

# Paluse Research Grant Application

**Project Title: *Metanomic Echos***

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Final Proposal

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## 1. Introduction

We are applying for a Paluse Faculty Research Grant to research, fabricate, design and execute an ambitious interactive, interspecies multimedia eco-installation in the Gumberg Library called *Metanomic Echos*. The purpose of this project is to educate the public about the ongoing climate crisis affecting Earth, through an immersive multimedia experience. Our efforts will lead to at least one published paper in a top-tier research journal such as MIT's *Leonardo*. We will also organize a public round-table discussion about the climate crisis with four prominent Duquesne professors on Earth Day (22 April 2022), coinciding with the exhibition's opening.

This project not only sets ambitious technical and aesthetic goals (all of which have already been successfully tested), but also it relates to Spiritan interest in the integrity of creation. It pertains directly to the concerns Pope Francis expressed in his 2015 encyclical, "Laudate Si".

Apart from bringing attention to the climate crisis, the exhibition promotes ongoing research in hardware/software design and multimedia installation fabrication, which will have many positive ripple effects throughout Duquesne University and the surrounding community.

## 2. Topic to be investigated and its significance

Since 1965, computer models have predicted that increases in atmospheric CO<sub>2</sub> levels causes global warming and other significant atmospheric changes.<sup>1</sup> According to the Sixth Intergovernmental Panel on Climate Change (IPCC)'s 2021 Working Group 1 report,

It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred (IPCC 2021, SPM-5).

The nearly 4000-page report continues,

Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened... (ibid., SPM-10).

The IPCC's report outlines five possible future scenarios, ranging from very high greenhouse gas emissions to net negative CO<sub>2</sub> emissions. Under these varying scenarios, global temperatures rise from anywhere between 1.5°C to 4.5°C in the time frame 2081-2100 (ibid., SPM-16). The report projects *medium confidence* that by 2300, surface temperatures will be 2.3°C to 4.6° higher than in 1850-1900. The last time this occurred (roughly 3 million years ago in the mid-Pliocene Warm Period), Earth's shorelines were 5 – 25 meters higher than today (ibid., TS-11).

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<sup>1</sup> Manabe, Smagorinsky and Strickler 1965. Manabe shared a 2021 Nobel Prize in physics for his pioneering work.

The Catholic Church has responded to these deeply troubling developments. In his encyclical *Laudate Si'*, Pope Francis writes:

[Earth] now cries out to us because of the harm we have inflicted on her by our irresponsible use and abuse of the goods with which God has endowed her. We have come to see ourselves as her lords and masters, entitled to plunder her at will. The violence present in our hearts, wounded by sin, is also reflected in the symptoms of sickness evident in the soil, in the water, in the air and in all forms of life (Francis, §2).

Spiritans have taken Francis's words to heart, particularly in their focus on honoring the integrity of creation.<sup>2</sup> In 2015, the Conference of Major Superiors of Men (CMSM) adopted a resolution entitled "Cherish All of Creation" at their Pittsburgh meeting.<sup>3</sup> The Conference pledged to work towards a

...more just and equitable system where mitigating climate change, which disproportionately affects the poor and vulnerable, is part of the ongoing ministries of each congregational member of CMSM (ibid.)

Spiritans also recognizes the inherent beauty of Creation. The CMSM document poetically states,

...we have come to listen to the 'music of the universe' – water flowing over rocks, the wind, trees bending in the wind, raindrops pattering the roof. (ibid., fn. 6)

This is the main inspiration behind *Metanomic Echos*.

### **3. Contribution the proposed project will make**

#### **a. Installation**

The core project is an interactive, interspecies multimedia eco-installation. Natural electrical signals generated by four living plants affect the playback of a sound layer composed of recorded samples of earth, air, fire and water. Using a custom-designed iPad interface, a walk-up participant controls a second layer made of sounds from the human world – e.g. bells, children, street merchants, or a movie projector.<sup>4</sup> When a participant triggers a human sound sample, it distorts, punctures, and degrades the nature sounds in unpredictable and sometimes violent ways. It also produces dramatic changes in abstract live-generated 2D and 3D animation on a large video screen. If left alone, the human sounds slowly fade out over a minute or two,

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<sup>2</sup> "The Jewish and Christian faiths have come to the realization that Scripture gives no warrant to humankind for unlimited exploitation of the earth, but rather to shepherd it, just as the earth shepherds us." Okoye 2018, p. 32.

