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Abstracts

Sonar Pulse Detection Using Chirp Rate Estimation and CFAR Algorithms

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This paper presents a new approach to sonar pulse detection. The method uses chirp rate estimators and algorithms for adaptive threshold, commonly used in radiolocation. The proposed approach allows detection of pulses of unknown parameters, which may be used in passive hydrolocation or jamming detection in underwater communication. Such an analysis is possible thanks to a new kind of imaging, which presents signal energy in function of chirp rate. The proposed method rely on chirp rate estimation of received signal, and then calculation the local threshold level depends on noise and reverberations what makes it possible to detect a particular type of signal.

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Inertial Sensors Applications in Underwater Measurements

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Over the past decades microelectromechanical systems (MEMS) researchers have demonstrated a number of microsensors for almost every possible sensing modality, including attitudes. Current MEMS inertial measurement units (IMU) come in many shapes, sizes, and costs – depending on the application, and performance required. MEMS sensors have proved and demonstrated performances exceeding those of their macroscale counterpart sensors.

In the paper chosen IMU applications in underwater measurements are presented. First, for reduce of instability underwater sensor during measurements, like multibeam echosounder system (MBES), where the MEMS parameters' quality are crucial for further MBES record- processing. Second, in underwater navigation systems, for determine the position of an underwater vehicles, like Remotely Operated Vehicles (ROV) and, more recently, Autonomous Underwater Vehicle (AUV) or improve other positioning methods.

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Integrated Acoustic-Optical System for Inventory of Hydrotechnical Objects

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The knowledge of the location, shape and other characteristics of spatial objects in the coastal areas has a significant impact on the functioning of ports, shipyards, and other water-infrastructure facilities, both offshore and inland. Therefore, measurements of the underwater part of the waterside zone are taken, which means the bottom of water and other underwater objects (e.g. breakwaters, docks, etc.), and objects above the water, such as the above-water part of the waterside, breakwaters, hydraulic constructions, and other objects of the waterside infrastructure.

In this paper, project results of integrated acoustic-optical system for inventory of hydrotechnical objects were presented. The aim of the project was to elaborate a mobile underwater scanning system which could be applied in various works that require precise, detailed and coherent, underwater and above-water measurement, especially in areas associated with surveying, inspection and monitoring of objects in coastal areas.

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Acoustic Analysis of Remote-Controlled Surface and Underwater Vehicles

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Technological progress have made the use of remotely controlled objects moving on the surface and underwa-

ter for a variety of purposes has become extraordinarily popular. The widespread use of such vehicles enables to unauthorized use. Therefore knowledge of the hydroacoustic field characteristics makes it possible to recognize by the passive underwater observation systems.

The paper presents the results of narrowband and one-third-octave frequency analyzes of remote-controlled surface and underwater vehicles. The change in sound pressure was recorded for vehicles moving a short distance away from the hydrophone. The research was carried out in difficult conditions, propagation, on a small depth in the coastal zone.

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MEMS Technology Evaluation for Underwater Vehicle Navigation

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The article undertake some vital aspect of an inertial positioning using MEMS. Although MEMS inertial sensors offer affordable, scaled units, and though their inherent measurement noise can be relatively easily mitigated, there are still parameters due to they are not currently capable of meeting all requirements for the accurate inertial positioning. The article presents a few aspects of MEMS gyro errors and their estimation process in the context of INS processing flow. These errors have a serious impact on overall inertial system performance. The results of undertaken researches in that area, and pointing out the main difficulties behind the INS when using a few top MEMS technologies where presented as well.

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Multidimensional GIS for Satellite Imagery Analysis

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Multidimensional Geographical Information System allows storing, querying and processing of multidimensional query data. It is able to process satellite imagery and provide tools for its analysis. In the article authors present the developed system that analyzes a time series of SENTINEL-1 mission satellite imagery acquired over the coast of Poland. Algorithm used finds and detects changes in the the shape of coastline over long period of time.

System uses Raster Data Manager array database management system to simplify the process of data querying, trimming, storing and analysing. Authors present how the recent trends in GIS development, like RASDAMAN, can be applied to satellite imagery processing.

