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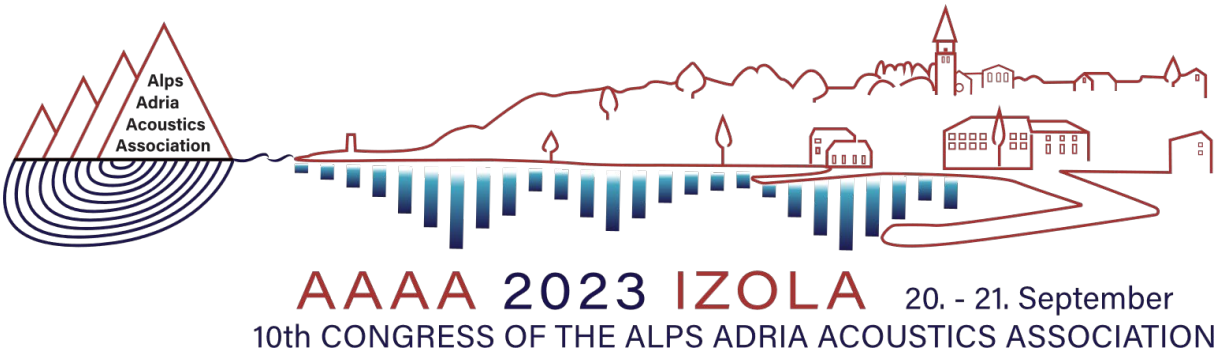
10th Congress of the Alps Adria Acoustics Association

International Scientific Congress

20. – 21. September 2023, Izola, Slovenia



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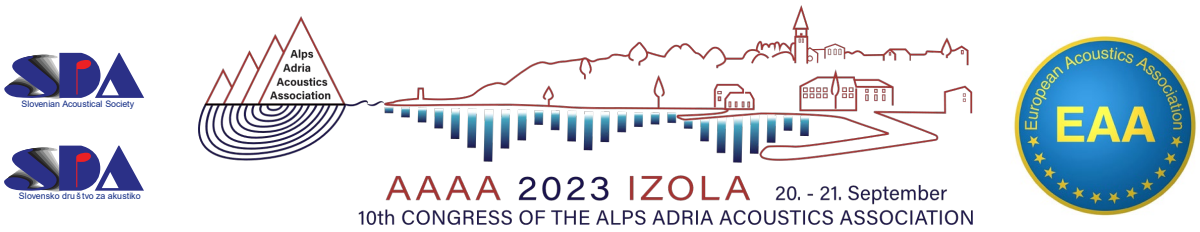

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10th Congress of the Alps Adria Acoustics Association, 20. – 21. September 2023, Izola, Slovenia.
International Scientific Congress

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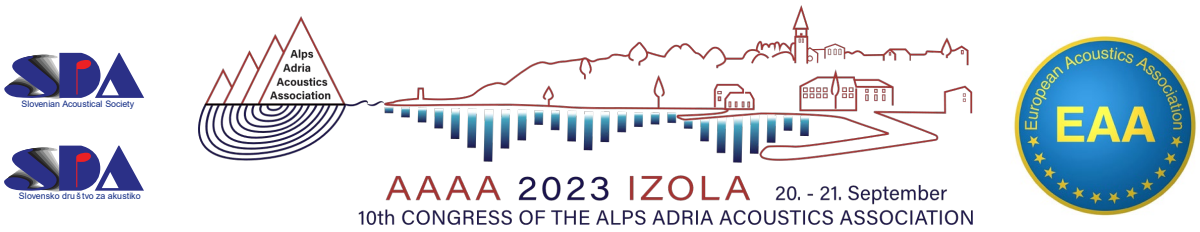

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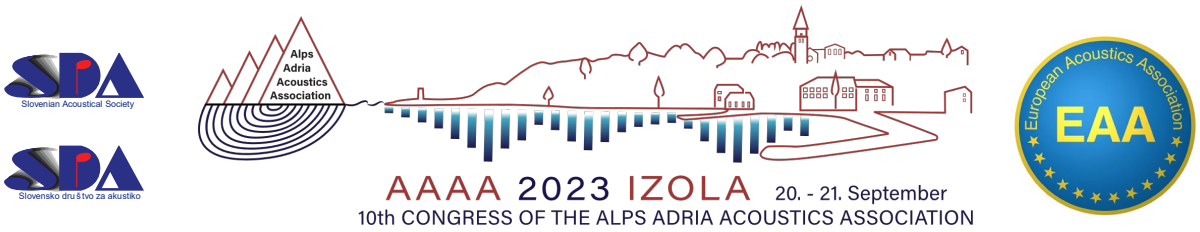

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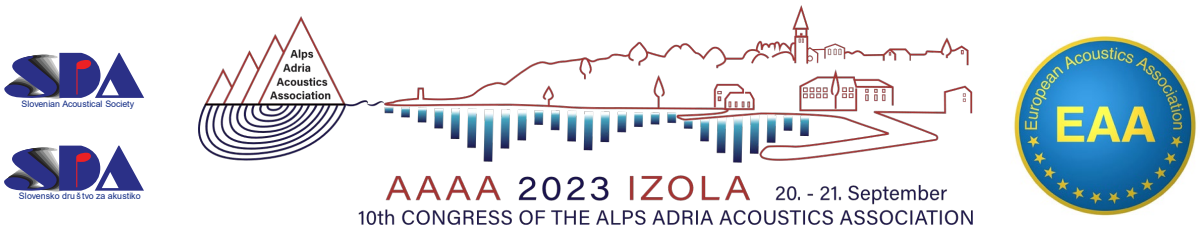

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Preface

Welcome to the 10th Congress of the Alps Adria Acoustics Association! The 10th Congress of the Alps Adria Acoustics Association will be held in Slovenia, at InnoRenew CoE in Izola, from 20th to 21st September 2023.

The Alps Adria Acoustics Association (AAAA) was founded by the acoustics societies of Slovenia, Croatia and Austria in 2002 as a new regional association. In 2019 the Hungarian Scientific Society for Optics, Acoustics, Motion Picture and Theatre Technology (OPAKFI) joined instead of Austria. The original goal of AAAA was to promote all aspects of research in the field of acoustics in the region. In addition, the Association's aim was to improve the overall cooperation among the countries and their respective national societies.

Every two years, one of the three member societies of the AAAA organises a scientific congress on acoustics. The main goal of these congresses is to bring together acousticians from Croatia, Hungary and Slovenia, as well as from the other European countries, in order to exchange knowledge, share research outcomes and strengthen mutual cooperation among these societies for the benefit of the whole region. The last event took place in Budapest in 2021. During the congress days, national and international experts present a number of scientific and applied papers on their research and professional activities in all fields of acoustics. In particular, the congress topics cover architectural and building acoustics, auditory and speech acoustic, environmental and transportation noise, machinery noise and vibration control, computational acoustics, electroacoustics, legislation in acoustics, musical acoustics, measurement techniques, non-linear acoustics, psychoacoustics and perception of sound, signal processing, sound generation and radiation, ultrasonics, hydroacoustics, etc.

The scientific programme includes keynote lectures given by eminent international experts. The AAAA 2023 Congress deals with topics that are the focus of interest in the scientific community and among researchers working in the industry. The 2023 Congress is organised by the Slovenian Acoustical Society (SDA) acting on behalf of the Alps Adria Acoustics Association.

The conference is planned to be a live conference. Looking forward to meeting you in Izola in September 2023!

Assoc. Prof. Dr. Mateja Dovjak, Congress Chair, President of the Slovenian Acoustical Society (SDA), Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Slovenia

Program overview

WEDNESDAY, SEPTEMBER 20	TIME	LOCATION
REGISTRATION	8:00 - 9:00	SEQUOIA LECTURE ROOM
OPENING CEREMONY	9:00 - 9:30	SEQUOIA LECTURE ROOM
KEYNOTE Invited speech: Prof. Dr. Janko Slavič	9:30 - 10:30	SEQUOIA LECTURE ROOM
COFFEE BREAK	10:30 - 10:50	MAIN HALL
MORNING SESSIONS	10:50 - 12:50	SEQUOIA AND QUERCUS LECTURE ROOM
LUNCH BUFFET	12:50 - 13:50	MAIN HALL
ACOUSTIC LABORATORY VISIT - GROUP 1	13:50 - 14:10	ACOUSTIC LABORATORY INNORENEW COE
GOLDEN SPONSOR PRESENTATION - SPONSOR ROTHOBLAAS	14:10 - 14:20	SEQUOIA LECTURE ROOM
GOLDEN SPONSOR PRESENTATION - SPONSOR KNAUF INSULATION	14:20 - 14:30	SEQUOIA LECTURE ROOM
KEYNOTE Invited speech: Prof. Dr.-Ing. Roland Sottek	14:30 - 15:30	SEQUOIA LECTURE ROOM
COFFEE BREAK	15:30 - 15:50	MAIN HALL
AFTERNOON SESSIONS	15:50 - 17:30	SEQUOIA AND QUERCUS LECTURE ROOM
FREE TIME		
TRANSPORTATION TO DINNER	18:45	IN FRONT OF INNORENEW COE BUILDING
GALA DINNER	19:00-22:00	RESTAURANT KAMIN

