Virtuosic Embodiment of a Modalys String through Color Tracking Technology

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Simulation Video: https://youtu.be/LVZNo8wqeVM?si=Ev_Bgcubc8dWdOZ3

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ABSTRACT

This paper introduces the use of Modalys (a physical modeling synthesis tool) String in live settings by utilizing color tracking technology through MaxMSP/Jitter. This essay explores the approach of creating highly detailed and creative sounds by adjusting parameters such as the density, radius, and length of various physical materials. Furthermore, it discusses methods for effectively performing and composing in a live environment.

1. INTRODUCTION

Modalys is software that allows the modification of physical parameters, creating various materials and textures through coding to produce sounds such as strings, reeds, pipes, percussion bodies, mallets, and bows. By connecting the virtual objects of Modalys using a *connect* object, sound is generated by modifying values like position or gravity. Pitch depends on factors such as the length, stiffness, and smoothness of the object, and altering these factors allows for the production of various pitches.

Modalys string is divided into a mono-string object, primarily used for plucking, and a bi-string object, used for bowing. Each object generates sound by receiving values for horizontal and vertical positions, simulating the actual friction between the bow and the string. Additionally, factors such as weight, rosin, and access position significantly influence sound generation.

In this project, a total of three Modalys objects are used: two bi-strings and one mono-string. The bi-strings are connected using a hybrid object, while the mono-string is used separately. However, in the Max/MSP environment, when pizzicato is played, the bow is automatically limited in terms of volume and sound generation.

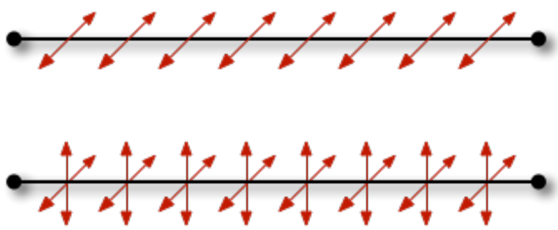

Figure 1. Mono String (Top) Bi-String (Bottom)[1]

[1] Image Source: Internal Help Files of Modalys

2. PARAMETERS OF MODALYS STRING FOR GENERATING SOUND

To effectively simulate realistic string behaviors, precise parameter tuning is crucial. Each parameter directly affects the quality, timbre, and dynamics of the generated sound, offering a broad range of sonic possibilities. This section explores the specific parameters involved in creating sound with Modalys strings and examines how adjustments to these parameters influence the resulting sound.

In the experiment regarding bow contact points on Modalys strings, various parameters were analyzed. The analysis method involved moving the bow vertically and horizontally across the strings at different pitches and materials to examine how the string responds. It is impossible to perfectly replicate the exact movement of an actual bow, the string's reaction, and the object's behavior. (Furthermore, the aesthetic significance of reproducing an exact sound is somewhat nonsensical—after all, while theoretically possible, it would be far more efficient to play an actual cello rather than perform complex calculations.) Nevertheless, the imperfect and peculiar sound generated here is unique to Modalys.

The detailed values are as follows:

The vertical position ranged from -0.001 to 0.001, where values below the minimum (upper side) produced a light, harmonic, sul tasto sound, while values at the maximum (lower side) created a harsh, tough, sul ponticello sound. The horizontal position varied between -4 and 4, determining the lateral smooth movement. Weight was tested between 0.7 and 1.0, affecting the pressure applied to the bow and thereby influencing the dynamics of the sound. Finally, the access position ranged from 0.5 to 0.01, controlling the precise point of contact on the string and significantly impacting the tone quality.

Figure 2. Sound Characteristics According to Position

Such values make it possible to generate realistic sounds through physical modeling technology, which leverages actual techniques. This approach can also produce unexpected and unique sounds by chance. Consequently, it allows for the creation of sounds that are theoretically possible but practically unattainable. These sounds, shaped by the material characteristics of Modalys, provide compositional opportunities and expand creative possibilities.

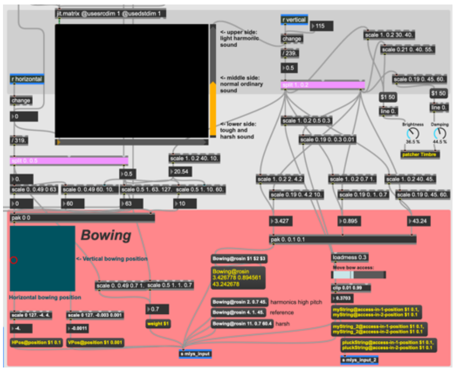

Figure 3. MaxMSP patching for the primary parameters for Modalys.

