www.czasopisma.pan.pl PAN www.journals.pan.pl
Archives of Acoustics Vol. 47, No. 3, pp. 425–442 (2022), doi: 10.24425/aoa.2022.142016

Chronicle

68th Open Seminar on Acoustics September 12 – 16, 2022, Solina, Poland

Open Seminar on Acoustic is an annual conference that brings together researchers and scientists from acoustics. It is organized under the patronage of the Committee on Acoustics of the Polish Academy of Sciences in turns by different divisions of Polish Acoustical Society – in 2022 by the Rzeszów Division of Polish Acoustical Society jointly with the College of Natural Sciences, University of Rzeszów.

It is our pleasure to present abstracts of the papers submitted for the 68th Open Seminar on Acoustics – OSA 2022 – that was held September 12–16, 2022 in the Solina Resort located in the South-East Poland.

Abstracts

Pickering droplets and capsules under magnetic fields – calorimetric and ultrasonic studies

Rafał Bielas, Bassam Jameel, Andrzej Skumiel, Arkadiusz Józefczak

Adam Mickiewicz University in Poznań
Poznan, Poland

Nanoparticles and their derivative materials, such as particle-covered droplets (Pickering droplets) or capsules, hold promise to be utilized in biomedicine, for instance, to enable targeted drug release and improve the efficiency of thermal therapies. Using such materials simultaneously with diagnostic modalities (e.g. Magnetic resonance imaging or ultrasound imaging) opens the possibility of the so-called theranostic approach, in which combining multiple modalities into one platform may provide numerous benefits for patients.

Herein, we present the potential use of magnetic fields for future theranostic applications. We investigated the temperature elevation when Pickering droplets were exposed to the alternating or rotating magnetic field. When the temperature exceeded the temperature of glass transition, the thermo-sensitive polymer particles partially sintered and formed a rigid shell around the droplets (colloidal capsules). For testing the behaviour of droplets during magnetic heating, the non-destructive ultrasound measurements were performed and showed no significant difference in acoustic properties after exposition to magnetic fields. In the future, the acoustic method could be also used for evaluation of the efficient capsules formation.

This work was supported by the project no. 2019/35/N/ST5/00402 (Preludium) of the Polish National Science Centre.

⋆ ⋆ ⋆

Leaky partial updates to control a real device casing

Dariusz Bismor

Silesian University of Technology
Gliwice, Poland

Structural active noise control (ANC) is one of few solutions applicable when global noise reduction is required: control of a whole device casing allows to lower the acoustic energy emitted by this device. Unfortunately, structural ANC usually requires a large number of sensors and actuators, making the control system multichannel with large dimensionality. This in turn presents a huge computational power demands. There are several ways to lower this demand, the partial updates being one of them. The goal of this paper is to show applicability of the leaky partial update LMS algorithms in structural ANC of a washing machine casing. The transfer functions of the numerous device paths were identified using a real washing machine present in the ANC laboratory. The identified transfer functions allowed to create a simulation system, where different algorithms could be easily tested. The results of the simulations confirm effectiveness of the proposed solution.

⋆ ⋆ ⋆

Sound source localization – comparison of six popular microphone systems for stereo recordings

Lukasz Blasiński, Jedrzej Kociński, Stanisław Kasprzyk

Adam Mickiewicz University in Poznań
Poznan, Poland

Dating back to the early 30's and the beginning of stereo recording, many sound engineers experimented with different multi-microphone techniques to capture the sound in a way that it would be natural to the human ears when listening. Many different techniques of stereo sound recording have been developed so far. Among them two-microphone techniques AB, XY or ORTF should seem to be the most commonplace ones.

The goal of our research was to investigate which two-microphone stereo techniques system is the most compatible to human perception of sound source localization. Six popular stereo recording techniques were analysed.

More than 80 listeners took part in a remote, internet survey and headphone listening test with recordings from above mentioned stereo solutions. Over 20 participants of a control group have been audiologicaly tested and took part in a listening test under controlled listening conditions.

The results show that listeners perceived the sound localisation differently for different techniques. Some of them drastically disturbed the spatial perception.

To conclude one may state that the type of recording influences the spatial perception thus the choice of the microphones settings is crucial for further spatial effect while listening.

⋆ ⋆ ⋆

Design of the test facility for measurements of sound silencers

Romuald Bolejko[1], Andrzej B. Dobrucki[1], Przemysław Plaskota[1], Krzysztof Pruc[2]

[1] Wrocław University of Science and Technology
Wroclaw, Poland
[2] BH-Res
Rzeszow, Poland

In a paper, a description of the test facility designed and implemented for measurements of noise silencers according to the methodology specified in the PN-EN ISO 7235 standard is presented. It is possible to measure the insertion loss, flow noise, and its pressure loss on the test stand. In particular, the following issues were presented: noise protection in the low frequency range, the design of the anechoic termination, and measurements of the sound pressure level in the flow. To obtain a sufficiently high noise protection, three noise transmission paths were considered: direct, indirect, and flanking. The design of the anechoic termination was based on the profile of the catenoid tube, which made it possible to obtain strong sound absorption in the low frequency range while maintaining a limited length of terminator. A specially designed microphone cap was used to measure the sound pressure level in the flow field. The article also presents results of selected measurements that illustrate the possibilities of the designed test stand.

⋆ ⋆ ⋆

Influence of the passage of time on the effectiveness of the aural identification of the speaker

Stefan Brachmański, Bartosz Hus

Wrocław University of Science and Technology
Wroclaw, Poland

For many years, both in Poland and in most courts around the world, aural identification of a person is allowed, i.e. Such testimony in which the witness can identify the speaker or other auditory impression. Psychologists, crime acoustics specialists, and researchers dealing with the perception of hearing and the broadly understood forensics describe many cases in which such testimonies resulted in a wrong judgment. The article presents the results of an experiment, the aim of which was to investigate, in the conditions of the Polish language, to what extent the passage of time deteriorates the correct identification of a person. Research conducted for a female voice showed that only 30% of the experiment participants correctly identified the person 31 days after hearing the voice for the first time. Similar research on the male voice showed that after 31 days, correct identification was in the order of 50%. Earlier studies conducted in the English language showed that after 3 months, another 35% of the survey participants correctly recognized the person.

⋆ ⋆ ⋆

Project of acoustic adaptation of the church with a long reverberation time

Adam Brański, Lucjan Janas, Edyta Prędka, Rafał Klich

Rzeszow University of Technology
Rzeszow, Poland

Long reverberation times are a problem in modern churches. General methods of solving the problem are given in the literature. The basic approach is to increase the acoustic absorption of the church, and this can be achieved by placing sound-absorbing materials on the walls. Due to the price, materials with a high absorption coefficient are not used. They are replaced with sound-absorbing plasters. For the known coefficient of sound absorption by plaster, the problem is to calculate the surface of the plaster coverage and its distribution on the surface. This problem was solved for the Academic Church in Rzeszów, the Roman Catholic parish of St. Jadwiga Królowa. The reverberation time before adaptation is $T_1 = 6.78$ s, while the predicted time after adaptation is $T_2 = 1.98$ s.

⋆ ⋆ ⋆

Comparison of echolocation abilities of blind and normally sighted humans using different source sounds

Michal Bujacz, Bartłomiej Sztyler, Piotr Skulimowski, Aleksandra Królak, Paweł Strumiłło

Lodz University of Technology
Lodz, Poland

The ability of some humans to echolocate has become widely known primarily due to a small number of famous expert echolocators who are capable of extraordinary feats such as riding bicycles. However, a lesser-known fact is that all humans exhibit this skill unconsciously and can learn it relatively quickly and implicitly through repeated practice. In our experiments we tested groups of 12 blind and 14 sighted untrained participants in a simple echolocation test – localizing a 1 m × 2 m vertical wall at distances between 1 and 3 m using 10 different types of sounds as the source signals for the echolocation attempts. There were significant differences between the participant groups and between some of the tested sounds. Although the groups were small, a clear difference was also observed between the experienced totally blind participants and the legally blind

visually impaired participants that had residual light sensitivity. From the compared sounds 3 kHz and 4 kHz synthetic percussion sounds, pink and blue noise were among the sources that led to the highest chances of correctly guessing the obstacle's direction and distance.

⋆ ⋆ ⋆

Initial assumptions of the system for automatic detection and classification of acoustic events related to the flights of aircraft

Michał Bukała[1,2], Artur Nowoświat[1], Andrzej Chyla[1]

[1] Silesian University of Technology
Gliwice, Poland
[2] SVANTEK Sp. z o.o.
Warsaw, Poland

The carried out task envisages the development and implementation of an algorithm for the automatic separation of acoustic events related to the flights of aircraft. Data are provided by noise monitoring stations operating as part of multi-point continuous noise measurement systems around small and medium-sized airports and helicopter landing sites in Poland. The article presents the initial assumptions of the method being developed based on the conclusions of the conducted research. For this purpose, two different methods of airborne noise signal detection will be discussed. The first applied method is based on the analysis of the approximation value of the derivative of the signal being the difference between the value of the analysed sample and the value of the h-th previous sample of the recorded sound level time history. The second one uses a convolutional neural network operating on values recorded in 1/3-octave bands. The conclusions will lead to the examination of the effectiveness and limitations of the selected methods based on the collected representative input data.

