




Soundscape to Music: Experiences in an Additive Manufacturing Open Lab

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Abstract. The CTI Renato Archer's Open Laboratories have their own ambience, the lo-fi soundscape mostly hidden in the routine of researchers is an important part of the act of experiencing the work space and trying to reach a higher level of awareness about the surroundings through sound is part of a more compelling path to understand the space and how the interactions between individuals and machines develop. By recording the soundscape during routine work fabricating objects using Additive Manufacturing (AM) and conducting experiments, this work aims to bring to the foreground the sound layers emanating from the machines and materials used at the 3D Print Open Lab (LAprint) and the Micro and Nanoimaging Open Lab (LAimage), blending it with musical instruments to generate compositions. The musical instruments used to add to the soundscape tracks were a Clarinet, a Baglama, a PVC flute and Mouth Harps. For all instruments, 3D printed objects were fabricated and used as accessories, such as clarinet reeds and guitar picks. All recordings were made with a TASCAM DR-07X and treated with Audacity 1.3 software. The detachment from the vision perspective of the space by isolating sounds provides a more accurate analysis of the machine components activated in each routine. In addition to the art produced, the recordings can be useful for teaching, equipment troubleshooting and it has a particular important role for presenting technologies to people with blindness and visual impairment.

Keywords: Additive Manufacturing · Field Recording · Audio Art

1 Introduction

Music and Additive Manufacturing (AM) developed a tight relation, as it became a popular fabricating method more examples of applications in music can be found for readily available technologies such as Fused Filament Fabrication (FFF) [1, 3, 12, 15]. More restricted AM technologies, such as Electron Beam Melting (EBM), were also used to fabricate musical wind instruments showing very particular characteristics and a new biomorphic concept of titanium alloy flute was proposed [8]. AM fabricates parts by adding layers of material consecutively using a digital 3D model as the base for design [14] and is considered a digital fabrication method also known as Rapid Prototyping and 3D Printing.

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Besides the potential for fabricating musical instruments and accessories, an AM laboratory has its own ambience. Sounds emerge from vacuum pumps, compressed air lines, fans, motors, materials tinkling and parts being sanded. All the machinery symphony hides behind human interactions, only emerging to attention when a distinguished noise is not expected or the lack of noise disrupts the work routine, meaning that the sound or the lack of the sound in this context is only noticed when it's a problem.

The Renato Archer Information Technology Center (CTI Renato Archer) is a Brazilian research center located in Campinas, state of São Paulo. It supports academic and industrial research with AM technologies such as Selective Laser Sintering (SLS), EBM, FFF and Polyjet through the 3D printing Open Lab (LApriint). CTI Renato Archer has another Open Labs available, such as the Micro and Nanoimaging Open Lab (LAimage) which was also involved by having its ambience recorded.

In a lo-fi soundscape possibility of a research center with heavy machinery, full of workers and close to the road connecting key cities in São Paulo state, the audio obtained can be analysed and separated in three components: figure, background and field [2,13] to consciously define the portions of the audio file which are going to be suppressed or enhanced depending on the intended effect. The figure is the center of attention to the listener, the background comprises other elements in the soundscape and the field is the place. Three aspects were further analysed: onsetness, loudness and pitchness. Those aspects were used previously as descriptors for soundscape design in the context of algorithmic composition and simulated evolution [5,10].

The interdisciplinarity of the author arises from the inability to give less importance to a particular activity, insulating certain subjects by defining them as hobbies, sentencing it to never have a leading role in life. The pharmacist Msc in biotechnology always curious about electronics and open technologies eager to absorb and share knowledge, now shares her adventurous experiments in field recording and sound art. This work aims to bring from the background the sound layers emanating from the machines and materials used at LApriint and LAimage, emphasizing and transforming it into compositions. To transport the soundscape where the researcher is immersed every day, the author takes inspiration in Throbbing Gristle, Jean-Michel Jarre, Hermeto Pascoal, Thomas Rohrer field recordings and many others.

2 Methods

All sounds were recorded using the portable digital recorder TASCAM DR-07X with dual unidirectional condenser microphones for A/B or XY stereo recording techniques and a Sennheiser HD 65 TV headphone. The recorder was mounted on a Manfrotto adjustable Tripod when necessary and a windscreen was used when recording outdoors. The following musical instruments were played and sampled: a Clarinet, a Baglama, a PVC flute and Mouth Harps. For all instruments, 3D printed objects were fabricated and used for specific functions, such

as clarinet reeds and guitar picks. One of the Mouth Harps employed was fully 3D printed [7].

The 3D Printer used to fabricate parts is a Prusa Mendel i3 FFF equipment, part of the author's personal collection, assembled with the E3D REVO™ SIX hotend employed for filament extrusion of PLA, PETG and ABS.

Machine sounds were generated by the AM equipment available at LApriint and the imaging equipment available at LAimage, both open laboratories the author uses to develop her current lines of research focusing on process optimization.

The WAV samples were sorted and organized using Sony Sound Organizer 2 and treated with Audacity 1.3 for the final compositions. For analyzing files and composing, the sound system employed a TEAC AG-D8900 AV Digital Home Stereo Surround Sound Theater Receiver and two Wharfedale Modus Five speakers using Amphenol audio connectors.

3 Results

The following sections will discuss results regarding sampling strategies, equipments and materials used for recording and interesting insights about sound handling and composing.