<sup>3</sup> [https://d2y1pz2y630308.cloudfront.net/22800/documents/2019/5/2015\\_Resolution\\_ChерishCreation.pdf](https://d2y1pz2y630308.cloudfront.net/22800/documents/2019/5/2015_Resolution_ChерishCreation.pdf).

Accessed 6 December 2021. This is available through the main Spiritan web site, <https://spiritans.org/evangelization-justice-and-peace>.

<sup>4</sup> The sound samples come from the BBC Sound Effects archive, a large collection available for free non-commercial use at <https://sound-effects.bbcrewind.co.uk>.

and the natural sound layer regains equilibrium. After a human intervention, the relationship between the four nature sounds permanently changes.<sup>5</sup> This is meant to convey the optimistic belief that nature can restore its balance, even after being damaged.

Although the installation can be experienced on its own as live sound and video art, we intend it as a metaphor for human interaction with our ecosystem. We want to reach beyond the material world, and suggest that mitigating climate change involves more than simply solving technical challenges. Referring to Patriarch Bartholomew, Francis writes in *Laudate Si'*,

Bartholomew has drawn attention to the ethical and spiritual roots of environmental problems, which require that we look for solutions not only in technology but in a change of humanity; otherwise we would be dealing merely with symptoms (Francis, §9).

*Metanoia* (μετάνοια) is a Greek word tied to the notion of repentance and spiritual growth. It appears in the New Testament twice, both in extraordinary contexts (Mark 1:15, Matthew 27:3). *Metanoia* is itself translated from the Hebrew verb שׁוּב (shûb), meaning “to turn back, to return”. The Greek word *echos* (ἤχος) means “sound” or “noise”. Consequently, we understand *Metanomic echos* as *sound* or *noise* that could provoke one to *turn away from* (or at least mitigate) wasteful, exploitative, and destructive behavior that negatively impacts our environment, our neighbors and ultimately ourselves.

*Metanomic Echos* implements two novel technologies. The first concerns the hardware design. An interface is necessary to convert the electrical signals in plants into information that can be used in a live sound and video installation.<sup>6</sup> Several commercial products harness plant electrophysiology to produce music. They are all quite expensive.<sup>7</sup> Moreover, some commercial

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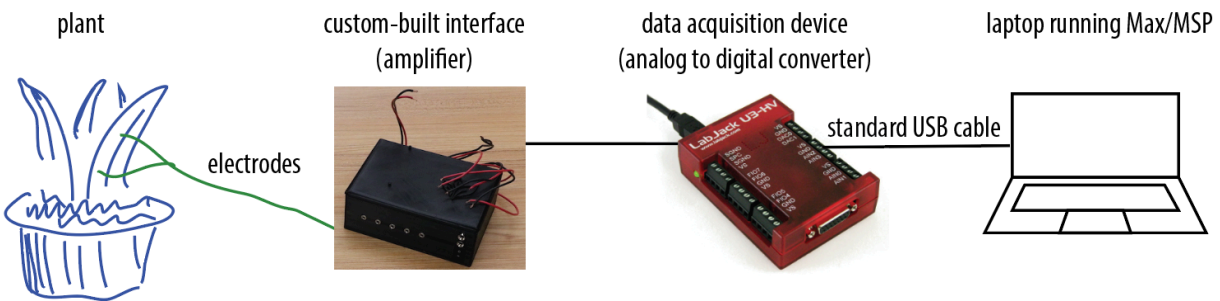
<sup>5</sup> One could think of this as revoicing a four-part choir. Before the human intervention, the nature sounds earth, air, fire, and water could be in a soprano, alto, tenor and bass configuration. After the human sounds intervene, the nature sounds might regain equilibrium as alto, baritone, bass, and soprano. This is but one of the many ways in which this sound layer could slowly reach a new, unforeseeable balance.

