explored in HCI research. Most work has centered around using sticks as pointers or wands, so that they enable users to control digital information intuitively [2] or to provide vibration or force feedback to users' hands [4][6]. Commercial gaming systems [8] such as the Wii or PS4 also have stick-like controllers to detect motion gestures by users.

In our system, we propose a stick-shaped interface that can change its shape dynamically to convey another person's actions.

Figure 5: The Slave Device

Linked-Stick

We introduce Linked-Stick, a shape-changing stick-based-device that can mimic the motion of someone else using a stick-like tool. By representing this motion not just visually, but also using haptic feedback, users are able to feel like they are 'jacked-in' to another's experiences with the sensations the stick provides.

Implementation

As a system, Linked-Stick can be divided into 2 parts: the master and the slave (Figure 4). The master device is composed of a 3-axis accelerometer to detect the motion of the stick. The slave device includes a 3-axis accelerometer and 2 servomotors. In a master-slave (performer-audience) configuration, one stick transmits its rotational data to the other, which calculates the difference between the angles of the two sticks and then uses the servomotors to move the stick to reduce the difference in angles to 0. This motion data can either be pre-recorded and synced to some source (such as a music video) or transmitted in real-time.

The actual length of the slave device is 42cm, (grip part is 16cm), and the diameter is 2.6cm (Figure5). For the servomotors, we used HS-7775mg by Hitec, which has speed of sec/60° and torque of 9.0kg.cm.

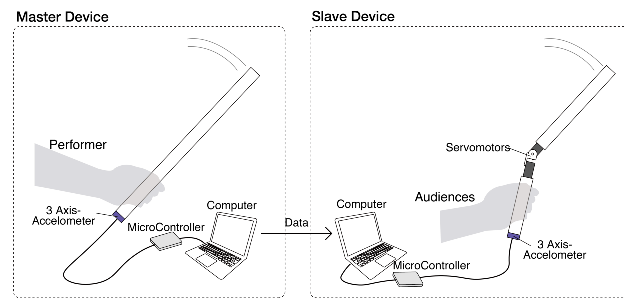

Figure 4: System Configuration

Applications

In this paper as applications we demonstrate 3 concrete scenes where this system can be used (Figure6).

The first such application is for listening to music. Normally a purely auditory experience, we explored how while holding the device and listening to music, users can feel the movement of instruments or of a conductor. In the case of a conductor using a baton, a user may listen to classical music with the device synchronized to the motion of the baton. In this way they can feel not only the tempo but also the emotion of the conductor and imagine how the instruments are positioned according to where the baton is pointing.

Figure 6: 3 Use Cases (conductor, baseball and sword battle in fictions)

The second application is for sports. Many sports use stick-like tools as part of the game, such as baseball, tennis, hockey or fencing. Our device is capable of enhancing the experience of watching those sports either live, or pre-recorded. For example, a baseball fan can experience a major leaguer's home-run swing in front of the TV, feeling the power, speed and technique of the player.

Finally, it may open up possibilities of feeling experiences that were never real to begin with, such as in a movie. Imagine watching StarWars while being able to feel the swing of the hero's lightsaber in a fight. By feeling jacked-in to this experience, the audience might feel as if they themselves are the hero.

Future Works

Future development will focus both on improving technical properties of the current prototype, and on enhancing the user's tangible experience.

Firstly, the applications of Linked-Stick explored in this paper are focused on master-to-slave configurations. More work can be done in exploring peer-to-peer interactions with feedback from both sticks. In a one-to-one setting it can be used to such as to enhance a learner-teacher relationship. For example, if the teacher is reproducing a specific movement, while the learner tries to mimic it, the first will be able to see how far off the learner's movements are, and the latter

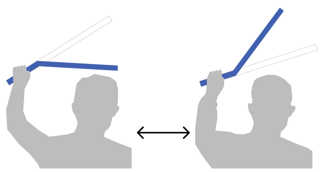

Figure 7: Image of bi-directional interaction using the device of Linked-Stick.

will understand how he needs to adjust his gestures (Figure7).

Another aspect that can be improved is the capability of the stick to communicate physical experiences. The current prototype has only 2 degrees of freedom in motion, which can be alleviated by adding more servomotors. Furthermore, physical experiences are characterized not only by motion, but also texture, size or firmness. In the future, we may explore adding other tangible feedback methods such as pneumatic actuation to change the diameter of the stick's handle or create a specific texture. These changes aim to let the user experience move beyond just motion into other physical qualities.

We also plan to make the device wireless by packaging in a blue-tooth enabled microcontroller and battery. Accordingly, by connecting the device to smartphone apps, it is easy to imagine the possibility of a future in which people don't only exchange texts or pictures or videos but also tangible experiences.

The implementation of all these features requires, however, a consistent evaluation of how effectively motions and emotions can be actually communicated and recognized by the users, and in general an understanding of how people would naturally interact with such interface. These are important questions to answer in order to strengthen the concept and improve the design. Therefore testing the device with a larger number of people and in various scenarios (not just music, sports or sword fighting but also cooking, calligraphy, fishing and so on) is a critical step in our investigation.

Conclusion

In this paper we have proposed a system that allows the user to tangibly experience other people's motions that are accomplished with a stick-shaped interface. We have explored how our shape-changing stick can replicate motions related to music, sports and fictional scenarios and make the user more involved in the action by adding physical sensations to it. In addition, Linked-Stick has the potential to be used as a learning (and synchronization) tool and as new platform to exchange and communicate motion-based experiences. User testing will help us refine the current design and investigate new applications.

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