Sensattice: An emerging collaborative and modular sound sculpture

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ABSTRACT
The concept of sound sculpture can accommodate a rich variety of artistic manifestations and disciplines since it contains music, plastic arts and performance, to say the least. Even the conceptual and spatial design or the manual skills necessary to transform physical materials account for its interdisciplinary potential.
Sensattice is an emerging sound sculpture that takes advantage of organic raw materials considered waste to convert them into biopolymers and explores their acoustic and haptic potential taking "skin and bone" as a conceptual premise to synthesize the two fundamental materials of his proposal. These materials were obtained by applying biomaterials engineering and 3D modeling and printing as parallel processes.
Sensattice seems to be an emerging system since it is not reduced to mere materials, but involves people and situated epistemic approaches that literally shape a sculptural lattice through the sensory and symbolic perception of skin and bones.

Author Keywords
Sound sculpture, Interdiscipline, Emerging systems, biomaterial engineering, Haptic interfaces, collaborative performance

CCS Concepts
• **Hardware** → **Emerging technologies** → *Analysis and design of emerging devices and systems*; • **Social and professional topics** → **User characteristics** → *Cultural characteristics*; • General and reference → Cross-computing tools and techniques → Empirical studies

1. INTRODUCTION
When we talk about sound art, it doesn't matter if the acoustic product we perceive is generated with a digital synthesizer or by hitting two stones. In all cases, the acoustic result will depend on the materials involved in its generation and its diffusion, so product and sound source are inseparable factors. This relationship becomes closer if we refer to sound sculpture [9], since the very concept makes them codependent. Since the creations of the Baschet brothers, the concept of sound sculpture has been based on the acoustic potential of materials, on discovering little-explored aesthetic possibilities or as a technological alternative when there are limited resources [12]. The material relevance doesn´t distinguish between heavily processed materials such as metals or non-human intervention materials, such as phonolite rock.
But what if the timbre qualities are “poor”? What if the materials are not acoustically attractive enough? Is it a limitation of the material or a limitation of whoever listens and plays the material? We could say that sound art has made us rethink the value of listening, even the role played by the environment with its materials and its aesthetic perception. A sound proposal based on a broom rubbing the floor can be as valuable as a ritual dance hitting rhythmically on the same floor, we would only have to ask ourselves where each idea, each sound object, points to.
Even if we decide to ignore these questions, two possibilities arise: expand or underestimate the relationship between source and sound product. In one hand, the use of a certain material does not mean that we have to limit ourselves to its acoustic properties, subsequently we could expand the relation between sound and source by amplify and process those properties, as happens in electroacoustic instruments and the human voice. We could also capture acoustic phenomena and abstract them from their sources to re-signify them as in concrete music. On the other hand, if we wanted to discard this relationship, we could eliminate all trace of the material source from the sound product simply by using the materials as a transduction method for a digital instrument, which we frequently do with capacitive sensors. So, no matter how we see it, in all these cases the materiality is implicit. One way or another.

2. PROPOSAL
Sensattice is a sound sculpture proposal that explores materials with acoustic characteristics that could be considered as poor. These materials are biopolymers obtained through chemical engineering processes that take advantage of organic raw materials considered waste. Conceptually, the sculpture has the premises of "skin and bone", suggesting two main materials with complementary characteristics. Its morphology is based on a modular emergent lattice, its shape is variable and depends on the people involved at the time of its construction. The modules are the same bones that, when assembled in hexagonal geometric patterns, form a three-dimensional framework in whose negative spaces the skins are stretched. The volumetric dimensions are also variable since a single hexagonal pattern of six bones and a

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skin is enough to form a cell, having all the sound possibilities available for just one person, however, if we assemble multiple cells together, the sculpture can become a collaborative instrument where several people can explore an embodied performance.

