The Hexenkessel: A Hybrid Musical Instrument for Multimedia Performances

Jacob T. Sello
ZM4 - UMIS Project
HfMT Hamburg
Hamburg, Germany
jacob.sello@hfmt-hamburg.de

ABSTRACT

This paper introduces the Hexenkessel - an augmented musical instrument for interactive multimedia arts. The Hexenkessel is a classical timpani with its drumhead acting as a tangible user interface for expressive multimedia performances on stage.

Author Keywords

NIME, augmented timpani, tangibles

ACM Classification

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing, H.5.2 [Information Interfaces and Presentation] User Interfaces — Input devices and strategies

1. INTRODUCTION

The Hexenkessel (witch's cauldron) is an augmented musical instrument, combining a classical orchestral timpani with multitouch tracking technology and embedded video projection. Unlike traditional acoustic instruments, where sound production is inseparably linked to the physical construction, the Hexenkessel acts as a gestural interface for computer music, controlling live-electronics, sound synthesis and even stage-lighting, without affecting the original sound and functionality of the timpani.

The initial prototype (figure 1) was realized in a tattered 21" timpani from the 1960s. After six month of tedious experiments with different systems for projection and mallet-tracking we succeeded in putting together a stage-proof setup that was publicly premiered with the composition *Licht & Hiebe* in 2010. In 2011 the Hexenkessel was shipped to the U.S. as submission to the Margaret Guthman New Instruments Competition in Atlanta. In this international competition for innovative musical instruments the Hexenkessel was awarded an honorary mention by the jury which included Sergi Jordà (Reactable) and John Chowning (FM-Synthesis). Various concert performances followed: NIME 2011 (Oslo, Norway), ZKM (Karlsruhe, Germany), Greatest Hits Festival (Hamburg, Germany) and others.

1.1 Related works

Apperently the Hexenkessel was inspired by the well-known Reactable [5, 3] that was initially showcased at the International Computer Music Conference (ICMC 2005) by the Music Technology Group of the Universitat Pompeu Fabra in Barcelona. The Reactable is designed as a modular music creation and performance system, using tagged physical objects as haptic input devices. A variety of technologically similar so called tangible user interfaces appeared in the following years, documented as open-source projects on the internet. Most of these multitouch-interfaces are constructed as tables with a semi-transparent acrylic surface and graphical interface elements projected from below. A camera-based tracking system for fingers and objects allows interaction with the computer system. In contrast to traditional touchscreens, the ability to track multiple inputs simultaneously permits the recognition of complex gestures.

Figure 1: Hexenkessel prototype (2010)

While the enclosures of these multitouch-tables usually do not deliver any specific functionality besides housinig their components, the Hexenkessel' technology is embedded in a classic orchestral timpani, extending its artistic potential by adding the vast possibilities of interactive computer-music.

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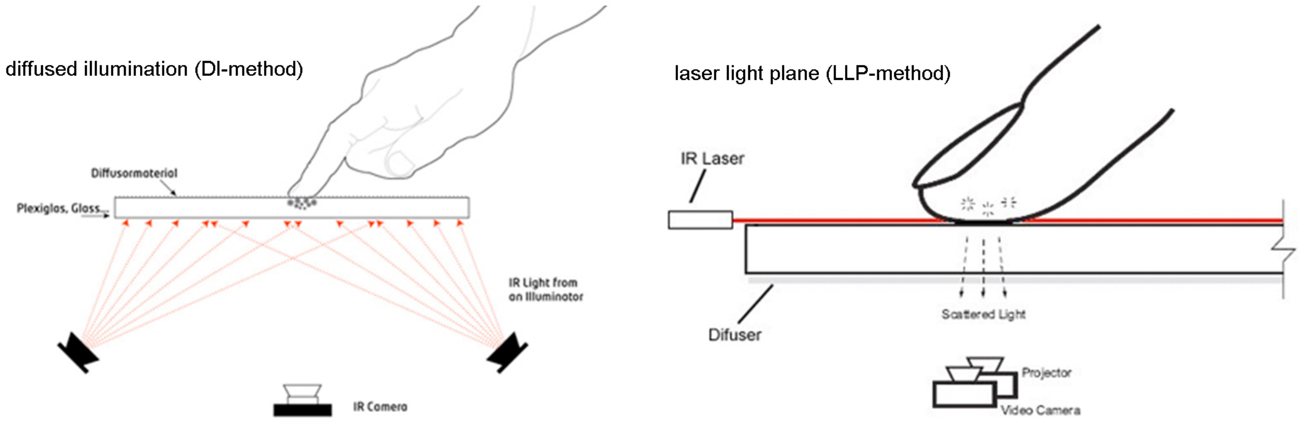