Exploring Modalys through Max is particularly meaningful because Modalys is highly effectively integrated with Max, allowing for the efficient application of a wide range of values. For instance, it enables manipulation using a mouse, visualizing bow movements through cues, or randomly controlling the bow. Additionally, as in this project, it is possible to simulate bowing movements directly using color tracking.

3. A DIVERSITY OF MATERIALS FOR MODALYS STRING

Modalys creates strings from a variety of materials by adjusting the density and Young's modulus values of different metals, woods, and synthetic materials. The range of material properties studied at IRCAM spans from spider silk to uranium, allowing for extremely nuanced changes in sound. This information can be input into Max/MSP, making it easy to implement and manipulate sounds in real-time.

Tables of Material Properties

Metals

Material Properties of Metals

Material	Density kg/m^3	Young N/m^2	poisson
Aluminium	2700	7.0e10	0.35
Bismuth	9780	3.2e10	0.38
Brass	8500	1.0e11 - 1.25e11	0.33
Bronze	7400 - 8900	9.6e10 - 1.2e11	0.34
Cesium	1930	1.7e9	0.3
Copper	8940	1.1e11 - 1.28e11	0.35
Gold	19300	7.9e10	0.43
Iridium	22560	5.2e11	0.26
Iron	7870	1.9e11 - 2.11e11	0.30
Lead	11340	1.6e10	0.43
Lithium	534	4.9e9	0.36
Magnesium	1740	4.3e10	0.29
Mercury	13600	2.85e10	(0.5)*
Nickel	8900	2.1e11	0.30
Osmium	22570	5.5e11	0.25
Platinum	21450	1.68e11	0.39
Silver	10500	8.3e10	0.37

Table 1. Tables of Material Properties[2]

Physical modeling synthesis with Modalys requires recomputation each time parameters change, which can lead to clicking and other issues. Traditionally, the melt-hybrid object has been effectively used when changing materials or pitches. Therefore, I connected the two strings in a hybrid configuration and implemented a separate mono-string for plucking, thus completing the Modalys coding.

[2] IRCAM, "Object Properties: Material," IRCAM Modalys Documentation, https://support.ircam.fr/docs/Modalys/3.3/co/object_properties_material.html, accessed August 10, 2024. I have attached the method for organizing these values in Max as an appendix.

Figure 3. Modalys coding in the Max/MSP environment.

Figure 5. Example of the pictures of the pitches and materials in the hybrid object section.

The content of the coding contains default values for various basic objects within the object (such as length, radius, etc.), but these values are dynamically altered through Jitter-based color tracking technology and Max algorithms.

Additionally, materials and pitch changes through the hybrid system are designed so that while String 1 is producing sound, String 2 undergoes modifications over time. These changes and visual information are then patched and displayed to the performer. Additionally, the hybrid system allows the performer to anticipate the next pitch and material in advance, enabling unique musical choices during performance. This hybrid approach was designed to address issues such as glitches and noise caused by Modalys's high CPU computation by using two strings, ensuring calculations are performed on the inactive string. Furthermore, the hybrid system was devised to facilitate otherwise extremely challenging pitch modifications.

In Figure 5, the left side represents String 1, and the right side represents String 2, each with different pitches and materials. The central slider indicates the current degree of hybridity. In this case, Figure 5 shows S2 at 100%, producing the pitch C7 with an iron string.

The next sound is D3 with a maple string from S1. This allows the improviser to visually anticipate the next pitch and material through names and images, providing essential information in advance. After the sound transitions to S1, the material and pitch of S2 are modified based on the moment when S1 reaches 100%. At this point, glitches and noise issues are prevented by ensuring S2 does not produce sound during the transition.

4. COLOR TRACKING APPROACH VIA JITTER

Important parameters of Modalys string are adjusted by tracking colors captured by the camera through Jitter. Specifically, the blue globe on the left controls the hybrid position, enabling changes to the pitches and material properties between the two strings. The green and red globe on the right is used, with the red side for bowing the string and the green side for plucking the string. Three-dimensional gesture control is used for manipulating these parameters through Jitter.

The glove was designed with the inside of the right hand in green and the outside in red. This setup mimics the act of playing the cello: the red color on the back of the hand, visible when holding the bow, triggers bowing, while the green color visually simulates plucking as the palm faces the string. The left hand was designated as blue to control the vertical value, which adjusts the slider for the hybrid position. Depending on the vertical value, the system transitions between S1 and S2, allowing the material and pitch to change freely, thereby surpassing many limitations of Modalys.

