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Towards the Classification of Recording Devices

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ABSTRACT

This paper outlines the foundation of a classification system for recording devices that organizes them by what they can do. It outlines the purpose of the classification system, how it was developed and defines its conception of recording devices and their functional capabilities. It then details four major classes of recording device and their subclasses according to their common and distinct functional capabilities (what they can do). It then identifies the responsible properties through the process of facet analysis to produce a definition of each class according to these properties (or facets). This classification system organizes recording devices in a way that provides new tools for comparison and analysis. The paper briefly examples applications for these analytical tools before indicating the status and direction of future research. This paper represents a component of the primary author's ongoing doctoral thesis due for submission in 2025 and is an iteration upon a presentation made by both authors to the Adelaide AES Chapter in February 2023.

1 Introduction

This paper contains an introduction to and outline for a proposed classification system for recording devices. This classification system organizes recording devices into classes based on their fundamental capabilities (what they can do). The arguments presented here represent a fragment of the ongoing iteration of this research effort, with the intention of inviting feedback from fellow recording practitioners. The intended outcome of this research is to further develop these ideas into a system of intellectual and practical value to the recording community.

This paper does not attempt to present the total extent of this classification system or theory in detail. However, such research is intended to be submitted to the AES in a format more suited to peer review upon further development.

2 What is the classification system?

The classification system put forward by this paper is a way of understanding recording devices by their similarity to other groups of recording devices. Any classification system can be organized arbitrarily according to the specific properties of objects one is interested in differentiating. For example, one could create an extremely thorough and accurate classification of recording devices which organizes them according to the color of their chassis, however such a system would be of little use in telling you which of those devices can perform an overdub.

The classification system presented in this paper has been designed to organize recording devices according to what we have termed their functional capabilities. These functional capabilities are a collection of specific properties which each respectively differentiate a boundary between two classes of recording device. Each of these properties is defined in the description of each class as appropriate.

3 What is this classification system for?

The goal of this research project is to develop a classification system which can identify the functional capabilities of a given recording device and assign that device to a class representing all recording devices with those same functional capabilities. Using such a system it becomes possible to analyze and compare groups of recording devices to develop new insights that were not possible through analyzing individual devices in isolation. Some examples of the products of this classification system include:

- The ability to observe, describe and predict patterns of properties amongst recording devices which would otherwise be disconnected.
- The ability to predict the potential change in functional capabilities of a given recording device as consequence of specific changes(s) to its operating principles.
- The ability to predict what modification(s) to a given recording device will have to its functional capabilities.
- The ability to hypothesize modifications necessary to achieve a desired functional capability. This is of special interest to efforts to develop future recording technologies.
- The opportunity for the re-clarification of existing language and theory describing the operating principles and functional capabilities of recording devices.
- The ability to identify devices which demonstrate an artificial reduction in functional capability (defeaturing).

These abilities correlate with what researchers in taxonomy have identified to be four primary benefits of an effective taxonomic (or classification) system [1]–[5]. Firstly, such a system can provide a common language and facilitate knowledge sharing between disparate fields [1, pp. 61–66], [6]. Secondly, it can conceptually illustrate the relationships between categories and their components, leading to a better understanding of previously concealed connections. Thirdly, it can help identify gaps in knowledge and suggest avenues for further research. And fourthly, it can inform the development of new research tools or technologies.

4 How was this classification system developed?

The initial efforts of this research project were an attempt to identify and analyze the properties responsible for the observable differences in capabilities between the contemporary digital audio workstation and the previous generations of recording technologies. Through the process of identifying and analyzing these properties, it became clear that groups of recording devices with similar properties could be differentiated from other groups according to those properties, and that these properties defined what a given recording device can do. This approach was informed by the work of researchers in other fields who have established methods and solutions to taxonomic problems with special attention paid to examples of taxonomic work related to technology [5].

The structure of the relationships between classes first became apparent in the form of what could be considered a folksonomy, a hierarchical structure based on subjective and qualitative distinctions informed by common practice. This approach to classification often has the advantage of being more intuitive to practitioners in a field, however it can also have the disadvantage of lacking clear or rigorously defined classes which can limit its potential precision as a predictive (or scientific) tool.

