Bangarama: Creating Music With Headbanging

Laszlo Bardos, Stefan Korinek, Eric Lee and Jan Borchers
Media Computing Group
RWTH Aachen University
52056 Aachen, Germany
{bardos, korinek, eric, borchers}@cs.rwth-aachen.de

ABSTRACT

Bangarama is a music controller using headbanging as the primary interaction metaphor. It consists of a head-mounted tilt sensor and a guitar-shaped controller that does not require complex finger positions. We discuss the specific challenges of designing and building this controller to create a simple, yet responsive and playable instrument, and show how ordinary materials such as plywood, tin foil, and copper wire can be turned into a device that enables a fun, collaborative music-making experience.

Keywords

head movements, music controllers, interface design, input devices

1. INTRODUCTION

An essential part of the musical experience in rock music is in the body movements, and a very characteristic movement is the vigorous nodding of the head in sync to guitar strokes or the beat, also known as *headbanging* (see Fig. 1). This relationship between body movement and music inspired us to create a music controller that uses headbanging to trigger sound samples, so that a headbanger can influence the music with her movements instead of merely reacting to the music passively.

As part of a graduate-level computer science course examining new interaction metaphors for multimedia, our goal was to create a simple and intuitive music controller that is playable by non-musicians, but still retains enough flexibility to be of interest to musicians. Playing a classical musical instrument often requires executing complex hand and/or foot sequences, so we opted for a more simplified interface that naturally maps movements to sound generation and provides immediate feedback to the headbangs for increased playability.

In this paper we will provide an overview of Bangarama's design and its interaction metaphors. Then we will discuss the individual hardware and software components in more detail. Finally, we will discuss the results of observing users using Bangarama and collecting their feedback.

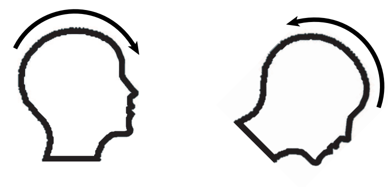

Figure 1: "Headbanging" refers to the fast, abrupt movements of the head in the forward direction.

2. RELATED WORK

Guitar-like controllers which introduce new methods of musical interaction and expression have been presented before. Jordà's QWERTYCaster [4] allows a user a large degree of freedom in creating MIDI music by attaching a keyboard, trackball and joystick to a single, guitar-shaped wooden controller. Unlike QWERTYCaster, Bangarama allows the user to interact with the system using only one hand, leaving opportunities for interacting with additional devices. Bangarama's style of buttons in place of frets also offer clearer affordances to users who may have seen a person playing a guitar, but do not know how to play themselves.

Merrill uses visual recognition of head nods and shakes to change sound attributes while playing guitar [6], as an alternative to foot switches, which can be difficult to operate. In his system, head movements are used to modulate the sound output from an ordinary electric guitar. Lyons' Mouthesizer implements a similar camera-based system which measures the shadow area in the player's mouth [7]. The size of the area is mapped to MIDI control changes. Bangarama, in contrast to these two systems, uses a simple mechanical sensor to minimize latency; head movements directly trigger sound samples.

Sheppard's digital guitar [9] replaces strings with several infrared and touch sensors. Four infrared beams simulate the same number of strings and are triggered by crossing the beams with the fingers of the right hand, and a matrix of 4x12 touch sensors represent the frets and are operated with the fingers of the left hand. This setup allows users to play the digital guitar very much like they would a real instrument; the disadvantage, however, is that the complex finger positions associated with guitar-playing must also be learned. Bangarama uses a different approach, by providing a simplified interface with affordances similar to a string instrument, and with the addition of headbanging.

