TECHNICAL REPORT

Designing and making musical instruments to form sounds

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Abstract: We studied the sound forming process for making musical instruments in musical instrument play systems, to find what factors effect the process of designing and fabricating the musical instrument has on forming the sound and we attempted to model the musical instrument sound forming process.

Keywords: Tone color, Musical instrument, Design, Making, Process

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1. EVALUATING SOUND IN THE MUSICAL INSTRUMENT PERFORMANCE SYSTEM

1.1. Musical Instrument Sound Forming Process

A model made of the performance system for musical instrument is shown in Fig. 1. In this figure, FB and fb indicate the feedback, and FF and ff indicate the feedforward (default setting). The sound is formed from the characteristics of the musical instrument and performer (method of play). The sound obtained was then rated by the listener.

1.2. Elements in Forming Sound of Musical Instrument

The instrument performance system of a piano which has the most complex elements and related technical issues are shown in Fig. 2. The piano sound has been formed and evolved based on these technologies.

Acoustic elements typically used in forming sounds include: pitch, interval, volume, resonance, emissivity, sound productivity, damping, frequency component spectrum, noise components, attenuation characteristics, modulation, and consonance, etc.

2. SOUND RESEARCH IN THE MUSICAL INSTRUMENT DESIGN AND FABRICATION PROCESS

Figure 3 shows an example of a typical research and development and fabrication process for musical instruments.

The music instrument R&D process differs according to the musical instrument. The techniques also vary according to the aim of the development design or that designer and manufacturer. However the process mainly progresses as outlined here. The latest in available technology at the time is applied to the process. In this section, the elements of a typical sound forming process in each of four types of musical instruments that the author has engaged with are discussed in the light of the following subjects:

- Piano: Piano structural factors and acoustical characteristics [1].
- Brass instruments: Tone interval characteristics and sound quality [2].
- Percussion instruments: Structural vibration characteristics and sound [3].
- String instruments: Violin shape dimensions and sound [4].

3. SOUND FORMING IN SILENT INSTRUMENTS

Instruments referred to as silent instruments and their structural principle from the viewpoint of quietness are grouped as shown in Table 1 [5]. In this figure, BI indicates the built-in type, and RF indicates the retrofit type. Here, “SILENT” is a registered, commercial trademark of the Yamaha Corporation.

Silent instruments are an attempt at reorganizing the instrument performance system. Here we evaluate the basic elements in forming sounds using some typical instruments.

- Silent piano: No actual striking a chord, sound is expressed by high quality sound source and non-contact sensors.

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Fig. 1 Instrument performance system model.

Fig. 2 Piano instrument performance system elements.

Fig. 3 Music instrument R&D process.

Table 1 Silent instrument types.

<table>
<thead>
<tr>
<th>Function</th>
<th>System</th>
<th>Musical instrument forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silenced type</td>
<td>No real sound</td>
<td>Silent piano (BI)</td>
</tr>
<tr>
<td></td>
<td>(Has noise or mechanical noise)</td>
<td>Silent piano (RF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silent session drum</td>
</tr>
<tr>
<td>Silent quality</td>
<td>Muffled sound type</td>
<td>Gran'Touch</td>
</tr>
<tr>
<td></td>
<td>Slight real sound</td>
<td>Silent violin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silent cello</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silent bass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silent guitar</td>
</tr>
</tbody>
</table>

Here, “SILENT” is a registered, commercial trademark of the Yamaha Corporation.
Silent violin: Lightweight electric violin without body make small actual sound.

Silent brass: Lowers sound with special mute function and sound is monitored on headphones.

4. MODEL OF MUSICAL INSTRUMENT SOUND FORMING PROCESS

We previously showed structural elements and sound forming for natural and silent musical instruments. Here we present three models for the sound forming process and for evaluating that process.

4.1. Musical Instrument Design and Fabrication Process of the Sound Forming Model

Figure 4 shows a model of the design and fabrication process for musical instrument sound forming.

Depending on the musical instrument, some elements are missing. Some elements might be impossible to integrate into the instrument. In using this model it is extremely important to know the characteristics in each step. This model is effective in setting target improvements and evaluating those improvements when attempting to improve the acoustical characteristics and thus the sound. Changing the upstream elements requires making matching corrections in the downstream process [6]. The sound quality can be improved by processing the materials and surface coating specifications, at the stage that the unit shape dimensions and structural strength can be recreated.

4.2. Plan for the New Sound Rating System; Sound Creation & Evaluation by Performer

The performer has a large role in forming the sound of the musical instrument. Here, we offer system for quantitatively and qualitatively evaluating the sound of the musical instrument that involves the sound created by the performer (Fig. 5).

This process for altering the acoustic signal for recording and PA (public address) also provides a means for the performer himself to correct the acoustic characteristics of the instrument in the performing environment. It is also a valuable tool for rating the sound of the silent instrument [7] and setting target improvements. Various unique acoustic emission elements must be prepared for making the silent musical instrument a self-perfecting instrument [8]. If the performance input method can also be evaluated, then the system can be used in an expanded range of fields [9].

4.3. Evaluating the Piano Unit by Auto Player; Selecting the Instrument from the Audience View Point

We propose a system for evaluating a piano for example with an auto performing system. This serves as one means for evaluating the musical instrument sound. Auto performing preferably uses a robot [10] to play the keyboard, rather than the built-in (BI) type. The sound field also exerts an effect here so the sound field characteristics may be set with a DSP (Digital sound processor). The evaluation points are preferably clearly specified and a quantitative evaluation then made. An auto-performing system is not available for some musical instruments so in that case a standardized performance should be given by the performer.

5. CONCLUSION

5.1. Music Instruments of the 21st Century, Handling Diverse Musical Scenarios

The coming generation will continue to demand even better concert grand pianos. The chief issue here will be how to produce even better music performance expression and a more beautiful sound. Accomplishing this will require focusing on factors not noticed up until now and factors not held as relevant up until now. The key here will be how to learn from the past. Another direction will be a demand to respond to diversity on the music scene and the information media, where the piano itself will be a part of the media. Other musical instruments will show a trend in the same directions. New musical instruments will be created from this environment.

5.2. Planning the Musical Instrument Design and Fabrication Process; Passing on and Using Technology

Figure 6 shows an engineering model of the musical instrument design and fabrication process. The cases here are grouped into an original design and a design copy. The
The process in the latter case (design copy) is the so-called reverse engineering. Three-dimensional (3D) design is assumed as a prerequisite for upgrading efficiency at the developmental stage, target goals are clearly set and analysis evaluation tools are utilized. Preferably, a more scientific analysis evaluation system is used since evaluating the sound and playability is particularly important. Using this kind of model accumulates information and will likely make the development stage more efficient and assist in transferring and using technology. Differing ages make differing demands, so musical instruments will be different from the mass-produced instruments made up till now. These future musical instruments should be developed to have a higher innate value and respond to a variety of needs.

REFERENCES