SALTO: A System for Musical Expression in the Aerial Arts

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ABSTRACT

Wearable sensor technology and aerial dance movement can be integrated to provide a new performance practice and perspective on interactive kinesonic composition. SALTO (Sonic Aerialist eLecTrOacoustic system), is a system which allows for the creation of collaborative works between electroacoustic composer and aerial choreographer. The system incorporates aerial dance trapeze movement, sensors, digital synthesis, and electroacoustic composition. In SALTO, the Max software programming environment employs parameters and mapping techniques for translating the performer's movement and internal experience into sound. *Splinter* (2016), a work for aerial choreographer/performer and the SALTO system, highlights the expressive qualities of the system in a performance setting.

Author Keywords

interactive systems, aerial dance, myo armband (sensors), synthesis, mapping

ACM Classification

H.5.5. Information Interfaces and Presentation: Sound and Music Computing —Systems. J.5. Arts & Humanities: Performing Arts (e.g. dance, music).

1.INTRODUCTION

Interactive systems for dance and electronic music have long been developed alongside research in musical gesture, choreological approaches, and Human-Computer Interaction (HCI). These have included the use of consumer and custom-built motion-based technologies like Wii controllers[1], Kinect sensors[2] and the Leap Motion[3] controller. Historically works and research in this field have focused on more traditional and contemporary forms of dance [5, 11, 12, 13]. They have yet to include the unique experience and range of motion possibilities found within the aerial dance art forms. This paper presents SALTO (Sensory Aerialist eLecTrOacoustic system), a new musical system designed in MaxMSP[4] that utilizes the Myo Armband[5] (a wearable gesture and motion control device made by Thalmic Labs) for collaborative works in aerial dance. SALTO was developed to encourage further exploration into interactive musical systems and aerial dance performance practice. The system uses sensor data from aerial movement to control and generate sonic material that translates the kinesonic experience of the aerialist [13]. Movement drives both choreographic and compositional choices. *Splinter* [6] (2016), a composition for aerial choreographer/performer and SALTO, provided the initial and conceptual framework for experiments in mapping and performance technique (Figure 1). The paper begins with a technical description of the system and then describes the expressive capabilities of the system in performance.

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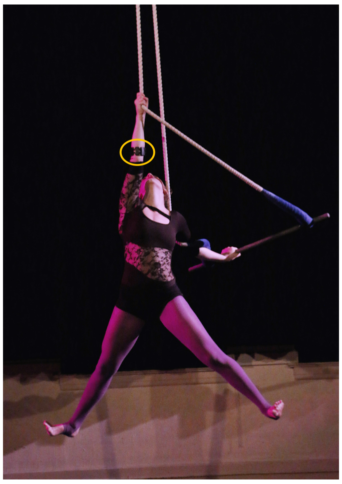

Figure 1. Still from *Splinter* (2016) with Myo Armband highlighted. Performer: Katharine Geber

2.MYO ARMBAND

The Myo Armband is a wearable, gesture capture and motion control based device designed to interface with computers/laptops, smartphones, and other controllable electronics. In recent years composers and technologists have been expanding its capabilities and developing software to use the Myo as a controller for digital/software and analog instruments [14, 19]. So far, it has proven to be a robust and reliable device with great potential for creativity and experimentation within the NIME community.

[1] http://wii.com/

[2] www.xbox.com/en-US/xbox-one/accessories/kinect

[3] www.leapmotion.com

[4] cycling74.com

[5] www.myo.com, www.thalmic.com

[6] video of *Splinter*, https://vimeo.com/199972423

The Myo Armband contains eight electromyographic (emg) sensors, and a nine-axis inertial measurement unit (IMU) consisting of an accelerometer, a gyroscope and magnetometer. It is worn on the upper part of the forearm, beneath the elbow and communicates via Bluetooth. Using a C++ language binding wrapper, the Open Sound Control (OSC) protocol is easily accessible, allowing the raw sensor data to be sent and used in any application.

