DJammer: a New Digital, Mobile, Virtual, Personal Musical Instrument

Mat Hans, April Slayden, Mark Smith, Banny Banerjee[1], Arvind Gupta[1]
Mobile and Media Systems Laboratory
HP Laboratories Palo Alto
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E-mail: mat.hans@hp.com

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Named for the combination of the words DJ and Jamming, the DJammer allows its users to manipulate their music using standard DJ techniques as well as interact with others in virtual jam sessions through the exchange and sharing of multiple music streams. In this paper, we describe the evolution of the DJammer including the interactive process and evaluation which led to the latest prototype. This latest prototype allows its users to "touch" their digital music through single-handed manipulation and control. By allowing both creativity and communication with digital music, the DJammer is a new musical instrument which takes the next step in the evolution of portable music players.

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Mat Hans, April Slayden, Mark Smith (HP Labs, Palo Alto, CA)
Banny Banerjee, Arvind Gupta (IDEO, Palo Alto, CA)
mat.hans@hp.com

Abstract

Named for the combination of the words DJ and Jamming, the DJammer allows its users to manipulate their music using standard DJ techniques as well as interact with others in virtual jam sessions through the exchange and sharing of multiple music streams. In this paper, we describe the evolution of the DJammer including the interactive process and evaluation which led to the latest prototype. This latest prototype allows its users to "touch" their digital music through single-handed manipulation and control. By allowing both creativity and communication with digital music, the DJammer is a new musical instrument which takes the next step in the evolution of portable music players.

1. Introduction

With the rise in popularity of portable digital music players and the availability of digital music content, consumers are now able to own and transport hundreds of hours of music in their pockets. Their deployment has changed the way and on what platforms individuals consume and exchange prerecorded music. A digital audio player often has functions that allow a user to interact with digital audio content in different ways. These functions may include playback, record, forward, reverse, skip, random play, and repeat. We believe the next steps in the evolution of digital music are in areas of creativity and communication.

Existing digital audio players generally do not provide any audio content manipulation such as mixing, scratching, fading, reverse play, and looping. These functions are provided by specialized DJ turntables [1], and are used to create audio content for subsequent distribution via some type of media or for live events. They are generally designed to be used by an individual performer and are not readily usable by groups of performers to construct spontaneous

Figure 1. New DJammer prototype.

collaborative audio sessions, especially if the collaborators are not in the same physical location.

After attending a presentation by DJ Gerald "World Wide" Webb, a digital turntablist, at the NYU Department of Music during the summer of 2002, and realizing that "turntables have become the new electric guitar," [2] the HP Labs team began thinking how the digital audio experience could address both creativity and communication. This paper describes a new DJammer prototype shown in Figure 1 that achieves an advanced level of interactivity and communication capability in mobile music players that is attractive to both consumers and professional DJs alike.

2. Standard DJ Techniques

One essential DJ technique, record *scratching*, involves directly manipulating the sound of the music by moving a vinyl record located on the turntable [3]. DJs scratch by placing their hand on the record and pushing the record forward, pulling the record backward, or holding the record in place. Each of these motions changes the direction that the song is played, and the speed at which the motions are performed changes the pitch of the song thereby affecting the sound that is produced.

In addition to moving the record on the turntable, DJs also use the crossfader to manipulate the sound of the music by a process known as *fading* [4]. The crossfader is often a slider located on the mixer (or directly on the turntable in the case of digital turntables) and controls the volume of the sound coming out of the mixer. The slope of the crossfader determines if the sound from the turntable changes gradually with the movement of the crossfader or if it changes instantaneously once the crossfader reaches a certain point known as the cut-point. A sharp slope setting essentially reduces the crossfader slider to a button and the process of fading to muting/unmuting the sound. It is important to note that the fading process affects only the sound coming out of the mixer/speakers. The DJ can always hear the currently playing record through headphones which is necessary for cueing.

Before scratching or fading the music, the DJ must first identify the sample or particular piece in the music to be manipulated. This process of identifying the location of a particular sample is known as *cueing* [4] or finding the breakpoint. Identifying the breakpoints on a record can be done by placing visual aids such as stickers on the record at the beginning of particular songs or at the locations of specific samples. DJs can also identify a breakpoint by listening to a song through their headphones and then navigating to the intended sample by moving the record. Breakpoints are most commonly found at the beginning of each song but can be located anywhere within the song depending on the DJ's preferences.

3. Early Prototype

With these techniques in mind, the HP Labs team invented the DJammer. This new personal entertainment device brings turntable-like creative functionality to the digital MP3 mobile world while offering a virtual collaborative platform by sharing the creative process over the network.

