An Ethics Framework for the Internet of Musical Things

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***Abstract*—The Internet of Musical Things (IoMusT) is an emerging field of academic and industrial research that extends the Internet of Things to the musical domain. Scarce research has been conducted on the field's ethical aspects, and to fill this gap we propose a framework for the ethical design and evaluation of IoMusT technologies and applications. Besides being ethically rigorous, the framework seeks to be accessible for information engineers, musicians, and the wider circle of participants in the IoMusT. The purpose is to facilitate and quicken the process of ethically designing and evaluating work at the intersection of network-based technology and musical creativity. Finally, we exemplify the framework by applying it to an IoMusT experimental performance. Beyond facilitating the ethical evaluation of technologically enhanced music, the framework also advances work in contemporary AI ethics in two ways. First, by introducing the principles of creativity and decentralization as critical to ethically exploring musical creativity. Second, by organizing the principles of AI ethics under a human-centric logic.**

***Index Terms*— Internet of Musical Things, ethics, ethics evaluation, design framework**

I. INTRODUCTION

THE Internet of Things (IoT) refers to the network of physical objects augmented with sensing, actuation, computing and communications capabilities [2]. This paradigm is constantly evolving and is impacting several industrial sectors and areas of everyday life, including transportation, agriculture, and healthcare. Given its ubiquitous nature and widespread socio-economic impacts, the IoT is a matter widely investigated at both technological (e.g., interoperability, wireless infrastructures, communication protocols) and non-technological levels (e.g., privacy, ethics, sustainability) [54, 55].

Recently the IoT paradigm has made it inroads into the musical domain, leading scholars to formulate a proposition for the so-called Internet of Musical Things (IoMusT) [1]. This is a rapidly growing area of computer science, engineering and art research in both academic and industrial contexts. It is positioned at the intersection of the Internet of Things [2], New Interfaces for Musical Expression [3], Ubiquitous Music [4], human-computer interaction [5], artificial intelligence [6], technology-mediated audience participation [7], and Semantic Web [56].

As the general IoT, the IoMusT is based on the central pillars of heterogeneous devices, communication infrastructures, applications and services, as well as ecosystems of humans and machines [54, 55]. From a computer science perspective, the IoMusT refers to the networks of computing devices embedded in physical objects (musical things) that produce and receive musical content [56]. Musical things, such as smart musical instruments [8] or musical haptic wearables [9], are connected by an infrastructure that enables multidirectional communication, both locally and remotely. The digital and physical domain connections are enabled by information and communication technologies, which foster novel musical applications and services.

The ecosystems associated with the IoMusT include interoperable devices and services linking musicians and audiences, and to support musician-musician, audience-musician, and audience-audience interactions. The IoMusT, consequently, enables and supports a wide range of novel human musical experiences including: 1) augmented and immersive concert experiences; 2) audience participation; 3) remote rehearsals; 4) music e-learning; and 5) smart studio production [1].

Like any field of innovation, the IoMusT will create ethical dilemmas. Scarce research, however, has been conducted in the area [10]. In the broader IoT, researchers have identified ethical issues including privacy, security, transparency, social equality, and legal responsibility. Social factors influencing IoT acceptance have also been investigated [11, 12, 13]. However, little comparable work has crossed into the IoMusT. Some authors have warned of risks associated with music streaming services and their monitoring of user behavior [14, 15]. Other scholars have investigated ethics in the field of Music Information Retrieval, and argued that the technology is not value-neutral, but influenced by design choices with social implications [16, 17]. In a different vein, researchers from the field of New Interfaces for Musical Expression have focused on discussions surrounding political debates inherent in new musical instruments [18], environmental sustainability [19], gender diversity [20], accessibility [21, 22] and inclusion [23]. All these lines of research are also pertinent to the IoMusT, although no published investigations have been conducted to

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our best knowledge.

To fill these gaps, this paper assembles a framework for ethical design and evaluation of productions in the IoMusT. The narrative framework's purpose is to help musicians, musical collaborators, and engineers ask the right questions about the ethics of their projects, and produce a coherent description of their work on the ethical level. To the authors' knowledge, this is the first ethical framework customized for the IoMusT.

After this introduction, the article develops the principles of the ethics framework. Then, the method of evaluation is described. Finally, the principles and method are employed in a use case.

II. IoMusT Ethics Framework

A. Principles of the IoMusT Ethics Framework

Ethics renders human experience in terms of values. Where economics understands the world with the vocabulary of financial incentives, and psychology understands by referencing mental states, ethics operates through principles including autonomy, dignity, fairness, and similar.

Consequently, information technology ethics is delineated by the specific values or principles it uses to comprehend experience. A cascade of them have been proposed in recent years [24]. Subsequent attempts have been made to organize the work into a consolidated set governed by two opposed requirements. On one side, the set should contain all the most commonly used principles. On the other, the list should be limited in length to be manageable and useful [25, 26, 27].