THURSDAY, SEPTEMBER 21	TIME	LOCATION
KEYNOTE Invited speech: Prof. Dr. Jonas Brunskog	8:30 - 9:30	SEQUOIA LECTURE ROOM
TECHNICAL KEYNOTE Invited speech: Assist Prof. Dr. Rok Prislan	9:30 - 10:30	SEQUOIA LECTURE ROOM
COFFEE BREAK	10:30 - 10:50	MAIN HALL
MORNING SESSIONS	10:50 - 12:50	SEQUOIA AND QUERCUS LECTURE ROOM
LUNCH BUFFET	12:50 - 13:50	MAIN HALL
ACOUSTIC LABORATORY VISIT - GROUP 2	13:50 - 14:10	ACOUSTIC LABORATORY INNORENEW COE
GOLDEN SPONSOR PRESENTATION - SPONSOR DEWESOFT	14:10 - 14:20	SEQUOIA LECTURE ROOM
GOLDEN SPONSOR PRESENTATION - SPONSOR IMS MERILNI SISTEMI D.O.O.	14:20 - 14:30	SEQUOIA LECTURE ROOM
KEYNOTE Invited speech: Prof. Dr. Goran Pavić	14:30 - 15:30	SEQUOIA LECTURE ROOM
COFFEE BREAK	15:30 - 15:50	MAIN HALL
AFTERNOON SESSIONS	15:50 - 17:30	SEQUOIA AND QUERCUS LECTURE ROOM
CLOSING CEREMONY	17:30 - 18:00	SEQUOIA LECTURE ROOM

Program

Registration **WEDNESDAY, SEPTEMBER 20 8:00 - 9:00**

Opening ceremony **WEDNESDAY, SEPTEMBER 20 9:00 - 9:30**

Assoc. Prof. Dr. Mateja Dovjak, Congress Chair, President of the Slovenian Acoustical Society (SDA), Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Slovenia

Welcome speech

On behalf of Slovenian Acoustical Society and Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Assoc. Prof. Dr. Mateja Dovjak, Congress Chair, President of the SDA, Slovenia

On behalf of InnoRenew CoE, Prof. Dr. Andreja Kutnar, director of the InnoRenew CoE, Slovenia

On behalf of Hungarian Scientific Society for Optics, Acoustics, Motion Picture and Theatre Technology (OPAKFI), Beáta Mesterházy, M.Sc., President of the Department of Acoustics of OPAKFI, BME (Budapest University of Tecnology and Economics), Department of Building Constructions, Laboratory of Building Acoustics

On behalf of Hrvatsko akutsičko društvo, Acoustical Society of Croatia (HAD), Prof. Dr. Marko Horvat, President of the HAD, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia

WEDNESDAY, SEPTEMBER 20 - morning session

SEQUOIA LECTURE ROOM
SS04 - ROOM ACOUSTICS
Session chair: Prof. Dr. Kristian Jambrošić, University of Zagreb Faculty of Electrical Engineering and Computing

TIME	TITLE	PRESENTER
10:50	Acoustic Design of a New Concert Venue for Classical Music in Split, Croatia	Kristian Jambrosic (University of Zagreb Faculty of Electrical Engineering and Computing)
11:10	Real or Synthetic? A Machine Learning Approach to Classifying Room Impulse Responses	Marko Pap (School of Electrical Engineering, University of Belgrade)
11:30	LCA study of different recycled sound absorbers from melamine foam waste	Urban Kavka (InnoRenew CoE)
11:50	Multichannel Reverberation Time Measurements of Miura-Ori Origami in Alpha Chamber	Andrej Hvastja (University of Ljubljana, Faculty of Mechanical Engineering)
12:10	Reverberation time estimation from emotional speech signals	Andrea Andrijasevic (Polytechnic of Rijeka, Croatia)
12:30	Determination of the position of equipment noise sources in educational institutions according to subjectively evaluated speech intelligibility	Mateja Dovjak (University of Ljubljana, Faculty of Civil and Geodetic Engineering)

QUERCUS LECTURE ROOM
SS01 - NOISE AND VIBRATIONS
Session chair: Prof. Dr. Antonio Petošić, University of Zagreb, Faculty of electrical Engineering and Computing

TIME	TITLE	PRESENTER
10:50	Integration of Psychoacoustic Perception for Enhanced Design of Axial Fans	Nejc Cerkovnik (University of Ljubljana, Faculty of Mechanical Engineering)
11:10	Noise generating mechanisms analysis and its optimisation on electronical commutated wet-dry vacuum cleaner suction unit	Andrej Biček (Nela d.o.o)
11:30	Modeling and assessment wind turbine noise at different meteorological conditions	Antonio Petošić (University of Zagreb, Faculty of Electrical Engineering and Computing)
11:50	Evaluation of model based noise protection study based on in-situ vibro-acoustic railway track analysis	Krešimir Burnać (Faculty of Civil Engineering, University of Zagreb)
12:10	Steel reilway bridge noise, lack of reduction effect on airborne noise due to vibration dampers possibly acting a s noise sources	Rok Rudolf (ZAG)
12:30	Psychoaoustics of Pseudosound in Turbulent flow of Centrifugal Fan used in Household Appliance	Jurij Prezelj (University of Ljubljana, Faculty of Mechanical Engineering)

WEDNESDAY, SEPTEMBER 20 - afternoon session

SEQUOIA LECTURE ROOM
SS02 - ADVANCED MEASUREMENT TECHNIQUES IN ACOUSTICS
Session chair: Assist. Prof. Dr. Rok Prislan, InnoRenew CoE

TIME	TITLE	PRESENTER
15:50	Challenges in the introduction of timbre coordinates for violoncelli	Daniel Svenšek (University of Ljubljana, Faculty of Mathematics and Physics)
16:10	Soundscape monitoring system for earthquake-affected urban spaces – Zagreb case study	Karlo Filipan (Catholic University of Croatia)
16:30	Immission Directivity as a tool for generation of Noise Maps	Jurij Prezelj (University of Ljubljana, Faculty of Mechanical Engineering)
16:50	Data Selection for Reduced Training Effort in Vandalism Sound Event Detection	Stefan Grebien (Joanneum Research)
17:10	Experimental sound field characterisation with automated high-resolution impulse response measurements	Rok Prislan (InnoRenew CoE)

QUERCUS LECTURE ROOM
SS06 - ACOUSTIC SOFTWARE AND TRAINING
Session chair: Assoc. Prof. Dr. Mateja Dovjak, University of Ljubljana, Faculty of Civil and Geodetic Engineering

TIME	TITLE	PRESENTER
15:50	Audio exercises: quality, pitch statistics and long-term spectra of the sound files	Andrea Andrijasevic (Polytechnic of Rijeka, Croatia)
16:10	Acoustics Knowledge Alliance project: the development of open-access interactive online educational materials in acoustics - strategy and results	Marko Horvat (University of Zagreb, Faculty of Electrical Engineering and Computing)

THURSDAY, SEPTEMBER 21 - morning session

SEQUOIA LECTURE ROOM
SS05 - BUILDING ACOUSTICS
Session chair: Beáta Mesterházy, M.Sc., President of the Department of Acoustics of OPAKFI, BME (Budapest University of Tecnology and Economics), Department of Building Constructions, Laboratory of Building Acoustics

TIME	TITLE	PRESENTER
10:50	Design and construction of a temporary test facility for sound insulation measurements of doors	Nika Šubic (MK3 d.o.o.)
11:10	Acoustic performance of buildings, components and materials as a parameter for ecological and social sustainability assessments	Franz Dolezal (IBO - Austrian Institute for Building and Ecology)
11:30	Possible applications of high-performance floating floors and consequent relevant dimensions of performance and design criteria	Zoltán Horváth (CDM Stravitec Kft.)
11:50	Improvement of impact sound insulation with tile underlay materials – impact sound insulation without floating floors	Beáta Mesterházy, (Department of Acoustics of OPAKFI, BME)

QUERCUS LECTURE ROOM
SS01 - NOISE AND VIBRATIONS
Session chair: Prof. Tino Bucak, HAD, University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia

TIME	TITLE	PRESENTER
10:50	ILEGAL USE OF FIRECRACKERS AND ITS CONSEQUENCES - CASE STUDY OF HUMAN RIGHTS VIOLATION AT SLOVENIAN COURTS – PART I: LEGISLATION AND COURT PROCEEDINGS	Ferdinand Deželak (Retired researcher)
11:10	ILEGAL USE OF FIRECRACKERS AND ITS CONSEQUENCES - CASE STUDY OF HUMAN RIGHTS VIOLATION AT SLOVENIAN COURTS – PART II: PHYSICAL BACKGROUND	Ferdinand Deželak (Retired researcher)
11:30	Low frequency noise measurement in the passenger cabin	Samo Beguš (University of Ljubljana, Faculty of Electrical Engineering)
11:50	Measurement and Characterisation of Control Valves Noise	Egon Susič (Danfoss Trata d.o.o.)

