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**35th Symposium on Hydroacoustics**  
**Polish-German Structured Conference on Acoustics**  
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**Abstracts**

**Low Noise Pavements in Germany:  
Established Concepts and New Ideas**

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Traffic noise, and road traffic noise in particular, is a problem to be solved in densely populated regions worldwide. Tire-road noise is the main source for road traffic noise and low-noise road surfaces are an effective measure for its reduction. In Germany, most low-noise surfaces are built in asphalt, giving a good acoustic performance whereas their durability under heavy traffic is not optimal. Concrete, instead, is very durable and ideal for roads under heavy traffic, but there are only a few concepts of low noise concrete road types. In several research projects a number of low-noise concrete road surface concepts have been investigated, including the optimization of standard road surfaces like exposed aggregate concrete or the postprocessing of concrete roads by diamond grinding. In addition, several new surface types have been developed from a virtual design, taking into account the deeper understanding of tire-road noise generation: these concepts include specifically designed road surface textures, novel materials for road construction such as ultrahigh performance concrete or specially designed porous materials.

The paper resumes the well-established low noise road surface concepts used in Germany and the outcomes of the above-mentioned research projects.

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**Active Vibration Reduction  
of Ship Propulsion Systems**

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Demands on the development of ship propulsion systems are an increase of efficiency and its vibro-acoustic behaviour. The paper gives an overview of the development methodology of active measures to reduce torsional and translational vibration of a ship propulsion system. Based on experimental investigation of a ship, a numerical model of the propulsion system is setup and updated by experimental results. The simulation model includes the rotational and translational vibration behaviour. The model structure follows an admittance-impedance description that is most suitable for the design of active vibration control systems. Different concepts for reducing vibration are evaluated and compared numerically compared. The realized systems are characterized in a propulsion system testing environment and eventually implemented in the real ship. Examples of realized measures as an inertial mass actuator and an energy-harvesting absorber are presented.

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**Decibel Algebra in Acoustics**

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**Digitally Controlled PA-Systems in Churches**

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Room-acoustic conditions in churches, especially in old large churches protected as buildings of historic impor-

tance, may not be a favourite for speech intelligibility. Therefore, speech enhancement systems are a requirement. A typical low cost solution is to install column loudspeaker systems with highly directed radiation. Unfortunately, the directivity always points out perpendicularly from the centre of the column, which in many applications leads to a tilting of the column. Moreover, a frequency independent directivity becomes difficult to achieve and the overall response in many cases is not satisfying.

To overcome these limitations a novel design with digitally controlled loudspeaker columns is available since several years and leads to a much better coverage. Due to the better steering of the sound distribution in space the number of loudspeakers can be reduced drastically thus reducing the interference with the preservation order.

In this paper, the result of three different PA system designs will be discussed which were installed in the Cathedral of Cologne, the Cathedral of Münster and a Baroque Church in Münster.

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### Ultrasonic Studies on Pickering Emulsion Formation Process

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### Acoustic Data Analysis for the Assessment of Wood Boring Insects' Activity

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The following paper presents the methodology for the acoustic analysis of the wood boring insects activity. Their detection in the consumer wood has significant economic impact. The most important is the measurement of energy generated by the larvae feeding on the piece of wood. To detect the candidate sounds, the moving narrow time window was implemented. The analysis was performed in the noisy environment, therefore the Support Vector Machine classifier was used to distinguish between the larva-generated sounds and all other coming from the environment. Results show the usefulness of the approach to assess the larvae activity based on the measurement of intensity and energy of sounds generated by them.

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### The Hopping Discrete Fourier Transform to Speed Up Convergence of a Frequency-Domain Active Noise Control System

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Frequency-domain least mean square (FDLMS) algorithm is a good alternative to traditional, time-domain processing. It requires less computational demand and offers a possibility to individually adjust the convergence speed of different frequency components. Moreover, it allows to shape the frequency response of an adaptive filter easily. The classical implementation of the FDLMS uses a block size of double the adaptive filter length to avoid the circular effects. Considering that active noise control systems use long adaptive filters, and that the update of the filter coefficients is once per the block size, this implies the update is not performed very often and introduces an unwanted time delay in the control path. However, it is possible to adjust the block size to values different than double the adaptive filter length. The negative aspect of this attitude is that the growth of the computational demand. The use of real-time discrete Fourier transform algorithms allows to fight this negative effect.

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### Feedback Loops in Models of the Auditory System

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Current advanced models of the auditory system consist of an intelligent network of signal-driven (bottom-up) and hypothesis-driven (top-down) algorithms. These systems are built to identify and characterize auditory objects and to interpret and understand auditory scenes. Among other things, this enables them to help plan and initiate appropriate actions. Further, they are able to make judgments – for example, on the quality of experience in spaces for musical performances. To achieve these goals, adequate feedback loops have to be considered, simulated, and implemented. In this talk, the basic architecture of such an advanced model is presented and some feedback loops that have already been realized and evaluated are described and discussed.

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### Comparison the Beamforming Method with Standard Acoustics Measurements in Industrial Environment

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Characterizing the source of noise from a machine is an important task for manufacturers of consumer goods. The main problem is often related to the industrial environment, in which the noise level is results from many production processes occurring simultaneously. There are several measurement methods for measuring the sound level of acoustic source. The conducting research to develop noise controls for production process involves: 1) noise source identification; 2) development of noise controls; 3) evaluation of the developed noise controls. In this work the application of beamforming for identification of noise source on the production line for plastics processing is presented. The performance of the proposed technique is also evaluate by comparison with method based on ISO 3746: Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane. However, the microphone array technique is very fast and can use to acquire acoustic emission of the machine or all production line in standard work condition. This method focuses on the microphone sensitivity what allows avoid disturbance of surrounding environment other machines.

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#### Design of Acoustic Chamber for Loudspeakers Measurements

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The design of small anechoic chamber dedicated for measurements of acoustical parameters of hi-fi loudspeaker systems is presented in the paper. Sound insulation, noise from technical equipment and acoustics of the room are discussed. The laboratory consists of three main rooms: anechoic chamber, control room and equipment room. The chamber of 140 m<sup>3</sup> effective inner space with full anechoic condition from 100 Hz is planned as “box in box” construction. The acoustics of the measurement room allows for loudspeaker measurements according to EN 60268-5 standard. Sound absorption of acoustical wedges made from polyurethane foam and rockwool is also measured and compared. The disadvantages of foam wedges are discussed. The new idea of loudspeaker-microphone-walls setup that allows for measurement in the frequency range above 80 Hz is proposed. This frequency lies below the chamber cut-off frequency. The applied technical solutions of sound insulation are also discussed.

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#### Volumetric and Acoustic Properties of Ionic Liquid [bmim][BF<sub>4</sub>] in Methanol and N,N-dimethylacetamide

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This study is a part of larger study which examines the thermophysical (acoustic, volumetric, conductometric, refractometric and viscosimetric) properties of selected imidazolium ionic liquids in various molecular solvents. Densities and sound velocities of 1-butyl-3-methylimidazolium tetrafluoroborate in two different solvents, protic methanol and aprotic N,N-dimethylacetamide have been measured. The studies were conducted in dilute solutions at temperatures ranging from (283.15 to 318.15) K and atmospheric pressure. Apparent molar volumes, apparent molar isentropic compressibilities and their values at infinite dilution have been evaluated. These results have been discussed in terms of ion-solvent and ion-ion interactions.

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#### Quality Evaluation of Speech AAC and HE-AAC Coding

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The paper presents the results of quality assessment of speech signals transmitted via DAB+ system. The subjective research was provided with the use of ACR procedure, according to the International Telecommunication Union recommendation, and the results have been presented as the MOS values for various bit rates. The comparative analysis of the subjective assessment for speech encoded with AAC and HE-AAC techniques were presented. The subjective tests were carried out for the testing material prepared for Polish speech.

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#### The Analysis of Sound Propagation in Opera Houses in the Context of Stage Curtains Legs Arrangement

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Stage curtains legs are an inseparable element of the theatre stage, but it can appear in many forms and types of construction. The basic function of the legs is the visual separation of the backstage and off stage with a simultaneous possibility for the actors to move around. However, due to their large size and location within the main stage action, the surfaces of the legs have a significant impact on the sound propagation in the room. Most often they are made of textile materials stretched on the frame, which creates a sound-absorbing and reflective acoustic system. The degree of sound absorption and the shape of these surfaces will determine the energy of the sound reflected and transmitted to the audience. The properly selected number of legs and the type of fabric also have a positive effect on obtaining comparable acoustic conditions in the audience and stage. The article presents the analysis of the influence of the structure and shape of the stage curtain set layout on

the distribution of the sound power parameter at the audience, and also the analysis of the interaction between the stage and orchestra on the example of selected interiors of opera theaters. The research was carried out on computer models using geometric methods. The results indicate to what extent the type and shape of the legs can affect the transmission of sound from the stage to the audience.

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### Bearing Calculation Accuracy for a Simulated Noise Source Using a Hydroacoustic Tetrahedral Antenna

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Moving object in the marine environment is a source of hydroacoustic disturbances. Detection of the acoustic disorder is possible using a single hydrophone, while tracking changes of object bearing requires multi-sensor solution. There are well known solutions such as linear and tetrahedral multisensor antennas. The advantage of the second solution is the use of 4 sensors located on the vertices of a regular tetrahedron instead of 6, i.e. 3 pairs for each axis of the Cartesian coordinate system. The proper rotation of the tetrahedron around the center of the coordinate system makes it easier to determine the object bearing in the vertical and horizontal plane. The publication will present the results of the algorithm calculating the bearing angle of the apparent moving object and discrepancies depending on the input values.

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### Low-Power Ultrasound Imaging on Mixed FPGA/GPU Systems

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Portable and hand-held ultrasound imagers have a potential to revolutionize Point-of-Care medical diagnostics. There is great need for low-cost, portable scanners with extended battery life. In this paper, we focus on hardware-software partitioning in heterogeneous systems where both field-programmable gate array (FPGA) and graphics processing unit (GPU) resources are available. We present an architecture of a prototype test scanner for the evaluation of various hardware-software partitioning strategies. The system is equipped with the Intel Arria 10 FPGA and the Nvidia Tegra X2 mobile GPU. FPGA-based beamformers: Delay-and-Sum and Filtered Multiply-and-Sum, were implemented. These 32-channel beamformer blocks are integrated into a complete dataflow along with the data

acquisition, RF filter, quadrature demodulator, and envelope detector. The designed dataflow allows to allocate processing functions to either hardware (FPGA) or software (GPU) to explore various imaging scenarios and optimize power consumption. A dedicated measurement setup facilitates measuring power consumption of both FPGA and GPU. The developed setup will provide a reliable experimental system power characterization.

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### Secondary Paths Analysis of an Active Casing Placed at a Wall

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The active casing approach is to reduce device noise by controlling vibration of its casing. Its efficiency was confirmed by the authors in laboratory experiments and it was reported in previous publications. However, the casing was distant from walls of the enclosure. Now, a new configuration is considered, when the casing is placed at a wall, and the actuators mounted on the casing from the side of the wall are also employed to actively reduce the emitted noise. In such configuration the acoustic reflection from the wall is intentionally used. The considered wall is smooth and rigid, thus it is highly acoustically reflective.

In this paper, a preliminary experimental investigation of such concept is presented. The primary and secondary paths analysis is given. Advantages and limits of the proposed approach are pointed out and discussed.

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### Soundscape Analysis of Selected Places in Longyearbyen Area

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Longyearbyen is the largest settlement and the administrative and tourism center of archipelago Svalbard located in the Arctic Ocean. This settlement is located on Spitsbergen – the largest Island of archipelago. Svalbard is interesting for many different researchers because it has an arctic climate and at the same time it is relatively easily accessible by plane. Climatologist, geologists, glaciologists, biologists and even anthropologists could find here interesting theme to investigate. Also soundscape of Spitsbergen is intriguing and need complex acoustic investigation. Since 2016, a group of scientists from the Department of Mechanics and Vibroacoustics of AGH University of Science



and Technology conducted 3 scientific expeditions to Spitsbergen – 2 during the winter and 1 during the summer. Performed field acoustic measurements included acoustic monitoring of Longyearbyen, sound pressure level measurement for noise map of settlement Longyearbyen, Pyramiden and Barentsburg, ambisonic recordings and soundscape analysis of places interesting because of tourism, and ice cave impulse response measurement. This paper presents comparative analysis of soundscape of various landforms nearby Longyearbyen in Management Area 10. This analysis showed variability and characteristic features of the natural Arctic soundscape.

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### The History of Acoustics in Breslau/Wrocław in 20-th Century – a Bridge Over Time

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Breslau had a long academic tradition. The acoustics was practised at the University since 19-th century. Ernst Chladni, lectured at the University. Gustav Kirchhoff was professor of physics here. In 20-th century acoustics was practised at University and at Polytechnics (Technische Hochschule), which was created in 1910. In the beginning of century professor Otto Lummer was active in the fields of optics and acoustics at the University. His successor was professor Clemens Schaefer. Professor Erich Waetzmann, was active at the TH Breslau. He was in years 1930-32 the Rector. Other significant acousticians were Kurt Schuster, Erwin Meyer, H.-J. von Braunmühl, Ludwig Bergmann, H.-O. Kneser. After World War II, Breslau became a city in Poland as Wrocław. In 1945 the common University and Polytechnics has been restituted. Both Universities have been separated in 1951. Acoustics is practised mainly at Polytechnics, at Faculty of Telecommunications (since 1966 Faculty of Electronics). The first professor of acoustics was Zbigniew Żyszkowski. His students were prof. Wojciech Majewski, Janusz Renowski, Janusz Zalewski, Bronisław Rogala and a few PhD's. Nowadays, in Department of Acoustics and Multimedia are prof. Andrzej Dobrucki and Tadeusz Gudra, who belong to third generation of Polish acousticians in Wrocław.

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### Assessment of Cortical Bone Microstructure from Backscattered Waves

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Clinical studies using high-Resolution X-ray CT have revealed that cortical bone porosity is a major risk factor for fracture. However, the Change of cortical bone microstructure is poorly captured by common X-ray based techniques. We have developed a method to retrieve information about fracture-strength associated changes in cortical

bone using a conventional medical ultrasound scanner (Ultrasound Touch Research) equipped with a 3D linear transducer array (4DL14-5/38) and a 128-channel data acquisition box. Special beam-steering sequences were developed to transmit focused beams at multiple inclination angles to the cortical bone surface. For each transmitted beam, the full aperture is used to obtain a wide-angle phase-sensitive detection of backscattered signals. The spectral data analysis provides a normalized depth-dependent backscatter spectrum. The method was applied ex-vivo to 18 human proximal femur shaft bones. Site-matched pore morphology was obtained from 100-MHz acoustic microscopy images. Pore density, pore size and porosity were highly correlated with the derived backscatter coefficients (adj. R2 up to 0.85). A backscatter model derived from a parametric numerical sound propagation study will be presented. The results open a new path for a non-ionizing, non-invasive diagnosis of bone pathologies.

