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A basic study on modification of fundamental frequency in synthesis of chorus

Akihiro Kuwahara (0710027)

School of Information Science,
Japan Advanced Institute of Science and Technology

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Music is one of the communication means to express human feelings and thoughts in a similar manner as speech and gesture. Wonderful music can sometimes give people a strong impression. Then natural questions are: how can we perform a wonderful music? which part of music impresses us so strongly? Such questions on "impressive music" motivate many researchers to study basics of the music play.

In cooperative music performance, evaluation of an individual performance is of course important. However, relationship between the performers is also quite important. Many researches have been carried out to study fundamental frequency, rhythm etc. between the performers. Despite such investigations, still few is understood about the relationship between various acoustic features. Objective evaluation is also not enough. Among various acoustic features, fundamental frequency between performers plays a key role especially in the evaluation of cooperative music performance. Therefore, quantitative analysis of the fundamental frequency is very useful.

In this study, we aimed at quantitative evaluation of cooperative music by focusing on the fundamental frequencies of the performers. We study singing voice in chorus, since fundamental frequency is more freely controlled compared with other musical instruments. We investigated which feature of fundamental frequency influences the evaluation of chorus. In

real human singing, it is impossible to accurately control the detailed structure of the fundamental frequency. So it is difficult to study the relationship clearly by such a chorus of real human. Therefore, we utilized a synthetic chorus which can control various features artificially, and investigated the synthetic sounds by listening examination. As main features of the fundamental frequency, we focused on frequency mismatch, timing mismatch, and phase and frequency mismatch of vibrato.

We synthesized chorus with various features and carried out the listening test. As a result, we found that the evaluation falls down rather distinctively with frequency mismatch of 30-40 cent and with timing mismatch of 40-60 ms. Our results also imply that the frequency mismatch has stronger influence on music evaluation than timing mismatch. In vibrato singing, critical value has been found with a phase difference of 0.25π - 0.5π and frequency difference of 0-0.5 Hz.

Moreover, to verify the validity of these criterions, we measured and analyzed chorus of real human subjects. One group of singers belong to a choir group, whereas another group of singers doesn't have special experience of chorus. As a result, we have seen that the criterions obtained by the synthesis experiment can roughly classify the two groups. Because the frequency mismatch classified the two groups more clearly than the timing mismatch, there is a possibility that the frequency mismatch has stronger influence on music evaluation than the timing mismatch. Thus, we confirmed that the results obtained by the synthesis experiment are consistent with the chorus experiments of real human.