Sixth Training Event of NDTonAIR

Signal and Image Processing & Ultrasonic Imaging Workshop

13-17 May 2019

Venue: Santaka Valley, Barsausko 59, LT-51423, Kaunas, Lithuania

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Invited speaker: *Prof. Dr. Liudas Mazeika*

Bio: Liudas Mazeika graduated as engineer – mathematic from Kaunas Polytechnic Institute (currently Kaunas University of Technology -KTU) and in 1986 defended scientific degree doctor of science in technology (Ph.D) in field of measurement of mechanical quantities. The PhD topic was related to modelling of ultrasonic piezoelectric transducers using finite element method. His carrier started as engineer in the same institution. From 2002 is the professor in the KTU faculty of Electrical and electronic engineering. Currently he is the director and principal researcher in the Ultrasound Research Institute of Kaunas University of Technology. He is the member of PhD committee of Measurement Engineering and Chairman Electrical and Electronic Engineering. Mazeika has close to 40 years of experience in ultrasonic measurements and NDT, participated in numerous international projects and contracts with industry, is co-author of more than 100 publications including 75 according Clarivate Analytics.

Topic: Signal processing in ultrasonic measurements and NDT

Abstract: This presentation will give a look at key aspects related to ultrasonic measurements and ultrasonic NDT as part of measurements. The most important quantities that needs to be measured, their relation to characteristics of ultrasonic signals and 3D aspects will be discussed and signal-processing algorithms will be analysed. The presentation will consider main signal processing techniques used in ultrasonic NDT, their advantages, influence of various side factors. The peculiarities of the ultrasonic guided waves and problems related to processing of such signals will be analysed. The importance of the modelling will by underlined also. The main steps and efficiency of methods will be demonstrated for the cases of different applications of ultrasonic NDT with advanced signal processing.

Invited speaker: *Prof. Dr. Linas Svilainis*

Bio: Dr. Linas Svilainis graduated with a M.Sc. in Radioengineering from KPI in 1988, acquired PhD degree from the Kaunas University of Technology (Lithuania) in 1996. Visiting scientist at Linkoping University, University College London. Since 2009 he is a Full time Professor at the Department of Electronics Engineering, Kaunas University of Technology, Lithuania. Visiting lecturer at National Technical University of Athens, Technical University Sofia, Miguel Hernández University of Elche. Senior IEEE member, member of UFFC, Instrumentation and Measurement societies. Worked in private company as a head of R&D department for large scale LDE video displays development. More than 20 years experience in Electromagnetic compatibility, consultancy work for industry. Member of national standard Committee for Electromagnetic Compatibility. Winner of 2013 Lithuania Academy of Science award in Electronics. Expert at various national and international agencies, editorial board member of 4 journals. Has over 30 years of experience in ultrasound electronics, signal processing for ultrasonic imaging and measurements. Since obtaining his PhD he published 123 papers, was supervising several R&D industrial contracts, national and international research projects. Dr Svilainis is currently working on spread spectrum signals, time of flight estimation and adaptive deconvolution.

Topic #1: Time of flight estimation and deconvolution

Abstract: Estimation of the time-of-flight is the most recently used procedure in material thickness measurement, ultrasound velocity estimation, mechanical load or stiffness evaluation, curing or melting monitoring, temperature measurement, food processing etc.

This presentation will review a pulse time of flight (temporal position or time delay) estimation techniques. Starting from simple ones and ending with high accuracy, more advanced techniques that use maximum likelihood criteria for time position estimation. Likeness between the reference (transmitted) signal and received signal is analyzed here. A comparison of the correlation maximum, difference L1 norm minimum and difference L2 norm minimum techniques is given. Sources of both random and bias errors in the time-of-flight estimation will be outlined. Cramer-Rao lower error bound is discussed. Review of errors introduced due to acquisition equipment and digital domain processing will be given. Bias errors introduced by parabolic, cosine and Gaussian interpolation are analyzed and compared to frequency domain interpolator.