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### Study of High Pressure Thermophysical Properties of Ionic Liquids. Part II. Acoustic Method – Advantages and Disadvantages

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Knowledge of thermodynamic speed of sound in ionic liquids (ILs) allows its use in attractive applications such as interaction of ultrasounds with medium in hydrolocation and medicine, prediction of thermal conductivity of ILs as solar fluids, compressibility of ILs as hydraulic fluids. The pVT data obtained by the acoustic method belong to the most reliable ones, since dependence of speed of sound on pressure and temperature is determined with high accuracy. The great advantage of this method is ability to determine pressure dependence of isobaric heat capacity. Interpretation of speed of sound values and their usability for determination of related thermophysical properties is possible only on basis of knowledge of relaxation regions. Ultrasound absorption spectra of some ILs show dependence on frequency at frequencies of transducers operating in ultrasound devices. In that case, speed of sound cannot be regarded as thermodynamic quantity; thus it is not possible to use Newton-Laplace equation for determination related thermophysical properties. Particularly, it should be taking into account for speed of sound measurements at low temperatures and/or high pressures. This work presents analysis of temperature dependence of speed of sound and temperature and pressure dependence of classical ultrasound absorption in order to approximate dispersion region.

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### Acoustic Enhancement for Orchestra Players

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During the last years, the number of venues which are using electroacoustic enhancement systems to improve

their acoustic conditions in general or for special purposes has been increasing considerably. The reason for this is that for a number of years the average quality of these installations has reached a certain standard that typically provides a good acceptance among musicians which has been a severe issue in the early days of such systems. Based on experiences with the electroacoustic enhancement system Vivace this paper explains the fundamental principles and the special usage of such systems to support orchestra players on stage or in an orchestra pit. A number of example installations are presented in detail. During the tuning process of these installations and the corresponding discussions with the musicians interesting aspects of the perception and acoustical needs of the various groups inside a classical orchestra could be discovered which also can be a valuable support when designing natural acoustics for stages or orchestra rehearsal rooms. Especially for orchestra rehearsal rooms an elaborated combination of room acoustical treatment and a specialized enhancement support might be a chance for achieving solutions that seemed to be impossible up to now.

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### Radio Simulcasting at a Glance: a New Look at Broadcasting and Streaming Services

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Radio is by far one of the most popular and accessible medium. With its availability it attracts listeners all around the world. There are numerous ways of delivering content to consumers. The present situation is characterized by the convergence of acoustics, computer science and telecommunications. This paper reviews the current status of radio broadcasting and streaming services. It describes a subjective study concerning different ways of providing content through analog and digital terrestrial, as well as Internet networks. It analyzes the possibilities and limitations related with each technology, from an economic and technological point of view, as well as resource sharing mechanisms.

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### Analysis of Sources of the In-Duct Acoustic Pressure Measurements Errors

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The paper presents the analysis of the sources of errors of the acoustic pressure field measurements carried out on a measurement set-up which allows testing waves in the form of single modes propagating inside a rigid cylindrical duct equipped with anechoic terminations to model an infinite waveguide. The measurement set-up consists self-designed single mode synthesizer located inside anechoic termination and a measuring section with the microphone moving along the waveguide radius. Each of the individual elements of the measurement set-up may cause some errors affecting measurement data. The article analyses discrepancies in the results of the acoustic pressure measurement carried out for measuring point located on the duct axis at a chosen distance from the sound sources. Several measurement series were carried out for each of the generated consecutive single modes, ie. (0, 0), (1, 1), (2, 1), (0, 1), and a frequency wideband signal for an axisymmetrically and non-axisymmetrically position of a single sound source. For each case, calculations of the mean value and the type A standard uncertainty were executed by means of the classical method but also by the bootstrap estimate of the mean value and the bootstrap estimation of the uncertainty. The results obtained applying each of the listed methods were discussed and compared with each other.

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### Hydroacoustic Study of Benthic Habitats in Southern Baltic Sea (Review of Three Projects)

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The results of three projects, financed by Polish Government and motivated by the development of hydroacoustic techniques for southern Baltic benthic habitat classification, are discussed.

The first project (Development of hydroacoustic technique for monitoring underwater meadows in Puck Bay, 2001–2003) was addressed hydroacoustic distinguishing between sea floor, covered and uncovered by underwater vegetation and determining vegetation canopy height.

In the frame of the second project (Development of hydroacoustic techniques for study of benthic habitats of Southern Baltic Sea (study area: Rowy), 2007–2009) the algorithms were developed to distinguish three different habitats connected with a fine-grained sand, a coarse sand with a gravel as well as a seabed with a lot of stones, covered mainly by mussels.

The algorithms, developed in both projects, were verified using results of ground truth sampling and visual inspection. In the projects, the sound interaction with seabed was modelled theoretically in order to deeper understand the obtained results.

The third project (Study of the impact of microalgae photosynthesis on the acoustical properties of the Baltic seabed sediments, 2011–2013) was addressed the understanding of the effect of microphytobenthos photosynthesis on the interaction between acoustic wave and seafloor that is important in the hydroacoustic techniques development.

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### Depth Determination Accuracy of the Modified Prony Method in Swath Mapping Application

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This article presents the performance of the modified Prony method in swath mapping application. Depth determination accuracy is assessed by processing raw signal acquired by EdgeTech 6205 swath bathymetry system over flat seafloor. An updated version of the method proposed previously by the authors is used to determine the number of signal echoes. The number of signal echoes is essential for performing the low-rank approximation of the data matrix in the modified Prony method. The achieved accuracy results are also compared to the results of other methods applied to the same signal and International Hydrographic Organization standards.

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### My Adventure with Hydroacoustics

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### Sensing and Measurement of Acoustic Signal from an Arterio-Venous Fistula

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A properly functioning arteriovenous fistula is the best vascular access in chronically hemodialyzed patients. It is extremely important for such patients to be able to quickly diagnose the deterioration of fistula function, which can be assessed by analyzing the acoustic signal emitted by the flowing blood. In effective diagnostics it is necessary to eliminate distortions of the recorded sound resulting from the measurement method. This article describes the prototype of a device designed to record the acoustic signal emitted by the blood flowing through the fistula. The original design of the head for acquisition of sound emitted by the fistula eliminates distortions resulting from classical measurement techniques. The device was created as a result of the theoretical analysis and the empirical verification of the propagation of sound waves. It significantly influenced the quality of data obtained in the diagnostic process.

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### Photoacoustic Spectroscopy Studies of Biofilmcovered Solid Substrata Submerged in the Sea

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Biofouling on solid substrata was studied in coastal waters of the Baltic with a photoacoustic spectroscopy (PA) technique. Several substrata biotic and abiotic of varying surface energy and bioaccumulation efficiency were deployed, for a certain time corresponding to the characteristic stages of biofilm development. Periphyton consists of algae, cyanobacteria, and heterotrophic microbes which stand for a photosynthetic system with a mixture of pigments. PA signal amplitude and phase were evaluated using the phase-sensitive method with a novel closed-cell type photoacoustic spectroscopy (PAS) system. Photosynthetic apparatus properties (photosynthetic energy storage (ES), PA amplitude and phase spectra) exhibited a seasonal variability. ES values were higher, for a season of high primary production. In addition, ES values were found higher by a factor of 1.5–2, for biofilm settled on biotic macroalgae. The peak values in PA signal amplitude spectra maximum at  $\sim 680$  nm were highest for biotic substrata, lower for filtered planktonic phase, and lowest for abiotic surfaces. The photoacoustic parameters (ES and PA signal amplitude) turned out to be unequivocally related to the biofilm structural signatures (thickness, volume, number of cells, fractal dimension etc.) as learned from confocal microscopy and wettability techniques.

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### Methods for Selecting Multicomponent Layers which Match the Acoustic Impedance of Ultrasound Transducers to Various Media

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The problem of optimal selection of materials for matching layers e.g. of piezoceramic transducers for ultrasonic emission and reception is closely related to the type of medium into which ultrasonic energy is radiated. Due to the unfavourable ratio of acoustic impedance between piezoelectric ceramics and gaseous, liquid and biological media, the conversion of electrical to acoustic energy introduces significant losses. The paper presents, among other methods of impedance-matching layers selection, a method based on genetic algorithms. The method enables the search of state-space of possible solutions – in this case, of combinations matching layers' materials. The optimal choice of computation method depends closely on ultrasonic impulse parameters such as: impulse shape, impulse energy, transmission band shape and width. When

using a single matching layer, its impedance can be calculated based on upon Chebyshev's, DeSilets' or Souquet's criterion. The choice of criterion depends on, among other factors, the expected shape of transfer function; the calculated values of matching layer's impedance exhibits large variability, so the choice of suitable material is a complex task. The solution might be use multiple matching layers. The use of genetic algorithm allows for finding the optimal matching layers combination fulfilling the chosen matching criterion.

\* \* \*

### Effectiveness in the Identification of Respiratory System Auscultation Sounds

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A cross-sectional assessment of the skills of physicians and medical students in the field of acoustic classification of respiratory sounds in children is presented in this paper. The experiment consisted of a survey where the respondents answered questions about their experience, skills, education, etc. and a practical part – a test set of sounds from the respiratory system, to which the participants had to listen and then match each signal to the descriptions of specific sound classes. The results show how accurately physicians and medical students categorize auscultation sounds according to various factors. The results of the survey highlighted the problem of insufficient instruction on auscultation both during study programs and during further medical practice. Moreover, in the medical environment in Poland there is a perceived need to standardize the nomenclature of auscultation sounds. This is also confirmed by the results obtained in the practical part, which are significantly improved when sound classes are grouped together to form more general ones. Among the study groups, pulmonologists obtained the best results, statistically, compared to the other groups. In general, however, the results of the experiment show the need to minimize the number of acoustic classes and to standardize the vocabulary for respiratory sounds

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### Traffic Noise and Noise Action Planning in Germany

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The Environmental Noise Directive requires the member states of the European Union to determine the noise exposure of the population. In addition, the noise action plans should contain appropriate measures to reduce high noise

exposure. The noise maps for Germany show high exposure to traffic noise, especially road traffic noise. Therefore, the focus of the noise action plans is on measures like speed reductions, noise barriers, low-noise road surfaces and traffic management. The Directive also require wide public participation in the development of action plans. The competent authorities have therefore taken into account the requests of the public, the legal framework for such measures, the financial framework and the technical requirements. Moreover, the competent authorities for the action plans and the authorities for the implementation of the measures are often not the same. Close coordination between all authorities is therefore necessary for successful noise action planning.

\* \* \*

### Audio Signal Equalization Based on Spectral Characteristics of a Listening Room and Music Content Reproduced

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This study presents investigations of the influence of the room acoustics on the frequency characteristic of the audio signal playback. First, a concept of a novel spectral equalization method of the room acoustic conditions is introduced. On the basis of the room spectral response, a system for room acoustics compensation based on an equalizer designed is proposed. The system settings depend on music genre recognized automatically. In order to acquire room acoustic characteristics, a series of measurements are performed. The impact of the enclosure on particular music genre spectral characteristics has also been presented. In the analyses a comparison of spectral characteristics obtained with pink noise and music genres as measurement signals is presented.

\* \* \*

### Music Recognition Algorithms Using Queries by Example

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With the appearance of audio databases novel information retrieval methods are required. A natural way of searching in a musical audio database is by humming or whistling the tune of a song as a query, which is so-called "query by humming". In this study five different techniques for effective and efficient querying by humming are described and compared. For this purpose, a system



that allows searching songs in a pre-prepared database using various pitch tracking methods was implemented. The system uses hummed part of a song or recording of live singing as an input signal for which melodic contours are created. These contours are then compared with sample songs in the database. Five different algorithms were implemented to search the pitch of the input signals. The implemented application allows the users to select the algorithm and to define additional parameters related to the contour generation and the comparison method. The users can also see the list of compositions in the database and manage the list by adding or removing the song. The user is also able to see the graphs from the analysis performed for the melodies hummed or whistled

\* \* \*

### Inter-Subject Differences of Head Related Transfer Functions

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Examination of the characteristics of individual Head Related Transfer Functions (HRTF) requires the use of a specific measurement setup and procedure. This paper describes the design of a far field HRTF measurement setup in which the subject is continuously rotated towards a sound source placed at a certain elevation angle. Currently the system allows for the acquisition of HRTF pairs (left and right ear) at 370 source positions in the surrounding space. The test signal is recorded by two miniature microphones placed at the entrance to the blocked ear canal. Completing of a set of HRTFs at all spatial positions takes about 45 minutes for one subject. The present measurement setup was evaluated by acquiring HRTFs with the use of an acoustic manikin and with the participation of subjects. The paper discusses inter-subject differences among measured HRTFs, both in horizontal and vertical planes, with reference to the results obtained with the use of the acoustic manikin.

\* \* \*

### Safety Issues of Novel Ultrasound Imaging Modalities

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Medical ultrasound technology is characterized by a continuous high rate of innovation, which involves also new scanning sequences. The setup of the scanning sequence (acoustic pressure, pulse duration and pulse repetition rate) determine the safety relevant acoustic output. Novel safety relevant imaging modalities are fast and ultrafast imaging and shear wave elastography. Fast imaging methods based on plane wave excitations are probably safe (provided that the acoustic pressure will not be increased). Shear wave elastography methods using push pulses to excite the shear waves (e.g. ARFI methods) are safe for soft

tissues, except bone interfaces (provided that the acoustic pressure will not be increased). In any case, the exciting time – hence the duration of the scanning procedure – is still a relevant factor. Furthermore measurements of acoustic output parameters on clinical devices on the market are required for validation.