Huott [2] created a ski-shaped device, played like a cello by laying the upper part over the shoulder and selecting notes by placing the fingers on the "neck" of the device. Instead of strings, the device has a rectangular patch of tactile sensors, covering an area of approximately 20 square inches. Sounds are generated and manipu-

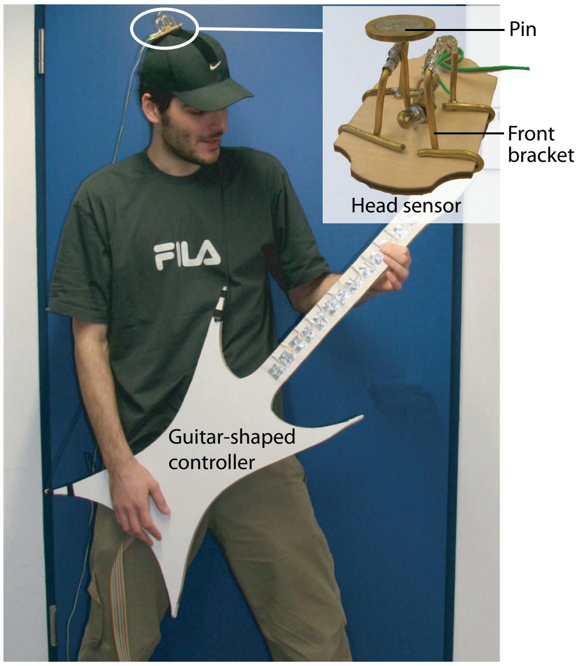

Figure 3: Bangarama player with head-mounted sensor and guitar-shaped controller.

lated by touching and moving the fingers on the patch. Again, Bangarama also uses the string instrument metaphor, replacing strings with touch sensitive sensors, but adds headbanging to the interaction.

3. DESIGN

Our system implements Wanderley's abstract digital music interface representation [12], which separates the gestural controller from the sound generation unit. Bangarama consists of three main components. A sensor is used to recognize head movements, and a guitar-shaped controller for selecting sound samples. The input is passed to a software subsystem created using Max/MSP, which selects the appropriate audio sample and plays it (see Fig. 2).

Bangarama uses a simple mechanical sensor mounted on a baseball cap to measure if the head is in an upright or downwards-tilted position. An upright-to-tilted transition triggers playback of a digital sound sample, selected by pressing one of the buttons on the guitar. The software subsystem allows any arbitrary digital audio sample to be played. We decided to use digital audio samples, rather than MIDI, to allow a wider range of sounds. For example, while the standard half-tone scale for a particular instrument can be used, other types of audio, such as speech, can be incorporated as well. We have also found that using audio samples of power chords makes it easy to create realistic sounding rock music. Power chords are triads consisting of the root, the fifth and the octave. Power chords are often used in rock music, played by distorted electric guitars.

We also tried using short sound bites from movies, played to the accompaniment of popular music. This choice proved to be an enjoyable alternative over standard music instruments, and is an example of how using digital audio provided greater flexibility than MIDI music.

Bangarama offers two modes of operation. In *freeplay mode* the user manually selects the sample to play using the buttons on the guitar, while in *automated mode*, the sequence of samples is preprogrammed into the system, and the user simply controls the timing. In both cases, the user has the choice of playing with a background accompaniment in the form of a looped audio sample to simulate the experience of playing in a band.

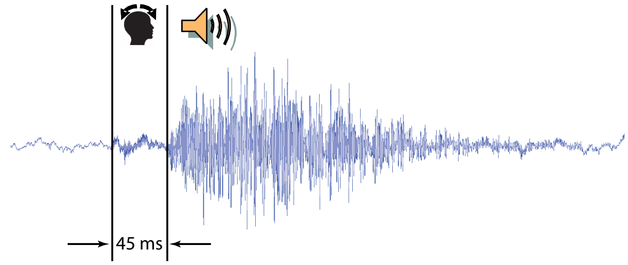

Figure 4: Measurement of Bangarama's overall system latency. We recorded the sound of the sensor pin hitting the bracket, together with the audio output from Max/MSP, and measured the latency in the resulting waveform.

