Example Design Process for Audio Signals in a Digital Camera

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ABSTRACT

Design guidelines were proposed to provide a general workflow for the creation of audio signals for digital cameras, which recently continue to diversify. The steps for the initial phase—from the formulation of basic sound design concepts to the extraction of the design item and the construction of an outline for creating an actual sound—have been defined, and trial audio signals that are expected to be incorporated into a wide variety of electrical appliances have been created. In addition, hypotheses on the circumstances under which the equipment will be used have been deduced, and the evaluation methods of trial audio signals, points of improvement in the sound quality and the necessary precautions for incorporating the audio signal into the equipment have been investigated.

1. INTRODUCTION

Starting with household appliances, auditory signals[1] made of simple sound waves, such as pure tones, generated and controlled by microprocessors, have come to be used as part of the user interface of electrical devices manufactured in Japan. More recently, advances in device capabilities, changing user needs, and other factors have given rise to a trend towards the design of distinctive, original auditory signals. This is particularly true for the very popular digital camera, as competing manufacturers release new models with distinctive shutter sounds and operation confirmation sounds. This paper introduces a guideline of basic audio signal design made by Minolta's design department. The audio signals were designed assuming that they would be used for Minolta products such as the DiMAGE X, DiMAGE S404, and DiMAGE S304.

2. BASIC LOGIC OF AUDIO SIGNAL DESIGN

Figure 1 shows a flowchart of the logic behind basic audio signal design. The first step when equipping a product with audio signals is the formulation of basic concepts in accordance with such factors as the corporate identity, social needs and environmental background, followed by the creation of an outline for incorporating the sounds into the actual product. Next, the process continues with the following steps: study of relevancy to the screen layout, operation buttons and other interface items; selection of the audio signal types and items; clearing of the conditions for supported hardware such as playback devices; and creation of an actual sample. Afterwards, test installation on the product is performed, followed by extensive audio evaluation and checking for changes in sound quality due to the product housing and other factors, what effect the operating environment might have on the sound, etc. Next, the final volume and sound quality settings are specified before commercial application of the product begins.

The objectives for introducing audio signals into products are as follows:

1) To improve the functionality (ease of use and sense of operating security) as part of the equipment's interface

2) To create an image for the equipment in order to differentiate it from other manufacturer's products (Taking the digital camera as an example, this is the first step in expressing a feeling of high quality, coolness or stylishness.)

The items described below were defined as the basic concepts during the initial phase.

1) Brightness
Light symbolizes the core technologies of a company that possesses advanced optical technology. Because of this, "brightness" is selected as the keynote image.

2) Universality of Use
Considering that more than half of the products are used outside of Japan, sounds should be culture-neutral, without adhering to the Japanese musical scale or western musical scale. In addition,

sound volume and frequency must take the hearing characteristics of seniors into consideration in order to make the sounds suitable for all age levels.

3) Futuristic Mechanism
Audio signals added to a digital product should maintain mechanical and analog sound elements, while creating a futuristic image through their tempo, phrasing, etc.

4) Multi-modality
Machine interfaces should consist of interrelated visual, tactile and sound elements. The design of audio signals must be coordinated with other interface elements, and the sounds must be produced at the appropriate time in order to provide the user with the appropriate information. Coordination with voice guidance must also be taken into consideration.

Since these basic concepts take other future products besides digital cameras into consideration, the relevant design department is distributing them throughout the company.