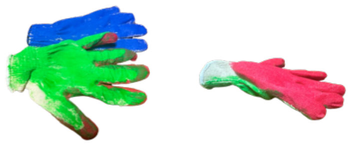

Figure 6. RGB globes for the color tracking.

When selecting RGB values, there were no specific restrictions, but for red (R), pure colors such as 255, 0, 0 were found to be the most advantageous. This is because pure colors are more easily detected by camera sensors and Jitter's color-tracking algorithm. Furthermore, using matte paint reduces light reflection and enhances consistent tracking. Diagram 1 provides a simple summary of the role of the gloves, highlighting the effectiveness of pure colors in achieving stable and precise tracking.

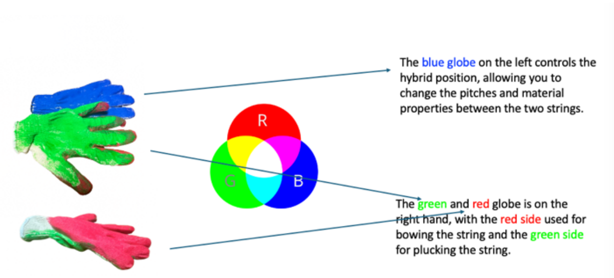

Diagram 1. Role of Gloves in RGB Color Tracking

In this case, the glove serves as the simplest example, and RGB colors were chosen for their efficiency in computation and tracking. However, this patch can be implemented with any color or tool. Since color tracking is sensitive to lighting conditions and clothing colors, special attention must be paid to the environment and lighting when realizing the patch.

The three-dimensional gesture control for Modalys String operates as follows: the horizontal value obtained through Jitter adjusts parameters related to bowing, such as the horizontal and vertical positions and the weight. The vertical position value modifies the rosin, access position, and timbre (including constant-loss and frequency-loss).

Figure 7. RGB tracking (left) and the tracked amount (right)

In Figure 7, the amount and position of the red color are shown. In the figure, it is located at the bottom-left corner, and the amount is moderate. Therefore, the Z-value is likely to be moderate as well; however, since it is positioned at the bottom, a harsh sound, such as sul ponticello, will be produced. Additionally, as it is at the beginning on the left side, the friction between the string and the bow has just started.

The second green color shows no amount at all since the palm is not visible. An algorithm has been applied so that the bow sound, if present, is inversely proportional to the amount of green detected.

In the case of the third blue color, it shows only a very slight amount. This is because the color tracking has been intentionally set to be less sensitive. Blue is relatively easy to track, and since the hybrid value could accidentally appear and significantly affect the system, its tracking sensitivity has been reduced for practicality. Blue, which only receives vertical information, has a weaker tracking intensity to enhance usability.

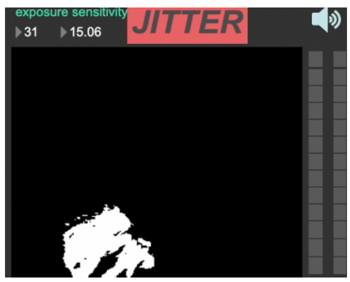

Figure 8. The degree of color exposure is represented in black and white.

Finally, the third dimension, the Z-axis, uses the amount of color tracking as its value.

This is represented as white on a black screen to provide an instant visualization of the amount. These values are confined to ranges derived from extensive research and experimentation, with the scope of limitations adjusted variably depending on the pitch. For example, lower pitches may have a broader range of allowable values, while higher pitches may require more precise tracking for stability.

Additionally, the three-dimensional control and the three colors enable a wide range of parameters to be manipulated simultaneously, offering both flexibility and precision. This not only enhances real-time control but also minimizes the performer's cognitive load, as the visual representation makes the interaction more intuitive.

By dynamically combining bowing (red), plucking (green), and vertical hybrid adjustments (blue), the system allows for seamless transitions between pitches, materials, and playing techniques. As a result, the performer can produce nuanced sound variations and explore textures that are otherwise impossible to achieve with conventional instruments. This creates an environment where technical precision meets creative freedom, enabling performers to realize projects that are both highly expressive and uniquely innovative.

5. DETAILED APPROACH TO IMPROVISING STRATEGIES

The strategies applied for using this patch for live improvisation are as follows:

The strategy requires nothing more than a glove and a computer. The performer can demonstrate bowing using the glove or any other tool. By utilizing color, the performance showcases pitch changes and material transitions through the hybrid system.

