A Context Aware Music Player: A Tangible Approach

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ABSTRACT
In this paper we explore new ways of interacting to configure and personalize music selection in ambient environments. We propose a prototype for a context aware music player and a novel interaction concept to deal with it. Context information refers in this work both to the user, especially the mood situation, and the environment. The interaction concept lets the user express information about the mood and the current activity in a subtle way and customize the system to music preferences. This is achieved by using sensors to capture the environment data and a tangible user interface to enter and modify the context information related to the user. In usability tests of the prototype and in analysis of the interviews we conducted with test users we found out that customization options and making autonomous decisions transparent are two key factors to enhance user experience in context aware music systems.

Author Keywords
Context awareness; user-centred design; tangible user interface; sensor-based; mood.

ACM Classification Keywords
H.5.2 User Interfaces: Input devices and strategies, prototyping, user-centered design.

INTRODUCTION
Music is often consumed in the background, especially in ambient environments. People listen to music, while they read, workout, or while they are having dinner. Choosing the right music can be time consuming and distract users from what they wanted to do in the first place. Context aware music systems aim to free the user from choosing music and creating playlists. This is achieved by sensing the environment and gathering information about the user. Based on this information, music that fits the current situation is selected. The findings and figures in this paper are based on the master's thesis of the first author [12].

In the past, some research had the focus on specific parts of context aware music systems, such as music categorization [5] or reasoning [7, 9]. Most of the resulting prototypes are rather systems evaluated in lab environments and not ready to be applied by real users outside the research environment. They neglect design questions about the actual use of such systems.

In this paper we explore new ways of interacting to configure and personalize music selection in ambient environments. First we discuss the role of context information to capture certain data about the use environment. Then we briefly present mood models we used in our work before we introduce our approach and the resulting prototype. After the description of the tangible front end interaction interface of the system, we explain how we implemented the configuration and the automatic rating used in music selection. We conclude our paper and point out some future work.

CONTEXT AWARENESS
In real settings context information is very valuable to capture the current situation and circumstances of use. Context information can be gathered implicitly, by using sensors or explicitly by simply asking users. While implicitly captured information seems to work well for context information about the environment including light, temperature, and noise in the room, sensing the users' mood implicitly is a difficult task. Some of the existing research projects try to avoid user input at all cost. This leads to constructs where they even try to determine mood based on information like a users' stock portfolio [4].

The problem every context aware music system faces is music selection. This can be done based on audio-analysis and classification of songs. One problem that comes with automatic classification is that it neglects personal preferences. For example, one would think that uptempo music is the obvious choice for people while they workout. According to a 2012 survey [2] college students in the US prefer Hip Hop music, which typically has a rather low number of beats per minute, while they exercise. This shows that personal preferences play an essential role for music selection, and we therefore suggest that users need configuration options, which let them customize the system to their preferences.

Unlike Cunningham et al. [3], we believe that the users' mood cannot be determined based only on the information about the environment. It should also be seen as an additional contextual factor for music selection. Even if we try to sense a user's mood by making them wear a cumbersome brainwave detection sensor [8], we would still only have information about the current mood. Since people use music also for

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mood transition, we would still need to know the users' desired mood.

MOOD

We believe that mood models for context aware music systems should be based on models and insights from the field of psychology. There are many different approaches and models, when it comes to moods and emotions. Some of them are even complex 3-dimensional models [10]. For our context aware music player we needed a model with moods that makes sense for music selection. Most people would find it hard to think about music that fits to the feeling of surprise or disgust. Han et. al [5] used a 2-dimensional mood model based on Thayer's insight about human emotion [13]. Since we wanted that users are able to easily make a connection between music mood descriptions, we decided to further simplify the model for our system, by keeping only extreme moods (see Figure1).