<sup>6</sup> All plants naturally pass electrically charged ions through their cell membranes. They do this to regulate metabolism, respiration, photosynthesis, and other essential processes (Fromm/Lautner 2007, Szechynska-Hebda et. al. 2017). Some plants use electrical signals to trigger movement: Charles Darwin first noted this in the Venus flytrap (*Dionaea muscipula*) (Burdon-Sanderson 1873, Darwin 1875, 1880). Later it was discovered that all plants transmit charged ions through their tissues, principally via xylem and phloem tubes (Pickard 1973, Canales et al. 2018). Lacking nerve cells, plants do not have brains or other specialized organs devoted to processing sensory information, but as sessile organisms they have evolved extraordinary capabilities to sense, respond to and shape the surrounding environment (Chamovitz 2012). Some writers have vastly overstated plant “intelligence”, provoking vigorous backlash (Tompkins/Bird 1973, Galston/Slayman 1979). Modern scientific laboratory studies have corrected earlier unfortunate exaggerations and made considerable strides in understanding plant neurobiology (Volkov et. al. 2012). Neurobiologists typically expand the term “neuron” beyond its traditional definition as a specialized animal cell with particular anatomical structures. There is some consensus that plants experience an emergent intelligence which, in some ways, resembles an insect colony (Trewavas 2004).

<sup>7</sup> Examples include Plantwave, The Damanhur Bamboo device, and Instruo’s “Scion” module for Eurorack synthesizers. <https://www.plantwave.com>, <https://alliancewithnature.com/index.php/product/music-of-the-plants-bamboo-m/>, <https://www.instruomodular.com/product/scion/>. One Plantwave costs \$300; Damanhur’s device costs over \$700; Instruo’s *Scion* module is \$350.

products create output that is mediated, so the music they make conforms to human stereotypes of what a plant “should” sound like. In spite of this, independent researchers and artists have produced good results with off-the-shelf hardware by implementing a customized software layer (Lucchesi 2018). Others have gone further and constructed their own hardware and software interfaces (Leudar 2018).

After extensive testing using Instruo’s *Scion* module (Miller/Riordan 2019), we built our own high-performance hardware and software interface for *Metanomic Echos*.<sup>8</sup> Our design is essentially a very high impedance amplifier. After passing through two amplifiers, the plant signal is sent to a data acquisition device. From there, digital information goes to a laptop running Max/MSP.<sup>9</sup> A custom-designed Max/MSP external receives up to eight plant signals. This information can then be applied in various ways: to directly create notes, to process sound in more abstract applications, or to affect video animation or synthesis. Example 1 shows our signal chain.



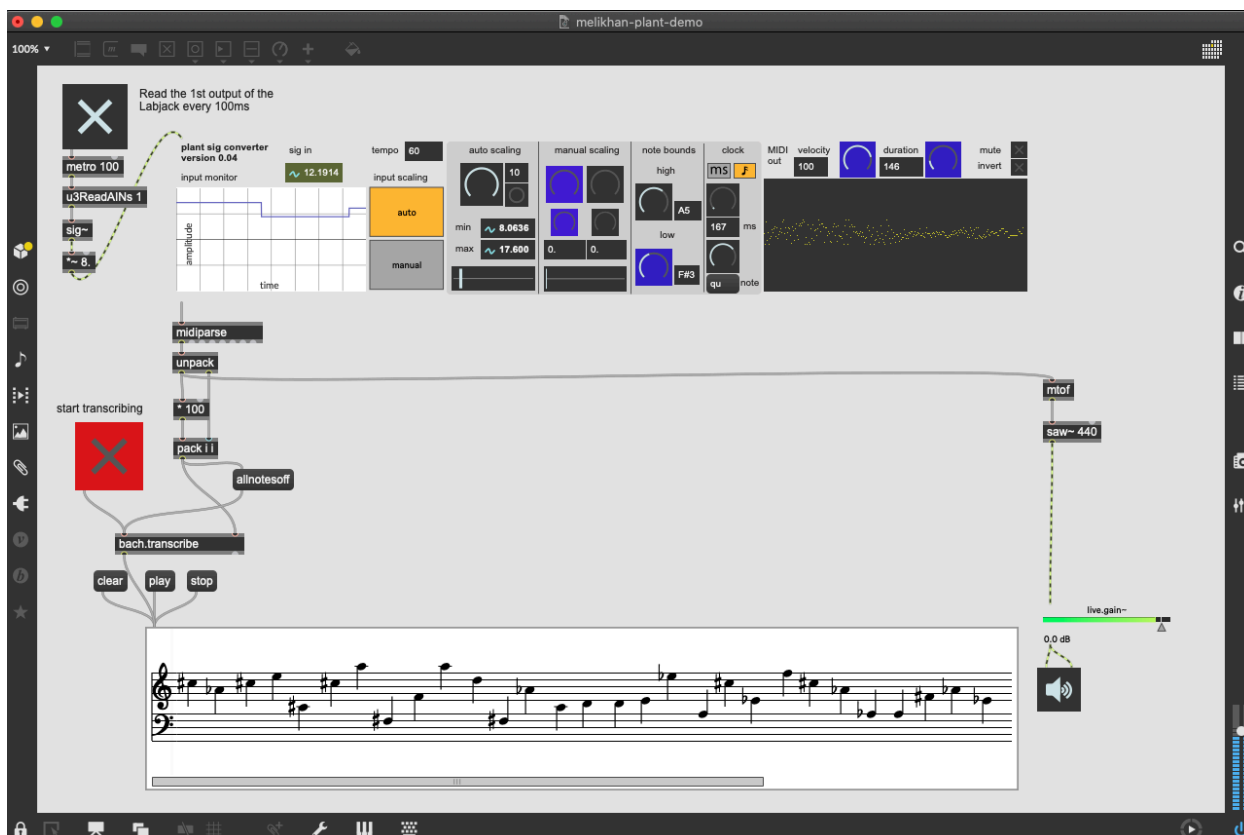
Example 1. Hardware design: signal flow of electrical signals from plant source to laptop.

