Focal Feedback for Finding

Krispin Leydon

Interaction Design Centre
University of Limerick
Limerick, Ireland
Krispin.Leydon@ul.ie

Abstract. Tools we employ to reveal hidden features of the physical world provide feedback with a focus. When we tune a radio, aim a flashlight, position a magnifying glass or follow a Geiger counter, we experience sensory feedback along a smooth focal gradient, a gradient that guides us into alignment with the phenomenon we seek to examine. Focal feedback contributes to seamlessness as we transition between spaces of direct and mediated perception.

In transitions between the physical world and digitally mediated spaces, seamlessness represents a fundamental challenge. "Feedback for Finding" explores how one particular form of physical/digital transition — item identification through use of a hand-held scanner — is changed by the introduction of continuous focal feedback. Anticipated outcomes of this research include support for locating physical objects digitally, an improved understanding of manual scene analysis and a platform for further exploration.

Keywords: vibro-tactile display, haptic, targeting, location, tracking, radio frequency identification, augmented reality

1 Introduction

Warm,
Cold, colder, cold...
Warm - getting warmer.
Hot. Very hot – You've found it!

This reconstructed exchange from the popular children's game "find the spoon" (known by various names in various places) illustrates how the presence of a *focal feedback gradient* – in this case a "hot" center surrounded by an increasingly "cool" periphery – can assist a seeker to locate an object of search. We experience similar gradients in everyday targeting activities such as aiming a flashlight, tuning a radio and positioning a magnifying glass. But where does "cold" end? Where does "hot" begin? What factors influence this categorization, and to what extent? This research explores how alternate contours mapping proximity to feedback stimulus intensity effect targeting times within "find the spoon"-like location activities. The contours in Figure 1 illustrate several possible distance/intensity mappings. The research informs development of a hand-held locating device that provides proximity cues through vibro-tactile feedback.

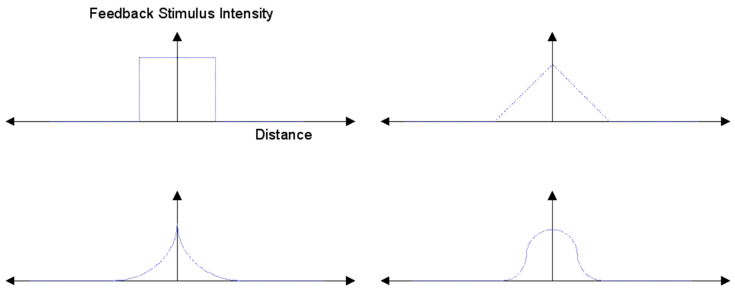

Fig. 1. Four possible contours for mapping distance (between seeker and sought) to the intensity of a feedback stimulus

2 Outline

In this paper, I first present three scenarios illustrating how vibro-tactile targeting cues could enhance and enable certain human activities. Next, I recapitulate related research. Finally I discuss work accomplished on the project thus far and outline future plans.

3 Scenarios

What, practically, would it mean to have automated assistance for targeting the location of everyday objects in room-sized environments, assistance that is provided by a vibro-tactile feedback gradient? The following scenarios illustrate how such gradient-based assistance might prove beneficial.

3.1 Easing Eye Contact

Rupa is a cashier at Radio House, a small consumer electronics store. She rings up hundreds of products each week, and her handling of individual products during checkout provides customers with the opportunity to ask last minute questions. Rupa can "feel" the location of product identification labels on packages through the handle of her hand-held scanner. Since she can locate and scan IDs largely by touch, she is free to maintain eye contact and conversation with customers more easily during checkout than she could while using a traditional product ID scanner. Touch adds a nuance to her use of the hand-held scanner, a nuance that facilitates hundreds of transactions each week.

3.2 Dowsing for Documents

Alfred, a research scientist, dreams of the ability to summon documents to his fingertips instantaneously from the cluttered corners of his office. Locomotive magic pending, he settles for automated assistance. A wand with twitching behavior akin to a dowsing rod's facilitates retrieval of his papers while not precluding other techniques for location nor interfering with his existing systems of organization that suffice most of the time.

3.3 Supporting a Soundscape

Nathan, a sound engineer and environmental activist, wishes to juxtapose urban and pristine wilderness sound recordings in an exhibit calling for ecological responsibility. The exhibit consists of a large globe centrally located in a room and a rack of stethoscopes to one side. Upon entering the room, visitors receive a stethoscope and the injunction to examine the "pulse of the planet". By moving stethoscope heads over the globe surface visitors tune between spatially mapped sound recordings as if tuning between stations on an analog radio. Low frequencies are translated into vibrations of the stethoscope head; this vibration facilitates location of planetary sound sources, improves perceived sound quality and communicates that the planet is alive. Visitors leave the exhibit having considered their own relation to the earth as a doctor/patient relationship and having had the opportunity to traverse their own unique paths through a sonic world.

