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Original Article

A Study on the Implementation of the Foley Sound for Medium-Sized Bird Wing Flapping Sound

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Abstract - *Various sounds are often required when working on audio for dramas or movies. Currently, simultaneous recording is activated, and almost all of the field sound is recorded and used, but Foley Sound using tools are used for parts where simultaneous recording is still insufficient or where sound needs to be emphasized. In this paper, we compared and analyzed the Foley Sound of medium-sized birds and the real bird's wing beat sound to confirm the value of using it as sound content. Medium-sized birds commonly found in South Korea include pigeons, magpies, and crows, and we compare and analyze the average wing flapping real sounds of these birds with their corresponding Foley sounds. To compare and analyze the real sounds and Foley sounds of medium-sized bird wing flapping, we first study the principles of wing flapping sound production and the forms and implementation methods of the Foley Sound tools. In addition, to prove the similarity between the real sound of a medium-sized bird flapping and the Foley Sound, sound analysis tools and the MOS(Mean Opinion Score) test were used to prove it in various ways. In the process, it was found that Foley Sound, a medium-sized bird's wing sound, is very unique and interesting in its tool shape and implementation method, so it has sufficient equipment to develop into sound contents related to performances, exhibitions, and experiences as well as broadcasting and movies.*

Keywords - *Foley sound, Real sound, Medium-Sized birds, Analyze, Forms, Methods, MOS test, Sound contents.*

1. Introduction

In the process of broadcasting or film production, sound work is the final work that enhances the perfection of the work. Nowadays, the sound is mostly recorded on-location through simultaneous recording. However, there are cases where sound needs to be completed through post-production for imperfectly recorded parts. In this paper, the sound of wing beats of medium-sized birds was studied among the sounds to be completed in post-production. Medium-sized birds inhabiting South Korea include pigeons, magpies, and crows. As a post-production method to complete the sound of the wings of this medium-sized bird, among the sounds that have already been recorded and stored as data, the sound of the wings used in a similar scene can be used, but there is also a way to create and complete the sound using tools to realize a sound that is perfect for the scene. The Foley Sound is a method of producing sounds using tools like this. In this paper, we try to use it correctly by proving the similarity between the sound of the wings of a medium-sized bird that was actually recorded and the sound of a bird made of Foley Sound. Furthermore, we aim to explore ways to utilize the Foley Sound implementation for various contents such as broadcasting, movie production, performances, exhibitions, and interactive experiences. First, through the study of medium-sized bird flapping Foley Sound, real bird wings and the Foley Sound tool of bird flapping sound were compared, and the implementation method and principle of Foley Sound were identified and established. Next, the similarity was demonstrated by comparing and analyzing the actual sound of the wing beat of a medium-sized bird and the Foley Sound. For scientific analysis, Adobe's audition program, a sound analysis tool, was used to analyze time, energy, and frequency domains. For auditory analysis, a short survey an MOS test, was performed. The research results aim to promote the proper implementation of the Foley Sound for medium-sized bird wing flapping and its utilization in various content creation fields, including broadcasting, movies, performances, exhibitions, and interactive experiences.

2. Types of Medium-sized Birds

In South Korea, medium-sized bird species include pigeons, magpies, and crows, native birds that inhabit the country throughout all four seasons. Pigeons primarily dwell in urban areas, while magpies and crows are commonly found in suburban and peripheral regions such as mountains and fields. In terms of average size, magpies are the smallest, followed by pigeons, and crows are the largest. The size of their wings also correlates with their body size, with magpies having the smallest wings and crows having the largest in terms of width and length. All of these birds possess strong wing flapping skills, resulting in captivating and rhythmic sounds during flight. [1, 2]

2.1. Pigeon

Pigeons belong to the Columbidae family and are widely distributed globally, comprising around 308 species, making them commonly seen due to their strong reproductive abilities. Pigeons can be broadly classified into two groups: "Dove" and "Pigeon." Doves are slightly smaller than pigeons and possess beautiful feathers, while pigeons appear slightly larger and sturdier, commonly found in urban areas. The medium-sized bird to be dealt with in this paper is to deal with Pigeon. Pigeon's appearance is generally elliptical, and it walks with a moderately long neck, moving back and forth on a small head and flies in groups for short distances. Pigeons are mostly white or gray with iridescent wings. The wingspan is more than 15cm, the length of the wings is more than 20cm, and the tip is slightly curved. They have 15 or more feathers, consisting of primary and secondary feathers. Pigeons exhibit vigorous wing flapping with their robust wings, producing unique sounds while taking flight.