\* \* \*

### The Potential of Ultrasound for Image Guided Therapies

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Diagnostic ultrasound (US) imaging is an important tool to guide and control medical interventions. Benefits of US include real-time capability, high availability, flexibility, cost effectiveness and safety for patients and user. Moreover, contrast enhanced abdominal US (CEUS) has a comparable diagnostic value as CT. Disadvantages are the limited acoustic window, restricted by bony and airfilled structures, the user dependency and the absence of an accurate tissue thermometry. Especially important is US guidance for the support of minimally- and non-invasive therapy procedures. Examples are needle based interventions, e.g. radio frequency (RFA) and cryo-ablation or, since recently, irreversible electroporation (IRE). Also the combination of diagnostic US with therapeutic ultrasound, like high intensity focused ultrasound (USgHIFU) has found the way into clinical practice, e.g. for the treatment of prostate cancer, thyroid nodules or uterus fibroids. Beside therapy planning and guidance the real-time capability of US image acquisition is also favorable for the detection and tracking of organ motion. This allows for motion compensation in FUS but also in radiation therapy. In conclusion, diagnostic ultrasound is an ideal tool for imaged guided therapies. With the growing field of non- and minimally-invasive therapies, the role of ultrasound will also gain importance in the next decade.

\* \* \*

### Theranostic Nanoparticles for Ultrasound Imaging and Therapy

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Ultrasounds can be used for therapy and also for imaging and monitoring the therapeutic process and efficiency. Commonly used ultrasound contrast agents – microscale bubbles are still too big to extravasate from the vascular lumen. The smaller size of nanoparticles which increases the therapeutic efficacy of ultrasound hyperthermia and thermoablation can also influence ultrasound contrast imaging. Nanoparticles can act as theranostics. For theranostic purposes different types of nanoparticles can be used, such as gold nanoparticles, gold-based composite, silica, carbon-based, and magnetic nanoparticles. A nanosystem can be used for ultrasound-triggered drug release, photoacoustic imaging, ultrasound imaging, or ultrasound therapy. The results of studies show that magnetic nanoparticles have good characteristics for ultrasound theranostic

therapy which is a combination of therapy and diagnostics functions in the same nanoparticles. Magnetic nanoparticles are also suitable for other types of theranostics procedures, such as magnetic hyperthermia, magnetic drug targeting, or magnetic resonance.

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### Research on Underwater Communication Modem with FSK Modulation

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An article presents research on underwater communication modem designed and created by team of Hydroacoustics Department of Polish Naval Academy under "Motyl and Motyl II" research and development project. The modem uses FSK (Frequency-Shift Keying) frequency modulation for data transmission in aquatic environment.

The article presents results of research conducted in hydroacoustics lab of Polish Naval Academy along with a way of error-correcting coding of information transmitted by the modem. Subsequently, the results are being presented in real-life conditions for two reservoirs: enclosed basin of yacht marina, where a phenomenon of sent signal multipath has been observed; and Gulf of Gdańsk reservoir, where the level of reflected signals was negligibly small. Research focuses on signal received by underwater communication modem, at band pass filters output and comparator output.

\* \* \*

### Ultrasonic and Dielectric Relaxation of Associating Liquids. Translation-Orientation Coupling and Concentration Fluctuations

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Broadband (100 kHz–2 GHz) ultrasonic spectra and results from UV and X-ray Brillouin spectra are discussed for water, monohydric alcohols and carboxylic acids as well as mixtures of water with the alcohols and acids. Comparison is made with dielectric spectra (10 MHz–2 THz) of the liquids in order to investigate correlations between the density fluctuations of the hydrogen bond networks and the reorientational motions of the molecules. When water and the alcohol systems are discussed in terms of the wait-and-switch model of dielectric relaxation, the structure relaxation times are found to agree with waiting period in the molecular dipole moment reorientation times. This finding indicates a coupling between translational and orientational molecular motions and confirms the idea of defect diffusion mechanisms of the liquid dynamics. The dielectric spectra of the mixtures of water with carboxylic acids reveal two relaxation terms which are assigned to liquid phases of different composition. Ultrasonic spectra for mixtures with propionic, butyric, and isobutyric acid support this assignment. In addition to terms related to the

dimerization and dimer isomerization equilibria, they disclose a contribution due to noncritical fluctuation in the local concentrations. The fluctuation correlation length derived from the spectra fits well to data for mixtures of water with other substances.

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### Heating Induced by Ultrasound in the Presence of Magnetic Nanoparticles

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Ultrasound hyperthermia is a medical procedure which involves temperature rise in tissues up to 43–45°C. As a heat source either focused or non-focused ultrasounds can be applied. The efficacy of ultrasound hyperthermia can be improved by using so-called sonosensitizers – the solid nanoparticles that enhance the absorption of the acoustic energy. The experiments on ultrasound hyperthermia were carried out using the tissue-mimicking phantoms doped with magnetic sonosensitizers at various ultrasound frequencies, intensities, concentrations of magnetic nanoparticles, and distances from the center of ultrasound focus point. Additionally, SAR values, which describes the heat deposition in the tissues, were evaluated. The obtained results show that the presence of sonosensitizers in tissue-mimicking phantoms affect the rate of heating. Temperature rise during ultrasound heating and SAR values in phantoms doped with sonosensitizers are greater than those in pure agar phantom. Moreover the highest SAR values were obtained in the ultrasound focus and their value decreases with the distance from it.

\* \* \*

### Problems of Acoustic Treatment in Historic Halls

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Historic cultural objects, such as theaters and philharmonic halls are particularly valuable national heritage. Renovation and modernization of listed buildings are usually strictly supervised by a conservation officer, who introduces significant design and construction restrictions for use of modern technologies. The problem of room acoustics addressed by the author concerns new equipment and changes related to the binding building regulations. Based on several renovated halls the author shows the process of modernization of individual elements and indicates their impact on the interior's acoustic parameters. Special attention is dedicated to solutions shaping the first reflections around the stage, the orchestra pit and the back wall. Application of dedicated reflective and diffusive panels on concave surfaces under the balconies and selected orchestra pit walls, significantly improved the objective and subjective acoustic parameters of the analyzed interiors. The

conclusions are based on simulations and measurements in selected objects.

\* \* \*

### Optimization of a Non-Linear Mass Damper

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Many technical systems are sensitive to vibrations. Those disturbances can be handled with active and passive counter-measures. In the literature you can find dimensioning methods for passive mass dampers. Those methods use analytic models of the combined system. This paper deals with the question whether a simulative optimization based on Matlab/Simulink leads to better results than an analytic calculation.

\* \* \*

### Acoustical Analysis of Coupled Rooms Applied to the Deutsche Oper Berlin

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The aim of the project SIMOPERA is to simulate and optimize the acoustics in large and complex rooms with special focus on the Deutsche Oper Berlin as an example of application. Firstly, characteristic subspaces of the opera are considered as the orchestra pit, the stage and the auditorium. Special attention is paid to the orchestra pit, where high sound pressure levels can occur leading to noise related risks for the musicians. However, lowering the sound pressure level in the orchestra pit should not violate other objectives as the propagation of sound into the auditorium, the balance between the stage performers and the orchestra across the hall, and the mutual audibility between performers and orchestra members. For that reason, a hybrid simulation method consisting of the wave-based Finite Element Method (FEM) and the Boundary Element Method (BEM) for low frequencies and geometrical methods like the mirror source method and raytracing for higher frequencies is developed in order to determine the relevant room acoustic quantities such as impulse response functions, reverberation time, clarity, center time etc. Measurements in the opera will continuously accompany the numerical calculations. Finally, selected constructive means for reducing the sound level in the orchestra pit will be analysed.

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### Estimation of Coherence Bandwidth for Underwater Acoustic Communication Channel

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Shallow underwater acoustic communication channel is characterized by strong multipath propagation. The signal reaching the receiver consists of a direct waveform and a number of its delayed and suppressed replica. A significant time dispersion of transmitted signal and selective fading of its spectrum are observed. Coherence bandwidth defines maximal bandwidth, wherein the channel amplitude characteristic remains constant and its phase characteristics is linear. It is one of the channel transmission parameters that determine the physical layer of data transmission. Coherence bandwidth can be calculated on the basis of the channel impulse response, measured by correlation method with the use of wideband frequency modulated signals or pseudo-random binary sequences. Both types of probe signals have an impulse-like autocorrelation function whose influence on the impulse response estimate is often considered as negligible. However, probe signals practically used in measuring systems have a limited bandwidth, which causes their correlation properties to be different than in truly wideband case. This has a direct impact on impulse response and transmission parameters estimates. In particular, the coherence bandwidth can differ significantly depending on the probe signal used. The paper proposes a method of correction of the probe signal influence on the estimate of channel coherence bandwidth.

\* \* \*

### Perceptual Evaluation of Music Similarity

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In this contribution, the perceptual similarity between musical sounds is evaluated. The sounds consist of the same note (C#5), played on seven historical pianos built in the 19th century. The goal was to establish the perceptual distance between notes, with the future possibility to relate these distances to the mechanical construction of the instruments. As ground truth we obtained data via triadic comparisons. In this task, subjects are confronted with a triplet of sounds, to which they can listen as much as they want, and have to decide which pair of sounds is the most similar and which pair is the most dissimilar. The similarity matrix is then used to construct a perceptual space, in which the distances between individual instrument sounds are used as indication for the perceptual distance. We also evaluated a newly developed method, in which subjects have to discriminate two instrument sounds. In this task, a specific noise is added to the sounds, which has the same spectro-temporal pattern and has the function to make the discrimination more difficult. In particular, we evaluated the signal-to-noise ratio at discrimination

threshold for each pair and found a significant correlation with the distances obtained from the triadic comparison.

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### **Determination of the Reflection Coefficient of The Anechoic Termination Installed at a Duct-Like Measuring Set-up**

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The paper presents an analysis of the measurement error introduced by the anechoic terminations installed at the constructed experimental set-up to meet the assumptions of some mathematical models under which the sound field phenomena are investigated most frequently. In the measuring set-up the anechoic terminations were installed at both ends of the acoustic waveguide to justify application of the mathematical model of an infinite duct and at one end for a semi-infinite model. Numerous measurements of the acoustic pressure distribution inside the duct with the two ends equipped with these devices were taken and the results confirmed accordance of the constructed set-up properties with theoretically assumed model of a straight hard duct of infinite length. To model the semi-infinite duct the anechoic termination was mounted at the source end. Also in this case the measurements taken at the duct outlet and outside the duct in the far field were consistent with theoretical predictions of the implemented mathematical model. The anechoic termination is also a part of the self-designed mode synthesiser composed of 13 point sources arranged in triangle-shaped grid. It allows to generate a single higher order cut-on mode by setting properly modulae and phases of each of the point sources. However the appearance of other undesired modes while generation of a single mode was observed and one of the reasons might have been the quality of used anechoic termination. Despite receiving in all proceeded measurements results consistent with mathematical models the determination of measurement error is an indispensable part of the measuring data analysis and the reflection coefficient of used anechoic terminations can show how they influence the obtained data.

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### **Beamforming – Microphone Arrays Technique for Aeroacoustic Applications**

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Beamforming is a technique that uses a sensor array to visualize the location of a signal of interest. The technique have become an important tool in the localization of noise sources. Beamforming is a method for processing microphone array data to produce images that represent the

distribution of the acoustic source. It is an imaging technique that applies to continuous or discrete source distributions. The aim of this paper is then to show that the time-domain beamforming technique allows assessing the nature of aeroacoustic sources. The use of beamforming requires an assumption on the stationarity of the sources as it works with a time-averaged estimate of the cross-spectral matrix. As a consequence this technique provides an estimation of the average position (in space and time) of an aeroacoustic source. Beamforming is a new powerful, flexible, and continuously evolving measurement technique in aeroacoustics. The method was applied to experimental wind-tunnel measurements with outlet to anechoic chamber. The noise produced by the flow was analysed by using beamforming and compared with single microphone method. Structure and spectrum of frequency analysis of such an aeroacoustic source was investigated. The advantages and disadvantages used methods were discussed.

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### **Sound Transmission Loss Analysis of Plates Using Calculation Models**

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The research concerns the analysis of acoustic properties of materials and constructional solutions in reducing of vibroacoustic hazards. This type of solutions distinguishes materials resistant to the penetration of sound waves, which can be used individually, such as single homogeneous soundproofing baffles, as well as sound absorbing materials, which are used as lining or sound-absorbing cores in layered baffles. Airborne sound insulation of materials is determined primarily in laboratory conditions. To determine it, theoretical calculation models are also used, which is the subject of the paper. The test objects were samples – homogeneous materials of various thicknesses, which were steel, aluminum, PVC, acrylic and plexiglass plates. The sound-insulating properties of these materials are used in sound absorbing and insulating enclosures for the construction of layered baffles or some of them as wall elements of acoustic barriers. The acoustic insulation characteristics obtained from the calculations were compared with the results of laboratory tests carried out on the stand for airborne sound insulation testing.

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### **Listening to Live Music: Life Beyond Music Recommendation Systems**

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This paper presents first a short review on music recommendation system based on social collaborative filtering. A dictionary of terms related to music recommendation systems, such as music information retrieval (MIR), Query-by-



Example (QBE), Query-by-Category (QBC), music content, music annotating, music tagging, bridging semantic gap in music domain, etc. is introduced. Bases of music recommender systems are shortly presented, including mechanisms underlying these systems. Also, usage of machine learning versus statistics is discussed with regard to the recommender systems working. Moreover, listening to music through players implemented on computers or mobile devices is opposed to listening to live music in the context of social and technology implications, i.e. live performance contrasting issues related to music quality. Finally, future directions in the music recommendation area and live music are discussed, including performance on virtual musical instruments.

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### Measurement Methodology for Interiors Coupled with Sound Reinforcement Systems

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This paper presents a description of the methodology of performing acoustic measurements in acoustically difficult enclosed spaces in order to obtain a repository of impulse responses. As a part of the research, acoustic parameters important in the context of public address and sound reinforcement systems were first reviewed. A measurement methodology was proposed that employed various test signals to determine impulse responses. In addition, in the process of evaluating the sound system performance, signals enabling direct objective measurement of the STI (Speech Transmission Index) coefficient, and in particular the STI-PA (STI for Public Address systems) ratio, were utilized in accordance with the measurement standard. Sound systems installed in the selected acoustic interiors were used in the measurements. A comparison of the results obtained for different length of Sweep Sine stimuli was made that enabled to recommend the latter test signal as more suitable for such interiors coupled with sound reinforcement systems.