3.THE SALTO SYSTEM

SALTO is a musical software system designed in Max software that receives and filters sensor data from the Myo Armband. The system maps the sensor data collected from aerial dance movement to parameters within three sound processing modules. The name "Salto" is derived from the movement term used in gymnastics and aerials to define a frontwards or backwards flip (full inversion and rotation of the body).

Aerial dance provides a set of movements which utilize the full range of motion and muscle tension measurable by the Myo. Further, the sleek design of the armband provides little interference with the performer's movement further maximizing choreographic and expressive potential. Figure 2 demonstrates the system architecture for SALTO.

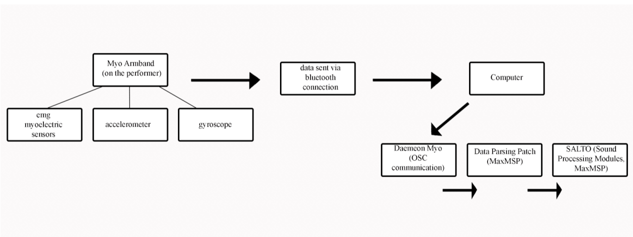

Figure 2. System architecture for SALTO.

The current design of the system creates an interactive soundscape where the choreographer can articulate smaller musical gestures as well as alter overarching textures within the soundscape. The system allows flexibility for the performer to emphasize gestural movements, dynamic whole body inversions and rotations, or any combination of these types of movements. A composer can work with a choreographer to further define the character and timbre of the soundscape depending on the source musical samples used in each synthesis module.

3.1.Mapping

SALTO is comprised of three sound processing modules. The data streams from the emg sensors, the accelerometer and the gyroscope are mapped to each of the sound modules respectively.

The emg sensors are linked to a digital synthesis module which uses the click~ object (an impulse generator), a resonant filter, and spectral delay. When a muscle in the forearm contracts, an electrical(neural) impulse is sensed through the skin. If the electrical impulse reaches the threshold set at 0.33 in the Max software, then it triggers an impulse from the click~ object. This is then run through a resonant filter where each individual emg sensor is assigned a different center frequency. This creates short percussive 'plink' sounds similar to a vibraphone with no motor or pedal. The eight emg center frequencies are tuned to a pitch cluster focused around 900Hz. These are best heard when the performer is climbing or when gripping the ropes or trapeze bar.

The accelerometer is mapped to a granular synthesis module. This module relies on Timo Rozendal's grainstretch~[7] object to drive the granular processing. The changes in velocity within the x, y, and z planes correspond to grain size, playback speed of the grains, and pitch modulation. Depending on the source sound material used this module can create a gestural voice within the resulting composition. For this module, we used a fixed sample of a marble rolling around in a temple bowl. This allowed the performer to use smaller movements to almost "draw" sonic gestures.

The gyroscope is mapped to a filtering module with an automated delay. This module uses the iosc~ and cascade~ objects. Recorded sound material is loaded into the bank of oscillators to create the shape of the amplitude envelope and then the iosc output was further processed with notch filters and a delay of 300ms. The pitch and yaw of the gyroscope control the center frequency of the filters and the roll controls the gain of each filter. This module creates a sweeping sensation that reflects and echoes micro and macro cyclical movement (singular rotation of the arm versus full rotation of the entire body), see Figure 3. This musical gesture follows the performer, tracing the movement sonically.

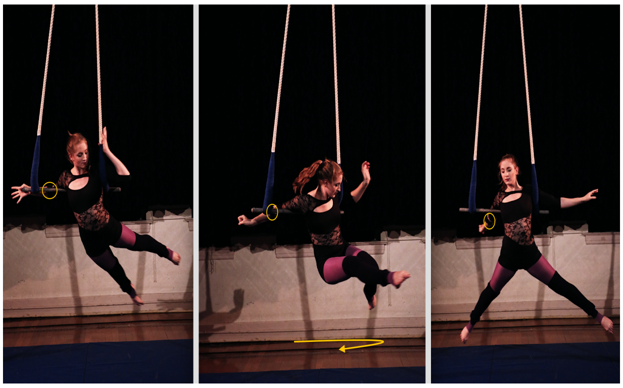

Figure 3. Example of full body rotation.