2.2. Magpie

Magpies, belonging to the Corvidae family, are smaller in size compared to pigeons and crows. Like pigeons and crows, magpies have long been considered indigenous birds of South Korea. In particular, magpies have been considered auspicious in Korea since ancient times, so when a magpie cries in front of a house in the morning, it is said that a welcome guest will come. Their bodies have a harmonious blend of black and white feathers, with both males and females exhibiting similar patterns. Magpies have short, black beaks, and their wings are longer than 17cm, while their tails are black and approximately 24cm long. Magpies build their nests on high tree branches, sometimes on telephone poles or power lines, causing trouble. Occasionally, they may build nests on the ground, approximately 4 meters above the ground, in pine or fir trees. The nest is made of dry twigs as the main material and made in a round shape, somewhat hardened with soil, and a doorway is made on the side. During flight, the white feathers on the lower parts of the wings are prominent, and their wing flapping produces an energetic and soaring sound as they fly gracefully through the sky.

2.3. Crow

Crows, like magpies, are birds that can be commonly seen as resident birds in South Korea. Crows are all black in body color, so they are called ‘Kkamagwy’, which means black in Korean. Now, thoughts have changed a lot, but in the past, in Korea, crows were regarded as bad omens and looked down upon. However, in legends and folktales, they are sometimes depicted as birds that bring lovers together or symbolize strong friendship and filial piety. The body of a crow grows to 48 to 52 cm as an adult, and its beak is longer and stronger than that of pigeons or magpies. Crows have a habit of singing loudly and quickly three or four times in a row, sitting on a high place like the top of a tree. Some crow species in the northern hemisphere are particularly large, with wingspans exceeding 1 meter, making them appear like birds of prey. In particular, crows are known for being smart enough to use tools and recognize themselves when looking in the mirror.[3, 4]

(a) Pigeon **(b) Magpie** **(c) Crow**

Fig. 1 Types of medium-sized birds

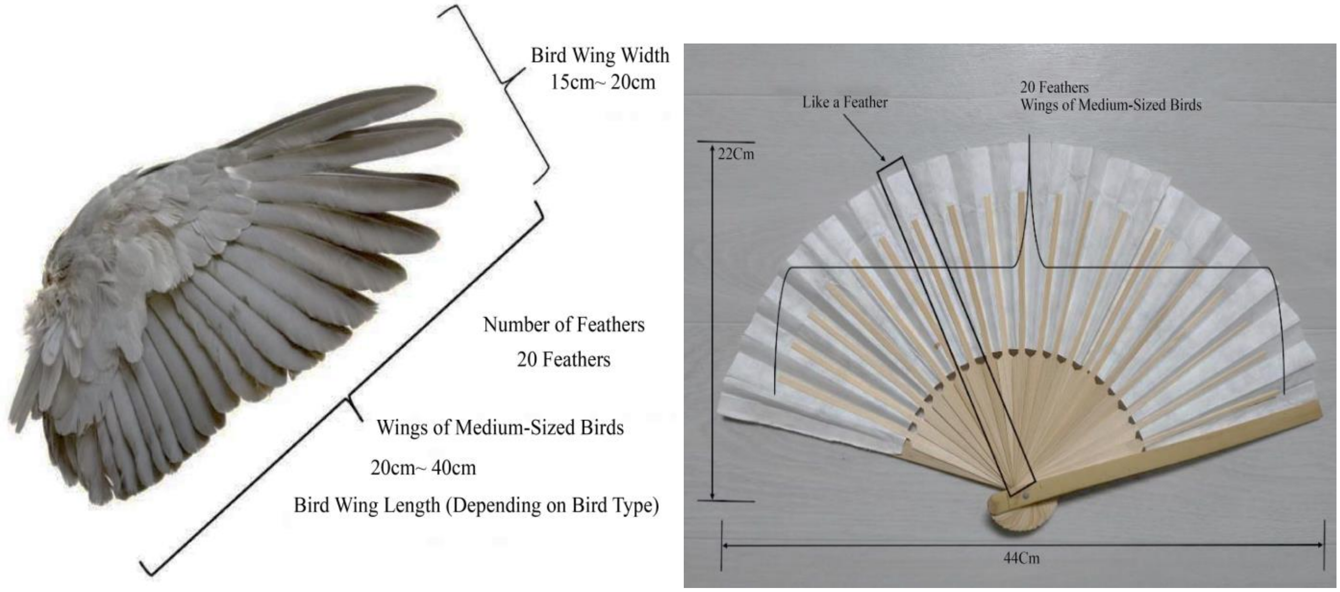
3. A Study on Foley Sound for Medium-Sized Bird Wing Flapping Sounds

Birds range from very small hummingbirds to cute-sized birds such as sparrows and titmouses, pigeons, mid-sized birds such as crows, and large-sized birds such as eagles and hawks. What they have in common is that they fly because they have wings, and the difference is that the size of their wings increases as their weight class increases. This paper aims to conduct research on the implementation of the Foley Sound for the wing-flapping sounds of medium-sized birds. For the Foley Sound study of wings of medium-sized birds, first of all, the shape of the wings of medium-sized birds and the Foley Sound tools were compared visually. Subsequently, we study the implementation methods of the Foley Sound for medium-sized bird wing flapping.

