THE MUSICAL ACOUSTICS OF BUNDENGAN

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Abstract

Bundengan is an Indonesian musical instrument developed by duck herders in Wonosobo, Central Java. Recently the organology of the bundengan has been studied by M. Sa'id Abdulloh from ISI Surakarta. We build upon this result and use quantitative measurements and computations to reveal the exact mechanisms of the *bundengan* strings (see: http://tinyurl.com/Bundengan). Our measurements show that the small bamboo clips attached to the strings is the key element on how the strings generate metallic gong-like sounds. As the string is plucked, the bamboo clips divide the string into several parts, each of them vibrating with different frequencies. This results in non-harmonic spectra, resembling the sounds from metallic instruments. Our computation show in more details how the mass of the bamboo clips determine the string vibrations.

Keywords:*Bundengan*, acoustics, music.

Introduction

Bundengan is a musical instrument that was first developed by duck herders in Wonosobo, Central Java, Indonesia (Cook 2016). A *bundengan* is a hybrid of a lamellophone and a chordophone. Figure 1 shows a picture of a *bundengan*, exhibited at the Museum Sonobudoyo in Yogyakarta, Indonesia. Inside its resonator dome, we can find a set of strings and a set of bamboo plates. Interestingly, the strings can be used to imitate the sound of a partial set of *gamelan* while the bamboo plates can be used to imitate the sound of a *kendang* drum.

In 2017, M. Sa'id Abdulloh published his research report on the organology of the bundengan (Abdulloh 2017). Among many things analyzed in that report, Abdulloh investigated the mechanism of the frequency tuning of the *bundengan* strings. These strings are equipped with small bamboo clips, as shown in Figure 2. By sliding these clips along the strings, the player can adjust the pitch and timbre of the sound generated by the strings. On top of that, Abdulloh also suggested that the bamboo clips are the key to the mechanism behind the metallic sound generated by the strings.

Figure 1. A *bundengan* exhibited at the Museum Sonobudoyo in Yogyakarta.

Figure 2. A set of *bundengan* strings equipped with bamboo clips.

In this paper we build upon Abdulloh's work. We use quantitative measurements and computations to reveal the exact mechanisms of the *bundengan* strings (see: http://tinyurl.com/Bundengan). Our measurements show that the small bamboo clips attached to the strings is the key element on how the strings generate metallic gong-like sounds. As the string is plucked, the bamboo clips divide the string into several parts, each of them vibrating with different frequencies. This results in non-harmonic spectra, resembling the non-harmonic sounds from metallic instruments. Our computation show in more details how the mass and position of the bamboo clips determine the string vibrations.

Methods

We perform high-speed video recording of the vibrations of a *bundengan* string equipped with bamboo clips. This video recording allows us to observe the string vibrations in 1000 frames per second (Parikesit and Kusumaningtyas 2017). Meanwhile, we also use computer simulations to study the string vibrations. The computer simulation is performed using the software Scilab.