Figure 2: IR-Illumination for the optical finger-tracking. [Graphic-source: wiki.nuigroup.com/hardware]

Sensing mallets and hand-gestures on percussive instruments is not a novel idea: As soon as 1973 Moog introduced the 1130 Drum Controller as input-device for percussive synthesized sound. Various companies sold similar products in the following decades, usually utilizing force-sensitive resistors (FSR's) to measure the velocity of strikes in order to trigger synthesizers or samples. In modern electronic drumsets such as Roland's V-drums, still only the intensity of the input is captured. Thus, by analysing the waveform, the input's distance from the centered sensor can be estimated, giving information on the strike's location [1]. But there are alternative approaches: The Radio Drum [2], built by Bob Boie and furtherly enhanced by Max Mathews, operates with magnetic coils in the tips of two batons and an array of antennas in the corners of the rectangular sensing area. The batons' locations in 3D-space are determined by the electrical capacitance between coils and antennas. In contrast, Korg's original Wavedrum (1994) uses the drumhead's acoustic sound to drive physical-models for sound synthesis. A piezo-electric sensor, located below the drumhead, picks up vibrations and sonic peak detection is employed to trigger sounds. Depending on the algorithm used for sound production, also spectrum-analyses are performed to feed the physical models for sound synthesis. [1] In 2006 Maki-Patola, Hämäläinen & Kanerva presented their Augmented Djembe Drum at NIME. As in the Reactable a camera-based tracking system determines the position of hands and fingers to allow expressive interaction (leaving out the Reactable's visual component). [6] Sokolovskis & McPherson [10] describe their method of approximating the location of drum strikes, by calculating time difference of arrival (TDOA) between six optical sensors mounted below a common drumhead.

2. TECHNOLOGY

Different ideas and technologies that had been brought up under the DIY-acronym (Do It Yourself) were adapted for this project: For example the construction of the tracking system is based upon approved methods published by the NUI Group[1], originally developed for multitouch-tables. In contrast to this, the interactive graphical interface was custom made for this instrument. Here the artistic constraints are defined, so this software component is comprehended as part of the particular composition. Besides the conception and realization of such an interface, the main goal was the implementation of a reliable hardware setup within the tight fittings of the timpani's kettle with maximum cost-efficiency. The original prototype was developed at the expense of approximately $ 500 (US).

Figure 3: Hexenkessel v.2, inner view

2.1 Projection

For the projection from within the timpani's kettle a LED-based projector (Optoma ML-750) was chosen. This projector offers a very compact size, accompanied with low heat-emission, which is crucial for the operation considering the poor air-circulation inside the instrument. For these features we accept weak light output (700 ANSI-Lumen) and fairly low resolution (1280 x 800 pixels) as trade-off.

To achieve the desired projection-size with the drumhead's diameter we developed a custom lens for the initial prototype and deflected the picture twice with mirrors. While this led to a sufficient screen size, it resulted in a significant loss of light intensity and problems with focussing. To overcome these issues, for the current setup we use the projector's standard lens in combination with a concave mirror (originally intended for fork-lifters). The optical

[1]The *Natural User Interface Group* with its more than 5000 members documents various multitouch-techniques and provides a lively forum for the free transfer of ideas and experiences: `http://nuigroup.com`

distortion resulting from this setup is digitally eliminated. While the original design could hardly fit the needed size of the 21" drumhead, our present setup can easily handle larger screens, so a bigger scale timpani can be modified in the same way. For the new Hexenkessel a 26" instrument by the Dutch manufacturer Adams was acquired.