While a stable consensus has not yet been achieved, perspectives on a common set of principles have been converging [28]. Leading commentators have cited the European Commission's *Ethics Guidelines for Trustworthy AI* [29] composed of seven principles as a central source for future work [30]. Also, recent and exhaustive surveys have identified the leading, recurring principles in technology ethics publications. In the case of Prem [25], nine principles are ultimately listed. In the case of the frequently cited article by Jobin et al. [27], eleven principles were listed.

Further refinement can be achieved along two vectors. First, terminological differences can be harmonized across distinct proposals. For example, the *Ethics Guidelines for Trustworthy AI* [29] cites "Human agency and oversight," while the set of principles gathered in Jobin et al. [27] cites "Freedom and autonomy." These are not perfect synonyms, but their overlapping is sufficient to warrant consolidation in the name of practical efficiency.

Another decluttering strategy is human-centric organization. The most frequently cited and applied ethics principles in technology divide organically into three categories. First, there is the ethics of the individual, or of *me*. These are values applicable to the experiences of singular people and their unitary lives. These principles commonly include personal autonomy, human dignity, and privacy. Then there is the ethics of society, of *us*. These principles apply to the way we live together. They commonly include: fairness, solidarity, and social wellbeing. Finally, there are the principles of the machine. These are ethical values applying to how technology functions. They commonly include: explainability and accountability, safety, and performance. The overall result is an initial set of ethical principles that are repeatedly cited, manageable in size, and organized for application.

Next, customization is required for the reality of technologically connected music. The process is heuristic, meaning initial definitions can be proposed, and left open for modification during the process of application to real cases. Also, further work will be required in this area as different areas of the IoMusT are explored in ethical terms, and as the technology develops. However, two principles that manifestly apply to the kind of artistic collaborations gathered by the IoMusT are originality and decentralization.

For any art, originality is critical, it is an essential element of what it means for something to be art. To the degree that the IoMusT claims to build upon the established history of music, consequently, its compositions will command respect at least partially because they create something that did not previously exist. Originality, in other words, is a fundamental value in the IoMusT.

Then, with respect to decentralization, because the technology contributes to music by *connecting* participants interactively - from composers to instrumentalists to audiences - the degree to which it facilitates decentralization reflects its success. On the human level, it may even be that, ultimately, the *purpose* of IoMusT technology is to express decentralization in music, as opposed to the conventional purpose of musical technology, which is to allow individual artists to express themselves more richly to a passively receptive audience.

The assembled framework is captured in *Table 1*. It depicts the IoMusT ethical framework principles in alignment with two related frameworks. One is the *Ethics Guidelines for Trustworthy AI* [29] which is a leading single source of ethical principles in the area of artificial intelligence, broadly construed. The other is the frequently cited Jobin et al. set [27], which results from a survey of commonly used ethics principles in technology ethics. As is visually evident, the IoMusT framework is compatible with technology ethics generally, while also defining its own place within the artistic context of music.

TABLE I

PRINCIPLES DEFINING THE PROPOSED IOMUST ETHICS FRAMEWORK IN THE CONTEXT OF OTHER LEADING SETS OF TECHNOLOGY ETHICS PRINCIPLES.

	IoMusT	Ethics Guidelines for Trustworthy AI (European Commission, 2019)	Survey of Ethics Principles (Jobin et al 2019)
Individual	AUTONOMY	HUMAN AGENCY & OVERSIGHT	FREEDOM & AUTONOMY
	ORIGINALITY		
	DIGNITY		DIGNITY
	PRIVACY	PRIVACY & DATA GOVERNANCE	PRIVACY
Social	FAIRNESS	DIVERSITY, NON-DISCRIMINATION, FAIRNESS	JUSTICE & FAIRNESS
	SOLIDARITY		SOLIDARITY
	DECENTRALIZATION		
	SOCIAL WELLBEING	SOCIETAL & ENVIRONMENTAL WELLBEING	SUSTAINABILITY
			BENEFICENCE & NON-MALEFICENCE
Technical	PERFORMANCE		TRUST
	SAFETY	TECHNICAL ROBUSTNESS & SAFETY	
	EXPLAINABILITY & ACCOUNTABILITY	TRANSPARENCY	TRANSPARENCY
		ACCOUNTABILITY	RESPONSIBILITY

B. Define the Principles of the IoMusT Ethics Framework

The next step is to provisionally define the principles' guiding design and ethical evaluation in the IoMusT. As oriented by work already done in the history of philosophy and ethics, as well as more specialized work in technology ethics, initial definitions are the following:

Autonomy may be based on the philosophy of John Locke, and taken to mean self-determination, both physically and mentally [31]. Users should be able to conceive IoMusT tools as instruments they use for experimentation and self-expression, as opposed to perceiving themselves as tools of the technology.