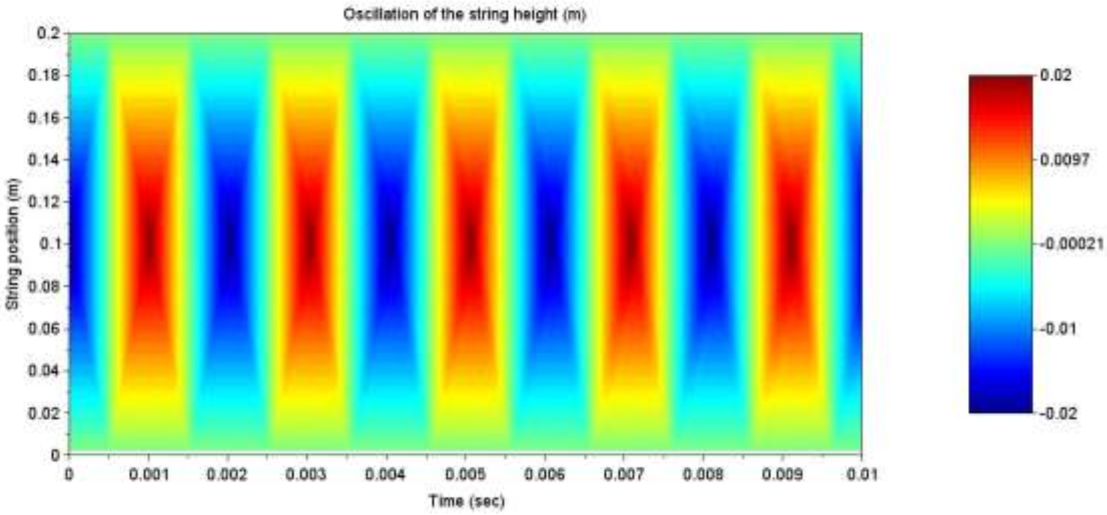
Results

An example of our high-speed video recording is publicly available on https://www.youtube.com/watch?v=8PpKIq75vFY. This video is played back in 30 frames per second, hence the string vibrations are slowed down approximately 30 times. From this video, we can observe that the string vibrations are very different than conventional string vibrations without clips. It seems that the bamboo clips divide the vibrating string into two parts. The longer part of the string exhibits a relatively higher vibration frequency, while the shorter part of the string exhibits a relatively lower vibration frequency. To better understand this phenomenon, we use computer simulations.

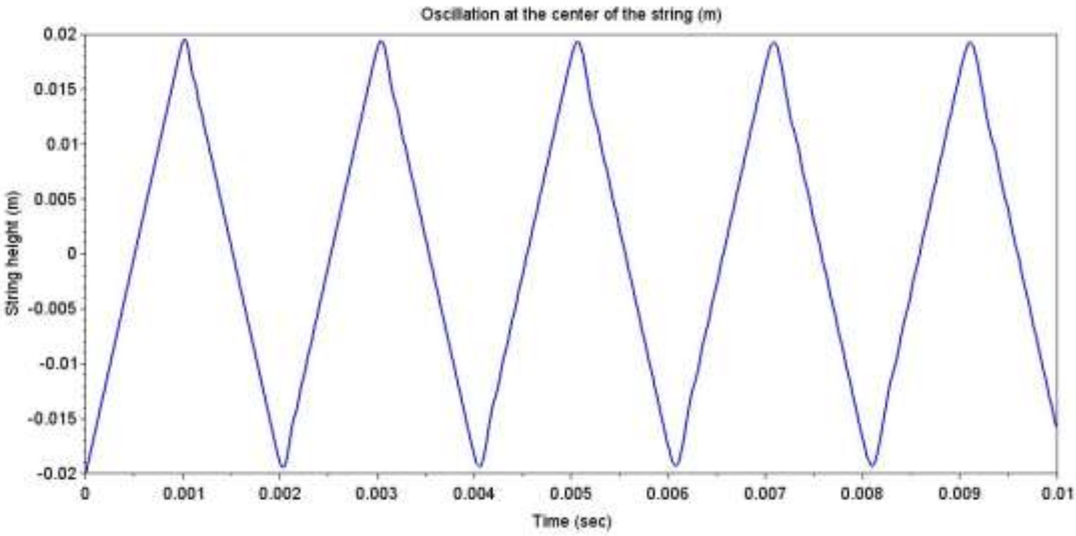
Figure 3(a) shows a computer simulation of the vibrations of a conventional string, i.e. without any bamboo clip. In this simulation, the string is plucked at its center. As expected, the string oscillates periodically, with peaks located at the plucking point (Fletcher and Rossing 1998). In Figure 3(b) we can see this oscillation, occuring exactly at the center of the string.

Figure 4(a) shows what happens when we attach a bamboo clip on the string, where the mass density of the clip is 500 times heavier than the mass density of the string. Meanwhile, Figures 4(b) and 4(c) show the string oscillations in time, at the shorter and the longer parts of the string, respectively.

Figure 5 shows a situation where the mass density of the bamboo clip is made 10^6 times higher than the mass density of the string. Here the bamboo clip is so heavy such that it barely moves during the string vibrations. Comparison between the results shown in Figures 3-5 also indicate that the bamboo clips result in non-harmonic vibrations at the string. This may explain how the strings generate metallic sound, which is also known to be non-harmonic (Fletcher and Rossing 1998).