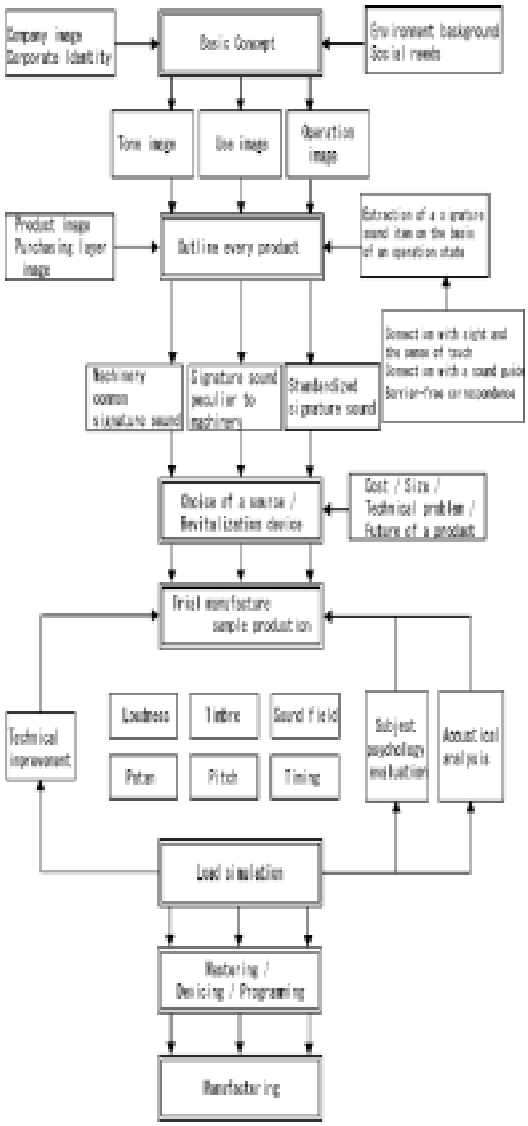


Figure 1. *Flowchart of basic audio signal design*

3. EQUIPPING A DIGITAL CAMERA WITH SOUNDS

In accordance with the basic concept, an outline is created for equipping an actual digital camera product with sounds. During this phase, the operating conditions and audio signals of current digital camera models are evaluated, and market research is conducted on the trends of competing products, etc. The following is an outline of audio signals.

1) Selection of tones (frequency range and musical tonality)
2) Configuration of note series (number of notes)
3) Selection of timbres
4) Sense of coordination with operation
5) Selection of volume, etc.

For hardware conditions, the following two options were formulated and used for trial manufacturing.

1) Audio signals composed of a sine wave or rectangular wave produced by microprocessor control of a piezoelectric element

2) Audio signals stored as a wav file in the product memory and played through a small speaker

Trial versions were also produced to test for sound quality changes when source sounds (44.1kHz, 16 bits) are down-sampled (8kHz, 8 bits) to incorporate them into the product.

In the past, audio signals for equipment were mostly "simple beeps", generated through pure tone methods using microcomputers as described above. Those audio signals were meant to express multiple functions according to the combination of several parameters, such as the pitch, length (onset and offset time) and volume. In addition, they had huge limitations from the point of view of production. Recently, diversification in device and recording media capabilities, increased capacity and decreased costs have brought about the production and editing of unrestricted sound sources that can be used generically with a computer, such as the wav file format. Even on the production side, this brings the level of work to the same as that of creating music. However, with small-sized electrical equipment, many acoustically negative factors remain, such as playback on small-size speakers, the sampling frequency at a low rate, and the small number of concurring sounds. Currently, since we can say that this is a transition period, this creation of the many types of audio signals described above was attempted.

4. TRIAL AUDIO SIGNALS

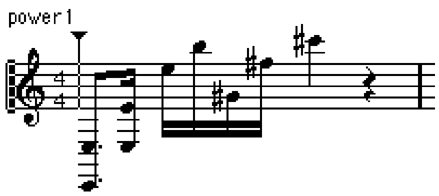
Trial versions of pure tone patterns and wav file patterns of the following audio signals that are expected to be incorporated into a wide variety of electrical appliances were created.

(1) POWER: Power turned on
(2) END: Power turned off
(3) OK: Operation OK
(4) NG: Operation NG
(5) INCOMPLETE: Operation incomplete
(6) HELP: HELP button pressed
(7) ALARM: Device malfunction occurred

The following describes the conditions when the equipment is used, the production designs for the desired function, and an example for creating the signal from wav files for each audio signal.

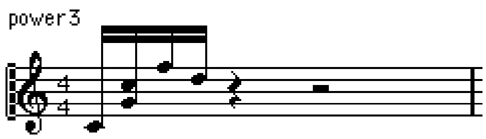
4.1. POWER ON

This is a sound that is played whenever the product is used. It must be relatively long because it also serves to mask time lost during the startup period between power on and the point when the device is ready for use. In the sense that it is a greeting sound the first time the product is used, it is one of the most important items for cultivating a favorable company image. For this reason, an audio signal with a strong message is desirable.



Score 1. *Power on audio signal example 1*

This audio signal was inspired by the Minolta sound logo used in television commercials. Rather than trying to create a sonic representation of the word “Minolta”, an attempt was made to start the logo with an orchestra hit for impact, then flow smoothly into the phrase that follows.
This audio signal is the only one in the key of E Major. (All other sounds are in C Major.)

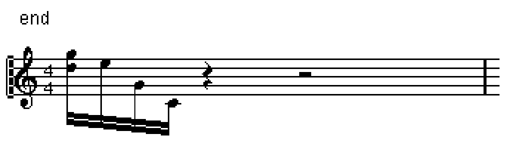


Score 2. *Power on audio signal example 2*

This is a simple sound that creates a pleasant feeling without a sense of being noisy.

4.2. END

This is a sound that is played when operation of the product is finished or discontinued. It must express finality within a short period of time. In addition, an audio signal that also provides a warning while the product is being operated, for example, about the battery level, is desired.