Also, one narrower aspect of this principle with special application here is intellectual property rights. Distinctions may be knotted given the inherent difficulties in distinguishing those rights within a performance constructed to maximize collaboration. It can be difficult to determine, in other words, who specifically owns a piece of music when technological tools are employed to blend the work of the human participants.

Originality may be based on the philosophy of Gilles Deleuze, who proposes that the creation of technical and musical concepts must always be new [32]. The innovation may occur on the level of form or content, and it may be technical or musical in nature.

For example, the technical structure for unifying musical participants may be innovative as occurs when a new haptic device is invented for transferring the vibrations of a musician's notes directly onto the skin of audience members [33]. Or, a familiar device may be infused with new content, with a different musical source for the vibrating as occurs with the musical haptic armband reported in [9].

Similarly for the music itself, new forms of sound production may be invented by electronically harvesting audience movements. Or, familiar instruments and their players may produce new content by exploring untapped sources of inspiration in the connected environment.

Dignity as based on the philosophy of Immanuel Kant conceives human participants in IoMusT productions as holding intrinsic value. They are ends and not means to the ends of others or of the technology [34]. Respect for cultural diversity forms one aspect of dignity in this realm, given the highly personal and diverse beliefs and practices concerning the quality of music, and even what counts as music. Optimally, the IoMusT provides the widest possible platform for music to be expressed and respected.

Privacy as based on the research of Alan F. Westin [35] means control over access to one's personally identifying information. As opposed to the rudimentary idea of secrecy, privacy is the decision about what aspects of your life are, and are not secret. In the context of widespread collaboration and mutual reinforcement that describes the IoMusT, the idea of consent is important here. Optimally, individuals fully control those elements of their identifiable musical selves that mix into the public world.

It should be added that the privacy questions press especially hard against the IoMusT given the intimate nature of the musically interactive experience. As described by [9], "musical haptic wearables for audiences have the potential to enrich music in terms of arousal, valence, enjoyment, and engagement." All of these terms suggest levels of personal experience that are private as much as public, even at a festival concert.

Fairness is based on the philosophy of Aristotle, and it translates into the imperative to treat equals equally and unequals proportionately unequally [36]. Within the context of the IoMusT, fairness implies that users with similar capabilities and interests should gain similar access to musical resources, data, services, or experiences. Analogously, treating unequals proportionately unequally implies, among other things, appropriately distinct forms of contribution to the musical performance. For example, musical haptic wearables could allow auditorily-impaired audience members to understand and participate in a performance through mechanical as opposed to auditory vibrations.

Solidarity – sometimes referred to as "equity" – is based on the philosophy of John Rawls [37], and it is the principle of distributing the greatest advantage to the least advantaged. Within the context of the IoMusT, the disproportionate distribution in favor of the neediest may be construed as platforms built to ensure that those with fewer resources or abilities are granted additional support as potential collaborators in performances mediated by musical things.

As opposed to fairness which stresses equality and proportion in distribution, solidarity aims for inclusiveness, which may be reflected across different abilities, across differences in learning styles, or through diverse levels of experience with the interfaces and instruments. In every case, the least advantaged receive the most support in order to maximize inclusion.

Decentralization integrates participants horizontally more than vertically in the collaborative experience. The IoMusT,

consequently, may diverge from conventional Western hierarchization in music, it separates from composers writing pieces to be interpreted by instrumentalists and then received by audience members. Instead, the optimized IoMusT elevates all participants onto the same level in the sense that they are enabled to share in every aspect of the performance. When everything is connected, everyone can be a composer, an instrumentalist, and a listener at the same time. The bodily movements of dancing audience members, for example, is caused by instrumental sound following scripted music, but those movements in turn can be harvested and fed back into the central mixing of the performance, perhaps by raising and lowering the volume of the rhythm section in accordance with dancing intensity.

Interoperability among devices is a major component of decentralization. Nevertheless, as for the IoT, IoMusT devices are heterogenous, thus sharing data between such devices, their users, or between users and devices is a significant hurdle in IoMusT utilization. It is therefore crucial to rely on communication protocols ensuring an effective exchange of musical information, so that the proposed decentralization principle is accomplished in a proper manner. A noticeable recent endeavor towards this direction is the Musical Semantic Event Processing Architecture reported in [56].

Social Wellbeing is based on the utilitarian philosophy of Jeremy Bentham and John Stuart Mill [38]. As a principle, it distributes the greatest amount of good or happiness to the greatest number of people. The idea converts ethics into a happiness calculation as summed across society's members, with higher total happiness implying higher value, or ethical achievement. In other words, the more total joy produced for the community as a result of technological support for musical creation, the higher the ethical score.