To counteract this, this classification system has been developed through the supplementary use of facet analysis. This involves the conceptual reduction of recording devices into the minimum possible number of precisely defined properties (or facets) [1, pp. 33–42]. These facets can then be used to define each class by their relationship to them. The benefit of applying facet analysis is that it allows for the reduction of complex language into simplified mathematical expressions which can be efficiently and precisely expressed. This improves the precision of the overall classification system in both the definition of its classes and the boundaries between them.

5 What is a recording device?

As this classification system is an attempt to organize recording devices, how a recording device is defined determines much of the usefulness of that system. It is beyond the scope of this paper to detail the theoretical framework upon which the definition of recording devices has been developed, but some key points are follows.

Recording devices may be constructed from any number of components and the term can refer to a singular device or systems of devices operating in concert. In this way a recording device of a given Class can be constructed through the combination of plural recording devices of a lower numbered Class.

The component parts of recording devices have themselves been conceptualized as part of this framework in a similar manner to the work of Claude Shannon with some key distinctions [7], [8]. In this proposed model, terms such as source, encoder, medium, decoder, and destination and the relationships between them are precisely defined. This model also draws from wider research in audio engineering to precisely define recording itself as the subject of recording devices.

This classification system does not differentiate recording devices according to how they achieve a given functionality, only on what they can do. In other words, properties such as a recording device being analogue or digital, tube or solid state are aesthetic and do not supersede the organization of recording devices according to what they are able to do. Finally, often a given recording device will demonstrate a potential to perform certain capabilities (as indicated by the properties of its underlying components) however these features may be absent from the device. This phenomenon is here termed defeaturing.

6 Outline of the classification system

The classification system as presented takes the form of four major classes for recording devices. The naming convention of this classification system uses a number to denote a major class that is followed by a letter where necessary to denote subclass within that major class. The structure of this classification system reflects the relationships between properties and reflects some degree of hierarchy between classes, however it is not necessarily the case that a 'higher' class device is necessarily more useful in every case than a 'lower' classed device.

Class 1:
All Class 1 recording systems record onto a medium that cannot be edited or modified after the initial recording. Class 1 represents some of the simplest forms of recording device only capable of capture and reproduction with no functionality for editing. They are divided into two subcategories 1A and 1B.

Class 1A:
Class 1A recording systems: 1. Can only record one signal, which embodies all information recorded in that pass. 2. Do not allow for the deletion of a section of the medium once recorded without the necessary destruction of the medium itself. 3. Can adjust the amplitude of playback, however this change is a circumstance of the reproduction and not a component of the recording itself. 4. Can commence or cease reproduction at any point in the recording. Class 1A represents the simplest of recording devices. Historically, almost all commercial releases of recorded works have been issued on media for Class 1A devices. Some examples of Class 1A recording systems include the record lathe, domestic turntables, and other examples of mechanical or electromechanical recording via disk or cylinder, Red Book CDs, SD Card audio recorders, simple portable recorders, and Dictaphones. It is worth observing that most PCM based recording devices of Class 1 are examples of defeaturing.

Class 1B:
While Class 1A recording systems often record stereo signals, the individual channels of a stereo signal cannot be edited separately from one another. They are inseparable components of a single multiplexed signal. Class 1B devices are similar in every aspect to Class 1A devices, however they are capable of multi-track recording and reproduction. They are otherwise identical to Class 1A devices. Examples of Class 1B devices are bit common or even known to the authors. They need be cited because they are possible. A vinyl record cut with multiple simultaneous cutting heads is a theoretical example. The importance of the distinction between multiplexed and multitracked recording becomes clear in the case of Class 2.

Class 2:
Class 2 recording systems share some characteristics with Class 1 recording systems; however, they record onto a medium that can be physically cut and re-sequenced after recording. As physical position corresponds to temporal position, the resequencing of the recording medium corresponds to the resequencing of reproduction. This enables what is generally referred to as editing. Class 2 recording systems can be further broken down into two sub-classes: Class 2A and Class 2B, as follows.

