Mubone: An Augmented Trombone and Movement-Based Granular Synthesizer

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ABSTRACT

The mubone is an incremental evolution of the slide trombone based on a system of electronic augmentations which allow the spatial orientation of the instrument to be incorporated into the control of algorithmic sound and music synthesis. We present our conceptual design for this new instrument, detail its practical implementation with a spatially-controlled granular synthesizer, and discuss initial creative uses.

CCS CONCEPTS

• **Applied computing** → **Performing arts**; **Sound and music computing**; • **Human-centered computing** → *Gestural input*;

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KEYWORDS

augmented musical instruments, gestural control of sound, granular synthesis, trombone

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INTRODUCTION

The practice of electronic augmentation of acoustic instruments such as the trombone draws on a long history of instrumental preparation and extended techniques. Trombonists have adopted a variety of sometimes unexpected objects, e.g. the toilet plunger, into the standard set of mutes [4]. Other oddities, including garden hoses and balloons, have been attached to the trombone for theatrical effect, and in fact, these sorts of preparations are championed by virtuoso trombonists, such as Mike Svoboda and Felix Del Tredici. Along with extended techniques, like split-tone and vocal multiphonics, these instrumental preparations extend the sonic range of the acoustic trombone. Electronic augmentation is a logical continuation of this line of creative inquiry [1], further extending the capabilities of the trombone.

The mubone was conceived out of Kalun Leung's object-oriented performance practice[1] that was developed over several years of exploring alternative applications for the trombone in improvised theatre, dance, and electronics. This approach draws its inspiration from the Fluxus concept of intermedia [6], as well as from artists including the double bassist Ben Patterson, whose unconventional use of their instrument was a response to the instrument's inherent physical characteristics [10]. Leung's application of the trombone as a stage prop in SIRI Breakup (2017)[2], in the sound installation Die Posaune (2018)[3], and as a percussion instrument in Picnic Electronic (2019)[4] are precedents to the development of the mubone as a trombone-gestural controller. The mubone seeks to challenge the traditional role of the trombone by unveiling an alternative caricature of the instrument that foregrounds its inescapable gesture and physicality.

We developed our conceptual design based on our initial design considerations and review of the literature. Inspired by the handle found on the sackbut (a predecessor of the modern trombone) as well as Henriques' Dual Slide Controller [5], we envisioned a right hand controller with several buttons and an orientation sensor, so its orientation with respect to the trombone could be used as another continuous control source. We refer to this attachment as 'the yoke,' in reference to the flight yoke of an aircraft. A counterweight-style attachment would contain a second orientation sensor allowing the directionality of the mubone to be measured. We decided to use an optical approach to slide position sensing in order to keep a simplified implementation (compared to e.g. the sophisticated ultrasonic

[1] Object-oriented in the sense of object-oriented ontology, rather than e.g. object-oriented programming

[2] https://kalunleung.ca/2017/12/27/182/. Accessed 2019-08-05.

[3] https://kalunleung.ca/2018/07/21/die-posaune/. Accessed 2019-08-05.

[4] https://kalunleung.ca/2019/06/21/picnic-electronic/. Accessed 2019-08-05.

approach of the uSlide system), as well as to avoid having a mechanical linkage between the inner and outer slide.

For sound production, we wanted to design a synthesis approach in which the directionality of the trombone would play an essential role. Inspired by Borderlands [3], GrainTrain [2], and Nathan Weitzner's 3D Granular program[5], we imagined a granular synthesis environment in which the sounds of the mubone could be 'planted' in a specific location by pointing the instrument in that direction when the sounds are recorded. Then, when the sounds should be granularly played back, the performer could simply point the instrument in the same direction again.

[5]https://youtu.be/HyNhEc4VYmk?t=39. Accessed 2019-03-31.

IMPLEMENTATION

Hardware

For orientation sensing, we chose to use magnetic, angular-rate, and gravity (MARG) sensors. We calibrated the accelerometer and gyrometer using the method described in [14] and the magnetometer using the method described in [7]. Finally, we implemented the sensor fusion algorithm described in [8] and [9] based on the open source implementation available online[6].

[6]https://x-io.co.uk/open-source-imu-and-ahrs-algorithms/. Accessed 2019-08-05.

The counterweight module consisted of a single orientation sensor and an ESP8266 WiFi-enabled microcontroller unit (MCU), both powered by a lithium polymer (LiPo) battery. The circuit was attached to the crook of the tuning adjustment slide at the back of the trombone with gaffer tape. The yoke was implemented with the same kind of MARG sensor, microcontroller, and battery, with the addition of three buttons. We opted to use only three buttons, preferring to use multiple-button combinations to increase the number of possible inputs rather than additional buttons, allowing each finger to have a single job (either to press a button or to hold the instrument).