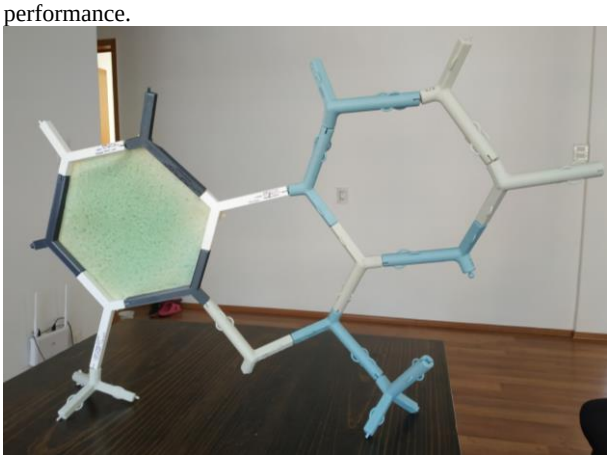

Figure 1. Sensattice mini sculpture

Since research on materials is a strong point of this project, I will now describe the processes used to obtain them.

2.1 Skin

The skin is influenced by the bacterial cellulose membrane of Eingeweide [1], a performance piece by Marco Donnarumma and Margherita Pevere. In this project, the skin is a biopolymer obtained from waste materials from the food distribution chain. The fundamental materials are orange peels and fish scales (robalo, huachinango and mojarra) that were rescued from the waste of the Mixcoac and La Viga markets in Mexico City. In order to obtain the polymer, these materials were cleaned, dehydrated and pulverized to later be mixed in a vinegar and glycerin solution where, thanks to the method known as solvent evaporation [13], thin films with certain mechanical characteristics were obtained. Depending on the concentrations of solute (orange and fish powder) and solvent (vinegar and glycerin) the thickness, elasticity, texture, humidity, resistance, and plasticity of the film will change. Even applying heat to the solution can improve resistance and elasticity. In addition, during their preparation these films can be loaded with dyes and essences that give visual and aromatic properties to the final product.

Figure 2. Skin

The material obtained can be used in multiple applications but following the concept of skin for this project, an elastic, light, moisty and translucent film was chosen to be used as a percussion patch or as a kinesthetic and tactile haptic interface [10].

As can be seen, low-cost and easily accessible biomaterials are used in this process and its preparation does not necessarily require specialized equipment or laboratory reagents, so the procedure can be replicated in any kitchen or space outside the laboratory with little investment and does not represent any more danger than prepare a soup for dinner.

2.2 Bones

As we anticipated, on the other side of the project, the bones are 3D printed modular pieces that, thanks to their design, can be assembled without the need for blocks or additional parts, achieving articulation and versatility. However, the geometric assembly that achieves greater stability and allows a self-supporting three-dimensional lattice construction is the hexagon. The bones have as a base design three arms with different sizes that are joined with others by means of two types of mechanical assembly. The first is sphere type, incorporated in arm “A”, the shortest, which will be introduced into the cavity integrated in arm “B”, the longest. To maintain geometric consistency and give stability to the structure, these two arms are 1/3 and 2/3 of the total length of the hexagonal edges, although as they are mobile assemblies, it is possible a 360° rotation between the pieces. The second assembly is fixed and is at the end of the remaining arm “C”, there we see three cylindrical cavities and a cylindrical stem arranged in a 2x2 pattern. This arm is half the length of the hexagonal edge so it can be assembled exclusively with a similar one in other pieces.

Figure 3. Variety of bones

From this base design, three other iterations emerge that include textured bones that enrich the lattice in terms of sound possibilities, tactile stimuli, and variability in the three-dimensional assembly. The first iteration has four arms, a second arm “C” that aims to extend the sculptural construction indistinctly in the X, Y and Z axes. The second iteration is a double flute-bone with its three piped arms, two of them with perforations for fingering and the remaining one with a mouthpiece to be used as a wind instrument. The third iteration is intended to assemble a drum, these bones, unlike the previous ones, can only be assembled in one plane, so they can form a two-dimensional frame where the skins can be stretched and tightened. Due to their modular and printable design, these bones can be struck, scratched, rubbed, or blown to produce sound.

We decided to print the bones in PLA materials, since they are bioplastics based on sugar cane or corn that are compostable. For

this project we use not only regular PLA, but also composite filaments added with particles of stone, wood, and copper, seeking to increase the richness of the tone in the finished pieces.

