Evaluating The Privacy of Using
Mobile Devices to Interact In Public Places

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The Musicology project explores how personal mobile devices, such a users' cell-phones, can be used as conduits for bringing musical expression into public places such as cafés and coffee shops. This capability represents advanced usage models for emerging handheld devices, enabling personal music to be a more social experience by allowing people to easily play their music for others around them. Survey results highlight users' perception of public and private interaction in shared spaces, refining the role of privacy in these contexts. Music can be a very personal expression of a individual's identity, overlapping in surprising ways with the personal nature of users' handheld devices.

Introduction

The Musicology system brings a person's personal musical tastes into a public setting, such as a public café, highlighting the fundamental relationship between a user's private world, embodied by their mobile device, and the social world, which is represented by the public establishment. A significant research question then becomes how does a user's notions of privacy and social interaction affect their view of using personal mobile technology to interact with public space. For the most part, this is *not* a question about usability: instead, this work addresses fundamental issues focusing on the user's relationship with three different interface modalities:

- *Public*, where a user must physically interact with the system in such a way as others can *see* who they are, but don't obtain any detailed information (e.g., their name or email address).
- *Anonymous*, where user's can anonymously interact from their mobile device, revealing no personal information about themselves either the environment (e.g., store owners) or others around them.
- *Registered*, where user's can interact from their mobile device, but implicitly share a personal digital profile with the owners of the establishment.

The underlying user interaction for playing personal music in public spaces is quite simple: it's a matter of selecting a song or indicating (dis)approval of a currently playing song. However, the necessity for a profile or social interaction revolves around the need for trade-offs induced by the shared access to a public medium (the music playing in the background). For example, while at home it is natural to have strict veto

power over playing music, affording the ability to easily skip an undesirable song; in a public setting, however, it might be more appropriate to put the song to a vote, only allowing the owners of the space veto power. So, instead of allowing a user to anonymously vote against a song from their phone, they may need give up some of their digital or social anonymity.

This paper studies issues underlying mobile interaction in public spaces, focusing on issues of digital vs. social public interaction in order to understand the underlying issues and constraints. Specifically, it examines the impact that a person's public/private disposition has on their potential interaction with public music systems.

Motivation

The primary motivation behind the Musicology project is the emergence of advanced mobile devices, notably mobile cell-phones and music players, coupled with many people's desire to express their personal identity through music. Currently, mobile devices only afford limited expression to others in the form of *which* mobile device somebody chooses to own. (Although in some cultures, such as Japan, external charms and ornamentation is also very popular.)

Advanced mobile devices starting to appear on the market possess virtually all of the technical capabilities necessary to act as a personal wireless music player. The primary characteristics of these devices include enough storage to hold the songs and short-range low-power wireless communication. Most stand-alone music players, such as the iPod or iRiver, typically focus on high-storage capacity but currently do not posses integrated wireless capability. Mobile phones, on the other hand, possess short range wireless in the form of Bluetooth, and are just recently starting to have enough built-in storage to serve as effective mobile music players. As the market moves forward, these technologies are likely to converge on a generation of ubiquitously available mobile devices that can easily wirelessly serve a user's music to anything around it.

One underlying motivation for *why* people want to share their music is a need to express their personal identity: akin to how they continuously express their identity through the clothes they wear and the way the speak. Meanwhile, the only common technological forms of personalization fall into very limited expression in the form of the device's background wallpaper, or music content available on the device: the device is personalized, but only the immediate owner or user can see that personalization unless explicitly shown to others. The Musicology project, therefore, is looking at how these emerging technologies will enable a new kind of personal expression by allowing people to seamlessly share their musical tastes with others around them – an effective way of displaying their identity through their music.

Related Work

There are multiple pieces of related work that address aspects of public music systems and music sharing. However, there are a number of angles to the basic problem, and

although some systems cover similar basic ideas as Musicology, they all approach the underlying questions from different angles and (therefore) provide different insights into the underlying system dynamics.

