Development of new diagnostic techniques

Takuji KOIKE Laboratory

Takuji KOIKE

Summary of Research

Collaboration Between Vibration and Acoustic Engineering and Medical Science

Our laboratory pursues basic and applied research to clarify the structure of body tissue and their functions, based on sound-wave and vibration measurement, numerical analysis, and image processing. We also perform studies related to applications and development across a broad range of fields, including the development of novel measuring technologies and devices that can be used for treatments, the development of optimal surgical techniques with numerical simulations, and the development of new communication devices.

Mechanisms of Hearing and Hearing Impairment

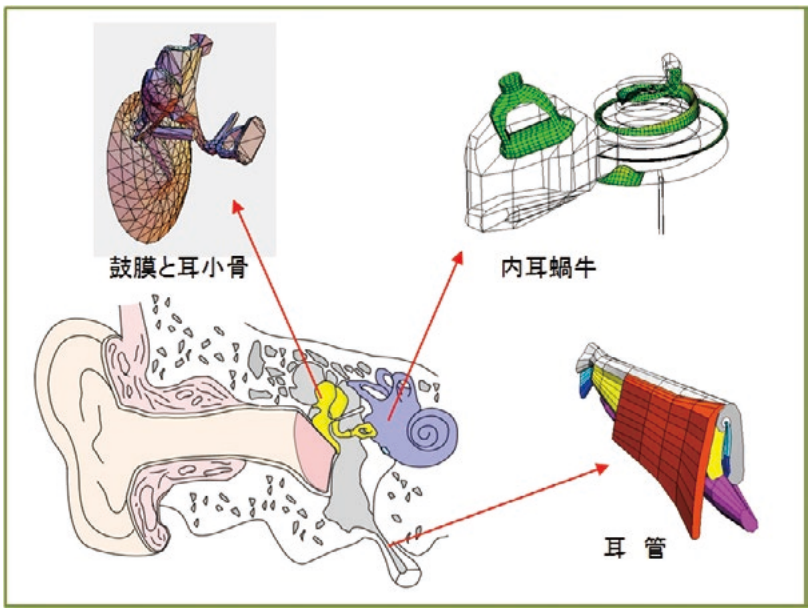
In the field of sensory organs, we pursue studies to elucidate the functions of the auditory organs, as well as applied studies for disorder diagnosis and function recovery. Our goal is to elucidate the mechanisms underlying hearing by performing computer simulations on nano-level vibrations and to determine the mechanisms involved in hearing impairments.

A System for Optimal Surgery Presentation

Effective methods for hearing impairment can be examined and proposed to surgeons by performing virtual surgery with computer simulations for the corresponding pathology.

Mobility Measuring Instrument for Auditory Ossicles

One example of our research on the development of instruments for diagnosis of disorders of auditory organ and function recovery involves the development of a quantitative evaluation device concerning the mobility of auditory ossicles (the small bones that transmit the vibrations of the eardrum to the cochlea), which until now had been evaluated based on the doctor's experience in clinical situations. The hand-held device developed applies a small displacement of about 10 micrometers to the target of measurement (the auditory ossicles) and measures the reaction force (on the order



Clarifying the function of auditory organs through computer simulations

Keywords

Surgical navigation system, bioengineering, functional elucidation of sense organs, simulation, virtual surgery, measurement of vibration and sound, PVDF film, biomedical applications, human-machine systems, hearing impairment, auditory ossicles, bone conduction hearing aids

Affiliations	Japan Society of Mechanical Engineers; Acoustical Society of Japan; Society of Biomechanisms Japan; Oto-Rhino-Laryngological Society of Japan; Japan Otological Society; Japan Audiological Society; Japanese Rhinologic Society; Association for Research in Otolaryngology
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of about several millinewtons). The device allows surgeons to evaluate the mobility of the auditory ossicles during surgery and provides them with information for selecting a safe and effective surgical procedure to achieve improved post-operative results.

Artificial Hearing System

We are also developing compact embedded bone conduction hearing aids that offer high sound quality. Using as its oscillator a giant magnetostrictive material, this device is implanted under the skin. Mutual induction between coils sends energy and audio signals percutaneously from the external unit. Our goal is to develop a hearing aid capable of reproducing clear high-frequency sounds that are difficult for conventional hearing aids based on normal sound waves.

Using PVDF films, we are also measuring the epidermal vibrations created during vocalization to develop a system capable of acquiring clear audio signals, even in noisy environments.

Advantages

Measurement and Simulations in Otology - a Rarity in Japan

To date, various surgical navigation systems have been developed for otological surgery. However, no system has been developed to provide surgeons with real-time information on the causes and mechanisms of impaired physical function, including what the current problems are, what can be done about them, and what results we can expect, and present them with the optimal surgical procedure and prognosis, all based on the results of in-surgery measurement and simulation.