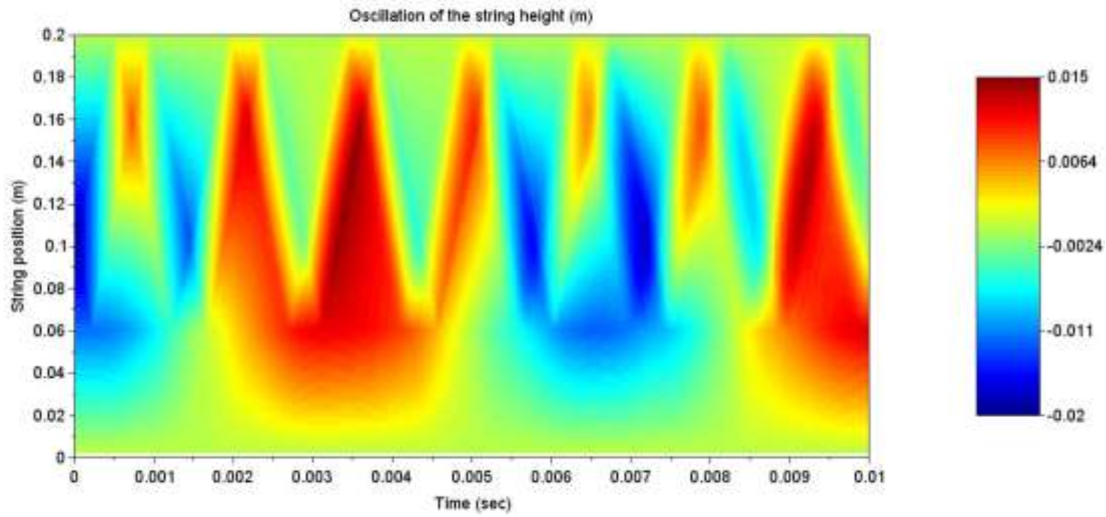


(a)

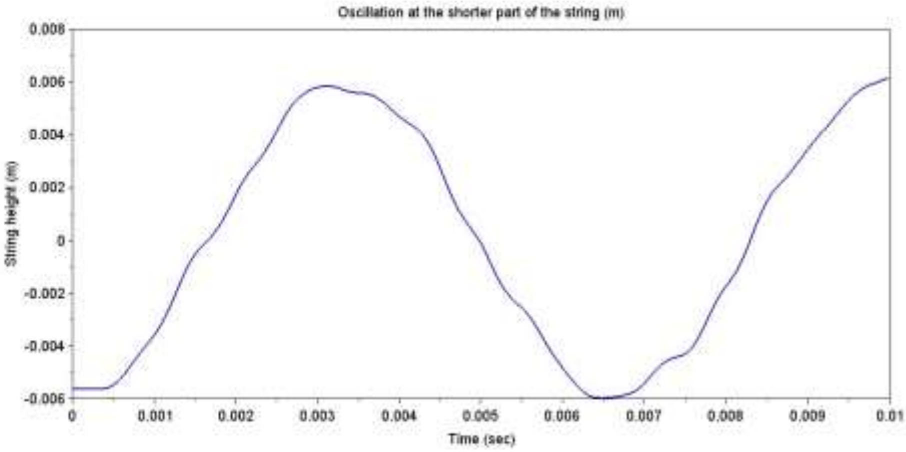


(b)

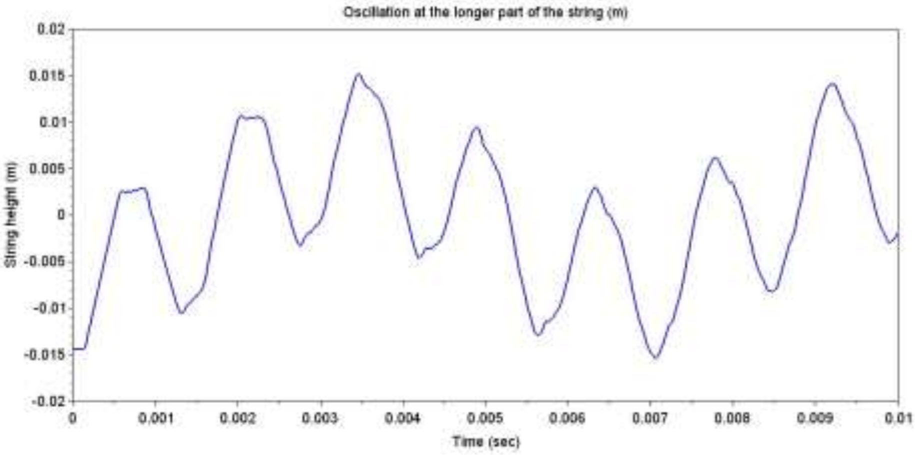
Figure 3. Vibration of a string without any bamboo clip: (a) as a function of space and time, and (b) as a function of time, located at the center of the string (i.e. string position: 0.1).