Class 2A:
Class 2A recording devices can perform the same functionalities as a Class 1A recording device, however as Class 2 devices they have the additional functionality of being able to re-sequence their recording medium and are thus capable of editing. Like Class 1A devices, Class 2A recording devices may only record one simultaneous (potentially multiplex) signal. Examples of Class 2A recording systems include all full width erase head magnetic tape, wire, or optical recorders.

Class 2B:

Class 2B recording devices can perform the same functionalities as Class 1B devices and (like Class 2A devices) they have the additional functionality of being able to re-sequence their recording medium. They are differentiated from Class 2A devices by their capability for multi-track recording, and thus their ability to selectively address recording 'tracks'.

This distinction is what enables simultaneous recording and playback (termed an overdub). This represents a distinctive technological innovation over the previously detailed classes of recording devices, the effects of which on both examples of recording technology and recording practice are significant, but beyond the scope of this paper to explore in detail.

Examples of Class 2B recording systems include multi-track tape recorders of various models including for example the OTARI MTR-10 series ½" Tape Recorders and Studer A80 when configured as a (24 Track 2" Tape Recorder).

Class 3:
Class 3 recording devices can perform the same functionalities as Class 1 and 2 devices; however, they have the additional capability to selectively edit any portion of a recorded signal regardless of its location on the medium or track. They are capable of what is often referred to as non-linear editing.

For Classes 1 and 2 there is a direct relationship between temporal position of a sound within a recording and the physical position of its storage on the recording medium. This is no longer a necessity for Class 3 devices, made possible by their application of what we have here termed a proxy medium. In brief, the use of a second (proxy) medium separate to the original, primary medium allows Class 3 recording devices to both record and playback simultaneously (like Class 2B devices), but also break the synchronization of events which was previously fixed by their position in the recording medium. A section of recording can now be edited separately from other recordings located adjacent to it on the recording medium through asynchronous use of more than one medium. It is for this reason that before the advent of affordable digital audio workstations, many Class 3 recording systems were constructed from the combined use of more than one Class 2B device, which can mimic this functionality (albeit with their own inconveniences).

Pure Class 3 recording devices include early digital audio workstations including the Akai Dr-4D, the Fairlight MFX3 or the Akai DD-1500. Their features also comprise the core functionality of contemporary Digital Audio Workstation.

Class 4:
Class 4 devices are separated into Classes 4A and 4B as distinguished by whether the device is capable of storing the processed signal (it has a medium), or manipulates a signal stored on another device (it does not have a medium). All Class 4 recording devices share the distinctive capability to perform edits on behalf of the operator, according to general parameters set by the operator and without the requirement for moment-by-moment control. In a word they are automated and represent the first appearance of automation in our hierarchy.

Some of these recording devices may not appear to be 'recording devices' at first glance in the same way as Classes 1 through 3 more obviously are. However, upon close inspection it becomes clear that they can be described by the same framework as other examples of recording devices and can thus be classified here.

Class 4A:
Class 4A recording devices are capable of the same non-linear editing as Class 3 recording devices however, they have the additional capability to perform edits on behalf of the operator, according to general parameters set by the operator and without the requirement for moment-by-moment operator input.

For example, a Class 4A device familiar to the reader would be that of a simple digital reverb device which takes an input signal and produces many repeats with delay (and various other modifications) to simulate the sound of a space. While the total number of edits required to produce such an effect is very large, each of them is fundamentally simple in nature and no different from the kinds of edits that are possible through the (laborious) use of a Class 3 recording device.

In other words, what a reverb or delay device does could be (and sometimes is) manually recreated by a human operator using a Class 3 device. A Class 4A device is essentially a Class 3 device with the addition of a non-human operator that follows predefined directions. These directions might be for example, the total number of edits to perform, or the range of parameters permitted for a certain operation.