3.1. Size comparison of Medium-sized Bird Wings and Foley Sound Tools

To create the Foley Sound for the desired object or animal, a detailed analysis of the characteristics of the target sound is necessary. In order to create the Foley Sound of the flapping sound of medium-sized birds studied in this paper, it is necessary to examine the structure of the wings of medium-sized birds and analyze how the wings operate. The size of medium-sized bird wings ranges from about 20cm to 40cm in length, with a width of about 15cm to 20cm. Among medium-sized birds, magpies have the smallest wings, followed by pigeons, while crows have the largest wings. As such, the size of birds' wings differs according to the type of bird, and the young of the same type differ slightly depending on the nutritional status or innate shape. However, the size of wings can vary slightly even among individuals of the same bird species due to nutritional status and innate characteristics. Thus, we based our research on medium-sized bird wings with an average size.

When observing the specific wing structure of medium-sized birds (Figure 2a), we find that one wing typically has ab out 20 feathers. From this perspective, to imitate the wing fla pping sound of medium-sized birds with the Foley Sound, we selected the traditional Korean folding fan (Folding fan mad e of bamboo and Korean paper), called "Hapjukseon" in Kore an, as the suitable Foley Sound tool.



(a) Wings of Medium-Sized Birds **(b) Hapjukseon(Folding fan made of bamboo and Korean paper)**

Fig. 2 Comparison of bird wings with foley sound tool

The reason for selecting the folding fan(Korean: Hapjukseon) is that when fully opened, its size is slightly larger than the average medium-sized bird wing, with a width of 22cm and a length of 44cm, which closely resembles the size of a medium-sized bird wing. This makes it adequate for depicting the wing-flapping sounds of medium-sized birds. Moreover, the fan's structure, composed of 20 ribs and supported by paper, closely resembles feathers, and we anticipate it can serve a similar function as the feathers of medium-sized birds. [5, 6]

3.2. Comparison between Feathers of Medium-sized Bird Wings and Foley Sound Tool "Hapjukseon"

To create the Foley Sound for the wing flapping of medium-sized birds, a more detailed comparison between the medium-sized bird's wing and the Foley Sound tool, "hapjukseon," was conducted. Hapjukseon is a traditional Korean fan. It is a beautiful and wonderful fan used by folding and unfolding after making a frame with bamboo, making a framework by weaving several (approximately 20) thin bamboo fan blades inside, and then attaching hanji (Korean traditional paper).

It is a beautiful and elegant accessory that people carry and use as a fashion item, sometimes writing various poems, phrases, or drawing pictures on the hanji of the Hapjukseon, making it attractive regardless of the season. It was fashionable to carry around and use at any time of the year, not just in summer. Figure 3 is a picture proving the similarity between a part of the Hapjukseon, which is a Foley Sound tool selected to imitate the wing beat sound of a medium-sized bird and a part of a bird's feather.

In real bird feathers, the bone that runs through the center is called 'Calamus (Quill)'; the middle part to the top, where the feathers are attached, is called 'Rachis'. This place is like a thin bamboo rib inside the Foley Sound tool(Hapjukseon). In addition, the delicate hairs attached to both sides of the feather are the 'Vexill' part and form from the lower part 'Downy barbs (Plumulaceous)' to the middle part 'Barbs' and 'Feather tip'. This part is the part that replaces Hanji in Hapjukseon. Since Hanji is a soft and tough paper made with a unique manufacturing method using the bark of a mulberry tree that grows wild in Korea, it is comparable enough to the delicacy of a bird's feather [7, 8].

4. Implementation Method of the Foley Sound for Medium-Sized Bird Wing Flapping

In order to implement the sound of a medium-sized bird's wings with the Foley Sound tool, it is necessary to analyze the flying shape of a real medium-sized bird in detail and mimic the unique bird's movement to implement the sound.

When a medium-sized bird takes flight, the rhythm, melody, and repetition of the bird's wing sound should be the basis, and the dynamics should be adjusted to imitate as similarly as possible.