(a)



(b)



(c)

Figure 4. Vibration of a string with a bamboo clip that has a mass density 500 times higher than the string: (a) as a function of space and time, (b) as a function of time, located at the shorter part of the string (i.e. string position: 0.03), and (c) as a function of time, located at the longer part of the string (i.e. string position: 0.13).

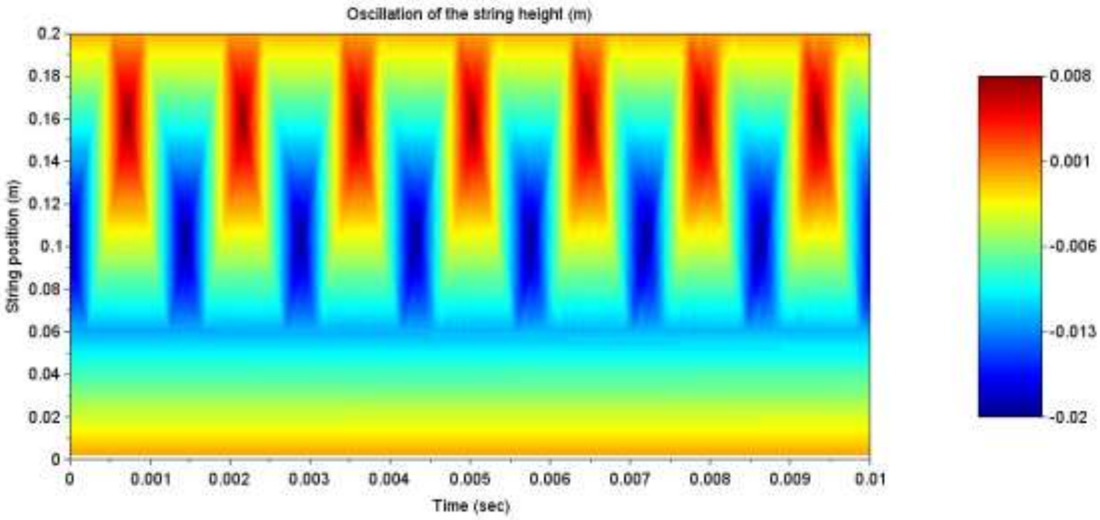


Figure 5. Vibration of a string with a bamboo clip that has a mass density 10^6 times higher than the string.

Table 1 shows the various frequencies observed from the computer simulation for different mass density ratios between the bamboo clips and the strings. From this table we can see in more details how the mass of the bamboo clips determine the string vibrations.

Table 1. Various vibration frequencies for different mass density ratios

Mass density ratio	Frequency (in Hz) at string position 0.03	Frequency (in Hz) at string position 0.1	Frequency (in Hz) at string position 0.13
1	500	500	500
100	300	300	700
200	225	700	700
300	200	700	700
400	150	700	700
500	150	700	700

Conclusions

In this paper we continue the work previously published by Abdulloh (2017) on the organology of the *bundengan*. We use quantitative measurements and computations to reveal the exact mechanisms of the *bundengan* strings. Our measurements show that the small bamboo clips attached to the strings is the key element on how the strings generate metallic gong-like sounds. As the string is plucked, the bamboo clips divide the string into several parts, each of them vibrating with different frequencies. This results in non-harmonic spectra, resembling the sounds from metallic instruments. Our computation show in more details how the mass of the bamboo clips determine the string vibrations.

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