⋆ ⋆ ⋆

Road traffic noise influence on wind turbine noise detection

Maciej Buszkiewicz, Andrzej Wicher, Roman Gołębiewski, Remigiusz Pyffel

Adam Mickiewicz University in Poznań
Poznan, Poland

Wind turbines are considered as green energy sources due to minimal CO_2 emission. However wind turbines generate noise which in certain conditions is believed to have negative impact on human health and well-being. Although for dwellings located at typical distance from a wind turbine the noise level does not exceed 45 dBA, this source is considered as annoying. One of the main reasons for the annoyance is periodic variation of the sound level over time due to the passage of the turbine blade near the turbine tower. Literature often describes this phenomena as amplitude modulation (AM).

Among the most important problems related to wind turbine noise is the determination of thresholds for perceiving this type of noise under specific acoustic conditions, as well as the assessment of the annoyance of wind turbine noise in the presence of various naturally occurring sounds.

The aim of the present study is to determine the distance between the wind turbine and the observer for which wind turbine noise begins to be perceived relative to other environmental noise. The present study is focused on road-traffic background noise from an expressway. Recordings of wind turbine and road-traffic sounds were conducted for several distances at specified wind speeds and other meteorological factors.

The recordings allowed the preparation and calibration of a test procedure based on a psychoacoustic experiment with listeners. The experiment required the subjects to indicate the level for which they have barely perceived the wind turbine noise against the road-traffic noise. The indicated noise level was related to the distance of stimulus modified by so-called transfer function based on the Nord2000 noise propagation model. The transfer function defined the values of the sound level in one-third octave bands for a given distance from the observer, at fixed propagation conditions: wind speed, air temperature, humidity and ground type – to reproduce the original recording of the wind turbine noise at the tested "distance".

Depending on the responses during experiment the source-observer distance was increased or decreased using the adaptive method and noise signal was modified accordingly with transfer function. The stimulus level at which the subjects barely perceived the wind turbine noise against the road-traffic noise was considered as the threshold of masking of the wind turbine noise by the road-traffic noise. Transfer function enabled to indicate the threshold distances of wind turbine noise detection.

The research was performed within the Polish-Norwegian project No. NOR/POLNOR/Hetman/0073/2019-00.

⋆ ⋆ ⋆

Experimental verification of similarity criteria for sound absorption of simple metamaterials

Aleksandra Chojak

AGH University of Science and Technology
Krakow, Poland

The paper concerns the dimensional analysis of simple acoustic metamaterials and its experimental verification. Due to their decreased thickness caused by thermo-viscous losses and sound dispersion that occur in acoustic metamaterials, such structures are gaining popularity, both as sound absorbers and diffusers. This implies the need to find their equivalents to be used at scale – both for modeling interiors with metamaterials and developing more complicated structures. The paper discusses the dimensional analysis performed for a generalized unit cell of a metamaterial with a resonator. The dimensional analysis shows the need for scaling both geometrical dimensions of the structure and the parameters of the medium – air. The dimensional analysis was derived based on the transfer matrix method and was proven correct with finite element method model. The paper also discusses the consequences of neglecting the air criteria, which are impossible to be fulfilled. This opens the question of finding new criterial numbers allowing the correct reflection of acoustic metamaterials at scale.

⋆ ⋆ ⋆

Miniature omnidirectional sound sources used in acoustic scale modeling – measurements and validation

Bartłomiej Chojnacki

AGH University of Science and Technology
Krakow, Poland

Acoustic measurements such as scale modeling measurements require a particular type of miniature omnidirectional sound source. The most important aspects of those devices are small sizes (usually below 100 mm in diameter) and different frequency ranges compared to traditional, omnidirectional sound sources used in room acoustics. The required frequency range differs regarding the used scale factor in different models, which leads to the troubles in frequent source changes and the need for a unique source design for every model. The project will present the recent achievement in miniature omnidirectional sound sources development. The optimal sound sources for the given measurement functions were developed based on the previous numerical simulations and experiments such as FEM sound directivity simulations or transducers' parameters tolerance testing. The sound sources presented are used for applications such as acoustic sound insulation scale measurements (frequency range 800–63000 Hz), scaled reverberation chamber measurements (300–80000 Hz), or acoustic reduction models measurements (400–70000 Hz). The paper will cover a detailed technical explanation of the laboratory environment's source construction aspects and validation measurements.

* * *

Low frequency acoustic field distribution at the neolitic rondel in Heldenberg

Ireneusz Czajka,
Katarzyna Suder-Dębska,
Paweł Łojek

AGH University of Science and Technology
Krakow, Poland

Neolithic objects known as rondels have been discovered in many places in Europe. The purpose of these facilities is not fully defined. This research work was undertaken to verify the hypothesis regarding the apotropaic function of this type of objects from the acoustic point of view. As the research object the Neolithic rondel in Heldenberg, Austria was selected. During the research, the distribution of the acoustic field for the infrasound frequency range was determined and possible screening effects were searched for. As the object is over 25 m in diameter and because taking into account only the low frequency range, the boundary element method was chosen as the calculation method. Available open source software package called AcouSTO was used. The performed calculations did not allow for a definitive confirmation of the hypothesis about the apotropaic function of the object. This issue requires further analysis.

* * *

Experimental research of the AMWG algorithm for assessing amplitude modulation in wind turbine noise

Marcjanna Czapla,
Tadeusz Wszołek

AGH University of Science and Technology
Krakow, Poland

The operation of a wind turbine (WT) is characterized by fluctuations in sound pressure amplitude associated with the passage of the propeller blade through the tower. Amplitude Modulation (AM) is one of the factors contributing to the increased annoyance of wind turbine noise. The phenomenon of AM is currently the subject of research in many research centers around the world in the context of parametric assessment of its impact on annoyance. Despite the development of many methods to measure the AM of a WT noise, there is no commonly accepted method. This paper discusses the most crucial factors that stimulate the phenomenon of AM and the implementation in the MATLAB environment of the algorithm to find the frequency and depth of AM proposed by the Amplitude Modulation Working Group (AMWG). The results of verification of the developed algorithm as well as the measurement results of the frequency and depth of modulation for two measurement samples of a 2 MW wind turbine are presented.

* * *

Cognitive science as an interdisciplinary science

Henryka Czyż[1],
Adrianna Gardzińska[2]

[1] University of Information Technology and Management in Rzeszow
Rzeszow, Poland
[2] Rzeszow University of Technology
Rzeszow, Poland

Computer science is formal basis of some cognitive science research. The foundations of computer science include acoustics, interdisciplinary science covering issues related to wave generation, propagation and interaction with the medium where they propagate, and wide applications in engineering and technology.

This article presents the problems of interpreting IT concepts in the modeling of cognitive processes. Cognitive science aims at human understanding mind by integrating the results of various teachings, including acoustics. The task of cognitive science is to create models of the mind compatible with all branches of knowledge. So it is great integration of research results from many independent domains. Basic concepts of computer science related directly to the cognitive activity of the mind, i.e. they can be interpreted cognitivistically. They can also perform heuristic functions, setting new issues, theories and research directions. This work deals with the analysis by all of the heuristic function of computer science, which is valuable to cognitive scientists.

* * *

Musical "Ignacy Łukasiewicz – our compatriot and patron"

Henryka Czyż[1],
Wojciech Rdzanek[2]

[1] University of Information Technology and Management in Rzeszow
Rzeszow, Poland
[2] University of Rzeszów
Rzeszow, Poland

Ignacy Łukasiewicz belongs to the group of Poles whose work and activity had a great, positive impact on the development of our country and the whole world. He was born 200 years ago, in March 1822. He is the founder of the global oil industry. In 2022, the scientific achievements of Ignacy Łukasiewicz were commemorated. Nowadays, many branches of the chemical, cosmetic and modern technology industries are based on the crude oil distillation process. A series of events commemorating the activity of this great Pole has been prepared in our voivodship. In the second half of 2022, the Lukasiewicz Science Center will be opened, in Jasionka, near Rzeszow. Among the achievements of Lukasiewicz, the creation of the world's first crude oil mine in Bobrka in the Krosno poviat, and then the commissioning of several refineries is of particular importance.

The students of Rzeszów University of Technology and University of Rzeszów prepared a musical about this great chemist and inventor, based on the script and directed by Tadeusz Urban – a student of the University of Rzeszów at the Faculty of Music Education.

Through music, singing and dance, students from the Rzeszow University of Technology choir recalled the life and activities of this outstanding pharmacist and philanthropist. The musical emphasizes the importance of Łukasiewicz's role in the history of the most important inventions in the history of mankind. In the musical, the youth sang many songs, among others the anthem for the city of Rzeszów, The Drilling Ballade, the anthem of the Rzeszow University of Technology. Since 1974, Ignacy Lukasiewicz has been the patron of the Rzeszow University of Technology.

Musical fragments will be presented at the conference.

* * *

Nonlinear distortion in loudspeakers – causes, symptoms, measuring

Andrzej B. Dobrucki

Wrocław University of Science and Technology
Wroclaw, Poland

This paper reviews the causes of nonlinear distortion in loudspeakers. These include distortions caused by non-homogeneity of BL in the magnet gap, non-linearity of suspensions, dependence of coil inductance on its position, as well as distortions caused by the Doppler effect. Mathematical models of distortion and measures of distortion magnitude are presented. Methods of measuring distortions using sine wave signal, two-tone signal, non-harmonic multitone signal and noise are given.