As opposed to the solidarity preference for inclusiveness, the utilitarian approach risks leading toward a star system: if certain musicians or kinds of collaborative performances maximize overall happiness, even while excluding some members, the exclusion will be justified if it is required to achieve the higher global result. In simple terms, this is an ethical justification for not giving instruments to bad musicians. Of course, it is also true that platform inclusiveness is favored, so long as it does not detract from the broader enjoyment of the musical experience.

Performance in IoMusT technology is the art of the technology itself, it is the value the software and hardware hold *because* it functions in accordance with its purpose, even while remaining independent of that purpose.

This value - to the degree it exists - does not depend on the quality of musical experience that gets produced, it depends solely on the potential for musical experience that exists because of the technology. In a sense, the technology is like a musical instrument itself. No one discredits a Stradivarius violin because it is abused by an amateur, the reason a Stradivarius holds value independent of how it is played is because of the music it makes possible. So too with any instantiation of the IoMusT, it holds ethical value to the degree that it performs, to the degree that it enables musical excellence.

Explainability and Accountability are connected ethical imperatives that begin with users' ability to understand the technology driving IoMusT collaborations, and understand in the terms of their own experience. The explanatory content will differ across domains – from software engineers to musicians – because of their divergent interests and kinds of expertise. For example, automatic algorithmic decisions about which parts of a musical collaboration receive priority when it comes to the transmission of musical data are significant because of the sensitivity of time in this context, since participants in different places are working to the same beat, literally (see e.g., the topic of the so-called cognitive networks [39]). The distribution of Internet transmission priority, consequently, is a proxy for quality of participation in the musical event. So, understanding the prioritization's rules will be critical for both engineers and musicians, but engineers will want to know about code, musicians will want to know how they adjust their headphones to stay in time.

Accountability is the ability to attribute credit or blame for a system's functioning, and it derives from explainability. If no one understands how the machine works, no one can be credited or blamed for what it does. The contrary is also the case, and is significant for ethical reasons already considered, for ensuring autonomy, creativity, intellectual property rights, and similar.

Safety is a leading ethical principle in the Internet of Things. Driverless cars, for instance, pose lethal threats. Safety in the IoMusT is less pressing in general, but nevertheless remains applicable as the imperative for IoMusT manufacturers to ensure that their products do not harm their users, and that risk prevention strategies are activated. It should also be noted that there do exist potentially high-stakes IoMusT safety scenarios, including participatory concerts in festival settings where large numbers of people and infrastructure are involved.

Summarizing, the principles and accompanying definitions framing ethics for the IoMusT are gathered in Table 2. Below, the framework will align with the socio-technical analysis executed on a musical case.

Finally, some readers may be interested in the precursors to current frameworks in AI ethics. One early source is the frequently cited *Principles of Biomedical Ethics* by Beauchamp and Childress [40]. Those four principles are: autonomy, non-maleficence, beneficence and justice, and they are crafted to manage ethical dilemmas in healthcare, including questions surrounding the care of non-cooperative patients in medical facilities [41]. These principles are visible in the European Union's *Ethics Guidelines for Trustworthy AI*, where they are modified into: respect for human autonomy, prevention of harm, explicability, and fairness. From there, the EU authors modified the principles to more closely fit the specific functioning of AI tools and the breadth of application across human experience [42]. Another example of the transition from healthcare-related ethics to a wider vision of

principles applicable to ethics discussions across the range of digital applications can be found in Mittelstadt's [43] survey, "Ethics of the health-related internet of things: a narrative review."

Alongside the transition of ethical frameworks from medical fields to the expanding applications of AI technology, there have also arisen refinements and extensions of the principles. Privacy, for example, can be examined not only philosophically and ethically, but also culturally. That is, the solid definition of privacy as control over access to one's personal information can be extended into studies about the kinds of information that people tend to want to restrict, and how that restricting transforms from place to place and time to time (see e.g., Nissenbaum [44]). Ultimately, the historical study of the development of the principles is important, though outside the scope of the present paper which aims to facilitate the application of ethics to music in the context of contemporary technology.

TABLE 2
DEFINITIONS OF PRINCIPLES DEFINING THE PROPOSED IOMUST ETHICS FRAMEWORK

	IoMusT Ethics Framework	
Individual	AUTONOMY	Self-determination physically and mentally (Locke)
	ORIGINALITY	Creation of musical concepts – technical and musical – that are new (Deleuze)
	DIGNITY	Humans as holding intrinsic value, and not existing solely for purposes of others or technology (Kant)
	PRIVACY	Control over access to one's personally identifying information (Westin)
Social	FAIRNESS	Treat equals equally and unequals proportionately unequally (Aristotle)
	SOLIDARITY	Inclusiveness, the greatest advantage distributed to the least advantaged (Rawls)
	DECENTRALIZATION	Integration of participants horizontally instead of vertically
	SOCIAL WELLBEING	The greatest good to the greatest number (Bentham)
Technical	PERFORMANCE	Functioning in accordance with purpose
	EXPLAINABILITY & ACCOUNTABILITY	Transparency of processes in terms appropriate to users, and ability to attribute responsibility for benefits and harms
	SAFETY	Resilience to attack, reliability, and endowed with a fallback plan