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Theoretical Analysis of New Approach to Order Determination for Modified Prony Method in Swath Mapping Application

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This article presents a new approach to determine the model order (number of principal components) in the modified Prony method applied to the swath acoustic mapping. Determination of the number of principal components is a crucial step in the modified Prony method. In the proposed approach the model order is chosen based on the underlying physical model of underwater acoustic environment and utilised signal processing operations. This data-driven approach, attempts to make use of all available information to assess the number of signals arriving at the receiver using pipeline processing in lieu of iterative processing.

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Accuracy of New Approach to Order Determination for Modified Prony Method in Swath Mapping Application

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This article presents performance of a new approach to determine the model order for the modified Prony method applied to swath acoustic mapping. Key requirements for any mapping application are depth determination accuracy and angular resolution. Depth determination accuracy is strictly related to angular accuracy and geometrical relations between receiver and sources of backscattering signal. Angular resolution determines detection capabilities of targets laying on the sea-floor. Performance of the proposed method, in therms of these two key parameters, is tested against simulated signal in a number of generic configurations and compared to results of other approaches applied to Prony method.

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Analysis of Distance Measurement Errors in CW FM Sonar with MLS Code Modulation

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Although used in the classic silent sonar, the CW FM sounding signal has a major flaw which is its inaccuracy

in determining the distance to a target. The authors of the article have developed a concept of silent sonar using frequency modulation signals switched by pseudo-random codes, already discussed in their previous work. This article presents a detailed analysis of errors in CW FM sonar with pseudo-random sequence code modulation confronted with errors which occur in similar sonar without code modulation.

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Historical Torpedo Proving Ground on the Puck Bay and Polish Navy Control and Measurement Unit

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This article presents briefly description of historic use of the Puck Bay area to test military equipment and the history of the Polish Navy Control and Measurement Unit, main tasks and facility. The aim of this presentation is to bring together participants in the symposium of the general background of activities in the area of hydroacoustics many times presented previously. In addition, the present symposium is devoted to the memory of CAPT Ignacy Gloza, who has served here for many years. Finally, the traditional annual tour organized during the symposium this year took place in the waters of the Puck Bay and one of the aims of this presentation is to bring the participants closer to what they see.

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Automated Bimodal Ultrasound Device for Preclinical Testing of HIFU Technique in Treatment of Solid Tumors Implanted Into Small Animals

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In Poland, cancer is the second cause of death overall and the first before 65. Demand for new anticancer therapies is increasing every year. The main objective of studies on medical and technical aspects of new anticancer methods is to reduce unwanted side effects and costs associated with conventional methods of treatment. Percutaneous (noninvasive) HIFU (High Intensity Focused Ultrasound) technique gives the chance to radically reduce both of these factors. A main goal of this work is automation of HIFU technology for producing thermal damage to the entire volume of a solid breast tumor implanted into a rat mammary gland using the proposed bi-modal ultrasound equipment enabling the ultrasonic heating of a small volume within the tumor under the ultrasonic imaging control, as well as 3D scanning of the heating beam focus throughout the entire tumor volume. Design of the proposed equipment include the heating probe of low frequency (about 1 MHz), allowing penetration of pulsed focused waves into tissues, and the linear phased array probe of high frequency (4–10 MHz), allowing visualization of the locally heated area inside the tumor in real time. Automatic 3D scanning of the heating beam focus provide the thermal damage to its entire volume.

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Use of Hydrophone Housing and Influence on the Voltage Sensitivity

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The subject of the carried out examinations is to verify receiving sensitivity of the hydrophone placed inside the protective housing. In order to increase resistance to damage, the hydrophone Reson TC4032 has been adapted to work in difficult environmental conditions. Using the comparative method, there was analyzed the receiving sensitivity within a predetermined frequency band. The experiment was carried with two hydrophones: examined and reference one. An underwater speaker with a function generator were used as the sound source. The studies have been conducted in the water tank in laboratory conditions. In situ studies have determined decrease of receiving sensitivity of hydrophone equipped with a protective housing.