Such performances do not limit the visualization of material changes to the performer alone; these changes can also be displayed to the audience. This allows the audience to simultaneously experience both sound and visual information, transforming the performance into a multimedia experience.

The green and red globe on the right-hand side is used to control different aspects of the string. Specifically, the red side is designated for bowing the string, while the green side is used for plucking. Since these colors are opposites, the Z-axis value, which reflects the amount of green color, indicates their contrast. As a result, an increase in the Z-axis value of the green color reduces the amplitude of the bowing sound, while the red color, being its opposite, enhances it. This method effectively intercrosses the bowing and plucking sounds by utilizing the color contrast to adjust their relative intensities. Specifically, the left hand (blue color globe) controls pitch and material changes by smoothly adjusting the hybrid position.

By using a MIDI pedal for pedaling, random materials and pitches will appear. These images and pitches will provide visual information that influences the performer in a virtuosic manner.

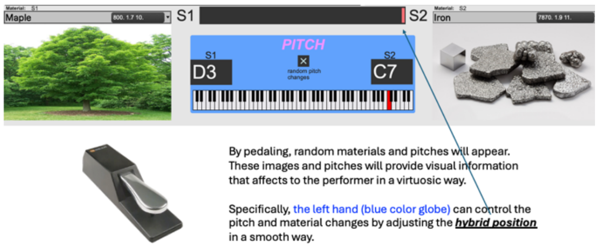

Figure 9. The Pedal and Its Role

6. PROSPECTS AND LIMITATIONS OF THE MODALYS PATCH

Furthermore, anticipated benefits include precise cues for sound processing (such as AM, RM, etc.), the ability to work with limited scales for specific pitches, and the integration of audiovisual elements with material properties. This approach not only simplifies the process for performers unfamiliar with string instruments, allowing them to perform immediately, but also encourages intuitive and interactive exploration of sound.

By bridging sound generation, material properties, and visual representation, this method transforms traditional performance into a multi-sensory experience. Performers can experiment with dynamic pitch transitions, textural sound shifts, and visual feedback in real time, enabling the creation of immersive and responsive compositions.

Additionally, the real-time visual information provided by color tracking and the hybrid system facilitates seamless communication between the performer and the audience. The audience can visually perceive changes in pitch, material, and gesture, enhancing their understanding and engagement with the performance. This opens up opportunities for multimedia integration, where sound, motion, and visuals interact to create a unified artistic expression.

However, the use of three Modalys instances and the graphical elements of Jitter can result in significant CPU overload. Nevertheless, with further optimization of the Jitter components and leveraging Modalys's support for MC (multi-channel), a more efficient and stable performance can be expected.

Moreover, a significant merit of this system is its ability to be used not only for improvisational performance but also for highly organized compositions. Pre-determined notes and cues can be arranged to form structured pieces, offering composers a flexible and precise method to design musical works while retaining the system's interactive and innovative potential.

In addition, beyond the material values provided by IRCAM, this system allows for exploration of new values outside of those predefined parameters, enabling access to entirely novel and unique sounds. This flexibility opens up further opportunities for sonic experimentation, pushing the boundaries of what can be achieved with physical modeling synthesis.

In essence, this system not only democratizes musical performance by lowering technical barriers but also expands creative boundaries, providing composers and performers with tools to push beyond conventional limits. It invites new possibilities for improvisation, composition, and live performance, fostering innovation in contemporary music and multimedia art.

In addition to color tracking, it can also be controlled through various technologies such as ring mice, sensors, Arduino, and Raspberry Pi. Depending on the method used, the algorithm for processing values will need to be adjusted accordingly, as each technology offers unique inputs and interaction dynamics that influence how the system processes and responds to data.

7. CONCLUSIONS

Modalys, despite its challenges in live performance due to computational complexity, has demonstrated significant potential when paired with color tracking and controlled parameter adjustments. This patch showcases an innovative approach that makes real-time sound generation accessible and manageable even for those unfamiliar with Max/MSP/Jitter or Modalys.

The integration of color tracking as an intuitive interface allows performers to interact naturally with pitch, material, and hybrid transitions, simplifying the complexity of live implementation. While current performance may encounter CPU overload when using multiple Modalys instances alongside Jitter graphics, the system remains promising. Future refinements, including Jitter optimization and leveraging Modalys’s multichannel (MC) support, will further enhance efficiency and usability.