* * *

Effect of high-pass filtering on the speech transmission index

Paweł Dziechciński

Wrocław University of Science and Technology
Wroclaw, Poland

High-pass filters are commonly used in the signal chain of public address systems. One of the reasons for using a high-pass filter is to protect the loudspeaker from unwanted low-frequency signals. In addition, it can increase the intelligibility of speech. In this paper, the effect of the cut-off frequency and order of a high-pass filter on the speech transmission index, the crest factor, and the sound level are presented. Analyses were performed for an ideal transmission channel, taking into account reverberation time, interfering noise, and high levels of sound. A computer model of the public address system developed by the author, based on the direct STIPA method, was used. This model enables analyses in the nonlinear range of power amplifier operation, which is often used in public address systems but is not considered in commercially available simulation programs.

* * *

Evaluation of wind turbine noise annoyance based on pre-learned patterns

Jan Felcyn, Anna Preis, Robert Gogol

Adam Mickiewicz University in Poznań
Poznan, Poland

The annoyance of wind turbine noise is usually assessed on the basis of surveys conducted among people living in the vicinity of the turbines. Such surveys provide information on the overall assessment of the annoyance of noise generated by the turbines, but do not allow to determine the impact of individual parameters of this noise source on this assessment. The basic parameters affecting the formation of an overall annoyance rating are the noise level, its time course, the length of noise exposure, and the distance of the noise source from the listener. Therefore, detailed studies of the effects of each of those parameters on the human body individually, are conducted in the laboratory. Due to the fact that laboratory conditions are very different from natural conditions, i.e., the conditions in which people living near wind turbines live, we propose a solution to reduce this difference. Our approach consists of calibration of signals presented both, to the participants of the questionnaires, and the participants of the laboratory experiments. This is combined with teaching them how to assess the annoyance of model noise samples. Namely, prior to both the surveys, and the laboratory experiments, participants were asked to familiarize themselves with 7 environmental signals presented through headphones. They are informed about the annoyance assigned to each signal, expressed as a number between 0 (not annoying signal) and 10 (extremely annoying signal). This was a type of training in which participants learned how to use numbers to assess the annoyance of a sound. Participants were then presented with new 5 environmental sounds and asked to rate the annoyance of each sound according to a previously learned method. The purpose of this procedure was to have

both the participants in the questionnaires and the participants in the laboratory experiments rate annoyance based on the same rule they had learned.

* * *

Enhancing speech signals based on an MEMS microphone array and temporal differences in the incoming signal

Jan Felcyn[1], Michał Raszewski[1]

[1] Adam Mickiewicz University in Poznań
Poznan, Poland
[2] LARS Andrzej Szymański
Niepruszewo, Poland

The development of the Internet of things and automatisation in everyday life also influences our houses. There are more and more devices on the market which can be controlled remotely. One kind of such control involves the use of voice signals. This method tends to use microphone arrays and dedicated algorithms to enhance the speech signal and recognize the words in it. In this project, a small 5-microphone array was developed. To enhance the quality of the signal, dedicated software was written. It consists of several modules, including the direction of arrival estimation, denoising, and differentiation between adults and children. The results showed that the custom algorithm can increase the signal to noise ratio by up to 6 dB.

* * *

Research on the influence of airflow resistance of layered porous structures on the sound absorption coefficient

Artur Flach

AGH University of Science and Technology
Krakow, Poland

The article presents studies of the influence of airflow resistance on the sound absorption coefficient of layered porous structures. For the calculation of the sound absorption coefficient, models of layered sound-absorbing structures were developed with the use of numerical computational models. Using the developed models, optimization was carried out to maximize the average sound absorption coefficient of the systems for a given frequency range. As a result of the research, the dependence of the change in airflow resistance for the successive layers of the material was determined.

* * *

Application of the scattering matrix method to evaluate acoustic mufflers properties

Łukasz Gorazd

AGH University of Science and Technology
Krakow, Poland

The aim of the paper is to analyse acoustic reflective muffler applying the scattering matrix method. In general, the method is based on dividing the muffler/system into separate subsystems and apply the acoustic multi-ports theory to calculate the scattering matrix of each element to finally combine the results and obtain the scattering matrix of the entire system/muffler. The multi-port procedure is derived from the theory of electric networks and allows to analyse acoustic devises of complex geometry with prescribed accuracy. Based on the scattering matrix (S), the transmission loss (TL) was determined.

* * *

A device supporting the rehabilitation of spasticity as a recorder and player of low-frequency mechanical vibrations

Marcin Grochowina

Decylion Sp. z o.o.
Rzeszow, Poland

Spasticity is a chronic disease characterized by muscle contractures. Affected patients require intensive and systematic rehabilitation. It involves, among other things, performing exercises that stretch the muscles. During rehabilitation, simple movements are repeated many times, straightening and bending the limbs, trying to widen the range of movements in each repetition. The correctness of the treatment is supervised by a rehabilitator who, based on the analysis of the patient's health, adjusts the appropriate set of exercises.

These movements can be described as low-frequency mechanical vibrations that can be analyzed and processed using methods known from digital signal processing.

In order to streamline the rehabilitation process and improve its accessibility, a device has been developed that allows for the recording of individual cycles of movements during exercises in order to reproduce them later. The movements are repeated by a mechanical excitation system, equipped with angular position and excitation force sensors, and a servo drive with adjustable speed and force. The control system has built-in algorithms that estimate the range and strength of movements and adjust the registered patterns to changing conditions during exercise playback.

The process of processing the registered patterns uses the filter, interpolation and decimation algorithms known from DSP. Algorithms have also been implemented to stabilize the actuators and eliminate their vibrations during exercise replay.

* * *

Genetic algorithms in active vibration reduction problem

Marcin Grochowina

University of Rzeszów
Rzeszow, Poland

The design of active vibration reduction systems usually consists in selecting a control algorithm and determining the value of its settings. This article presents the results of research on the concept of using genetic algorithms to induce the settings of control systems. To test the concept, a simple pulse-excited flat bar model was selected. The vibrations were suppressed by the PID controller. Genetic algorithms with two types of crossover were tested – arithmetic and uniform. As a result, the settings for the PID

controller were obtained, enabling effective reduction of vibrations in a short time.

* * *

Vibration transmission analysis through mounting elements of wall cladding panels

Julia Idczak, Jarosław Rubacha, Tadeusz Kamisiński

AGH University of Science and Technology
Krakow, Poland

Vibrations in building constructions may propagate through mounting elements to wall cladding panels. It is confirmed that they can have an impact on the sound pressure level radiated from panels and might have a significant influence on the total SPL in a room. In this work possibilities for calculating a parameter determining a change of SPL value depending on the number of panels and its mounting method are presented. A computational model based on vibration velocity measurements was used to estimate the total SPL value in a room. The laboratory and in situ measurements are presented. Transfer function for two elastic elements used as additional elements in a junction was calculated. Finally, ΔL_p and ΔL_v were calculated, as parameters defining the impact of various panel mounting methods on the reduction of sound pressure level and vibration level value, respectively.

* * *

Calculation strength optimum of surgical robot effector for mechanical eigenproblems using FEM and genetic algorithm

Grzegorz Ilewicz

Warsaw University of Technology
Warsaw, Poland

It is essential to check whether the surgical robot end effector is safe to use due to phenomena such as linear buckling and mechanical resonance. The aim of this research is to build an multi criteria optimization model based on such criteria as the first natural frequency, buckling factor and mass, with the assumption of the basic constraint in the form of a safety factor. The calculations are performed for a serial structure of surgical robot end effector with six degrees of freedom ended with a scalpel. The calculation model is obtained using the finite element method. The issue of multi-criteria optimization is solved based on the response surface method, Pareto fronts and the genetic algorithm. The results section illustrates deformations of a surgical robot end effector occurring during the resonance phenomenon and the buckling deformations for subsequent values of the buckling coefficients. The dependencies of the geometrical dimensions on the criteria are illustrated with the continuous functions of the response surface, i.e. metamodels. Pareto fronts are illustrated, based on which the genetic algorithm finds the optimal quantities of the vector function. The conducted analyses provide a basis for selecting surgical robot end effector drive systems from the point of view of their generated inputs.

* * *

Characterization of magnetic and non-magnetic nanoparticle suspension by ultrasound spectroscopy

Bassam Jameel, Tomasz Hornowski, Rafał Bielas, Arkadiusz Józefczak

Adam Mickiewicz University in Poznań
Poznan, Poland

Ultrasound attenuation spectroscopy has found wide application in the study of colloidal systems such as emulsions or suspensions. The main advantage of this technique is that it does not require sample preparation and can penetrate optically opaque mixtures, which made ultrasound attenuation spectroscopy an attractive method to study suspensions with a relatively high concentration of magnetic nanoparticles.

In this research, we used the ultrasound attenuation coefficient to study the suspension of magnetic and non-magnetic nanoparticles dispersed in a high viscous medium. A model based on the Epstein-Carhart-Allegra-Hawley's (ECAH) ultrasound scattering theory was utilized to analyse the results of ultrasound attenuation for characterizing particle suspensions by considering thermal, viscous, and acoustic properties of each phase. We studied suspensions of magnetite and silica nanoparticles dispersed in castor oil and compared the theoretical predictions with the experimental results. The results indicate the different tendency of magnetite and silica nanoparticles to agglomerate that was not reflected in the results from other experimental methods such as electron microscopy imaging.

This work was supported by the project No. 2019/35/O/ST3/00503 (Preludium BIS) of the Polish National Science Centre.