The speed at which birds beat their wings is inversely proportional to their body size. In other words, the smaller the bird, the faster it beats its wings. The wing beat the speed of medium-sized birds is slower than that of small birds, such as sparrows and titmouses, and faster than large birds, such as eagles and hawks. Figure 4 'a' illustrates a crow in flight, showcasing both its wings (circled as A and B) that resemble the Foley Sound tool "Hapjukseon" when fully extended on both sides, giving the appearance of flapping wings. Figure 4 'b' depicts a Foley Artist holding the unfolded “Hapjukseon” and mimicking the sound of medium-sized birds in flight. By completely extending the hapjukseon (shown in hand B) and rapidly shaking it back and forth against the palm of the other hand (hand A), the artist generates frictional sounds that mimic the wing flapping of medium-sized birds, gradually decreasing the volume [9, 10].

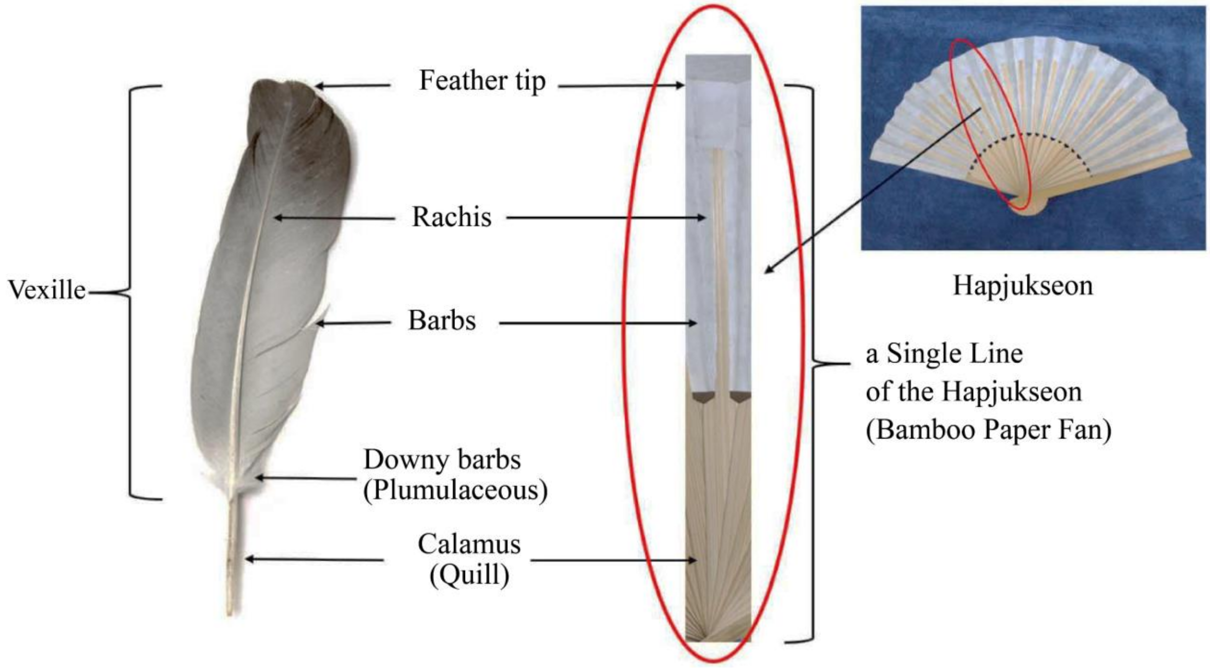
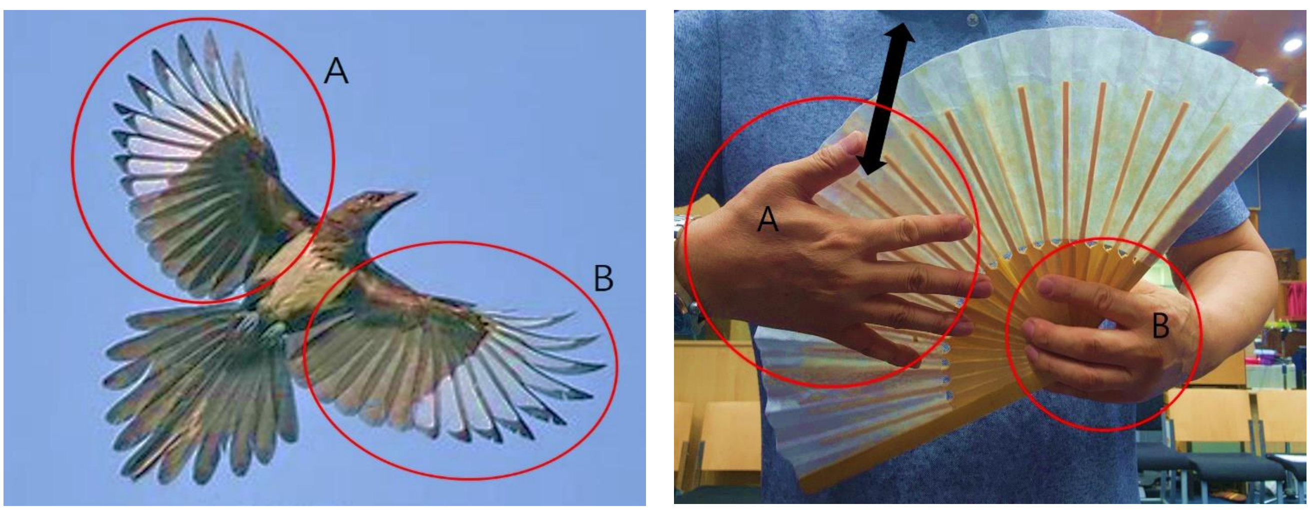


