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

Marcelo Mortensen Wanderley
Nicola Orio

Presented by Erdem Unal

Outline

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

The Authors

- Marcelo Mortensen Wanderley
  Gestural Capture
  Human Computer Interaction

- Nicola Orio
  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.
  \[ T = a + \frac{b}{\log_2(2A/W)} \]
  - 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
  \[ T = a + b \log_2(2A/W + 1) \]
- Meyer’s Law: Valid for multidimensional movement
  \[ T = a + b \log_2(2A/W)^a \]
- Steering Law: Valid for movement through a curve $C$
  \[ T_C = a + b \int \frac{1}{W(s)} \, ds \]

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

- **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.

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.

Contexts in Interactive Computer Music

- Note level control, or musical instrument manipulation (pitch, loudness, timber)
- 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.

- 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 substantial improvements in both fields