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# Extracting Human Expression For Interactive Composition with the Augmented Violin

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## ABSTRACT

As a 2010 Artist in Residence in Musical Research at IRCAM, Mari Kimura used the Augmented Violin to develop new compositional approaches, and new ways of creating interactive performances [1]. She contributed her empirical and historical knowledge of violin bowing technique, working with the Real Time Musical Interactions Team at IRCAM. Thanks to this residency, her ongoing long-distance collaboration with the team since 2007 dramatically accelerated, and led to solving several compositional and calibration issues of the Gesture Follower (GF) [2]. Kimura was also the first artist to develop projects between the two teams at IRCAM, using OMAX (Musical Representation Team) with GF. In the past year, the performance with Augmented Violin has been expanded in larger scale interactive audio/visual projects as well. In this paper, we report on the various techniques developed for the Augmented Violin and compositions by Kimura using them, offering specific examples and scores.

## Keywords

Augmented Violin, Gesture Follower, Interactive Performance

## 1. INTRODUCTION

The Augmented Violin project brings together the development of motion capture systems and the study of bowed string performance. The outcome of this project is essentially an "augmented bow", which can be used to control digital media. It is not an extra contraption one needs to install on the acoustic violin or bow, nor a mechanical device to replace the existing instrument. The Augmented Violin honors the violin as is, and simply extracts expression from what is already happening in performance, which seems like the most practical approach that makes sense for musicians.

To start our research, we first laid out specific goals related to the potential compositional schemes pursuing our work with IRCAM's Augmented Violin (customized) and using a new series of software tools, such as the gesture recognition system based on the MuBu-GF platform [3] as well as other specific developments.

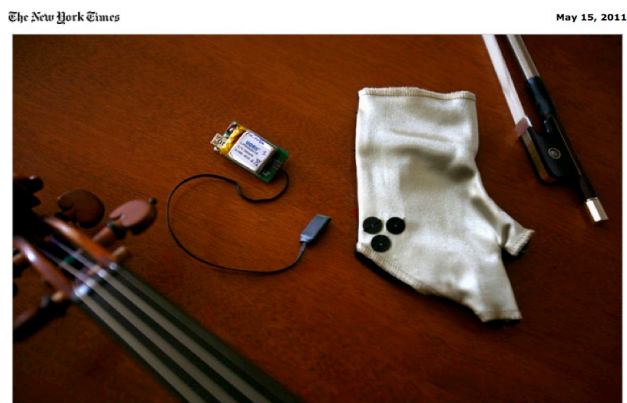
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## 2. BACKGROUND

At NIME 2006 conference, Kimura learned about IRCAM's Augmented Violin, and since has been working on creating several compositions and presenting more than dozen premieres and performances incorporating the Augmented Violin into her compositions. Improving on the original design of the Augmented Violin, which required wearing a wrist band to house the battery portion connecting to the sensor attached to the bow with an 'umbilical' cord, Kimura commissioned a custom-fit glove created by New York fashion designer Mark Salinas. This glove, worn on the right hand, houses both the sensor and battery portions of the Mini-MO, a wireless 3D accelerometer and 3-axis gyroscope motion sensor developed by Emmanuel Fléty [17]. The Mini-MO communicates with the computer via an Ethernet receiver, thus freeing the violinist's bow arm completely from any wiring. The thin, flexible latex fabric of the glove houses the small device un-intrusively for performance: a practical solution for violinists (see Figure 1).



**Figure 1. The Augmented Violin Glove, with the latest Mini-MO (Modular Musical Objects) created by IRCAM.**

In 2007, during her residency at Harvestworks in NYC, Kimura created her first work for Augmented Violin entitled *VITTESSIMO* [4] in collaboration with Frédéric Bevilacqua; she also described the creative process of this work [5]. For a general review of related works on augmented and hyper-instruments based on strings instruments, we refer the reader to Poepele, Overholt [15] and Bevilacqua *et al* [16].

### 3. RESEARCH

#### 3.1 ‘Cloning’ with MuBu-GF

*CLONE BARCAROLLE* (2009) by Kimura [4] uses the ‘cloning’ function with GF. The “cloning” is made possible using the gesture follower (using the *gf* and *mubu* externals in Max). When a musical phrase is played for the first time, the patch records both the audio and the sensor parameters. The audio is stored in a buffer, while also analyzed to obtain the audio energy profiles. These audio energy profiles are then combined to the sensors parameters of Mini-MO to form a multimodal set of data that is memorized by the gesture follower. All parameter profiles are normalized (between 0 and 1) and form a complementary set of descriptors of the phrase: the accelerometer/gyroscope give very precise information on the bowing attacks and releases while the audio energy gives more global information on the phrase morphology.