2.3 Modular construction

The bones, as mentioned above, can be assembled forming the edges of the three-dimensional hexagons of the lattice, this geometric pattern leaves hollow spaces, where the skins can be laid. Although all the bones can be assembled, only three of the four types of bone allow the skins to be laid in two ways, where each one provides different characteristics: in the first, the skins are hooked from their vertices by means of tension springs; this laying is focused on the haptic interaction taking advantage of the springing product of the tension and resistance of the springs and skins. For the drum bones, we use the second type of laying, this one has perimeter fixation to provide uniform tension throughout the entire area of the skin and thus achieving a percussive patch. The dimensions and final design of the sculpture are dependent on the number of bones and skins available and the aesthetic preferences of the people at the time of construction.

Regardless of the assembly possibilities, we can see that the bones have individual sonic and tactile value due to their textures and the possibilities that each iteration proposes, these are the fundamental elements of Sensattice's sound production.

2.4 Sonic outcome

As this is ongoing research, at this moment it´s difficult to have a detailed report of the sound product of the materials. About skins, the biopolymer has been used mainly as a haptic and sensory element, although they have already been stretched within the bone structure. In that matter, research is currently being carried out to chemically crosslink the skins to improve their mechanical characteristics and thus obtain more resistant percussion heads.

For the bones, on the other hand, the sonic outcome has a high variability in terms of acoustic characteristics. The bones have been made to sound in different ways, rubbing, hitting them against each other, percussion and even, for the flute bone, blowing. The acoustic test that we have standardized to evaluate the timbre and resonance of each iteration is by percussing each type of bone with a glockenspiel stick. It is important to say that, when printing these pieces, the quality of the material, its elasticity, the density and filling of the pieces, the wall thickness and even their orientation on the printing platform are extremely relevant to the sound product.

Consecutively each iteration of bone has a different material density, and this depends on the geometries and particular design of each one of them. Furthermore, if we look at each iteration, we will see that the materials vary in color, elasticity, roughness, and even melt temperatures. This gives each bone its own acoustic characteristic that is difficult to replicate with the rest.

If the acoustic variability is already present in each iteration, when assembling the bones, the variability grows even more since the vibration of the oscillating elements is not even in all directions. However, this should not be seen as a drawback since our intention is not to standardize acoustic properties, we prefer to use that randomness as an emerging aesthetic element, finding value and potential in difference.

2.5 Mechanical and acoustic characterization

Within the next few months, a couple of papers that account for the experimental research applied to materials will be published. These studies, carried out in the laboratory, include the mechanical characterization of the crosslinked skins and formal studies of the acoustic characteristics of the bones in all their variations. Within the study on bones, the use of PLA of different qualities and compositions is also observed, including those containing wood, copper, and stone.

With these studies it is hoped to shed light on the properties and acoustic possibilities of the materials and their possible viability within sound and musical contexts.

3. INTERACTIVE AND PERFORMATIC PROPOSAL

When we conceptualized Sensattice we looked for three degrees of interaction that start not only from the design of materials but also from the number of modular pieces and the number of people involved, these degrees range from the intimate, the collective and the intrapersonal interactions.

The intimate is that experience whose subjective significance may or may not involve other people or objects, but which is catalyzed by an external stimulus while seeking to achieve an affective disposition. We appeal to the intimacy of people with sensory experiences, playing an active role in the sound and tactile textures in the bones or the humidity, color, lightness, and aroma of the skins.

Unlike the above, the collective experience is intended to be more extroverted, with the intention of transcending the objective experience of a group of two or more people to arrive at the perception of an intersubjective reality through the participation of everyone both in the construction and design of the sculpture in situ as well as in the sound ensembles that can emerge before, during and after the construction itself.

Finally, the intrapersonal degree takes part in each of the aforementioned interactions and those others that as conceptualizers we have not yet glimpsed. Within this spectrum, the cognitive processes of everyone are contemplated by their symbolic, affective, communicative, sensory, social, epistemic meanings. They realize the impact that this artifact may or may not have on people and their community.

As expected in a sound artifact like this, one specific way of interacting with objects is not prescribed beyond their artifactual agency and the guidelines that it gives to people both individually and collectively to follow certain paths and still it is up to the free will of the participants to be carried away by these intuitions or to reject them.

Figure 4. Drumming on tightened skin.

Let's keep in mind that the bones are useful to build a sculpture, in a small scale can function as an individual musical instrument or in a large scale, assembling dozens of bones can become a collective experience where participants can move through space

at will, with different levels and heights to interact with each other and the sculpture. This is not a musical instrument that requires a certain technique, and it is not intended exclusively for people with familiarity in musical practices, anyone who wants to take part in the activation of the objects and interact with them are welcome.

