SIGNAL PROCESSING GROUP (GTS) GTS lab

HEAD OF THE GROUP RESEARCH REPORT

The Signal Processing Group (GTS) produces high-quality basic and applied interdisciplinary research in signal processing and data science. Currently formed by 19 researchers, the GTS faculty, students, and staff continue to work on national and international research projects. The application areas include medicine, industry, underwater acoustics, and technologies for the arts.

The GTS is currently involved in a LIFE European Green Deal project managed by the European Climate, Infrastructure and Environment Executive Agency (CINEA) "Reducing the impact of underwater noise on the marine environment of the Port of Cartagena" (LIFE PortSounds), and several Spanish government-funded projects such as the "Smart sensing of composite materials through non-linear mechanical wave signal processing algorithms" (SMARTSENSE) and the "Informed Methods for Signal Synthesis" (MISS)

A complete list of research activities can be found at http://www.iteam.upv.es/group/gts/

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1.- Project activities

The GTS has continued researching the established research lines and other emerging activities. A summary of some of the main activities is listed below:

- Signal processing techniques applied to ultrasonic and impact-echo methods for the characterization of composite materials (including cementitious materials): The research has produced innovative techniques for material characterization, damage location, and tomography reconstruction (FANSIRAS and non-contact airborne ultrasound techniques are clear examples). These techniques have proven to be helpful in the characterization of both natural and artificial stones. The GTS collaborates, among others, with the ICITECH (Institute of Science and Technology of the Concrete), the Department of Civil & Environmental Engineering (University of Illinois), the University College Cork, and with the Centro Superior de Investigaciones Científicas (CSIC).

- Passive acoustics monitoring: We develop acoustic sensors and signal processing algorithms to advance the study of marine animal populations and the impact that anthropogenic sounds have on them. The aim is to help ensure marine biodiversity conservation and sustainable use. For this purpose, we design surveillance systems, create real-time noise maps, and evaluate the results using a risk-based approach. The group collaborates, among other institutions, with the Instituto Español de Oceanografia (IEO) for the Spanish approach to the Marine Strategy Framework Directive (D11), with the Oceanogràfic of Valencia, and with the Cartagena Harbor Authority.

- Applications of biomedicine: Advanced digital image processing through artificial intelligence (deep learning) for biomedical applications, in collaboration with the Clinical Medical Imaging Area of the Hospital Universitario y Politécnico La Fe in Valencia, and the global leader in whole-body medical imaging analysis Quibim.

- Graph Signal Processing (GSP): We continue developing new methods of classification, fusion of classifiers, and signal surrogates based on GSP, which are applied to various practical problems.

- Emerging Signal Processing Techniques for Big Data Health Applications.

- Technologies for the Arts (Soundcool): Last year, we opened a new line of research to use innovative audiovisual technologies derived from Soundcool for treating neurodegenerative diseases. The system is constantly evolving and has adapted to COVID social distancing to be able to work online with users in their own homes. Most of the groups affected by neurodegenerative diseases are the elderly and have been the hardest hit by the pandemic. Especially the group of patients with a mild-moderate impairment who maintained activity outside the home (day centers, etc.) has been those who have shown more significant deterioration with confinement due to the interruption of therapies. Providing them with new alternative therapies suitable for social distancing and working from their homes or centers is essential in the current situation.

1.1.- Ongoing projects

Name of the project: *Reducing the impact of underwater noise on the marine environment of the Port of Cartagena (LIFE PortSounds)*

Summary of the project: *In the first year of the LIFE PortSounds, we thoroughly studied the cetacean species in the Port of Cartagena area. We also defined where the project's impact and control zones will be located and did the first deployments of the PAM devices in these two areas. The towed array recordings are being analyzed, and shortly we will start creating the database of marine mammal sounds in the area.*

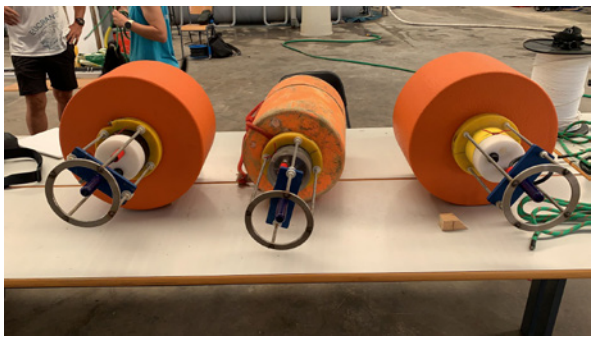
Funding entity: *LIFE20 ENV/ES/000387.*

The first deployment of the LIFE PortSounds PAM device and towed array recording campaign

Name of the project: *Spanish implementation of the Marine Strategy Framework Directive.*

Summary of the project: *We continue to work with the Spanish Institute of Oceanography (IEO), developing technology and analyzing data for noise assessment according to the Spanish implementation of European Directive 11 (D11). Specifically, they use our PAM system (named SAMARUC) and the software analysis SamLab. See https://samaruc.webs.upv.es for more details.*