Through this handing over of predefined tasks to a non-human operator it becomes possible for a Class 4A device to perform a numeric magnitude of edits which is impossible for a human operator to perform within the same period. The operation can be said to be infeasible in a similar way to the usage of the term in computer science. For this reason, Class 4A devices are extremely useful as they allow practitioners to perform tasks that would otherwise be impossible such as pitch correcting a vocal recording in near real-time or produce (and change between) an arbitrary delay, reverb, or temporal effect they may desire, regardless of whether such a space exists in reality (or) outside the device itself.

Examples of Class 4A devices include (but are not limited to): digital, acoustic, and mechanical reverb devices, time alignment systems, flangers, and other temporal effects, equalizers, phasers (and other devices which operate by delaying the phase of the incoming signal), pitch transposition devices, clipping and distortion reconstruction tools. Contemporary digital audio workstations also fall into this class, as they contain examples of the above devices in addition to their other capabilities.

Class 4B:
Like Class 4A devices, Class 4B devices are capable of editing signals according to predefined parameters set by an operator. Their distinction is that they do not have the ability to modify the sequence of their incoming signal as Class 4A devices can. Because of this limitation, Class 4B devices exclusively perform amplitude modifications, and often specialize in doing so dynamically over time.

A compressor is an example of a Class 4B device as it modifies the amplitude of its incoming signal according to parameters such as threshold, ratio, attack, release, etc. which are predefined by the operator. Other examples of Class 4B devices include limiters and duckers, expanders and gates, as well as fader automation systems, clippers and other distortion effects.

7 Incorporating Facet Analysis

The classification system proposed above defines each of its classes using a framework which is intended to reflect the ways that recording technology is used and understood by practitioners. Through the application of facet analysis, this paper proposes that the above classification system can be expressed in a reduced form using just four facets as follows:

1. The number of tracks that can be simultaneously recorded, represented by the symbol T (for Track). The value of T for any recording device is described as either T=1 or T>1 as follows:
T=1 A device that can only record one simultaneous track (although this track may represent multiple signals in multiplexed form).
T>1 A device that can record more than one simultaneous track.
The separation between T=1 and $T>1$ represents a categorical distinction in capability made possible through the availability of more than one simultaneously recordable track as exampled by the overdub.

2. The ability to re-sequence an incoming signal represented by the symbol R (For Re-sequence), which can be described as $R=0$ or $R=1$ as follows:
$R=0$ A device that cannot re-sequence its input signal.
$R=1$ A device that is capable of re-sequencing its input signal.
Re-sequencing is exampled by the cutting and splicing of tape, however the method of reordering sections of recorded signal varies between devices.

3. The ability to perform automated editing functions beyond human feasibility, represented by the symbol I (for Infeasible).
I=0 A device which is only capable of performing functions that are directly performed by the operator.
I=1 A device capable of performing editing functions on behalf of and at the direction of the operator to an extent that would be infeasible for a human operator to perform under the same parameters.

4. In all recording devices spatial displacement in one dimension in the recording medium corresponds to the passage of time at the recording event. For some recording devices this means that because of the nature of their recording medium, they are incapable of selectively addressing and editing one section of recorded signal from adjacent sections on the same medium. Whereas other recording devices are capable of such arbitrary edits.

Put another way, some recording devices must maintain a one-to-one correspondence between the passage of time and the sequence of recorded signals as it appears on the recording medium, and some devices do not require a one-to-one correspondence. The facet C (for Correspondence), denotes this property, where:

C=0 The synchronization of all recorded tracks on the recording medium is fixed, and thus arbitrary track editing is not possible.
C=1, The synchronization of all recorded tracks on the recording medium is malleable, and thus arbitrary track editing is possible

For *C*=1, a recording device must make use of more than one simultaneously recordable track. This secondary track is used to store a given portion of signal to then be placed elsewhere on the primary medium from which it was taken, termed the proxy medium. For this reason, recording devices where *C*=0 must necessarily be of *T*>1.