Yet, in case of majority of applications object structure or measurement setup are arranged in such a way that multiple reflections exist. Usually temporal positions are required for all reflections. Iterative deconvolution is a better approach than simple peaks extraction. Unfortunately, probing signals are affected by probe bandwidth so have a limited bandwidth and therefore easily overlap. If reflections overlap, time of flight estimation becomes not a trivial task. It will be shown that neighboring reflections influence each other's temporal position, causing bias errors. Reiterative deconvolution was proposed to solve the issue. Decomposition techniques will be discussed. Signals also undergo frequency dependent attenuation, velocity dispersion, mode conversion, diffraction and this results in shape distortion. Reference signal derivation techniques will be presented. Reasoning for the need of adaptive reference will be given.

Topic #2: Ultrasound electronics and spread spectrum signals

Abstract: Ultrasonic measurements quality is directly influenced by electronics used. Then it becomes important for experimenter to understand what electronics is used for ultrasonic signals acquisition, why and how it operates in such way. What can be done to improve the quality of signals collected?

This presentation will analyse the ultrasound electronics structure, discuss the most important blocks used in acquisition and their functions and parameters.

Most of ultrasonic systems use simple signals such as pulse or tone burst, because these are easy to generate and interpret the results, but they either lack either energy or bandwidth. Spread spectrum (SS) signals, such as arbitrary waveform, chirp (FM-CW, LFM), nonlinear chirp (NLFM) and PSK sequences appear to be a solution for these shortcomings. These signals offers significant advantages: better SNR can be achieved by increasing duration and not losing the bandwidth; spectrum can be programmed or bandwidth expansion / losses compensation exercised. Though there are shortcomings too which will be discussed. SS signal types, essential properties will be outlined. Probing signals can be classified by the way how they are generated: i) arbitrary waveform generators use DAC plus linear power amplifier; ii) rectangular excitation is more attractive because of its simplicity and equipment size and cost, has higher efficiency. Shortcomings and ways to solve it for rectangular signals will be discussed.

Invited speaker: *Dr. Serge Dos Santos*

Associate Processor, Hab. Dir. Rech.
INSA Centre Val de Loire, Inserm iBrain, Blois, France
Full and Council Member of Academia NDT International
Director of the IIAV (2018-2022)

Topic #1: The physical meaning of autocorrelation functions: how Nonlinear Time Reversal signal processing help us?

Abstract: In this talk, I will present a review of different signal processing tools highly used in the imaging sciences: correlation, convolution, cross correlation, and autocorrelation [1-3]. Usually, it is known that if the autocorrelation function vanishes quickly, it means that the value of the function at some time cannot be predicted with success from neighbouring values. Furthermore, if the function is periodic, autocorrelation function comes out also periodic after a transient state. Finally, for Brownian stochastic motion, the autocorrelation function decays very fast, and for a perfectly random system, autocorrelation that looks like a delta function. The talk will try to highlight the physical interpretation of these functions using examples coming the propagation of ultrasonic (or electromagnetic) waves in complex (biological or not) media. I will try to convince you that, adding a physical and pragmatic meaning of these mathematical functions will help you to understand, analyse and interpret several statements and results where correlation is the main keyword.

[1] M. Lints, S. Dos Santos, A. Salupere, Solitary waves for Non-Destructive Testing applications: Delayed nonlinear time reversal signal processing optimization, Wave Motion, Volume 71, June 2017, Pages 101-112, ISSN 0165-2125, http://doi.org/10.1016/j.wavemoti.2016.07.001 .
[2] Heaton, C.; Anderson, B. E. and Young, S. M. Time reversal focusing of elastic waves in plates for an educational demonstration, The Journal of the Acoustical Society of America, 2017, 141, 1084-1092 http://dx.doi.org/10.1121/1.4976070
[3] M. Miniaci, et al, "Proof of Concept for an Ultrasensitive Technique to Detect and Localize Sources of Elastic Nonlinearity Using Phononic Crystals", Phys. Rev. Lett. 118, 214301 (2017).