Funding entity: *Ministry of Ecological Transition.*

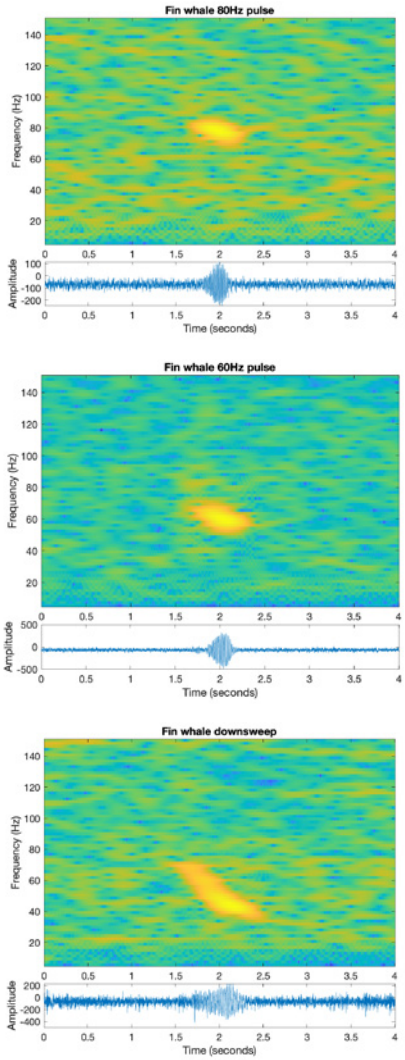


Several SAMARUC recording devices ready to be deployed.

Name of the project: *Cabo Fin Whale Project (CaboRorcual)*

Summary of the project: *The Cabo Rorcual project is a multidisciplinary project that aims to study the fin whale as it passes next to the coast of Dénia and Xàbia (Spain). The goal is to determine the population and route of these marine mammals. We are in the last year of the project, and we have achieved to collect an extensive catalog of fin-whale vocalizations to train automatic deep-learning detection & classification techniques. In addition to the well-known 20 Hz fin-whale notes, we have detected 60 Hz, 80 Hz, and down sweep fin-whale notes.*

Funding entity: *Fundación Biodiversidad*



Fin-whale 60 Hz note, fin-whale 80 Hz note, and fin whale down sweep note.

Name of the project: *Non-destructive testing based on mechanical waves*

Summary of the project: *The UPV is studying the use of mechanical waves for the quality control of artificial marble stones. The final goal is to design a system that will be installed in the production line and inspect 100% of the production.*

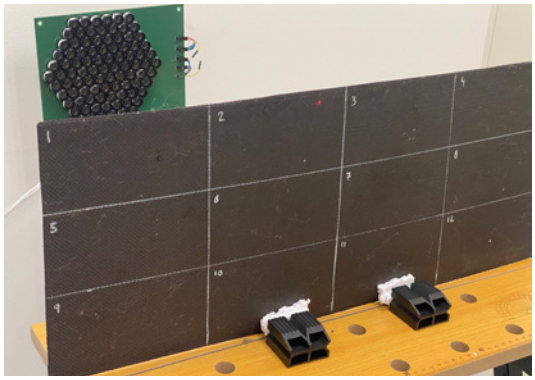
Funding entity: *Cosentino*

Name of the project: *Smart sensing of composite materials through non-linear mechanical wave signal processing algorithms (SMARTSENSE)*

Summary of the project: *This year we have studied different non-destructive testing (NDT) techniques for quality control of different materials (including composite materials). For that purpose, we compared the mechanical waves obtained using traditional accelerometers and ultrasonic sensors, with those obtained with interferometric sensors, and fiber optic sensors embedded in the material itself. Two examples are Using an automatic shaker to control the impact energy achieving repeatability in NDT of artificial stones, and using an ultrasonic speaker and an automated laser to generate and sense mechanical waves in composite materials.*

Funding entity: *Spanish Government, PID2020-120262GB-I00.*

Automatic impact hammer system.



Monitoring a composite material through an automated scanning laser system and ultrasound parametric speaker.

Name of the project: *Modelos innovadores para la predicción de impagos*

Summary of the project: *This is a project carried out for CAIXABANK, whose objective is to predict defaults on both personal and legal entity loans. The greatest innovation is the implementation of optimal fusion techniques so that the complementarity of different classifiers can be used to achieve a better performance of the final classifier. It has been demonstrated the interest of the approach over thousands of real data provided by CAIXABANK.*

Funding entity: *CAIXABANK***.**

2.- Research results

2.1.- Featured publications

- ***On training road surface classifiers by data augmentation.*** *A. Salazar, A. Rodríguez, N. Vargas, L. Vergara, Applied Sciences, Applied Sciences, Special Issue in Novel Methods and Technologies for Intelligent Vehicles 2022, 12 (7), 3423.*

  It is demonstrated that data augmentation is a promising approach to reduce the size of the captured dataset required for training automatic road surface classifiers. The context is on-board systems for autonomous or semi-autonomous driving assistance: automatic power assisted steering. Evidences are obtained by extensive experiments involving multiple captures from a 10-channel multisensor deployment: three channels from the accelerometer (acceleration in the X, Y and Z axes); three microphone channels; two speed channels; and the torque and position of the handwheel. Those captures were made under different settings: three worm-gear interface configuration; hands on or off the wheel; vehicle speed (constant speed of 10, 15, 20, 30 km/h, or accelerating from 0 to 30 km/h); and road surface (smooth flat asphalt, stripes or cobblestones). It has been demonstrated in the experiments that data augmentation allows a reduction by an ap-proximate factor of 1.5 in the size of the captured training dataset.