Fig. 3 Feathers of a medium-sized bird's wing and part of a foley sound tool "Hapjukseon"



(a) Flying magpie **(b) Foley sound for bird flapping**

Fig. 4 Implementation of the foley sound of medium-sized birds beating their wings

5. Comparison and Analysis of the Real Sound and the Foley Sound for Medium-Sized Bird Wing Flapping

In order to compare the flapping sound of medium-sized birds with the Foley Sound, we analyzed the soaring sounds of real medium-sized birds and their Foley Sounds in various ways. First, to compare the real sound and the Foley Sound of a medium-sized bird flapping wings, the actual sound and Foley Sound of a medium-sized bird flapping were collected and prepared. The H2 digital recorder was used for recording, and the analysis was performed using Adobe's audition program; the channels were Mono, Sample Rate was set to 1,600Hz, and Bit Depth was set to 32bit. The actual sound and Foley Sound of the prepared medium-sized bird's flapping sound were analyzed by dividing them into time, energy, frequency, and MOS test domains. Through the time domain, the similarity between the real sound of a bird's wing and the sound of the Foley Sound was identified over time, and through the energy domain, the energy of the real sound and the Foley Sound was compared. In addition, the verification result through the MOS test was additionally used as a similarity verification procedure and the preference for using Foley Sound as a sound effect was investigated and reflected in the result [11, 12].

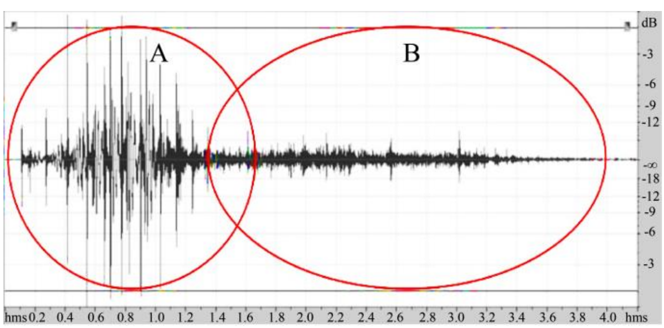
5.1. Time Domain Analysis

The real sound of medium-sized bird wings and the change in sound of Foley Sound over time can be identified through time domain analysis. Since the time-domain analysis shows the expression of the pitch and rhythm of the sound of a wingbeat of a medium-sized bird through a waveform, the overall similarity of the two sounds can be compared. In order to prove the similarity of sound in the waveform analysis for comparison and analysis of the real sound of the medium-sized bird's flapping sound and the Foley Sound, the time domain graph was analyzed, and the result value was obtained. Comparing the real sound of the medium-sized bird flapping and the time domain graph of the Foley Sound in Figure 5, it can be seen that the real sound 'a' and Foley Sound 'b' show similar waveforms regarding sound width and spacing over time. For this reason, it can be confirmed that the Foley Sound tool for medium-sized bird flapping is reasonable; the Foley Sound tool for medium-sized bird wing flapping shows a reasonable implementation of the speed, rhythm, and dynamics of actual bird wing flapping. In order to prove the similarity of the sound in the waveform analysis for comparison and analysis of the Real Sound of a medium-sized bird's wings flapping and Foley Sound, the Time Domain graph was analyzed, and the resulting value was obtained.