Topic #2: The digital transformation of modern NDT using Nonlinear Ultrasound: the signal processing point of view

Abstract: Nonlinear acoustics can be used to explain the nonlinear propagation of mechanical waves in solids, liquids and complex bubble or composite media, for example [1,2]. Nonlinear ultrasound (Nonlinear US) is thus progressively returning to the daily routine of experimentalists because of the need to know exactly the amplitude of their signature, close to the level of noise measured during experiments conducted in the field of Non Destructive Testing (NDT) or medical ultrasound. Thus, harmonic imaging, exploiting the nonlinear signature of the second order, has been able to take advantage of the nonlinear acoustic response which is greater in fluids than in solids. Thanks to new signal processing methods, extraction, identification and localization of nonlinear acoustic sources has been conducted in recent years within the nonlinear acoustics community. After twenty years of modelling, simulations and experiments [3], the international community of NDT recognizes the emergence and potential of nonlinear ultrasound to bring the NDT into the digitalization of industry with the advent of the fourth industrial revolution (Industry 4.0) and the Internet-Of-Things (IoT). In this presentation, we propose to present some experimental results obtained over the last twenty years in the context of the NDT of complex structures. In order to illustrate these results, it is through the use of a symbiosis of the time reversal process (TR) and the nonlinear elastic wave spectroscopy (NEWS) that allow via the use of an excitation coding process to propose to the community the TR-NEWS methods confirming the concept of "Nonlinear Time Reversal" as a great potential for the localization of nonlinearities of a complex system [4].

[1] B.E. Anderson, M.C. Remillieux, P.Y. Le Bas, T. Ulrich, in Nonlinear Ultrasonic and Vibro-Acoustical Techniques for Nondestructive Evaluation (Springer, 2019), pp. 547–581
[2]. G. Busse, D. Van Hemelrijck, I. Solodov, A. Anastasopoulos, Emerging Technologies in NDT. Balkema - proceedings and monographs in engineering, water and earth sciences (Taylor & Francis, 2008). URL https://books.google.fr/books?id=M0KEYUaJuDMC
[3]. D. Burgos, L. Mujica, J. Rodellar, Emerging Design Solutions in Structural Health Monitoring Systems. Advances in Civil and Industrial Engineering Series (IGI Global, 2015)
[4]. S. Dos Santos, A. Masood, S. Furui, G. Nardoni, in 2018 16th Biennial Baltic Electronics Conference (BEC) (2018), pp. 1–4. DOI 10.1109/BEC.2018.8600977

Invited speaker: *Prof. Dr. Igor Solodov*

Igor Solodov received the M.Sc. degree in physics from M.V. Lomonosov Moscow State University, Moscow, Russia followed by a Ph.D. and D.Sci. degrees from Faculty of Physics MSU where he held a full Professor position at the Department of Acoustics. As a visiting scientist he worked at the University of California (Berkeley), Stanford University, University of Maryland (College Park), (USA), Nanjing University (China), and the University of Windsor (Canada). In 2003, he joined the NDT group at the University of Stuttgart (Germany). He published more than 250 papers in the fields of nonlinear acoustics of solids, non-classical acoustic nonlinearity of imperfect materials, nonlinear methods for material characterization and defect imaging, interface, surface, and guided elastic waves, air-coupled ultrasound, acoustics of composite materials.

Topic #1: Classical and non-classical nonlinear acoustical techniques for NDE & NDT

Abstract: The majority of ultrasonic instruments widely used in industry and technology for material characterization and quality assessment make use of a linear elastic response of materials that generally results in the amplitude and phase variations of the input signal. The nonlinear approach to ultrasonic NDE/NDT is concerned with nonlinear material response, which is inherently related to the frequency changes of the input signal. Classical nonlinear acoustics, systematically established since 1960s-1970s, dealt with homogeneous (quasi-flawless) solids, whose nonlinearity is associated with lattice anharmonicity and reveals nonlinear behaviour of inter-molecular forces in materials.

A drastic departure from fundamental “classical” nonlinear effects was then revealed in materials with cracked defects. A series of experiments on nonlinearity of contact interfaces led to a concept of contact acoustic nonlinearity (CAN) that will be discussed followed by the analysis of CAN mechanisms and scenarios for the frequency conversion by nonlinear defects. The family of new phenomena observed for these highly nonlinear defects was found and proposed as a sensitive and efficient tool for nonlinear defect imaging and NDT.

Topic #2: Local nonlinearity for monitoring of bonding quality in composite aerospace components

Abstract: A direct way to evaluate nonlinearity in composite laminate plates is based on the second harmonic measurements for propagating Lamb modes. This technique is believed to be prospective for plate-like components and received considerable attention in literature. To generate the so-called cumulative second harmonic of a Lamb wave mode, however, the two crucial conditions are required: phase velocities of the fundamental and the second harmonic modes must be equal and the power flow between them must be non-zero. These strict conditions for selection of the experimental parameters make the nonlinear plate wave technique barely applicable in industrial environment.