To do this, the DJammer implements a virtual turntable using signal processing technology. This provides the user with a means to create, alter, or composite music and audio in real time. Because the turntable is virtual, a DJammer can have multiple channels of audio interacting together simultaneously. A comprehensive analog and digital user interface enables a variety of sensors to be used as actuators for the virtual turntables. An early version of the DJammer, shown in Figure 2, was demonstrated with shock sensing accelerometers and contact position detecting optical sensors. These sensors allow the user to scratch and interact with their music using a
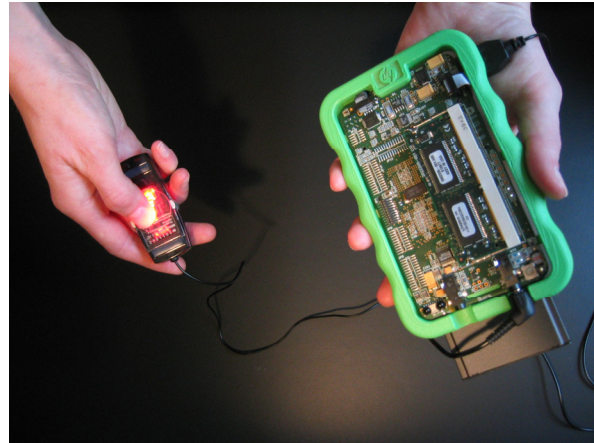

Figure 2. Early DJammer prototype with onboard accelerometer and handheld optical sensors.

percussive striking motion, or a variety of actions involving motion detection such as sliding or strumming.

The streaming media communication technologies in the DJammer leverage industry standards and allow consumers to exchange, share and interact together with multiple music streams. A complete description of the early prototype can be found in [5] and [6].

4. A New Musical Instrument

In the summer of 2004, the HP Labs group teamed with the industrial design firm IDEO to create a new prototype to be used by DJs in combination with their traditional equipment. Since the DJammer was a new paradigm in the world of DJ equipment, the early prototype afforded a myriad of directions that the final design could assume. This prototype had demonstrated the ability to use sensor input in order to carry out essential DJ functions. In order to establish an appropriate direction for the physical interface and the choice of sensors, the team tested the prototype with some leading DJs.
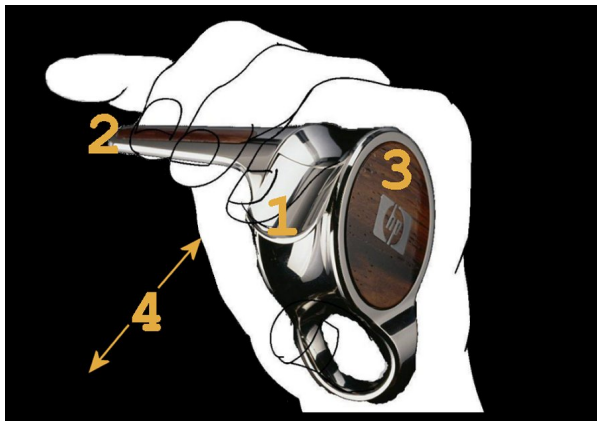
Cut Chemist and DJ Gawk1, both famous DJs experienced at evaluating prototypes for new DJ equipment, tested the DJammer prototype outfitted with a proximity sensor as the scratching interface and momentary switches for other controls. The DJs provided important feedback that was pivotal in influencing the interface design. Their feedback clearly indicated that latency between user input to the resulting audio effect was critical. The latency in any viable DJ equipment has to compare with the low latency in traditional DJ equipment using vinyl records. In addition, the DJs pointed out the complex level of timing involved in the other controls like "enable-disable", cross-fade and finding a cue. The

other important feedback was that the interface had to be operated in a manner where one could develop good proprioceptive sense for and development of muscle memory, much like any musical instrument. Being able to activate multiple sensors in quick succession with one's fingers was deemed as a requirement for scratching effectively. Finally, the sensors had to be able to record small subtle motions rather than large sweeping ones.

The findings from user testing indicated that instead of using a proximity sensor for scratch input, a handheld interface with an accelerometer would afford better mapping between physical motion and music manipulation. The new team quickly focused on a design that would allow the DJ to scratch one stream wirelessly away from the DJ console while interacting directly with the audience. It was felt that in order to create an interface that truly exploited the freedom from the proximity of the DJ console, the DJammer interface had to be one-handed rather than two-handed.

The design of the DJammer interface was arrived at through rapid prototyping. Several iterations of crude prototypes were created in order to simulate the input device. These were put in the hands of people with different hand sizes to understand the various issues surrounding comfort and activation speed.

Mapping the complex controls of a traditional DJ station onto one hand deserved a great deal of care. Various locations and mappings for different controls were prototyped in an iterative process with feedback provided by a professional scratch DJ. Figure 3 depicts the final mappings for the new prototype.

