Multi-Channel Acoustic Data Transmission to Ad-Hoc Mobile Phone Arrays

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1. Introduction

There are many uses for a reliable communication channel from an event (at entertainment or show environments like cinemas, theaters and sport stadiums) towards the mobile phones of the audience. Such a channel enables new mobile applications that should interest the SIGGRAPH Mobile community: For example, events in a movie can trigger assisting information to appear on a phone's display ("second screen"). or games involving the phones and the event are enabled through synchronous message transmissions. Real time information about an event can enrich the story telling when augmented-reality is applied. We report on a prototype system that operates only with the audio channel and the existing audio infrastructure. The system does not require any dedicated wireless (radio) infrastructure such as Wi-Fi access points to be set-up in the environment. This setup maps nicely to many event environments: Avoiding the need for a new wireless infrastructure, a movie (or a show, concert, etc.) can directly interact with mobile phones in virtually any location across the world.

We will demonstrate a novel way of decoding the received data so that quality and reliability of the audio communication are greatly improved, as described in the next section.

2. Approach and System Architecture

By offering users to connect their phones with other participants via Wi-Fi or Bluetooth ad-hoc networks, a group of connected phones acts as an ad-hoc microphone array and exploits the diversity of the individual message receptions. Different phones are likely to observe transmission errors at different times. Hence, bit errors are more likely to be identified and corrected in a joint, cooperative approach. Such a multi-phone approach is known from distributed radio networks and referred to as cooperative diversity

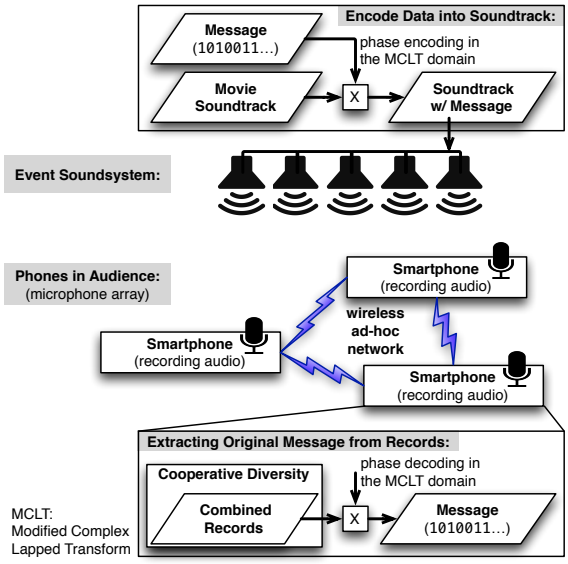

Figure 1: System architecture: Messages are encoded so that they are not hearable. Participating phones in the audience connect with each other (wireless ad-hoc network) and exchange their received data. Final decoding and error correction is performed jointly and the resulting messages are shared with all phones.

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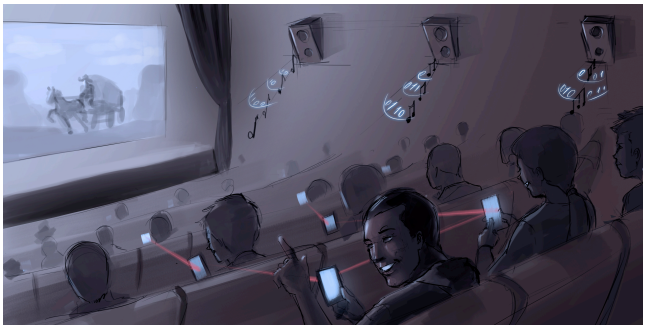

Figure 2: Concept art illustrating the use case in a cinema. Phones jointly decode the received data, acting as an array, which greatly improves the quality of the communication channel.

Yuksel (2007). Messages are encoded into a movie soundtrack with the help of the Modulated Complex Lapped Transform (MCLT) as described by Cho (2010) and modified towards multi-channel usage as described by Frigg (2013), so that they are hidden and not hearable. Participating phones exchange their received data streams and the results of the redundancy check. The decoding and error handling is then performed on one of the phones, and the resulting messages are shared with all phones.

Today's mobile phones are increasingly powerful with fast graphics and signal processing units, at reduced power consumption. These features enable a cooperative resource sharing in applications such as mobile social games. When offering ad-hoc connectivity, privacy and security aspects will have to be taken into account. However, there is also an opportunity to address a social demand, because users with common interest will be able to share their experience immediately.

3. Demo

The concept can be demonstrated with a laptop as mockup source, and a handful of iPhones as receiving devices. Note that it is not required to create a strong and loud sound with additional loudspeakers, in order to operate the prototype. The basic principle of the cooperative diversity reception can be demonstrated at normal loudness. It might help to set up a larger monitor with a slideshow in the background, and to use additional iPad tablets to engage in technical discussion for example about the MCLT implementation, or our recent measurement campaign and experiments in a cinema.

4. References

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