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### Effects of Fast-Acting Hearing-Aid Compression on Audibility, Forward Masking and Speech Perception

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Dynamic range compression (DRC) is a widely-used compensation strategy in hearing aids. However, the choice of the compression parameters, such as time constants, is still a subject of an ongoing debate. This contribution evaluates the efficacy of fast-acting DRC as a hearing-loss compensation strategy in a range of experimental conditions. First, fast-acting DRC was investigated considering temporal masking of narrowband stimuli. The results of a model-driven evaluation showed that the measures of temporal resolution can be improved with fast-acting compression with a very short release time (10 ms). Second, the effects of compression on speech audibility and noise-induced forward masking were evaluated in a highly-controlled scenario. The application of very short compression time constants was shown to improve HI listeners' consonant recognition performance. Finally, despite the benefits of fast-acting compression apparent in controlled conditions, it may introduce distortion in realistic scenarios, such as a reduction in the signal-to-noise ratio (SNR). A novel signal-to-noise-ratio-aware compensation strategy is discussed, which switches between fast- and slow-acting compression depending on the presence of the target signal and therefore preserves the natural relationship between the target and the background. An objective evaluation of the algorithm is presented and its potential applications are discussed.

\* \* \*

### How to Adjust Room Acoustics to Multifunctional Use at Music Venues

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Multifunctional venues such as local culture centres have to be flexible to host many different kinds of concerts, theatre shows, and various other events. Additionally, many existing venues such as theatres, concert halls, and even opera houses need to present shows which are not typical for their purpose. This situation caused a strong need to change acoustic parameters of the venue between different types of events. The paper presents a few ideas on how to meet this need, based on several realized music venues. Technologies used to change room acoustics are explained, as well as final results taken by acoustics measurements.

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### Ultrasound Thermal Effect Enriched by Adding Micro and Nano Particles to Tissue Mimicking Materials

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Agar-gel based materials are widely used as tissue mimicking materials. Pure agar-gel is stable up to 60°C but

exhibits small ultrasound attenuation compare to a soft tissue. To enhance the attenuation of agar-gel we fabricated samples of agar-gel with adding of graphite micro particles (GMPs), magnetic micro particles (MMPs) and magnetic nano particles (MNPs) with two weight fractions of dry powders added before the formation of the gel to the aqueous agar solution, namely 0.8% and 1.6%, respectively. In order to compare the thermal effect caused by addition of particles, the samples immersed in a water bath were heated by 2 MHz circular focused transducer (diameter 44 mm), with power of 1, 2, 3 and 4 W. The temperature increase curves were measured by thermocouples. The temperature change rate (TCR) in the initial point of heating was calculated. For 0.8% weight fraction the MMPs sample had the highest TCR value at each sound power tested, the smallest value had the MNPs sample. For the 1.6% weight fraction, the highest TCR value had the MNPs sample, while the smallest TCR had the GMPs sample. We stated that for the higher fraction of particles, the MNPs material had the highest TCR value for all powers, and besides the difference between TCR in MMPs and GMPs samples was less than the difference between TCR in MMPs and MNPs samples. Besides, in this case, the MNPs sample exhibited the minimal exposure time to achieve the temperature increment of 5°C, which was only to 6 s for the acoustic power of 4 W. This facts underline the unique properties of MNP material and its usefulness as a model material for ultrasonic hyperthermia experiments.

\* \* \*

#### **Acoustic Detection of Macroalgae in a Dynamic Arctic Environment (Isfjorden, West Spitsbergen) Using Single- and Multi-Beam Echosounders**

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Acoustic imaging of seabed morphology and benthic habitats is a fast-developing tool for investigating large areas of underwater environment. Even though single- and multi-beam echosounders have been widely used for this purpose for many years, there is still much to discover, especially in terms of processing water column echoes to detect macroalgae and other scatterers (e.g., fishes, or suspended sediments).

In July 2016 and 2017 eight areas (4 northern and 4 southern of the fjord) were mapped in Isfjorden (Svalbard) using single-beam sonar Biosonix DTX (420 kHz) and multibeam sonar Norbit iWBMS (330 kHz). These multi-disciplinary expeditions to investigate macroalgae spatial distribution in areas under the increased influence of glacial melt water were founded by Polish National Science Centre (project MAKAK: UMO-2015/17/B/NZ8/02473).

We covered 6.6 km<sup>2</sup> of seabed in shallow, coastal zone, collecting a unique data set showing variability of acoustic properties among different macroalgae species, supported by very well correlated ground-truth data (video) and environmental measurements (CTD, ADCP).

Using modern processing techniques we analysed morphology, backscatter intensities and water column data signals of both acoustic instruments allowing us for kelp detection. We also demonstrated high efficiency of compact multibeam systems for benthic habitat mapping in Arctic conditions.

\* \* \*

#### **Highly Impulsive Noise of Collisions of Train Cars: Distinctive Feature Vector Development**

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The issue of objective assessment of impulsive noise still remains one of the important problems of environmental acoustics. Current, arbitrary classification methods partly solve the problem of identification, but the issue of differentiating the degree of annoyance of highly impulsive and also high-energy sound sources is still unresolved. Therefore, it is reasonable to search for effective methods in the process of objective assessment and classification of highly impulsive noise. As one of the possible approaches, the authors find the application of artificial intelligence methods.

The paper presents a proposal of a vector of distinctive features of highly impulse noise from collisions of train cars, which can be useful in the classification of impulses due to their degree of annoyance. A set of measurable parameters in time and frequency domain have been selected for the construction of the feature vector. Their usefulness in the classification of the impulses has been verified on the basis of principal component analysis and cluster analysis.

\* \* \*

#### **On Some Problems with Vibroacoustic LDV Measurements for Windows**

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Acoustic insulation of windows was tested with the help of laser Doppler velocimeter (LDV). LDV in window research could, for example, checks the correctness of the window fixing and determine the map of acoustic energy passing through the window. During testing, a very large 3-wing window, overheated of the loudspeaker occurred in the transmitting chamber and jumps in the emitted acoustic power appeared. For the saving of the measurement results after overheating the loudspeaker, the correction of results in the final part of the examined area was applied. Problems with correcting these results are described in the article.

\* \* \*

### What is Acoustic and Electromagnetic Wave Motion “Governed By”?

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Contrary to common belief, wave equations do not “govern” wave phenomena, but merely describe their global effects, seen in a larger spatial and temporal scale. In fact, both acoustic and electromagnetic wave motion is the result of dynamic action sequence “governed by” the pair of first order relations, Euler’s and Maxwell’s respectively, met locally at every elementary volume of respective physical space, and at any moment. The sequence forms a circular feedback loop combining space imbalance of measurement quantity (intensity) of one kind, as the local cause, with time change of material quantity (density) of the second kind, as a prompt effect. The essence of wave motion in both considered cases is thus in a double dynamics of amorphous medium endowed with internally cross-coupled physical properties, that gives to any disturbance a kind of dynamic equilibrium. Next, the disturbance is being pushed out from the area, accordingly to the local law of energy conservation expressed by the differential relationship forcing a phenomenon dynamic change as the effect of its space divergence. The symmetry of the paper approach proves a crucial role of physical properties in both fluid acoustic media and radio/light-carrying space (inaccurately declared “empty”).

\* \* \*

### Vibrational Relaxation in Several Derivatives of Benzene

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Acoustical spectroscopy at frequencies up to 10 GHz gives the possibility of relaxation process observation which is caused by energy transfer between translational and vibrational degrees of freedom. The compounds presented in this article belong to this group of liquids. The acoustic investigations in the group of benzene derivatives, particularly research of the dependencies of acoustic parameters and the structure of organic liquids, demonstrated some interesting regularities in the group of these compounds.

There will be presented the results of research on five cyclic liquids: bromo-, chloro-, fluoro-, iodo-, and nitrobenzene as well as toluene and aniline are discussed and compared to benzene. The acoustic relaxation observed in part of these compounds was found to result from Kneser’s processes (vibrational relaxation). Based on investigations by the author as well as by other people, and taking into account experimental and literature data concerning a great number of compounds, one can draw a conclusion that almost all acoustic relaxation processes in liquids can be described using a single relaxation time. It also seems that all

vibrational degrees of freedom of the molecule take part in this process.

However, benzene derivatives with amino, nitro, and methyl groups and halides show the other relaxation process.

\* \* \*

### Development of Metrological Infrastructure in the Field of Underwater Acoustics in Poland

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This paper contains a concept study of development of metrological infrastructure in the field of underwater acoustics aimed at ensuring metrological traceability and supporting research activity in this field in Poland. First of all, a review of the activity of different institutions in various areas of underwater acoustics has been adopted. An overview of the marine research areas such as oceanography, underwater security of critical infrastructure and maritime defence, marine physics, and biology has been made. Additionally, the implementation of EU Marine Strategy Framework Directive was analysed. Different metrological needs resulting from a wide spectrum of activity have been analysed. Moreover, analysis of documentation standardization regarding the calibration of underwater transducers as well as the entire signal processing channel has been performed. Based on the selection of the measurement methods, the metrological infrastructure necessary for calibration and testing has been determined. The advantages resulting from the development of national metrological infrastructure are defined as an uninterrupted continuity providing measuring equipment with quality and reliability confirmed by calibrations and metrological checks.

\* \* \*

### Acoustical Helicoidal Resonators Connected in Series Inside Straight Cylindrical Duct – Numerical Analysis of Transmission Loss and Pressure Drop

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This paper describes the possible use of acoustical helicoidal resonators connected in series inside straight cylindrical duct. The range of discovered solutions were extended in relation to previous studies of the transmission loss (TL) and pressure drop analysis of helicoidal resonators. In the field of the ratio  $s/d$ , which is the helicoidal pitch  $s$  to the duct diameter  $d$ , the research were extended below  $s/d = 1.0$  and above  $s/d = 4.0$ . Also the number of helicoidal turns  $n$  was extended above  $n = 1.0$ . A few

helicoidal resonators with highest TL and lowest pressure drop were selected for considering the connection in series. The TL and pressure drop were calculated by the use of numerical analysis with finite element method. The change of rotational position and distance between helicoidal resonators were analyzed. The results were presented as numerical maps of integrated TL and total pressure drop coefficients ( $\zeta$ ).

\* \* \*

### Vibroacoustic Analysis of Selected Sources of Low-Frequency Noise in Residential Buildings

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This paper is related to the existence of low-frequency noise in residential buildings. Single-family and multi-family houses are equipped with internal heating installations, which could be the sources of noise – mainly low-frequency. In paper are presented results of undertaken measurement of vibration and sound inside selected residential buildings. In many cases, the Polish standards of noise limits are not exceeded, but the noise is audible and annoying. We presented the results of measurements of noise spectrum with A correction characteristic and with linear characteristics. The obtained results were assessed according to the Building Research Institute instruction no. 358/98.

\* \* \*

### Seafloor Characterisation Using Underwater Acoustic Devices

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Remote sensing of the seafloor constitutes an important topic in exploration, management, protection and other investigations of the marine environment. In the first part of the paper, a review of underwater acoustic technology and methodology used in seafloor characterisation is presented. It consists of the techniques based on the use of single-beam echosounders and seismic sources, along with those developed for the use of the sidescan sonar and multibeam sonar systems. In the second part, the review is followed by description of the combined approach to seafloor characterisation developed by the authors. This relies on calculation of several descriptors related to seabed type using three different types of multibeam sonar data obtained during seafloor sensing, viz.: 1) the grey-level sonar images (echograms) of seabed, 2) the 3D model of the seabed surface which consists of bathymetric data, 3) the set of time

domain bottom echo envelopes received in the consecutive sonar beams. The proposed methodology has been tested using field data records acquired from several bottom types in the Southern Baltic Sea. The seafloor classification was carried out by using several statistical methods applied for analysis of a set of seafloor descriptors derived from multi-beam data.

\* \* \*

### Normal to Whisper Voice Conversion Using Active Tone Cancellation

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According to previous researches (own and literature), normal voice and whisper voice have similar components of the spectrum, although fundamental frequency (F0) and harmonics frequency does not exist in a frequency spectrum of whisper voice. This study was carried out to determine the ability of normal voice to be transformed into whisper voice by using digital signal processing. Fundamental frequency and its harmonics have been cancelled by an algorithm based on active noise cancellation theory using a synthesis of cancellation signal. A time-domain signal has been transformed to frequency-domain. The maxima of the frequency-domain signal have been found. Later proper cancelling signal has been synthesized and has been added to the primary signal. Theoretical analysis and experiments have been conducted for Polish vowels. Results have been compared to recorded whispered voice.

\* \* \*

### Spatial Hearing Beyond the Horizontal Plane

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Millions of people use headphones every day for listening to music, watching movies, or communicating with others. Nevertheless, sounds presented via headphones are usually perceived inside the head instead of at a naturally external location. Generally, spatial hearing involves perceptual effects like externalization, localization, apparent source width, listener envelopment, and spatial unmasking. The acoustic basis for these effects is described by the listener-specific head-related transfer functions (HRTFs). Binaural virtual acoustics based on listener-specific HRTFs can create sounds presented via headphones being indistinguishable from natural sounds. In this talk, we will focus on details of sound localization that are particularly sensitive to listener-specific HRTFs, that is, along sagittal planes (i.e., vertical planes being orthogonal to the interaural axis) and near distances (sound externalization/internalization). We will discuss recent findings from binaural virtual acoustics and present models aiming at predicting sound externalization and localization in sagittal planes considering listener's HRTFs. The sagittal-plane localization seems to



be well understood and its model can already now reliably predict the localization performance in many listening situations. In contrast, more investigation is required in order to better understand and create a valid model of sound externalization.

\* \* \*

### Duration Time Discrimination of Ultrashort Acoustic Pulses

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This paper demonstrates that an effective pitch can be attributed to acoustic signals shorter than tenths of milliseconds. A power-law dependence of this pitch on the signal's duration time is found for subjects tested with Gaussian pulses. The discrimination threshold for the pulse duration time reported on the basis of the effective pitch increases proportionally to the duration time itself, i.e. it follows the Weber-Fechner law. A model based on the "Helmholtz's harp" idea, i.e. a series of damped resonators tuned in the audible range of frequencies reveals the mechanism of producing a maximum in the filtered spectrum of the pulse and corroborates the power law in the dependence of the position of the maximum on the duration time of the pulse. The model indicates a possibility of a man-made device designed to determine durations so short that they are inaccessible by direct measurements.

\* \* \*

### Sound Level Control Based on Grey System Theory for the Protection Against Hearing Damage Risk in Music Entertainment Venues

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The personnel of entertainment venues are often exposed to music exceeding the maximum permissible sound levels specified in occupational safety and health standards to protect the employees against excessive, harmful exposure to noise. As communication medium and source of aesthetic experience, music is not usually associated with noise – a term denoting an unwanted, annoying sound – therefore the sound levels of music are not monitored in most venues. As a result, both the personnel and the audience are often exposed to sound levels from loudspeakers or headphones that pose high risk of hearing damage. In this paper we propose a solution intended to reduce the risk of hearing damage by predicting the daily noise exposure level

(LEX, 8h) and automatically limiting the level of reproduced sound. Both the prediction method and the sound level controller are based on the concept of a first-order prediction model GM(1, 1) derived from the grey systems theory (GST). The paper presents the results of simulation calculations for different parameters of the prediction model and configurations of sound level adjustment.