A new approach based on measurements of a local nonlinear response of the laminate is suggested and applied to characterizing contaminations of adhesive bonding in carbon fibre-reinforced polymer (CFRP). A contaminated boundary layer of the adhesive contributes to an overall nonlinear response of the laminate that enables to evaluate and quantify bonding quality caused by various types and levels of single contaminations. All kinds of single contaminations studied in the context of aviation applications result in enhancement of the nonlinear response of the CFRP laminate which is an indication of deterioration of bonding quality.

Topic #3: Resonance of damage: a new approach to NDT and defect imaging

Abstract: Traditional ultrasonic NDT methods consider and use the attenuation and scattering of high-frequency ultrasound as the primary effects of its interaction with defects. The so-called secondary (derivative) effects activated in acoustic wave-defect encounter include e.g. nonlinear, thermal, acousto-optic, etc. responses also widely applied for NDT and acoustic imaging of damage. These secondary effects are normally relatively inefficient so that the corresponding NDT techniques require an elevated acoustic power and stand out from conventional acoustic NDT counterparts for their specific instrumentation particularly adapted to high-power ultrasonics.

The way to dramatically enhance the efficiency of the wave-defect interaction is concerned with activation of mechanical resonance in localized inclusions and defects: Local Defect Resonance (LDR). A frequency match to the damage resonance provides an efficient energy delivery from the wave directly to the defect. Unlike the resonance of the entire specimen, LDR NDT addresses the impact of the defect severity to its own resonance response, which is far stronger and identifies (even possibly quantifies) the damage by its resonant response clearly distinguished and independent of the rest (intact) part of the specimen. The objective of the talk is to demonstrate that the frequency- and spatially-selective activation of defects via the concept of LDR is the way to boost efficiency and sensitivity of diagnostic imaging of damage by using derivative NDT methodologies. Multiple case studies to be considered include resonant imaging of various defects in composite materials via laser vibrometry, thermosonics, and nonlinear acoustic techniques.

Invited speaker: *Prof. Dr. Rymantas Kazys*

Bio: Prof. KAZYS Rymantas graduated from the Kaunas Polytechnic Institute, Lithuania as an electronic engineer and afterwards worked in the same institute. He received his Ph.D. degree and Doctor of Science (Dr. Hab.) degree from the Kaunas Polytechnic Institute. In 1998 in ABB (Sweden) he has obtained III level (highest) certificate of an expert in a non- destructive testing. In 2001 he was elected to Academy of Sciences of Lithuania. In 2009 was elected to Academia NDT International. Since 1996 till 2016 he was a director of the K. Barsauskas Ultrasound Institute at the Kaunas University of Technology. From 2016 till now he is research supervisor of the K. Barsauskas Ultrasound Institute.

Prof. R.Kazys is a president of the Lithuanian Society for Non-destructive Testing and Technical Diagnostics. He is also the life senior member of Institute of Electrical and Electronic Engineers (IEEE, USA) and a member of the Acoustical Society of America.

From 1985 his work includes development of non-destructive testing and evaluation of elastic properties of various materials including composite materials, acoustic imaging for NDT purposes, computer modelling of radiation, propagation and scattering of ultrasonic waves and processing of ultrasonic signals. At Lorentzen & Wettre (Sweden) as a chief scientist, he was responsible for development of new ultrasonic systems for on-line measurement of the tensile strength of paper during manufacturing process. He was in charge of 28 FRAMEWORK 5, 6 and 7 programs projects, one HORIZON 2020 program project, ten years duration project with Belgium Nuclear Research Center and other contracts with various industrial companies in Europe.

Topic: Air- coupled ultrasonic NDT

Abstract: This presentation will give a look at key aspects related to air- coupled ultrasonic measurements and NDT. Problems caused by attenuation of ultrasonic waves and big differences of acoustic impedances of air and the structures under investigation will be analyzed. Air- coupled ultrasonic transducers and arrays for excitation and reception of ultrasonic waves will be presented.