III. IOMUST ETHICS EVALUATION METHOD

Ethics in information technology is more theoretical than practical in the sense that more has been written about *how* to do it than about actually doing it [45]. Real ethics evaluations have been performed, however, including those by a group of philosophers, computer scientists, lawyers and domain experts organized out of the Frankfurt Big Date Lab in 2019 [46, 47, 48, 49, 50, 51]. The process described here developed from that work.

A. Prepare

There are three major stages to an ethics evaluation: preparation, evaluation, resolution [46]. The preparation begins with the collection of the participants. Optimally, they represent the full stakeholder spectrum: musicians, experts in networking and haptics, philosophers and ethicists, and associated domain experts, including lawyers versed in intellectual property.

With the participants established, a social-technical summary follows. The technology and its human relations are explained in comprehensible terms for the entire range of represented domains. What is critical is that participants translate their understanding into accessible terms. Computer scientists describe their technology in ways that musicians can understand, musicians describe in ways that are comprehensible for ethicists, and so on. Naturally, details and sophistication will be limited by the process since rendering the separate domains mutually comprehensible requires some simplification. In the real world, an ethics evaluation is a constant exchange of profundity and nuance for practical results [46].

The social-technical summary is also the initial phase of project documentation. In ethics evaluations that have already been accomplished, one of the more valuable elements has been an interactive webpage - specifically a Google doc - that all participants may view and edit [49]. This working document informally records the work that has been done, charts the tasks that remain, and allows all participants to comment and make changes. Typically, it will begin with a list of participants and their backgrounds. The next section is the social-technical summary. Each subsequent step in the evaluation forms another section in the running narrative.

One key element of the dynamic webpage is its asynchronous nature. At any time, any participant may review the project, propose changes, add advances and conclusions. One reason this is critical is that ethics evaluations are not information-in, information-out processes. Participants need their own time to think, and then their own schedule for participation. Of course, there are group meetings also. They may be live or online, and will begin with a kickoff meeting, and follow at regular intervals. These meetings are especially important for coordinating responsibilities as the process advances.

B. Evaluate

The second stage of an IoMusT ethics evaluation is the analyzing process. It is dual, from the top down and from the ground up [37]. Going from the top down, the established definitions of ethical principles are employed to explore a IoMusT performance. For example, starting from the idea of human autonomy, it would be natural to ask whether a smart musical instrument [8] increases or decreases the artists' control over their own production. Does it enhance their power to control the music they make?

The top-down process then repeats for each principle. Originality, dignity, privacy, fairness and the rest are considered until the list has been exhausted. Further and more specific examples will be offered in the next section's case study.

The top-down process is complemented by an analysis going the other way, from the ground up. Open-ended

questions are posed to those involved about their ethical and human experiences when using the technology. Here, for example, it would be natural for a musician to ask about intellectual property and the ability to claim some sense of credit for the music that is created.

Openness to participants' experiences is required here to widen the evaluation as far as possible. Still, for useful results to emerge, work must be done to fit those experiences within the set of existing principles. There may be a discussion, for example, about whether the intellectual property concern should be rendered ethically as a matter of autonomy or of dignity. Possibly, it could also be gathered under the heading of originality. Regardless, what is important is that the bottom-up results are converted from an individual's experience into a generally understood and categorizable ethics concept.

C. Narrate and Recommend

With the ethical dilemmas located, described, and named, the evaluation process can resolve with a narration and possibly recommendations.

As part of the final narration, distinctions are drawn between ethical considerations and dilemmas. Ethical considerations are simply questions that rise on the level of human values: Does the performance enhance musical originality? Is the privacy of participants ensured? Do diverse participants have access to the collaboration? Ethical tensions are a special case in which considerations are bound together in the inverted sense that resolving one increases the acuity of the other [51]. For example, steps taken to ensure user privacy definitionally inhibit fairness because we cannot guarantee access to diverse participants when we do not know the personal characteristics of those participating. Here, there are no ethical solutions, only trade-offs.

The process of summarizing the evaluation in narrative form culminates the evaluation and extends organically from the interactive documentation page accompanying the entire process. Essentially, the webpage provides the first draft of the conclusion. Recommendations may also be proposed at this stage, as well as plans for future work.

Figure 1 provides a graphical illustration of the proposed evaluation method.