\* \* \*

### The Study of the Usefulness of Acoustic Parameters of Speech of Stutterers

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Speech is one of many ways of communicating information. It is an intellectual process. In the case of people stuttering communication is very difficult, sometimes even impossible. Stuttering makes it impossible to move smoothly from one articulation to the other, as well as maintaining proper tempo, rhythm and intonation of speech. This disorder is caused by, among other things spasticity respiratory muscle movement, phonation and articulation and the lack of proper coordination, or incoordination of the entire respiratory and articulatory. They are classified as clonic stuttering, or the repetition of these sounds, syllables, words or phrases, or as a tonic blocking, which is the inability to notice the sound, desire, and at the same time the impossibility of extraction speak. Pathological stuttering is accompanied by physiological symptoms, often combined with body movements, facial, hyperactivity and spasticity, emotional influencing language and social communication, where the inability to smooth the notice will lead to tension and stress associated with speaking up and logophobia. The paper presents the research methodology, the results of which will get to know the phenomenon of stuttering in the voice channel (larynx), it also supports the process of rehabilitation of people stuttering.

\* \* \*

### The Dynamic Response of the Basal Membrane to Short Acoustic Pulses

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We present results of studies of extremely short acoustic pulses as recorded by an artificial ear in an anechoic chamber. Two types of ultrashort acoustic pulses have been used: cosine signal with the Gaussian envelope and the Gaussian envelope itself. All pulses had duration times be-

tween 0.14 ms and 27.21 ms. The recorded spectra exhibited a maximum whose position shifted towards higher frequencies with decreasing duration time. This corroborates the concept of effective pitch sensation produced by pulses beyond the uncertainty principle. Two mathematical models have been used to reveal the reaction of the basilar membrane to the pulses and their distortions by electronic devices.

\* \* \*

### **Active Vibration Control of Rectangular Plate Using Smart Materials**

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The article concerns the problem of searching the effective controller design method to suppress the vibration of rectangular plate clamped at the edge. The paper presents active vibration reduction system, in which the smart materials such as the collocated MFC sensor and actuator are used for vibration cancelation. For the considered system, the ARX method of discrete-time model identification for real-time active vibration control has been applied. On the basis of this model, the control algorithm has been developed. The correctness and effectiveness of the regulator has been verified using different measuring techniques, including scanning vibrometer. The simulation results show that the designed structure of a close-loop system provides substantial vibration suppression.

\* \* \*

### **Method to Determine Sound Insulation of Enclosure in the 8–50 kHz Frequency Range**

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Emission of ultrasonic noise from sources have been studied for many years at the Central Institute for Labour Protection – National Research Institute. In the near future, the works will concern soundproof enclosures for the sources. In this area it's important to determine sound insulation by the enclosure. Currently used methods to determine acoustic insulation are in the frequency range up to 8 kHz. The article shows the methods to determine sound insulation of enclosures in frequency range from 10 kHz to 40 kHz. The paper shows two kinds of methods: sound power insulation and sound pressure insulation. Both of them are based on using special laboratory sound source. This source was built in Central Institute for Labour Protection – National Research Institute. Both parameters are determined by measurements in the anechoic chamber on the reflecting floor. Source and enclosure were placed on reflecting floor or on special laboratory table to determine sound power insulation or to determine sound pressure insulation. In the article was also given result of measurement tested wood sound enclosure.

\* \* \*

### **Speech Intelligibility and A-weighted Sound Pressure Level of Speech During Occasional Connection of Conference Rooms**

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In conference complexes, rooms are occasionally combined to create one larger room. The acoustic properties of such a combined room may differ from the acoustic properties of unconnected rooms. In most cases, the combined room is disproportionate wider or more often disproportionately longer while maintaining the same height. The effect of increasing the size of the room is larger distance of listeners from the lecturer. This results in a reduction of the A-weighted sound pressure level of the speech reaching the listeners. It is interesting how this combination of rooms influences the speech intelligibility in the rooms, where no sound equipment was used. The article presents the results of calculations of acoustic properties of combined and unconnected rooms. The quantities used for a room rating are the reverberation time, distribution of the speech transmission index STI in the room and distribution of the A-weighted sound pressure level of speech in a room. The research was carried out on the example of a real small conference complex.

\* \* \*

### **Poroelastic Road Surface – a Promising Road Traffic Noise Abatement Solution**

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Road surfaces have a direct impact on the generation of noise by rolling tyres, the main and dominant source of noise of moving vehicles, as well as may affect propagation of noise emitted by all noise sources of a vehicle. Thus there is no doubt that pavement should be considered as one of the major potential road traffic noise abatement measure.

Low noise pavements of existing types may in new conditions provide up to 8 dB of noise reduction but the reduction decreases with time, usually 0.5–1.0 dB per year. For higher noise reductions an innovative solution like poroelastic road surface (PERS) must be considered. PERS is a porous wearing course with a high content of interconnected voids and with an elasticity due to the significant amount of rubber (virgin material or recycled) in the aggregate volume.

The paper presents the state-of-the-art of poroelastic road surfaces including the results of noise measurements performed on experimental test sections of this pavement in comparison to typical road surfaces. An impressive traffic noise reductions up to 12 dB can be achieved using PERS but its insufficient durability is the most important issue to be solved before this type of pavement will be widely used.

\* \* \*

### Aircraft Lining Panels with Low-Cost Hardware for Active Noise Reduction

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Passive structures are augmented with actuators, sensors and control to implement the task of active noise or vibration reduction. Such systems are considered smart because they have advanced functionalities compared to conventional structures. A smart aircraft lining is able to reduce the low frequency cabin noise induced by tonal or multi-tonal external noise sources. Such noise sources are for example fuel-efficient rotor engines like counter-rotating open rotors. Research on smart systems starts on a laboratory scale by using low-noise sensors and high-performance rapid control prototyping systems. The replacement of such costly and bulky laboratory hardware is one important precondition for the commercialization of smart structures. The increased internal noise, the reduced computational performance and other restrictions of low-cost hardware must be taken into account during the design of a smart system. Experimental results on the noise reduction of a smart lining with low-cost hardware show that a replacement of laboratory hardware will not lead to a loss of performance. The smart lining achieves tonal interior sound pressure level reductions of up to 25 dB with a mass increase of only 2%. Even a mass neutral implementation seems possible, if conventional loudspeaker-driven passenger announcements are realized with smart linings.

\* \* \*

### Musician Hearing Enhancement: Where and When It Occurs?

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Numerous studies suggests that musical training develops not only musical hearing abilities, but also enhances various non-musical auditory skills. The advantage of musicians over non-musicians in auditory tasks not related to music has been known as the musician hearing enhancement (MHE) effect. This paper argues that the occurrence of MHE and the degree to which the MHE effect is pronounced depend on the mode of listening, a concept representing the subject's listening strategy, related to the purpose of listening and the type of sounds being listened to. The modes of listening have been divided into three categories in the literature: 1) the causal mode, focused on auditory orientation in the environment, 2) the reduced mode, focused on extracting the meanings conveyed by the sounds by means of a certain code, 3) the semantic mode aimed at the perception of the inherent sonic characteristics with no connotations to any sound sources. Recent studies of the recognition of environmental sound sources

suggest that the MHE effect, largely evidenced in auditory tasks based upon reduced and semantic listening, is much less pronounced in the causal mode of listening.

\* \* \*

### The Method of Soundscape Evaluation of Selected Urban Parks in Poland

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This paper presents the results of objective measurements in urban parks in Poland. The main aim of the survey was to evaluate the minimum and the maximum of the sound level in urban open public spaces. The evaluation component was the scope of changes in the sound level in parks compared to the spread of the sound level values on selected cities' streets near parks. The measurements were taken in 44 urban parks in 7 cities. Although some differences have been found, it was possible to estimate the soundscape of the city and urban parks in every one of them. Among the measured parks, the largest range of sound level occurred in the Dąbrowski Park in Poznań – this park is situated next to the Stary Browar. The smallest range of sound level among the parks has been noticed in the Bogucice Park in Katowice. The largest differences in noise levels have been found in the city centers of Kraków and Wrocław. The findings show that the objective measured range between the minimum and the maximum sound level may be another factor for the subjective evaluation of the soundscape in urban open public spaces.

\* \* \*

### The Methods of Measurement of Acoustic Parameters of IEC 60318-1 Ear Simulators

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Ear simulators, often called “artificial ears”, are important devices for objective evaluation of the acoustic performance of supra-aural and circumaural earphones, used for example in audiometry and telephonometry. They are widely used for calibration of audiometric equipment. In the paper the methodology for calibration of ear simulators specified in IEC 60318-1, implemented in Central Office of Measures, is presented. There are two acoustic parameters that should be determined during calibration: the acoustical impedance of ear simulator and the overall pressure sensitivity level of the ear simulator's microphone and associated measuring system. Different measurement methods for determination of these parameters have been investigated and the preliminary results of measurements as well as assessment of the selected ear simulators are presented. The measurement set-ups and problems that may occur during calibration are also discussed.

\* \* \*

### Evaluation of Acoustic Properties of Sound Insulating Enclosure with Actively Controlled Double-Panel Structure Using Various Measuring Techniques

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In this article evaluation of acoustic properties of sound insulating enclosure with actively controlled double-panel structure in one wall is described. The structure consists of two fully clamped aluminum plates with dimensions  $40 \times 60$  cm. Sound transmission through the structure is reduced by using active structural acoustic control (ASAC) technique. In described structure the FxLMS algorithm, two inertial actuators, two macro-fiber composite (MFC) sensors and virtual error microphone technique have been used. Acoustic properties of the enclosure, for tonal signals at the selected frequencies, were evaluated during tests in the semi-anechoic chamber using different measuring techniques. The performance of ASAC was assessed by measuring sound pressure level at the virtual microphone site and at selected locations in the chamber. Sound radiation from the enclosure and especially from the double-panel structure were analysed by using acoustic camera and Scan & Paint 3D measuring system.

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### Automatic Audio Mastering System

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The modern music production process requires multiple steps of digital signal processing such as audio frequency response equalization or dynamic range compression. In order to process the original audio material the mastering engineer controls the parameters of these processing algorithms with respect to genre and style of audio content. Main purpose of this processing is to aesthetically enhance perceived acoustic characteristics of the signals. The selection and the adjustment of these parameters relies on the continuous interaction between the audio mastering engineer and the apparatus that handles the audio signals. Modelling such dynamic operations becomes very important in automated applications. In this work we present a system which automatically enhances unprocessed audio signal with respect to the specific parameters of the reference audio material. These parameters are obtained through analysis of magnitude spectrum (spectral roll-off point and energy calculated for specified frequency bands), amplitude histogram, audio content tempo, signal envelope's timing features and LUFS parameter. Results from conducted online listening

tests are presented and discussed along with objective measurements of unprocessed and reference audio signal.

\* \* \*

### Determination of Airborne Sound Insulation by Reference Curve Method. Are Reference Curves Still Useful in the Context of New Building Materials?

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For the description of airborne sound insulation, a frequency-dependent sound insulation standard  $R$  [dB] is generally used. It is defined by the logarithmic ratio of the sound output on one side of a component to the sound power emitted on the other side. To get a practical measure a single value is generated from the frequency course of the sound insulation, the so-called sound insulation standard  $R_w$  or  $R'_w$ . The reference curve has the idealized course of the sound insulation dimension of a full brick wall 25 cm thick. The measured sound insulation measure is then the value of the shifted reference curve at 500 Hz. This reference method was established in the 50th based on heavy materials and heavy constructions. Nowadays, however, due to thermal demand of the building, materials and constructions are getting lighter and more complicated, i.e. compound materials. Also, the single number value of a construction is the same the subjective impression is not. This is due to the method of how the individual number evaluation is performed. This paper discusses the method of obtaining a single number quantity in conjunction with new materials.

\* \* \*

### An Index-Based Method for the Assessment of the Acoustic Quality of Public Spaces

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The acoustic quality of many spaces is often a problem that confronts the designer. Ensuring adequate speech reception in different spaces is one of the key factors determining the acoustic quality of a space, which is determined on the basis of the reception of speech sounds. There are numerous parameters and methods that express or determine the acoustic quality of public spaces; however, many of them fail to take into account the special nature of special shaped spaces.

Speech intelligibility is one of the key factors determining the acoustic quality of spaces. Ensuring adequate speech reception is often one of the key challenges that the designer has to tackle. Consequently, expertise necessary to select proper parameters to achieve best acoustic quality of a space, at the design stage, is still insufficient.

The aim of the paper is to demonstrate the possibility of developing an index-based method for the assessment of the acoustic quality of special shaped spaces that takes into account the architectural and acoustic properties of spaces. The paper also claims that it is possible to select



such a reverberation time and to arrange sound-absorbing and sound-scattering structures in such a way as to make the acoustic quality of that space suitable for the purposes of the reproduction of speech sounds.

\* \* \*

### The Value of Flow Mediated Dilation in Prediction of Vascular Disorders

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Endothelial monolayer plays important role in anti-inflammatory and vasoregulatory functions. It has been shown in numerous studies the increase of vessel dilation after sudden increase of blood flow/ shear stress in the vessel after several minutes hyperemia, so after “mechanical” stimulation of the endothelium. Most of the reported research was conducted on the brachial artery. We are proposing measuring flow mediated dilation FMD and shear rate SR in the radial artery exhibiting higher FMD than the one in the brachial artery. In order to improve the measurements precision of vessel diameter and blood flow we have designed a high-frequency scanning system consisting of a 20 MHz linear array transducer combined with 20 MHz pulsed Doppler probe. The degree of radial artery FMD and SR was evaluated in 14 healthy volunteers and 12 patients with chronic coronary artery disease CAD. Statistically significant differences in FMD and SR between the two groups were confirmed by a Wilcoxon-Mann-Whitney AUCs of ROC curves for FMD and FMD/SR were greater than 0.9. The results confirm the usefulness of the proposed measurements of radial artery FMD and SR in differentiation of normal subjects from those with chronic CAD.