In essence, this work bridges technology and creativity, offering new possibilities for live performance and real-time sound exploration. It highlights an adaptable and user-friendly framework, paving the way for further development in multimedia and performance art.

REFERENCE

IRCAM. *Modalys Documentation*. Accessed August 10, 2024.

https://support.ircam.fr/docs/Modalys/3.8.0/index.html.

(Appendix)

I have briefly listed the material properties from the Modalys documentation and attached a photo showing an example organized in a menu.

1. Excerpted Material Values for the Coll Object

Material	Density kg/m^3	Young N/m^2	poisson
Aluminium	2700	7.0e10	0.35
Bismuth	9780	3.2e10	0.38
Brass	8500	1.0e11 - 1.25e11	0.33
Bronze	7400 - 8900	9.6e10 - 1.2e11	0.34
Cesium	1930	1.7e9	0.3
Copper	8940	1.1e11 - 1.28e11	0.35
Gold	19300	7.9e10	0.43
Iridium	22560	5.2e11	0.26
Iron	7870	1.9e11 - 2.11e11	0.30
Lead	11340	1.6e10	0.43
Lithium	534	4.9e9	0.36
Magnesium	1740	4.3e10	0.29
Mercury	13600	2.85e10	(0.5)*
Nickel	8900	2.1e11	0.30
Osmium	22570	5.5e11	0.25
Platinum	21450	1.68e11	0.39
Silver	10500	8.3e10	0.37
Steel	7700	2.0e11	0.31
Tin	7310	4.7e10	0.35
Titanium	4540	1.2e11	0.34
Tungsten	19250	4.11e11	0.28
Zinc	7100	1.08e11	0.25
Arsenic	5700	8.0e9	-*
Diamond	3500	1.22e12	0.2
Granite	2700	1.0e10 - 7.0e10	0.1 - 0.3
Graphite	1400 - 2250	1.7e11 - 3.4e11	0.13
Limestone	2700	1.5e10 - 5.5e10	0.18 - 0.33
Marble	2560 - 2760	5.0e10 - 7.0e10	0.1 - 0.22
Quartz	2650	7.6e10 - 9.7e10	0.17
Sandstone	2000	1.0e9 - 2.0e10	0.21 - 0.38
Sapphire	3980	3.45e11	0.25 - 0.28
Shale	2500	1.0e9 - 7.0e10	0.2 - 0.4
Silicon	2330	1.3e11 - 1.88e11	0.36
Uranium	19100	2.08e11	0.23
Carbon Fiber	1400	8.9e11 - 1.3e12	0.25
Catgut	1300	5.5e9 - 6.5e9	-*
Flax Fiber	1450	5.0e10 - 7.0e10	0.4
Hemp Fiber	1480	3.0e10 - 8.0e10	0.4
Horse Hair	1200 - 1400	4.9e9 - 7.0e9	-*
Nylon	1150 - 1200	4.5e9 - 5.5e9	0.4
Silkworm Silk	1300 - 1380	5.0e9 - 6.0e9	0.4
Spider Silk	1300	2.0e9 - 5.0e9	0.4

Material Properties of Other Natural and Synthetic

Material	Density kg/m^3	Young N/m^2	poisson
Bone	1900	9.0e9 - 1.8e10	0.15
Carrot	1140	1.36e6	0.15 - 0.35
Concrete	1680 - 3000	3.0e10 - 5.0e10	0.1 - 0.2
Cork	200 - 250	2.0e7	0*
Glass (Borosilicate)	2300	6.2e10 - 8.1e10	0.2
Glass (Soda-Lime)	2500	7.2e10 - 7.4e10	0.23
Ice	920	1.2e10	0.33
Marshmallow	370	2.9e4	-**
Olive Oil	920	1.35e9	(0.5)***
Rubber (hard)	1100 - 1200	1.0e7 - 2.3e9	0.48 - 0.5
Rubber (soft)	950	3.0e6 - 5.0e6	0.48 - 0.5
Seawater	1020	2.34e9	(0.5)***
Tooth Enamel	2900	8.3e10	0.28
Water	1000	2.15e9	(0.5)***

Ash	710	1.6e10	1.6e9	9.0e8	-	-
Balsa	160	6.0e9	3.0e8	1.0e8	-	-
Bamboo	300 - 400	1.4e10	-	-	-	-
Beech	700	1.4e10	2.2e9	1.1e9	-	-

2. Material List Managed with live.menu in Max