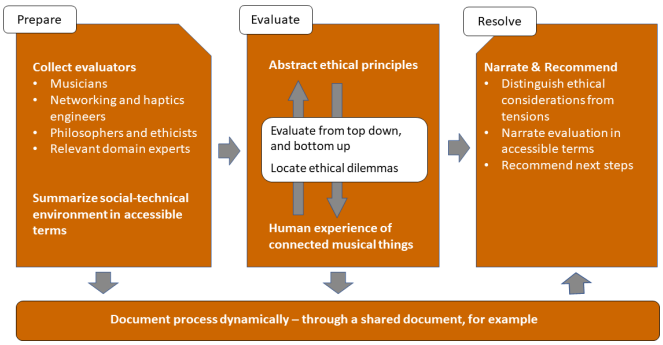

Fig. 1. IoMusT ethics evaluation process.

IV. Case Study

A. The Case

To validate and exemplify the proposed framework, we apply it to a musical performance as presented in the academic paper, *Touching the audience: musical haptic wearables for augmented and participatory live music performances* [9]. In this case, a mandolin was extensively wired for connected functioning, including the installation of sensors that allowed the instrumentalist to press and slide across the instrument frame. These pressure applications passed through the connected system and reached wearable vests that were tailored to hold vibratory motors across the front and back. Audience members wore the vests while listening to the mandolin's music. By applying pressures to the instrument, the mandolinist activated certain motors, and so created a haptic musical experience to complement the acoustic sound of the instrument. A video of the functioning system is at: https://youtu.be/KR6M7oCoXDk.

The performance occurred in a controlled environment, was granted ethics approval, and consisted of the instrumentalist playing for two listeners at a time, with their vests activated and deactivated throughout, so as to facilitate a comparison of the two experiences. In essence, the split divided conventional acoustic music from an IoMusT experience.

The listeners' reactions were recorded, and formed part of a technical and artistic review. That published review, in turn, will be analyzed here as an opportunity to ethically evaluate the performance and its technological design. Importantly, a full ethics evaluation will not be presented. It would go far beyond the scope of this paper, which only seeks to establish a structure for evaluating, and exemplify its application. To provide some sense of the length of a full evaluation, one of this paper's authors has participated in ethics evaluations where the documented process has extended for well over one hundred pages of single spaced, 12 font type [52]. The work could have converted into a book.

Here, the three stages of an ethics evaluation will be sketched as a way of demonstrating how a full review could proceed, from preparation to evaluation to narration of results.

B. First Stage of an IoMusT Ethics Evaluation: Prepare

The initial preparation step to gather the evaluation participants. They should represent the case's vital stakeholders, and typically would include musicians, engineers of information and sound, philosophers and ethicists, adjacent domain experts like lawyers versed in intellectual property, as well as audience members. For this sketch, and because one of the authors participated in the experiment serving as the case here, the authors together will represent the various individuals and kinds of expertise and experience.

Step two is the socio-technical summary of the experience. In this case, the summary has already been accomplished in the form of the paper reported in [9]. Though the publication is academic in nature and does contain highly technical information, there are also graphics and accessible descriptions that respond to the central requirement of this

task: ensure that experts versed in distinct fields and operating with different languages are able to interact productively. The goal is to get everyone onto the same page of understanding the musical experience across technical specifications and human diversity.

In a full ethics evaluation, the documentation of these initial steps would be executed on an interactive, living webpage which would allow participants to provide a brief biography of their expertise in section one, and then work together to refine the socio-technical summary in section two. This strategy is critical because it allows the process to actualize itself: the shared authoring of the socio-technical summary and then the subsequent ethical discussions are not just descriptions that everyone can understand, the describing is also the *way* they come to understand. Doing the case and documenting the case are related symbiotically.

C. Second Stage of an IoMusT Ethics Evaluation: Evaluate

The ethical evaluation of a design for, or an execution of a connected musical experience operationalizes the IoMusT ethical principles following a dual strategy. Analysis moves from the top down by starting with the principles and then applying them to the experience. Analysis *also* moves from the ground up by asking open-ended questions to participants about the human effects of their experience. Even questions as simple as what they found enjoyable or annoying can be useful. The subsequent work is to convert those reactions into ethical claims aligned with the eleven principles reported in Table II.

In this case, provisional work can be done as an indication of the larger project. There is no claim to be exhaustive in the following, instead, the purpose is to outline how the project happens. Analysis could begin from the top down, or from the bottom up, but here it will begin with the former, and with the principle of autonomy.

Autonomy means self-determination, and one consideration would address the mandolin and raise this question: At what point – if any – does the extensive electronic modification of the instrument flip the relation between the artistic tool and technology? Does the tech serve the musician and the instrument, or do the mandolin and musician end up contorting themselves and their skills to the point where they are serving the technology? The addition of pressure points and the awkward mechanical appendages would be part of this analysis, along with the lived experience of the musician.