The Jukola [2] system presents a public kiosk interface where users can nominate a song to play in a public place, using mobile devices within the space to vote to play one of the nominated songs. Jukola is similar to Musicology in that it explores the use of mobile and fixed devices in a public setting to control music playback; however, in Jukola, the task division between mobile and infrastructure devices is fixed, not directly investigating all the potential options for interaction. Musicology, on the other hand, focuses on the affordances of the different kinds of interfaces.

iTunes can be used to share music over a local area network, highlighting users' underlying perceptions about identity [4]. Standard iTunes software is used to share music across a local area network: users are not necessarily co-located when sharing, and the music consumption is not a shared experience. The Musicology system, in contrast, aims to look at the shared consumption of music in public places catalyzed by mobile devices, and also explores how the different kinds of interfaces, public or private, can be used to interact with music.

Privacy considerations with mobile devices has mostly come up in the context of location-based services: e.g., the Reno system aims to understand the implications of sharing your location with others [5]. Location-based privacy considerations address a very different aspect of personal privacy than the Musicology model, simply because with Musicology it is assumed that you are co-located with people you don't know, while Reno considers physically separated interactions with people you do know.

Architecture & Implementation

The overall architecture of the Musicology system, shown in Figure 1, reflects the underlying social structure implicit in the base interaction. The fundamental tensions supported by the architecture are that of contributor/listener (producer/consumer) and device/kiosk (private/public), giving rise to the four communication paths in the architecture diagram. The encompassing context of this architecture is any public place with consumable media; or, in a more generalized sense, any social context – such as a home environment – where visitors would desire to either provide or consume media (not just music).

User Roles

The two dominant user roles in this architecture are the contributors and listeners; the greater surrounding ecosystem also includes the roles of proprietor (or host), and (service) provider, but these roles are out of the scope of this work. In short, the contributors play music for the listeners. Given the shared nature of audio, there can really only be one contributors at a given time, and at other times the same individual will take on the role of listener.
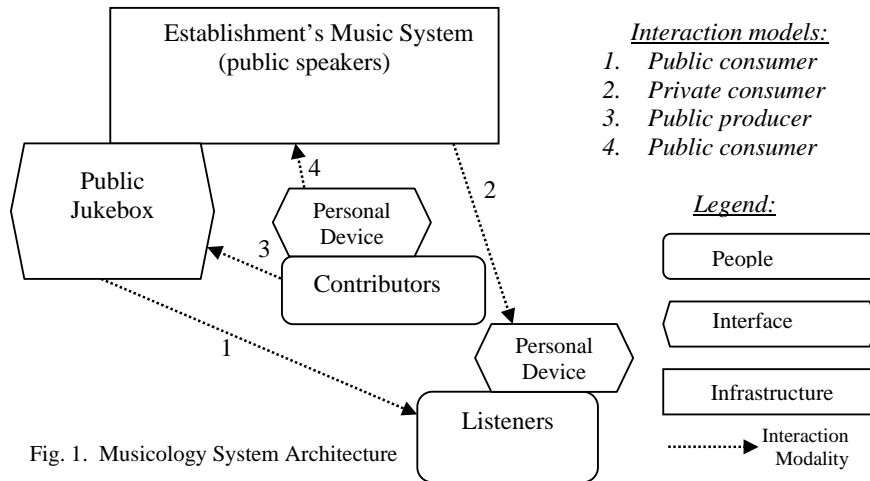
Fig. 1. Musicology System Architecture

Contributors provide content and intent: the actual songs to play and a preference about *which* song to play. For example, a person could walk into a bar (ha ha) with some selection of songs on their mobile device or a preference for certain kinds of music. Once they are in the environment, they can participate either actively, by selecting individual songs to play in the environment, or passively, by letting the system automatically select songs to play. By default, many establishments' owners or staff take on the role of contributor: providing the content and ambiance for a given location – the Musicology system changes this dynamic by allowing individuals to contribute to a locale.

Listeners, on the other hand, interact with content provided by a contributor, either by listening, voting for/against song, capturing details (song title/artist), or browsing other patron's playlists. Listeners are very important to the overall ecosystem because they provide the impetus for some contributors (i.e., so they can show off) and the overall ecosystem (possible revenue stream for content providers).

