ABSTRACTS

Keywords: underwater robotics, autonomous unmanned underwater vehicles, navigation and control systems, deepwater areas and troughs (faults).

Matvienko Yu.V., Kiselev L.V., Inzartsev A.V., L'vov O. Yu. ON THE PROJECT OF DEVELOPMENT OF UNDERWATER ROBOTICS COMPLEX FOR RESEARCH OF ULTIMATE OCEAN DEPTHS // Underwater Investigations and Robotics. 2016. № 2 (22). P. 4–12.

The project of development of underwater robotics complex for operation at great and ultimate ocean depths assumes development of general requirements answering the purposes of the vehicle and its ability to solve complex problems at extreme surrounding. This project is based on many years of experience of the IMTP FEB RAS in development and practical application of autonomous unmanned underwater vehicles (AUV) and their various systems. In scientific and applied aspects the exploration of geological characteristics of seabed, hydrology, geophysical and geochemical processes, biodiversity, and many other physical properties of deep-water areas of the ocean are of the greatest interest. A robotics complex that can solve such challenges in whole or partly becomes the object of pioneering development. The project addresses the issues related to optimal option of composition of systems and characteristics of the complex consisting of the autonomous unmanned underwater vehicles (AUV), navigation and communication facilities, surveying bottom transponder, bottom fixed station. The major targets for research and development are the features of AUV structure, positioning facilities, data exchange, planning and performance of operation missions at great and ultimate ocean depths.

Keywords: voxel space, 3D reconstruction, triangulation mesh, cap holes, marching cubes, parallel computing.

Bobkov V.A., Kudrjashov A.P. CREATING 3D MODELS OF SEABED BY VOLUMERTIC METHOD // Underwater Investigations and Robotics. 2016. № 2 (22). P. 13–18.

A volumetric method of 3D reconstruction of underwater scenes using multiple sets of depth maps generated from stereo images is presented. Stereo data is obtained from the calibrated stereo camera with known internal and external parameters. This volumetric method uses the transfer of available depth maps into a single voxel space scene. Each voxel represents a value of a continuous implicit function, constructed during the processing of new views. Empty voxels are filled by the diffuse blurring of neighboring voxels. The resulting surface is formed by marching cubes algorithm. Proposed algorithm improves the computational performance and quality of the generated triangulation model. The algorithm acceleration is reached by using of indexes structure of triangles. For quick and realistic filling of large holes we use the diffuse blurring on different octree levels. The scheme for multiprocessing based on the implementation of two-level parallelism is considered.

Keywords: visual odometry, autonomous underwater vehicle, navigation, stereo images, adaptive method.

Bobkov V.A., Melman S.V., Tolstonogov A. Yu., Scherbatyuk A.F. ON SOME ALGORITHMS FOR VISUAL NAVIGATION AUTONOMOUS UNDERWATER VEHICLE USING STEREO // Underwater Investigations and Robotics. 2016. № 2 (22). P. 19–24.

The method of visual navigation of autonomous unmanned underwater vehicle from stereo images is described. The adaptive technique of calculating the trajectory and 6-cloud algorithm for calculating local displacement using data from on-board navigation sensors are implemented. The method is based on the implementation of the approach, known as visual odometry. The proposed adaptive technique optimizes the step size in calculating the trajectory based on the data of the scene geometry, pre-defined degree of overlap of neighboring views and speed of the vehicle. As a consequence the time of the trajectory calculation is significantly reduced without affecting navigation accuracy. The 6-cloud algorithm for calculating of local displacements expands the classical scheme of formation of 3D clouds due to the data from the 3 neighboring positions. The inclusion in computing circuit of the visual method of additional information received from the on-board navigation system (measurement of the orientation angles) allowed reducing the magnitude of accumulated error localization. The estimations of the effectiveness of the algorithms on simulated and real data are obtained. The simulator for the research of management methods and simulation of AUV missions that was previously developed by the authors is used for the preparation of virtual scenes and measurement of the visual method errors.

Keywords: autonomous underwater vehicle, waters monitoring, coverage path, obstacles avoidance, mission planning, tactic level agents, simulation system.

Inzartsev A.V., Bagnitckii A.V. MOTION PATH PLANNING AND IMPLEMENTATION FOR AUV WHEN MONITORING IN VARIOUS TYPES OF WATER AREAS // Underwater Investigations and Robotics. 2016. № 2 (22). P. 25–35.

Small-sized autonomous underwater vehicles-robots (AUV) are used for monitoring of aquatic environment and bottom surface in different waters. When performing such operations it is necessary to solve interconnected tasks of AUV motion path preplanning in freeform bi-dimensional areas and AUV reaction when meeting unforeseen obstacles (natural or human origin). In the latter case this means organization of obstacle avoidance or robot preset motion path re-planning. The requirements imposed to the algorithm of preliminary trajectory planning are formulated. They take into account the features of the onboard search equipment, and the need to implement the algorithm in the computer of ship operator post, as well as on board the AUV. Using these requirements a number of coverage algorithms used in the ground or in the underwater robotics was analyzed. The quasi-optimal algorithm, which has low computational resource consumption, was developed as the result. The algorithm can be used both for pre-planning the trajectory (in off-line mode), and for its replanning onboard the AUV in real time. The paper also deals with the algorithms of unforeseen obstacles avoidance during the implementation phase of the desired path. The algorithms are based on behavioral and goal-directed approaches. Both model results and field test results of algorithms are at issue.

