Education, Entertainment and Authenticity: Lessons Learned from Designing an Interactive Exhibit about Medieval Music

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Abstract
In this paper we describe the design experience gathered from creating an interactive exhibit about medieval music. This system was designed as an educational exhibit that relies on audio as its only feedback channel. We focused our work on three major goals: educational value, entertainment aspects, and historic authenticity. We present insight into the challenges in designing a system with these goals, and how they could be solved.

Keywords
Music, multimedia, education, entertainment, interactive exhibits.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
Interactive exhibits in museums can serve as a useful medium to convey information on various historic, cultural and scientific topics. For example, Mazzone et al. [2] explain that "museums play a significant role as learning contexts especially when they provide

Figure 1: Virtual Conductor lets visitors conduct a recording of the Vienna Philharmonic Orchestra (House Of Music, Vienna).

Figure 2: The REXband exhibit. Hurdy gurdy, frame drum and harp in a table setup.

interactive experiences, which may or may not be technologically enhanced." The design space for interactive exhibits is very large [7], and includes successful systems as diverse as the *Virtual Conductor* (see Fig. 1), an exhibit that allows visitors to conduct a recording of the famous Vienna Philharmonic Orchestra [5], and *Free2choose* in the Anne Frank House in Amsterdam (www.annefrank.org), that lets visitors vote on questions about conflicting fundamental rights and see the results instantly.

However, creating interactive exhibits includes some unique challenges that have to be dealt with. We identified three major goals in our work:

- Education: The exhibit should convey information on a certain topic.
- Entertainment: Using the exhibit should be easy and enjoyable.
- Authenticity: The content that the exhibit presents should be relevant for the given context and accurate.

We believe that a successful interactive exhibit should be aware of these three aspects and balance them carefully. We will begin with a short system description, outline the particular challenges of such an audio-only system, and go into detail on how we tried to achieve our three goals and balance them.

REXband

The system we designed was an educational interactive exhibit about medieval music. The exhibit was developed for the "Regensburg Experience" (or "REX"), a new visitor centre in Regensburg, Germany and was dubbed "REXband".

Our idea was to let users play authentic replicas of medieval music instruments (harp, hurdy gurdy, frame drum) and use a computer system to support their playing, give feedback and play an accompaniment. We implemented a simple melodic correction scheme that ensures users can only play "correct" notes by fitting their input to the musical scale of the accompaniment. A virtual audience gives audible feedback and creates the atmosphere of a medieval tavern. Our goal was to create an exhibit that is not only fun and enjoyable but also conveys knowledge about medieval music and its instruments.

The instrument replicas were created by an instrument builder specialized in creating medieval music instruments. They were made to look and feel authentic, but to not produce any sound themselves. Instead, we modified the instruments using various sensors. The sensor signals are fed into a computer system via sensor-MIDI interfaces and used to trigger appropriate instrument samples. This allows us to correct the users' input and make sure that the instruments' output fits to the accompaniment. The accompaniment is a medieval dance piece that we recorded with musicians from a medieval music ensemble.

REXband has already been shown as a temporary exhibit on several occasions (see Fig. 2). Although we used a standard iterative design process to create the system, some of our challenges and resulting approaches turned out to be quite unique.

A video figure included with this submission explains the system and the interaction.

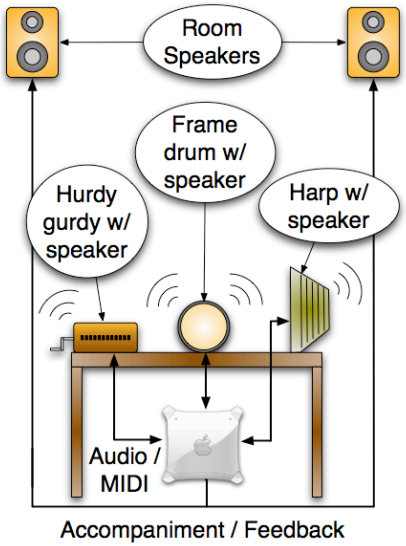

Figure 3: Technical overview on our system setup. Instrument sounds played through speakers placed close to the instruments, while all other audio is played through surrounding speakers.

Challenges in a pure audio system

We consciously designed the exhibit as a pure audio system without any visual feedback. We made this design decision because we wanted to ensure the users focus on the instrument replicas and the opportunity to play, instead of being distracted by visuals. However, due to the nature of audio feedback, we encountered some problems:

When testing an early prototype that only featured the hurdy gurdy replica for input and a set of stereo speakers for output, we found that users were confused about which parts of the music they could influence. We solved this by routing the audio output to different speakers that were placed according to their function. We put one hidden speaker close to each instrument that would only output the sounds of that instrument, simulating a naturally created instrument sound. Another set of speakers was placed around the exhibit to output the accompaniment, feedback and atmospheric sounds (see Fig. 3). This created the illusion of the instruments actually creating sound themselves, and of invisible, virtual musicians and audience in the room. Placing a speaker very close to the instruments also caused the wooden bodies to vibrate noticeably, making the instrument replicas feel more like real instruments.

