

Evaluation of Input Devices for Musical Expression: Borrowing Tools from HCI

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Outline

- Human-Computer Interaction (HCI)
- Existing Research in HCI
- Interactive Computer Music
- Evaluation of Interactive Music Systems
- Conclusion

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Gestural Capture
Human Computer Interaction



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*Digital Libraries,
Music Information Retrieval,
Automatic on-line alignment,
and Topic segmentation*



HCI

- **Drawn from 4 domains:** software engineering, software human factors, computer graphics and cognitive science
- **Interaction:** a process of communication or information transfer from the user to the computer and from the computer to the user
- The user starts an interactive process to achieve a given task
- The task normally requires the user to monitor the system's status and to manually modify the system's parameters by respectively using output and input devices
- Therefore, the research on input device **evaluation** plays an important role in HCI.

Existing Research In HCI

- Evaluation Tasks and Methodologies
 - Buxton(1987) proposed the following tasks as a means to evaluate the match of input devices to applications.
 - Pursuit tracking
 - Target acquisition
 - Freehand inking
 - Tracing and digitizing
 - Constrained linear motion
 - Constrained circular motion
- The existence of an evaluation methodology for target acquisition –**FITTS'S LAW**- has made it the most widely used among the proposed tasks

Fitts's Law

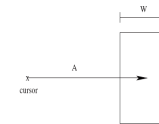
- Predicts that the time needed to point to a target of width **W** at a linear distance **A** away from the initial hand position in **T** seconds.

$$T = a + b \log_2(2A/W)$$

- The logarithmic term is called the *index of difficulty* (ID)
- The reciprocal of b is called the *index of performance* (IP)

- **Interpretation**

- *Big targets at close distance are acquired faster than smaller targets at long range*



Refinements on Fitts's Law

- **Shannon Formulation:** Always give a positive score for ID

$$T = a + b \log_2[A/W + 1]$$

- **Meyer's Law:** Valid for multidimensional movement

$$T = a + b n (A/W)^{1/n}$$

- **Steering Law:** Valid for movement through a curve C

$$T_c = a + b \int_C \frac{1}{W(s)} ds$$

Interactive Computer Music

- A highly specialized field of HCI
- Interaction engages several complex cognitive and motor skills
- The goal of the interaction is part of the bidirectional communication between the performer and the computer
- Input devices: gestural controllers
- Although various controllers have been proposed, they usually have been developed in response to precise artistic demands.

Applications of HCI Results to Music

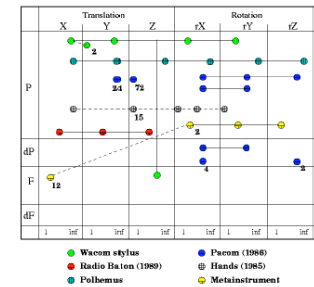
- **Navigation in a Multidimensional Space**

Vertegaal and Eaglestone (1996):

- Proposed the comparison of several input devices in a timbral navigation task.
- Three devices were used to navigate in a four dimensional timbre space
- Users were asked to reach a given timbre with each device.
- An evaluation of users' movement time and errors were used

Applications of HCI Results to Music

- **Taxonomy of Gestural Controllers**



- Six controllers are compared with respect to their degrees of freedom, the physical variable sensed and their resolution

Applications of HCI Results to Music

- **Design Methodologies**

- Concerning the design of new controllers and the new applicability of results from other fields, few attempts have been proposed
 - Vertegaal, Ungvary and Kieslinger presented a methodology to match transducer technologies to musical functions, taking into account the types of feedback available with each technology.
 - They proposed diagrams where transducer technologies are rated with respect to their suitability to perform a certain musical function and their intrinsic feedback properties.

Contexts in Interactive Computer Music

- Note level control, or musical instrument manipulation (pitch, loudness, timbre)
- Score level control (ie. A conductor's baton used to control sequence)
- Sound processing control, or post production activities (digital effects)
- Contexts related to traditional HCI (navigation in a mm space)
- Interaction in multimedia installations (human actions are sensed as input)
- Interaction in the context of dance/music interfaces (choreography of dancers' movements)
- Control of computer games (manipulation of a computer game input device)

Evaluation of Interactive Music Systems

- Once the context is chosen, it is necessary to find a suitable approach for the evaluation of interactive musical systems.
- 3 main concepts to consider
 - Usability of Controllers
 - Proposed Musical Tasks
 - Comparison with HCI Research

Usability of Controllers

- Learnability
 - It is essential to take into account the time needed to learn how to control a performance with a given controller.
 - Lehman: a musician needs more than 10 years to master a musical instrument, a time far too long for any kind of measurement in the world of controllers.
- Explorability
 - A characteristic of interest is the possibility of exploring the capabilities of the controller, that is the number of different gestures and gestural nuances that can be applied and recognized
- Feature Controllability
 - It is important to account for how the user perceives the relationship between the gestures and changes in the performance features
- Timing Controllability
 - A characteristic of music that differentiates it from the classical HCI context is the central role of the time.
 - Time it takes to complete a given task VS precise timing of given tasks

Proposed Musical Tasks

- Musical Instrument Manipulation Metaphor
 - Tasks can be related to control of pitch, including isolated tones with different loudness; basic musical gestures, like glissandi, trills, vibrato, and grace notes; and musical phrases, from scales and arpeggios to more complex contours with different speeds and articulations.
 - For each of these tasks, a measure indicating the degree of polyphony is to be added

Proposed Musical Tasks

- Other Metaphors
 - Score level metaphors: triggering a musical sequence
 - Continuous feature modulation: regarding how many simultaneous sequences
 - Synchronization of processes: when two or more sequences start at different moments and, for example finish together
- Considering HCI-related metaphors, a more direct application of the methods and measurements previously reviewed in this article is possible

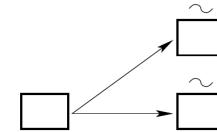
Example: Combination of Simple Tasks

- Wanderley
 - Subjects were asked to perform different musical tasks by moving a stylus on the graphical tablet shown in the figure.
 - use of piano keys mapped on to the board
 - Use of circular paths
 - Target acquisition task
 - These initial tasks were then followed by supplementary actions applied to specific notes



Example: Combination of Simple Tasks

- The final selected and evaluated task was a simple continuous feature modulation task that was performed after the user had generated a transition between two isolated tones.
- In other words; the total task consisted of first moving the tablet stylus from one rectangle to another –a target acquisition- task and only then performing the continuous feature modulation task (the evaluated task).



Conclusion

- A review of various methodologies for the evaluation of input devices from HCI
- Their applications to the musical domain
- The presence of an evaluation methodology can be useful both for designers and composers
- Bidirectional flow of knowledge between HCI and the design of new musical instruments can lead to substantiate improvements in both fields