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ACOUSTOMAGNETIC DETECTION OF MAGNETIC NANOPARTICLES IN A MODEL SAMPLE OF THE BIOLOGICAL SUBSTANCE.

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Objectives: Magnetic rianoparticles (MNPs) are used in medicine for targeted drug delivery to the area of cancer. There is the problem of remotely determining in vivo concentrations of MNPs. The aim of our work was to experimentally test acoustomagnetic method (AMM) for detecting MNPs in a model sample of a biological substance (BS).

Methods: A colloidal solution of Fe304 nanoparticles in a mixture of oleic acid and kerosene was used as a mode! sample. The weight concentration of the MNPs in the solution was 0.15%, and the viscosity of the solution was close to the blood viscosity. To detect MNPs in solution, a special experimental setup was developed. The installation consists of an ultrasound generator, a permanent magnet, a glass container with a solution, an induction multi-turn coil near the glass tube, and a voltmeter as a measure of the voltage across the coil. Ultrasound causes periodic movement of the particles of the solution together with the MNPs along the container axis. The magnet orients the MNPs in the direction perpendicular to the axis of the container. As a result, the summation of MNPs creates an alternating magnetic field with an ultrasonic frequency in the coil area. An alternating voltage (U) arises on the coil, as measured by a voltmeter.

Results: As measurements have shown, the magnitude of the voltage is proportional to the concentration of MNPs in the field of action of the ultrasound and the magnet field, as well as the intensity of the ultrasound. In particular, when the intensity of ultrasound was at the level of 0.02 W/ cm2, U = ImV was obtained.

Discussion: The experimental results are consistent with the calculated estimates and suggest that AMM can be used to detect MNPs in a real BS. Considering that the magnitude of the constant magnetic field in these experiments was 0.1T, we can also conclude that this method is safe, more accurate, and easier to implement than traditional X-ray and MRT methocjs.

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MULTISCALE QUANTITATIVE ANALYSIS OF MICROSCOPIC IMAGES OF ICE CRYSTALS

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Objectives; Modern research in cryobiology requires a deeper understanding of the influence of different factors on the cryopreservation of cells, tissues, and organs. One of these factors is ice crystallization which has a tremendous impact on the surveillance and quality of live objects during freezing, long term storage, and thawing. Analysis of this process requires software which should be able to obtain quantitative parameters of crystals in a human-like manner with acceptable processing speed. The purpose of this work is to consider the possibility of using the multiscale image representation for the quantitative analysis of ice crystals.

Methods: In our research, we used microscopic images of ice crystals during crystals formation and thawing. In previous studies for the segmentation of ice crystals on the image, we used different approaches such as active contour. At the same time, it should be noticed that the speed of active contour expansion is low and thus time-consuming to process large time sequence. Thus, we suggest the application of a Gaussian Pyramid. This multiscale representation allows analysis at a low scale and improves at a high scale.

Results: We have analyzed multiple images using the proposed approach. The results in the first approximation show a 2-fold increase in speed when using our implementation of active contours. At the same time, the segmented areas of crystals correspond to the approach without the use of multi-scale image representation.

Discussion: The results of this work show that multiscale image representation can be applied to improve the speed and applicability of modem software for automated image analysis. The next steps will include applicability evaluation of multiscale representation for different cases as well as the development of software realizing vector processor architecture.

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EVOLUTION-BASED PREDICTION OF ANTIBIOTIC RESISTANCE

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Objectives: Biofilms on percutaneous leads of implanted blood pumps can cause severe infections. By treating infections with antibiotics over a long period of time, bacteria develop resistance. Today, in a clinical setting, antibiotic resistance is determined in-vitro for all available drugs. The aim of the EvolChip project is to predict the probabilities of resistances that might evolve and suggest combinations of antibiotics that slow down or even prevent future resistance.

Methods: The EvolChip reactor consists of an agar plate that serves as a diffusion and growth medium. Three membranes permit diffusion of active substances from microfluidic channels into the agar medium. Two of these channels serve as sources for different antibiotics, the third one as the sink. As a result, two overlapping drug gradients establish, with a low concentration near the sink and high concentration close to the sources. Antibiotics were mixed with a nutrient solution to promote bacteria migration towards higher concentrated areas. The bacteria contain a green fluorescent protein gene, which enables real-time tracking via polarisation filters and a camera.

Results: In preliminary experiments, the gradient course could be characterized by making use of fluorescent markers. Only resistant bacteria migrated towards the sources with high antibiotic concentration. The spatial distribution of bacteria facilitates the identification of optimal concentration ratios and mixtures of antibiotics. In addition, the speed of resistance evolution with respect to different antibiotic mixtures was determined.

Discussion: The proposed EvolChip concept showed promising results in preliminary experiments. Further geometries, growth media, and bacteria will be tested. In order to validate the method, patient strains with known treatment and resistance history will be compared to the predictions of the presented method.