Our user tests also showed an entirely different problem: balancing the various audio sources is not only an issue with purely artistic implications, but also strongly affects the user experience. For example, we used a clapping sound as a rewarding feedback when users played well enough. However, we had set the volume level of that sound too high so that users winced when it was triggered. On the other hand, we had various comments about the volume level of the accompaniment: some users had problems hearing it and playing to it while others found it annoying after we had turned it up.

These observations give user tests an extended role in the development process: they serve not only as a method to detect design flaws but are also needed to adjust system parameters. We believe that these adjustments cannot be done analytically; a good balance of volume levels is highly subjective and also depends on the audio system used, the room in which the system is installed and other factors. Understanding the meaning of various sounds and presenting them to the user in appropriate ways, as suggested in [4], can be a viable approach to this problem.

Authenticity

We took great care to ensure the historic authenticity of all relevant system parts.

We designed the instrument replicas to sound and feel like real instruments. Because the replicas did not generate any sound by themselves, this had to be modeled in software. This was a challenge especially for the hurdy gurdy replica: the real instrument includes strings that can be caused to vibrate by turning the crank on the side of the instrument. The buttons on the back can then be used to shorten some of the strings at certain fixed points. This results in some unique characteristics such as a constant humming sound while the user is turning the crank, and the possibility to create warbler-like sounds using the keys.

We used a combination of sensor technology (see Fig. 4), a fixed audio track, samples of single notes and a

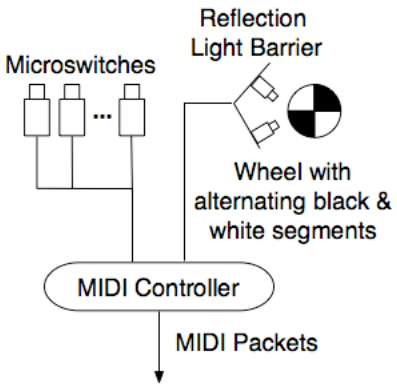

Figure 4: Schematic diagram of the electronic parts inside the hurdy gurdy replica. The microswitches detect button presses. The wheel can be turned using a crank which is then measured by a light barrier. Both types of data are output as MIDI.

software filter modeling the playing behavior of the instrument to make the replica feel almost like a real hurdy gurdy, but somewhat easier to play. Feedback from a hurdy gurdy player [6] who tried our system confirmed that the replica sounds and feels typical.

Education

Conveying knowledge about medieval music and its instruments was one of the main goals for this exhibit. The instruments we used were quite common in medieval times, but are rather uncommon today.

We did a user study to test our claim that users actually learn about medieval music from using our exhibit. 18 users participated in a user study in which users played the exhibit in groups of two or three people. Each group had to play to the accompaniment track four times, with users taking turns on the three instruments so that each user played each instrument at least once.

Users were given only minimal instructions. How to play the instruments was not explained to them. At the end of each session, we interviewed the group and solicited feedback on the overall usability of the system, and users' prior experience with medieval music and music in general. Of our 18 test users, only three claimed to have seen a hurdy gurdy before and none of them had ever played one. However, when asked to explain some characteristics of the hurdy gurdy, all of the users were able to correctly identify some characteristics (e.g., one has to turn the crank to play it, one can only play one note at a time, instrument produces a constant humming sound while the user is turning the crank). While all of our test users had at least seen a harp, only one had played one before. When asked for the playing techniques they used, users reported various techniques that are also used by trained harp players.

Although the interaction in this user test was longer than we would expect a typical interaction in a museum to be, it gave us some valuable insights on how users perceived the system. We did additional, more realistic user tests in public settings in which we concentrated more on observation instead of interviews [6].

Entertainment

We wanted to make playing our exhibit appealing to museum visitors and fun to play so that it would attract as many visitors as possible. Several design decisions were aimed at this goal:

Atmosphere

We wanted to make users feel as if they were playing the instruments in a medieval tavern, not in a modern museum. REXband supports this in various ways: when the system is not in use, it constantly plays background sounds that set this atmosphere (e.g., people talking, glasses clinking). It also plays short voice samples in random time intervals that encourage the user to start playing the instruments. As soon as a user starts playing, the accompaniment track starts. The final exhibit will also feature an interior space design that supports this atmosphere.

Feedback

We decided to use only positive feedback rewarding the users' performance. While it would have been easy to include negative feedback if users play badly, we decided against this. We felt that the quality of a musical performance can hardly be measured

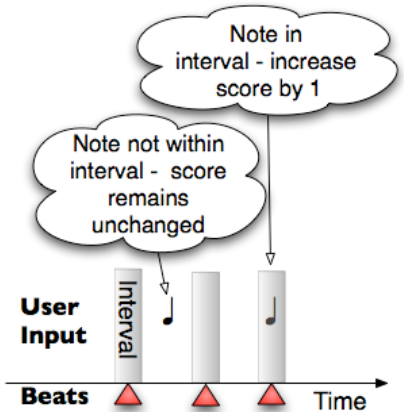

Figure 5: The users' performance is determined by a simple rhythmic criterion. The score increases when the users match the rhythm of the accompaniment. The score is only reset at the end of the accompaniment piece.