SEQUOIA LECTURE ROOM
SS03 - SOUNDSAPE AND SOUND REPRODUCTION TECHIQUES
Session chair: Prof. Dr. Marko Horvat, President of the HAD, Faculty of Electrical Engineering and Computing, University of Zagreb

TIME	TITLE	PRESENTER
12:10	The soundscape of university campuses: sound essays on the Polytechnic University of València	Alberto Quintana-Gallardo (Centre for Physics Technologies (CTFAMA), Universitat Politècnica de València)
12:30	Accuracy of Dynamic Sound Source Localization in Binaural Audio Systems with Head-Tracking Utilising Generic and Individual HRTFs	Vedran Planinec (Faculty of Electrical Engineering and Computing, University of Zagreb)

THURSDAY, SEPTEMBER 21 - afternoon session

SEQUOIA LECTURE ROOM
SS03 - SOUNDSCAPE AND SOUND REPRODUCTION TECHIQUES
Session chair: Prof. Dr. Marko Horvat, President of the HAD, Faculty of Electrical Engineering and Computing, University of Zagreb

TIME	TITLE	PRESENTER
15:50	Application of Ambisonics to Building Acoustics – Challenges and Opportunities	Armin WILFLING (IBO)
16:10	A Comparison between Real and Reproduced Sound Fields for Impact Noise Annoyance Ratings	Martina Vrhovnik (InnoRenew CoE)

QUERCUS LECTURE ROOM
SS01 - NOISE AND VIBRATIONS
Session chair: Dr. Egon Susič, Danfoss Trata d.o.o., Slovenia

TIME	TITLE	PRESENTER
15:50	Proposing noise barriers along existing national roads through settlements - the case of Novo mesto and its surroundings	Mihael Žiger (Nacionalni laboratorij za zdravje, okolje in hrano)
16:10	Measurement and modeling uncertainty in accredited acoustic procedures	Antonio Petošić (University of Zagreb, Faculty of electrical Engineering and Computing)
16:30	Development of a special standard for outdoor music events in Slovenia based on measurements and calculations	Luka Čurović (University of Ljubljana, Faculty of Mechanical Engineering)

SEQUOIA LECTURE ROOM
SS02 - ADVANCED MEAUSREMENT TECHNIQUES IN ACOUSTICS
Session chair: Assist. Prof. Dr. Samo Beguš, University of Ljubljana, Faculty of Electrical Engineering

TIME	TITLE	PRESENTER
16:30	Estimating Speed of Sound in Granular Materials: Impulse Response Extraction and Wave Decomposition in an Extended Impedance Tube	Anže Železnik (University of Ljubljana, Faculty of Mechanical Engineering)
16:50	A smart method to calibrate universal testing machines by incorporating acoustic methods	Sharath Peethambaran Subadra (Hochschule für Angewandte Wissenschaften Hamburg)
17:10	Unsupervised Classification of Welding processes based on Psychoacoustic Sound Features	Jurij Prezelj (University of Ljubljana, Faculty of Mechanical Engineering)

Closing ceremony **THURSDAY, SEPTEMBER 21 17:30 - 18:00**

Assoc. Prof. Dr. Mateja Dovjak, Congress Chair, President of the Slovenian Acoustical Society (SDA), Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Slovenia

An invitation to the 11th AAAA in Zagreb 2025: Prof. Dr. Marko Horvat, President of the HAD, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia

Keynote
Invited speech

WEDNESDAY, 20. September 2023, 9:30 - 10:30, SEQUOIA LECTURE ROOM

High-speed camera based identification of sound and vibrations

Prof. Dr. Janko Slavič

Ladisk, Faculty of Mechanical Engineering, University of Ljubljana

E-mail: janko.slavic@fs.uni-lj.si

Professor Dr. Janko Slavič is a full professor at the Faculty of Mechanical Engineering at the University of Ljubljana. Prof. Slavič is a recipient of the Fulbright scholarship (University of Texas at Austin 2005-2006) and is a co-author of 82 scientific articles, 56 of which are in category Q1. His works have been cited over ten thousand times. As a mentor or co-mentor, he has supervised 16 completed doctoral theses. In the last 10 years, his research has made significant contributions to the development of science in four scientific areas: vibration fatigue, experimental modal analysis based on high-speed camera recordings, 3D printing of sensors, and research based on open-source code.

Image-based measurement techniques have recently gained popularity and are increasingly used in various applications as a viable alternative to traditional measurement methods. Image-based techniques offer high spatial density of information, and with advancements in hardware, they can also provide a high frequency of image acquisition, such as 20k frames per second at megapixel resolution.

In his lecture, dr. Slavič will review the origins of image-based methods and explain the well-established classical method of digital image correlation (DIC). Advanced signal processing methods will be presented, as well as the challenges associated with noise and overdetermination in image data. It will be shown that amplitude identification is successful for harmonic motion up to the resolution of 1/100,000th of a pixel. Finally, selected methods will be explored that have great potential for future research, such as 3D vibration reconstruction based on frequency domain triangulation and the spectral optical flow imaging experimental technique.

Sessions

WEDNESDAY, 20. September 2023 - morning session: 10:50-12:50, SEQUOIA LECTURE ROOM

SS04 - ROOM ACOUSTICS

Session chair: Prof. Dr. Kristian Jambrošić, University of Zagreb Faculty of Electrical Engineering and Computing

10:50 **Acoustic Design of a New Concert Venue for Classical Music in Split, Croatia**

Kristian Jambrosic (University of Zagreb Faculty of Electrical Engineering and Computing)

This paper presents the key points of acoustic design of a new concert venue in Split, based on the revitalisation of an old building. This venue is dedicated to showcasing classical music performances by soloists and small orchestras. It is built as a classical shoebox-shaped main hall with a small balcony and a seating capacity of 250 that is used for small ensemble performances, accompanied by a smaller hall accommodating up to 60 attendees that is used for mostly solo performances. Throughout the design and construction phases, careful consideration was given to preservation of the historical and architectural value of the building. The acoustic design process aimed to create an exemplary venue lauded for its superior sound quality by both the audience and performers. The paper outlines the decision-making process behind the selection of appropriate interior materials and the placement of acoustic elements, to achieve optimal acoustics in the halls. Furthermore, the paper presents the results of comprehensive acoustic measurements conducted during the construction period, highlighting the effectiveness of the implemented design. By evaluating the acoustical performance of the halls before and after their refurbishment, this study provides valuable insights into the successful integration of architectural design and acoustic considerations.

11:10 **Real or Synthetic? A Machine Learning Approach to Classifying Room Impulse Responses**

Marko Pap (School of Electrical Engineering, University of Belgrade)

This paper presents an innovative dual-branch neural network classifier designed to discern between real and synthetic room impulse responses. Responding to the critical need for verifying the authenticity of room impulse responses used in applications such as audio forensics, acoustic environment modeling, and virtual reality, our classifier uniquely combines a Convolutional Neural Network (CNN) and a Fully Connected Network (FCN) to analyse both spectrogram data and a set of acoustical features. The CNN branch processes spectrogram representations, capturing time-frequency characteristics, while the FCN branch attends to a set of predefined acoustical features, enabling comprehensive analysis. This dual-branch approach allows the classifier to leverage the strengths of both networks, contributing to an exceptional performance of 99% accuracy on the test set. We provide a detailed description of the classifier's architecture, underlining the features and design

	choices that enable its high accuracy. Our results imply the classifier's potential as a tool in maintaining the integrity and authenticity of room impulse responses. We discuss the potential applications and directions for future work, adding a valuable contribution to the field of audio and acoustic research.
11:30	**LCA study of different recycled sound absorbers from melamine foam waste** **Urban Kavka (InnoRenew CoE)** *When designing room acoustics, the environmental impact of the used materials is often overlooked, although the negative environmental impact of the building industry is nowadays unquestioned. In order to improve this relevant aspect, elements of room acoustic treatment, can be either designed using renewable or recycled waste materials.* *The main focus of this study was to explore the utilisation of melamine foam waste in the production of sound absorption panels, with an emphasis on conducting a Life Cycle Assessment (LCA) analysis for two different types of sound absorbers. LCA impacts have been studied for panels made from rigid monolithic melamine foam and from randomly cut fragments. Even though the two different types of panels were made using the same materials, they differ in amount of each material as well as technology and equipment used for production. Most importantly, different shape related requirements can largely influence the recycling potential of the material. Environmental impacts have been calculated per different units. It has been shown that per surface area of the sound absorbing panel, which is 0,675 m^2, the difference between the two types can be misleading. Therefore, evaluating the environmental impact per sound absorption area at 125 Hz, in which the two types mostly differ, a greater potential in monolithic type of absorber is exposed. Together with studies of acoustic performance overall performance and impact of each type has been acquired. The study offers an important insight into the evaluation process, where acoustic performance is not sufficient measure to choose overall best performing absorber type, there's need to also include the environmental perspective.*
11:50	**Multichannel Reverberation Time Measurements of Miura-Ori Origami in Alpha Chamber** **Andrej Hvastja (University of Ljubljana, Faculty of Mechanical Engineering)** *In this research, we introduce and validate a novel LabVIEW program tailored to evaluate sound absorption characteristics of materials in custom made alpha chamber, specifically for Miura-Ori origami structures crafted from thick paper. Initial validation involved simulating sound dissipation signals, using harmonic signal with an exponential function representing sound energy decay. Software validation was performed by matching synthesised theoretical signal with the program's outputs. Practical validation was demonstrated using a stone wool sample, with known sound absorption from interlaboratory comparison. During validation a hypothesis that progressively increasing the number of reverberation time evaluations in the alpha chamber, averaged result drifts closer to its inherent reverberation time. The purpose of new LabView program for multichannel measurements of reverberation time and sound absorption is to observe a relationship between material/structure acoustic attributes and experimental setups, and to confirm the hypothesis that a significant correlation exists between the sound absorption frequency and the spatial frequency of the Origami surface. This hypothesis was placed after a reactive behavior in the sound absorption mechanism of Miura-Ori Origami structure was identified while observing a correlation between the sound*

