VICTORIA COUNTS – A CASE STUDY WITH ELECTRONIC VIOLIN BOW

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ABSTRACT

This paper gives a glimpse into the ongoing process of equipping a violin bow (as well as the violin itself) with electronics adequate for real-time manipulation of the sound. In this project there exist several sound sources: (1) the violin sound, which is picked up by built-in microphones of the electric violin, (2) a number of pre-recorded everyday sounds to be cued in by the performer during performance, and (3) several pre-recorded series of counting, where the performer's voice is heard. Controlled by bow gestures these different sounds are filtered through one or more Max/MSP patches followed by playback through a quadraphonic speaker system. From time to time permutations of objects between speakers, including the movement on stage by the performer herself, take place.

1. INTRODUCTION

There exist already a number of techniques for bow-gesture capture, some of which have been used for sound manipulation or synthesis [1],[2],[3],[4],[5]. Typically, one finds miniature accelerometers and gyroscopes utilized for recording the bow's movement, and strain gauges included for measurements of bow force ("bow pressure") against the string. Other sensors, such as radio transmitters/antennas, and separate video cameras (recording markers on bow and instrument), have also been utilized, but may be problematic for real-time sound manipulation if used by an improvising performer, moving on stage.

The most straightforward task with existing techniques is to cue patches by use of acceleration or angular velocity (delivered by the gyroscopes). In these cases a simple pattern-recognizing algorithm can cue initiation of patches when confirmed. We are then talking about "switched-on" systems. However, filters that are continuous over an extended range—e.g., shelving- or peak filters where the player can control the boost frequency in order to emphasize certain spectral features—are not so easily implemented, simply due to the non-DC nature of the sensors, which makes reliable real-time integration difficult. For miniature accelerometers, the effect of gravity changing with bow angle is also an important obstacle.

With ideal sensors, one could easily utilize bowing gestures that are not commonly used in "normal playing" for controlling continuous filters or filter banks. E.g., the tilt angle of the bow hair with respect to the string makes very little spectral difference after the tone onset on an acoustic instrument: With fair-resolution information about this tilt angle, it would be easy to control a peak filter's centre frequency.

Since information of absolute angle is not easily obtainable we are employing a different strategy for controlling this kind of filters:

2. THE PROJECT "VICTORIA COUNTS"

2.1. The artistic concept

The Armenian philosopher and mystical Georges Ivanovitch Gurdjieff once gave a student the exercise to count from 1 to 50 and backwards seven times. This exercise should show the student how difficult it is to concentrate even on something that easy as counting. Continuous streams of thoughts, memories and associations try to take away our concentration. The composer Henrik Hellstenius has provided violinist Victoria Johnson with a piece based on this counting exercise, where also trivial domestic everyday distractions are mixed in.

While counting provides the background, a relatively slowly-moving solo part, with frequent occurrences of dissonant double stops and other whims, is subjected to gentle sound filtering in order to create a variety of textures and sonorities along with the pre-recorded sound clips.

2.2. Interfacial requirements

This piece was originally performed with the assistance of a sound technician, who would start and stop the sound clips, and adjust Max/MSP patches, e.g. to achieve granulation of the violin sound, etc.

In the present setup, the player must herself be able to start and stop the sound clips from the bow, as well as choosing adequate filtering/mapping for all musical situations that should occur in the piece. Since a good part of this is improvised, the filter setup cannot be fixed to a predetermined sequence, but individual configurations need to be invoked through some sort of devoted gesture. The omission of a technician is meant to give the violinist more freedom of expression, so it is paramount that the electronic interfaces are not perceived as extra obstacles.

2.3. Switches and sensors

In addition to the 3D accelerometers and 2D gyroscopes we mounted two switches and one pressure sensor in the vicinity of the frog. The switches were positioned on the stick just at the end of the wrapping, a few millimetres away from where the right-hand index finger is normally placed. With two adjacent switches it is relatively easy to change between a number of programs, patches or other cues used in the performance. The pressure sensor was placed on the wrapping just below the middle finger (which normally remains rather inactive during playing), and is meant for deliberate fine adjustment of filters (See Figure 1 below). Adjustment could also be made by means of bow tilt or other movements, but as was said before, since these sensors do not respond to position directly, the effect will be somewhat delayed, and precision somewhat harder to achieve. However, with a combination of the pressure-sensor value and the angular-velocity value it becomes a straightforward matter to perform useful integrations without much waist of time (see Figure 2).