Our second novel technology is the software design. When the plant signals arrive at the laptop, they need to be processed so that they can be meaningfully used by a program (in Max/MSP nomenclature, a program is called a “patch”). We created a *channel strip* architecture to do this. The channel strip converts the plant signals to MIDI notes under various constraints. These constraints can be modified dynamically by hand, or even by the patch itself.

MIDI notes carry pitch, velocity, and duration information. If we choose to, we can directly use the MIDI information to produce musical notes. In November 2021, we successfully demonstrated such a patch in Professor Meikhan Tanyeri’s Signals and Systems class (part of Duquesne’s Biomedical Engineering Program). Shown in Example 2, this patch uses one channel strip to create conventional musical notes from a single incoming plant signal. The pitches are transcribed in real time and plotted in standard staff notation right before the viewer’s eyes. They can easily be recorded and played back later if desired.

<sup>8</sup> The University of Pittsburgh profiled our early work on a podcast. See <https://www.music.pitt.edu/news/do-plants-make-music>. In 2020, Duquesne published a short story about us online and in the alumni magazine. See <https://www.duq.edu/news/featured-stories/have-you-ever-heard-a-plant-play-music>.

<sup>9</sup> Max/MSP is an industry-standard software that has been continuously developed for over 30 years. See <http://www.cycling74.com>.



Example 2. Software design: Experimental Max/MSP patch showing incoming plant signal on our channel strip. The strip produces MIDI notes, which are transcribed in real time on the musical staff at bottom.

In *Metanomic Echos*, the four plants do not produce musical notes as shown in Example 2. Rather, the MIDI information affects the signal processing of the four natural sounds (air, earth, water and fire). Consequently the plants' effect is not entirely obvious at first hearing. This is because we wish to avoid anthropomorphizing plants. Instead of using plants to make music that conforms to preexisting stereotypical human aesthetic categories, we want to create something mysterious and even perhaps challenging to human perception.

For the trial run of *Metanomic Echos*, we extensively tested and refined our installation during a very successful three-week public preview in the Mary Pappert School of Music's atrium.<sup>10</sup> We received many comments from students and faculty. We will be using the information we gathered to develop our patch further for the exhibition at the Gumberg Library. Notably, there were no hardware or software failures during our trial period.

During our preview, pairs of listeners could use headphones while viewing a large TV monitor. To scale *Metanomic Echos* to the exhibition space at Gumberg, we want to project the sound through four loudspeakers, a configuration that is typical for a more immersive multimedia installation. This will ensure that as people walk through the space, they experience a rich,

<sup>10</sup> An informal video documented these efforts. See <https://www.youtube.com/watch?v=imZdFGm8PjY>.

continuously changing sonic field. We will construct our third-generation interface, allowing us to place plants further apart from one another and obtain better signal fidelity. We will generate educational material describing the climate crisis, and clarifying some of the choices that went into designing the installation. Finally, we will create a multimedia web site so that people who cannot visit Gumberg in person can still experience the installation.

Soon after *Metanomic Echos* closes, we will submit our work to a top-tier peer-reviewed journal such as MIT's *Leonardo*. This journal has a history of publishing articles that involve bioelectric signals in live sound installations. In the longer term, Dr. Miller is planning a trip to LINV (the International Laboratory of Plant Neurobiology) in Florence, Italy to research improved transducer designs for the next generation of bioelectric interfaces.<sup>11</sup> This one-week trip will greatly increase the likelihood of future external funding and publication.