4. DEVELOPMENT AND INTERDISCIPLINARY COLLABORATION

The initial proposal for this project is not the one presented today, it was conceived as something very different, something even limited, but thanks to the participation of a group of people since the initial stages of conceptualization, the project has grown in vision and has been enriched by varied perspectives such as music technology, sound art, chemical engineering, additive manufacturing, biotechnology, industrial design, performance, and specialists in media and systems theory contributing with their ongoing work or sharing their knowledge through advice and recommendations. The articulation of this multitude of points of view is a constant negotiation between the disciplinary perspectives with their own objectives, concepts, methodologies and what the project contribute to the interdisciplinary crossing both technically and ontologically. Indeed, this project poses a constant research question about collaborative methodologies and their tensions within creative processes, whether artistic or scientific, but beyond the incidents, it has been and will continue to be a reason to break disciplinary paradigms and get closer to a better understanding of each other through the consensus and disagreements that occasionally occur in living and open systems like this.

5. A CASE STUDY

The first activations of this sculpture were carried out in March 2023. The first control group within the Faculty of Music, UNAM and the second at the V International Acoustics Congress at the National Polytechnic Institute (IPN) in Mexico. The difference in the profiles of the people in these meetings made it possible to gather different impressions and approaches to sculpture. For instance, at UNAM the participants are academic musicians and improvisers with experience in sound art. In contrast, in IPN the profile of the participants tends more to the technical and scientific side. It is notable that, although we consider different profiles, in both cases the participants in the two activations allowed themselves to playfully interact with the bones and skins seeking to integrate sensory stimuli and personal significance from their own story.

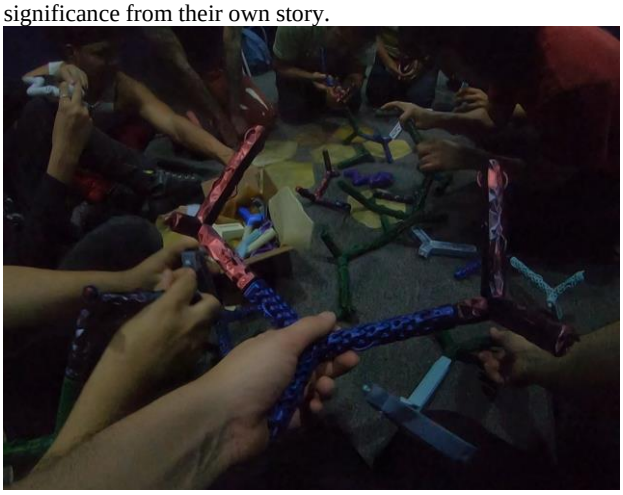

Figure 5. Control group experimenting with the modules.

It should be noted that, in the first contact with the pieces, a particular way of interacting with the materials was not prescribed. I will briefly describe some observations resulting from these first case studies:

- The assembly of the bones was one of the most intuitive interactions with objects.
- The morphology of the flute bones satisfactorily fulfilled its purpose and found willingness in the participants to be used as wind instruments.
- The different textures, colors and sensations achieved contrasting relationships, both liked and rejected by each participant with the bones.

Figure 6. Stretching the skins

After the first contact, the particular methods of assembling and laying skins on the assembled structure were demonstrated to learn about the armed sculpture. Some of the sound affordances found were the following:

- Blow and finger the flute bones
- Rubbing of bones and skins
- Scraping various textures with bone drumsticks
- Percussion of stretched skins
- Percussion of bones between them and with a drumstick.
- Stretching springs as a vibrating string

As these were the first control groups, the interactions were also useful to recognize opportunities for improvement in manufacturing and design, some of which are mentioned in the Sonic outcome and mechanical and acoustic characterization sections.