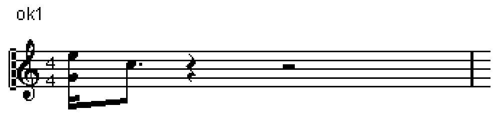


Score 3. *Power off audio signal example*

An audio signal with an image symmetrical to that of the power on signal was developed. The use of a descending phrase emphasizes the feeling of completion.

4.3. OK

This is a sound that is probably played most frequently while the product is being operated. Compared with other audio signals, it should be the most simple in structure. In addition, it is necessary to thoroughly investigate into a sound level and sense that can be heard when buttons are quickly pressed in succession.



Score 4. *OK audio signal example*

4.4. NG

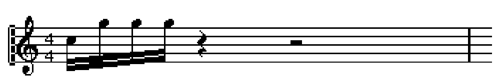
This sound warns the user that an operation error has occurred. It should be expected that this sound will be played frequently during operation, like the OK audio signal. Compared with the ALARM audio signal described later, the level of danger is low and therefore must not be overemphasized.

Score 5. *NG audio signal example*

The audio signal is constructed of three notes so that it gives a symmetrical image to the two-note structure of the OK audio signal. By using a descending phrase, a negative image is emphasized.

4.5. INCOMPLETE

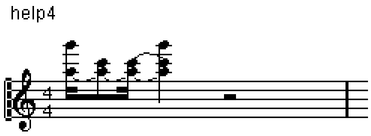
This sound is played to notify the user that the machine is performing an operation and that it is necessary for the user to wait unit a new operation can be performed. It should be assumed that this sound will be used at the same time that an operation is completed.



Score 6. *Incomplete audio signal example*

4.6. HELP

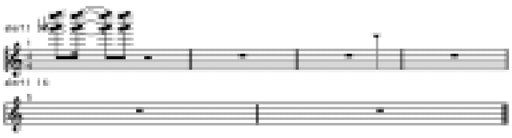
This is a sound where the desired function can change to either “ASK” or “INFORMATION” depending on the equipment in which it is used. Score 7 is an example that was created to give an “ASK” image.



Score 7. *Help audio signal example*

4.7. ALARM

This sound warns the user that the equipment is not operating normally. It is necessary that the image of this audio signal change according to the severity of the warning. Score 8 assumes a level of medium urgency, such as the batteries are empty.



Score 8. *Warning audio signal example*

By using an odd number of notes and an irregular harmonic structure, an unstable image is emphasized.

The following points were considered when these wav file sound sources were created.

1) A keynote was specified as a basis, and a peaceful feeling was maintained throughout the audio signal series.

2) Compared with equipment operation functions, a relevance to the sense of the operation and the image of the audio signal was maintained through the combination of the number of notes, the chord structure and the phrasing (ascending or descending interval).

3) Despite a deterioration in the sound quality (such as a loss of sound in the high ranges and a coarseness in the sound due to low quantization) that can occur when the sounds are used in equipment, sounds that have little extreme effects will be used.

Based on the creation of these wav file audio signals, a series of audio signals produced by microprocessor control of a piezoelectric element, such as a sine wave or a rectangular wave, was also created; however, detailed information on it is omitted.

5. EVALUATION OF TRIAL AUDIO SIGNALS

The trial audio signals were ranked and grouped based on set evaluation standards. It would be necessary to perform careful evaluation tests using multiple test subjects. However, this paper will report the subjective evaluations of one person who analyzed the playback of the trial audio signals from a computer, then propose the establishment of an evaluation method for the future.

5.1. Evaluation of generality

The trial audio signals created here are appropriate for general use in any electrical appliance, and can even be used in products other than digital cameras. Therefore, they were ranked on the basis of whether or not they can be used generically in other types of equipment. Overall, the audio signals that used a sine wave can be considered to have a higher generality because “they had a particular image that was difficult to remember”, “they were simple” and “they were not tiresome”. The results of the ranking in each group for the sinusoidal wave signals and the other signals are shown in Table 1.

	Considered to have the higher generality		
wave file format	p1-1 uc2-1	ask3-1 alert1-1	
pure tone format	e-s3-0	uc-s2 ask-s3-0	help-s1-0 alert-s1
	Difficult to specify		
wave file format	p3-1 e3-1	ng1-1 uc1-1	ask4-1 alert2-1
pure tone format	p-s1-0 ok-s1-0	ng-s1-0 uc-s1	ask-s4-0 alert-s2
	Considered to have the lower generality		
wave file format	p2-1 ok1-1	ng2-1 ask4-6	ask5-1
pure tone format	p-s3-0 ng-s2-0		

Table 1. *Evaluation of generality*
(The information in the table shows the file names of the trial audio signals.)

