Journals

e107, Monday 14 November 2011 - 16:09:26

» Y. Visell, F. Fontana, B.L. Giordano, R. Nordahl, S. Serafin, R. Bresin, Sound design and perception in walking interactions, Int. J. Human-Computer Studies 67 (2009), pp. 947 959.

This paper reviews the state of the art in the display and perception of walking generated sounds and tactile vibrations, and their current and potential future uses in interactive systems. As non-visual information sources that are closely linked to human activities in diverse environments, such signals are capable of communicating about the spaces we traverse and activities we encounter in familiar and intuitive ways. However, in order for them to be effectively employed in human computer interfaces, significant knowledge is required in areas including the perception of acoustic signatures of walking, and the design, engineering, and evaluation of interfaces that utilize them. Much of this expertise has accumulated in recent years, although many questions remain to be explored. We highlight past work and current research directions in this multidisciplinary area of investigation, and point to potential future trends.

» Y. Visell, A. Law, J. Cooperstock, Touch is Everywhere: Floor Surfaces as Ambient Haptic Interfaces. IEEE Transactions on Haptics, 2 (3), July-September, 2009.

Floor surfaces are notable for the diverse roles that they play in our negotiation of everyday environments. Haptic communication via floor surfaces could enhance or enable many computer supported activities that involve movement on foot. In this paper, we discuss potential applications of such interfaces in everyday environments, and present a haptically augmented floor component through which several interaction methods are being evaluated. We describe two approaches to the design of structured vibrotactile signals for this device. The first is centered on a musical phrase metaphor, as employed in prior work on tactile display. The second is based upon the synthesis of rhythmic patterns of virtual physical impact transients. We report on an experiment in which participants were able to identify communication units that were constructed from these signals and displayed via a floor interface at well above chance levels. The results support the feasibility of tactile information display via such interfaces, and provide further indications as to how to effectively design vibrotactile signals for them.

» Y. Visell, Tactile Sensory Substitution: Models for Enaction in HCI. Interacting with Computers, 21 (1-2), Elsevier, 2009.

To apply enactive principles within human-computer interaction poses interesting challenges to the way that we design and evaluate interfaces, particularly those that possess a strong sensorimotor character. This article surveys the field of tactile sensory substitution, an area of science and engineering that lies at the intersection of such research domains as neuroscience, haptics, and sensory prosthetics. It is argued that this area of research is of high relevance to the design and understanding of enactive interfaces that make use of touch, and is also a fertile arena for revealing fundamental issues at stake in the design and implementation of enactive interfaces, ranging from engineering, to human sensory physiology, and the function and plasticity of perception. A survey of these questions is provided, alongside a range of current and historical examples.

» G. Cirio, M. Marchal, S. Hillaire, A. L écuyer, Six Degrees-of-Freedom Haptic Interaction with Fluids, IEEE Transactions on Visualization and Computer Graphics, in press.

We often interact with fluids in our daily life, either through tools such as when holding a glass of water or directly with our body when we swim or we wash our hands. Multimodal interactions with virtual fluids would greatly improve the simulations realism, particularly through haptic interaction. However, achieving realistic, stable and real-time force feedback from fluids is particularly challenging. In this work, we propose a novel approach that allows real-time 6 Degrees of Freedom (DoF) haptic interaction with fluids of variable viscosity. Our haptic rendering technique, based on a Smoothed-Particle Hydrodynamics physical model, provides a realistic haptic feedback through physically-based forces. 6DoF haptic interaction with fluids is made possible thanks to a new coupling scheme and a unified particle model, allowing the use of arbitrary-shaped rigid bodies. Particularly, fluid containers can be created to hold fluid and hence transmit to the user force feedback coming from fluid stirring, pouring, shaking and scooping, to name a few. Moreover, we adapted an existing visual rendering algorithm to meet the frame rate requirements of the haptic algorithms. We evaluate and illustrate the main features of our approach through different scenarios, highlighting the 6DoF haptic feedback and the use of containers.

» S. Papetti, F. Avanzini, D. Rocchesso, *Numerical Methods for a Nonlinear Impact Model: A Comparative Study With Closed-Form Corrections*, IEEE Transactions on Audio, Speech, and Language Processing, 19(7), pp. 2146-2158, 2011.

A physically based impact model already known and exploited in the field of sound synthesis is studied using both analytical tools and numerical simulations. It is shown that the Hamiltonian of a physical system composed of a mass impacting on a wall can be expressed analytically as a function of the mass velocity during contact. Moreover, an efficient and accurate approximation for the mass outbound velocity is presented, which allows to estimate the Hamiltonian at the end of the contact. Analytical results are then compared to numerical simulations obtained by discretizing the system with several numerical methods. It is shown that, for some regions of the parameter space, the trajectories of the discretized systems may significantly drift from the analytically derived curves. Two approaches, based on enforcing numerical energy consistency, are then proposed to improve the accuracy of numerical simulations.

» R. Nordahl, S. Serafin, L. Turchet, *Sound synthesis and evaluation of interactive footsteps and environmental sounds rendering for virtual reality applications*. IEEE Transactions on Visualization and Computer Graphics, 17(9):1234-1244, 2011.

We propose a system that affords real-time sound synthesis of footsteps on different materials. The system is based on microphones, which detect real footstep sounds from subjects, from which the ground reaction force (GRF) is estimated. Such GRF is used to control a sound synthesis engine based on physical models. Two experiments were conducted. In the first experiment, the ability of subjects to recognize the surface they were exposed to was assessed. In the second experiment, the sound synthesis engine was enhanced with environmental sounds. Results show that, in some conditions, adding a soundscape significantly improves the recognition of the simulated environment.

» Y. Visell, B. Giordano, G. Millet, J. Cooperstock, *Vibration Influences Haptic Perception of Surface Compliance During Walking*. PLoS ONE 6 (3), March, 2011.

Background: The haptic perception of ground compliance is used for stable regulation of dynamic posture and the control of locomotion in diverse natural environments. Although rarely investigated in relation to walking, vibrotactile sensory channels are known to be active in the discrimination of material properties of objects and surfaces through touch. This study investigated how the perception of ground surface compliance is altered by plantar vibration feedback.
Principal Findings: Subjects walked in shoes over a rigid floor plate that provided plantar vibration feedback, and responded indicating how compliant it felt, either in subjective magnitude or via pairwise comparisons. In one experiment, the compliance of the floor plate was also varied. Results showed that perceived compliance of the plate increased monotonically with vibration feedback intensity, and depended to a lesser extent on the temporal or frequency distribution of the feedback. When both plate stiffness (inverse compliance)

and vibration amplitude were manipulated, the effect persisted, with both factors contributing to compliance perception. A significant influence of vibration was observed even for amplitudes close to psychophysical detection thresholds.
Conclusions/Significance: These findings reveal that vibrotactile sensory channels are highly salient to the perception of surface compliance, and suggest that correlations between vibrotactile sensory information and motor activity may be of broader significance for the control of human locomotion than has been previously acknowledged.