In each of these scenarios, the ability to sense physical proximity via virtual touch facilitates an activity. Tactile location allows Rupa to attend more fully to customers while scanning products, provides Alfred with an auxiliary way to retrieve documents from his paper archives[1] and offers Nathan a compelling medium for his ecological message.

4 Related Research

This project sits at the intersection of two streams of research. One concerns haptic cues for targeting, the other concerns automated techniques for sensing the proximity and identity of everyday objects (books, pens, keys, clothes, etc.) in room-sized spaces.

1 This scenario presumes a) that there is an effective mechanism for registering documents that enter Alfred’s collection and b) that Alfred has an easy way to specify the document he seeks. Although these are considerations of over-riding importance, they are beyond the scope of this project.

4.1 Haptic Targeting Cues

In 1954, Fitts [1] derived a "quantitative predictor for movement time in peg-in-hole ([physical] targeting) type tasks", an empirical relationship that has become known as "Fitt's Law" [2]. Card [3] adapted this relationship to the study and refinement of pointing devices for computers, an application contributing to the commercial introduction of the mouse. Hasser et al. [4] later examined mice equipped with haptic feedback and demonstrated that "attractive basins" synthesized through active force feedback could reduce movement times required for mouse-based targeting tasks. Martin et al. [1] built upon these findings to demonstrate that active force feedback can reduce movement times required for mouse-based steering and combined steering-targeting tasks.

The research trajectory presented above focuses on the role of *force* feedback accompanying pointer movement in *virtual* environments. The role of *vibro-tactile* feedback accompanying pointer movement in *physical* environments is largely unexplored and is the subject of this investigation.

4.2 Sensing the Identity and Proximity of Everyday Objects within Room-Sized Spaces

While numerous electronic & computational techniques have been developed to measure relative proximity, few have the potential to support "find the spoon"-like scenarios due to the technically demanding set of constraints they would entail:

- Range suitable for room-sized spaces
- High spatial and temporal resolution
- Wirelessness
- No line-of-sight requirement. Objects are "findable" even if visually obscured.
- Minimal on-object label/tag/marker requirements. Markers, if necessary, do not require batteries and do not restrict the use or placement of marked objects.

Given these constraints, the tracking techniques of greatest relevance are "Ring-Down" and "Swept-RF" tracking, both pioneered by Hsaio [5]. Both methods make use of received signal strength from magnetically-coupled resonant tags[2] (serving as on-object markers) to assess proximity. In both Ring-Down and Swept-RF tracking, tags' resonant frequencies function as unique identifiers for tagged objects. In Ring-Down tracking, frequencies are polled one by one, while in Swept-RF tracking an entire ID frequency range is examined in a continuous fashion. While these frequency-based identification techniques have numerous advantages (principally high speed and minimal inter-tag interference) they limit the number of objects that can be identified and necessitate careful system calibration. The method I've chosen for assessing proximity is inspired by Hsaio's work, but relies on the received signal

[2] Such tags are commonly used in electronic article surveillance (EAS) systems to prevent theft in retail establishments.

strength of RFID tags – tags that communicate through a digital protocol – to accommodate a large set of “findable” objects and simplify system calibration.

5 Work Overview & Future Work

Analysis of vibro-tactile cues for targeting in physical environments depends first and foremost on the development of a sound experimental apparatus. Figure 2 depicts a high level block diagram for the apparatus currently under construction.

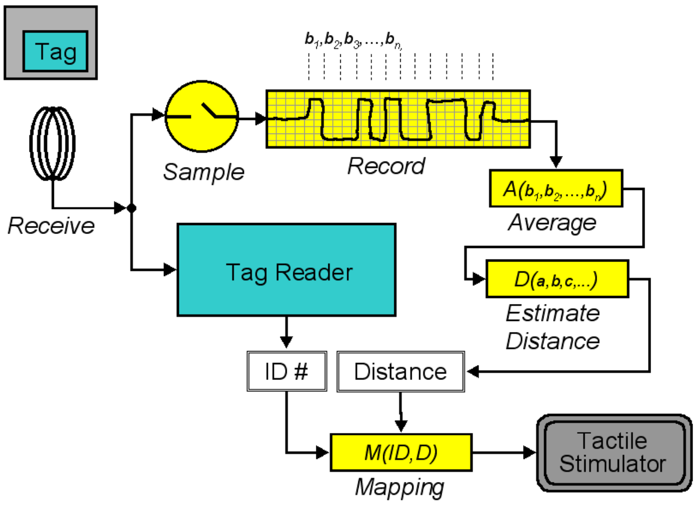

Fig. 2. System diagram for the experimental apparatus

The system functions as follows: First, an antenna receives a transmission from an in-range RFID tag. The transmission is then decoded to reveal the tag’s unique ID number. Simultaneously, the transmission’s amplitude is recorded to obtain a measure of the received signal’s strength. This signal strength is then used to construct a distance estimate for the tag. Based on the distance estimate and tag ID number, a mapping function modifies a tactile stimulator’s amplitude of vibration. Changes in the intensity of the stimulator’s vibration are sensed by the seeker through a hand grip, and the resulting percepts used to home in on the location of the tagged item. Figure 3 illustrates the system in use.