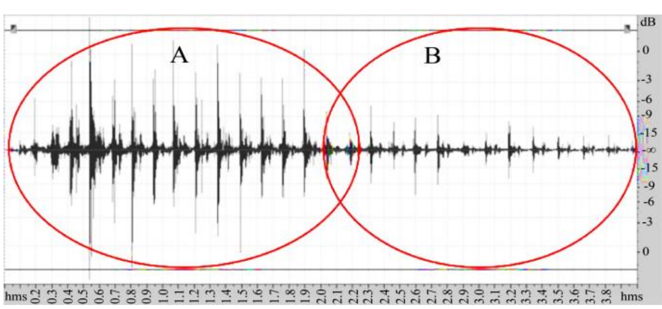
Looking at the time domain graph above, both the medium-sized bird's flapping sound 'a' and the medium-sized bird's flapping Foley Sound 'b', the red circle 'A' part, which is the part where the wings are flapped strongly to take off at the beginning, shows a strong and wide waveform, and the red circle part 'B', which moves away while flying, narrows the sound width and expresses a thin waveform for a long time. However, in the real sound 'a' of the medium-sized bird's wing beat, the red circle 'A' part, which starts to fly up, is shorter than the Foley Sound 'b', and the red circle 'B' part, which is the part where it flies away, is expressed longer. The reason for this is that Foley Sound 'b', the wings of a medium-sized bird, expresses the part 'A' of the red circle, which is the part of the wing that starts to fly up several times as people express themselves gradually weakening with tools. This is just a difference in the number of flapping wings, and the similarity of sound is judged positively when viewed from the overall graph [13, 14].

5.2. Energy Domain Analysis

Spectrogram analysis was performed to compare and analyze the sound energy distribution of the Foley Sound and the actual sound of the wing flapping sound of medium-sized birds. The spectrogram analysis is a program that can more clearly analyze the energy component elements expressed by the sound. It aims to verify the similarity of timbre and volume for each sound to be compared. The spectra were compared and analyzed to compare the characteristics of each frequency band of Foley Sound with the Real Sound of a medium-sized bird's flapping wings.

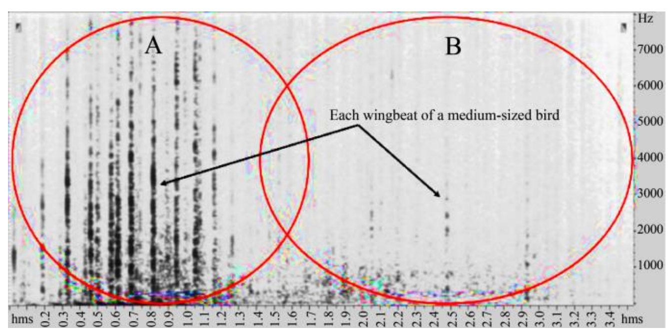


(a) Real sound of a medium-sized bird flapping

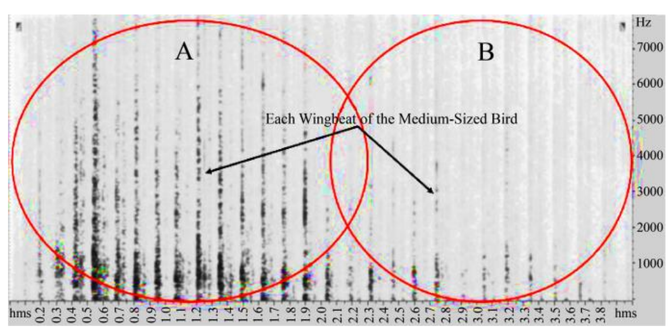


(b) Foley sound of a medium-sized bird flapping

Fig. 5 Time-domain analysis of the real sound of a medium-sized bird beating its wings and the Foley Sound



(a) Real sound of a medium-sized bird flapping



(b) Foley sound of a medium-sized bird flapping

Fig. 6 Spectrogram analysis of the real sound of a medium-sized bird beating its wings and the foley sound

In the Frequency Domain analysis, the Frequency Domain components were analyzed using the FFT concept to identify the Real Sound of a medium-sized bird's flapping wings and the frequency characteristics of the Foley Sound, and the resulting values were obtained.

As shown in the figure above, in the spectrogram graph of the sound of a wingbeat of a medium-sized bird, both the real sound 'a' and the Foley Sound 'b' have several bar-shaped vertical lines arranged in dark and light parts. In both graphs, the vertical line in the red circle 'A' is expressed thickly, and the vertical line in the red circle 'B' is expressed lightly. The vertical line of the red circle 'A', which is expressed thickly, is the part with strong sound energy, and the strong wing flapping when the bird first takes flight is expressed. The red circle 'B', expressed as a light vertical line, is the gradually weakening wing flapping sound.