Using these facets, we can describe each of the classes as can be seen in Table 1. From this table each class can be defined by its own unique presentation of facets which defines both its fundamental limitations and its relationships with other classes of recording device with the minimal number of descriptive properties.

Class:	***T***	***R***	***I***	***C***
Class 1A	1	0	0	0
Class 1B	>1	0	0	0
Class 2A	1	1	0	0
Class 2B	>1	1	0	0
Class 3	>1	1	0	1
Class 4A	>1	1	1	1
Class 4B	1	0	1	0

Table 1. Classes of recording device as defined by the facets *T, R, I,* and *C*.

8 Example Applications

A detailed analysis of this classification system and its application is beyond the scope of this paper. However, the following are two example applications for this framework explored in the process of its development.

8.1 The identification of critical facets

The outcome of this facet analysis has provided the simplification of an enormous number of recording devices which are represented by this classification system using only four facets.

This represents a significant reduction in complexity compared to the magnitude of recording devices that can be observed. Doing so makes the comparisons of these properties, and of the classes they distinguish, much more meaningful than comparisons of other properties. It clarifies which properties of recording devices are necessary to facilitate a desired function, and it allows the reprioritization of properties which can be identified as non-critical for a given application.

For example, this classification system has allowed us to answer our initial research questions on the distinction between using tape machines and a contemporary DAW in a way that was previously unclear and which now follows a logic which is consistent and measurable across a wide range of recording devices.

Each of these are comparisons that were not possible before the development of this classification system. It is anticipated that the continued expansion of this research project may provide opportunities for the further refinement of recording technology, and the continued development of a more comprehensive 'theory of recording'. Such an effort would likely provide more and better tools for the analysis and comparison of both historical and future recording technologies.

8.2 The trend towards synthesis

There are several non-technical observations that can be made on this classification system which we believe can provide insights and discussions from this new perspective. For example, one of the most interesting trends which can be observed as one ascends the numbered categories, is the increased capacity to create modified versions of reality. For example, at Class 1A, a recording device is only capable of the simple capture and reproduction of a signal without editing of any kind. In the context of audio, this means that a Class 1A device can only capture and reproduce a performance, it provides no facility to edit it in any way.

However, as we begin to ascend the numbered categories, this limitation is gradually lifted, and it becomes increasingly possible to produce increasingly modified versions of what was initially captured. This is what allows us to create new versions of a performance which did not exist before it was recorded, or even performances that never happened. The recording device itself has created a new output from its input, under the direction of the operator.

At this stage of research, we hypothesize the expansion of this classification system to include other devices which can be described using the same framework. And our initial research into the classification of these devices appears to confirm this overall trend. This is to say that the classification system appears to continue to map out this tendency for increasingly capable recording devices to provide for increasingly modified or artificial reproductions of reality.

Furthermore, this trend towards synthesis is reflected in the history of recording practice. As new, more capable recording devices have become available, we have seen a corresponding change in the style of recorded music itself, from simple capture and reproduction of a performance without modification (as found in the earliest examples of recording). To the production of music separate from any real-world performance, as has become commonplace in contemporary music production practice.

This insight, and others, can be incorporated into the analysis of both recording practice and wider music culture and help provide new understandings of the relationships between recording technology and recording art and culture.

9 Conclusions

This paper has outlined a classification system for recording devices that combines both conventional classification methods and facet analysis. Through this it has developed an expression of the functional capabilities that can be used to differentiate between these categories of recording devices. It has then provided examples of applications for this framework and commented on opportunities for future research.

The authors of this paper believe that this classification system has demonstrated partial achievement of its stated research goals. It has successfully produced a framework which can describe a wide variety of recording devices in what we consider a comparatively simple and logically consistent system. It has also produced analytical tools which were not previously available and has attempted to outline their potential applications.

However, these applications remain untested and will require the continued pursuit of this research project. In doing so the authors of this paper intend to demonstrate and test the application of these tools to the analytic and predictive tasks outlined in its research goals. The outcome of our goal of re-clarifying recording technology language and theory will be dependent both on our success in communicating our ideas, and the interest of the wider community in the merits of such an approach.

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