User-Defined Gestural Interactions Through Multi-Modal Feedback

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Abstract

Rapid advancements are being made in the field of HCI. However, most commercial designs using these technologies employ limited control schema and privilege interactions borrowed from pre-existing technologies. This paper suggests considering the whole body to create rich environments using co-adaptive technologies.

Author Keywords

Multimodal; Accessible Interfaces; Musical Interfaces Physical Games; Machine Learning; Dance

ACM Classification Keywords

H5.2. Information interfaces and presentation: User Interfaces

Introduction

Advancements in sensor and actuator technologies have driven a rapid rise in the prominence of embodied interaction in the field of HCI. Amongst the most recent advancements in sensor technologies are the Google Soli and the Myo armband.

However, current commercial designs using these technologies employ limited control schema and privilege interactions borrowed from pre-existing technologies. For example, Soli markets its main use case as replacing knobs or interface elements on existing, screen based applications. By limiting the interaction range to such a small possibility space, the potential to leverage a full range of motions is curtailed. The problem lies not in the sensor itself but in the limiting paradigms within which their use is conceived. This calls for deeper consideration and leveraging of knowledge around kinesthetics.

State of the field

One area where this is happening is in research into sensory substitution and multi-modal experiences which replace and expand our current sensory systems. Research by Eagelman and Novich couples sensory substitution with sound and haptics to convey visual information. Their research reveals how to convey precise visual information through the positioning of vibrotactile feedback for optimum results on the lower back [1].

As these interfaces intertwine with our physicality, the connection between motion, affect, and the contextual environment becomes a fertile ground for exploration. Sheets-Johnstone sees motion as deeply connected to affect; “Emotions are prime motivators: animate creatures ‘behave’ because they feel themselves moved to move” [2]. Such conjectures are supported by research by Carney *et al.* which demonstrates how chemical changes in our brains occur as the body adopts different postures. High-power postures caused elevations in testosterone, decreases in cortisol, and increased feelings of power and tolerance for risk whilst low-power postures caused the opposite [3].

We have used such research to inform our own practice. Perry and Fox’s Nightmare Kitty attempts to give children an opportunity to encounter and understand their experience of fear in an immersive environment [4]. Using head tracking via a kinect sensor, the game leverages power poses to build embodied interaction directly into the game mechanic. Children duck and pull their limbs in tightly in a low power pose to avoid falling characters and conversely sit on characters to explode them. This motion directly facilitates and augments the action of the game supporting a deeper affective response.

In placing the body at the center of the interaction in this way, we must consider means which take different bodies into account or face the pitfall of ableism. Towards these ends our research explores the development of customisable and adaptive interfaces through Interactive Machine Learning (IML). In doing this we draw heavily from Fiebrink’s work around interface customisation for expert musicians using through her platform Wekinator [5].

In 000000SWAN, Perry and Schedel used Wekinator to build gestural interaction. They used a Kinect Sensor and K-Bow, to control movement through a 3D environment forming the basis of an audio-visual performance. By using the Kinect and IML, Perry, who suffers from RSI and Carpal Tunnel Syndrome, was able to design within the affordance of her range of motion allowing for longer and more comfortable control. Similarly, Schedel used the K-Bow to digitally augment the sound of her Cello through the motion and tilt data produced by playing it. [6]

However, such user customisation does not guarantee the generation of viable gestural interfaces especially in cases of more casual use by non-expert users. Previous work by Katan *et al.* has shown inherent difficulties for users in designing, memorising and performing custom gesture vocabularies [7]. The application of co-adaptive learning offers a potential method for achieving a more accessible form customisation. Envisioned is a scenario where both user and machine iteratively adapt to converge on a viable solution.

Towards achieving this goal, we propose the user refinement of motion in response to aural and tactile feedback as a first step. Prior research by ourselves and others reveal how sonification of movement aids the rehearsal and performance of motions. Grosshauser et al. apply real-time sonification of motion and foot pressure to the teaching and training of dance students [8]. In this research auditory display forms a “closed interaction loop” for use by the teacher and student to analyse particular components of predetermined dance moves which the student is attempting to learn. Grosshauser identifies sonification as ideal for this application as a consequence of the high resolution the human auditory system which “enables listeners to recognize small and even invisible changes in body movement.” Furthermore, work in the field of stroke rehabilitation indicates auditory-motor coupling at a neurological level. Research has shown music-supported therapy to lead to marked improvements of motor function “accompanied by electrophysiological changes indicative of a better cortical connectivity and improved activation of the motor cortex” [9]

Our own recent research has applied more open-ended approaches to sonification for expressive applications around music and dance. Research from Katan, Fiebrink, and Grierson explored the use of IML to support musical interface development through workshops with disabled people [7]. Using Wekinator as middleware, we experimented with different approaches to interface design by developing twelve custom interfaces over a period of six months. We observed that, given continuous control spaces rich in gestural and sonic possibilities, users were able to intuitively develop “effective customisation strategies” bypassing the need for interactive re-training. We found that the approach yielded a wider variety of more finessed gestures performed with greater consistency.

Similarly work by Perry explores the use of gestural control spaces with haptic reinforcement to facilitate the creation of music by children. Nightgames [10] allows groups of up to six children to communally play a piece of music through physical gestures. Each child controls an identifiable sound via intuitive and discoverable gestures with a PlayStation Move. Aside from this trained environment, no further structure was imposed. Given this open-ended environment we found that participants rapidly developed game rules according to their experiences and group dynamics.

A more recent study by Katan investigates the application of IML to sonify the movements of visually impaired dancers during rehearsal. Rich control spaces were employed to provide an extra modality of synthesised sound. The aim was to address issues of gestural communication between the participants. Wearable equipment providing localised sonification for each dancer was tested over the course of a three-hour workshop with a choreographer and four visually impaired dancers. We found sonification to support the dancers’ understanding of each other's movements particularly with regards to the timing of moves and the magnitude of movement. In particular the technology allowed the dancers to phrase simple movements in synchronisation through intuitive micro-adjustments informed by the sonic feedback.

Conclusion

In this paper we have highlighted the limitations of current interface design approaches for emerging sensor and actuator technologies and advocated a more embodied approach to HCI. We have identified work which employs cross-modal interaction and feedback for sensory augmentation and substitution, and posited how an affective understanding of motion and posture can be used to communicate emotional information to the user. We have explored techniques and issues around using IML as a means of interface customisation, and proposed the open-ended use of rich control spaces as a starting point for co-adaptive learning. More than making accessible interfaces possible, this collection of techniques indicates a path towards a fundamental change in the relationship between human and machine. Through the discussed approaches we envisage more intuitive, flexible methods of control ultimately allowing for the human computer relationship to become a collaborative one. Human Computer Interaction is now at a crucial juncture. Current designs for emerging technologies may well be used for many years to come. It is essential that we embed them with a thoughtful ecological approach to motion and affect to encourage holistic interaction models that embrace the full potential of the human body.

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