\* \* \*

### Ultrasonic Imaging of Radial Artery Reactive Response

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A comparison of 7 MHz and 20 MHz scanners for flow mediated dilation (FMD) and shear rate (SR) measurements in radial artery is reported. The experiments proved over three times better resolution of the high frequency 20 MHz scanner over the 7 MHz one. The sensitivity of the external single transducer 20 MHz pulse Doppler proved to be over 20 dB better than the pulse Doppler incorporated into linear 7 MHz linear array. 12 healthy volunteers and 14 patients with chronic coronary artery disease (CAD) were included. The Imaging/Doppler system was modified by adding the single element 20 MHz pulse Doppler to the

linear array transducer. The normalization of FMD to shear rate was done by dividing the peak FMD by the AUC-SR. In-group of 12 healthy volunteers, FMD was  $15 \pm 4.8\%$ , and in-group of 14 CAD patients, FMD was significantly less at  $4.6 \pm 4\%$ . A similar difference in tests groups was observed after normalizing to account for the effect of time integral of shear rate. Specifically, the ratio FMD/SR, was equal to  $5.36 \pm 4.83 \cdot 10^{-4}$  in group I and  $1.3 \pm 0.89 \cdot 10^{-4}$  in group II. The results confirm the usefulness of the proposed measurements of radial artery FMD and SR in differentiation of normal subjects from those with CAD.

\* \* \*

### Weighted Reduction of Impact Sound Pressure Level for Floating Floor According to ISO Standard and Laboratory Measurements

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Insufficient impact sound insulation of floors in present architecture has been a frequent issue reported by owners of flats sold in past few years. Floating floor is one of few ways to improve this kind of insulation, as well as to increase the airborne sound insulation of the ceiling. A revision of EN ISO 12354-2 standard published by the end of 2017 brings new formula used to calculate weighted reduction of impact sound pressure level for floating floor screeds made of sand/cement or calcium-sulfate. The aim of this study is to point and discuss the differences between new and old formula, both compared to laboratory measurements carried out in Building Research Institute (ITB).

\* \* \*

### New Acoustic Classification Scheme for Residential Buildings in Poland

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Acoustic quality of a dwelling plays pivotal role in its overall ranking. Dwelling, from a customer and final user view point, is a basic, but very expensive product so its properties should be well defined and customized to individual needs and expectations. Besides, the acoustic performance of a building should be adjusted to its general class, whereas in practice luxury apartments with poor acoustics are quite frequent. Since acoustic quality as a whole depends on different parameters, there is a need for an effective assessment tool transforming them into a single number quantity. The paper presents new acoustic classification scheme for multifamily buildings in Poland. It takes into account all basic acoustic factors that contribute to the holistic evaluation of a flat. Single number indicators selected for the assessment of airborne and impact sound insulation, noise level and reverberant conditions, as well as their threshold values are discussed. They should be well balanced and harmonized for each building class. As

the acoustical characteristics of residential environment depends on a building itself and also on conditions prevailing in its surroundings, the next step is to develop an acoustic categorization for residential areas.

\* \* \*

### Crosstalk Effect in Medical Ultrasound Tomography Imaging

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The ultrasound tomography (UT) is a modern method of medical imaging that has been intensively developed recently to diagnose female breasts in vivo. This method makes it possible to acquire images in various ultrasound modalities simultaneously – both transmission and reflection ones, without any focusing. Therefore, the ultrasound intensity level when scanning individual coronal breast sections is relatively low. Data for reconstruction of images are obtained by means of a multi-element array of small piezoceramic transducers spaced evenly on the inner side of the ring surrounding the breast immersed in water. The main problem with such arrangements is the occurrence of crosstalk, which introduce specific errors to measurement data. Crosstalk is a result of deficiency in electrical or mechanical isolation between array elements. Such errors lead to distortions in the reconstructed images. In the paper, the effect of crosstalk in the ultrasound tomography ring array was examined and analysed. The influence of crosstalk on the reconstructed images of the breast structure was shown, as well. Conducted studies enabled the detection of the sources and paths of crosstalk and, as a consequence, it allowed to improve the design of the multi-element ultrasonic transducer ring array and to reduce crosstalk.

\* \* \*

### Implementation of Acoustic Methodology for Investigation of The Ecology of Gas-Containing Toxic Cyanobacterium *Microcystis* sp.

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Toxic cyanobacterium *Microcystis* sp. affects functioning of aquatic ecosystems and water quality. New remote sensing approaches need to be developed for in situ study of *Microcystis* bloom development. The aims our work were to display the advantages of hydroacoustic techniques for in situ studying the gas-containing cyanobacterium *Microcystis* sp. and to examine the role of physical factors in

*Microcystis* bloom and surface scum formation. We found that gas-containing *Microcystis* colonies are strong acoustic backscatterers at ultrasound frequencies. This allowed developing a novel approach for in situ quantification and of *Microcystis* populations. Dynamics of echo-reflecting layer monitored with the bottom-mounted ADCP showed distinct near-diurnal vertical fluctuations caused by vertical migration of the cyanobacterium in response to development of diurnal thermocline in late winter – early spring 2013, 2017 and 2018. During the periods of *Microcystis* bloom volume backscattering strength in the water column was quantified with the echosounder EY60 and calibrated versus fluorometrically measured chl-a concentration (a proxy of *Microcystis* biomass during the bloom development). We investigated the process of surface scum formation in relation to physical forces and water motions and concluded that formation of surface scums plays important role in enlargement of *Microcystis* biomass in lakes. Our study showed that hydroacoustic methods can be successfully used for in situ investigations of spatiotemporal variability of the gas-containing cyanobacteria.

\* \* \*

### Underwater Navigation System Based on Doppler Shifts of a Continuous Wave

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The paper describes a concept of an underwater navigation system designed to determine the location and speed of its ROVs or divers. Conducted by the Department of Marine Electronic Systems at the Gdańsk University of Technology for several years, research has focused on navigation systems which determine positions on the basis of Doppler shifts of echo signals reflected from a moving object. This article presents a different version of such a system. With a source of a sinusoidal acoustic wave placed on a moving object, four hydrophones, transmitting and receiving electronics and a computer, the system determines Doppler deviations of the received signals and calculates the position and speed of the moving object. Simulation studies have shown that the system can offer an alternative solution for tracking its underwater objects.

\* \* \*

### Ultrasound Propagation in Cancellous Bone: Theory and Experiment

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The paper present theoretical and experimental issues related to application of Quantitative Ultrasound (QUS) for potential assessment of cancellous bone quality and prediction of bone fractures. Commonly used for modeling of ultrasonic wave propagation in cancellous bone, the

macroscopic Biot's theory and its various modifications are discussed in context of its applicability for theoretical prediction of wave parameters: phase velocity and attenuation coefficient as function of frequency and porosity.

The analysis of the model is focused on the absorption and scattering mechanisms responsible for wave attenuation and dispersion in cancellous bone, which based on the ultrasonic experiments, play a predominant role in the total attenuation. Moreover, the problem of interaction of the ultrasonic wave with the slab of water saturated cancellous bone, modeled as a saturated porous material, is solved and its influence on the total signal loss is considered.

The suitability of the model is discussed and verified by comparison of results of sensitivity analysis of the model with in vitro experimental ultrasonic data for cancellous bones filled with different fluids obtained for the frequencies ranged from 0.2 to 3 MHz.

\* \* \*

### Comparison of Different Methods of Acoustic Signal Detection for Monitoring of Nocturnal Birds

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Monitoring birds migrating during a night is a very challenging task. Modern technologies such as radar detection, thermal imaging and acoustic recordings are more and more used. The latter is especially interesting as the sound recording devices are the most cost-effective option so many attempts are made to develop new methods of processing of such signal.

In the article we present different parameters which can describe calls of migrating birds. We discuss the choice and reduction of parameters and then different classification methods, from simple ones – like logistic regression models – to more complicated models of machine learning such as: support vector machines, neural networks,  $k$ -neighbours models or decision trees. Obtained results show that acoustic recordings are promising methods of an extension of standard bird monitoring techniques.

\* \* \*

### Parametric Assessment of Esophageal Speech in Post-Laryngectomy Patients

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In this paper, we present the analysis of esophageal speech recorded for 27 patients after larynx excision. Classical time-frequency parameters were determined and compared with undeformed, natural speech. Next, we described voice source parameters using inverse filtering techniques.

Also, an attempt was made to find out useful parameters for esophageal speech quality description. We discovered that some parameters responsible for speech intelligibility are similar to those in natural human voice. Another conclusion drawn is a possibility of voice quality assessment by using glottal flow characteristics. The results are promising, showing the potential of the proposed methods in monitoring voice rehabilitation process.

\* \* \*

### ADCP Observations of Diel Vertical Migration of Biological Layers in Gulf of Gdańsk

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The study of Diel Vertical Migration (DVM) of biological organisms is important for better understanding of different aspects of Baltic Sea ecosystem functioning, including the behaviour of biological organisms as well as marine carbon budget, which could be under DVM impact. Ecosystem of semi enclosed Baltic Sea is especially sensitive to human impact. Its monitoring is important and requires rapid, relatively effortless and non-invasive techniques. Hydroacoustic methods meet these requirements. The main objectives of our research was, basing on hydroacoustic technique, to determine the DVM velocities of Baltic biological organisms and understand the impact of environmental factors (salinity, temperature) on the magnitude of the Diel Vertical Migration. The ADCP data (volume backscattering strength and the DVM velocities), collected near Hel Peninsula from April 05, 2014, to April 06, 2014, were used in the analysis. The ADCP, working at the frequency 300 kHz, was placed on a seabed. Three methods differing in used measurement data, were applied to determine the DVM velocities. The distinction between the results obtained using different methods was discussed.

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### Noise in the Arctic Settlements

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In the remote regions of the Arctic Spitsbergen there are four settlements inhabited by people and one ghost city, without the presence of residents. Where there is a human being, there are also sources of noise. They occur in parallel with natural sound sources. In the article, we want to present problems related to noisy human activity in these difficult areas in terms of climatic conditions. Acoustic studies of traffic and industrial noise are presented in the

area of Longyearbyen, the capital city of Spitsbergen. The influence of nature sounds on the acoustic climate of the settlement is shown. The results of sound measurements in other locations such as Pyramiden and Barentsburg are also presented. In the final part the what if analysis is shown for noise problems in the developing Longyearbyen environment.

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### The Risk of Asymmetrical Noise Exposure Among Music Students

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The amount of sound exposure was measured during music practice for a group of students at the Fryderyk Chopin University of Music in Warszawa. The measurements were taken separately at the left and at the right ear, using a two-channel noise dosimeter. The results show that the sound exposure during rehearsals, concerts and individual practice of music students exceeds in many cases the permissible limit of 85 dB(A). For some instruments (e.g., the flute or the trombone) the sound exposure is asymmetrical, which means that the sound levels are different at the left and at the right ear. Such an exposure may cause an asymmetrical noise-induced hearing loss reflected by different noise induced permanent threshold shifts (NIPTS) in the left and the in the right ear. This paper presents examples of sound exposure levels measured in the left and in the right ear of various instrumental musicians.

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### Quantitative Ultrasound for Chemotherapy Monitoring

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Neoadjuvant chemotherapy (NAC) is used in breast cancer patients to reduce tumor size, decrease the risk of local recurrence, and diminish the likelihood of metastases, all of which reduce patient mortality. Assessment of the response to NAC at an early stage of treatment allows therapy to be personalized. The quantitative ultrasound

method is a novel diagnostic approach with great potential to improve outcomes for breast cancer patients. The aim of this study was to analyse the variability of the integrated backscatter coefficient (IBSC) in the context of the assessment of changes in tumour tissue structure resulting from chemotherapy, and to evaluate use of IBSC to predict the effectiveness of treatment. Ultrasound data (B-mode images and raw ultrasonic radio frequency signals RF) were collected from cancerous tumours from patients intended to NAC before starting treatment and a week after each chemotherapy dose. Data were processed to generate IBSC maps and to determine IBSC mean values. The assessment of tumours using IBSC, in comparison with histopathological verification, showed that IBSC changes can be associated with changes which tumor structure changes during NAC. IBSC analysis correlated better with the results of histopathological verification than B-mode imaging.

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### Acoustics Surface Waves in Scientific and Practical Applications

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### Vibroacoustic Measurements and Analysis of High Energy Impulses

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Blasting works cause short-term high-energy shock waves – acoustic, air (blow) and paraseismic. The duration of the event can be up to 2–3 s, while the rise time to the peak value is directly related to the delay between the individual explosive charges (EC) and the firing sequence and ranges from a few to several milliseconds. Their propagation in the environment can affect people, animals and construction structures located not only in the close but also further distance from their source. If EC is placed on the surface of the earth during the detonation, the shock wave spreads evenly in all directions in the half-space, and when the detonation follows in rock, the wave usually travels in one direction and is accompanied by a paraseismic wave. However, the sound heard when detonating is part of the wave spectrum in the band from 20 to 20000 Hz, while the shockwave itself has a frequency of less than 20 Hz. Since at some distance from the detonated EC, the parameters of the shockwave are close to the parameters of the acoustic wave, the method of spreading the acoustic wave depends to a great extent on atmospheric conditions, i.e. density, temperature and humidity of the air, and from wind speed and its direction. To get to know the essence of the phenomenon of the impact of blasting works, measurements are carried out considering the propagation conditions, i.e. meteorological conditions as well as vibration analysis in the ground itself and on the building foundation. This paper presents the results of research carried out by the Authors



in terms of the correct assessment of the impact range of EC detonation placed on the surface.

\* \* \*

### **Pilot Studies on the Effects of Tonal Noise Annoyance Impact on Workers Performing Their Primary Tasks**

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Numerous references indicate that the subjectively assessed annoyance of tonal noise is higher than that of wide band noise. There are no criteria for the impact of tonal noise in assessing the occupational environment for both indoor areas (construction standards) and workplaces (annoyance assessment). As a stressor, noise can contribute to the development of various types of illnesses (e.g. hypertension, peptic ulcers, neurosis), it causes distraction of attention, hinders work, and reduces personnel performance. The pilot studies involved 11 people (6 male and 5 female) fulfilling the audiometric qualification criteria. The group of test participants was diversified in terms of noise sensitivity. The research method used both the questionnaire studies and computer psychological tests checking work performance, attention level, and memory. Four types of generated test signals were developed (filtered noise – A, and three signals with tonal components 125 Hz, 1600 Hz and 8000 Hz – B, C, and D) at the same sound level A of 55 dB. Results of the statistical analysis based on the questionnaire studies, as well as for the psychological tests, did not show a statistically significant variation between individual signals. The absence of variation in test results between the individual signals presented in the statistical analysis does not give any reasons for applying correction of tonality measurement results according to ISO 1996-2.

