別紙様式５(Attached Form 5)

学位論文要旨 Abstract of Thesis

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Title of Thesis

Development of Dual Loudspeaker System for Controlling Unidirectional Sound Propagation in Low Frequency Range.

（低周波数帯域における単一指向性音響信号伝搬制御を目的とした 2 スピーカシステムの開発に関する研究）

Abstract（within 1600 words）

Geographically, Indonesia is an archipelago country between Asian and Australian continents, most of capital cities are mainly coastal lowlands lying between the Indian and Pacific oceans. Natural disaster especially earthquake are common in Indonesia. Because of tsunami swept across the Indian ocean in Indonesia on December 2004, there are more than 200.000 people died. Human safety is the most important issue in disaster management, so it needs to protect the public against disasters. An emergency evacuation systems is necessary to be developed for evacuation people in public buildings. Inspired by the visible running light system as a directional pointer sharply, came an idea to develop the digital sound signage for evacuation people when smoke-filled disaster occurred. Existing alarm system is used bell sound just for information about emergency situation, it can not guide people to emergency exit gates. Speech is a sound signal containing information that is easily and quickly understood. Using speech as sound signage in emergency systems can effectively increase human safety in low or poor visibility conditions. Combination of two tones of multiple harmonic tone and speech that are separated by time-delay had been developed. This emergency sound is one of an effective way to evacuate people in tunnels when smoke-

disaster occurred. However, quality of the speech will be reduced when the designed emergency sound is sounded simultaneously on array loudspeakers. It is necessary to control each loudspeaker for sounding alternately. For this purpose, there is application of time-delay technique in an array loudspeakers for developing directional sound signage. This system uses trumpet loudspeakers and requires to set the time-delay according to the distance between the two loudspeakers. Other research had successfully developed unidirectional sound reproduction system for speech frequency range from 500 Hz to 4000 Hz. However, reflections of sound through walls, ceilings will affect clarity of speech. Unfortunately, characteristics of sound reproduction systems, a single loudspeaker propagates sound waves in omni-directional at low frequencies. Therefore the propagation of each loudspeaker in reverse direction direction will interfere sound quality of the loudspeaker that stands behind it, consequently emergency speech becomes difficult to understand. This research proposes a simple dual-loudspeaker system for reproducing sound wave as well as speech, with unidirectional characteristics focused on frequencies up to 600 Hz. The proposed system consists mainly of a primary loudspeaker for introducing sound as a main lobe, a secondary loudspeaker is used for reducing gain in the undesired direction, and digital filters. An adaptive finite-impulse-response (FIR) filter is used to produce the controlling sound by implementing a filtered-x least-mean-square algorithm, and a delay filter for adjusting the time alignment of sound propagation between primary and secondary sources at the control point. Several operational conditions for illustrating real situations and reflections were considered in an anechoic chamber. Experimental results show the unidirectional propagation patterns of the proposed dual-loudspeaker system for the required conditions. In a low frequency range, the system is able to control unidirectional sound propagation; there is a main lobe of sound in the desired direction, and conversely reduction of the undesired gain in the direction around the control point.