	absorption spectrum and the spatial Fourier transformation spectrum of the origami structure surface.
12:10	**Reverberation time estimation from emotional speech signals** **Andrea Andrijasevic (Polytechnic of Rijeka, Croatia)** *Many of today's speech signal processing systems, from the low-power ones embedded in the hearing aids to the large and complex deep learning based systems for automatic speaker identification, and speech or speech emotion recognition, rely on their speech enhancement pre-processing module to reduce the signal degradation introduced by the room reverberation and background noise. Even though in the former type of systems this type of pre-processing is performed in order to improve the intelligibility of the input speech, whereas in the latter so as to provide feature robustness, in each case the room parameters need to be estimated from the received signal, most commonly the full-band reverberation time (T60). In this study, we examined the robustness of two reverberation time estimation algorithms to changes in speaker's emotions encoded with the acoustic features such as tempo, voice intensity and pitch height. The results obtained on a set of room impulse responses measured in 11 rooms with T60 in the 0.2 to 1.2 s range, indicate that a spectral decay distributions-based estimator is less sensitive to such type of changes than an estimator based on the modified IS0 3382-2:2008 method. The performance of the latter was successfully enhanced with the introduction of a dynamic range criterion, however it did not surpass the performance of the former algorithm.*
12:30	**Determination of the position of equipment noise sources in educational institutions according to subjectively evaluated speech intelligibility** **Mateja Dovjak (University of Ljubljana, Faculty of Civil and Geodetic Engineering)** *Building-equipment noise is the primary source of background noise in buildings. It is a key factor influencing speech intelligibility, along with room acoustics, sound insulation of the building envelope and the noise level in the room. The impact of building-equipment noise on the acoustic environment in educational institutions is poorly addressed in current design practice; attention is focused only on the requirements for maximum background noise levels and not on the position of noise sources in the room. Our study focuses on a characteristic lecture hall of an educational institution where an artificial speaker was used to simulate the speaker, while the noise typically produced by an HVAC system was generated by an* omnidirectional *loudspeaker. The position and level of the generated noise were varied for two listening/microphone positions. Under these conditions, (i) the Speech Transmission Index (STI), which objectively determines speech intelligibility, was measured, (ii) listening tests were performed to assess intelligibility of digits, and (iii) subjective assessment of intelligibility was performed using questionnaires. On this basis, recommendations for speech intelligibility in lecture halls and classrooms were developed in terms of equipment position and background noise level. The results show that although the position of the noise source has no significant influence on the STI, it can influence the perceived intelligibility. As such, background noise is not a sufficient criterion for including noise sources in the built environment, and the position of noise sources can be optimised in the design phase. This research was approved by the Ethics Committee for Research Involving Human Subjects, University of Ljubljana (012-2021; Ljubljana, 18 February 2022).*

WEDNESDAY, 20. September 2023 - morning session: 10:50-12:50, QUERCUS LECTURE ROOM

SS01 - NOISE AND VIBRATIONS

Session chair: Prof. Dr. Antonio Petošić, University of Zagreb, Faculty of electrical Engineering and Computing

10:50 **Integration of Psychoacoustic Perception for Enhanced Design of Axial Fans**

Nejc Cerkovnik (University of Ljubljana, Faculty of Mechanical Engineering)

Axial fans are widely used in cooling systems but often contribute significantly to environmental noise. Although optimising the fan geometry usually leads to a reduction in sound power, related noise annoyance is usually not considered. Therefore, the geometry design focus was shifted towards optimising the geometry for psychoacoustic perception. A psychoacoustic model is developed to correlate measured noise characteristics with subjective noise evaluations, enabling the objective psychoacoustic evaluation of fan prototypes. Psychoacoustic tests were conducted with 100 respondents evaluating recorded signals of noise from nine different axial cooling fans operating at different conditions. Psychoacoustic features were extracted from the recorded signals and correlated to survey results using linear regression analysis. This approach provided a robust model for future evaluation of fan prototypes noise annoyance. The results show that high-frequency components have a major impact on the perception of fan noise. The use of aero-acoustic features on fan blades is suggested. This study highlights the importance of considering subjective noise evaluations in the design of axial fans. By integrating psychoacoustic perception into the optimisation process, cooling systems can be engineered to minimise noise annoyance. The developed psychoacoustic model serves as a valuable tool for evaluating axial cooling fan noise of various prototypes, providing insights for future fan design improvements in terms of both acoustic performance and cooling efficiency.

11:10 **Noise generating mechanisms analysis and its optimisation on electronical commutated wet-dry vacuum cleaner suction unit**

Andrej Biček (Nela d.o.o)

Vacuum cleaner's market in EU has after cancelation of Energy labelling of vacuum cleaners nowadays face with the revised regulation which is expected to be started in autumn 2023. The Regulation will establish eco-design requirements for electric mains operated vacuum cleaners including hybrid vacuum cleaners. Domel as leading European producer of vacuum cleaner suction units today produce over 75% of those units in range of 600 to 900 watts of input electric power. Important share of production present electronical commutated motors and vacuum cleaner suction units for commercial and industrial applications. Demanding mounting conditions of those motors into devices and heavy operating duties requires introduction of new development methods and new technologies in production. Through this paper is presented systematic approach of detection of sound mechanisms and their optimisation on electronical commutated wet-dry vacuum suction unit will be presented.

11:30 **Modeling and assessment wind turbine noise at different meteorological conditions**
Antonio Petošić (University of Zagreb, Faculty of electrical Engineering and Computing)
In this paper, a model for predicting wind turbine noise under different meteorological conditions (i.e., wind speed magnitudes and directions at 10 metres height) is shown, and residual noise is measured at several different locations around the wind turbine site. The CONCAWE meteorological model method is used for estimating the influence of meteorological parameters with different meteorological classes on noise propagation from the wind turbine as a noise source with different sound powers at different wind speed magnitudes. The modelling results and uncertainties are discussed in terms of acquired meteorological and residual noise levels at considered micro locations around the site. The limit rules for those types of sound sources are analysed for the day/evening/night period regarding the distance from the houses and residual noise at different wind speed magnitudes. Regarding the noise legislation, the measures for reducing wind turbine noise and its influence on energy production are discussed.

11:50 **Evaluation of model based noise protection study based on in-situ vibro-acoustic railway track analysis**
Krešimir Burnać (Faculty of Civil Engineering, University of Zagreb)
In the design phase, newly built or reconstructed railway infrastructure requires a noise protection study to investigate noise sources and the need for noise protection around the railway line. Usually, such studies are based on modelling noise sources and their propagation through the environment, and they tend to overestimate actual noise levels. Therefore, in certain cases, before noise protection is built, investors want to re-evaluate the position, height, and length of noise protection walls foreseen by the noise study. This paper presents a novel approach to the evaluation of a noise protection study on a newly reconstructed railway line in Croatia. It involves vibroacoustic techniques for the characterisation of vehicle pass-by noise and railway track properties such as rail roughness and track decay rate. Based on such properties and a series of in-situ measurements on a reference railway track and the observed newly built track, the noise protection study has been re-evaluated and need for noise protection walls reduced. Results of noise propagation models have further been tested and verified when the railway line has been completed.

12:10 **Steel reilway bridge noise, lack of reduction effect on airborne noise due to vibration dampers possibly acting a s noise sources.**
Rok Rudolf (ZAG)
Steel railway bridges can be quite loud, especially in the low frequency range, and they typically last over 100 years- presenting a very persistent noise pollution problem. One way to tackle this problem is to use noise dampers on the bridge itself, damping vibrations and reducing the airborne noise emissions from the bridge. In one practical application case however, it became apparent that the noise dampers on a specific pilot bridge have substantially reduced the vibration of the bridge, but the airborne noise was barely affected. One possible explanation

	for this is that the noise dampers themselves act as sound sources. To research their contribution to total sound levels of the bridge, we have mounted one of the noise dampers on a vibration machine in a laboratory, and measured emitted sound during various excitation schemes. This way, we were able to assess the noise emitted by the damper at vibration levels typically encountered on a bridge during individual train pass-byes. This allowed us to add dampers as noise sources in a computer noise emission model of the bridge. Using this model, we assessed the effect that dampers as noise sources have on total noise, as measured on site.
12:30	**Psychoaoustics of Pseudosound in Turbulent flow of Centrifugal Fan used in Household Appliance. Jurij Prezelj (University of Ljubljana, Faculty of Mechanical Engineering)** *As the performance metrics of household appliances from various manufacturers converge, acoustic performance is emerging as a pivotal differentiator for consumers. While strides have been made in noise control, further reductions in noise levels are challenging due to inherent physical constraints. Hence, the focus is shifting from merely reducing noise levels to reshaping noise to be less intrusive or even pleasant. While noise arising from vibrations has been largely manageable, aerodynamically generated noise, primarily due to the chaotic nature of turbulent flow, presents a significant challenge. The early turbulent flow studies introduced the term "pseudosound," highlighting the intricate connection between turbulence and acoustics. This research, with a focus on the centrifugal fan in a tumble dryer, employs a psychoacoustic approach to analyse turbulent flow. Our findings indicate a correlation between psychoacoustic features, namely roughness and fluctuation strength, and the turbulent properties of flow when analysed through hot wire velocity signals. This leads to a compelling question: Why does human auditory perception possess the ability to discern the turbulent characteristics of flow?*