The spectrogram analysis indicates that both the real sound 'a' and the Foley Sound 'b' exhibit similar patterns of vertical bars with consistent spacing, suggesting overall similarity in sound. However, there are some differences in the number of intense and weak vertical bars between the two graphs. The reason for this disparity is that the Foley Sound 'b' attempting to replicate the medium-sized bird wing flapping likely included a few more repetitions of wing flapping cycles. The real flapping sound of a medium-sized bird suddenly became smaller because it had to record the situation in which it flew away while flying up into the air. The real sound 'a' was recorded while the bird flapped its wings in mid-air, resulting in a sudden reduction in sound amplitude, whereas the Foley Sound 'b' using the tool "Hapjukseon" for wing flapping was expressed more gradually without the bird soaring into the distance. Nevertheless, both graphs accurately depict the strong sound energy at the beginning of the bird's wing flapping and the gradual decrease in sound energy as the bird takes off, which is a crucial characteristic. Therefore, it can be concluded that the real sound and Foley Sound are generally well-represented and similar in their expression [15].

5.3. Frequency Domain Analysis

The spectrum was compared and analyzed to compare the characteristics of each frequency band between the real sound of the wingbeat of a medium-sized bird and the Foley Sound. In the frequency domain analysis, the frequency domain components were analyzed using the FFT concept to identify the real sound of the wingbeat of a medium-sized bird and the frequency characteristics of the Foley Sound, and the result value was obtained.

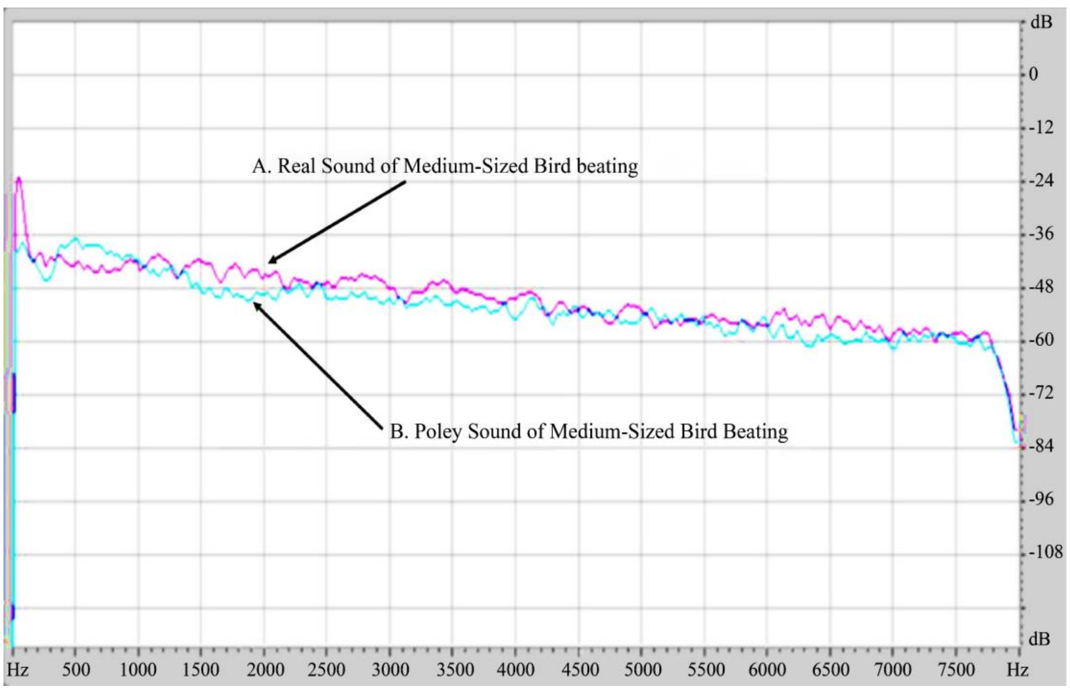


Fig. 7 Comparison of average spectrum between real sound and foley sound of medium-sized birds wings flapping

Table 1. MOS Test Results for the real sound and the foley sound of medium-sized bird wing flapping

Types	A	B	C	D	E
Wing Flapping Real Sound	5/4	4/4	5/5	5/4	4/3
Wing Flapping Foley Sound	4/4	4/5	3/4	4/4	4/5

Highest score: 5 points each, Score classification: Similarity score / Preference score

In Figure 7, the spectral comparison graph of the real sound and the Foley Sound of the medium-sized bird wing flapping demonstrates that they possess nearly identical frequency bands, proving that Foley Sound exhibits similar characteristics to the real sound. The graphs of the real sound 'A' and the Foley Sound 'B' of the medium-sized bird's wing beat are very similar, drawing parallel lines in the entire frequency domain. However, the red graph representing the real sound of medium-sized bird wing flapping 'A' shows slightly higher decibel differences in the overall frequency range from low to high frequencies compared to the Foley Sound of medium-sized bird wing flapping 'B', highlighting its more naturalistic expression. The spectral analysis results confirm that the medium-sized bird wing flapping's real sound and Foley sound form wide bandwidths and share similarities across the entire frequency domain [16, 17].