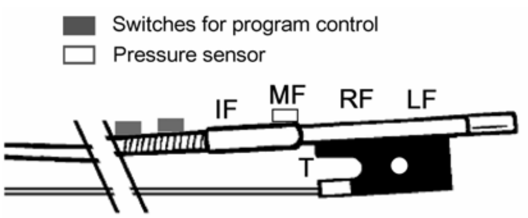

Figure 1. Positions of the (index-finger) switches and the middle-finger pressure sensor. All other bow-gesture sensors are mounted on a circuit board at the frog.

2.3.1 *The bow- force sensor (discussion)*

So far a bow-force ("bow-pressure"-) sensor has not been mentioned. There is a reason for that. Different from other violin motion-capture systems we have decided to omit it. In principle four different systems have been designed for measuring the bow-hair's force against the string. Askenfelt, who was first, had the bow hair cut and glued on to thin metal strips fastened at the tip and the frog [6]. When applying force against the string these strips were bent and the amount of bending picked up by strain gauges fastened to the metal.

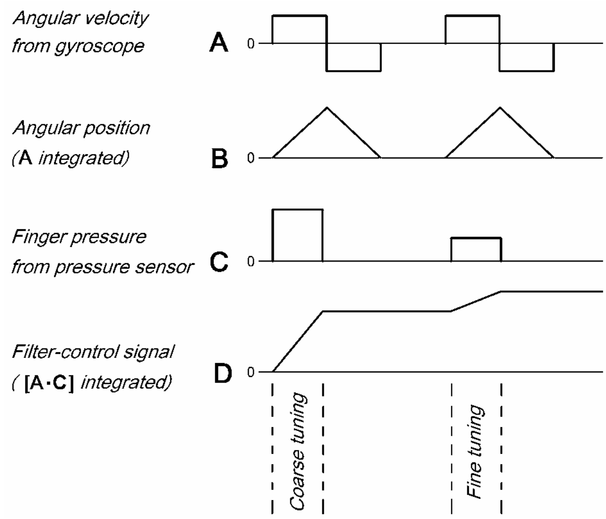

Figure 2. Routine for integration of the angular velocity, **A**. Instead of utilizing the automatically integrated values of **B**, the middle-finger pressure, **C**, controls the integration, thus permitting variable sensitivity and lasting values, **D**.

Democron's system [3] is a further development of Askenfelt's approach, and seems to be the most widely used system at present. To our knowledge it is also by far the best and most reliable in terms of measuring the true bow force. Demoucron's device is a small bracket fastened to the D-shaped ring (ferrule) of the bow's frog. At the end of the bracket, which is equipped with strain gauges on both sides, a small wooden cylinder is pressed against the bow-hair ribbon and deflects with its changing angle during playing. In the required calibration equation, both playing position along hair length and bow hair tension are necessary terms, so precision increases with use of optical devices. If during practical performance the player adjusts the hair tension, this to some extent interferes with calibration.

The third approach is to place the strain gauges on the bow stick at positions where the stick is deflecting during playing [4]. There are several problems involved here. First, the deflection of stick varies considerably more with the bow/string's contact position than does the angle of bow-hair: from negative by the frog to positive by the tip when played with constant bow force. Second, signals get very weak when playing close to the frog. Third, when playing rapid dynamic strokes, such as spiccato, the stick bending is not in phase with the bow force. (When the bow is thrown onto the string for a downbow, the string's force against the hair tends to straighten the stick. Whenever the index finger is pressing on the stick, this effect is counteracted).

A fourth configuration has been suggested by Paradiso and Gershenfeld [7]. Here the bow pressure is derived from the right-hand index-finger pressure on the stick. This solution has some of the same shortcomings as Young's Hyperbow, since finger pressure varies independently of the bow force, not only as a function of the string's position on the bow-hair ribbon (reaching zero when bowing in the vicinity of frog), but also with the *dynamics* of the bow stick in general, thus making reliable calibration rather difficult. On the other hand, even if the latter system is not suitable for accurate bow-force measurements, its potential for creating deliberate control signals seems clear, and, in contrast to the three other systems, it works independently of hair tension.

The main advantage with the two latter approaches, however, is that electronics are out of the way for the player, who otherwise easily could hit and break the devices when using the full hair length during playing (like most skilled players prefer).