6. DISCUSSION AND CONCLUSIONS

We consider Sensattice an open and emergent system [5], since it is not simply reduced to the disciplines involved, the methodologies used or the proposals put forward, subsequently other supra and subsystems come into play that have equally relevant implications for the central system. These considerations are also political, economic, and social, and are situated in a specific reality; they also come from people with specific material conditions. Nevertheless, this project is aimed at impacting other individuals and their realities, similar and equally diverse. From the encounter of these situations emerge phenomena that can hardly be predicted and yet, Sensattice's central thesis is to discover emergencies resulting from the integration of people and conditions prior to this symbolic crash. After reviewing some aspects of the first stage of the Sensattice project (focused on the development of the materials and the first

tests of use), we can note that the potential of the materials obtained exceeds the actual project they emerged, for example, research on the skins is projected to be used as a widely used bioplastic that can replace polyethylene in some applications and could also replace leather to make drumheads with low production cost.

Sensattice is a project that arose from the need to vindicate sensory experiences within an ocean of virtuality and algorithmic developments in the box. Also, it is an awakening from the lethargy produced by the confinement of the Covid-19 pandemic and remote communications to resume all those physical activities that we miss and satisfy the need for contact both with others and with the environment. But this proposal is not only an alternative to the digital technological trend, it is an invitation to recognize our biological interfaces, those capacities that we lean on to approach life and apprehend the world with our mind and body.

The growing preference for digital media is a concern of great weight for this project since materiality and multisensory object-person relationships have fallen into the background. Digital technology and its strong impact on culture seem to be part of a "FOMO" that focuses on audiovisual products and content directed and experienced through screens, but let's not forget what Fernández-Vicente [4] tells us on this issue: "limiting the field of perception to two senses... is a sensory deprivation". Through this reflection we question digital fetishism in order to find a balance that does not overshadow the multidimensional experience [8] of the people.

Based on the above, Sensattice's proposal gains value since it goes beyond the merely technical aspects of a musical performance or even the immateriality of the digital world to involve a multidimensional perspective in the aesthetic experience that attends to the materiality, cognition, affectivity, communication, and others that unknowingly take part in the assimilation of our daily experiences.

It is also important to say that although these materials were obtained in a university context, we seek the transmission of these methods and their appropriation in different social contexts for the applications that best suit their users following the same logic of use, rescue, and adaptation of available resources. This set of mind approaches the "resourcefulness and ransacking" [3] conceptual methodologies that Mayra Estévez Trujillo observes as forms of cultural resistance that privilege appropriation and technological innovation.

7. FUTURE WORK

7.1 An augmented Instrument?

The first stage of Sensattice aims to explore as deeply as possible the acoustic characteristics of the materials already described, however, as we anticipated in the introduction to this text, our relationship with materiality and sound production transcends the material itself. Therefore, a second stage of this research that is being carried out involves the amplification and processing of the timbral qualities implicit in the bones and skins using the programmable card Bela [7]. Two methods are foreseen to work with the microcontroller, an "analog" one focused on capturing the sound vibrations of the sculpture through piezoelectric sensors mounted at different points, both skins and bones, to be amplified in the sculpture itself with vibratory actuators (similar to Rmesh's proposal [6]). A second method, now digital, would use the skins and bones only as an input method to trigger sound events and modify parameters using Trill touch sensors developed by Bela team and other capacitive and inertial sensors. The inclusion of these circuits extending through the sculpture and the Bela card imply a nervous system, one more conceptual element that complements the already existing skin and bones.

Just to be clear, the incorporation of an electronic method for amplification and audio processing does not nullify or contradict the technological criticism in the previous section. Since we know our time and space of action, we do not opt for the denial of digital technologies, we rather put forward the notion of an instrument distributed in various agents and agencies through embodied experiences with a relational approach.

7.2 Didactic and pedagogical proposal

This project also has a didactic and pedagogical proposal as it closely follows the participatory methodology of Gilberto Esparza's Korallysis project [2], and Baschet philosophy [11], in multiple perspectives. In addition to the most obvious similarities between sound sculpture and participatory performance, another objective of the project is the transfer of technical knowledge, the approach of DIY technologies for the recirculation of materials and the appreciation of the aesthetic possibilities in our respective environments. Therefore, within the medium term, we pursue the formation of interdisciplinary workshops centered in aesthetic awareness around intermedial technologies with specialists in biomaterials engineering and 3D printing to share the methods developed in this research. We believe that, in relation to technology, achieving the right balance between the pragmatism of technical knowledge and aesthetic appreciation is a key to transforming the individual through critical thinking that at the same time potentiates social transformation.

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