For improvement of the efficiency of air-coupled ultrasonic transducers PMN-32%PT piezoelectric crystals which possess very high piezoelectric properties may be used. For air- coupled ultrasonic NDT two major techniques- through transmission and based on excitation of Lamb waves can be used. Application of such waves for of multi-layered metal-composite laminates, CFRP and honeycomb structures is discussed. The single-side access technique based on interaction of the guided A0 Lamb wave mode with delamination type defects is analysed. Ultrasonic guided waves for detection and investigation of impact type defects in honeycomb samples are suitable also. Two different single-side air-coupled ultrasonic techniques for detection and visualisation of defects in aerospace composite materials are presented. The first technique is based on the pitch-catch arrangement of the transducers and application of the A0 Lamb wave mode which is shielded by defects. The second method, which gives more accurate results of defect geometry estimation, is based on the same orientation of the transmitter and the receiver for reception of the Lamb wave scattered-reflected by the defect. The damage visualisation results of both techniques are investigated.

Invited speaker: Prof. *Dr. Mathias Kersemans*

Bio: Mathias Kersemans obtained an Engineering degree in both Electro-Mechanics and Physics from UGent. He received his PhD in 2014 from UGent on the subject of Ultrasonic inspection and characterization of Fiber Reinforced Plastics. During his post-doctoral term at UGent, he extended his research to other NDT techniques, including Local defect resonance, Guided waves, Optical infrared thermography, Vibro-thermography, Luminescence … Since 2017, he is appointed Professor in the research group Mechanics of Materials and Structures MMS at UGent, where he is leading the research on NDT of Composites and 3D printed materials.

Mathias Kersemans is promotor of 10 running research projects. His research is on the fundamental as well as the applied level, and he has good collaboration with many leading companies in aerospace, automotive, nuclear and wind energy.

Topic: Full-field NDT techniques by the use of Local Defect Resonance and Guided waves

Abstract: Local Defect Resonance LDR is a technique which gained a lot of interest in recent years. LDR is a vibrational technique which exploits high-frequency vibrations. At certain elevated frequencies, defects will start to resonate locally (hence Local Defect Resonance), which can then be easily imaged by scanning the part with laser Doppler vibrometry. As such, LDR provides a sensitive approach to detect defects in composites.

In this talk, the concept of LDR will be introduced, and various results on a range of defected composites will be shown and discussed. Further, several recent extensions to the classical LDR will be presented, e.g. automated LDR extraction, nonlinear LDR, in-plane LDR for improved defect sensitivity, thermal signature of in-plane LDR … Apart from the steady-state LDR technique, we will also focus on full-field guided wave imaging approaches. Applying appropriate post-processing approaches in time/frequency/wave vector domain provide endless opportunities for sensitive NDT of composites. Several state-of-the-art guided wave approaches will be introduced and demonstrated.

Invited speaker: *Dr. Bernd Koehler*

Bio: Dr. Koehler studied physics at the Technical University of Dresden, where he also received his doctorate and German habilitation. He worked at the Nuclear Research Institute Rossendorf near Dresden in the field of NDT for nuclear power plants. From 1992 until today, he has worked at the Fraunhofer-Gesellschaft in the institutes IZFP and IKTS. His research interests include methods for NTE and structural health monitoring with a focus on high-resolution methods and methods combining different interaction phenomena. He received the Research Award (Berthold Prizes) of the German Society for NDT, published more than 100 papers in peer-reviewed journals with over 600 citations and he holds several patents.

Topic: Non-Conventional Ultrasonic Imaging Applications

Abstract: The talk describes three unconventional ultrasound imaging techniques that have been developed for significantly different application fields. The examples show that thinking outside the box can lead to progress in areas where conventional ultrasound imaging is not sufficient.

The first field is civil engineering. When ultrasound transmitted into concrete, large scattering at grain boundaries appear. Therefore, low ultrasound frequencies have to be used, reducing scattering. Due to the rather high wavelength, a very large aperture must be used to allow focussing. The approach uses a conventional piezoelectric transducer for transmission and scanning laser detection for reception of the signals.

Another challenge appears in the field of Scanning Acoustic Microscopy (SAM): the imaging of elongated scatterers with surfaces, which are not parallel to the scanning plane. The presented solution named SAM-tomography combines the focussing to the incident plane with the Synthetic Aperture Focussing Technique (SAFT).

The third field is material characterization. In scanning Laser Doppler Vibrometry (SLDV) of ultrasonic wave fields, we have observed that under some conditions there is more information in the wavefield images than just the wave trains. By skilfully extracting this information, it can be recognized as a grain structure. This approach called grazing incidence ultrasound microscopy (GIUM) is demonstrated for austenitic welds.