It is difficult to connect our actions today to the problems they cause many years in the future. This is partly because of our relationship to time: we tend to perceive events that occur over seconds and minutes, not years and decades. *Metanomic Echos* allows us to experience a simulation of our environmental impact on a rapid time-scale, making a visceral impression that will hopefully elevate participants' consciousness and have some positive impact.

#### **b. Roundtable**

A crucial element of our proposal is a public round-table discussion, which will provide a forum to discuss issues relating to climate change as well as artistic and musical responses to the unfolding crisis. This is scheduled to happen at the Gumberg Library on Earth Day, 22 April 2022. Confirmed participants on this diverse panel include Duquesne faculty Paul Miller (Music), John Stolz (Biology and Director, CERE), Pinar Geylani (H. J. Halliwell Faculty Fellow, Economics), and Fr. James Okoye (C.S.Sp., Director, Center for Spiritan Studies).

By bringing together an unusual group of scholars, we will provoke unexpected conversations and spark mutual understanding across different parts of Duquesne University. The goal is to raise awareness of the climate crisis not only on a material level, but also to address spiritual questions, particularly those addressing Creation and our obligation to steward it.

#### **c. Secondary outcomes**

This project makes several significant contributions to the fields of electronic biointerface fabrication, software design and interactive media construction. It will rank as one of the most ambitious multimedia installations in Duquesne's history. It will increase Duquesne's prominence in the area of music technology and multimedia architectures. Since we have a thriving music technology program at Duquesne, there are many collaborative possibilities. In the second half of 2022, we plan to either distribute our plans under a GNU license, or pursue a commercial partnership with a local electronics fabrication firm.<sup>12</sup>

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<sup>11</sup> LINV is a sizable research institute housed within the University of Florence. <http://www.linv.org>.

<sup>12</sup> Russell Hoffmann at Evaton technologies is interested in working with us further. He assisted as a *pro bono* consultant to our current project. See <https://evatontechologies.com>.

#### 4. Methodology and Assessment Standards

One could assess the effect *Metanomic Echos* has on participants' views of climate change, environmental issues, etc. We prefer that the installation has a fluid, meditative ambiance, undisturbed by surveys or questioning. Crucially, we do not need to show any quantifiable effect on participants in our discipline to get published; rather, what is most important is to demonstrate significant technological innovations coupled to well thought-out aesthetic choices, resulting in a successful installation.

We will assess our project through the impact of the public round-table discussion, and by having conversations with people who experience it firsthand. On our planned companion web site, we will open an online moderated bulletin board where participants can post thoughts or narratives about their experience.

#### 5. Relation to the mission of Duquesne University and the Catholic intellectual tradition

*Metanomic Echos* fulfills two of Duquesne's core mission statements.<sup>13</sup> First, it shows *profound concern for moral and spiritual values*. As many have noted, environmental values often go hand-in-hand with issues of justice and equity. The poor often suffer the most when their ecosystems are degraded to harvest marketable minerals or resources. Therefore our project underlines the connection between the environment and moral and spiritual values.

Second, Duquesne strives to provide *service to the Church, the community, the nation and the world*. *Metanomic Echos* amply fulfills this goal as it creates an experience whereby participants can reflect on the climate crisis.

By scaling the project up to the exhibition space at the Gumberg Library (and publicizing it,) we will reach a large audience. Consequently the installation will play a major role in advocating urgent moral and spiritual values while providing service to the community and the world.

Regarding how *Metanomic Echos* connects to the Catholic intellectual tradition, please see §2.

#### 6. Schedule for conducting the research project

Tuesday, 19 April 2022	Set up installation in the Gumberg exhibition space
Friday, 22 April 2022 (Earth day)	Official opening, roundtable from 12:00 noon – 1:30pm
Monday, 2 May 2022 (Reading day)	Take down/strike installation
4 – 8 July 2022	Miller visits LINV in Italy
Friday, 1 August 2022	Submit manuscript to MIT's <i>Leonardo</i> journal
Fall 2022	Pursue further work on transducer & interface design
2022 – 2023	Release open-source plans or pursue commercialization

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<sup>13</sup> See <https://www.duq.edu/about/mission-and-identity/mission-statement>.



## 7. Selected Bibliography

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