Keywords: autonomous underwater vehicle; automatic monitoring of water areas; sonar image; objects detection; objects recognition; mission planning; simulation system.

Inzartsev A.V., Pavin A.M., Lebedko O.A., Panin M.A. SMALL OBJECTS DETECTION AND SURVEY USING AU-

TONOMOUS UNDERWATER VEHICLES // Underwater Investigations and Robotics. 2016. № 2 (22). P. 36–43.

Side-scan sonar (SSS) is an effective tool for bottom objects detection and monitoring of underwater areas using autonomous underwater vehicle (AUV). Automatic monitoring consists in search steps using SSS and subsequent objects survey using photo-system. In the case of a single AUV these steps are performed sequentially. For a group of robots these steps can be performed in parallel mode to reduce the monitoring time. Detection of the particular objects on the acoustic images is performed using the next steps: gradient maps reconstruction, edges detection and objects isolation using clustering procedures. The coordinates are determined for the selected objects with particular characteristics. These coordinates are used to organize photo-observation of the detected object by the same or another AUV (in the case of group work).

Simulation tests are carried out with the use of the developed integrated AUV control/simulation system. All algorithms are realized as software modules suitable for use in AUV. The simulation results show the possibility of application of the developed algorithms for real work.

Keywords: signal detection, maximum likelihood estimation, vector-scalar sensor, power flow, signal/noise ratio, probability density.

Seleznev I.A., Glebova G.M., Zhbankov G.A., Mal'tsev A.M., Kharakhash'yan A.M. PROBABILISTIC SIGNAL DETECTION CHARACTERISTICS OBTAINED USING VECTOR-SCALAR SENSOR // Underwater Investigations and Robotics. 2016. № 2 (22). P. 44–49.

Signal detection characteristics obtained using single vector-scalar module are being studied. The signal processing algorithm, which provides for detection of the desired signal in the presence of background noise of the sea, is based on the maximum-likelihood estimation method. The statistical characteristics of vector and scalar components of the noise field obtained using computer simulation are compared with the experimental data. The experiments prove that the power flow density distribution corresponds to the Laplace distribution. Neyman-Pearson criterion is used for the comparison of the noise immunity of detection algorithms that employ different components of the vector-scalar acoustic field.

It is shown that signal detection probability is significantly higher when using vector-scalar sensor, which measures power flow, in comparison with a scalar sensor. High probability of detection is achieved by using a power flow component with significantly lower observation time or with lower signal to noise ratio.

Keywords: gas bubbles, underwater seeps, marine sediments, acoustic monitoring.

Maksimov A.O., Burov B.A., Salomatin A.S. SOUNDS OF UNDERWATER SEEPS // Underwater Investigations and Robotics. 2016. № 2 (22). P. 49–55.

The paper reports on the field experiments designed to describe the structure and mechanisms of generation of sounds emitted by marine seeps. This study was initiated to address the problem of estimating of methane emissions at the Arctic shelf and the need to develop effective methods for underwater pipelines leakage detection. Gas escape involves the formation and release of bubbles of different sizes. Each bubble emits a sound at a specific frequency depending on its size. Therefore, by analyzing the sound it is theoretically possible to know how many bubbles are produced and of what size they are. Observations of bubbles in the near-bottom layer using the «Artificial gas flare» stand were carried out in the coastal zone of the Sea of Japan. Substantial irregularities have been revealed both in the time intervals between successive moments of the bubble formation and the intensity of the emitted signals. The available experimental data were analyzed on the basis of theoretical models. It was found that the interaction between a birthing bubble with the gas filled channels within the upper sediment layer exercises significant influence over the form of the observed signals.

Keywords: sea water, bubbles, size distribution function, sound scattering, sound attenuation, acoustic spectroscopy, nonlinearity, cavitation strength.

Bulanov V.A., Korskov I.V., Popov P.N., Storozhenko A.V. RESEARCHES OF SOUND SCATTERING AND ATTENUATION, ACOUSTIC NONLINEARITY AND CAVITATION STRENGTH OF SEA WATER IN SUBSURFACE SEA LAYER // Underwater Investigations and Robotics. 2016. № 2 (22). P. 56–66.

The subsurface sea layer is characterized by the developed turbulence, abnormal high concentration of gas bubbles. It leads to the increased sound scattering and absorption, to strengthening of nonlinear characteristics of such layer.

Nevertheless, interrelation of linear and nonlinear acoustic characteristics (coefficients of sound scattering and attenuation, parameter of acoustic nonlinearity, cavitation strength) with presence of gas bubbles in sea water has not been clarified yet. To do it the experimental studies were conducted. The interrelation of nonlinear acoustic parameter of liquid and cavitation threshold with parameters of a polydisperse mix of bubbles in liquid is established.

The results show that the data on sound scattering allows estimating concentration of bubbles, cavitation strength, acoustic nonlinearity of sea water with bubbles and their total quantity in the range of sizes on the basis of inversion method. The measurements of nonlinearity and cavitation strength of sea water in situ revealed agreement of experimentally measured values with the theoretical estimations of the specified parameters on the basis of the computational method, the basis of which was formed with the data on sound scattering in air bubbles in subsurface sea layers. The results show that the presence of «bubbles clouds» under the sea surface essentially increases the parameter of acoustic nonlinearity of sea water and lowers cavitation strength of sea water.