Controlling Trajectories with OneButton and Rhythm

Alessio Bellino
Pontificia Universidad Católica de Chile
Santiago, Chile
abellino@uc.cl

Davide Rocchesso
Università degli Studi di Milano
Milan, Italy
davide.rocchesso@unimi.it

ABSTRACT

We demonstrate two-dimensional navigation with velocity control on a single button. Users can vary the speed of the controlled object by rhythm tapping, and can control direction by pressing and tilting, releasing the button once the desired rotation is achieved. Feedback is multisensory. Tactile pulses are being delivered at 30-degree intervals during rotation, simulating the detents of a rotary encoder. Simultaneously, a sonic glissando accompanies rotation, raising or lowering pitch according to the change of direction. Absolute positional feedback is provided visually as well as auditorilly, with an intermittent auditory tone whose pitch conveys vertical position, panned to the left or to the right depending on horizontal position. The rhythmic pace corresponds directly to the on-screen element speed, defined by the tapping interval. Participants will be engaged in a target-following task, thus being able to appreciate the precise speed and direction control of the multisensory navigation experience.

CCS CONCEPTS

• **Human-centered computing → Auditory feedback**; **Interaction techniques**; • **Hardware → Tactile and hand-based interfaces**.

KEYWORDS

Multisensory interaction, Rhythmic interaction, Two-dimensional navigation

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1 INTRODUCTION

The intrinsic relationship between rhythm and spatial movement is evident, particularly in the rhythmic nature of animal locomotion. Analyzing footsteps, for instance, allows us to deduce various aspects of a person's walking behavior, including their speed in the environment. Given the fundamental connection between spatial motion trajectories and rhythmic patterns, it is logical to anticipate the use of rhythms for both controlling and monitoring moving objects.

Despite this potential, the exploration of rhythm in navigating spaces, particularly through the generation and adjustment of rhythmic patterns, remains largely unexplored in the literature on rhythmicity for interaction.

In prior research, we investigated navigating two-dimensional spaces using rhythmic patterns generated by tapping two buttons, demonstrating users' ability to control the direction and speed of a moving object through discrete duplets or triplets [7]. In our current work, we introduce a technique within a similar domain, relying on rhythm but with a streamlined interaction mechanism. Notably, we now utilize a single button instead of the previously explored two-button setup.

2 MULTISENSORY RHYTHMS IN HCI

Rhythm has been examined in various contexts, involving sensory modalities such as auditory, visual, and tactile, due to its amodality [3]. Previous studies have suggested the use of rhythmic tutoring through handclapping for interaction purposes [5]. Additionally, rhythmic patterns, incorporating short and long taps and breaks, have been proposed as an input method to replace single commands. Evaluation has been carried out on recall efficacy, revealing similarities to keyboard shortcuts [4]. Rhythmic microgestures have been introduced as a means of non-visual interaction in mobility scenarios [2]. The exploration of control selection through visual rhythmic patterns and motion synchronization has been investigated across a diverse range of users [1]. Additionally, rhythmic tactons have been implemented in the context of the car driving environment [6].

We previously embarked on an initial exploration of navigation of two-dimensional spaces by rhythmic patterns using two buttons [7]. As a novel alternative, this demonstration introduces an interaction within the same thematic stream, using a single button, referred to as OneButton. Rhythmic interaction for motion control naturally leads to discrete control actions, in the sense that a rhythmic cell may be introduced at discrete points of the space-time continuum, when and where an existing trajectory needs to be adjusted or modified. The multisensory display and iteration of such cell would enable continuous monitoring of the object motion. In the proposed interaction, it is not necessary to maintain continuous engagement with the control button, as it may be disregarded once the controlled object is set to persist in Galilean inertial motion. From the user perspective, this then necessitates only intermittent actions, rendering the interface conducive to peripheral interaction without demanding persistent and continuous action.

3 INTERACTION RATIONALE

We aimed for simplicity in our interaction mechanism, opting for a minimalist design. To enhance the user experience, we incorporated a multisensory approach into a button, integrating tactile and

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auditory feedback. Similar to our earlier project, TickTacking [7], users can regulate the speed of the arrow-like element by adjusting the tapping rate. However, we have also introduced the capability of holding down the button to control the rotation of the element.

