Sound Quality Estimation using Human Hearing Sensation

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Abstract: This paper is on a study of objective sound quality estimation by using human hearing sensation. Six parameters were defined, which are related to the sound quality (Loudness, Sharpness, Fluctuation Strength, Roughness, Pleasantness, Annoyance), and signal processing methods for them were developed. In this way, a system that measures human hearing sensation was implemented. To prove objectivity of the system, its results were compared with subjective test results which were given by people. The overall average error rate was about 13%, which showed that it is very useful.

EXPERIMENT

The proposed Sound Quality Estimation System is divided into four parts: three analyzing parts in time domain, frequency domain and bark domain, and a calculating part for parameter values. The analysis in time domain determines modulation frequency and modulation depth of a sound. The analysis in frequency domain measures frequency density of a sound through 24 filters. The analysis in bark domain has the following two procedures: masking-effect analyzing and unit converting from dB to sone. By using time information and the analysis results obtained from the three domains above, the proposed system calculates the hearing-sensation-related sound parameters.

(1) Analysis in time domain
Two factors on how often a given sound's envelope changes and how deeply it fluctuates are measured here. These two factors are closely related to sound vibration, and influence on most of the six parameters.

(2) Analysis in frequency domain
Human hearing system breaks the audible frequency range (20~20,000Hz) into 24 bands and percepts each frequency density separately. To consider this feature, 24 filters were used.

(3) Analysis in bark domain
Masking effect is considered here and dB unit is converted into subjective loudness, sone.

(4) Parameter calculation
The equations, which were made by extensive experiments, can approximate the human hearing sensation. They determine the parameter values by using the analysis results.

RESULT

To prove the system's objectivity, subjective tests by people were conducted in parallel with the objective tests by the system. Two kinds of the result were compared so as to see how reliable the system is. FIGURE 2 represents the...
flowchart. The experiment was conducted for 12 sounds and for 20 people. The sounds were chosen from the seven kinds of sound group, and the people were selected in between 20 and 40. FIGURE 3 shows the results for the main song of a movie, 'Romeo & Juliet.' In FIGURE 3(b), the solid line with star marks (+) depicts the results taken from the system, and the dashed lines came from 20 people. FIGURE 3(c) means the average error rates between the two experiment results.

CONCLUSION

The average error rates between objective tests and subjective tests were 8.1% in loudness, 12% in sharpness, 16.1% in fluctuation strength, 17.8% in roughness, 5.5% in pleasantness, 19% in annoyance, and the total average rate was 13%. The conventional sound estimation has been carried out by people, which is not reliable and very dependent on many factors. Therefore, this system is expected to solve the problems and will be more accurate if binaural effect is considered in the future.

REFERENCES