Our solution to the problem is to use the microphone signal as reference when trying to derive bow-force information. As it happens, the spectral envelope (slope) has been shown to be function of bow force and bow speed only, that is, independent of contact point on the string(!) [8]. A fast algorithm (FFT not needed) for determining the approx. energy ratio between band-passed 5.0 – 7.5 kHz and low-passed 2.5 kHz, gives, after some smoothing, a fair indication of bow force variations, suitable for controlling some filters.

However, the bow is not the only part of the instrument that is furnished with electronics. As has been demonstrated by Diana Young with her Hyperbow, mounting a more or less identical set of sensors on the body of the instruments facilitates cancellation of motions where the bow and violin move in parallel, for instance when the player moves her body or changes position on the stage. But, this also opens for using the movements of the instrument body separately (not for cancellation) at certain instances, when desirable.

3. TECHNICAL INFORMATION

Our technical approach is to find a way to measure physical properties in a nonobtrusive way, with precision sufficient for patch and filter control. In addition, our technical solution should be easy to use during practice and concert situations. The data sent by the device should facilitate straightforward interface with live electronics.

We found a balance between these constraints by creating a small unit that can be mounted on the bow or on the instrument, and that measures acceleration (3D) and gyration (2axes). To get further control possibilities, we mounted a pressure sensor and switches that could be activated by fingers holding the bow. The measuring unit sends data to a computer via a Bluetooth transmitter.

For measurements of acceleration an ADXL330 3D accelerometer made by Analog Devices is used. It features 3 analogue outputs for acceleration along each of 3 axes, and is capable of measuring up to ±3 g. To measure angular velocity an IDG300 dual axis gyroscope of InvenSense is used. It features 2 analogue outputs for angular velocity around each of 2 axes, and is capable of measuring up to ±500 deg/s. As a future enhancement, it would be desirable to measure angular velocity along a 3rd axis, effectively enhancing the unit to a 6 degrees inertial system. This would enable us to separate the effect of gravitation from the acceleration induced by the performer.

To sample and filter analogue and digital data, a C8051F530 microcontroller made by Scilabs is used. It features an internal 12 bit A/D converter with up to 16 external inputs and a sample rate of up to 200 ksps. This allows us to apply simple digital filtering to the input signals, before the data is sent further through the Bluetooth link.

To transmit the signals wirelessly, the Bluetooth module RN-41 made by Roving Networks is used. It allows us to send serial data from the microcontroller transparently to a Bluetooth-equipped PC.

All electronic components are capable of running on 3 - 3.6 V. The original prototype was powered by a 3-cell NIMH battery, but when designing the first unit to be used on stage, we decided to use a removable commercially available 1.5 V AAA battery. This enables the performer to insert a fresh battery right before the concert.

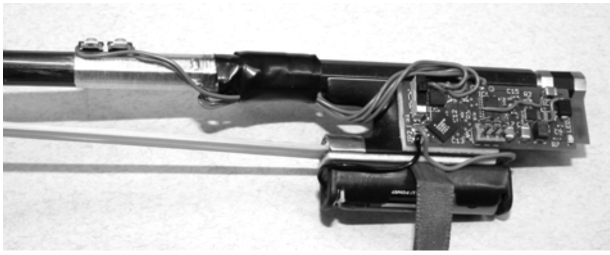

Figure 3. Electronics of the NOTAM bow (total weight ca 25 g including a 12 g AAA battery).

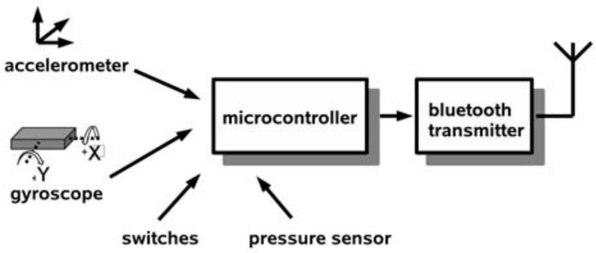

Figure 4. Block diagram of sensor/microcontroller setup.

To be able to power the unit with voltages as low as 0.9 V, a DC/DC converter was implemented using a MAX1760 made by Maxim. When powered by 1.5 V, the unit consumes approximately 100mA. This would allow a theoretical runtime of about 8hours when using a 1Ah alkaline battery, but as the Bluetooth module causes strong pulses in the current consumption, the battery voltage drops early under the lower threshold of 0.9 V, and the runtime is reduced to about 3 hours.