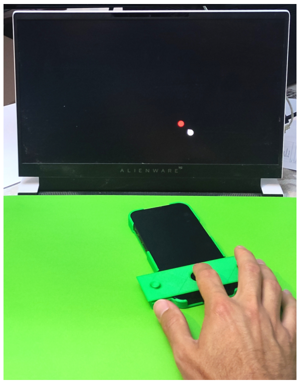

Figure 1: The experimental setup illustrates the path-following task, where the user controls the gray arrow-like element with the goal of staying as close as possible to the red point. The iPhone simulates the button using its Taptics Engine, delivering haptic pulsations.

In the early phases of our design, to ensure a consistent rhythmic control, we initially established a fixed clockwise direction and rotation speed while the button is held down. This choice aimed to maintain rhythmic control, as the act of keeping the button pressed can be viewed as a rhythmic expression in itself. To elaborate, it is comparable to a drummer striking a crash cymbal (similar to pressing the button) and then muffling the sound by damping the vibrations with their hands (analogous to releasing the button). This analogy underscores the rhythmic essence inherent in both actions – holding and releasing the button.

For precise control, we opted to utilize the tilting motion of the finger on the button to determine the direction of rotation (a right tilt corresponds to clockwise, and vice versa) and the speed of rotation (greater finger inclination results in a faster speed). While tilting may not possess inherent rhythmic features, this decision enables us to improve precision in control. To improve user feedback on rotation, we integrated a tactile pulse at intervals of 30 degrees of rotation, simulating the detents of a rotary encoder. Simultaneously, a sonic glissando accompanies rotation, raising or lowering pitch according to the change of direction.

Additionally, we incorporated auditory display in the form of sequences of piano-like tones, to convey two essential aspects: (1) the controlled-element position in the two-dimensional space and (2) the speed of the element. In representing position, we use pitch and spatialization. The vertical limits of the 2D plane correspond to a range of two octaves, and the pitch varies with very fine granularity, accurately corresponding to the element's position measured in pixels. Lower pitches signify a lower position and higher pitches indicate a higher position.

For horizontal limits on the 2D plane, we apply right/left spatialization by amplitude panning. This means that the extreme right position is accompanied by the tone exclusively on the right, and the extreme left position is associated with the tone exclusively on the left.

Speed is conveyed by the repetition rate (*tempo*) of the piano-like tones: higher tempi corresponding to faster motions.

When complementing visual information, sound and vibration may not directly enhance precision, but nevertheless provide additional information. They may increase awareness of the position/rotation of the controlled element, that is particularly beneficial when the element cannot be seen, either because the user is visually impaired or because their visual attention is directed somewhere else.

4 DEMONSTRATION

To illustrate the functionality of the interaction, we devised a target-following task. A target moves on the screen, tracing a regatta-like path, and conference participants are encouraged to track the target, staying as close to it as possible as illustrated in Figure 1. After completing the path-following tasks, participants can review their performance as illustrated in Figure 2. Additionally, participants have the option to experiment with the interaction by disabling tactile and/or auditory feedback to observe how partial sensory deprivation affects their performance. A demonstration of the task, along with path visualization, can be watched at: https://youtu.be/uLVLdQcD7l8

The interaction employs an Apple iPhone to simulate the button as illustrated in Figure 1. The iPhone, natively equipped with its Taptic Engine, provides effective tactile feedback. The smartphone is covered by a layer of plastic, featuring the designated hole, which indicates the point where users should interact with their finger. Touch, hold, and tilt[1] actions are detected by the touchscreen.

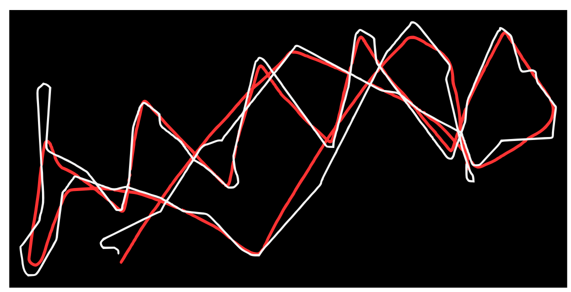

Figure 2: Visualization of path following data.

5 CONCLUSIONS

Ongoing studies are being conducted to examine precision and assess the impact of various tactile and auditory feedback mechanisms. These studies aim to contribute to a better understanding of multisensory interaction and its role in enabling two-dimensional navigation in a minimal and accessible way, particularly for individuals with disabilities like blindness or visual impairments.

ACKNOWLEDGMENTS

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[1]The finger inclination can be detected by analyzing the slight variation in its relative position.

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