Invited speaker: *Dr.-Ing. Hubert Mooshofer*

Bio: After graduating in Electrical Engineering & Information Technology he received his Ph.D. from Technical University of Munich in 2002. Since 2002 he works at Siemens AG Corporate Technology in Erlangen and Munich in the field of Nondestructive Testing. He is responsible for research and application projects ranging from developing new methods to their implementation as an inspection system or in terms of software. He is senior key expert for ultrasonic testing. The current focus of his research activities is on inverse methods such as SAFT reconstruction and FMC/TFM.

Topic: SAFT and FMC/TFM

Abstract: Reconstruction methods like SAFT (Synthetic Aperture Focusing Technique) and FMC/TFM (Full Matrix Capture / Total Focusing Method) significantly improve the sensitivity and defect separation capabilities of ultrasonic inspection. The principles behind SAFT and FMC/TFM are explained in this seminar. The similarities of both methods are discussed, and it is shown that they complement each other. While reconstruction methods are commonly treated as imaging tool, it is shown, that they can serve as a quantitative tool, as well. In this respect, defect sizing and scan grid optimization are illustrated. Last but not least, an outlook on advanced topics such as FT-SAFT and application for anisotropic material e.g. composite inspection is given.

Invited speaker: Prof. *Dr. Elena Jasiuniene*

Bio: Elena Jasiūnienė is senior researcher at prof. K. Baršauskas Ultrasound Research Institute and professor at Department of Electronics Engineering, Faculty of Electrical and Electronics Engineering, Kaunas University of Technology. Through a career acquired a very extensive and diverse knowledge in non-destructive testing, x-ray computed tomography, 3D imaging, and ultrasonic measurements. She is author or co-author of nearly 100 scientific papers was involved in many projects concerning various applications of non-destructive testing techniques for aerospace industry, space research, nuclear plants, material characterization, etc. Other activities include expert of European Commission, EASN (European Aeronautics Science Network) Association National Contact Point, expert for Research Council of Lithuania, member of Electronics and Electrical Engineering PhD committee, supervision of postgraduate and undergraduate researchers, and supervision of X-ray tomography lab.

Topic: Peering inside: 3D imaging of different objects using X-ray computed tomography

Abstract: There are different objects and structures around us, where we do not know, how their structure looks like inside. Tomography is a method of producing a 3D image of internal structures of a solid object. The invisible can be made visible. It allows quality evaluation of the different structures non-destructively. In addition, computed tomography can be used: as reference for other NDT methods; for determination of internal structure of materials; for assembly inspection; for determination of exact shape and size; dimensional measurements; reverse engineering; fault detection; organic structure analysis in medicine and biology. Various examples of 3D imaging using X-ray CT would be given in this presentation.

Invited speaker: *Dr. Stefano Laureti*

Bio: Stefano Laureti received the B.Sc. degree in energy engineering and the M.Sc. degree (cum laude) in industrial engineering from the University of Perugia, Italy, in 2011 and 2013 respectively, and the co-tutelle Ph.D. degree in engineering jointly from the School of Engineering, University of Warwick, U.K., and the University of Perugia in 2017. He is currently a Post-Doctoral Researcher with the University of Perugia and the Project Manager of the Marie Skłodowska-Curie European H2020 training network called “NDTonAIR.” His research interests include acoustic metamaterials, phononic crystals, thermography, ultrasonic testing, eddy current testing, image processing, and pulse-compression, in which fields he authored and co-authored more than 40 journal papers, book chapters and conference proceedings."

Topic: Workshop on ultrasonic imaging

Abstract: Signal and image processing include a very wide range of techniques that are aimed at manipulating signal/images for a better interpretation of them. When applied to ultrasonic testing data, signal and image processing are often used to extract features of interest, such as presence of flaws/inclusion and any defects. As an example, time domain analysis, frequency domain analysis, filtering, Chirp Z-Transform, spatial filtering are commonly used for data interpretation. This speech aims at giving an overview of some advanced signal and image processing techniques by applying them to a real set of ultrasonic data. Therefore, a database and a script will be provided to the ESRs so as to follow the lesson. Moreover, the ESRs and the speaker will interact together to implement any signal and image processing technique that can come in mind during the data manipulation.