Autonomy also has a property aspect: self-determination implies a clear sense of what is mine – what I control – and a question rises here about what belongs to who. While the instrumentalist certainly plays a role in creating the music, how much credit should be assigned to the engineers who imagined and then built the instrument? How can the credit be measured? In what ways apportioned? For any moderately complex IoMusT design, this old question about authorship will receive new challenges.

Originality measures the value of creativity, and this case appears to produce rich, new experiences. The imaginative ways that the mandolin's pressure points are converted into bodily sensations transmitted through the motorized vest introduce a fresh engagement with music. Of course, accounting must be done for those who found the vibrations to be annoying or disconnected from the sounds, but the ethical potential for originality subsists through the discussion.

Further, there are manifest pathways to increased originality. The musical experience only went one way, from instrumentalist to listener, but future iterations could experiment with two-way transmissions.

Dignity is the intrinsic value of being human. The autonomy question about the technology serving the musician or the musician serving the technology could be expanded here. Another line of considerations extends along the line of culture and its appropriation by others: to what extent does any musician have a right to transform the music composed for other times and places? In this specific case, venerable pieces of Italian and Swedish music were radically transformed for their new context and experience. That is the act of creation, of course, and it is always possible to further argue that one way to revere the past is to remake it. Still, the discussion cannot entirely escape the question about whether the use is exploitive.

Privacy will always be concerning in the IoMusT for the same reasons cited in the ethics of information technology generally. Any time personally identifying information is digitized, it becomes vulnerable to mass dissemination and unpredictable uses: it escapes the control of the person it identifies. That said, in this case, and for most participants, very little personally identifying information circulated through the experience and the subsequent publication. The situation would be different if the motors and devices engineered to apply vibrations to the users were also receptive of biometric information and bodily movements as that may escalate the privacy uncertainties since connections between unique people and their data may become more apparent.

Fairness is the idea that equals should be treated equally and unequals proportionately unequally. By nature, music tends toward fairness: a soundwave traveling through the air makes few distinctions for different ears. In this particular experiment, however, the music transforms into a bodily mold through the motorized vest, and it is obvious that the vibrating motors will produce distinct reactions across different body shapes and proportions ([9]: 761). Whether and how these physical differences translate back into divergences in musical quality form one direction for a fairness investigation in this case.

Solidarity means inclusiveness, the greatest advantage distributed to the least advantaged. The IoMusT, like the IoT, provides fertile ground for solidarity investigations. For example, it is commonly noted that technology-driven experiences can exacerbate social inequalities from the economic level: many cannot afford the devices and infrastructure required to participate. At the same time, inclusiveness is one of the prime virtues of the IoMusT. The idea of interactivity from audience to performer significantly broadens the range of those able to access real musical creativity. The same is true of smart musical devices: they can be engineered across skill levels and abilities. Unlike violins or bass guitars which require significant ability just to begin, the world of interactive music promises that even the dancer's

gyrating hips and swinging arms may be classified as elements in an instrumental ensemble.

Part of the IoMusT solidarity dilemma is that these two realities seem insurmountable and irreconcilable. The broadened musical access is provided precisely by the advanced technology which is the source of the economic narrowing of access. How can these two be measured against each other? On what grounds can the argument be made that the IoMusT is ultimately exclusive, or inclusive?

These questions only scratch the surface of the potential ethical investigating. And, the principles of **decentralization, social wellbeing, performance, explainability**, and **safety** remain untouched, though their definitions and descriptions above do provide good indications of how they could begin to be applied in this case. Still, what has been sketched is enough to indicate how a full ethics evaluation should work from the top-down. It starts with theoretical principles, and then applies them to the musical experience.

Working from the ground up forms the other half of the evaluation stage. Instead of principles to investigate human experience, the human experience is molded to a corresponding ethical principle.

Concretely, this means consulting with the participants in open-ended conversations about their musical experience, and then rendering those exchanges into specific ethical arguments. To exemplify the process, the paper *Touching the audience: musical haptic wearables for augmented and participatory live music performances* provides numerous opportunities to work from the ground up because the participants were interviewed about their experience ([9]: 765). One listener commented, “Avoid the vibrations on the whole part of the abdomen, they are sometimes painful if you are a woman.” Another said, “Sometimes the feeling is uncomfortable. Don’t provide vibrations in the region below the stomach.” These reactions lead naturally up toward a discussion of fairness, and the rule of treating unequals unequally. The difficulty is determining how. Given the anatomical differences, how can men and women be treated equally by a vest surrounding their upper body with vibrating motors? Of course, one answer is to limit the technology, to install only motors in the back. But the strategy can be defeatist: when ethical considerations are resolved by eliminating what is considered, it is hard to see how the process could be halted before eliminating the very technology that started the discussion in the first place. Stated less abstractly, eliminating motors on the vest’s front does not completely solve the problem as backs may differ among individuals as well. If that problem too is addressed by elimination, nothing remains for ethical consideration. A more viable solution might be to provide users with customization mechanisms, as proposed by the authors in [9].

