# Augmentation of Kinesthetic Sensation by Adding "Rotary Switch Feeling" Feedback

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## ABSTRACT
In sports, dancing and playing music, it is important to achieve correct body movement as it greatly affects performance. However, matching one's movement with ideal movement is fundamentally difficult, because we do not have a detailed perception of our own body movement. In this study, we propose to present "rotary switch feeling" feedback as a new haptic cue. A periodical ticking sensation, like that of a rotary switch, can be presented at each joint so that the user vividly perceives his/her movement. This paper presents a simple mechanical prototype that is attached to the elbow.

## Categories and Subject Descriptors
H5.2. INFORMATION INTERFACES AND PRESENTATION: User Interfaces – haptic I/O, prototyping.

## General Terms
Performance, Design, Human Factors.

## Keywords
Kinesthetic Sensation, Motion Instruction, Rotary Switch Feeling.

## 1. INTRODUCTION
In sports, dancing, and playing music, performance heavily relies on a person's body movement. Therefore, learning correct movement is important. However, following ideal movement is fundamentally difficult, since we do not have a detailed perception of our own body movement.

We grasp our body movement by integrating multisensory cues, especially the visual cue dominates [1]. Visually grasping our own body movement by directly looking at the body or using a mirror is one of the most obvious methods to grasp body movement. However, we cannot always look at ourselves during a performance. Furthermore, without a visual cue, the accuracy of movement drops significantly, which means that tactile sensation is not sensitive enough to grasp body movement.

To deal with this issue, we propose new haptic cues synchronized with body movements, which provides a new and much clearer kinesthetic sensation. In this work, we focus on the tactile feedback of "rotary switch feeling", which is a typical tick tack feeling presented by a rotary switch. This tick-tack feedback is often applied to a dial on the dashboard of an automobile, which allows the driver to adjust the dial without looking at their hand [2]. The periodical ticking sensation can be presented at each joint of the body so that the user vividly perceives his/her movement without visual cues. In this paper, we present a simple mechanical prototype that is attached to the elbow (see Figure 1).


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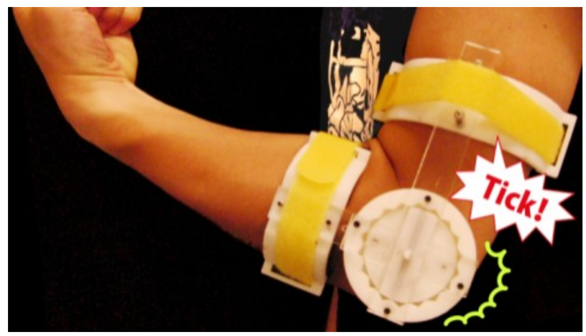


**Figure 1. Rotary switch feeling feedback at the elbow**

## 2. RELATED WORKS
A number of works have proposed the teaching of body movements through tactile feedback. Rosenberg proposed "Virtual Fixtures" [3] which are guiding force to simplify body movement. van der Linden et al. mounted a vibration motor on the waist, wrist and elbow to help violin training though position error feedback [4]. The training, however, revealed that the player committing to avoid vibrotactile feedback could no longer concentrate on playing. The fundamental problem of this scheme is that error feedback may accomplish correct movement, but the user could not experience "proactive" motion.

Some works have advocated that "proactiveness" is essential in motor training. Saga et al. proposed a haptic teaching system for handwriting, assuring proactiveness by generating a force that is in the opposite direction to the expert's ideal motion [5]. Lee et al. advocated that haptic disturbances may motivate subjects to try to do improve their form [6].

Our hypothesis to enhance teaching methods is that rather than presenting a "difference" between ideal and real movement, we should present the real movement itself. In other words, "enhancing" the kinesthetic sensation, rather than "correcting" error, should be effective for motor learning. The error feedback may realize the ideal path, but it lacks proactiveness, and we thus do not learn the motion, whereas if the real movement is clearly grasped, we do not lose proactiveness and we learn the motion more quickly.

## 3. DEVICE DESIGN

As shown in Figure 2, the device consists of a circular joint, forearm link, upper-arm link and attachment for mounting on the user's arm. The circular joint is composed of an outer cylinder and inner solid cylinder, which are connected to the forearm link and upper-arm link (see Figure 3). The outer cylinder has periodical bumps on its inner wall, and the inner cylinder has a spring inside. Two stainless-steel balls are sandwiched between the spring and the inner wall of the outer cylinder. This structure is employed in an ordinary rotary switch. The diameter of the inner wall of the outer cylinder is 50mm and there are 18 smooth bumps for every 20 degrees. The maximum height of the bumps is 3mm. The angular range of movement is 150 degrees.