Technology

Two main pieces of technology comprise the Musicology system: the mobile device, which is carried by the user, and the public infrastructure, which is installed in the establishment. For the most part, the public infrastructure component is functionally equivalent to system already found in many places, where people can walk up to a jukebox and select music (from a limited selection) to play; similarly, the personal devices are similar to emerging cell-phone devices in form and basic function. The technology contribution of the Musicology system is the cross between these ecosystems, and the components that allow them to interoperate.

The Public Jukebox component primarily consists of the audio equipment to play audio in the space, coupled with a public access jukebox, along with the capability to wirelessly interact with mobile devices. Given current technology, this wireless capability would be either Bluetooth or WiFi to connect with cell-phones and laptops, respectively. The jukebox component is central to the system because it allows people to interact with the system without compromising their digital privacy, fostering a more social means of identification, which is based on people seeing other people. The comparison between this digital and public means of interaction is the core of this work: exploring how personal mobile devices exist in a primarily social landscape.

The Personal Device component is primarily intended to be users' mobile phones, but could also be their laptops or wirelessly-enabled dedicated music player. The mobile device provides two main functions in the musicology system: one as a vector enabling users to bring personal music into the system, and the other to enable them to interact with the system from their table. The ability to bring music into the environment could take on many forms depending on the underlying technical implementation. Similarly, the personal device interaction model provides a way for users to maintain more social privacy by interacting from their mobile device without being "seen" by others in the space.

Privacy Evaluation

The main goal of the user evaluation of the Musicology system is to better understand the trade-offs and dynamics surrounding using mobile devices in public places: when is it ok, or when would it me more appropriate to use some other mechanism. Specifically, *how the introduction of personal mobile devices might enable new capabilities, and which interactions (if any) should be left to the infrastructure*. Based on this thesis, there are three main objectives of this evaluation:

- *Level of anonymity*: are people amenable to registering with the public space?
- *Effects of social pressure*: how does social visibility effect interaction?
- *Privacy disposition*: how do general privacy perspectives effect interactions?

These categories are fairly fundamental to the basic model of using mobile devices in public spaces, and do not directly focus on music consumption. Furthermore, they do not address many aspects of the design, many of which focus more on usability aspects such as is the system "easy to use" or the underlying desirability for the user.

To explore the relevant aspects of public/private interfaces in social environments, a survey questionnaire was crafted that explores a number of aspects of the problem. The survey asks a set of generic questions about a persons music-related background, and then a series of questions about their preferences for using a variety of interfaces. Furthermore, a standard set of privacy questions [6], used for determining participants' privacy perspectives, helps classify participants' privacy dispositions. These privacy questions can be used to contrast and compare the other results, highlighting the ways in which specific notions of privacy effect how people interact with pervasive computing devices in public spaces.
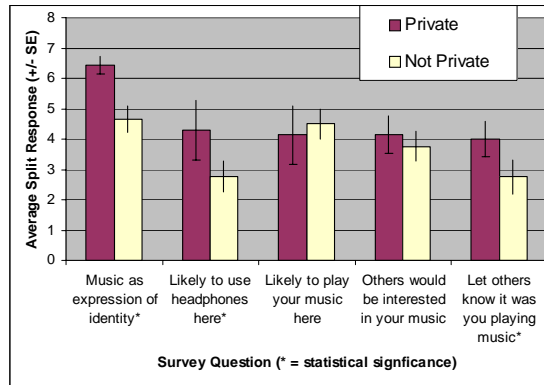
Fig. 2. : Basic survey results divided by privacy response (either above/below average response). Error bars indicate +/- one Standard Error (SE). Only questions marked with a * show a statistical difference ($p < 0.05$) between the private/not-private groupings.

The survey was administered to 20 participants in a public café setting, representative of a potential environment for the Musicology system. This *in-situ* deployment is important for capturing the public vs. privacy aspect of the various interactions, because it allows participants to answer interface questions in a realistic context. The results presented here are a subset of the entire survey, primarily considering aspects that focus on public/private distinctions.