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### **Investigation of Acoustic Properties of Fibre-Cement Boards**

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The paper describes two different techniques of ultrasound measurements performed in fibre-cement boards, the material widely applied in building technology. An in-house device dedicated for fibre-cement boards testing is also presented. To overcome the difficulty of determining the arrival

time of a waveform of longitudinal wave traveling across a thin and inhomogeneous body, cross-correlation method of signal processing was proposed and applied.

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### **Sensitivity to Changes of the Amplitude, the Center Frequency and the Bandwidth of Formants Imposed Over the Spectrum of Pink Noise**

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The paper reports the results of an experiment carried out to determine the just noticeable timbre changes of pink noise. The variations of timbre were obtained through changing the amplitude, the center frequency or the bandwidth of a formant imposed over the spectrum of a burst of pink noise. The difference threshold was measured for each of the spectral modifications with the use of an adaptive, three-interval, three-alternative forced-choice up-down procedure. The listeners' task was to indicate which of the three noise bursts presented in a trial was different from the other two bursts. The experiment was conducted on 11 sound engineering students. The results show that the difference thresholds for the formant parameters vary depending on the frequency region in which the formant is imposed. The results obtained with the use of an adaptive procedure are in fairly good agreement with similar measurements made with the use of a constant stimulus psychophysical procedure in a previous study. The present results will serve as reference for the measurements of the sensitivity of sound engineering students to spectral modifications of music recordings.

\* \* \*

### **Using a Large Hydrophone Array to Reduce Rapid Fluctuations in Underwater Acoustic Communication Channels**

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There is an expected growth in underwater acoustic data traffic, and to meet the demand of high data throughput a migration towards the very high frequency band (>100 kHz) will be necessary. The increment in frequency comes with two problems; higher propagation losses, and rapid channel fluctuations. One solution addressing both of these obstacles is the use of large hydrophone arrays. The increment in array gain can compensate for the increased path loss and channel variations can be reduced by means of spatial filtering or by the fact that uncorrelated fluctuations can be averaged out over the hydrophone array. We will in this paper examine this reduction in fluctuation for

large hydrophone arrays. Using data from a shallow water very high frequency (250 kHz) channel we will show that a reduction in channel fluctuations indeed occurs. Relaxing the need for rapid equalizer convergence rate, and that this effect can be achieved with a few tens of hydrophones.

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### Experimental Studies of Shallow Water Acoustic Noise Correlation Properties

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The article presents works related to examining the correlation properties of acoustic noise occurring in shallow waters. Knowledge of these properties is very important from the point of view of designing passive and active hydroacoustic systems. The experimental approach was based on the rejection of generally accepted assumptions, regarding the noise correlation properties, at the stage of simulation and design of sonar systems. At the initial processing stage of measurement signals, the Cut Noise Envelope (CUTE) algorithm, developed at the Department of Marine Electronic Systems at the Gdańsk University of Technology, was used. The article describes in detail the successive stages of the main processing algorithm of the measured signals, discusses and presents the results of research.

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### Derivation of Thermophysical, Caloric and Acoustic Properties of 1-butyl or 1-hexyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide at the Wide Range

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### Multiple Input, Multiple Output Technique for Underwater Acoustic Communication System

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The performance of underwater acoustic communication (UAC) system is limited due to a tough propagation conditions in UAC channel. Multiple-Input Multiple-Output (MIMO) technique can improve the reliability of the data transmission system, increase its speed, increase its range, and reduce the energy consumption. The paper presents an implementation method of MIMO technique in the form of coding the Space-Time Block Code and its optimal case in the form of Alamouti coding. The results of simulation tests in channel with the Rayleigh flat fading

were included, which were compared with the quality of the SISO system.

\* \* \*

### An Integrated Mechatronic Modelling, Simulation, and Optimization Approach for the Customized Design of Active Vibration Damping Solutions

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A crucial factor for the effective implementation of active vibration damping is the application of suitable actuators operating at optimal locations, combined with an appropriate control strategy. The actuators have to provide the required characteristics in view of the applied force in the relevant frequency domain. Additional restrictions such as dimensions, energy consumption, or costs of the system have to be accounted for. Hence, the determination of an optimized tailor-made solution for a vibration damping problem is of multi-objective character and cannot be achieved without consideration of the particular application. In this contribution, a holistic approach for the optimal design of vibration damping solutions is presented, taking into account the specific requirements of the considered application and including the mechanical system, the actuators, as well as the control strategy. The approach is realised within the simulation and optimization framework SyMSpace and applied to an existing use case representing a general vibration damping task based on electromagnetic actuators and an adaptive control strategy. Special attention is given to both the modelling and optimization work flow in SyMSpace as well as the experimental setup of the use case for the assessment of the results.

\* \* \*

### Reduction of Tyre/Road Noise Due to Application of Thin Pavement Layers

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An increasing problem of modern times is the noise pollution due to tyre/road noise caused by increasing traffic density. Primary noise reduction strategies attempt to reduce the noise generation at the contact area of tire and road. Within the present work, the physical effects of the noise reduction of thin pavement layers were examined. Therefore, acoustical measurements according to ISO 11819-1 and ISO 11819-2 as well as measurements of the properties of the road surface (texture profiles, sound absorption coefficient and specific airflow resistance) were carried out. Using the properties of the road surface as input parameters for the SPERoN model (Statistical Physical Explanation of Rolling Noise), the sound emission level

next to the road was calculated and compared to the measurement results. Finally, tendencies for the development of noise reduced pavements are derived.

\* \* \*

### Sonothrombolysis – Dissolving Thrombi by Interaction of the Drug and Ultrasound

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Under the influence of pathological changes, the blood coagulates inside the blood vessel, creating a thrombus. The thrombus dissolution process is called thrombolysis. The aim of the study is to evaluate the thrombolysis process by the interaction of the thrombolytic drug and the ultrasound. The clot dissolution process was analysed in the specially designed, transparent for ultrasound parallel plate flow chamber. Inside, a freshly coagulated human blood sample was exposed to ultrasound. A liquid containing the tissue plasminogen activator drug in a concentration of 10 µg/ml passed around the sample. The liquid flow was forced by a peristaltic pump. The source of ultrasound was a 1 MHz flat ultrasonic transducer with a 25 mm diameter. The transducer radiated 1000 periods burst, repeated every 2500 periods and space averaged time averaged intensities of 0.2–1.6 W/cm<sup>2</sup>. The efficacy of thrombus dissolution was observed by means of a designed parallel plate flow chamber and the time of thrombus complete dissolution was measured. The best result for the 1 MHz frequency and space averaged time averaged intensity of 1.6 W/cm<sup>2</sup> was recorded, where the thrombus was dissolved within 5.5 minutes.

\* \* \*

### Dancing Violins and Guitars

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The dynamic behaviour of violins and guitars was examined by means of experimental modal analysis. It is a method of description of vibrations of any objects that can be treated as a linear system. The purpose of modal analysis is to determine the so-called modes of vibrations,

or indivisible vibrations (basic, simple, own), described by modal parameters, i.e. modal frequencies, damping and associated deformations (modes). In the case of violins and guitars, “mode” means the vibration of the instrument together with the air contained in the resonant body and the air surrounding the instrument for a strictly defined (modal) frequency. Single copies of instruments of high concert or historical value, were studied by means of modal analysis quite often, while in the literature of the problem, very little space was devoted to comparative studies of instruments with modified structure. The comparison of the modal parameters of two violins and guitars differing in one intentionally introduced structural modification allows for a description of its impact on the dynamic behaviour of the instrument. Animations of modal envelopes reveal the complicated vibrations of top plates being the most efficient acoustic radiators – instruments “dance” in each modal frequency by performing specific movements. Results of experimental modal analysis of modified violins and guitars will be presented.

\* \* \*

### Results of Noise, Lighting and Microclimate Assessment at the Workstations in the Hospital

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Acoustic conditions in hospital premises are the result of noise coming from outside of the room, noise from any apparatus or tools used and reverberation noise, resulting from room characteristics. Acoustic factors could have some negative effects on an employee, causing i.e. irritation, decreased attention or fatigue. Exposure to noise with levels exceeding 80 dB results in permanent (hearing loss) or temporary shifts of hearing threshold. There is a need for acoustical conditions to be adjusted to the minimum necessary level of comfort in operating rooms, treatment rooms and medical diagnostic laboratories. The article presents the assessment of three physical factors of the work environment, i.e. noise, lighting and microclimate in selected rooms of the hospital. The examination rooms have been selected in cooperation with health and safety service employees. Measurements of quantities characterizing noise, lighting and microclimate were carried out in the operating room, as well as in the sterilization and pathomorphology rooms. For this purpose, the measurement methods established in the standards were applied.

\* \* \*

### Procedure of Experimental Derivation of the Two-Port Scattering Matrix Applying the Single-Mode Generator

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The paper presents procedure of experimental derivation of the acoustic two-port scattering matrix for a multimode wave propagating in a hard cylindrical duct applying the single-mode generator. The self-designed single-mode generator is constructed in a form of matrix of acoustic monopoles and is capable to generate a selected single mode. The scattering matrix formalism is a new approach to analyse the acoustical systems containing one or more duct-like elements (joints) connected by some undefined elements such as, for example, acoustic mufflers of different types and so the formalism is frequently applied to analyse the phenomena of noise reduction in such systems. Experimental derivation of the scattering matrix for a wave composed of  $N$  modes demands, in general, excitation of  $N$  different sound fields at each side of the two-port first. Finally the matrix composed of the modal pressures measurements obtained for each of the exited fields must be inverted to obtain the scattering matrix. Generating single  $N$  modes the matrix of the incoming pressure data is, theoretically, diagonal which makes derivation of the scattering matrix much easier. Generation of independent sound fields in the shape of single modes ensures the matrix to be well conditioned.

\* \* \*

#### **Influence of Natural Voice Disguise Techniques on Automatic Speaker Recognition**

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The problem of voice disguise is usually investigated in the context of surveillance and forensics. The biometric techniques applied for automatic or subjective speaker recognition can be deliberately or non-deliberately misled by technical or natural methods. The first investigations presented in the paper include data collection and automatic speaker recognition scores. The database consists of the utterances of several natural voice disguise techniques: phonation (raised and lowered pitch, whisper), phonemic (foreign accent), prosodic (speech tempo) and deformation (pinched nostrils and clenched jaws). The speaker verification was realised with the state-of-the-art system of MFCC (Mel Frequency Cepstral Coefficients) feature extraction and GMM (Gaussian Mixture Models) classification.

\* \* \*

#### **Problems with Classification of Open Plan Office Acoustic Comfort Using ISO 3382-3 Single Number Quantities**

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The study discusses methods for the measurement of room acoustic properties in open plan offices and classification of rooms based on them. The ISO 3382: 3 standard

has become the most common. It discusses the measurement methodology of parameters related to the propagation of speech and speech intelligibility in office interiors. Information about the room rating based on these parameters, in this particular standard, is residual. The concept of evaluation according to VDI 2569 seems more correct, but also not without reservations. The task is to pay attention to the problem of room classification according to the above standards. There will be cases described which, according to the author, show good conditions in the room, but do not meet the requirements of the above standards.

\* \* \*

#### **Comparison of Methods of Measuring the Insulation of Building Partitions from Air Sounds in the Field Using Pink Noise, MLS Signal and Swept-Sine**

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Measurement of insulation of building partitions from airborne sounds is used to assess and compare measurement results with standard values or design assumptions. In most cases, pink noise is used as the forcing signal for this type of measurement. In this work, the MLS (Maximum Length Sequence) signal and Swept Sine signal were additionally used. The last two signals make it possible to obtain a better signal-to-noise ratio, which is especially important in conditions of increased disturbances and in the situation of limitations in the level of sound system. The obtained results were compared and the conditions in which they could be more useful were analysed. The differences resulting from their use, in particular in the conditions of high acoustic background, are indicated.

\* \* \*

#### **Determining Chosen Parameters of Hydroacoustic Channel Basing on Impulse Response Estimate**

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In the paper a research is presented that allowed to estimate the impulse response of hydroacoustic channel. Basing on the channel impulse response the coherent band and coherent time are determined. The research was conducted in laboratory basins, lake and harbour.

\* \* \*

#### **Analysis of the Structure of Bottom Sediments of the Gulf of Gdańsk Based on Acoustic Images Obtained with a Parametric Echosounder**

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Bottom sediments and upper layer of the sea bottom have a varied geological structure. It is most often a mixture



of commonly found bottom materials such as sand, gravels, mules and clays. Very often we find gas concentrations in these areas. They are usually mixed with the structure of materials from which the seabed is built. The use of non-linear hydroacoustics achievements, the result of which is, inter alia, the parametric echosounder allows penetration of the seabed from a few to several dozen meters. This makes it possible to complain about acoustic images of the seabed section with regard to its structure. As a result of geobiological processes, there are areas in which there are gas clusters. The basic element of the paper is the analysis of the seabed structure in terms of detecting its heterogeneity, and in particular the detection of areas in which the concentration of gas bubbles is relatively large.

\* \* \*

### Some Recollections on the History of Acoustics at the Gdańsk Coast in the Last Decade 2008–2018

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In December 2008 at the session of the Polish Committee on Acoustics of the Polish Academy of Sciences the author (being then already retired) presented the review on his reminiscences and on the history of acoustics development at the Gdańsk Coast since 1950-ties. This year advantage of the 65-th Open Seminary on Acoustics meeting organization by the Gdańsk Division of the Polish Acoustical Society appears as a good opportunity to present a continuation of the history in the last decade 2008–2018 during which the author still happily participated. In the talk some selected facts and the author's recalls of the history of activity and cooperation among acoustical community at Gdańsk Coast during the last decade will be presented and illustrated.

\* \* \*

### Influence of Auditory Selective Attention on Word Intelligibility

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Auditory selective attention plays a key role in the cocktail party effect. There are many factors that influence this effect. Despite its importance, it is still unclear as to how auditory spatial attention distinguishes a target sound from others. In this study, we investigate how auditory spatial information affects word intelligibility in complex acoustic scenes. To simulate such scenes, a target sound is presented among spatially distributed non-targeted ones. By introducing beforehand, the listener's auditory spatial attention is attracted to a specific loudspeaker from which

target speech sounds are presented. This is done to examine how attention causes word intelligibility to increase and how large the spatial extent of the effect is. The results show that word intelligibility increases approximately 15% when the target sound is presented from a specific direction. Furthermore, word intelligibility decreases as the angular distance from the specific direction increases. This pattern shows a spread of the effects of auditory spatial attention.