When the same phrase is played the second time, the system is set to “follow mode”. In this case, the multimodal parameters (audio energy and sensors values), measured in real time, are compared to the stored data. This allows for the continuous estimation of playing speed. The original buffer can thus be replayed using the current playing speed. For this, a phased vocoder is used to preserve the original speed (superVP). The replay of the audio buffer is thus the “clone”, precisely synchronized to the current playing. This adaptive behavior provides the musician with a range of expressivity different from the standard use of “record/play” of samples with a fixed speed. (See Figure 2. Excerpt from “Clone Barcarolle” (2009))

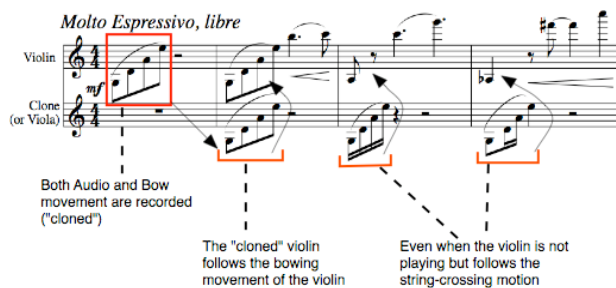


Figure 2. Excerpt from “Clone Barcarolle” (2009).

#### 3.2 Soft / Loud Ending

Kimura’s pieces are based on three main bowing gesture processing. They were designed upon the concept of movement qualities [6], where the goal is not to achieve a particular gesture or action but rather a way of performing it, i.e. a quality. We believe such an approach to be promising as it can provide for a higher level of abstraction in interaction design, while still keeping a sense of mediation [7].

Ending a performance can be done in many different manners. We decided to try detecting musical expressions including two different musical endings, shown in this example: 1) soft ending, 2) loud ending. Using the results of the analysis, we developed a simple “ending detector”, analyzing the combination of physical and musical gestures: right hand movement together with sound and musical context for the violin. (see Figure 3).

#### “Soft and Loud endings” example

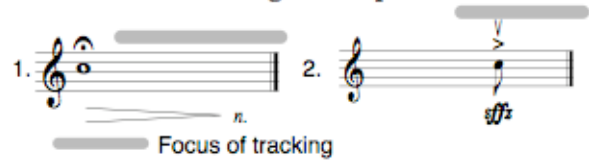


Figure 3. Soft (1) and Loud (2) ending tracking.

We here wanted to focus on soft on-the-string endings, versus loud off-the-string endings. The Soft/Loud Ending detection was designed to grab such ending qualities of Kimura’s performance. This detector is combining gesture and audio cues. It simply relies on bow orientation (tilt) when sound is fading away (audio energy). Based on this, two different configurations are registered, soft ending and loud ending. Through a k-Nearest-Neighbor algorithm operating on bow tilt and audio energy, we are able to distinguish in real time the performed ending quality.

#### 3.3 “Stillness” detector

With a realization that the cornerstone of a ‘bowed’ instrument is the ability to sustain sound, unlike ‘plucked’ instruments, we wanted to simply detect if and when the bow has achieved a “steady” state while holding a note. This “stillness” detector became one of the most important interactive methods in Kimura’s compositions.

The stillness detector actually tracks two kinds of bowing movements: smooth sustained movements and jerky fast movements. As such, it can be related to the musical flow created by the artist through the alternation of short and long, energetic and smooth strokes.

This gesture descriptor is based on the acceleration in the bowing direction. It enables one (1) to detect bow sustained movements and (2) to register the time this movement was maintained. ‘Stillness Detection’ can be used to recognize the sustained characteristics of a bowing movement, i.e. one of its movement qualities. Registered time can be used to differentiate short and long strokes, e.g. by setting threshold values, or to design time evolving interactions directly depending on the parameter value.

To compute the stillness gesture descriptor, we first derive acceleration in the bowing direction to get the movement smoothness, aka ‘jerk’. This value accounts for the level of movement smoothness. From this value we are able to distinguish between two states. ‘Still’ corresponds to low jerk values, i.e. smoothest movements, as opposed to ‘Non-Still’, with higher jerk values. This detection can be stabilized using an additional threshold for minimum time in a state. These two threshold values actually depend on each violinist, each musician having his/her own movement characteristics, and can be set during practice.

This “stillness” detector turned out also as a useful substitute for the *superVP.ring~* external in Max. A ring buffer is rather cumbersome to control in real time performance, since it constantly records a certain amount of the “past” then “rolls off”. Using the “stillness” detector, it is possible to simulate the ring buffer, which is used in Kimura’s composition *CANON ELASTIQUE* (2010). Using two *superVP.scrub~* externals controlled by “stillness” detection, it was possible to constantly change the 2<sup>nd</sup> voice (the “past”) by applying “stillness” control so as to follow the 1<sup>st</sup> voice (the performer). In *CANON ELASTIQUE*, one can create an “elastic” past (see Figure 4).

**Canon Élastique**  
for Augmented Violin (2010) Mari Kimura

Tempo "Élastique"

Figure 4. "Canon Élastique" creating 'elastic past'.

### 3.4 Agogic player, "flow-follower"

Another application of "stillness" detection is "agogic player", or what Kimura calls a "flow-follower", an alternative to a "score follower". Performers in real life don't have to follow note by note, beat by beat, in order to play together in sync. Rather, they follow each other's musical "flow" together, or agree on musical "common sense" of the particular musical scenario, a piece of music or context. By using "stillness" detection, it is possible to demonstrate how a quantized piano performance (either MIDI or audio) can co-perform, or follow the violinist's musical flow without using a score follower. Even when the violinist is preparing a stroke without playing, the piano part can naturally and musically be slowed down before the violin's entrance (see Figure 5).