3.1 Sampling

Some of the LApriint's sounds were generated by the AM equipments Sintertation® HiQ™ (3D Systems), Arcam EBM Q10plus (GE Additive), Fortus 400mc (Stratasys) and Object Connex 350 (Stratasys) and for LAimage sounds were recorded from the the X-Ray Microcomputed-tomography equipment, Bruker Skyscan 1272 and the Scanning Electron Microscope SEM-FEG Mira 3 XMU - Tescan. Figure 1 shows a portion of the LApriint, depicting EBM and SLS AM equipment recorded for the present work. The strategy for TASCAM recordings used the sampling A-B configuration to capture wider audio space, while X-Y focuses on the sweet spot for a tighter audio field.

The audio recorded directly from the machines was not generated for the exclusive purpose of composing it in the future, the recordings were captured while the author was performing experiments in the AM context, using the recording act as a self observation of the author's research activity, perhaps to have the soundscape as fond remembrance of the past. Dividing the elements in the recordings as Figure, Field and Background, the Figure is always a specific louder noise starting or ending a routine, the Field are the subtle noises generated from the main equipment recorded and others in each laboratory (the Background).

The usage of musical instruments and 3D printed objects have a more intentional role in composing, using it deliberately to fill the soundscape recorded making the compositions whole in the author's point of view. All of the recordings were manipulated and remixed freely, although the soundscape recordings were more carefully manipulated to remain recognizable.



Fig. 1. Panoramic picture taken inside LAprint depicting EBM and SLS AM equipment. Available at [4]

3.2 Reduce, Reuse and Recycle

To optimize the LAprint use of material, the 3D modeling and process planning strategies of AM were carefully designed to reduce the waste of material, mainly in the form of support structures used to fabricate parts. For FFF the support structures are generated to hold material in place in regions where overhangs are below 45°C . For EBM the supports have an additional role, to heat energy dissipation reducing curling or warping defects. The titanium alloy (Ti6Al4V) structures used in the sampling for high pitch sounds were support structures usually discarded after cleaning parts fabricated by EBM. Those parts were used as is for generating sounds or assembled together. Figure 2 shows two types of support structures generated for EBM AM that were used to generate sounds.

Although the recycling of plastics used for FFF AM is common, using printed parts for recycling and inserting it in circular economy strategies [6, 9] for metal Powder Bed Fusion (PBF) technologies such as EBM the most discussed topic on recycling is the continuous use of the powder for a number of process depending on the applications, but the fabricated parts can't be processed back to powder and reused. Thus re-purposing EBM supports reduces the waste generated by LAprint.

3.3 Compositions

Navigating through many audio files was facilitated using Sony Sound Organizer 2 software, as the files were sorted, they were used as input to Audacity 1.3, software in which each track was manipulated to be shortened, extended or had filters and effects applied to it as necessary. Each track was analysed and processed taking into account the field, background and place characteristics and onsetness, loudness and pitchness aspects, highlighting or hiding parts of the tracks.

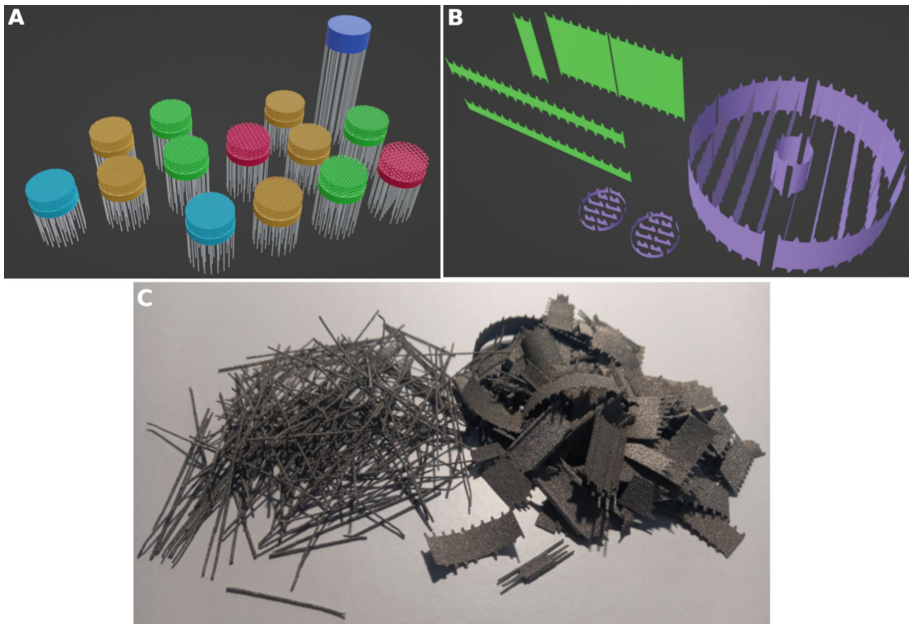


Fig. 2. EBM generated supports. (A) Cone type supports in white under the colored cylindrical models; (B) block type supports isolated from the main models, excerted from cylindrical surfaces and green from rectangular surfaces and; (C) the fabricated supports after having it removed from the main parts. (Color figure online)

4 Conclusions

The compositions created reflect the expression of art in which the machine manipulator can interpret it's functions and deals with the digital fabrication context in an oblivious reality, usually ignored or not important enough to the daily routine, interpreting this parallel and powerful connection to the space where the machines are situated and one can choreographically interact with them. The symphony of sounds emanating from each laboratory is unique and pervades the minds of the professionals who work in such place, capturing the influence of the machines' noises brings a new awareness of the space, with the sound components that were always present, resembling the definition of acoustemology [11].

The detachment from the vision perspective of the space by isolating sounds provides a more accurate analysis of the machine parts and which components are activated in each routine. In addition to the art produced, the recordings can be useful for teaching, equipment troubleshooting and it has a particular important role for presenting technologies to people with blindness and visual impairment, offering a way to interpret machine functions through sound. Future work involves the capturing of the soundscape recording as a tool for inclusion focusing on diversity and equity.

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