2.2 Tracking system

The mallet- and finger-positions are identified using a camera, sensitive infrared (IR) light, mounted inside the kettle. For the illumination, we conducted experiments with various well documented methods (figure 2). [8] In the original prototype we used the LLP-method (laser light plane), where IR-lasers with special lenses (line-generators) were mounted on the timpani to produce a plane of light in the IR-spectrum (780nm) just above the drumhead. For the current setup we use IR-LED-strips inside the kettle, realizing the DI-method (diffused illumination). Here not only the outlines of bodies touching the surface are recognized, but this method also allows detecting special markers (fiducials) attached to objects put on the drumhead, as demonstrated with the Reactable. This lighting-technique presents another advantage: The size of the resulting luminous spot (blob) is dependent on the pressure of the input on the surface, enabling more dynamic and expressive input recognition.

For the identification of input-gestures the open-source software Community Core Vision (CCV) is used. CCV reads and processes the camera's output: After eliminating the static background, different video-filters are applied in order to create distinct light blobs which are interpreted as touches. The coordinates of these input-events are sent, coded in TUIO-format [4], to the interpreting application. The data can be forwarded via network to another computer or can be further processed locally.

2.3 Interpretation of tracked input data

The tracking-data generated in CCV is received in the visual programming language Max where all further processing and interpretation is performed, such as the pre-distortion of the video-content to counteract the effect of the curved mirror or the mapping of tracking-coordinates to the corresponding pixel for calibration purposes. The rendering of interface elements, the implementation of interactive controls and the sound-processing are realized in Max as well. At this stage the technological and artistic development process merge. Since the needs and concepts might be unique to one particular piece, the implementation of the appropriate functionality can be considered to be part of the composition.

Of course, additional sensors can be added to the instrument, as we do it to track the position of the prototype's foot pedal utilizing a Sharp distance sensor. Also a DMX-interface to control stage-lights was integrated in the Hexenkessel, so the player can incorporate his own interactive light-show, making the Hexenkessel a truly versatile interface for interactive media art.

2.4 Shortcomings

Especially for percussive interfaces, latency is a critical issue. The currently used camera for the mallet-tracking operates at 60 frames per second (fps), accordingly the input is updated every 16.6ms. Adding up the time for processing and the audio-interface's latency, the delay sums up to approximately 25ms. Also the projector introduces additional latency. But since the graphics are only used as visual feedback for the performer, this issue is ignored at this stage of development. The overall system-latency would be considered unacceptable for a percussion trigger pad. But in the Hexenkessel the tangible input is mainly used for setting parameters of sound synthesis, effects and light control, where timing is less crucial. For time-critical interaction a microphone can be used, to perform audio-based onset-detection in order to initialize actions with minimal latency. This was done in *Licht & Hiebe* for triggering an electronic basedrum with a synchronized stroboscopic flash.

Another issue, specific to the Hexenkessel, is the choice of the drumhead: Different models have unique characteristics, concerning projection quality and translucency of IR-light. Both requirements are fairly contradictory and need to be balanced. And if the DI-method is chosen for IR-illumination reflections on the skin's underside can become problematic: In contrast to solid surfaces, where the static background and reflections can easily be eliminated by image processing, the vibrating drumhead produces constantly moving reflections that can cause false readings. After the comparison of numerous different models by various brands, the Remo's Suede series was chosen as drumhead for the Hexenkessel.