In this short excerpt of a Bossa Nova tune by Tom Jobim, which requires lucid tempo and *rubato*, the violinist starts playing as the piano plays the 8<sup>th</sup> note scale upward. The violinist' right arm movement at this point is still preparing to play the first note, and it is 'steady'. By applying the "stillness" detection here, it is possible to naturally slow down the piano part slightly, as any sensible human pianist would in real life.

In the second measure, the "stillness" detector also applies "agogic" or a small 'breath' between the beats. As a result, the computer piano naturally plays along, following the flow of the music created by the bowing, making human and machine interaction mutual and omni-directional: not one triggering and the other obeying.

"Eu Te Amo" by A.C. Jobim, arr. by Kimura

Stillness "preparation gesture"      Stillness "sustain" detections

Figure 5. "Flow Following" between human and computer.

### 3.5 Combining OMAX with Gesture Follower

While working on concatenating musical material using GF, we found interesting to join this system with the improvisational system called OMAX, developed by the IRCAM's Musical Representation Team [8, 9, 10, 11]. OMAX, which runs on MaxMSP, creates a "co-improvisation" that learns the player's improvisation performance and plays back

the concatenated performance in real time. OMAX was mainly designed to include a "computer operator" who controls its behavior such as 'fading out' to end its improvisation. Using GF interacting with OMAX, it is possible to create an autonomous improvisation without the computer operator performing OMAX. Working with the distinct behavior of OMAX, and with the aforementioned various gesture detections including "ending" or "stillness" detector, it is now possible to terminate OMAX's improvisation from pre-defined concatenated gestures, such as pizzicato or sustained fading tones. Kimura's compositions using OMAX and GF, to date, include *VIOMAX (2010)* and *Duet x2* for violin and cello (2011) using two Mini-MO-s.

## 4. CURRENT AND ONGOING

### 4.1 Recent multi-media projects

The Augmented Violin can be used for audio/visual projects as well as collaborations. Kimura's work *PHANTOM (2009)* is a collaborative project with New York-based artist Toni Dove in her multimedia work, "*Lucid Possessions*". In *PHANTOM*, the Augmented Violin controls interactive video and a robot with 3D projections.

More recent audiovisual works with the Augmented Violin include "*VOYAGE APOLLONIAN*" for interactive audio/video (visuals created by graphic artist Ken Perlin), which was recently featured in *Scientific American* [12]. The Augmented Violin was used to control the Quicktime movie using "stillness" and other concatenated gesture detections.

### 4.2 Eigenspace

Kimura's most recent project is entitled *EIGENSPACE*. For violinists, bowing motion is kind of an 'arc', which involves arm motions that include 'inertia' movements before and after the strokes. In *EIGENSPACE (2011)*, this 'inertia' movement is incorporated to interact with the audio and video (see Figure 6).

We came up with a concept to simulate this motion with a spring, using "eigenvalues". This last gesture processing introduces a physical behavior between bow gesture data and sound (or video) parameters. Similarly to works by Henry [13], interaction here is grounded on a damped mass spring system. In our case, however, the physical system is controlled by the bowing energy computed from bow acceleration. The musician can therefore imprint different movements to the physical system, which reacts according to its settings. Changing its parameters, like weight, mass or stiffness factor, alters the system reaction depending on the created eigenmodes. These eigenmodes can be related to different movement qualities as they exhibit various behaviors for a same mass displacement: jerky, smooth, or periodic. Playing on these modes enables to create an organic relation between the artist and the computer.

In *EIGENSPACE*, the graphics created by the team of Japanese movie director Tomoyuki Kato interact with the eigenvalues and the 'spring' motion during the 'retake' of the bow. Extracting the 'retake' motion of the bow, the 'spring' or the inertia mechanism, can be calibrated to the desired 'stiffness', 'reaction time' and 'damping' according to the composer's musical needs and the violinist's expressive bowing motion.





Figure 6. “Eigenspace” premiere at Roulette in Brooklyn, NY, Oct. 9th, 2011.

## 5. CONCLUSION

The Augmented Violin is one of the most unintrusive sensor devices available for violinists to provide bowing and motion data to a computer media system such as MaxMSP. Its main appeal to violinists is that it honors and enhances the existing instrument without any wirings and contraptions, which should be more user-friendly to average string players.

In this article, we have presented various compositional techniques that build on the unique capabilities of the Augmented Violin, illustrated through Kimura’s compositions. These include the ability to “clone” oneself, while applying various transformations to the “clone” controlled by the player via the Augmented Violin; recognizing different phrases in real time; analyzing “before” and “after” gestures; recognizing “soft” and “loud” endings; detecting “stillness” and following musical flow. We have shown how to combine the gesture follower with other systems, like the improvisational system OMAX (also developed at IRCAM), and into multi-media collaborations projects between Kimura and others. The Augmented Violin has also inspired other composers to create interactive compositions that had been previously impossible.

We will need to further develop user-friendly interfaces, thus affording many string players to try out this elegant musical system of the future.

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