5.2. Grouping the audio signal images

The evaluation of the image received from the trial audio signals can be perceived in many different ways. Normally, the image should be analyzed using a variety of assessment words; however, here, we grouped them on a three axes representing:

1) Simple – Abstract
2) Common – Unique
3) Rich – Light

1) is the evaluation axis that specifies whether the audio signal is “simple” (the item being defined or the appropriate operation is easy to understand) or “abstract” (difficult to understand). This strong element combines the physical factors such as the attack strength, modulation, tempo and the sound pressure level for the background noise.

2) is the evaluation axis that specifies whether the signal is “unique” or “common” (ordinary). This is the element that is concerned with relating the image of the product, as compared with audio signals used in the past, and is ultimately connected

with familiarity and conformity (the feeling that there is no incompatibility) of identity.

3) is the evaluation axis that specifies whether the signal is “rich” (heavy, thick, calm and stiff) or “light” (transparent, shining, lively and gentle). This element concerns whether or not “brightness” (one of the basic concepts) is felt, and is connected to the frequency component of sound, the envelope and the hardware factors such as the frequency characteristics of playback equipment.

Assuming an evaluation graph with these features on the axes as shown in Figure 2, the grouping of the image space was attempted. However, it is not mentioned here which audio signal is good or appropriate from receiving a high evaluation on any certain axis. For now, we will go no further than to attempt to group the images.

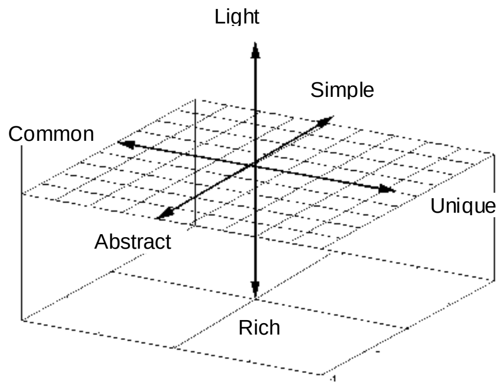


Figure 2. *Image Space of the Trial Audio Signals*

1) Simple, unique and light
p3-1, e3-1, uc2-1, ask3-1

2) Simple, unique and rich
Not applicable

3) Simple, common and light
p-s3-0, e-s3-0, ng-s1-0, ng-s2-0, help-s1-0, alert1-1, alert-s1, alert-s2

4) Simple, common and rich
ask-s3-0, ask-s4-0, alert2-1

5) Abstract, unique and light
p2-1, ask4-6, ask5-1

6) Abstract, unique and rich
p1-1, ng2-1, ask4-1

7) Abstract, common and light
ok1-1, ng1-1, uc1-1

8) Abstract, common and rich
p-s1-0, ok-s1-0, uc-s1 and uc-s2 are proposed.

6. EQUIPPING PRODUCTS TO BE COMMERCIALIZED

Using the trial audio signals as models, the development of audio signals that can actually be used in commercialized digital cameras was investigated. The following audio signals are assumed to be required for commercialized digital cameras.

(1) POWER: Power on sound
(2) KEYCLICK: Keying sound
(audio signal when the arrow keys are pressed to move the cursor within the menus)
(3) MODE DIAL: Mode dial switching sound
(changing the modes for previewing and photographing)
(4) AUTO FOCUS: Auto focusing sound
(5) SHUTTER: Shutter sound
(6) DELETE: Sound when completely deleting or finishing formatting
(7) ALERT: Sound for serious warnings
(8) ERROR: Sound for regular warnings

Through a process similar to that for trial audio signals, incorporating sounds into products is first evaluated with a computer. It is necessary to 1) check for sound quality loss after the downward conversion, 2) check basic elements such as the length, volume and repeating frequency of the sound, and 3) evaluate how the product was equipped with the sound, for example was the functional image maintained. Afterwards, the sound source is incorporated into the actual equipment, and then the playback is evaluated. Next, it is necessary to repeatedly evaluate and adjust the sound within the expected operating environment, for example, by adjusting the frequency component, running acoustic processing of the feed-out section, adjusting the volume balance between each audio signal, and correcting the sound quality by reducing resonance caused by the cabinet in addition to checking if the audio signal is provided with the appropriate timing as feedback for the operation of buttons, dials and the shutter and checking that the audio signal can be provided at an appropriate volume level in various operating environments.

7. CONCLUSION

This paper describes an example design process for implementing audio signals during the early stages of product development, methods for correcting problems that may arise in the next step to commercialization and methods for evaluating installed audio signals. Guidelines such as these make it possible to involve more individuals from other product development areas to help in the development of an interface design that uses high-level sounds. The product development cycle for digital cameras is extremely short, and from one to the next, new product concepts are continually being developed. Observing the design process for these basic audio signals would be helpful in establishing a user interface that is consistent with various products.

8. REFERENCES

[1] JIS S 0013-2002 "Guidelines for the elderly and people with disabilities－ Auditory signals on consumer products" Japanese Standards Association, Tokyo, 2002.