To develop such next-generation surgical navigation systems, we are currently collaborating closely with numerous faculties of medicine at both domestic and foreign universities.

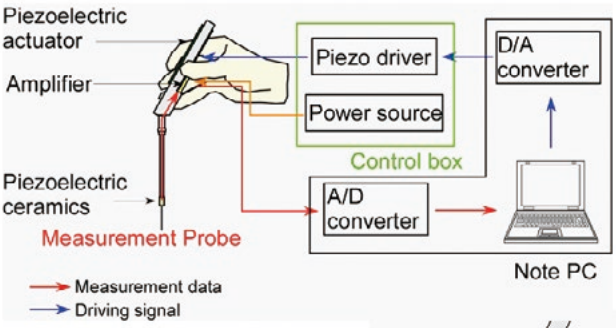
We are also seeking to develop a new communication device and an instrument based on totally new diagnostic and treatment principles.

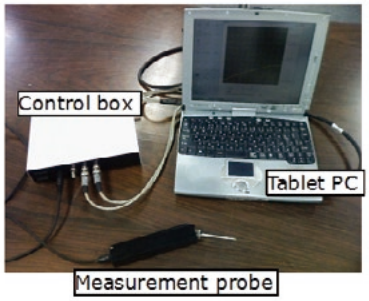
Future Prospects

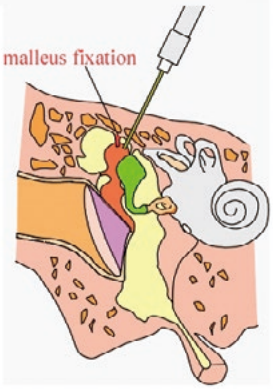
A Field Characterized by High Demand and Growing Prominence

In the future, we plan to elucidate the mechanisms underlying various disorders and to develop optimal surgical solutions based on simulations of the entire auditory system, taking into consideration electrical mechanisms as well as physical movement. We also plan to develop an innovative new hearing aid system.

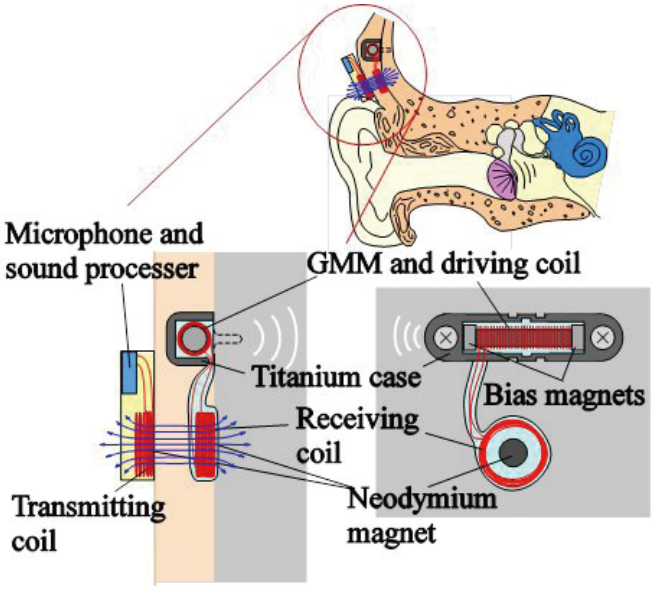
By developing products that embody the practical application of our sound-wave and vibration measurement and control technologies, we hope to expand our research fields to include such endeavors as the clarification of biological mechanisms and the development of biologically compatible devices.



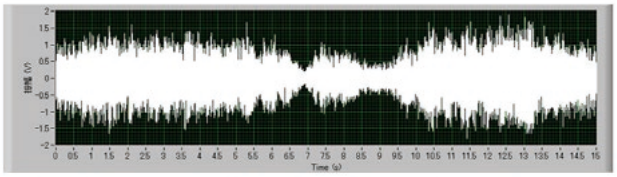




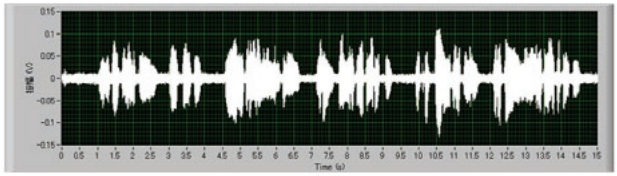
Mobility measurements of auditory ossicles



Implanted bone conduction hearing aids



(a) Audio signal obtained under noisy conditions with conventional microphone (construction site, 85 dB). The audio signal is buried in the noise.



(b) Vibration of skin surface obtained with PVDF film under noisy conditions. The noise is reduced and the audio signal is clearly recorded.

Audio acquisition device for noisy environments