Keynote
Invited speech

WEDNESDAY, 20. September 2023, 14:30 - 15:30, SEQUOIA LECTURE ROOM

Development of sound quality metrics using models based on human perception and their applications

Prof. Dr.-Ing. Roland Sottek

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Professor Dr.-Ing. Roland Sottek has a position as Adjunct Professor in Psychoacoustics at the Division of Applied Acoustics at Chalmers University of Technology since 2016. He received a diploma in Electrical Engineering / Communications Engineering from the Technical University of Aachen in 1987 and a doctor's degree in 1993 for his doctoral research study "Signal Processing Model of the Human Auditory System". From 1987 to 1988 he worked as a scientist at the Philips Research Laboratory Aachen. In 1989 he joined HEAD acoustics where he was first Principal Scientist, later Head of the HEAD Consult NVH department and since 2002 Head of the newly established HEAD Research NVH department. In June 2023 he received the new role of Chief Scientific Advisor, directly supporting the Managing Director with scientific expertise. During his work at HEAD acoustics, he was involved in numerous consulting projects mainly related to automotive applications, as well as in 18 publicly funded national and international research projects. He is author or co-author of more than 150 publications and supervisor of more than 30 theses. Current research work concerns models of human hearing, psychoacoustics, localisation and characterisation of sound sources, auralization of virtual environments, noise engineering and digital signal processing as well as experimental and numerical methods for sound-field calculation.

Sound quality metrics are often used to analyse complex sound scenarios, such as soundscape applications. Sound quality can also affect the health and well-being of people in a given environment. Therefore, it is of the utmost importance that the definition of good sound quality in a particular context is as precise as possible. In this aspect, psychoacoustic indicators are usually used to develop these metrics.

In his lecture, Roland Sottek will review the existing standardised time-varying loudness models: the Zwicker method (ISO 532-1) and the Moore-Glasberg-Schlittenlacher method (ISO 532-3), which he supported as project leader and as ISO working group member, respectively, as well as the Sottek Hearing Model Loudness (recently standardised in ECMA 418-2 2nd Edition), a new approach based on a nonlinear combination of partial tonal and noise loudness (introduced in ECMA-74 17th Edition as part of the Sottek Hearing Model Tonality, now moved to ECMA 418-2) to better account for the fact that the loudness of tonal components, i.e., tonal loudness, may have a stronger impact on the loudness perception than the loudness caused by the noise components, i.e., noise loudness. Additionally, he will give an overview of the psychoacoustic roughness based on the Sottek Hearing Model (standardised in ECMA-418-2 1st and 2nd Edition) for the evaluation of fast modulated sounds and on another model for slow modulated sounds: the Sottek Hearing Model Fluctuation Strength, which will be standardised in the near future.

The talk will also provide insights into the complex mechanisms of forming overall noise assessments for some application examples with highly time-varying signals.

Sessions

WEDNESDAY, 20. September 2023 – afternoon session: 15:50-17:30, SEQUOIA LECTURE ROOM

SS02 - ADVANCED MEASUREMENT TECHNIQUES IN ACOUSTICS
Session chair: Assist. Prof. Dr. Rok Prislan, InnoRenew CoE

15:50 **Challenges in the introduction of timbre coordinates for violoncelli**
Daniel Svenšek (University of Ljubljana, Faculty of Mathematics and Physics)
Musical instruments are known for their subtle nuances of sound, and as bodies of considerable size, they have complex radiation patterns. It is therefore a challenge to capture their sound in a robust and reproducible manner while preserving the finest structures required for timbre analysis. In fact, timbre has never been successfully used in practice as a measurable parameter of an instrument, although the ability of humans, especially musicians, to perceive subtle differences in sound colour between instruments of the same type has never been questioned. In recording cellos, we have succeeded in capturing their spectra in such a way that we can introduce harmonic timbre coordinates. These are quantifiers that represent the harmonic spectral aspect of an instrument's sound in a musically relevant way. The basic challenges of introducing timbre coordinates are presented using the cello as a case study, along with data processing steps required to generate timbre coordinates. The study is important because the introduced coordinates have the potential to change the world of musical instruments by providing an objective label for the harmonic sound color of each instrument.

16:10 ***Soundscape monitoring system for earthquake-affected urban spaces – Zagreb case study***
Karlo Filipan (Catholic University of Croatia)
The experience of a sound stimulus is closely related to the meaning that people attach to it. In Zagreb area, after the series of earthquakes which struck in 2020, people have started reporting the increased noticing and reaction to the sounds similar to the ones produced by earthquakes. During the last year, project In- SPE(S) was started with the goals: a) to establish the infrastructure for measuring sound and vibrations in earthquake-affected urban areas, and b) to examine the connection between objective characteristics of sound and vibrations with people's perception, personality traits and previous experiences of earthquakes. Monitoring methodology is structured in two ways: sound and vibration measurements are performed using a network of sensor nodes, while respondents who live near the sensors provide their experience of the salient events captured by the sensors through a mobile application. This contribution will present the soundscape monitoring system and research methodology utilised in the project as well as discuss some preliminary results of the measurements campaign.

16:30 **Immission Directivity as a tool for generation of Noise Maps**
Jurij Prezelj (University of Ljubljana, Faculty of Mechanical Engineering)
This research unveils a pioneering method for estimating the sound power level of elements on an emission plane, utilising a network of immission directivity sensors on a parallel receiving plane, yielding toward measurment based noise maps. Confronting the challenges of the ill-posed inverse problem in acoustics, we introduce an intuitive algorithm that draws from the statistical analysis of environmental noise source behavior in the time domain and statistics of their spatial distribution. Assuming the monopole character of environmental noise sources, we employ the basic equation for correlation between sound pressure and sound power above partialy absorptive surface. By statistical analysis of the set of the calculated sound powers for each element on the emmission plane, we regularise the problem, rendering it well-posed. This heuristic approach, reminiscent of optimisation techniques, requires further validation against more extensive experimental dataset. Our methodology, grounded in acoustics and signal processing principles, enables development of real-time visualisation of the spatial distribution and intensity of industrial noise sources. Remarkably, only a few sensors are necessary to compute a noise source map, or sound power map, which can subsequently be converted into a traditional sound pressure map. This innovative solution addresses a typically unresolved inverse problem in acoustics. Although our preliminary results are limited, they serve as a proof of concept, indicating the potential of this technique in enhancing environmental noise management, bolstering noise control measures, and guiding the design of future industrial sites to mitigate noise impacts.

16:50 **Data Selection for Reduced Training Effort in Vandalism Sound Event Detection**
Stefan Grebien (Joanneum Research)
Typical sound event detection (SED) applications, employed in real environments, generate huge amounts of unlabeled data each day. These data can potentially be used to re-train the underlying machine learning models. However, as the labeling budget is usually restricted, active learning plays a vital role in re-training. Especially for applications with sparse event occurrence, a data selection process is paramount. In this paper we (i) introduce a novel application for vandalism SED, and (ii) analyse an active learning scheme for reduced training and annotation effort. In the presented system, the employed machine learning classifier shall recognise various acts of vandalism, i.e., glass breakage and graffiti spraying. To this end, we utilise embeddings generated with a pre-trained network and train a recurrent neural network for event detection. The applied data selection strategy is based on a mismatch-first, farthest-traversal approach and is compared to an upper bound by using all available data. Furthermore, results for the active learning scheme are evaluated with respect to different labeling budgets and compared to an active learning scheme with a random sampling scheme.

17:10 **Experimental sound field characterisation with automated high-resolution impulse response measurements**

Rok Prislan (InnoRenew CoE)

The technical development of the equipment used for acoustic measurements has allowed us to automate measurements and to use a large number of microphones simultaneously. This opens up the possibility of scanning the sound field, i.e., capturing room impulse responses with a high spatial resolution. In this paper, the development of such a measurement approach is presented. Several challenges and technical details are presented in connection with the approach, including the method for accurately determining the coordinates of the moving microphones. The developed experimental technique is used to study the characterisation of the sound field. The study is therefore important to better understand concepts related to the diffuse and reverberant sound field, such as diffuseness and mixing, in the context of modal and statistical descriptions.

WEDNESDAY, 20. September 2023 – afternoon session: 15:50-16:30, QUERCUS LECTURE ROOM

SS06 - ACOUSTIC SOFTWARE AND TRAINING

Session chair: Assoc. Prof. Dr. Mateja Dovjak, University of Ljubljana, Faculty of Civil and Geodetic Engineering

15:50 **Audio exercises: quality, pitch statistics and long-term spectra of the sound files**

Andrea Andrijasevic (Polytechnic of Rijeka, Croatia)

Audio exercises is a free computer program created with the objective of supporting hearing therapy for adult persons with hearing impairments and tinnitus. It is intended for their home use and, as such, comprised of two parts: a set of twelve auditory exercises in the Croatian language to be used during the later stages of a person's adaptation to the prescribed hearing aid or cochlear implant, and a module for tinnitus perceived intensity reduction based on the Tailor-made notched music training (TMNMT) sound therapy approach. In addition to the program's main task of helping in patient's rehabilitation, it can also be used by the non-diagnosed individuals as a relatively straightforward monitoring tool that can inform them early of their hearing health deterioration. Given these manifold valuable potential applications of the program, in this paper we provide an analysis of the sound files quality as well as of the pitch statistics and long-term spectra of the speech and music examples provided in it. Since the auditory exercises are based on the verbotonal method that takes into account the optimal hearing frequencies of speech sounds, we also calculate the log-spectral distance between the long-term average spectra of the five classes of speech examples and, similarly, the distances between the spectra of the five music genres used for tinnitus therapy.