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Multibeam Data Processing for 3D Object Shape Reconstruction

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The technology of hydroacoustic scanning offers efficient and widely used source of geospatial information regarding underwater environments, providing measurement data which usually have the structure of irregular groups of points known as point clouds. Since this data model has known disadvantages, a different form of representation based on representing surfaces with primitive geometric structures, such as edges and facets, is preferred for data featuring seabed surface relief and various underwater objects. In this paper, the authors propose a multiple-step approach to three-dimensional surface reconstruction from multibeam sonar measurements, relying on the proper application of various algorithms for noise reduction, data rasterization and classification. The results obtained by com-

bining several different surface reconstruction algorithms with the proposed data processing technique were tested and the strengths and weaknesses of each method were highlighted.

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On Algorithm Details in Multibeam Seafloor Classification

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Remote sensing of the seafloor constitutes an important topic in exploration, management, protection and other investigations of the marine environment. In the paper, the combined approach to seafloor characterisation is presented. It relies on calculation of several descriptors related to seabed type using three different types of multibeam sonar data obtained during seafloor sensing, viz.: 1) the grey-level sonar images (echograms) of seabed, 2) the 3D model of the seabed surface which consists of bathymetric data, 3) the set of time domain bottom echo envelopes received in the consecutive sonar beams. The proposed methodology has been tested using field data records acquired from several bottom types in the Southern Baltic Sea. Using the examples of particular parameters, the influence on the specific manner and details regarding their calculation, i.e. the size of the applied current local window to a sonar image, on the obtained classification performance is discussed.

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Determining Hotspots of Sonar Targets Related to Chemical Munitions Dumped in Bornholm Deep and Gotland Deep using GIS

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According to the Helsinki Commission report from 1994 around 15000 tonnes of chemical warfare agents were dumped to the Baltic Sea after World War II as part of the demilitarization process of the former Nazi Germany. Continuing corrosion of metal encasements makes the dumped munitions a ticking bomb, which can potentially harm the whole Baltic Basin.

The presented work addresses important aspects for a proper evaluation of the threat; side scan sonar survey data storage and analysis of a spatial distribution of the sonar targets potentially related to chemical weapons. The chosen software environment was GIS oriented. ESRI ArcGIS built in tools were used to determine the hotspots of the targets on the official post-war munitions dumping sites; Gotland Deep and Bornholm Basin.

The automation process of mapping in GIS was also proposed. Therefore holistic approach for digital mapping of the sonar targets related to dumped munitions was created.

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Data Compression and Clustering of One-Third-Octave Spectra by "Acoustical Colors"

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This article presents a new approach for the data compression and clustering of one-third octave spectrum by using "acoustical colours". Using in-situ measurements by the IGLOO – sensor nodes it can show that this approach allows a clustering of the colors for a quick look classification. This is helpful using wireless acoustical transmissions with restricted transfer volume in underwater sensor networks without jamming their own measurements.

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Introduction to Tissue Shear Wave Elastography

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Ultrasonic elastography is a technique allowing imaging of the elastic properties of tissue. There are two basic techniques of elastographic imaging; compressional – displaying the evaluation of tissue deformation under the external stress and dynamic, tracking the propagation velocity of shear wave generated by the acoustic radiation force. Soft tissue bulk modulus varies from a few to several GPa, whereas the shear modulus is significantly smaller non-exceeding few hundred Pa for adipose tissue, breast or liver up to several hundred kPa for "hard" tissue. Forces generated in the tissue due to the external, axial piston-like stresses depend mainly on the shear modulus. In Shear Wave Elastography long, several tens of microseconds ultrasonic pulses successively focused at several depths are sent generating conical wave front moving with the "supersonic" velocity depending on the tissue stiffness. Velocity of propagation of shear wave depends on the shear modulus μ and the modulus of elasticity E of the examined tissue is equal $E = 3\mu$.

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On Acoustic Study of Zooplankton Diel Vertical Migration in the Black Sea

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Zooplankton is a key component of the Black Sea ecosystem food chain. Accounting for that this sea is one of the largest anoxic reservoirs, it is important to monitor the zooplankton resources using innovative fast and non-invasive hydroacoustic techniques.