3.2.Technical and Physical Limitations of the Myo Armband & Bluetooth Communication in Aerial Dance Environments

While aerial dance movement allows a composer access to utilize the full range of motion detectable from the sensors, gesture recognition and accuracy becomes difficult to isolate and maintain consistency. This initial mapping structure aimed to explore the responsiveness of the sensors under force and physical stress. This would determine the system's ability to match movement gesture with musical idea for a variety of movements within similar movement categories making repetition and reiteration possible sonically. An initial challenge was determining the physical range of the Bluetooth signal. For aerials and the safety of the performer and equipment, we needed the ability to be a significant distance from the rigging point and performance area. Fortunately, no noticeable limitations were found when the Myo was within 10-25 meters (30-90ft) of the receiving computer. Other challenges included determining the

[7] http://www.timorozendal.nl/?p=456

Table 1. Movement & SALTO system design.

Movement Category	Body Movement: Whole Body	Body Movement: Arm	Sonic Idea	Physical Sensation	Sensor
Spinning	rotation of the entire body and trapeze together	medial or lateral rotation of the arm	sweeping, dynamic filter of a resonant sound, echo	pressure (gravitational)	gyroscope
Inversion	Entire body is inverted, holding the body in an inverted position (getting on the trapeze, handstand in the ropes)	flexion, extension, abduction of the arm	granular	effort, pressure (gravitational)	accelerometer
Flipping (rotation + inversion)	full frontwards and backwards flip, roll ups, hip circles	circumduction of the arm	sweeping, dynamic filter of a resonant sound, echo	pressure (gravitational)	gyroscope
Static (balanced / hands free)	poses that don't require grip (ie: back balance, gazelle, hanging in ankles, around the world)	flexion, extension, abduction of the arm (any movement), can be gestural/expressive	granular	pressure (rope/bar)	accelerometer
Static (held / hands support position)	poses that require at least one arm holding onto the apparatus(ie: amazon, bird's nest)	grasping, holding on	percussive texture	effort, pressure (ropes/bar)	emg

maximum intensity of force, pressure, and speed that could be exerted on the device without interrupting or causing a jump in the data feed. No issues were found with spinning but certain drops with a harder impact landing caused a momentarily freeze in the data stream. Findings from these early tests pushed the system design to focus less on specific gesture recognition, and instead on the mapping of the sound modules to broader movement categories. These ideas essentially categorized large and smaller movements of similar kinds to one representative sonic idea. The idea then varied slightly in timbre and shape depending on the how the pressure and force impacted the raw sensor data (Table 1).

4.INTEGRATING AERIAL CHOREOGRAPHY AND COMPOSITION

During the conceptual, testing and development stages of SALTO, Katharine Geber, a dance trapeze artist and choreographer, and I, technologist and electroacoustic composer, worked intensively together. We collaborated on a work titled *Splinter,* for dance trapeze and the SALTO system. We worked through several iterations of the Max patch using aerial movement from static and dynamic categories to understand and learn the physical and technical limitations of the system. We also researched and discussed concepts from Rudolf Laban's choreological and movement theories as well as Trevor Wishart's gestural structure and spatial motion theories to develop our own kinesonic theories [4, 16, 20].

Conceptually Geber, and I were interested in the unique sensations of pressure (felt by the performer), as well as stillness and physical effort that accompany aerial movements. We aimed for mappings that could translate these sensations into sound and give the viewer a sense of the performer's relationship to sound and sonic choices when performing.

At any given moment in a routine, the performer experiences pressure. If the dancer is inverted, especially for an extended duration of time, they will feel pressure from the blood rushing to their head. In both static and dynamic movements pressure is produced wherever the metal bar and thick ropes of the trapeze are wrapped around the body. Effort is also a constant in aerial performance (Figure 4). While static poses may be places of 'rest' for the performer, often they can be just as physically demanding as dynamic movements too.