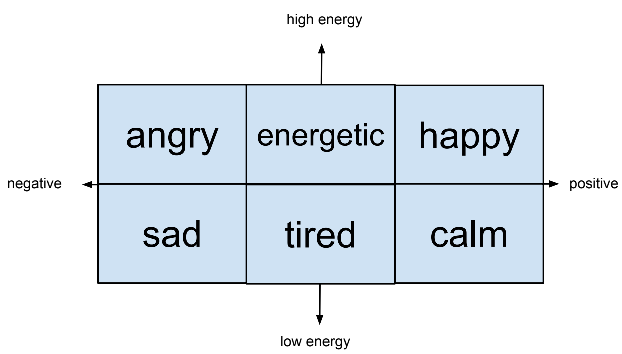

Figure 1. Simplified 2-dimensional mood model based on the work of Han et. al and Thayer.

APPROACH

We approached this research project with a user centered design process. After initial literature review, we started creating ad-hoc personas [1]. We then developed a first low-fidelity version of the prototype and evaluated it in a usability test with three participants, who resembled our identified personas. This version of the prototype featured the look and feel of the final product, and then we used the Wizard of Oz technique to mock its functionality.

Using the information we gathered from the evaluation, we implemented a second prototype. This second version is a fully functional integration prototype. We invited the three participants from the first test and three new participants for a second more detailed usability test. In this test users got specific tasks to solve, covering all features (including configuration). There was also a more realistic second part of the test, where users had to perform activities like cooking or reading a book while using the system. After the test we asked them some questions about the prototype in a semi-structured interview.

The usability test and the interview were video-recorded, in order to analyze them later in detail. The aim of these tests was to get detailed information about how participants use such a system, and how their thought process looks like while they use the system. This is why we used the thinking aloud technique during the tasks.

PROTOTYPE

The resulting prototype is a system that consists of a USB-device that functions as a tangible user interface, has a light sensor and a physical next-button attached to it, 9 single-sided activity cubes, 6 double-sided mood cubes, and a software application that runs on a Mac, gets weather information via a web-service, does all the reasoning, and plays back the selected music (see Figure 2). We used two Arduino Uno micro-controllers, equipped with two NFC-shields for identifying cubes and handling sensor input.

Figure 2. Setup of the system on a table.

Users can also access a graphical user interface via the computer, where they can customize the system. The idea is that once the system has been configured, there is no need to touch the computer again, unless the user wants to reconfigure it. As a source for music we used genre specific Internet radio channels, since they provide a wide variety of music, ranging from ambient music to death metal. The source for music can be easily substituted by local or online playlists, as long as the tracks featured in it have similar characteristics.

When the application gets launched, music starts playing immediately. When there is no user input, music gets selected purely based on environmental information. Users may then place up to two cubes on the tangible user interface.

There are two types of cubes. Activity cubes, which represent an activity, and show a symbol on just one side (white cubes in Figure 3). Mood cubes are double sided. They have a white side, which represents the current mood, and a black side, which represents the desired mood. Figure 3 shows both sides of mood cubes in the bottom right section.

The tangible user interface is a token and constraint interface [14]. The two cavities on the box are not only a constraint, but also cover exactly half of a cube. Thus, mood-cubes placed in one of the cavities appear as either black or white. Double sided mood cubes enable users to express mood transitions. For example, a transition from angry to calm may be expressed by placing the angry cube with the white side on top and the calm cube with the black side on top. When a new cube is placed on the device (cf., Figure 4) or an environment

Figure 3. Cubes used for expressing moods and activities.

factor (e.g., weather) changes, new ratings are calculated and usually new music starts playing.

We also implemented audio feedback for user input. When a cube is placed on the device a text-to-speech voice reads the input out loud. For the above given example this would mean that the system says "I am angry and I want to be calm". By repeating the user input, a dialogue between the system and the user is created. Users can thereby verify if what they wanted to express, was understood by the system. This feature has been added after the first usability test. It did not only help users prevent input errors, but also let new users identify symbols and learn how to use the system without even reading about the concept of current and desired mood on the provided info-graphic.

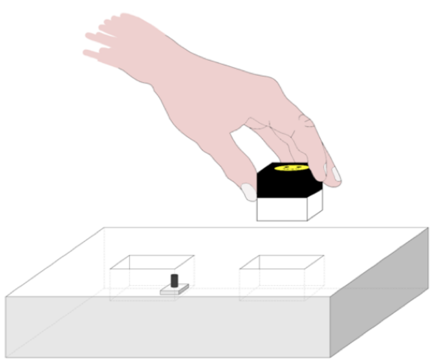

Figure 4. Expressing mood by interacting with double-sided cubes.