Figure 4: Hexenkesselchen (2015)

3. RECENT DEVELOPMENTS

Thanks to financial support from the Hamburg State Ministry of Science, Research and Equalization (BWFG) the development of the instrument could be resumed in 2014 after resting for two years as a research project at the Hamburg University for Music and Theatre (HfMT Hamburg). Various components of the prototype that appeared to be problematic in concert situations were able to be optimized. The main challenge was to reduce the time span necessary for setup and the possibility to easily reproduce the instrument and its parts. This was realized by replacing the doublemirror setup by the concave mirror in conjunction with a standard projector (figure 3). And the transition to the DI-illumination-technique made it possible to discard the unusual IR-lasers in favor of cheap IR-LED-strips, which could be permanently mounted inside the kettle.

Also the software was entirely rewritten, using several new features of recent Max-releases, thus enhancing the overall system-performance and simplifying the development of new interfaces. Namely the jit.phys-objects allow the quick realization of new graphical interfaces. This toolset is built upon the Bullet physics library, featuring 3D-physics simulation and collision reportings. Furthermore TUIO-like touch-messages are accepted as input for interaction.

With the recent development of the 'Hexenkesselchen' the technological concept was transferred into a standard 14" Floor-Tom (figure 4). All features of the original project could be retained, while offering a portable, low-cost solution for every drummer.

Figure 5: Hexenkessel v.2 (2015)

4. CONCLUSIONS

Within the three years of the ongoing UMIS project (Unified Musical Instrument Surfaces) the instrument will be further optimized and presented in concerts with student compositions. Also pieces featuring tangible score elements are in development. In the future the Instrument may even be used as interactive tool for practicing.

Whether the Hexenkessel's evolution will ever go beyond the status of a prototype, ready for small-scale production, remains to be seen. The target group of experimental timpani players appears too small to go into mass production. However, the Hexenkesselchen may appeal to a whole new group of potential users. Meanwhile the use of the Hexenkessel in the context of contemporary music and multimedia performance arts goes on: The updated Hexenkessel will be premiered on stage at the Sound and Music Computing conference (SMC 2016) in Hamburg.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] R. M. Aimi. *Hybrid Percussion: Extending Physical Instruments Using Sampled Acoustics.* http://opera.media.mit.edu_publications/aimi_phd_thesis_2006_hybrid_percussion.pdf, 2006.

[2] B.Boie, M. Mathews, and A. Schloss. *The Radio Drum as a Synthesizer Controller.* Proceedings International Computer Music Conference (ICMC), 1989.

[3] S. Jorda. *Digital Lutherie Crafting musical computers for new musics' performance and improvisation.* Universitat Pompeu Fabra, Barcelona, 2005.

[4] M. Kaltenbrunner, T. Bovermann, R. Bencina, and E. Costanza. *TUIO - A Protocol for Table-Top Tangible User Interfaces.* Proceedings of the 6th International Workshop on Gesture in Human-Computer Interaction and Simulation, Vannes (France), 2005.

[5] M. Kaltenbrunner, S. Jordà, G. Geiger, and M. Alonso. *The reacTable*: A Collaborative Musical Instrument.* Proceedings of the International Computer Music Conference, 2005.

[6] T. Maki-Patola, P. Hämäläinen, and A. Kanerva. *T. Maki-Patola, P. Hämäläinen, A. Kanerva.* Proceedings of the International Conference on New Interfaces for Musical Expression, 2006.

[7] E. R. Miranda and M. M. Wanderly. *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard.* A-R Editions, Middleton, 2006.

[8] NUI_Group_Authors. *Multitouch Technologies, 1st ed.* http://nuigroup.com/log/nuigroup_book_1, 2009.

[9] J. T. Sello. *Der Hexenkessel: Ein intermediales Hybridinstrument.* In: A. Weisbecker and M. Burmester and A. Schmidt (ed.): Mensch und Computer 2015 Workshopband, Stuttgart: Oldenbourg Wissenschaftsverlag, P. 331-337., 2015.

[10] J. Sokolovskis and A. P. McPherson. *Optical Measurement of Acoustic Drum Strike Locations.* Proceedings of the International Conference on New Interfaces for Musical Expression, 2014.