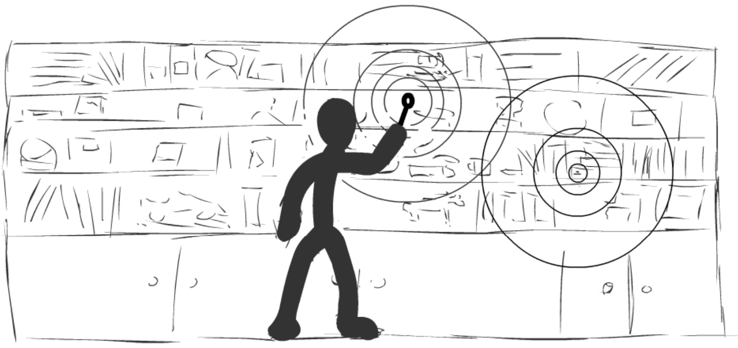

Fig. 3. Targeting the location of an item with the assistance of vibro-tactile feedback provided by a hand-held device

Two anticipated difficulties will limit the proposed system's utility as an experimental apparatus. First, it may prove infeasible to extend the system's tracking range beyond a meter. It may prove necessary to limit this study to shelf-sized rather than room-sized spaces. Second, the electromagnetic field that couples tag with reader will be non-linear and non-uniform, and this will have a pronounced effect on the accuracy of distance estimates. This, in turn, will constrain the variety of distance/intensity contours that can be synthesized and analyzed with accuracy. The extent to which this investigation will be limited by these two anticipated difficulties remains to be seen.

Implementation of the system's vibro-tactile component will be straightforward. I plan to use the VBW32 skin stimulator from Audiological Engineering Corporation [10] – a successor of the V1220 transducer recommended by Chang [6] and Gunther [7] – driven at a frequency between 200 and 250Hz, as per van Erp's [8] guidelines for vibro-tactile display.

The project's progress to date is as follows: I have implemented and refined an RFID tag reader design (published by Microchip Technology [9]) and am in the process of modifying it to estimate distance and provide vibro-tactile display. An evaluation plan based on specific targeting tasks will be constructed once the system has been fully implemented and its limitations are known.

References

1. Dennerlein, J. T, Martin, D. B. and C. Hasser. Force-Feedback Improves Performance For Steering and Combined Steering-Targeting Tasks. *Proceedings of CHI 2000*, 2(1):423-429, 2000.
2. Fitts, P. M. The Information Capacity of the Human Motor System in Controlling the Amplitude of Movement. Journal of Experimental Psychology, 47(6):381-391, June 1954.
3. Card, S. Available at <http://unrev.stanford.edu/presenters/stu_card/body_stu_card.html>, March 31, 2003.

4. Hasser C, Goldberg A, Martin K, Rosenberg L. User Performance in a GUI Pointing Task with a Low-Cost Force-Feedback Computer Mouse. Seventh Annual Symposium on Haptic Interfaces, International Mechanical Engineering Congress and Exposition, Anaheim, CA, 1998.
5. K.Y. Hsaio, Fast Multi-Axis Tracking of Magnetically-Resonant Passive tags: Methods and Applications. Masters Thesis. Cambridge, MA. MIT, 2001.
6. Chang, A, O'Modhrain, S, Jacob, R, Gunther, R. and H. Ishii. ComTouch: Design of a Vibrotactile Communications Device. Proceedings of DIS2002:312-320, London, June 2002.
7. Gunther, E, Davenport, G. and S. O'Modhrain. Cutaneous Grooves: Composing for the Sense of Touch. Proceedings of NIME2002:37-42, Dublin, May 2002.
8. van Erp, J.B.F. Guidelines for the Use of Vibro-Tactile Displays in Human Computer Interaction. Proceedings of Eurohaptics2002: 18-22, Edinburgh, 2002.
9. Microchip Technology Inc, MicroIDTM 13.56MHz RFID System Design Guide Available at <http://www.microchip.com>, Microchip Technology Inc, 2001 March 31, 2003.
10. See <http://www.tactaid.com/aboutus.html>, Audiological Engineering Corporation, March 31, 2003.