Users can always skip music they don't like, by either pressing the skip-button, which is the only physical button on the device, or by clapping twice. We experimented with clap detection software [6], because we wanted to give users the opportunity to skip music remotely in situations where they are not standing near the device, such as cooking or exercising. Users generally liked this feature, but the clap-detection did not always work properly. The clap detection software needs to be configured specifically for every user and one may also need to reconfigure it when using it in a different environment, since the acoustics change when the device is relocated.

CONFIGURATION

People describe their music preferences in sentences like "on a rainy evening, I like to read a book while listening to classical music" or "when I'm tired, house music gives me the energy to continue my workout". Our configuration approach tries to enable users to express it in a similar way by using tags. We translated sensor information into pre-defined tags, which users can assign to radio stations by simply clicking a button. Figure 5 shows a section of this user interface with activated context-tags for a lounge radio station.

Figure 5. Screenshot of a part of the configuration interface

Users can further customize the system by adding new activity cubes, new radio stations, and by changing the weighting of categories.

MUSIC SELECTION

In our prototype system music gets selected using a priority list based on a simple rating function (1). Basically ratings for radio stations (rating$_x$) score points for every context-tag that matches the current situation (NMC$_{x,n}$). In order to prevent music with a higher number of assigned tags from being ranked high in almost every situation, we subtract points for every non-matching context tag that is assigned to it ($-(TNC_{x,n} - NMC_{x,n}$). The complete rating is calculated by multiplying the score of each category with a weighting factor for that category and summing up all category scores. The weighting factors of the seven categories: activity, current mood, desired mood, weather, temperature, time, and light can also be changed by users using the configuration-GUI. This decision has proved to be right during the interviews, since every user stated that moods and activities are more important than other categories for their music selection.

$$rating_x = \sum_{n=1}^{7} WF_n \cdot (NMC_{x,n} \cdot rf - (TNC_{x,n} - NMC_{x,n}) \cdot pf) \quad (1)$$

Symbol	Name	Default-Value
rf	reward factor	5
pf	penalty factor	1
WF_n	weighting factor of category n	

Table 1. Constants

Sym.	Explanation
$NMC_{x,n}$	number of category-n matches with radio station x
$TNC_{x,n}$	total number of characteristics in category n assigned to x

Table 2. Variables

SOME FINDINGS

The prototype as well as the interaction concept proposed in this paper were accepted very well by the users. During the usability tests, we found out that when there is a lack of feedback, users tend use the system in a way it was not intended to by the designer. This is due to mismatching mental models of how the system works. When there was no audio feedback (as described above), people used mood cubes not to express their mood, but as a feedback mechanism, when they did not like the music that was playing (e.g., with a sad cube). One of the users stated that he wants an option to mute the audio-feedback, because he does not want everybody else in the room know, when he is in a bad mood.

One other interesting finding was that users who said that they felt in control of the system, also stated that they had a great experience using the system. Some users said that the tangible user interface gave them back some of the haptic experience they liked about CDs, but lost since they started listening to MP3s at home.

We tried to tackle the problem of awareness mismatch described by Schmidt [11] by making the music selection process transparent, by highlighting context tags of the presently playing radio station (on the computer screen) that are matching the current situation's context. Unfortunately users had problems recognizing changing highlighted tags, since changes usually happened while they interacted with the external USB-device, and therefore did not look at the screen.

CONCLUSION

In this paper we briefly presented a novel tangible user interface for context aware music player that integrates a customizable configuration interface for automatic music selection. Based on our observations, we conclude that for context aware music players, two key factors that influence user experience are customization options and making autonomous decisions transparent.

In the future we aim to further improve the visualization of the decision making. We also want to include the computer as well as some speakers into the box that is currently an external USB-device. We want to create a single device, which can be easily carried between rooms. The configuration GUI could then potentially be accessed via a web-interface from any device with a browser.

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