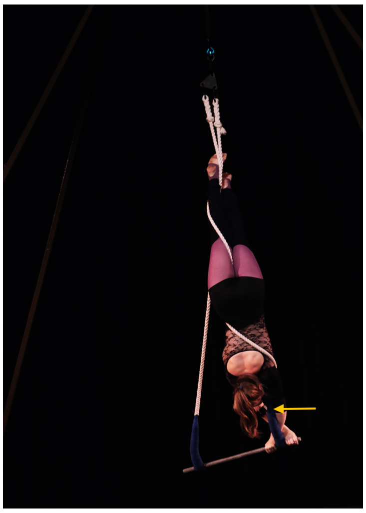

Figure 4. Depiction of inverted static pose where effort is

Transitions are a challenge for both composer and choreographer. A unique component of working on aerial choreography is that about 50-60% of any given piece is transitional material. Transitional aerial material includes climbing, setting up the wrap for a drop properly, and weaving between skills in nuanced ways (Figure 5). A choreographer often spends much of their time developing interesting and compelling ways of introducing variations on climbs as well as planning in gestural work with the arms and facial expressions to develop character. The aerial choreographer aims to distract the viewer from these necessary movements by presenting them often as part of the gestural material. In addition, there isn't much repetition in aerial choreography. However, musical repetition and reiteration can be key developmental tools in a piece. Geber and I blended temporal development techniques from aerial choreography and fixed electroacoustic composition in the transitional material.

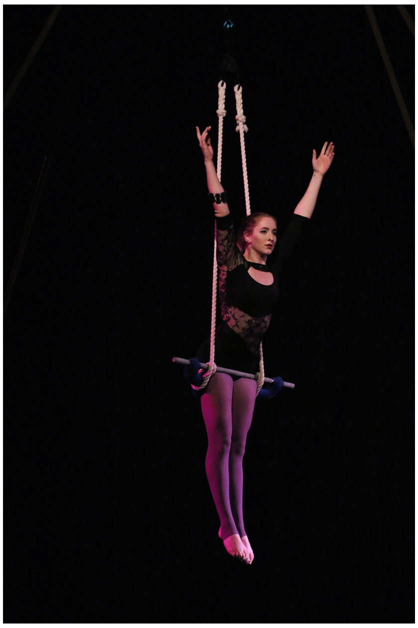

Figure 5. Depiction of transitional material, wrapping for a drop.

We used physical sensations to guide our compositional and choreographic choices. An aerialist's perception of sound during performance is unique in the way it is filtered by the body. This nuanced listening experience is one major element that helps the aerialist to achieve the maximum artistic expression of their movement. Often viewers have limited, if any, embodied idea of this kinesonic experience. Geber and I aimed to blend movement and music using the internal kinesonic experience of the performer to sonify those elements. The emg sensors provided a source of data for translating effort. The percussive plinks and trailing spectral delay provided a continuous texture sonifying the performer's internal state. By mapping the data from the accelerometer and gyroscope to a dynamic filtering module, the performer could make musical choices based on the pressure and speed felt during revolution and inversion. The sweeping motion of the filter traced and echoed the movement.

5.FURTHER DIRECTIONS

The first iteration of SALTO has been successful as *Splinter* was received well, but has also inspired plans for further development. This version of the system and performance style only touched the surface of compositional and choreographic possibilities. The short six-minute duration of the piece felt appropriate or the system's current state but would not sustain interest for a viewer, composer, and choreographer during a lengthier performance. In future iterations, I hope to expand SALTO to include more nuanced mappings and additional synthesis modules to create more dynamic sonic results which enhance the musical composition. Other future directions include incorporating multi-channel spatialization into the mapping. This will be valuable in further translating the performer's internal sensation to sound.

In conclusion, further detailed movement analysis, machine learning, and synthesis processing needs to be conducted to maximize the specificity of the data being collected from the Myo during aerial movements and to allow for longer compositional forms and nuance within a work. There is potential for SALTO to become a truly expressive virtuosic system where the performer is simultaneously musician and aerialist.

6.ACKNOWLEDGMENTS

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