In our design, we tried to minimize use of the mouse and keyboard, which is considered too technical and inappropriate for creating music [1]. In an earlier prototype of Bangarama, a keyboard was required to select the different sounds, which forced the player to sit in front of a computer while interacting with it. This phenomenon is also called the "laptop musician problem" [6], and in a subsequent version we used a guitar-shaped controller instead.

4. IMPLEMENTATION

Our original intention was to use an analog accelerometer for the head sensor, connected to a Teleo USB analog-to-digital converter [5] for measuring pitch and intensity of head movements. Using an analog device such as the accelerometer would be advantageous because it offers more degrees of freedom; for example, we wanted to map intensity of the movements to the volume of the samples. We also considered approaches based on head tracking and computer vision such as the one used by Merrill [6]. However, due to time and budget constraints, we decided to build a custom sensor that simply measures two states of head tilt. In retrospect, this solution turned out to be a better choice: compared to commercial head trackers and computer vision systems, our custom-made sensor is cheaper, less intrusive and easier to set up, factors which affect the overall immersiveness a system provides [11].

An evaluation of playability in a system often involves a measure of latency, with 100 ms being an often quoted upper limit for causality in user interfaces [3]. We measured the overall system latency by recording an audio clip of the sound when the pin hits the front bracket, followed by the resulting audio output triggered by this event. Examining the audio clip in a waveform editor, we found our overall system latency to be approximately 45 ms (see Fig. 4).

4.1 Head Sensor

The Bangarama sensor (see Fig. 3) is attached to a baseball cap using a Velcro strip, which allows each user to individually adjust the alignment of the sensor. The sensor is made of wire and works like a physical seesaw. If the head is moved downwards, the sensor pin tilts towards the front bracket and eventually closes the circuit. The contact opens when the head is moved back to its normal position. This creates two different signals that are evaluated in our software. In order to obtain better physical contact between bracket and pin, we weighed down the pin with a small coin and coated the

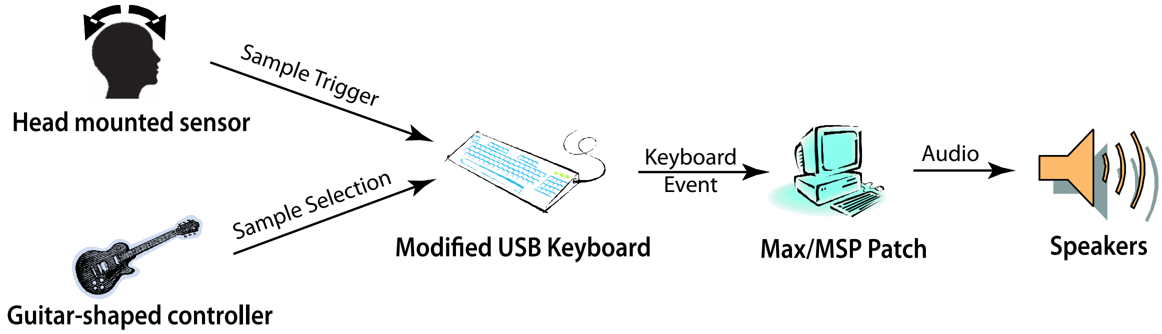

Figure 2: System overview. A head-mounted sensor triggers sound samples selected using a guitar-shaped controller. These devices are connected by a ribbon cable to a modified USB keyboard, which in turn passes the appropriate keyboard events to a Max/MSP patch that outputs the specified sounds.

Figure 5: Each pair of contact surfaces is connected to a corresponding pair of contacts on the keyboard.

bracket with tin foil. We differentiate between *open* and *closed* states, corresponding to the position of the pin.