The sample rate of the analogue signals is set to 3200 Hz for all channels, but data is averaged over 16 samples internally resulting in an effective sample rate of 200 Hz.

This is followed by other postprocessing done in the unit. We are experimenting with different methods of auto calibration and offset removal. Our aim is to present sensor data in a way that makes it easy to use it in applications like Max/MSP and Pd, but without loosing important physical information.

After postprocessing, data is sent via Bluetooth at a rate of 200 Hz. As data format, we implemented a simple binary protocol similar to the one used by the Bluetooth variant of the "Create USB Interface" [9]. A MAX-patch is used to receive data, and to redistribute it to other live electronics. The chosen binary transfer protocol is efficient, and is easily implemented on the receiving side. However, we will in future investigate the usage of a standardised protocol like OSC to achieve easier integration with existing live electronics.

The weight of the circuit board alone is 6 g. A typical AAA alkaline battery weighs approx. 12 g, the battery holder 3 g, cabling and switches together 4 g. The total weight of the unit as mounted on the bow is 25 g. With one AAA battery, the runtime is 3 hours, or more.

4. CONCLUDING DISCUSSION

The electronic equipment described above is of course not meant for one single piece of music alone. But the many intrinsic challenges of this particular composition make it very suitable as a starting point for the development of a more general electronic-bow system (or even a system for other instrumentalists whose playing techniques involve carefully controlled limb movements). Our intention was never to do high-quality measurements of bowing parameters. To do that, supporting optical measurements seem inevitable with today’s technology. Our focus is on *extending* the violinist’s palette of tone colours, and to do so *without replacing one set of colours with another one*.

The violin bow is unique when it comes to spectral control and envelope shaping for an acoustic instrument. The action is very direct, although the tone buildup is normally not as fast as for most wind instruments. On the other hand, when shaping attacks the dynamic properties of the bow can often be utilized for creating a desirable development, which means that one on beforehand can give the bow a certain (rotational) velocity/momentum towards the string and rely on the bow to do the remaining work as it hits it and the tone starts.

We feel that these qualities are very important to safeguard and they should not be sacrificed for the benefit of triggering a novel patch or two, as such a path would easily lead to a more restricted instrument. So, we are looking for bowing gestures that are *available*, meaning that are not commonly utilized for sound shaping.

There is also the theatrical or scenic aspect: The gesture should preferable melt in as a natural part of bodily expression in the act of conveying musical ideas. An example of the opposite is the musician who takes a step or two forward to press a pedal with the result that the sound from his instrument (loudspeaker) changes instantly and unexpectedly.

To sum up: we are trying to combine gestures and sensors in a way that facilitates extended control of the sound picture and will carry this out smoothly and naturally in response to the player’s instant ideas. At the same time we are searching for ways to *trigger* certain events such as on/off sound recordings, lights, video, etc., like exemplified in the piece “Victoria Counts”.

5. REFERENCES

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Victoria counts â€“ a case study with electronic violin bow. Guettler, Knut; Wilmers, Hans; Johnson, Skip other details (including permanent urls, DOI, citation information). Volume 2008, August 2008. Permalink: http://hdl.handle.net/2027/spo.bbp2372.2008.121. Violin bows are typically made of wood or carbon fiber for the stick, with horsehair used to apply pressure to the strings. But what are the best violin bows currently available to purchase? This article aims to help you answer this question by outlining various factors you should consider before purchasing. Factors we consider important to when purchasing a violin bow include the size, weight, hair used and stick material. If you are new to the buying process, it is vitally important that you take your time to do online research and read customer reviews before purchasing as this will give you the best chance of purchasing a great value violin bow.Â Suited to beginner and intermediate levels of play. Ships in a protective carry case. What could be better? Violin cases have come a long way since the days of a basic oblong black plywood case. In the last twenty years, several companies started to produce space-age, modern-looking, and lightweight cases in a variety of materials, shapes, and colors. Not only are there a multitude of choices for the violin, bow, strings, and rosin, but now even the case can be personalized to almost any preference. This buying guide of best violin cases and violin case reviews will help you narrow down your search to the perfect one to protect your most prized possession. Violin acoustics is an area of study within musical acoustics concerned with how the sound of a violin is created as the result of interactions between its many parts. These acoustic qualities are similar to those of other members of the violin family, such as the viola. The energy of a vibrating string is transmitted through the bridge to the body of the violin, which allows the sound to radiate into the surrounding air. Both ends of a violin string are effectively stationary, allowing for the...