To measure slide position, we chose to use an infrared time of flight (ToF) distance sensor; this type of sensor works by emitting an infrared signal and measuring how long it takes to reflect back to the sensor off of a distant object. Since the time of flight is a linear function of the distance from the sensor to the reflecting object, ToF sensing offers good measurement linearity compared to measuring the intensity of the reflected infrared signal. It has the advantage of requiring only a single sensor which both transmits and receives the infrared signal, and it can therefore be mounted on either the inner or outer slide of the trombone. Additionally, integrated-circuit infrared ToF sensors are readily available, making the implementation relatively trivial.

Audio–Directionality Recording System

We implemented the granular synthesizer and audio recorder in C++ using the JUCE library. The interaction with the synthesizer is based on the idea of sounds placed in space around the performer which can be recalled by pointing to their location. In order to achieve this interaction metaphor, we had to decide on a way to record the direction the mubone was pointed. We chose to express direction using a unit vector pointed in the same direction as the trombone. This gives a unique coordinate for every direction the trombone could be pointed, and allows euclidean distance to easily be used as a cheap distance metric[7]. This vector is determined by converting the quaternion representation of the orientation of the trombone to a rotation matrix representation, since this vector corresponds to the second column of the rotation matrix. We also could have used the orientation quaternion directly, but decided that a vector representation was more natural since it would be insensitive to the rotation of the trombone about its y-axis (the banking gesture of figure 1b). This insensitivity corresponded better with our sense of how directionality should work. Sounds are recorded in real-time along with a corresponding direction vector. Later, the sounds are recalled based on how close the direction of the sound is to the current direction of the mubone.

[7]We also considered using great arc distance as a distance metric (effectively the angle or arc-length between two points on the surface of a unit sphere), but we decided against it due to the requirement to compute an expensive arctangent function to calculate this metric. We consider euclidean distance as an acceptable approximation for great arc distance, especially for small distances.

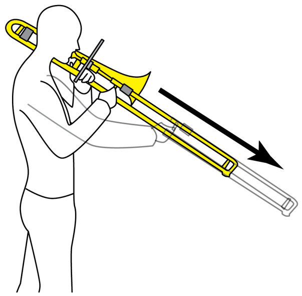
Synthesis Model and Mapping Strategy

The synthesis model is a fairly simple sound sample granulator using a synchronous granular synthesis (SGS) control scheme [11, ch. 3, pg. 93]. A grain cloud is considered as a module which generates grains, where each grain plays back a brief hann-windowed fragment of one of the sounds recorded earlier. Each cloud has a grain rate parameter controlling the frequency in Hz with which grains are generated and an overlap factor parameter controlling the duration of the grains as a function of the period of the grain rate. The grain rate is controlled by a throttle gesture with the yoke, similar to the gesture of revving a motorcycle (fig 1c), while the overlap factor is controlled by banking the trombone to the left or right (fig 1b).

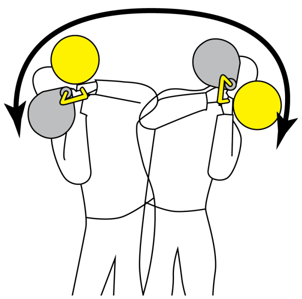
In addition to grain rate and overlap factor, which control the timing and duration of grains, a direction vector parameter and a search radius parameter are used to select the sound to be granulated from among the previously recorded sound samples distributed in the space around the performer. In the current implementation, the aforementioned list of direction-to-sound pointers is sorted by distance from the grain cloud's direction vector parameter, and then one pointer is selected randomly from all of the pointers whose distance is less than the search radius parameter. The search radius can be modified by holding a button combination on the yoke while using the slide position to set the parameter (fig 1a).

PRACTICE

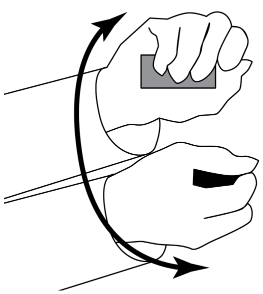
The mubone debuted at the NYC Electroacoustic Improvisation Summit at CUNY City Tech in February, 2019. Leung performed a 10 minute freely improvised piece that was described in the program as "extended trombone-driven granular synthesis." The mubone and its companion granular



(a) slide position → search radius



(b) bank → grain overlap



(c) throttle → grain rate

Figure 1: Overview of the granular synthesis control gestures

synthesis environment were tested and practiced during the two weeks leading up to the event, with subsequent solo performances in the improvised and new music scenes based in NYC.