4.2 Sample Selection

To enable the user to select the sample to play, we decided to use a guitar-shaped controller, following the DOMAIN APPROPRIATE DEVICES design pattern for interactive systems [1]. We cut out a guitar-shaped piece of a plywood and attached 26 aluminum contact surfaces along the neck of the guitar, two for each "fret". These contact surfaces are connected via ribbon cable to a USB keyboard. We removed several keys from the keyboard and directly soldered the wires from each pair of contact surfaces to the electrical contacts underneath (see Fig. 5). Each pair of wires is a different color, which helps the user learn and memorize finger patterns. The head sensor is connected in a similar fashion. While using Bangarama, the player must wear a strip of tin foil around his playing fingers, and selects a sound sample by placing those fingers on the appropriate contact surfaces, which in turn close the circuit and trigger the corresponding keys. We decided to include thirteen keys on the interface, corresponding to an octave plus the first note of the next octave, because popular songs often use the first note from this next octave.

4.3 Software

We used Max/MSP [8], a graphical, real time signal and event processing environment for MIDI and digital audio to output our sound samples. Our patch is responsible for catching events from the head sensor and Bangarama guitar. When the user selects a sound sample on the guitar, the attached USB keyboard sends a keyboard event, which causes the patch to switch to the specified sample. In a similar fashion, the patch receives a keyboard event when the user's head tilts downwards.

In our earlier prototypes, we encountered some stability problems with the head sensor: the pin of the sensor bounced when it hit the front bracket, resulting in additional, undesired keyboard events. This caused an irregular and quick repetition of the audio sample. To fix this issue, we implemented a time-based event lock, where subsequent events from the head sensor are ignored for the next 250 ms. We predicted that typical users would not headbang faster than 240 beats per minute.

As mentioned previously, Bangarama offers two different modes of operation, *freeplay mode* and *automated play mode*. In freeplay mode, the user selects the sound samples via the guitar-shaped controller, and in automated play mode, each headbang triggers a preprogrammed sequence of sound samples. After each head sensor event, the patch increments to the next stored sample.

The Bangarama patch also serves as the GUI for selecting the mode of operation, changing the volume, and triggering the background music. Max/MSP offers many standard UI components, such as buttons and sliders, so no working knowledge of Max/MSP is required from the user.

5. EVALUATION

We had the opportunity to demo and evaluate Bangarama at the annual Computer Science exhibition at RWTH Aachen University, where we received valuable feedback from visitors. Approximately 20 users of different age, experience level and professional background tried our system. Almost all of them could instantly grasp the functionality of Bangarama without extensive instructions. Of the professional guitar players, some found Bangarama an interesting and entertaining alternative to their real instrument, but some criticized its lack of flexibility and spectrum compared to a real electric guitar. As Jordà points out in [4], musicians need complicated tools with a high degree of freedom, but for casual users, simpler tools that convey the feeling of control and interaction while still producing satisfactory results are often sufficient. Jordà also points out that these two classes of users are often mutually exclusive. Feedback from a 10 year old seemed to confirm that our efforts to build a simple and intuitive interface for musical interaction was going in the right direction, as he was instantly able to successfully play in automated mode.

We were also surprised by the creativity of our users, who sometimes used Bangarama in "multiplayer" mode, where one user wore the headbanging cap, and the other selected the samples using the guitar. The potential for Bangarama to be used in such a collaborative environment was unexpected, and we hope to examine this phenomenon in more detail in future work.

During this demo session of Bangarama, we discovered two recurring problems that occurred during operation. The first problem arose because users would often look at the neck of the guitar while playing, and thus bow their heads to the side a bit. Since the head sensor was not designed to measure sidewise head movements, the system would occasionally miss a sample. Our second, related, problem occurred when users were too reserved in their head movements, in which case their movements would not produce enough kinetic energy to switch the sensor to the closed state. Perhaps they were afraid of causing damage to the system; however, this could also be due to the differing introvert versus extrovert personalities of users [10]. Stronger head movements eliminated the problems in both cases.