6. MOS(Mean Opinion Score) Test

The MOS (Mean Opinion Score) test is a short-form survey method to increase the reliability of various scientific analyzes (time domain analysis, energy analysis, spectrum analysis) performed above through the responses of 5 listeners who listened to the actual sound of the flapping sound of a medium-sized bird and the Foley Sound. In the MOS test method of medium-sized bird flapping sound, five listeners were asked to rate the similarity and preference by listening to the real sound of the bird flapping sound and the Foley Sound. The similarity score is a score to find out the similarity of the two sounds, and the preference score is a score to find out the preference for using the Foley Sound of medium-sized bird wings effectively in various fields.

For score calculation, 5 points each of similarity score and preference score were calculated as the highest score. First of all, listener A listened to the real sound of a medium-sized bird flapping and gave a similarity score of 5 and a relatively high score of 4 for preference to use it as an effect sound. After listening to the Foley Sound of medium-sized bird wings, the preference score was given 4 points, the same as the similarity score of 4 points. The reason was that the Foley Sound was very similar to the realistic sound, but the naturalness was somewhat less than the real sound.

Listener B gave the real sound similarity score of 4 points, the preference score of 4 points, and the Foley Sound similarity score of 4 points and the preference score of 5 points. The reason was that both sounded similar, but the Foley Sound felt more effective for use as an effect sound. Listener C gave the real sound 5 points for similarity and preference, and Foley Sound gave 3 points for similarity and 4 points for preference, giving a generally low score. The reason was that the actual sound was very real, but Foley Sound tried to imitate it similarly, but it sounded too artificial instead of natural. Listener D gave the same score to both real sound and Foley Sound as did A listener, and the reason was similar. Listener E showed opposite scores from C listeners when they heard the real and Foley sounds. The reason for this was that the real sound was realistic. However, the sound was somewhat rough, so it was not suitable for use as an effect sound, but the Foley Sound was not only very similar to the actual sound but also suitable for use as an effect sound because it was clear and clear. It was reasonable because the number of wing flaps could be freely expressed. Although there are some differences depending on each listening point of view, the five listeners generally expressed the opinion that the real sound of the bird's wings and the Foley Sound were very similar to each other. They responded that it was generally suitable for use as a sound effect [18].

7. Conclusion

Recorders in the early days of broadcasting were too large to be carried and had poor performance, so they could not be used in dramas with actual sound. Instead, all sounds had to be described as tools, and the sounds created using tools like this are called Foley Sound. In this paper, Foley Sound was studied to express the sound of the wings of medium-sized birds in broadcast dramas and movies. The Foley Sound study of the wing beat sound of medium-sized birds was conducted by comparing and analyzing the actual sound and the Foley Sound.

For a comparative analysis of the real sound of wing beats of medium-sized birds and the Foley Sound, first of all, the wing sounds of pigeons, magpies, and crows, which are active in Korea, were targeted. Among them, the actual sound of flapping wings of magpies flying up was prepared. Subsequently, we recorded the Foley sound of a medium-sized bird wing flapping using a tool called "hanjukseon" in a studio equipped with soundproof facilities. The prepared sound sources were analyzed for the characteristics and similarity of the two sounds through time domain analysis, energy analysis, and frequency analysis.

Additionally, we conducted the MOS test to determine the similarity and preference between the real sound and the Foley sound. The results showed that the Foley sound created using the "hapjukseon" tool accurately reproduced the rhythmic and temporal characteristics of the real sound, making it a highly similar alternative. As such, the Hapjukseon was an appropriate Foley Sound tool for the tone of the actual sound, and in its implementation method, it similarly imitated the dynamics control while keeping the tempo and speed, so the result of high similarity was obtained.

Even in the results of the MOS test, positive opinions were obtained, such as the preference score that the sound of the wings of a medium-sized bird and the Foley Sound are very similar and suitable for use as an effect sound. As a result of this study, it was concluded that the medium-sized bird wing flapping Foley Sound tool and Foley Sound implementation method are unique and interesting, so it is appropriate to use them as sound effects. Furthermore, it was concluded that this Foley Sound is a great item for exhibitions, experiences, and performances. It has a high possibility of being developed as sound content because it has enough advantages to get enough interest and response from the audience.

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