16:10 **Acoustics Knowledge Alliance project: the development of open-access interactive online educational materials in acoustics - strategy and results**

Marko Horvat (University of Zagreb, Faculty of electrical engineering and computing)

In 2020, an interdisciplinary consortium made up of four universities and four companies started the Acoustics Knowledge Alliance (ASKNOW) project funded by the Erasmus+ Programme of the European Union, with the goal to develop freely accessible, online, interactive educational materials in five fields of acoustics, to be accessible and available on the already established Acoustic Courseware (ACOUCOU) online platform. The mission and the vision of the consortium was to bring this knowledge closer to educators, students, professionals in acoustics, but also specialists in other fields, as well as lay people. In particular, the materials were developed in the fields of acoustic fundamentals, psychoacoustics, acoustic simulations and auralization, electroacoustics, and room and building acoustics, to be grouped in five corresponding online courses. The building units that form the developed materials are lessons and practical cases with a theoretical part that gives the underlying theory, a principle part that illustrates the phenomenon being presented, and a task part that contains one or more tasks to be solved. The process of developing educational materials that will reach out to users and present the knowledge in an interesting and captivating way is complex and

multidimensional, requiring an interdisciplinary approach. The intent of this paper is to present and discuss the key aspects of the development process. Moreover, as the project has reached its end, the paper will also present the overview of the content that has been developed, with selected examples of the developed materials in their final, ready-to-use form.

Keynote
Invited speech

THURSDAY, 21. September 2023, 8:30 - 9:30, SEQUOIA LECTURE ROOM

Challenges in sound insulation of wooden buildings

Prof. Dr. Jonas Brunskog

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Dr. Jonas Brunskog is Associate Professor at the Acoustic Technology group at the Department of Electrical and Photonics Engineering, at Technical University of Denmark (DTU). He is a co-author of 55 scientific journal articles, and more than 110 conference publications. His works have been cited 1960 times (Google Scholar). He has supervised 10 completed PhD theses as main supervisor, and 8 as co-supervisor. Scientific focus areas are: General acoustics, Vibro-acoustics, Building acoustics, Room acoustics, Numerical acoustics, Environmental acoustics, Signal processing, and Voice research.

Adequate sound insulation is important in buildings due to legal, comfort and health reasons, the latter emphasised by WHO. The sound insulation of a single homogenous wall is mainly given by the mass per unit area, the mass law, leaving not much room for improve-ment. Economic pressure as well as environmental demands of increased use of wood in buildings leads to reduced weight, which thus might resulting in poor sound insulation. However, there are also certain aspects that talk in favor for the use of wood constructions. In his lecture, Dr. Brunskog will review the acoustic challenges and possibilities when building with timber constructions. Timber constructions are used in both old traditional floor constructions in many countries, and in new innovative buildings with high sound insulation. Most traditional as well new timber floor constructions are spatially periodic, which will lead to periodic effects such as pass- and stop bands. In other areas of physics and engineering, such aspects are used as metamaterials. Another branch of constructions where innovative ideas are needed and are being used are CLT constructions.

Technical keynote
Invited speech

THURSDAY, 21. September 2023, 9:30 - 10:30, SEQUOIA LECTURE ROOM

Design and construction of the InnoRenew CoE Acoustics Laboratory

Assist Prof. Dr. Rok Prislan

InnoRenew CoE

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Dr. Rok Prislan is research group leader for Buildings and is leading research in the field of acoustics at InnoRenew CoE. Dr. Prislan is also holding the position of an assistant professor at the University of Primorska, where he teaches physics. His main research topics are advanced measurement techniques for sound field characterisation and geometrical room acoustic modelling. As part of his career, dr. Prislan was working as an acoustic designer/consultant and has led over 60 projects in the field of acoustics and noise control. Dr. Prislan has two master's degrees, one in physics (mathematical physics) from the University of Ljubljana and one in engineering acoustics from the Technical University of Denmark (DTU).

InnoRenew CoE was established in 2017 as an international research institute with the goal of providing innovation and conducting cutting-edge research in the broad field of sustainable and healthy built environment. In just five years, the institute was built from the ground up by assembling an international team of researchers, investing in state-of-the-art laboratory equipment, and constructing the laboratories. The acoustics laboratory was the most technically challenging laboratory to design and build. In this talk, dr. Rok Prislan, who played a leading role in the design, will present this process. For the newly built reverberation and anechoic chambers, dr. Prislan will provide an overview of the given requirements, explain how the chambers were conceived, what the main design challenges were, and address the uncertainties that arise from the undefined guidelines for the design of such facilities. Dr. Prislan also explains the approaches used in this engineering adventure, including the acoustic modeling methods used to predict and the experimental methods used to evaluate the performance of the chambers. The presentation of the main construction steps is supported by rich photographic and video material.

Sessions

THURSDAY, 21. September 2023 – morning session: 10:50-12:10, SEQUOIA LECTURE ROOM

SS05 - BUILDING ACOUSTICS

Session chair: Beáta Mesterházy, M.Sc., President of the Department of Acoustics of OPAKFI, BME

10:50 **Design and construction of a temporary test facility for sound insulation measurements of doors**

Nika Šubic (MK3 d.o.o.)

To fulfill the sound insulation requirements for separating elements in buildings a common concern is reaching sufficient sound insulation of smaller construction elements, such as doors. Besides the construction of the door leaf, achieving quality sealing of the door leaf with the frame and floor is important as well as the on-site execution, which can greatly impact the final sound insulation of the whole separating element. To optimise the design of doors regarding sound insulation, repetitive testing is required which can be time consuming and expensive when performed on a different location by an external contractor. To facilitate the process for a Slovenian company, a temporary test facility was designed on their premises. The test facility was constructed in the existing building of the company using lightweight materials. The design and construction followed the requirements of the ISO 10140 standard, and the finished test facility can test door specimens with sound reduction index values of up to 56 dB.

11:10 **Acoustic performance of buildings, components and materials as a parameter for ecological and social sustainability assessments**

Franz Dolezal (IBO - Austrian Institute for Building and Ecology)

Several initiatives have been launched to increase sustainability in the building industry. The consequence was a broader view of sustainability, not only based on the environmental, but on the economic and social performance of materials, components and buildings as well. A closer look on internationally acting Green Building Labels reveals that acoustic performance is, although a technical quality, handled as part of the social sustainability aspects of a building. Depending on the label, several credits are assigned for the fulfilment of requirements. Particularly for sustainable lightweight structures made of wood, sound insulation is to some extent defined by the properties of the insulation material, filled into the cavity of the timber joists. Especially the density and the dynamic stiffness, as well as the air flow resistivity, are important material parameters to achieve satisfying sound insulation properties. A comparison with different products and components has been carried out. It could be shown that the use of renewables leads to lower environmental impacts, though, the insulation material is not the most relevant parameter of the building components.

11:30 **Possible applications of high-performance floating floors and consequent relevant dimensions of performance and design criteria**

Zoltán Horváth (CDM Stravitec Kft.)

Increasing population density and urbanisation are making low noise and vibration standards increasingly stringent. As a result, there is an increased demand for high-quality and efficient noise and vibration isolation systems due to the need to build faster, lighter and with larger spans. These trends pose new challenges to the design of high-performance floating floor systems aimed at mitigating vibration and reducing impact and airborne noise. Today, floating floor systems are part of state-of-the art building technology. They are a cost-effective and efficient option to improve the acoustical performance of our buildings. Floating floors are usually made of poured-in-place concrete or of lightweight panels supported by resilient elements that transfer the loads from the floating floor to the subfloor. Floating floors are used where there is a requirement to either protect a noise sensitive area or to isolate an area where excessive noise is produced, isolating the working floor from the structure and being designed to take domestic, commercial or industrial loads. There are many applications in which an acoustic floating floor can be used. Some applications immediately come to mind, others are not so obvious, such as: cinema & theatres, recording studios, music practice & rehearsal rooms, mechanical equipment rooms (including inertia blocks), event spaces, swimming pools, basketball courts, bowling alleys, residential apartments and offices, medical laboratories, parking garages, rooftop helipads, gymnasiums, etc. As a result of such a variety of applications and their particularities, there are several variants of acoustic floors that can be designed to better achieve the system's noise vibration integrity and structural and functional integrity. In this paper, we review the performance of different floating floor systems by looking at their various dimensions of performance and the applications that better serve those same characteristics, referring to some case studies.