This paper is not the place to seek solutions, and it is also true that frequently no perfect solutions exist: there may always be some level of irresolvable unfairness in this experience, and if there is, a reasonable decision may be made to simply accept that reality at a certain level. As always, ethics is about understanding and justifying decisions affecting human-computer interaction more than it is about proving that one or another decision is irrefutably right.

Another instance of working from the ground up can be initiated by these comments from listeners: “The experience of the music with the vibrations is more engaging. It creates a sense of being more involved.” And, “I prefer the experience with the vibrations. My experience was more intimate, as if someone was interacting with me.” These reactions naturally lead up to the value of decentralization and the following set of questions. To what extent is the musical experience being decentralized by these vests? Is it better to require that truly interactive music somehow incorporate listeners into the positive production of the sound? For example, the vests’ motors could be interspersed with kinetic or biometric sensors that produce information about the listening experience. Assuming minimal latency, that information could be modified to affect the sounds being emitted by the smart mandolin, perhaps the volume, or the pitch, even the beat and speed to some extent. All of this folds into the value of decentralization and its maximization.

More could be made from the reactions of participants in the smart mandolin interactive performance but, here again, this paper is not dedicated to locating every ethical pathway or following any one to its end. The purpose is to show how the proposed ethics framework functions. During the evaluation stage, it functions from the top down, and from the ground up. From theories to music, and from musical experience up to theory.

D. Third Stage of an IoMusT Ethics Evaluation: Narrate and Recommend

The located ethical dilemmas are organized and addressed in the third stage. The interactive document initially used to summarize the socio-technological environment, and then used to describe the ethics explorations and discussions, comes to the fore at this stage. It serves as the basis for a formal narrative of the ethics evaluation. Because it naturally captures the process to this point, it facilitates the final organizing of findings.

One aspect of the organization is the relation between the described ethical considerations, especially with respect to dilemmas. It can happen that principles are opposed intrinsically, at least within the context of a use case, meaning explicit decisions need to be made about which principle to prioritize. For example, originality is inherently destructive: making something new repurposes the old and thereby also destroys it. In this case, the participants appropriated traditional Italian and Swedish music for their electrified experiments. The result was something interesting and new that also degraded the compositions as they were originally conceived and performed. It reduced the songs to material for others’ experimental composing. So, there is originality, but also a dignity violation, and what matters here is that it *must* be one or the other. As we are in the realm of art, the path followed is generally the creative one, but that does not eliminate the ethical dilemma, and it does not mean that the answer is *always* the creative one.

Another stubborn dilemma already referenced above sets privacy against inclusiveness. Ideally, no identifying personal information would be gathered about performance

participants. And, one virtue of the IoMusT things is that it facilitates inclusiveness by providing opportunities for those with auditory disabilities. That virtue cannot be pursued however, without cracking the privacy ideal: advancing inclusiveness requires knowing who is being excluded and why. Again here, no way to reconcile these ethical demands is apparent, but decisions need to be made.

No matter the decisions, the narrative goes forward to organize and review all substantial findings, and then concludes, potentially, with recommendations for the ethical refinement of the IoMusT experience.

V. Limitation

The foremost limitation of this work is also a significant virtue. The paper maintains the singular purpose of assembling a framework and method for practitioners in the IoMusT to facilitate the incorporation of ethics into their work. The paper limits itself to presenting the framework and method, and then to providing examples to clarify how the process functions. This publication does not aim to present a full application of the framework to a specific case as that is a different kind of paper.

Most important, a full application would require a pre-existing method and framework because the incorporation of ethics as envisioned here is a form of ethics-by-design [53], meaning that ethics is fully integrated into the technical development, and not just presented as an afterthought or checkbox. So, it is impossible to execute a full case study until the framework and method are formally established, and the project of this paper is to establish that framework and method.

What follows is the opportunity for practitioners to refer to this roadmap as they incorporate ethics into their own productions in the IoMusT.

VI. Conclusions

This paper proposed an ethics framework for evaluating the design and performance of IoMusT technology. The framework overlaps current practices in the ethics of technology, and the case study used to exemplify and verify the framework has much in common with ethics evaluations already executed in the area of artificial intelligence. The creative reality of the musical arts is sufficiently unique, however, to require a customized set of ethical principles, and an evaluation that is sensitive to the demands and hesitations of the creative arts.

Further work in this area could advance in at least two directions. First, the task of a full ethics evaluation of an IoMusT performance could be undertaken. Second, the eleven ethical principles and their definitions proposed here may be modified or supplemented in the light of new technology, and by musically inventive ways of creating sounds through machines.

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