Baseline Results

Figure 2 shows the baseline results that compare a selection of survey questions broken out by public/private response. Participants who answered more conservatively than average are grouped into the "Private" group, while those answering less conservatively were placed in the "Not Private" group. Based on these results, a number of basic observations can be made:

- Overall, there is a significant link between a person's privacy perspective and their link to music as an expression of their identity – showing a 1.8 point difference in response average. This indicates that concepts of identity and privacy are closely related, shedding light on the design of interfaces, such as those revealing identifying information, for pervasive music systems.
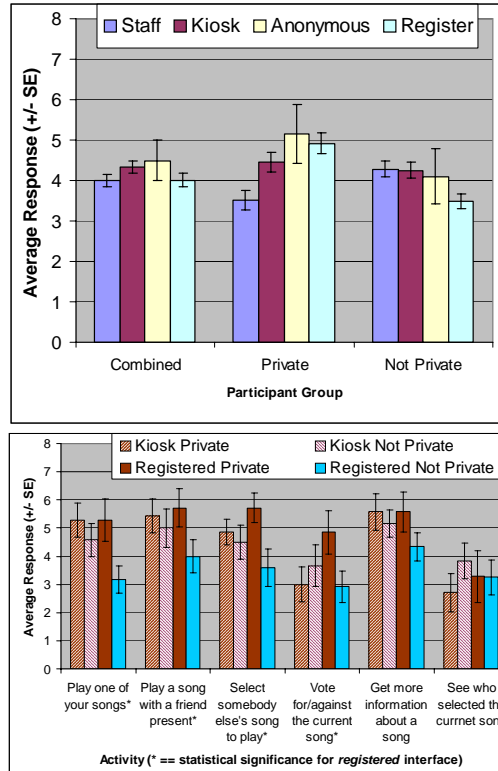
Fig. 3. Comparison of the influence of public/private disposition on various interfaces for a selection of tasks. Figure 3a (top), shows summary results for four major interfaces (interacting with the *staff* directly, using a *kiosk*, *anonymously* interacting from their phone, or *registering* with the establishment through their mobile phone). Figure 3b (bottom), shows a breakdown of kiosk vs. register interactions for a variety of tasks. There is statistical significance ($p < 0.05$) only for the indicated activities for the registered interface (the kiosk differences were not significant).

- Private participants are more likely to use headphones, which is not at all surprising. This presents a challenge to the Musicology system (in getting these people to not use headphone and rather socialize); other results (below), indicate that private participants are more likely to use a mobile device interface: a possible solution to bring them out of their self-created aural cocoon.
- Private participants indicated they were *more* likely to want to share their identity when they do decide to play music (i.e., if *they* were the ones who selected a song to play). This is somewhat counter-intuitive, because normally one would expect private people to be less likely to want to share. One possible explanation for this is an increased accountability for their behavior: they feel that sharing implicitly requires revealing their identity, and therefore constitutes more of a potential privacy violation.

Interface Results

Figure 3 shows a breakdown of interface specific results sorted by privacy disposition. Figure 3a focuses on the aggregate interfaces, while Figure 3b focuses in on a selection of activities comparing the kiosk (using a display situated in the environment) and registered (registering with the store staff through your mobile device) interfaces.

Based on this data, there are a number of interesting observations about the effect of privacy on such a system:

- The combined scores for the various interfaces are very similar, indicating that all interfaces are roughly similar; however, a breakdown sorted by privacy shows how/when some interfaces are more attractive than others for different segments of the population.
- People who are *not* privacy conscious *prefer* staff interactions, a more social interface, or a anonymous mobile interface. The sticking point seems to be having to register their information before interacting, which seems counter-intuitive given that they shouldn't be sensitive to invasions of privacy.
- Overall, voting for/against a song or seeing *who* is playing the current song are among the less interesting activities for all of the interfaces options involved. This dovetails with the need for private interfaces that don't broadcast user's identities, because people don't actually care who is doing things anyways.
- Private people seem generally *more* willing to interact with the system, except when it comes to voting for/against a song, where a more personal mobile interface is desired, or seeing who is playing a current song, which is of little interested.

Conclusion

The Musicology system aims to evaluate the introduction of mobile device interfaces into public spaces: specifically targeting the division of labor between a mobile device and a situated interface in a public context. The Musicology survey highlights the dynamics underlying public vs. private behavior in these environments and how they relate to different classes of interfaces. More private users present a potential challenge to the adoption of public music systems, but fortunately they are more amenable to mobile device interfaces.

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