11:50 **Improvement of impact sound insulation with tile underlay materials – impact sound insulation without floating floors**

Beáta Mesterházy (Department of Acoustics of OPAKFI, BME)

On the basis of Hungarian Central Statistical Office (KSH) in 2021 1 million m^2 residential buildings were built in Hungary, wherein in our estimation min. 50.000 m^3 estrich screed was built in with the expense of 2 billions HUF (approx. 5,3 millions Euro) and with the CO2 equivalent carbon footprint of approx. 142 290 tons. On the other hand the acoustical quality of existing buildings often can not be improved with floating floors considering the loadbearing capacity and interior height. Building material producers provide different tile underlay materials which can be covered directly, but the use of these materials compared with other solutions is insignificant. The main goal of the research was to assess and quantify the performance and application field of solutions with special underlay materials and to develop possible layer orders without screed. More than 50 measurements were carried out with 10 different underlay materials in the Laboratory of Building Acoustics of BME (Budapest University of Technology and Economics) and in-field. We found that the examined and

developed structural solutions can be used to increase the acoustical quality of existing buildings without floating floors and can be applied cautiously in new buildings as well. The base of this research was developed by the students of BME for a Students' Scientific Conference with the guidance of their professors. On the basis of this work we plan to carry out a research project in the future involving building material producers to develop specific solutions and layer orders.

THURSDAY, 21. September 2023 – morning session: 11:50-12:30, SEQUOIA LECTURE ROOM

SS03 - SOUNDSCAPE AND SOUND REPRODUCTION TECHNIQUES

Session chair: Prof. Dr. Marko Horvat, President of the HAD, Faculty of Electrical Engineering and Computing, University of Zagreb

11:50 **The soundscape of university campuses: sound essays on the Polytechnic University of València**

Alberto Quintana-Gallardo (Centre for Physics Technologies (CTFAMA), Universitat Politècnica de València, Spain)

The Polytechnic University of València (UPV) is the biggest polytechnic university in Spain. This university, which was founded in 1971, started as a small Education Institute and now has more than 28000 students in a 620000 m^2 university campus and has deep roots in the overall culture of the city of Valencia. This study reflects the acoustic heritage of UPV Campus de Vera and its value as an ever-changing cultural heritage. The objective is to produce sound essays that capture the ephemeral soundscape of the UPV campus and help the university community reflect on its influence on their day-to-day and even in the broader culture of the city. The methodology consists of three distinct phases. The first phase is a bibliographic study of the history of the UPV. This is done by analysing the architectural projects that defined the university and the published books on the topic. This part is crucial to put the study into context. The second part is recording soundscapes on the campus using ambisonics microphones, sound walks with binaural microphones, and interviews with professors, students, and other university employees. The last part involves editing the audio using a Digital Audio Workstation (DAW). The study results are four sound essays distributed as podcasts on online platforms. After concluding the project, it can be stated that reflecting on the acoustic heritage of university campuses can help students, professors, and other employees create a sense of belonging and ultimately foster their formal and non-formal educational path.

12:10 **Accuracy of Dynamic Sound Source Localization in Binaural Audio Systems with Head-Tracking Utilising Generic and Individual HRTFs**

Vedran Planinec (Faculty of Electrical Engineering and Computing, University of Zagreb)

The constant advances in spatial audio technology have the potential to revolutionise the overall audio experience through the integration of binaural systems with head-tracking devices. The hypothesis is that the use of individual Head-Related Transfer Functions (HRTFs) in binaural synthesis benefits the listeners by providing a deeper immersion into the sound scenarios created for virtual and/or augmented reality setups, and, ultimately, a more realistic listening experience. This paper presents the results of a listening experiment in which the listeners were asked to determine the position of a dynamic virtual sound source presented to them binaurally in the horizontal and the median planes, with the goal of assessing how accurately this determination can be done. The experiment was conducted in a controlled listening room environment using a wired head tracker in conjunction with headphones for

binaural audio reproduction. The influential factor investigated in the experiment were the HRTFs, which have been varied between a generic HRTF set and the individual sets measured for each listener. The aim is to evaluate if there is any difference in localisation accuracy between these two cases and to evaluate its significance through statistical analysis.

THURSDAY, 21. September 2023 – morning session: 10:50-12:50, QUERCUS LECTURE ROOM

SS01 - NOISE AND VIBRATIONS

Session chair: Prof. Tino Bucak, HAD, University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia

10:50 **Ilegal use of firecrackers and its consequences - case study of human rights violation at Slovenian courts – part I: legislation and court proceedings**

Ferdinand Deželak (Retired Researcher)

In first part of this paper a human rights violation at some Slovenian courts is briefly highlighted. This violation has been firmly proved not just through a judicial proofs, but also by a full physical analysis. Apart of the court proceedings some important physical facts are described, which were quite misunderstood and even intentionally neglected at more Slovenian courts. The corresponding legislation which was misinterpreted or even ignored is shortly presented as well. Such ignorance resulted in quite contradictory and illegal judgments. Some years ago, one attacker threw an explosive device at the victim, which consequently suffered a permanent hearing impairment. Although reporting this attack to the Police, further criminal and lawsuit proceedings at the different courts in Ljubljana against the attacker were corrupted, unprofessional and completely biased by some judges. Lawsuit proceedings were started by one corrupted judge, who was later found guilty of corruption and dismissed from judicial service. The next judge then appointed one retired court expert witness in order to solve some audiometric and acoustic problems concerning a victim's hearing loss as a result of this explosion. However, he was not familiar with basic facts of acoustics and was not able to do that job correctly.

11:10 **Ilegal use of firecrackers and its consequences - case study of human rights violation at Slovenian courts – part II: physical background**

Ferdinand Deželak (Retired researcher)

In second part of this paper a physical background of firecracker explosion and its influence on hearing damage is described. This explosion took place very close to the victim's right ear. The peak of its sound pressure was around 150 dBC. However, due to incorrect metrics used, the expert witness estimated intuitively this level to be much lower, with four hundred times to low energy value, received by the victim's ear. The expert completely misinterpreted several European directives concerning this field. Based on such erroneous assumptions, he concluded that no hearing damage could be possible as a result of this explosion. Apart from incorrect metrics, he also confused some important acoustic quantities and facts, resulting in additional cardinal errors. Due to a lack of fundamental knowledge regarding high impulse noise and its propagation, he was unable to recognise the importance of its amplitude and spectral characteristics for hearing damage. He further confused reflection, refraction, diffraction and other factors, resulting in misleading expert testimony and its wrong conclusions. Despite numerous warnings and evidence, the judges uncritically accepted these erroneous conclusions

	and made completely unacceptable and fraudulent judgments, resulting in the conscious violation of the victim's human rights by various Slovenian courts.
11:30	**Low frequency noise measurement in the passenger cabin** **Samo Beguš (University of Ljubljana, Faculty of Electrical Engineering)** *In recent years, the negative impact of sounds of infrasound and ultrasound frequencies on the health of people has been observed and documented. There are more and more sources of infrasound (e.g. traffic, wind farms) or ultrasound (e.g. electronic mole repellers, remote controls, sensors) in everyday life, but at the same time there are few recommendations and safety standards governing this area. Therefore, research on the impact of ultrasound and infrasound on humans is very important and necessary. A case study of the low frequency noise measurement in the passenger cabin is presented. A sound level meter with a separate microphone is used to assess the noise level in the passenger cabin when driving with closed or open window. Post processing is carried out later with different commercial and freely available software. The results show sound pressure levels of more than 100 dB and 110 dB in a car cabin with closed and open window respectively.*
12:30	**Measurement and Characterisation of Control Valves Noise** **Egon Susič (Danfoss Trata d.o.o.)** *Valves that control water flow in heating/cooling systems are often source of annoying noise. At the same time emitted noise can carry valuable information about flow condition. In spite that design of globe valves utilises similar principle for reducing flow, the resulting noise exhibits many different characters and levels regarding dimension and material used. To enable noise control a measuring system is designed and applied predominantly at development stage of new valves. Most of typical noises are characterised by power spectral density function. By analysing noise and correlations with respect to internal geometrical features and flow conditions we manage to produce quieter valves and push the boundaries of operating conditions.*

Keynote
Invited speech

THURSDAY, 21. September 2023, 14:30 - 15:30, SEQUOIA LECTURE ROOM

Modelling of sound and vibration using a virtual-source approach

Prof. Dr. Goran Pavić

Professor Emeritus at Institut National des Sciences Appliquées de Lyon, France

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Goran Pavić holds BSC in Mechanical Engineering and PhD in Goran Pavić holds BSC in mechanical engineering and PhD in vibration and acoustics. After spending most of his career in industry research he joined in 1998 the National Institute of Science in Lyon as a full professor and, after the retirement, occupies the post of prof emeritus. His research covers sound and vibration energy flow, vibroacoustic modelling, characterisation of sources and advanced experimental methods. He was actively involved in a large number of national and international research projects as well as in the organisation of numerous scientific events.

The virtual-source approach enables the use of known analytical solutions of either a vibration or a sound field of a simple surrogate space to construct the field of a more complex space of arbitrary shape and boundaries. The field of the targeted space driven by the original primary excitation is obtained by superposing two fields of the surrogate space: one produced by the same primary excitation, the other by a (large) number of virtual sources. The latter are tuned to the primary excitation in such a way as to reproduce the required boundary conditions of the target space. The tuning is normally obtained by an inverse procedure which leads to the discretisation of boundary conditions. It is shown how the error induced by discretisation is evaluated and controlled. Numerous examples of vibration and sound fields are shown to illustrate the approach.