Figure 6: Playing a hurdy gurdy. The correct playing position is to stand behind the instrument, turning the crank with one's right hand and reaching to the buttons on the back with the left.

objectively, and while this would also speak against including feedback at all, we thought that giving positive, reinforcing feedback could improve the perceived quality of our system. This follows the principle proposed by Reeves and Nass [1] who recommend to "substitute sugar for vinegar" in interactive system design and use positive feedback even if it is unwarranted.

REXband's feedback mechanism measures the users' performance and gives appropriate feedback based on a simple rhythmic criterion (see Fig. 5): it checks the rhythmic accuracy of the users' input in relation to the rhythm of the accompaniment track. This criterion is then used to compute a score that reflects the users' performance so far. If the users play well enough, they are rewarded with encouraging audio samples, such as cheering shouts, coins thrown, or applause at different levels of intensity at the end of the piece.

Context and affordances

We were able to identify various affordances of musical instruments in general and our instruments in particular through our user tests.

For example, several users did not play the hurdy gurdy correctly. The correct playing position would be to stand behind the instrument, turning the crank with one's right hand and reaching to the buttons on the back with the left (see Fig. 6). A photo close to the exhibit helped people with the correct handling.

A public user test in a local museum also showed the importance of good affordances and context. We set up our exhibit for one evening during a special museum event. We were assigned an attractive exhibit space close to the entrance, and several hundred visitors saw, heard and used our system. However, we did not anticipate one particular problem: the museum exhibits consisted mostly of old furniture, and visitors were not allowed to touch any of the other exhibits (security guards were present to enforce this rule). In contrast, our exhibit was meant to be used, but most visitors did not understand this at first, even though we had put up signs explaining our exhibit. Although we had originally planned to stay passive and only observe, we soon realized that this would not work, and started approaching visitors directly to encourage them to try our exhibit. From then on, however, the feedback was generally very positive, and many users tried out the exhibit without explicit encouragement after seeing others use it.

Again, we see this as an important design lesson: since the exhibition for which we created REXband has not been opened yet, we still have some influence over where the exhibit is placed and how the setup should look. We consider it essential to place the exhibit in context of other interactive exhibits so that visitors understand that the instrument replicas are meant to be used, or at least create a consistent labeling or color coding for interactive exhibits.

Balancing the goals

In retrospect, the major design decisions were made to carefully balance the three goals for our exhibit: education, entertainment and authenticity. While these goals are not inherently contradicting, it can be difficult to meet them at the same time. Fig. 7 illustrates the problem. We do not want to give general solutions here (and we doubt that this is possible at all), but we consider it useful to be aware of these problems:

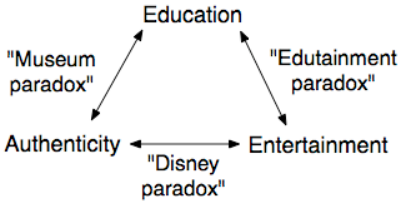

Figure 7: Our three main goals. Each pair of these goals has to be carefully balanced to avoid unwanted contradictions.

ENTERTAINMENT VS. EDUCATION: THE EDUTAINMENT PARADOX
Obviously, entertaining activities are not always educational, and vice versa. However, "museums must aim to provide entertainment that is simultaneously informative and educational." [3] In REXband, these goals were balanced, for example, by creating a system that implicitly conveys information about medieval music and rewards successful interaction.

ENTERTAINMENT VS. AUTHENTICITY: THE DISNEY PARADOX
Creating a system focused on entertainment is a goal typical for a theme park. Museums usually have different goals, but focusing on presenting authentic material can lead to an exhibition that consists mostly of classic exhibits that can only be looked at, not interacted with. Our solution here was to create the exhibit together with experts in medieval music and evaluate the system with potential museum visitors in both controlled lab settings and public environments.

AUTHENTICITY VS. EDUCATION: THE MUSEUM PARADOX
Museums can hardly present all the source material on a given topic, but have to focus on certain aspects of the topic that they are presenting and show visitors how to make sense of that information. We chose secular medieval music as one topic of medieval culture, and hurdy gurdy, frame drum and harp as representative instruments.

Conclusion

Developing this exhibit has brought up some interesting challenges, and we believe to have found good solutions that can be generalized to similar projects. We designed a system that conveys information in an authentic way without explicitly being a teaching system to the user. By extending the role of user tests from a method to detect design flaws to a way to adjust user-relevant system parameters we could understand how users perceived various volume levels. This could serve as a method to handle complex adjustment tasks in the future. Finally, we used the well-known concepts of designing in context and being aware of affordances and partly turned them around to actively influence the context and optimize the perceived quality of our system.

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