In the Black Sea hydroacoustic techniques were mainly applied to research zooplankton in its southern part. The echosounders and ADCPs, vertically sounding and working at the frequencies not higher than 200 kHz, were used in these studies. In our paper the data, collected in the north-eastern part of the Black Sea using ADCP, mounted on the Aqualog platform and worked at a higher frequency of 2 MHz, have been analyzed. The application of higher frequency provided a better measurement resolution.

The main objective of the analysis was to determine the velocity of zooplankton diel vertical migration in regard to oxygen conditions. The results of ADCP zooplankton speed measurements as well as hydrophysical and hydrochemical measurements have been analyzed.

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Measurement of Impulse Response of Shallow Water Communication Channel by the Correlation Method

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Performances of underwater acoustic communication (UAC) systems are strongly related to specific propagation conditions of the underwater channel that can additionally change in time due to the movement of the acoustic system transmitter and receiver or to reflection by underwater objects of the transmitted signal. The time-varying impulse response is a comprehensive description of dynamically changing transmission properties of UAC channel. It is a basis for estimation of stochastic parameters used for designing the signaling scheme of communication system. The paper presents the results of measurement experiment conducted in shallow water environment. The channel impulse response was measured by the correlation method with the use of two kinds of broadband signals: pseudo-random binary sequence (PRBS) and hyperbolic frequency modulation chirp (HFM). For each measurement result statistical transmission parameters, namely delay spread, Doppler spread, coherence time, and coherence bandwidth were estimated.

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Influence of Absorption and Scattering on Velocity of the Acoustic Streaming

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Streaming velocity depends on intensity and absorption of ultrasound in the media. In some cases, such as ultrasound scattered on the blood cells at high frequencies or the presence of ultrasound contrast agents, scattering affects the streaming speed.

The velocities of acoustic streaming in blood mimicking starch suspension in water and Bracco BR14 contrast agent were measured. The source of the streaming was a plane 20 MHz ultrasonic transducer. Velocity was estimated from the averaged Doppler spectrum. The single particle driving force was calculated as the integral of the momentum density tensor components. For different starch concentrations, the streaming velocity increased from 8.9 to 12.5 mm/s. This corresponds to a constant 14% velocity increase for a 1 g/l increase in starch concentration. For BR14, the streaming velocity remained constant at 7.2 mm/s and was independent of the microbubbles concentration. The velocity was less than in reference, within 0.5 mm/s measurement error.

Theoretical calculations showed 16% increase in streaming velocity for 1 g/l starch concentration rise, very similar to the experimental results. The theory has also shown the ability to reduce the streaming velocity by low-density scatterers, as was experimentally proved using BR14 contrast agent.

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Impact of Salinity on the Underwater Noise Generated by Small Scale Air Entrainment Events

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Some part of the energy released in the wave breaking process is transformed into the energy of the noise. This sound depends on water properties, however, there is a lack of reliable data concerning the underwater noise generated by less energetic events. The aim of this study was to understand the impact of salinity on the underwater noise produced during small scale air entrainment events, typical for low wind speed conditions. The tipping trough experiment was performed in a small tank to generate the small scale air injections. Four, linearly placed hydrophones HTI-96-MIN were used to record acoustic noise accompanying this phenomenon. The bubble plume development and underwater noise spectra were compared for salty and fresh water. The potential energy of the modeled events resulted in different spectra and salinity played an essential role in the emitted underwater noise.

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Passive Hydroacoustic Method of Detection and Tracking Object Moving on the Sea Surface and Floating in the Depth

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The main goal of the paper is to present passive, autonomous system to observe objects moving on the sea surface and floating in the depth prepared to work in very shallow water. Complete system will be described starting from hardware realization finalizing on configuration of sensors and presentation of algorithms implemented in prepared to this project software (alarm types, setting parameters responsible for alarm generation etc.). Finally example of object detection will be presented concentrating on remotely operate vehicles ROV – seabotix and combustion motorboat. At a given point of discussion, stability of algorithms eliminating the occurrence of false alarms will be presented.

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