* * *

Application of an ambisonic microphone for the measurements of room acoustics parameters

Maciej Jasiński, Jan Żera

Warsaw University of Technology
Warsaw, Poland

The most commonly used measurement technique in room acoustics employs a single omnidirectional microphone for recording the room impulse response and further derivation of such acoustical parameters as T30, EDT, C50 or C80. Instead, ambisonic technology makes it possible to measure a spatial room impulse response. Ambisonics decomposes the signal from the spherical microphone array into spherical harmonics to shape the directivity. Ambisonics lets to go beyond basic acoustical parameters and allows to determine spatial features of a sound field at the measurement point. This study presents the comparison of fundamental acoustic parameters measured in the recording studio by a single microphone and omnidirectional signal derived from ambisonic microphones of the first and third order. The results show the usefulness of ambisonic technology in terms of assessing basic room parameters.

* * *

Noise effect on parameters of quiet sonar with code modulation

Andrzej Jedel, Jacek Marszal, Roman Salamon

Gdańsk University of Technology
Gdansk, Poland

Earlier authors publications have shown, that the use of code keying mixed with the CW FM sounding signal allows to significantly reduce the distance measurement error, compared to the classic silent CW FM sonars. In addition to the code modulation parameters, the magnitude of this error is influenced, by the received input acoustic noise. The article shows the dependence of the input signal-to-noise ratio and the sounding signal parameters on the target distance measurement error and the detection conditions such as the output signal-to-noise ratio and the side lobes level. The results of the analysis were compared to the same parameters of the CW FM silent sonar without code modulation.

* * *

Magnetic nanoparticles and ultrasound transmission tomography

Arkadiusz Józefczak[1], Krzysztof J. Opieliński[2], Rafał Bielas[1], Piotr Pruchnicki[2]

[1] Adam Mickiewicz University in Poznań
Poznan, Poland
[2] Wrocław University of Science and Technology
Wroclaw, Poland

Magnetic particles can be used in numerous therapeutic procedures (e.g. drug delivery, thermal therapy, photodynamic therapy). Despite promising new therapies, they are still limited due to the difficulty of accurately controlling their effectiveness. Ultrasonic transmission tomography has been proposed to track ultrasonic heating using magnetic nanomaterials. Their influence on the contrast of imaging using ultrasound tomography and the possibility of monitoring the heating process were investigated. The results showed that ultrasound tomography is sensitive to the presence of magnetic nanomaterials and temperature changes. This combination of ultrasound and nanomaterials could be promising in relation to developing a more applicable theranostic platforms.

* * *

Sound transmission loss calculation for metamaterial plate using combined analytical and numerical approach

Klara Juros[1], Aleksander Kras[1], Tadeusz Kamisiński[2]

[1] Silencions Sp. z o.o.
Wroclaw, Poland
[2] AGH University of Science and Technology
Krakow, Poland

In recent years acoustic metamaterials are broadly investigated in many different fields of acoustics and one of them is noise and vibration mitigation. The best potential show locally resonant metamaterials (LRS), which by creation of band gap effect in flexural wave propagation in structure improve its Sound Transmission Loss (STL). Simulation procedures for STL calculation can be fully analytical or numerical. Analytical solution is fast but it doesn't take into consideration metamaterial geometry. On the other hand numerical solution even when considering small part of periodic structure, is time consuming and can generate numerical errors related for example to the mesh quality and acoustic – structure interaction. In this work combined analytical – numerical method is analysed as the alternative for STL calculation. This method can be an alternative for basic simulation procedures concerning vibro-acoustic metamaterials, showing that the simulations results match to each other but what is more important this method is less time consuming. Formulas and simulation procedure for the method are presented and compared with analytical and numerical simulation results as well as with STL measurement results.

* * *

Acoustic reflective systems for concert halls – selected projects

Tadeusz Kamisiński

AGH University of Science and Technology
Krakow, Poland

Acoustic reflective systems in a concert hall are the fundamental interior fittings that ensure predictable direction of sound reflection. Reflection from hard, flat or otherwise shaped structures allows for the preservation of valuable acoustic energy in the interior, while soft elements that absorb sound lose this energy irretrievably. The paper presents selected acoustic structures developed by the team of scientists from AGH and implemented in concert halls. A diffusion panel made of PVC with the extrusion method, a system of super-stage reflective panels, an orchestral barrier with adjustable elements and the structure of optimized Schroeder diffusers are shown. The implementations of inventions were presented on the example of the Opera in Lviv, the Variete Theater in Krakow and the Krakow Opera. Acoustic tests of materials, developed structures, acoustic parameters of concert interiors as well as information collected from users of adapted interiors will be used for further works.

* * *

Selected aspects of acoustic treatment of the orchestra pit

Tadeusz Kamisiński, Krzysztof Brawata

AGH University of Science and Technology
Krakow, Poland

The orchestra pit is not a friendly workplace for musicians, while the need to ensure their interaction with the stage and audience increases the related requirements significantly. The aim of this paper is to analyse different strategies for the acoustic treatment of the orchestra pit in the context of the expected results. Based on the simulation studies as well as on the experimental evaluation performed in the well-equipped orchestra pit of the Krakow Opera, the representative acoustic parameters allowing for an effective assessment of the results of an acoustic treatment have been identified. Further, the comparison of the reverberation time T_{20} and EDT measured for different variants

of the interior of the orchestra pit has clearly justified the proposed use of sound diffusing and absorbing systems in such an environment, as they spread the energy of the first sound reflections in time, reducing the risk to the musicians' hearing. Moreover, deployment of elements able to reflect and disperse sound within the orchestra pit guarantees the adequate audibility among the musicians.

⋆ ⋆ ⋆

Conditions for multiple acquisition of echoes from stationary targets in successive active sonar transmissions

Lech Kilian,
Aleksander Schmidt,
Mariusz Rudnicki

Gdańsk University of Technology
Gdansk, Poland

The highest possible number of contacts with a detected target is clearly decisive in echolocation on the possibilities of echo processing to optimize the estimation of distinctive characteristics of the observed target. In hydrolocation, the slow propagation of acoustic waves in water limits the number of sonar contacts with detected targets in the vertical cross-section of the transmitting-receiving beam. The article considers model conditions for acquiring multiple contacts with stationary targets detected by various sounding methods – with echosounders, classic active sonars and side looking sonars. Appropriate formulas explicitly linking the possible number of echo signals from the target in a specific geometry of the survey performed at the assumed speed were presented. These formulas are not complicated and intuitively clear, but their value lies in the ability to immediately combine the speed of the vessel with the survey effects and can be a clear argument for forcing the navigation unfriendly low speed.

⋆ ⋆ ⋆

Metrological capabilities of the acoustic testing laboratory – small anechoic chamber at AGH Department of Mechanics and Vibroacoustics

Maciej Kłaczyński, Wiesław Wszołek

AGH University of Science and Technology
Krakow, Poland

The small anechoic chamber is part of the research facilities of the Department of Mechanics and Vibroacoustics in AGH University of Science and Technology in Krakow and is a room corresponding to a free field, whose walls, ceiling and floor provide both very good sound absorption and isolation from external interference. The dimensions of the free space inside the chamber are $4.4 \times 3.8 \times 3.6$ m. The chamber was commissioned in the mid-1980s and has not undergone upgrades since. In December 2021, the upgrade of the small anechoic chamber was completed. As particularly important was the replacement of 5.5 thousand pieces of acoustic wedges made of polyurethane foam, which due to the aging process lost their sound-absorbing properties, for wedges made of mineral wool with glass fiber, adjustment of lighting inside the chamber to current standards, as well as equipping the chamber with a signal crossover and devices to regulate and monitor meteorological conditions inside the chamber. The paper presents a study of the properties of the small anechoic chamber in accordance with accepted standards for this type of rooms and its current research capabilities in the field of vibroacoustics in technology and medicine.

⋆ ⋆ ⋆

Assessment of wide-sense stationarity of an underwater acoustic channel

Iwona Kochanska

Gdańsk University of Technology
Gdansk, Poland

The performances of underwater acoustic communication (UAC) systems are strongly related to the specific propagation conditions of the underwater channel. Designing the physical layer of a reliable data transmission system requires a knowledge of channel characteristics in terms of the specific parameters of the stochastic model. The wide-sense stationary uncorrelated scattering (WSSUS) assumption simplifies the stochastic description of the channel, and thus the estimation of its transmission parameters. However, shallow underwater channels may not meet the WSSUS assumption.

This paper presents a method for testing the wide-sense stationary (WSS) part of the WSSUS feature of a UAC channel on the basis of the complex envelope of a received probe signal. Also, the dependence of the wide-sense stationarity of the UAC channel on its bandwidth is discussed.

⋆ ⋆ ⋆

Aeroacoustical studied of the serrated ventilation dampers

Joanna Maria Kopania, Kamil Wójciak,
Patryk Gaj, Grzegorz Bogusławski

Lodz University of Technology
Lodz, Poland

The serrated ventilation dampers for regulation of airflow volume were tested. The computer fluid flow analysis was conducted using the Comsol program. The nature of the flow through the serrated ventilation damper was analysed to identify the different turbulence regions formed on the airflow field. Additionally, the aerodynamical and acoustical parameters of these blades of ventilation dampers with different serrated trailing and/or leading-edge were studied. The aeroacoustic studies were done in the reverberation room. The sound power level and loss coefficient were determined for the studied models.