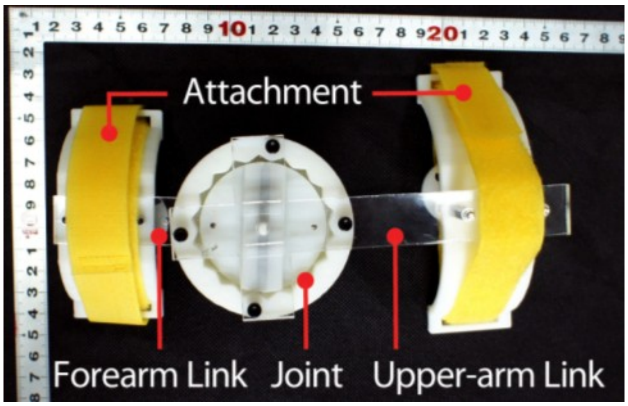


**Figure 2. Rotary switch feeling device**

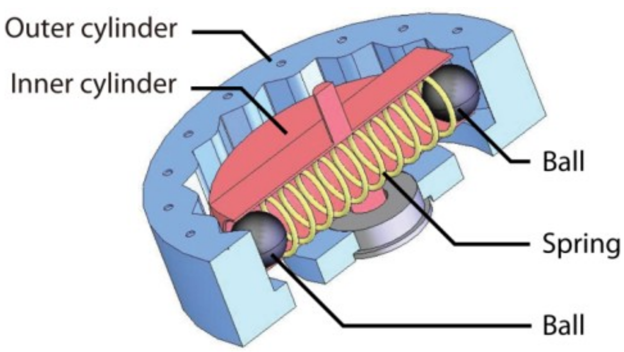


**Figure 3. Construction of the circular joint**

### 3.1 Principle of Tick-Tack Display

Figure 4 shows the principle of producing "rotary switch feeling" feedback. The balls are initially in the concave part of the inner wall of the outer cylinder (see Figure 4-1). By bending the elbow and rotating the inner cylinder, the balls move up the slope of a bump, while they compress the spring and generate an opposing force (see Figure 4-2). After the balls reach the top of their respective bumps, they travel down to the next concave parts, pressed by the spring. At this moment, elastic energy stored in the spring is released and converted to collisions between the balls and inner wall, which is perceived as a tick-tack feeling (see Figure 4-3).

Note that this device design is in its prototype stage. By varying the diameter of the inner wall, the number of bumps, the height of the bumps and the stiffness of the spring, it is possible to adjust the resolution and reactive force of the device. Optimization of the device is one of our future works.

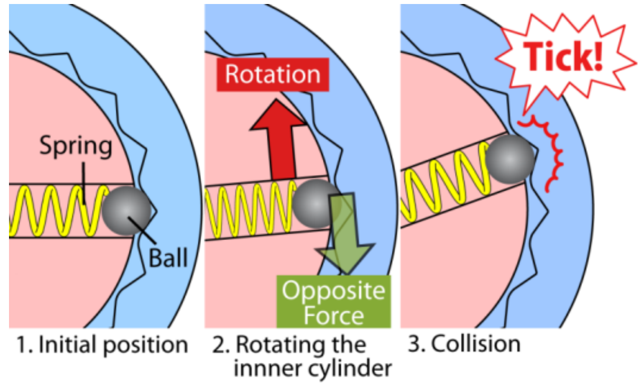


**Figure 4. Principle of the rotary switch feedback device**

## 4. CONCLUSION AND FUTURE WORK

This paper proposed the augmentation of kinesthetic sensation by presenting "rotary switch feeling" feedback at the elbow joint as a new haptic cue for enhancing the bodily sensation related to self motion. We also designed and built a simple mechanical device that can present clear discrete sensation at the joint.

We are currently evaluating the system in a haptic training scenario using a single joint. Our future efforts will be to attach the device to numerous parts of the body to apply the principle for whole-body motion.

In addition, we will investigate the possibility of using the device as a new haptic display. If the user is used to the device and can rely on the rotary switch feeling feedback, changing the resolution of the bumps during motion would induce an illusory kinesthetic sensation. We envision that this possible phenomenon can be applied to a large field of virtual-reality applications.

## 5. REFERENCES

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