  DOI*: 10.3390/app12073423*

- ***Automated Cervical Spinal Cord Segmentation in Real-World MRI of Multiple Sclerosis Patients by Optimized Hybrid Residual Attention-Aware Convolutional Neural Networks****. Bueno, A., Bosch, I., Rodríguez, A. et al., J Digit Imaging, Jul 5, 2022.*

Magnetic resonance (MR) imaging is the most sensitive clinical tool in the diagnosis and monitoring of multiple sclerosis (MS) alterations. Spinal cord evaluation has gained interest in this clinical scenario in recent years, but, unlike the brain, there is a more limited choice of algorithms to assist spinal cord segmentation. Our goal was to investigate and develop an automatic MR cervical cord segmentation method, enabling automated and seamless spinal cord atrophy assessment and setting the stage for the development of an aggregated algorithm for the extraction of lesion-related imaging biomarkers. The algorithm was developed using a real-world MR imaging dataset of 121 MS patients (96 cases used as a training dataset and 25 cases as a validation dataset). Transversal, 3D T1-weighted gradient echo MR images (TE/TR/FA = 1.7-2.7 ms/5.6-8.2 ms/12°) were acquired in a 3 T system (Signa HD, GEHC) as standard of care in our clinical practice. Experienced radiologists supervised the manual labelling, which was considered the ground-truth. The 2D convolutional neural network consisted of a hybrid residual attention-aware segmentation method trained to delineate the cervical spinal cord. The training was conducted using a focal loss function, based on the Tversky index to address label imbalance, and an automatic optimal learning rate finder. Our automated model provided an accurate segmentation, achieving a validation DICE coefficient of 0.904 ± 0.101 compared with the manual delineation. An automatic method for cervical spinal cord segmentation on T1-weighted MR images was successfully implemented. It will have direct implications serving as the first step for accelerating the process for MS staging and follow-up through imaging biomarkers.

DOI: *10.1007/s10278-022-00637-4*

- ***A Risk-Based Model Using Communication Distance Reduction for the Assessment of Underwater Continuous Noise: An Application to the Bottlenose Dolphin (Tursiops truncatus) Inhabiting the Spanish North Atlantic Marine Demarcation,*** *Bou-Cabo, M.; Lara, G.; Gutiérrez-Muñoz, P.; Saavedra, C.; Miralles, R.; Espinosa, M., J. Mar. Sci. Eng., 10, 605, 2022.*

  Over the last decade, national authorities and European administrations have made great efforts to establish methodological standards for the assessment of underwater continuous noise. The evaluation of the Sound Pressure Level (SPL) at the local or regional scale for 1/3 octave band of 63 Hz and 125 Hz and the identification of long temporary trends were considered to be a priority due to the valuable information they can offer in relation to continuous low-frequency noise. Nevertheless, the methodology to determine threshold values from which to evaluate the Good Environmental Status (GES) has become difficult to define, and new approaches and considerations are currently being discussed by groups of experts. This work presents a methodology to perform the assessment of the GES of a given area by providing a risk index that is related to potential appearance of masking effect due to the underwater noise produced by marine traffic. The risk index is hinged on the calculation of area under curves defined by the density of animals and a variable related to underwater noise SPL, defined as the percentage of communication distance reduction. The methodology presented has been applied to the bottlenose dolphin (Tursiops truncatus) inhabiting the ABIES—NOR marine demarcation to illustrate the possible use of risk-based models to manage marine areas related to human pressures, such as marine traffic, with the potential adverse impact on a given species.

  DOI: 10.3390/jmse10050605

- ***Impacts of underwater noise on non-mammal marine animals: first (2012-2018) and second cycle (2018-2024) of the marine strategies for the five Spanish marine subregions***, *José Antonio Esteban Simón; Paula Alonso Recarte; Ramón Miralles Ricós; Journal of Animal Law & Interdisciplinary Animal Welfare Studies, 9, 2022.*

  This paper aims to determine the legal context in which the control of harm to marine animals due to noise pollution does operate. It also describes the extent to which there is already sufficient scientific knowledge and technology to be able to set permissible underwater noise levels. Since the vast majority of studies generally focus on the welfare of marine mammals, particularly cetaceans, this paper focuses on the hearing and communication capacities of the rest of marine animals and advances in the identification of potential harm that may hypothetically result in direct injury - including death - or that may imply other types of mistreatment (increased stress, undesirable behavioral changes, etc.).

  Available at: https://www.iustel.com