⋆ ⋆ ⋆

Transmission loss of absorptive mufflers lined with expanded clay granulates

Krzysztof Kosała

AGH University of Science and Technology
Krakow, Poland

The article presents the results of tests on sound attenuation by two types of cylindrical absorptive mufflers of

the same length and with different diameters of chambers filled with expanded clay granulates. Using a laboratory stand for testing acoustic mufflers with an impedance tube, the transmission loss parameter was determined. To compare the effectiveness of sound attenuation, the transmission loss of mufflers without sound absorbing material was also determined. The results of these tests were compared to the results obtained with the use of a known calculation model for reflective mufflers. Using an impedance tube, the normal incidence sound absorption coefficients of the expanded clay granulates with thicknesses of material samples from 10 to 100 mm were determined. The dependence between the sample thickness and the first resonance frequency of the sound absorption coefficient was determined, which was then used in the proposed calculation model of the effectiveness of the cylindrical absorptive muffler with expanded clay granulates. Using the proposed theoretical model, the results of transmission loss calculations, satisfactory for engineering applications, were obtained.

* * *

GFCC-based x-vectors for Reinke's edema detection

Katarzyna Kotarba

AGH University of Science and Technology
Krakow, Poland

Automatic assessment of voice disorders is one of the most important applications of speech signal analysis. Various algorithms utilizing both sustained vowels and continuous speech have been successfully used to perform detection of many voice pathologies e.g. Dysphonia, laryngitis, and vocal folds paralysis. However, algorithms described in literature used for classification of Reinke's edema – one of the most severe smoking-induced voice conditions – are scarce and rely mostly on speech signals containing sustained vowels. In this paper, a method incorporating gammatone frequency cepstral coefficients (GFCC) based x-vectors extracted from continuous speech is presented. The extracted x-vectors are used to train a SGD classifier performing Reinke's edema detection. For validation folds, the proposed method yielded AUC ROC, accuracy, recall, and specificity of 0.96 (±0.03), 0.94 (±0.02), 0.92 (±0.03), and 0.94 (±0.02), respectively. For testing set, the method yielded AUC ROC, accuracy, recall, and specificity of 0.98, 0.89, 0.88, and 0.89, respectively.

* * *

Lossy coding impact on speech recognition with convolutional neural networks

Mateusz Kucharski

Wrocław University of Science and Technology
Wroclaw, Poland

This paper presents research of lossy coding impact on speech recognition with convolutional neural networks. For this purpose google speech commands dataset containing utterances of 30 words was encoded using four most common all-purpose codecs: mp3, aac, wma and ogg. A convolutional neural network was taught using part of the original files and later tested with the rest of the files, as well as their counterparts encoded with different codecs and bitrates. The same network model was also taught using mp3 encoded data showing the biggest loss in effectiveness of the previous network. Results show that lossy coding does have an effect on speech recognition, especially for low bitrates.

* * *

Influence of the PZT actuator arms asymmetry on the LQR control parameters in the active reduction vibration of beams

Romuald Kuras

Rzeszow University of Technology
Rzeszow, Poland

The paper deals with the active reduction of beam vibrations using piezoelectric transducers (PZT). The LQR parameters of the control of an asymmetric actuator (a-PZT) depending on the length of its arms were analysed. The results were compared to those of the symmetrical PZT (s-PZT), so far used as standard. The actuator is modelled with two bending moments or two pairs of forces. The design of the LQR controller also took into account the location of the PZT on the beam. The reduction efficiency can also be increased by using asymmetrical PZT. To obtain the vibration asymmetry of the beam, simply supported at both ends, an asymmetrically point mass was added. The LQR control was applied to an asymmetric actuator on the beam. Two-parameter optimization was used to find the optimal proportions of the a-PZT arms. For such a problem, the LQR control parameters were found, which ensure the highest efficiency of vibration reduction.

* * *

Experimental and CFD study of the selected acoustic helicoidal resonator as a final element of an air installation

Wojciech Łapka[1], Piotr Jakubowski[2]

[1] Poznan University of Technology
Poznan, Poland
[2] Maritime Advanced Research Centre
Gdansk, Poland

The work presents an analysis of the selected helicoidal resonator as the end element of the air installation. Laboratory tests of the acoustic pressure level were performed at the outlet of the air installation in a room for different flow speeds. The measurement methodology in accordance to standards PN-EN ISO 3741 and PN-EN ISO 5135, which describes the acoustic test facilities, instrumentation and procedures to be used for precision grade determination of sound power levels in octave or one-third-octave bands of a noise source in reverberation test rooms. The numerical CFD tests show the shape and range of the air stream in the room in the function of the distance from the installation outlet for different flow speeds. Due to the helicoidal shape of the analysed acoustic resonator, the air stream also turns, which can be used to effectively mix air in the room.

* * *

Vibration analysis and modelling of light-weight robot arms

Ryszard Leniowski, Michał Wroński

Rzeszów University of Technology
Rzeszow, Poland

Light-weight robots are a new generation of devices intended to be used not only for industrial tasks, but also to perform actions in the human environment. This work presents an analysis of selected basic problems related to the vibration properties of light-weight robot arms. The study of vibration is based on the analysis of the root locus on the plane of complex variables. It turns out that their distribution is non-stationary and depends on the parameters of the model (arm geometry, material parameters), but also depends on the type of realised motion, which is not so obvious. Depending on the manoeuvres conducted (acceleration/deceleration), the system may lose (or increase) its oscillating properties at higher frequencies, as well as introduce a structural (measurable) delay. Recognition of the discussed properties along with their modeling is an important element of the design process of the control system of modern, light-weight robots.

* * *

EMD-based time-frequency analysis methods of non-stationary audio signals

Marcin Lewandowski, Salomea Grodzicka

Warsaw University of Technology
Warsaw, Poland

To ensure that any time series data is appropriately interpreted, it should be analysed with proper signal processing tools. The most common analysis methods are kernel-based transforms, which use base functions and their modifications to represent time series data. This work discusses an analysis of audio data and two of those transforms – the Fourier Transform and the Wavelet Transform based on a priori assumptions about the signal's linearity and stationarity. In audio engineering, these assumptions are invalid because statistical parameters of most audio signals change with time and cannot be treated as an output of LTI system. That is why recent approaches involve decomposition of a signal into different modes in a data-dependent and adaptive way, which may provide advantages over kernel-based transforms. Examples of such methods include empirical mode decomposition (EMD), extended EMD (EEMD), variational mode decomposition (VMD), or singular spectrum analysis (SSA). Simulations were performed with speech signal for kernel-based and data-dependent decomposition methods, which revealed that evaluated decomposition methods are promising approaches to analyse non-stationary and nonlinear audio data.

* * *

Development of a calibrator for very low frequency pressure sensors

Karol Listewnik

Gdynia Maritime University
Gdynia, Poland

The aim of this article is to present a calibrator designed to calibrate pressure sensors of very low frequencies from 0.1 Hz to 10 Hz. Due to the growing demand for the research of the marine environment in the field of underwater noise, carried out in accordance with Directive 2008/56/EC, many models of autonomous underwater noise recorders, including those in the infrasound band, have been developed. Very low frequency pressure sensors are also used to measure the hydrodynamic field of the ship, both for the optimization of the hull shape and in military applications to estimate the risk of a mine explosion. The basis for ensuring the reliability of the recorded data is the calibration of the pressure sensors and, if possible, the calibration of the entire measuring system.

Based on the analysis of the literature, previously developed calibrators of low-frequency pressure sensors, it was decided to use a very low-frequency acoustic coupler using the vibrating water column method.

A low-frequency acoustic coupler located in the Underwater Acoustics Laboratory of the Central Office of Measures was used to develop the new calibrator, with the use of which pressure sensors were tested at very low frequencies. The conducted research and conclusions from these studies allowed to design a calibrator for very low frequency pressure sensors.

* * *

Impact of cavity edges shape on aerodynamic noise

Paweł Łojek, Ireneusz Czajka

AGH University of Science and Technology
Krakow, Poland

In this article, the analysis of influence of cavity edge shapes on flow-generated noise is performed. The acoustic wave propagation in the channel, that result from the flow, was analysed. A channel with rectangular cavity and perpendicular edges was adopted as the reference object, the shape of upstream and downstream edges was modified. The analysed problem is a coupled problem, and due to low flow velocities it was assumed that it is a unidirectional coupling. Solving such a problem requires solving the equations describing the flow field. On the basis of the pressure field obtained from the flow computations, the source terms were determined. They were used in the equation describing the field of acoustic disturbances, perturbed convective wave equation (PCWE). Numerical calculations and analysis of the obtained results were performed with the use of open source software. OpenFOAM software was used to solve the flow equations and OpenCFS to solve the wave propagation equations. Due to the size of the problem, the calculations were performed using the computing resources of the PLGrid infrastructure and the Prometheus supercomputer. The research showed a significant influence of the modification of the shape of the cavity edges on the generated noise. The change of downstream corner to both rounded or chamfered, allowed for significant reduction of noise in the entire analysed band and allowed for the reduction of overall sound pressure level (OASPL) by 5 dB. Modifications of the upstream edge did not bring such differences, change in OASPL was up to 1 dB. The obtained spectra of the sound pressure level showed compliance with the calculated natural frequencies of the analysed object, as

well as with some of the Rossiter modal frequencies, typical for the phenomena occurring in the cavities.