Special attention was needed to develop space and movement strategies during live performance and practice. In tackling the challenges of spatial memory, one strategy employed was to use objects within the space as references; picking a fixed point in space and pointing at it served as a good visual anchor for placing and recalling sounds. Another strategy was to designate spaces for certain functions. The area at the feet was designated for unused clouds and thus no sound was permitted to be recorded there. The area directly above the player was a another safe space where no sounds were recorded thus creating another area for silence. The location of placed sounds would also affect how the performer would navigate around the virtual sphere; if the sound placed in a particular location was not desired at a given moment, the player would need to avoid that area when moving between spaces. This growing collection of strategies forms the bedrock for a performance approach taking into account what Di Sicipio calls ecosystemic interactions [12]. This paradigm is a move away from traditional 2D or diametric sound processing and takes into account the space that the performer can actively interface with.

FUTURE WORK

Although the current implementation of the synthesizer and gestural interface already achieves the interaction paradigm we initially imagined, there remains significant room for improvement. In particular, the current implementation of the directional granular sampler by sorting the list of direction-to-sound pointers performs very poorly as the list grows larger (i.e. as more and more sounds are recorded). This places an upper limit on the amount of sound which can be recorded before the system becomes unstable. We are currently investigating strategies to reduce this computational cost. We are also excited to explore new mapping strategies and different ways of interacting with sounds placed in space including new synthesis approaches.

The mubone has reached a stable and performance-ready state of technical development, and research into how this new instrument can be performed has only just begun. Moving forward, research-creation with the instrument will explore how the mubone can interface with its environment through spatialized audio and site-specific projection mapping. Inspired by the medieval use of the trombone as an outdoor instrument, we hope to amplify the spatialization capabilities that the acoustic trombone offers in an abstracted audiovisual presentation.

We are also exploring how the mubonist's movements, gestures, and body can play a role in the performer's dynamic expressivity. Considering traditional pantomime, corporeal mime, and what Stover refers to as "interacting corporeal performing bodies" [13], what extra-musical sensations do the mubone-mubonist portray? Can the instrument-body sustain dramatic action in live performance? We begin to address this question by both allowing the electronics themselves to act as a sound source rather than always processing the recorded sound of the trombone and by enabling the ability to record gesture sequences.

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REFERENCES

[1] Bert Bongers. 2000. Physical Interfaces in the Electronic Arts Interaction Theory and Interfacing Techniques for Real-time Performance. In *Trends in Gestural Control of Music*, Marcelo M. Wanderley and Marc Battier (Eds.). IRCAM, Paris, 41–70. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.90.4997{&}rep=rep1{&}type=pdf

[2] AnÄśl ÇamcÄś. 2018. GrainTrain: A Hand-drawn Multi-touch Interface for Granular Synthesis. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. 156–161.

[3] Chris Carlson and Ge Wang. 2012. Borderlands: An Audiovisual Interface for Granular Synthesis. In *Proceedings of the International Conference on New Interfaces for Musical Expression*.

[4] S Dempster. 1979. *The Modern Trombone: A Definition of Its Idioms*. University of California Press. https://books.google.com/books?id=QpwIAQAAMAAJ

[5] Tomás Henriques. 2009. Double Slide Controller. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. 260–261. http://www.nime.org/proceedings/2009/nime2009{_}260.pdf

[6] Dick Higgins and Hannah Higgins. 2001. Intermedia. *Leonardo* 34, 1 (2001), 49–54.

[7] Xiang Li and Zhi Li. 2012. A new calibration method for tri-axial field sensors in strap-down navigation systems. *Measurement Science and Technology* 23, 10 (2012). https://doi.org/10.1088/0957-0233/23/10/105105

[8] Sebastian O H Madgwick. 2014. *AHRS algorithms and calibration solutions to facilitate new applications using low-cost MEMS*. Ph.D. Dissertation.

[9] Robert Mahony, Tarek Hamel, and Jean-Michel Pflimlin. 2008. Nonlinear Complementary Filters on the Special Orthogonal Group. *IEEE Trans. Automat. Control* 53, 5 (2008), 1203–1218. https://doi.org/10.1080/00207179.2012.693951

[10] Benjamin Patterson. 1962. Variations for Double-Bass. (1962).

[11] Curtis Roads. 2001. *Microsound*. MIT Press.

[12] Makis Solomos. 2014. Agostino Di Scipio: Audible Ecosystems. *Contemporary Music Review* 33, 1 (2014), 2–3. https://doi.org/10.1080/07494467.2014.906673

[13] Chris Stover. 2016. Musical Bodies: Corporeality, Emergent Subjectivity, and Improvisational Spaces. *M/C Journal* 19, 1 (2016). http://journal.media-culture.org.au/index.php/mcjournal/article/view/1066

[14] David Tedaldi, Alberto Pretto, and Emanuele Menegatti. 2014. A robust and easy to implement method for IMU calibration without external equipments. In *Proceedings - IEEE International Conference on Robotics and Automation*. 3042–3049. https://doi.org/10.1109/ICRA.2014.6907297