1 . **Mute: crossfading with a sharp slope**
2 . **Scratch Enable: placing hand on record**
3 . **Breakpoint: setting needle on record**
4 . **Pitch Speed: fast/slow turntable rotation**
   Pitch direction: push/pull of record

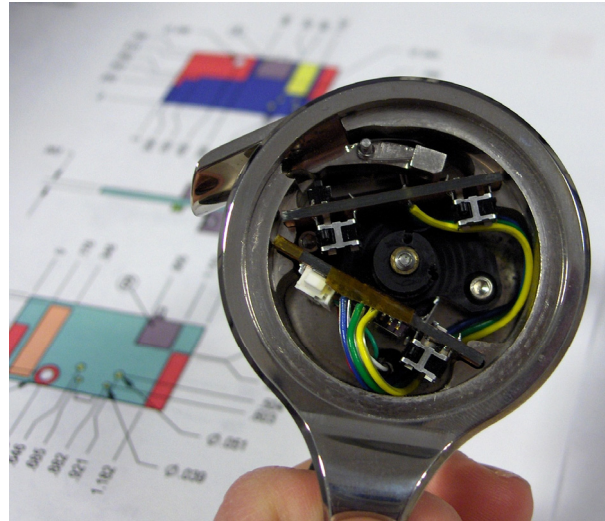**Figure 3. DJammer control mapping.**

Figure 4. Accelerometer in the handheld DJammer measuring position and velocity along board axis.

To accommodate the new sensors, a separate front end hardware unit was added to provide electrical interface and signal processing functions. The new front end hardware allows multiple diverse sensors to be used with the DJammer, some using very high data rates or a large degree of measurement precision such as micro machined gyros, linear accelerometers and proximity sensors. It offloads the raw sensor signal processing from the main DJammer unit, allowing it to be customized and optimized for new sensors and use models independently. It also allows HP to define and publish a DJammer Sensor API which would permit third party development of user interfaces and interaction mechanisms for the DJammer.

The sensor input for scratching was mapped to an accelerometer in the handheld shown in Figure 4 such that the motion akin to that of spinning the disk back and forth would simulate a similar effect on the digital music. Scratching music using vinyl records affords such a rich tactile feedback, it was felt that the "scratch-on/off" function had to map very intuitively to a motion similar to putting one's hand down to touch the record and lifting one's hand from the record. This semantic tie was tested with momentary switches on long levers in different positions. A long flat "paddle" stretching between the middle and little fingers proved to be a successful interaction.

The "mute/unmute" function, which is one of the key interactions in creating DJ music, needs to be activated in quick succession and closely tied to the scratch motion; hence this control was tied to a mechanically sensitive momentary switch placed under the tip of the fore-finger. The cue control is used with less frequency, hence it was felt that a large button on the side of the device which could be "thumped" with

the other hand or against one's body, would be adequate.

The current architecture was the result of a design aimed at creating a new type of musical instrument along with a process emphasizing human centered design. This led to the smooth forms through the use of polished metal and wood. The ring at the base of the thumb apart from aiding the aesthetic expression, serves to keep the device attached to the hand when all controls are released as shown in Figure 5. The redesigned DJammer is a striking ring of polished nickel-plated aluminum that fits snugly into the hand. The form and materials combine to give the feel and experience of a new musical instrument.

The new prototype was evaluated during a DJammer user study by six experienced non-professional DJs [7]. Each DJ used the device during a semi-structured one hour session. Due to the different sensory experience of air-scratching compared to that of scratching vinyl, the DJs noted that like any musical instrument the DJammer would take time to master. They all expressed openness to using the DJammer as an accessory to their standard DJ setup. They also had many positive comments regarding the size and weight of the DJammer:

"...how light it is and how it fits is a great concept."

"Ergonomically, this is kind of the natural feel…you have good response as having it naturally in your hand."

5. Conclusion

Showcased as HP's latest digital, mobile, virtual, and personal innovation, the DJammer was introduced to the press gathered for HP's Digital Experience Launch [8]. DJ Gawk1 –Figure 5– entertained the Digital Launch guests with his melodious creations using the DJammer and the team was able to demonstrate the progression from the purely analog standard DJ turntable setup to a completely new digital entertainment experience using the DJammer.

A significant contribution of the DJammer is in showing one way multimedia will be used as a communication modality. Interaction with real time media streams can not only change how people will create and consume music, but how they will composite it with other media such as video and speech.

Figure 5. DJ Gawk1 entertaining guests with the DJammer at the Digital Experience Launch [8].

6. Acknowledgments

7. References

[1] Gwertzman, M. "With a Nod to Vinyl, CD's Take Over the Turntable"*, The New York Times*, September 23, 2004.

[2] Roth, D., "Magna Cum Loud", *FORTUNE Magazine*, October 14, 2002, Vol. 146, No. 7.

[3] Webber, S., *Turntable Technique: The Art of the DJ*, Berklee Press, Boston, MA, USA, 2003.

[4] Broughton, F., Brewster, B., *How to DJ Right: the art and science of playing records*, Grove Press, New York, NY, USA, 2002-03.

[5] Hans, M., Smith, M. "A Wearable Networked MP3 Player and "Turntable" for Collaborative Scratching", IEEE International Symposium on Wearable Computers, White Plains, NY, October 2003.

[6] Hans, M., Smith, M. "Interacting with Audio Streams for Entertainment and Communication", ACM Multimedia, Berkeley, CA, November 2003.

[7] Slayden, A., Spasojevic, M., Hans, M., Smith, M., "The DJammer: "Air-Scratching" and Freeing the DJ to Join the Party", CHI, Portland, OR, April 2005.

[8] Miller, M. "Fiorina Charts HP's New Course*", PC Magazine*, September 9, 2004.