* * *

Numerical reconstruction of Cieszyn flute sound

Paweł Łojek, Ireneusz Czajka,
Katarzyna Suder-Dębska

AGH University of Science and Technology
Krakow, Poland

The paper presents part of the work on the functional numerical reconstruction of a historic mammoth flute from the collection of the Museum of Cieszyn Silesia. The flute was discovered in 2012 in Cieszyn. When it was found, it was already damaged, Unfortunately it was further deconstructed during conservation. Therefore, reverse engineering techniques had to be used to reconstruct the original shape of the instrument.

The 3D scans and geometric models of the flute were developed at the Faculty of Architecture of the Wrocław University of Science and Technology. They were used for numerical sound reconstruction. The work on the reconstruction consisted of several stages, the most important of which were: determining the characteristics of the excitation and of the flute itself as a resonant system. The first of these stages was carried out using the methods of computational fluid dynamics (CFD) and Curle's aeroacoustic analogy. The second stage was to solve eigenvalue problem using the finite element method The computations allowed to define the musical scale of the instrument.

At the same time, the work carried out at the Faculty of Architecture of the Wrocław University of Technology allowed for the physical reconstruction of the flute in the form of a 3D print. The object reconstructed in this way was used to verify the results obtained numerically.

* * *

Analysis of sound absorption performance of acoustic absorbers made of fibrous materials

Mirosław Meissner, Tomasz Zieliński

Institute of Fundamental Technological Research
Polish Academy of Sciences
Warsaw, Poland

Absorbing properties of multi-layer acoustic absorbers were modelled using the impedance translation theorem and the Garai and Pompoli empirical model, which enables a determination of the characteristic impedance and propagation constant of fibrous sound-absorbing materials. The theoretical model was applied to the computational study of performance of single-layer acoustic absorber backed by a hard wall and the absorber consisting of one layer of absorbing material and an air gap between the rear of the material and a hard back wall. Simulation results have shown that a high thickness of absorbing material may cause wavy changes in the frequency relationship of the normal and random incidence absorption coefficients. It was also found that this effect is particularly noticeable for acoustic absorbers with a large thickness of air gap between the absorbing material and a hard back wall.

* * *

Acoustic indices in the analysis of the soundscape of the Kościeliska Valley in the Tatra National Park – case study

Dorota Młynarczyk,
Jerzy Wiciak

AGH University of Science and Technology
Krakow, Poland

The development of our civilization and increasing noise pollution are strongly connected. In 2021, the Tatra National Park was visited by a record number of tourists – about 4 million 600 thousand. The previous record was broken in 2018 – then the Polish Tatra Mountains were visited by 3 million 800 thousand. People. The aim of the paper is analysis of noise pollution and soundscape of the most popular national park in Poland – Tatra National Park. The Kościeliska Valley was selected for the study, because it is the second area in the park in terms of the number of tickets sold according to the statistics kept by the Tatra National Park. The paper presents the results of the analysis of acoustic measurements and ambisonic recordings made in four seasons using classical method and the soundscape method. In addition, psychoacoustic parameters and acoustic indices such as: loudness, sharpness, or roughness, ACI (acoustic complexity index), NDSI (normalized difference soundscape index), BI (bioacoustic index), ADI (acoustic diversity index), AEI (acoustic evenness index) were calculated.

* * *

Modelling of an acoustic wave scattering on the aircraft surface using the boundary element method

Dawid Nowicki,
Katarzyna Suder-Dębska,
Ireneusz Czajka

AGH University of Science and Technology
Krakow, Poland

Sound localization tools are important in the environmental protection and the human searches. The article is one of the stages of the implementation of the concept of using aircraft to localize sound sources. The use of a fixed-wing aircraft instead of a multirotor would increase the total flight time, and expand the surveyed area. It is important to determine the most favourable positions of the receivers on the surface of the aircraft. The scattering effects of the sound waves coming from the ground source and aircraft engine on the acoustic field on the aircraft surface are not homogeneous. In the article the authors present the modelling of the scattering of the sound waves over the airplane surface with the usage of boundary element methods. After determining the effects from the sound source on earth and from the aircraft engine the conclusion was made, that the influence from the engine noise is greater than that from the ground source, and in order to localize the low amplitude signals, the aircraft need to glide. Considering only the effects of the ground source, the optimal areas for the microphones placement were determined.

* * *

Improving the acoustic climate of the city park

Janusz Piechowicz, Sylwia Gola

AGH-University of Science and Technology
Krakow, Poland

A city park is a place where, in an urbanized world, a person can experience nature. It is the green lung of the city, the numerous trees and shrubs in parks improve the air condition, especially in densely populated agglomerations. It is a meeting place and allows you to spend time actively. It allows recreation and relaxation for city residents. City parks are desirable, especially in city centers, densely populated and built-up places.

Designing parks should meet people's needs. It is extremely important to properly select space elements that will positively affect the comfort of use. Apart from the obvious issue of taking care of the park's aesthetics, its flora and appropriate equipment, an important role is played by an appropriate acoustic climate. Hence, when designing open spaces such as city parks, the cooperation of specialists in many fields is important: landscape architects, town planners, people dealing with nature protection, artists, and finally acoustics. This allows you to create a space that will meet the needs and expectations of residents. The paper shows the possibility of taking steps to correct the existing acoustic climate in selected places in the city park.

* * *

Lightweight floor screed with increased impact sound reduction

Adam Pilch[1], Piotr Duda[2], Jarosław Rubacha[1]

[1] AGH University of Science and Technology
Krakow, Poland
[2] JP Cover Sp. z o.o.
Kaczyce, Poland

Increasing requirements of users force to provide still better solutions, that reduce impact noise. A lightweight floor screed can be a favourable solution for existing buildings with limited ceiling load capacity, where high effective floating floors are too heavy to be used. In the paper further development of the impact sound reduction measurement method for small lightweight floor screed samples is presented. In order to protect the top layer of the sample from the hammers of the tapping machine, a thin concrete layer was coupled with the sample. What is more, a thin layer of sand below the sample was tested in order to improve the connection between the sample and the concrete floor. Based on obtained results, the concrete top layer and the sand bottom layer reduce slightly the effectiveness of the screed but decrease significantly the uncertainty of the results.

* * *

Simulation of infeasible instruments in a sound synthesizer – implementation and control

Marek Pluta

AGH University of Science and Technology
Krakow, Poland

Sound synthesis using mathematical modelling of musical instruments is a method particularly well suited for live performance using a physical controller. Depending on model complexity, it may be able to reproduce various subtle phenomena related to excitation and real time control of an instrument, providing an intuitive tool for a musician. A variant of physical modelling synthesis, referred to as the simulation of infeasible instruments, uses a model of an object that does not have a physical counterpart. Such model has some properties of a real object, which makes it still intuitive for a musician. However, other features, such as geometry, or material properties, are intentionally altered in such manner, that it could not function in reality. These infeasible features introduce new properties to the sound it produces. The study presents a few such models with a discussion regarding their implementation and control issues in a real-time sound synthesizer.

* * *

How to determine the annoyance due to wind turbines

Anna Preis

Adam Mickiewicz University in Poznań
Poznan, Poland

In the study of annoyance due to wind turbines, the dominant approach takes into account only the noise generated by these sound sources. In my speech, I will point out the disadvantages of the approach aimed at creating a one-factor noise assessment indicator for wind turbines, based on the measurement of the level of sounds produced by them (LDWN or LN). I cite works which show that the LDWN or LN value alone is not enough to explain why for the majority of people living near wind turbines their noise is extremely annoying, despite the fact that the measured sound level values are relatively low. I will also refer to an attempt to introduce a correction to the one-factor noise assessment index by taking into account the time variability (amplitude modulation) of the sound generated by wind turbines. I will present arguments "for" and "against" taking into account corrections for infrasound or low-frequency components present in the noise spectrum of wind turbines. I will also refer to the recently proposed so-called aggregate annoyance concept. Such a multifactorial indicator includes not only the above-mentioned noise parameters, but also non-acoustic characteristics (mainly visual), which are supposed to influence the overall perception of the annoyance associated with wind turbines. In the presentation, I will also compare the noise limits for wind turbines in selected European countries with those in force in Poland. Furthermore, I will discuss the limitations of the existing Polish regulations and present a proposal for determining the annoyance related to wind turbines, developed jointly under the Polish-Norwegian grant.

* * *

Psychoacoustic metrics in psychological diagnosis of noise annoyance

Jan Radosz

Central Institute for Labour Protection
– National Research Institute
Warsaw, Poland

Aim of the study was to asses noise annoyance in relation to psychoacoustic metrics of sound in office environment. The Vienna Test System was used for this purpose. Virtual office acoustic environments were developed with sources of different psychoacoustic parameters (loudness, sharpness, fluctuation strength, roughness) but with a constant A-weighted sound pressure level of 55 dB – sound environment with conversations, sound environment with office equipment (computers, printers, telephones) and sound environment with all office noise sources together. The reference environment was a quiet office room with no additional noise sources. Recorded real noise sources were transferred to a virtual 3D sound environment and converted into binaural sound, which was then played back on headphones. During the exposure to each of the acoustic environments, the subjects performed the ALS test (work performance series) and COG test (measurement of attention and concentration) and then assessed the given environment using a questionnaire. The paper presents the results of the statistical analysis – despite different psychoacoustic metrics of office noise sources in the examined acoustic environments, no statistically significant differences were observed in the results of psychological tests.