Sessions

THURSDAY, 21. September 2023 – afternoon session: 15:50-16:30, SEQUOIA LECTURE ROOM

SS03 - SOUNDSCAPE AND SOUND REPRODUCTION TECHNIQUES

Session chair: Prof. Dr. Marko Horvat, President of the HAD, Faculty of Electrical Engineering and Computing, University of Zagreb

15:50 **Application of Ambisonics to Building Acoustics – Challenges and Opportunities**
Armin Wilfling (IBO)

Concentrating on existing, standardised methods with an insufficient relation to human perception is not a satisfactory approach to comprehensibly characterise the nuisance caused by impact noise sources. Perception can no longer be condensed to a single number (the so called weighted impact sound pressure level), which is based on a low structural diversity of building components. Thanks to novel recording technologies, their unique combination and mathematical modelling, together with advanced methods for the analysis and interpretation of human perception, a holistic understanding of the acoustic and vibrating interrelationship between building and occupant can be created. Recordings of impact noise caused by neighbours are carried out using different methodologies with the intention to capture a full sphere surround sound for reproduction to test persons in an anechoic chamber. Impact noise caused by walking on a ceiling, built according to the (Austrian) standards, usually is of very low level with a low frequency emphasis. That specific kind of signal turned out to be challenging for Ambisonics© recording; the eigennoise of the microphones used became a limiting factor in the recording and reproduction process. Single microphone techniques were compared to multichannel recording systems, focusing on their performance on low level, low frequency signals.

16:10 **A Comparison between Real and Reproduced Sound Fields for Impact Noise Annoyance Ratings Martina Vrhovnik (InnoRenew CoE)**

The most common way to evaluate subjectively perceived annoyance of impact noise is conducted with the help of listening tests. Impact noise recordings are played back through headphones or loudspeakers under controlled conditions in which the reproduced impact noise should be perceived and rated consistently to the impact noise in a real environment. According to the standard ISO/TS 12913-2 binaural reproduction are preferred over a multichannel loudspeaker approach. Arguing that multichannel playback lacks a standard technique and examples of best practice. On the other hand, studies in the built environment imply that playback through loudspeakers contributes to the ecological validity of the test environment. Participants are able to move their head or entire body and get a better impression of the sound

field which leads to more valid test results. As such further investigations related to the optimal listening approach are needed. This paper presents a listening test in which the participants rated their annoyance when exposed to real impact sources and their acoustical reconstruction in a direct comparison. Participants were exposed to real impact noise, excited on the upper floor, and its reproduction through a higher order Ambisonics system. Annoyance ratings for different impact noises were evaluated regarding the distinguishability between real sound field and its reproduction through loudspeakers. Results expose differences in the perceived annoyance depending on the reproduction technique.

THURSDAY, 21. September 2023 – afternoon session: 15:50-16:50, QUERCUS LECTURE ROOM

SS01 - NOISE AND VIBRATIONS

Session chair: Prof. Dr. Tino Bucak, HAD, University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia

15:50 **Proposing noise barriers along existing national roads through settlements - the case of Novo mesto and its surroundings**

Mihael Žiger (Nacionalni laboratorij za zdravje, okolje in hrano)

Noise barriers are widely used in Slovenia along motorways and more recently along railway lines, to cope with exceedances of limit values, identified by noise monitoring and strategic noise mapping. Noise barriers along other national roads are mainly used for new developments (bypasses, reconstructions). As the use of passive measures along existing national roads through settlements was considered the only appropriate option, there has been virtually no systematic approach to noise barriers along the existing national roads. In 2021, the Directorate of the Republic of Slovenia for infrastructure (DRSI) commissioned noise studies along major roads under its management. Our institution has carried out a noise study for the area of the town Novo mesto and its surroundings, for three road sections with a total length of about 15 km, mostly within built-up areas. We have established baselines for the feasibility of noise barriers and found seven areas where noise barriers can be proposed. The results show that along the existing national roads through settlements - in addition to the usual passive measures on buildings, and considering limited possibilities of using quieter asphalt and lower speed limits - it is reasonable to consider noise abatement also by noise barriers.

16:10 **Measurement and modeling uncertainty in accredited acoustic procedures**

Antonio Petošić (University of Zagreb, Faculty of electrical Engineering and Computing)

The uncertainty in acoustic measurements and modelling is discussed in this article regarding the measurement method for determination of environmental noise parameters in accordance with ISO 1996-2:2017, the modelling methods in accordance with ISO 9613-2:1997, the NMPB-XPS 2007, and the EU CNOSSOS from the results of interlaboratory comparisons (ILC). Additionally, measurement uncertainties for airborne and impact building acoustic parameters measured in accordance with ISO 16283-1:2014, ISO 16283-2:2020, with determination of single number values in accordance with ISO 717-1:2020 and ISO 717-2:2020, from ILC are determined from each independent measurement and compared with tentative values from the ISO 12999-2020 standard and previous comparisons. The statistical analysis of the data shows that there is a significant difference in the proposed measurement uncertainty for equivalent sound pressure level at closer ranges. Modelling uncertainty from the findings is significantly less than the values provided by laboratories which use tentative value for umet=2 dBA which is the most dominant component in uncertainty budged. When discussing building acoustic parameters, there is no discernible difference between the ILC findings obtained with one independent measurement and those recommended in standard ISO 12999-1:2020 and previous comparisons. sound

16:30 **Development of a special standard for outdoor music events in Slovenia based on measurements and calculations**

Luka Čurović (University of Ljubljana, Faculty of Mechanical Engineering)

In Slovenia, the standard ISO 1996-2 is used to conduct the environmental noise measurements. When planning and performing measurements, a large number of variables must be taken into account, including the sound-emitting characteristics of the noise source, meteorological conditions, and the specifics of local geography and noise-sensitive areas. In general, the standard attempts to cover all types of sources, so it is best used as a basis for developing more specific standards for particular sources such as modern loudspeakers and outdoor sound systems. The objective of this paper is to present the acoustic characteristics of sound systems used at outdoor music events and to identify the main influencing variables that should be considered in the design and evaluation of environmental noise based on measurements and calculations. Such a study could be a first step in developing specific practice guidelines and standards for outdoor music events.

THURSDAY, 21. September 2023 – afternoon session: 16:30-17:30, SEQUOIA LECTURE ROOM

SS02 - ADVANCED MEAUSREMENT TECHNIQUES IN ACOUSTICS

Session chair: Assist. Prof. Dr. Samo Beguš, University of Ljubljana, Faculty of Electrical Engineering

16:30 **Estimating Speed of Sound in Granular Materials: Impulse Response Extraction and Wave Decomposition in an Extended Impedance Tube**

Anže Železnik (University of Ljubljana, Faculty of Mechanical Engineering, LDSTA)

The speed of sound in materials greatly affects their acoustic properties and is a key factor in determining the acoustic impedance of a surface, which governs the reflection, absorption, and transmission of acoustic energy. Granular materials offer an intriguing alternative to custom-made acoustic materials, as they can achieve high sound absorption or insulation through the use of different size fractions. By investigating the speed of sound within the pores of granular materials, one can estimate their acoustic properties. In this paper, a method for measuring the speed of sound in porous materials using an impedance tube and time-domain wave decomposition of the tube's impulse response is proposed, employing a single downstream microphone to assess various size fractions of recycled sand. The measurements encompassed granular fractions ranging from 0.1 to 4 mm. Notably, decrease in the speed of sound within granular materials as the granules became smaller can be observed, with the speed dropping below 100 m/s for the smallest fraction.

16:50 **A smart method to calibrate universal testing machines by incorporating acoustic methods**

Sharath Peethambaran Subadra (Hochschule für Angewandte Wissenschaften Hamburg)

The aim of this research is the development of a non-destructive testing methodology for tensile, compression and bending tests to ascertain the calibration status of universal testing machines. An algorithm which would be eventually included in the machine-bound control system keeps track of the calibration status by assessing errors which would be dependent on the acoustically determined material properties like elastic, shear and compression moduli. An "Acoustic Reference Sample" serving as a non-destructive reference material would be used to determine these properties. The reference sample material would have a large elastic range and hence can be loaded within this range several times to obtain the elastic properties, which would be subsequently cross-referenced with the acoustically determined material properties in the calibration stage. The machine-bound control system would make use of an in-built algorithm to keep track of this change in material properties and hence the calibration status. The development of this strategy would bring down costs associated with quality assessments and subsequently improve reliability of testing procedures considerably when there are long intervals in calibration of the testing equipment.

17:10 **Unsupervised Classification of Welding processes based on Psychoacoustic Sound Features**

Jurij Prezelj (University of Ljubljana, Faculty of Mechanical Engineering)

Welding processes, to ensure the quality of the final products, often need to be controlled through external sensors. In MAG/MIG welding, the welder or welding operator also relies on

hearing, i.e., audible sound emissions during the welding process. From the interpreted sound emissions during the welding process, the stability of the welding process can be determined. In the paper, we analysed short-circuit and pulsed MIG/MAG welding under different operating conditions. Signals of welding current, voltage and sound in the audible and ultrasonic range were recorded. During welding, we simulated poor welding conditions such as lack of protective gas atmosphere, distancing the welding torch from the welding surface, and improper preparation of the workpieces with greasy, coloured, and oxidised surfaces. Additionally, we applied unsupervised K-Means classification in combination with psychoacoustic features of audible sound to check the hypothesis that sound emission carries enough information about the process to classify it. By changing the number of classes, it was found out that sound can be used to monitor the welding process, identify the welding process type and further it revealed a specific mode of welding.

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