Some users also considered it slightly unnatural that samples were not triggered until the head reaches the downward position, which is when the switch closes. We are currently evaluating whether changing Bangarama such that samples are played at the beginning of head movements would increase usability. We furthermore shortened the sample lock time from 250 ms to 100 ms, as our assumptions regarding the maximum playing speed of our users turned out to be incorrect. The reduced lock time was still long enough to debounce the pin signal, but allowed faster guitar play.

6. FUTURE WORK

Our current version of Bangarama is still at an early stage of development; however, the initial feedback from testing with users has enabled us to adjust some technical aspects and uncover new possibilities for future development. We are currently evaluating the possibility of replacing the current digital switch-based sensor with an electrical or mechanical accelerometer. These sensors could measure the intensity of the head movements, which could be mapped to volume or speed. Multi-dimensional accelerometers could also open up possibilities for mapping headbangs in various directions to sample selection or other parameters such as distortion. Our current prototype also requires users to wrap a piece of tin foil around their fingers in order to play; in order to reduce the intrusiveness of the system the contact surfaces could be replaced by different touch sensitive components, such as the one used by Huott [2]. It is also desirable to remove any dependence on the mouse and keyboard from the interface, perhaps by installing the necessary controls on the controller itself.

We are also exploring the possibility of extending Bangarama for a more collaborative music-making experience, perhaps by adding more head sensors or controllers.

7. CONCLUSION

In this paper, we presented Bangarama, a prototype musical instrument that uses headbanging as the primary interaction metaphor. We showed how new and unorthodox musical interaction can be supported using only very simple, common motion sequences with the aid of cheap and widely available sensors and input devices. Bangarama offers the possibility to play guitar riffs, predefined sound sequences, unusual sound samples, and even provides the possibility for a multiplayer experience. Despite limited resources, we managed to produce a device that offers an entertaining and creative way of musical interaction for both skilled and unskilled musicians. We hope our project will serve as inspiration for others, and help them realize that expensive, complex hardware is not necessary to produce an innovative musical controller.

8. ACKNOWLEDGMENTS

The authors would like to thank Stefan Werner for his valuable advice and contributions during the development life-cycle.

9. REFERENCES

[1] J. Borchers. *A pattern approach to interaction design*. John Wiley & Sons, New York, 2001. http://hcipatterns.org.

[2] R. Huott. An interface for precise musical control. In *Proceedings of the NIME 2002 Conference on New Interfaces for Musical Expression*, Dublin, 2002.

[3] J. Johnson. *GUI Bloopers: Don'ts and Do's for Software Developers and Web Designers*. Morgan Kaufmann, 1st edition, March 2000.

[4] S. Jordà. Improvising with computers: A personal survey (1989–2001). *Journal of New Music Research*, 31(1):1–10, 2002.

[5] Making Things. Teleo. http://www.makingthings.com.

[6] D. Merrill. Head-tracking for gestural and continuous control of parameterized audio effects. In *Proceedings of the NIME 2003 Conference on New Interfaces for Musical Expression*, pages 218–219, Montreal, 2003.

[7] N. T. Michael J. Lyons, Michael Haehnel. The mouthesizer: A facial gesture musical interface. In *Conference Abstracts of the SIGGRAPH 2001*, page 230, 2001.

[8] M. Puckette. Max at seventeen. *Computer Music Journal*, 26(4):31–43, 2002.

[9] M. Sheppard. Digital stringless guitar. Master's thesis, University of Queensland, 2003.

[10] B. Shneiderman. *Designing the user interface*. Pearson Addison Wesley, 1997.

[11] M. Turk. *Handbook of Virtual Environments: Design, Implementation, and Applications*, chapter Gesture Recognition. Lawrence Erlbaum Associates, Mahwah, 2001.

[12] M. M. Wanderley. Gestural control of music. In *International Workshop Human Supervision and Control in Engineering and Music*, Kassel, Germany, September 2001.