⋆ ⋆ ⋆

Ultrasonic studies of colloidal capsules fabricated from Pickering droplets

Filip Ratajczak, Rafał Bielas, Arkadiusz Józefczak

Adam Mickiewicz University in Poznań
Poznan, Poland

Small capsules with shells made of microparticles became of great interest due to their potential in many fields. They can find applications in the food or pharmaceutical industry (e.g., in controlled drug release) because of their size and behaviour under external stimuli. The capsules can be fabricated from particle-stabilized emulsions (Pickering emulsions) by sintering together particles that cover Pickering droplets at high temperatures. One of the problems with such an approach is accurately controlling whether particles are already sintered and create the rigid capsule shell of a capsule.

We propose here the use of a non-destructive ultrasound method for monitoring of rigidity of the capsule shells. By measuring the velocity of ultrasonic wave propagating through emulsion or suspension of capsules, the change in the adiabatic compressibility before and after heating can be calculated for a quantitative evaluation of the encapsulation process.

This work was supported by the project no. 049/34/UAM/0043 (Study@Research – "Excellence Initiative – Research University" Programme).

⋆ ⋆ ⋆

Analysis of the possibility of shaping the sound diffusion coefficient of diffusers based on acoustic metamaterials

Jarosław Rubacha

AGH University of Science and Technology
Krakow, Poland

The article presents research on the influence of the type of metamaterial used in a diffuser on the sound diffusion coefficient. Diffusers composed of slots loaded with a quarter-wave resonator or a Helmholtz resonator were investigated. Such solutions induce dispersion and the slow sound effect to increase the effective depth of the quarter-wave resonator. The numerical models of diffusers were used to computation of the sound diffusion coefficient. The results of calculations for diffusers based on different metamaterials were compared with each other and compared with the results of calculations for Schroeder diffusers. As a result, it was shown that acoustic metamaterials affect the frequency band of the diffuser and the values of the obtained sound diffusion coefficients.

⋆ ⋆ ⋆

Localization of sound sources in binaural reproduction of first and third order ambisonics

Amaia Sagasti[1], Agnieszka Paula Pietrzak[2], Ricardo San Martín[1], Rubén Eguinoa[1]

[1] University of Navarra
Pamplona, Spain
[2] Warsaw University of Technology
Warsaw, Poland

The use of higher-order ambisonics in spatial sound recordings makes it possible to increase the accuracy of recording information about the direction from which the sound comes to the listener. However, with binaural ambisonic sound reproduction, the listener's ability to locate the sound source accurately may be limited. This paper presents a comparison of the listener's ability to locate a sound source during binaural listening to recordings made with first and third order ambisonic microphones. The analysis was carried out for two types of signal: pink noise and ringing sound. The analysis of localization errors depending on the ambisonics order, azimuth and elevation angles as well as the type of signal is presented. The obtained data indicate that in binaural reproduction of the ambisonic sound the localization errors in the azimuth plane were smaller for the third order ambisonics, compared to the first order. In the elevation plane both for first and third order the errors were significant.

⋆ ⋆ ⋆

Synchronization system for underwater acoustic communications using in shallow waters

Jan Schmidt, Aleksander Schmidt

Gdańsk University of Technology
Gdansk, Poland

A reliable synchronization system of the transmitted data frame has a significant impact on the efficiency of the underwater communication system. This applies in particular to communication systems dedicated to work in shallow waters, where the phenomenon of multipath permanently occurs. To overcome these difficulties, the concept of a synchronization system consisting of two broadband signals of opposite monotonicity was presented. The method of receiving these signals has been described in detail. The

stochastic channel model with Ricean fading and the Watermark simulator was used to test the efficiency of the synchronization system in the underwater multipath channel.

* * *

Analysis of the possibility of supervision of mechanical devices based on the measurement of the vibration level and one-class classifiers

Ryszard Schossler, Marcin Grochowina, Lucyna Leniowska

University of Rzeszów
Rzeszow, Poland

The paper presents the concept of diagnosing the technical condition of mechanical devices. The test is based on a non-invasive vibration analysis technique combined with the use of artificial intelligence method. The object of the research is an electric motor for which vibrations were recorded by a vibration sensor based on four 3-axis digital accelerometers and MPU-6050 gyroscopes. The effectiveness of the classification methods using the two-class and one-class classification was compared. It has been shown that the use of an incomplete pattern of the vibration model and a single-class classifier allows for effective detection of anomalies in the operation of an induction motor. Satisfactory efficiency of the classification was achieved, despite the limitation of the teaching set only to the information obtained during the correct operation of the device. The described method is universal and can be used to diagnose the technical condition of many different types of technical devices.

* * *

Comparison analysis of noise generated by wind turbines with other noise sources in outdoor environment

Andrzej Staniek, Janusz Kompała, Alicja Bramorska, Cezary Bartmański

Central Mining Institute
Katowice, Poland

The paper presents the comparison analysis of noise generated by wind turbines with those generated by other sources like ventilation shafts of working coal mines. The aim of the research was to compare the frequency and amplitude distribution of that sources, especially in the infra range. Eventually it is to be exploited in the estimation of possible environmental impact on human annoyance or severity. Additionally a measurement position of a microphone in relation to ground surface was observed. The possible influence of wind speed was also monitored. Measurements at ground level were performed according to the standard PN-EN 61400-11:2013-07 and in vertical position, where the microphone was mounted "upside down" with the grid flush with the board. The microphone was mounted asymmetrically to reduce the influence of the edges of the board. The results and discussion are presented.

Keywords: wind turbines, infrasound, human annoyance, sound propagation.

* * *

Recognition of the speaker's age group and gender for a large database of telephone-recorded voices

Piotr Staroniewicz

Wrocław University of Science and Technology
Wroclaw, Poland

The paper presents the results of automatic recognition of age group and gender of speakers performed for the large SpeechDAT(E) acoustic database for Polish language, containing recordings of 1000 speakers (486 males/514 females) aged 12 to 73, recorded in telephone conditions. Three age groups were recognised for each gender. Mel Frequency Cepstral Coefficients (MFCC) were used to describe the recognized signals parametrically. Among the classification methods tested in this study, the best results were obtained for the SVM (Support Vector Machines) method.

* * *

Sound power level estimation – choice of a prior distribution

Bartłomiej Stępień

AGH University of Science and Technology
Krakow, Poland

Bayesian inference can be used to estimate the sound power level of sources. This method requires knowledge of two densities: sample and prior. The sampling distribution is determined from the measurement sample from which the sound power level is determined. On the other hand, the prior distribution represents the researcher's initial knowledge of the source under investigation. Most often, this distribution is determined based on data from previous measurements. In the absence of such data, the shape of the prior distribution can be assumed on the basis of existing knowledge. In this study, the influence of the form of the prior distribution on the sound power level results was analysed. Real measurement data was used for this purpose. The results obtained by Bayesian inference were compared with the results of the sound power level determined by the precision method in an anechoic chamber. Inference was carried out based on the results of statistical tests at a significance level of $\alpha = 0.05$.

* * *

Auditory presentation of the environment for the visually impaired

Paweł Strumiłło, Michał Bujacz

Lodz University of Technology
Lodz, Poland

The lecture will review research on electronic systems assisting blind people in independent mobility and navigation. The main focus will be on sensory substitution techniques, which use sounds to visualise the surroundings for the visually impaired. The lecture will present systems developed at the Institute of Electronics of the Technical University of Lodz.

* * *

Validation of a 1:8 scale measurement stand for testing airborne sound insulation

Agata Szeląg[1], Bartosz Przysucha[2], Katarzyna Baruch[3], Krzysztof Brawata[4], Dominik Mleczko[4]

[1] Tadeusz Kościuszko Kraków University of Technology
Krakow, Poland
[2] Lublin University of Technology
Lublin, Poland
[3] Gorycki and Sznyterman Sp. z o.o.
Krakow, Poland
[4] AGH University of Science and Technology
Krakow, Poland

The work contains a detailed description of the design and validation of a measurement stand for testing the airborne sound insulation of specimens made at a small scale. The stand is comprised of two coupled reverberation rooms in which the geometry represents the full-size reverberation rooms used at the AGH University of Science and Technology at a 1:8 scale. The paper proves that both the scaled measurement stand and the testing methodology conform to the ISO 10140 standards, and that the obtained measurement uncertainty does not exceed the maximum values specified in ISO 12999-1. Moreover, the calculated uncertainty of measurements obtained for the 1:8 scale stand is comparable with the typical uncertainty given in ISO 12999-1 and the uncertainty obtained on the full-scale measurement stand. In connection with the above, the authors have proved that by using the scaled-down measurement stands, one can obtain reliable and repeatable results of measurements of airborne sound insulation.

* * *

Metasurface acoustic lens: design, simulation, 3D-printing and acoustic testing

Bartłomiej Sztyler, Paweł Strumiłło

Lodz University of Technology
Lodz, Poland

This work focuses on acoustic metamaterials as structures that interact with sound waves. Metamaterials are specially created structures that have properties not found in nature. Controlling acoustic waves in practical applications can often be difficult due to the size of structure needed at a given wavelength. Dividing the family of metamaterials into groups based on their spatial structure, we can distinguish between one- and three-dimensional structures. This article is devoted to metasurfaces, or two-dimensional structures. Metasurfaces exhibit unique properties of wave manipulation even at low frequencies. Such structures are cyclically composed of elementary blocks called meta-atoms. Theoretical considerations supported by the literature have enabled the development of an example metasurface model. A series of numerical simulations were carried out and an example model was produced using 3D printing technology. The simulation results show that unnatural refraction can be obtained for a flat metastructure with a thickness less than the specified acoustic wavelength. The experimental results show the assumed focusing effect of the lens, but not as accurate as in the simulation.