\* \* \*

### Comparison of Backscatter and Seabed Topographic Characteristics Recorded by Multibeam Echosounder at Rewal Area – Southern Baltic Sea

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The main purpose of this research is to develop efficient and reliable acoustic techniques for monitoring geomorphological and sedimentary features of the Baltic seabed. Multibeam echosounder (MBES) measurements were carried out in the Baltic Sea at the Rewal area, which is characterized by diversified types of sediments, geomorphologic forms, and benthic habitats. A MBES provides two types of information – bathymetric data needed for digital elevation model (DEM) construction and relative backscattering strength of the acoustic signal. The seabed features were extracted using 2D Fourier transformation of the DEM. Spectral parameters of bottom rough surface were used for the classification of seafloor morphological types using fuzzy logic classification algorithm. The other method was used for backscatter intensity, where the spectral and continuous wavelet transformation parameters of angular dependency of bottom backscattering strength were the input to the classification algorithm. The results of both methods were compared with the sedimentological information of the analysis of 56 sediment samples and a good compatibility of the classifications was obtained.

\* \* \*

### QoS by VoIP Under Use Different Audio Codecs

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VoIP is currently the most widely used technology in telephony. Many providers now implement it in their IP-based networks. However, as flexible and powerful as the IP transport platform might be, it is nonetheless prone

to packet loss. Network delay, out-of-order packet delivery and jitter are additional impairment parameters. As a result, Quality of Service (QoS) cannot be guaranteed in VoIP. What effects do network impairment parameters have on QoS in VoIP? What influence does the choice of audio codecs have? How can QoS in VoIP actually be measured in practice? What must a test environment look like if it is to produce reproducible measurement results of QoS in VoIP? What about security in VoIP? The work described in this paper aimed to find answers to these questions. The series of analyses was devised to show up the strengths and weaknesses of the audio codecs currently used in the VoIP service. The paper concludes with a summary and an outlook on further work.

\* \* \*

### **Prediction of Sound Pressure Levels in Rooms Using EN 12354**

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In residential and office buildings, service equipment can be annoying if it produces noise. To avoid noise, especially structure-borne noise, a prediction and calculation of sound power injected into the structure is necessary. For the prediction of sound pressure levels due to structure-borne sound sources in residential and office buildings the standard EN 12354 only provides little information regarding the characterization of a structure-borne sound source. Furthermore, there are little information about the uncertainties of the prediction itself. Especially for lightweight structures, when the mobilities of source and receiver could match, a practical method for the power prediction is missing. Nevertheless, they are necessary for an accurate sound pressure prediction. This paper focuses on the prediction of sound pressure levels in rooms due to structure-borne sound sources. Therefore, the characteristic source parameters were measured with the Two-stage reception plate method. With these source parameters, the sound pressure levels in a lightweight test facility were calculated and compared with measurements. Furthermore it will be referred, if the prediction method in EN 12354-5:2009 using TSM for source characterization is valid for the prediction of sound pressure levels due to structure-borne sound sources in light-weight constructions.

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### **Spatial Scanning of Sound Fields in Rooms**

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This presentation gives an overview of studies which have been performed recently by using a measurement and visualization approach for the analysis of sound waves in rooms and outdoors. By scanning sound field in auditoria in high spatial resolution, various features of the direct, reflected sound can be visualized. The comparison of repeated measurements with and without the presence of chairs or people allows a new perspective on grazing sound propagation over theatre seating ("seat dip effect") and of sound propagating through a standing crowd in open air concerts. Furthermore, the data can be assessed in order to derive uncertainty models for room acoustic measurements.

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### **Bridging Acoustics and Audiology by Research on Speech Recognition**

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The auditory system has a remarkable ability to perform well in acoustically challenging conditions. This ability worsens with increasing age and hearing deficits. Studies related to better understanding and improvement of speech recognition in diverse acoustic conditions for listeners with different hearing status will be a leitmotiv of this talk. First, matrix sentence test as a reliable, internationally compatible tool for speech recognition assessment will be introduced. Examples of application of the matrix type tests in basic research studies as well as in hearing diagnostics will be presented including joint projects between Germany and Poland. This will include studies related to the influence and interaction between background noise and room acoustics as well as consequences of hearing impairment on speech recognition in various acoustic conditions. Furthermore, the outcomes of the listening experiments will be compared to the predictions of effective speech intelligibility models like binaural speech intelligibility index-based model or automatic speech recognition-based model. Examples of application of this kind of models in assessment of the acoustic treatment of rooms or speech enhancement techniques in terms of speech recognition will be shown.

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### **Surprising Solutions of Several Problems of Mathematics and Mechanics**

WESOŁOWSKI Zbigniew

In many languages, if not all, there is something called a common sense. A sufficient understanding of processes, which may be referred to as a global experience. This paper, comprising of a dozen of elementary examples, not exceeding the first year of study at a technical university, shows that sometimes this common sense, gained in everyday experience, leads astray.

There are numerous examples from different fields of study. Few of them from mechanics show, that by reducing the cross section of a beam, i.e. simply by removing the material, one can increase the bearing capacity of a structure (a bent beam). Another example indicates that welding is not a trivial task and requires precaution. Next points out

that a twisted rod with a circular cross section becomes longer and not shorter. Further illustrates that an invention with a pipe, that does not lose stability when compressing, is false. The center of gravity of a ship does not have to lie below the center of buoyancy. Additional examples from probability theory show our misunderstanding of random events, which we often face ourselves (a group of students, spontaneous and accidental emergence of organic matter, tropical disease). Finally, examples from mathematics and logic (convict, incorrectly asked question, chain curve) teach us caution and accuracy when formulating a problem. Particularly surprising is the case of intransitive relations (4 dice) and two events, which have no rational explanation whatsoever (convict, wonderer in the desert).

\* \* \*

### Measurement Solutions for Industrial and Environmental Acoustics

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### A New Theory “Vortex Sound Theory” Changes Acoustic Paradigm?

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The question whether the contemporary “new theory of acoustic vortex flows” VST, which is currently emerging, indicates the introduction of revolutionary changes in principles and laws in classical acoustics, will be practically verified in scientific circles, probably over the next decades. In the speech of the author of the paper, such material for discussion on this subject is presented by the results of experimental research conducted by the author using acoustics orthogonal decomposition (AOD) disturbed acoustic fields generated in the natural environment. New analysis techniques resulting from the treatment of acoustic flows as an energy phenomenon – which they are in fact – are based on the analysis of vector parameters of the acoustic wave: of the acoustic particle velocity (also called acoustic velocity) and sound intensity. Vector analyses give the opportunity to visualize the acoustic wave flows and “watch” the structural effects caused by the wave reaction on obstacles. Visualization of such effects of scattering, reflection and refraction for various cases of vortex disturbed fields of real flows, which theoretical description deals with VST, is the main content of the presentation.

\* \* \*

### The Influence of Workstations and Office Equipment Setup on Acoustic Privacy in Open Space offices

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Providing comfort and acoustic privacy for people working in today’s open space office environment, where

over a hundred of them can be placed in one room, is a huge challenge. Workstations in such offices are often arranged in long rows placed one by one and divided only by vertical panels with maximum height lower than 1.2 m. Moreover, architects are moving away from the idea of covering structural ceiling with sound absorbing coffers, which makes it even more difficult to keep STI on a sufficiently low level. That raises a question – is it possible to find a compromise between office design trends and acoustic comfort? The influence of workstations placement, as well as usage of equipment like desk panels, office walls, ceiling mounted elements, etc. in different setups on acoustic parameters of open space offices is analysed. The paper will present results of acoustic simulations on computer models of rooms and classification based on ISO 3382-3 standard and VDI 2569. Author believes that this work will help in future design of open space offices, as well as in providing products intended for similar rooms, that will be more efficient and suitable at the same time.

\* \* \*

### Vertical Temperature Stratification of the Gulf of Gdańsk Water

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The Baltic Sea is characterized by variable hydrological conditions affecting the hydroacoustic conditions throughout the year. Even at a small depth, we can observe a large temperature gradient affecting the accuracy of the conducted research using hydroacoustic devices. A characteristic feature of the Baltic waters is their layering. In the Baltic Sea, we distinguish three main layers of water: surface, whose temperature is closely related to air temperature and varies within 1 to 22 degrees during the year, an intermediate characterized by the occurrence of a seasonal thermocline and deep sea temperature, which fluctuates within small limits from 4 to 6 degrees. There are many factors influencing water temperature changes, among others: heat exchange between water and atmosphere, floods of water with higher salinity from the North Sea, strong winds occurring in the autumn-winter period, upwelling phenomenon, inflow of fresh waters from rivers. The article presents the results of research carried out in the Gulf of Gdańsk and their impact on the acoustic conditions of the Baltic waters.

\* \* \*

### Sound Power and sound Insulation at low Frequencies

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In general, airborne sound power is considered to be independent of direction, distance and environment. Nevertheless, for single tone or low frequency sound sources, the sound power emitted into rooms depends also on the

environment and on the exact position in the room. This effect is investigated using Monte-Carlo simulations. It is then proposed to describe a source by the sound power that would be emitted into a free sound field. The consequences of this approach for measuring sound insulation are discussed.

\* \* \*

### The Proposition of Guitar Sound Parameters to Assess the Impact of Atmospheric Conditions on Acoustic Qualities of the Instrument

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Due to wood hygroscopicity, the properties of instruments with wooden elements are changing. The effect of this is an instability of the sound of the instrument. This paper presents a group of acoustic parameters describing changes in the sound of an acoustic guitar in an objective manner. During the research, we made some dedicated devices, among others an acoustic measuring chamber, a mechanism for repetitive string excitation, and a system enabling acoustic measurement with an equivalent noise level of 4.5 dBA. The instruments underwent a process of forced allocation of water molecules in wood (moisturizing). We developed parameters describing the sustain time, the character of sustain and tonal equalization of the sound of the instrument.

\* \* \*

### New Technologies in the Treatment of Tinnitus – Modulation of Sound Amplitude in Sound Therapies

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Due to its prevalence tinnitus (ringing in the ears) is considered as a civilization disease. Tinnitus affects around 10% of the general population, for some seriously debilitating the quality of life. Residual inhibition (RI) is a well-known phenomenon defined as a temporary reduction of tinnitus loudness after a prolonged exposure to an acoustic stimulus. Previous research suggested that amplitude modulated sounds may be also effective in reducing the tinnitus loudness. However, the question of whether RI depends on the frequency of the modulation remained unanswered.

Our aim was to test whether amplitude modulated broadband noise may be more effective in tinnitus masking and producing RI when compared to the same non-modulated stimuli. The second goal was to verify whether potential differences depend on the modulation frequency. We tested fifty seven volunteers with tinnitus for three frequencies of the modulation: 4, 32 and 64 Hz. The results showed that there is a dependency of the modulation

frequency on the minimum level required to produce RI – stimuli with relatively high-frequency modulation (32, 64 Hz) were more effective in reducing tinnitus loudness than non-modulated or low-frequency modulated stimuli. This study provides promising perspectives on clinical approaches based on acoustic simulation and aimed at maximizing RI.

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### Investigation of the Uncertainty of Determination of Long-Term Road Traffic Noise Indicators on the Basis of Short-Term Measurements

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The harmonized road traffic noise indicators Lden (day-evening-night equivalent sound pressure levels) and Lnight (night-time equivalent sound pressure levels) are the basic indicators used in strategic noise assessments, especially in strategic noise maps. However, their determination based on year-round monitoring is troublesome and time-consuming. Methods are needed to determine these indicators on the basis of short-term monitoring. This approach is associated with increased uncertainty in determining these indicators. Therefore, the work analysed the impact of partial uncertainties brought by the limitation of the length of the measurement sample, also the number of samples and the day in the week in which the sample was registered, on the result of the final uncertainty of estimation. The calculations were made for samples length from one day to one month, registered in the vicinity of the motorway, national road and road located in the urban area. The uncertainty budget also includes the partial uncertainty of the impact of disturbances and the efficiency of the filtration method used.

\* \* \*

### Phase-exact Adaptive Feedforward Control with Reduced Computational Complexity for Modulated Gear Mesh Vibration at 4.7 kHz

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The implementation of an active vibration control system for high speed planetary gearboxes is challenging because of the high mechanical frequencies to be controlled. Furthermore, gear mesh vibration in planetary gearboxes is amplitude and frequency modulated which results in a rich sideband structure. State of the art control approaches using feedforward control are able to achieve significant reductions at the target frequencies. However, sidebands around the nominal gear mesh frequency are typically amplified in the controlled case. This paper proposes a setup



for active vibration control to suppress transmission of gear mesh vibration to the surrounding structure using piezoelectric inertial mass actuators. The proposed control algorithm uses multiple adaptive feedforward controllers. The gear mesh vibration can be suppressed on the test rig at frequencies up to 4.7 kHz. To achieve the desired sampling frequency in real time several optimizations are introduced. A detailed analysis of the control approach is conducted using both simulation and experiment.

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### **Animal Mimicry in Covert Underwater Communication: Application of Syntax Generation and Simulated Genome Method**

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The paper proposes a covert underwater communication method based upon low-level genetic simulation and evolutionary syntax generation. The covertness is achieved through a LPD (low probability of detection) principle based upon mimicry of aquatic animal communication – the message is concealed as a vocal exchange between members of an aquatic species. The non-deterministic method generates polymorphic signals consistent with animal vocalisation syntax structure, which makes the probability of a third party identifying them as covert communication low. The non-determinism and polymorphism is achieved through the use of both a novel method based upon low-level genetic simulation, and a scheme for generating syntax rules. Since the method's principles of action are based upon genetics at the molecular level, the scheme's promised

benefits are akin to those offered by real-life genetics, namely robustness, compactness, and evolvability.

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### **The Wald Sequential Test as an Alternative Statistic Criterion in Staircase Adaptive Procedures**

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In adaptive procedures used in psychoacoustics, the Wald sequential statistical test has been employed only in the PEST procedure. A specificity of the Wald test is that it allows selecting the target threshold value at any point on the psychometric function. This feature is useful when there are special test requirements, such as selecting a point on a psychometric function corresponding to a given detectability index value. Adaptive, staircase, up-down procedures are based on rules of signal level setting that are simple to implement but, in contrast to the Wald test, they allow to estimate the threshold level only for a few points on the psychometric function. In this study the feasibility of an adaptive, up-down staircase procedure which uses a decision rule based on the Wald sequential statistical test was examined. The staircase procedures, combined with the Wald test for selecting signal level, were tested as to their ability to converge at various threshold levels, their accuracy, and bias. The study was aimed to determine whether the Wald test may serve as a proper replacement for standard rules of signal level setting in adaptive up-down procedures.

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