Individualisasi model parametrik head-related transfer functions = Individualization of parametric model of head-related transfer functions

Hugeng, author

Abstrak

Sintesis sistem audio spasial ditemukan dalam banyak aplikasi krusial, seperti dalam pesawat terbang militer maupun komersial, pengembangan virtual reality, termasuk di dalamnya aplikasi dalam permainan-permainan elektronik, maupun sebagai consumer electronics yang memberikan efek bunyi spasial dan kenyamanan bagi pengguna dalam mendengarkan musik. Hampir semua sistem yang mengaplikasikan sintesis audio spasial atau tiga dimensi, memerlukan Head- Related Impulse Response (HRIR). HRIR merupakan fungsi alih dalam kawasan waktu dari gendang telinga manusia yang melakukan penyaringan bunyi yang datang pada gendang telinga tersebut.
Pemodelan HRIR dengan parameter-parameter yang dapat diatur sesuai dengan antropometri pendengar merupakan salah satu solusi dari masalah yang timbul akibat menggunakan HRIR yang non-individual, seperti bunyi terdengar tidak seperti aslinya, serta bunyi terdengar di dalam kepala jika digunakan headphones. Hasil yang sangat bagus diperoleh jika digunakan HRIR individual milik subyek itu sendiri. Tetapi pengukuran HRIR individual ini memerlukan waktu, biaya dan energi yang tidak sedikit.
Di dalam penelitian ini, dimodelkan HRIR fasa minimum, di kawasan waktu, dan Head-related Transfer Function (HRTF) magnitude, di kawasan frekuensi, dengan menggunakan metode statistik Principal Components Analysis (PCA) dengan 10 vektor basis, untuk sumber-sumber bunyi di bidang horisontal dan di bidang median. Sedangkan individualisasi dari model HRIR dan model HRTF tersebut dilakukan berdasarkan Multiple Linear Regression (MLR) dari bobot-bobot vektor basis PCA yang dapat diatur, sesuai dengan 8 ukuran antropometris terseleksi. Seleksi 8 dari total 27 ukuran antropometris dilakukan berdasarkan analisis korelasi antara parameter-parameter psikoakustik penting dan bobot-bobot vektor basis PCA terhadap 27 ukuran antropometris.
Individualisasi model HRIR fasa minimum menghasilkan mean-square error (MSE) rata-rata yang cukup memuaskan sebesar 22,5% di bidang horisontal dan 20,42% di bidang median. Di kawasan frekuensi, dihasilkan MSE rata-rata lebih kecil untuk individualisasi model HRTF magnitude, yaitu 12,17% di bidang horisontal dan 11,21% di bidang median. Model-model HRIR dan HRTF individual dapat mengaproksimasi dengan baik pola-pola dan struktur-struktur detail respon-respon HRIR dan HRTF asli yang bersangkutan. Tes pendengaran dalam menentukan posisi-posisi sumber bunyi di bidang horisontal menghasilkan persentasi kebenaran yang lebih besar jika digunakan model-model HRIR individual daripada jika digunakan HRIR non-individual.
.....Syntheses of spatial audio systems are found in many crusial applications, such as both in military and commercial aeroplanes, development of virtual reality, electronics games, and consumer electronics that have given spatial effects on sound so that the listeners are pleasant in hearing their music. Most of the systems that synthesize spatial audio need head-related impulse responses (HRIRs) of human ears. HRIRs are impulse responses of human's eardrum, in time domain, that are responsible in filtering incident sound to that eardrum.

Modeling HRIRs with tunable parameters that are suitable to anthropometrie of a listener is a solution to emerging problems by using nonindividualized HRIRs, e.g. sound heard as if it were in head when using headphones and sound heard is not natural. The best results are obtained when the listener uses his/her own individual HRIRs. However, measurements of individual HRIRs require a huge amount of time, cost, and energy.

In this dissertation, minimum phase HRIRs were modeled in time domain and magnitude HRTFs were modeled in frequency domain, by using the statistical method named Principal Components Analysis (PCA) with 10 basis vectors, for sound sources on horizontal plane and on median plane. The individualization method used for the models of minimum phase HRIRs and the models of magnitude HRTFs, was based on Multiple Linear Regression (MLR) between weights of basis vectors obtained from PCA, that could be adjusted due to 8 selected anthropometric measurements. The selection process of 8 out of all 27 anthropometric measurements was performed based on correlations analysis between psychoacoustically crusial parameters; weights of basis vectors of PCA; and 27 anthropometric measurements.

Individualization of models of minimum phase HRIRs resulted in quite satisfying average mean-square error (MSE) of 22,5% for sources on horizontal plane and of 20,42% on median plane. In frequency domain, average MSE obtained from individualization of models of magnitude HRTFs was much better, that was 12,17% on horizontal plane and 11,21% on median plane. Individualized HRIRs models and individualzed HRTFs models were able to approximate very well the patterns and detail structures found in respective original HRIRs and HRTFs. Listening tests performed for sound sources on horizontal plane resulted in that larger correct rates were obtained, if models of individualized HRIRs were applied, than if models of non-individualized HRIRs were applied.