* * *

The specificity of acoustic measurements of rail vehicles

Anna Świerkoska

Łukasiewicz Research Network
– Poznań Institute of Technology
Poznan, Poland

The article is a review of issues related to acoustic measurements of rail vehicles using standardised methods related to the documents regulating the entry into service of objects. In the paper types of tested objects and the applicable requirements are presented, also the exceptions and conditions determining the needlessness of the tests is analysed. Examples of measurement results showing the condition of currently manufactured or modernized vehicles in terms of noise emissions and the comfort of passengers and drivers are presented. Factors limiting the possibility of noise level reduction and, consequently, meeting the requirements were considered. The conducted analysis of the research objects, requirements, methods, results typical for given types of vehicles and limitations is based on normative and legal documents, as well as on the conducted measurements and own experience.

* * *

Vibration reduction assessment of layered acoustic metamaterial

Patrycja Świrk, Wojciech Żyłka, Lucyna Leniowska, Marcin Grochowina

University of Rzeszów
Rzeszow, Poland

Acoustic meta-materials offer an approach to reducing the vibration and noise transmission through layered panels. In this paper the investigation of constructed meta-material for reduction of low frequency vibration and noise is a major concern. The key concept underlying this approach is to construct the meta-material as a highly-distributed system of tuned point masses that introduce instead of low resonance frequency one or more bands of higher frequency. They can be then successfully damped with passive methods. Using the modes method, a meta-material system with distributed point masses integrated into the honeycomb core was designed to be a representative layered panel. To determine the dynamic response of the global sandwich panel, the meta-material system was tested for 70 Hz excitation. The obtained results confirm the possibility of tuning the considered layered meta-material to the excitation frequency and shifting low frequencies towards higher frequencies.

* * *

Cartesian robot for enhancing the study of stringed instruments

Daniel Tokarczyk

AGH University of Science and Technology
Krakow, Poland

The paper describes the design and the implementation of a Cartesian robot for the purpose of enhancing the research of string musical instruments. Paper describes how the design requirements were set for the robot to be able play on plucked string instruments, and also presents the implementation of the system. The robot is built modularly, on an aluminium profile frame, this enables the installation of instruments of various sizes and types, e.g. acoustic, electric or bass guitars. The robot is also equipped with possibility to mount different end effectors, although for the article only a static pluck mount end point is presented. The paper also presents the systems possibilities of application in research of string instruments.

* * *

Effect of changing body position on selected voice parameters

Karolina Węglarz[1], Wiesław Wszołek[2], Daria Hemmerling[3]

[1] Andrzej Frycz Modrzewski Krakow University
Krakow, Poland
[2] Carpathian State College in Krosno
Krosno, Poland
[3] AGH University of Science and Technology
Krakow, Poland

Correct posture is a key element in the proper functioning of the entire body. Both defects and postural disorders lead to overload syndromes and degenerative changes in the musculoskeletal system. Different body positions correlate with respiratory parameters, which form the basis in modifying loudness and accentuation when speaking or singing Body posture can affect the quality of the voice signal and its fatigue. As movement and duration intensify, vocal effort increases. What is still open, however, is the problem of speech signal evaluation, especially in order to obtain assessments useful in the context of supporting medical diagnosis, optimizing therapy and monitoring rehabilitation. Meanwhile, such evaluations are what we need in medicine, rehabilitation and sports. This paper presents excerpts from a study of the effects of changes in posture and fatigue in healthy subjects, and those with phonation disorders, on changes in the acoustic parameters of the speech signal.

* * *

Piezoelectric square based sensor-actuator hybrid in vibration reduction

Jerzy Wiciak, Roman Trojanowski

AGH University of Science and Technology
Krakow, Poland

This paper presents the results of comparison of vibration reduction levels between standard square based piezo actuators and piezoelectric sensor-actuator hybrids. Modelling was done using FEM method in ANSYS software. Model consisted of a steel plate with piezo elements attached. One of the elements was used as an actuator to excite plate's vibrations. The other was either a standard homogeneous square based actuator or a sensor actuator hybrid with 2 possible sizes of the sensor part of said hybrid. Harmonic analyses were performed for the 1st, 2nd, 4th, and 5th mode shapes with the goal function being the minimalization of displacement vector sum of a number of nodes (there were 3 possible cases). Obtained vibration reduction levels ranged from almost 26 dB to more than 43 dB, with no significant differences in terms of obtained levels between standard actuators and sensor-actuator hybrids. The results also didn't show any significant changes for vibration level reduction when reducing the size of sensor part of sensor-actuators while somewhat mitigating the increase in voltage needed to achieve said reduction levels.

* * *

Correlation between the shape of substitution ducts and insertion loss of silencers

Kamil Wójciak, Joanna Maria Kopania

Lodz University of Technology
Lodz, Poland

Silencers are typical devices used for the reduction of noise in ventilation systems which can be found in almost all industrial, service or residential installations. Determination of acoustic parameters for specific HVAC devices, like silencers, are in the scope of specialized laboratories. With the silencers two main parameters should be taken care of, the first one is sound attenuation and the second one is pressure losses. In the presented paper, the focus is on measurement methods described by standard ISO 7235:2009. This standard specifies the methods for determining the sound power level of the flow noise generated by silencers, the total pressure of silencers and the insertion loss of silencers with and without airflow by using the substitute object. In this work, we focused on the correlation between the shape of the substitution duct and its acoustic parameters and relation to this with the final result of insertion loss of silencer.

* * *

Noise-controlling casings

Stanislaw Wrona

Silesian University of Technology
Gliwice, Poland

Some of the most common noise and vibration sources are devices and machinery, and commonly used sound-absorbing materials are ineffective, often causing further problems such as increased size, weight and potential to overheat. This study summarizes and compares alternative noise-reducing strategies that can be applied to device casings. Depending on the required performance and the availability of energy sources, three approaches can be distinguished: passive (no external energy is needed, but performance is limited), semi-active (little energy is needed, but performance achieves higher values) and active (best performance, but an external energy source is needed). Discussed solutions offer two very important benefits, which are global noise reduction (in an entire enclosure or the surrounding space) and compact technology (contrary to other active noise control solutions requiring a large number of

secondary sources and distributed sensors). Applications include industrial devices, household appliances, vehicle or aircraft cabins and more.

* * *

Measurement of the surface reflectance of an acoustic wave using wave packets propagating in a circular waveguide

Piotr Wrzeciono, Michał Szymański

Warsaw University of Life Sciences
Warsaw, Poland

The main idea of the measurement presented in this paper was to separate the incident wave from the reflected wave. For this purpose, short wave packets and a sufficiently long waveguide with a circular cross-section were used. Several types of wave packets were developed and used in the experiment. We found that a wave packet of 5 ms duration could be propagated in a waveguide of length 5.6 meters without significant sound level losses. We used an audio interface operating at a sampling rate of 96 kHz in the measurements. The limit of wave propagation without dispersion phenomenon was determined. The developed measurement methodology made it possible to maintain the same air temperature along the entire length of the tested waveguide since short pulses did not cause the speaker temperature to rise. Avoiding this effect reduced the measurement uncertainty of the reflection coefficient.

* * *

Proposal of infra and low frequency noise (ILFN) indicators and verification of their usefulness in the assessment of noise annoyance of wind turbines

Tadeusz Wszołek, Maciej Kłaczyński, Paweł Małecki, Paweł Pawlik, Bartłomiej Stępień, Dominik Mleczko

AGH University of Science and Technology
Krakow, Poland

Available research indicates that low frequency noise, especially in the infrasound band, is more annoying than noise in the audible band of similar loudness. Although the reasons for this are not fully known, tonality and time variation (amplitude modulation) are considered to be among the most important factors affecting ILFN annoyance. This paper presents a literature review of indicators used in the assessment of ILFN, based on C and G weighting and C–A difference curves as well as curves related to the loudness threshold. However, due to the low values of measured acoustic energy levels in the low frequency range, often at background level, it was additionally proposed to consider the influence of tonality and amplitude modulation (AM) for annoyance assessment. The statistical spread of the modulation depth L_{05}–L_{90} was taken as the basis for quantification of amplitude modulation. The research part of the paper presents measurement results in the environment of selected wind turbines at different wind speeds, with extraction of parameters describing tonality, amplitude modulation and distance from background and reference to the hearing threshold curve

* * *

Musical period as a factor in exposing orchestra musicians to loud sounds

Jan Żera, Paulina Goluch, Agnieszka Paula Pietrzak

Warsaw University of Technology
Warsaw, Poland

There are numerous studies on noise exposure and risk of hearing loss among musicians playing in symphonic or chamber ensembles. Typically these studies present data averaged over specific measurement time during which various repertoire is played usually not thoroughly analysed. This often creates concerns that selection of musical pieces at a time of measurement may be an important factor determining the exposure. Our study was undertaken to briefly examine how the musical repertoires from classical, romantic and 20th century musical periods differ in created exposure (L_{aeq} levels) as determined at close proximity to ears of selected musicians. Results showed that differences can be of 2 to 6 dB (A). In a case of certain instruments, such difference may be considered as a meaningful change in load imposed to musicians hearing.

* * *