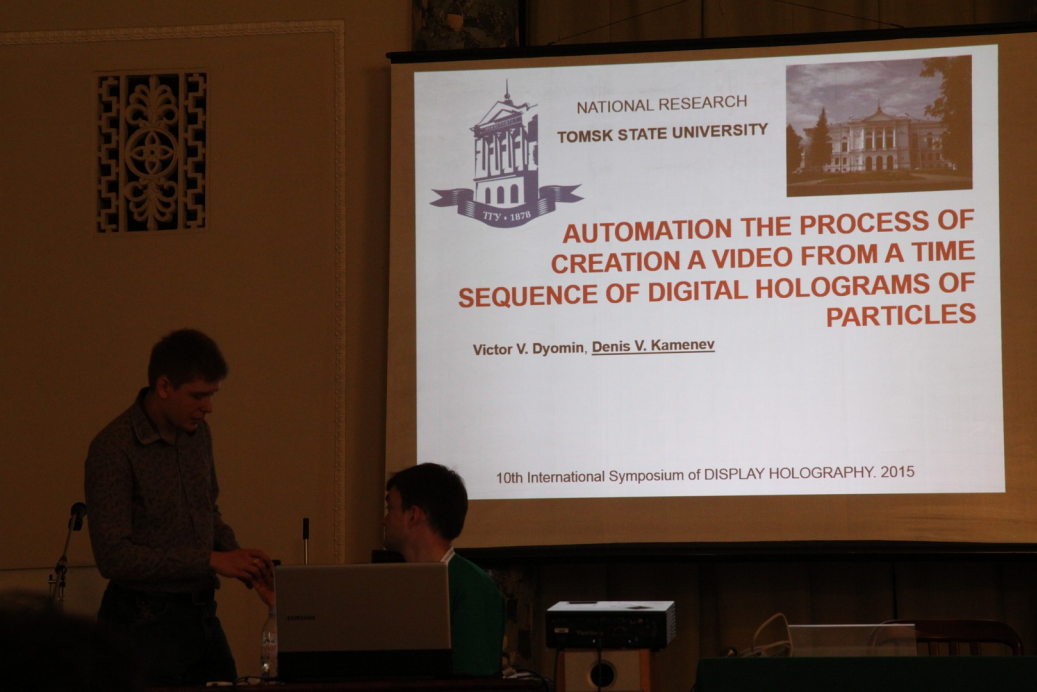
NATIONAL RESEARCH

TOMSK STATE UNIVERSITY

AUTOMATION THE PROCESS OF CREATION A VIDEO FROM A TIME SEQUENCE OF DIGITAL HOLOGRAMS OF PARTICLES

Victor V. Dyomin, Denis V. Kamenev

10th International Symposium of DISPLAY HOLOGRAPHY. 2015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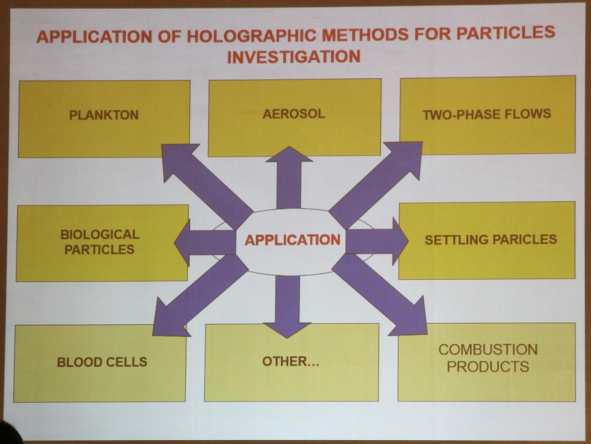
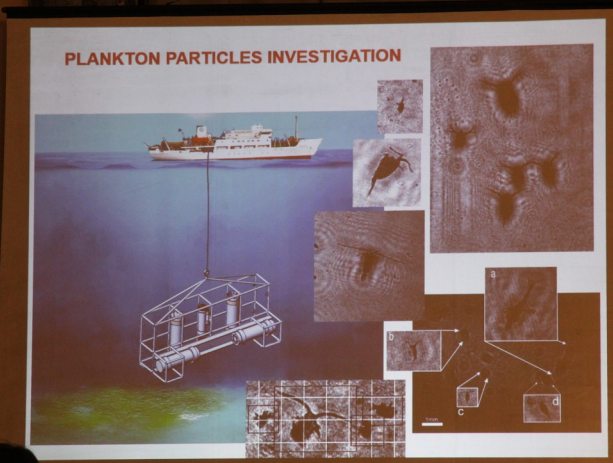

APPLICATION OF HOLOGRAPHIC METHODS FOR PARTICLES INVESTIGATION
PLANKTON
AEROSOL
TWO-PHASE FLOWS
BIOLOGICAL PARTICLES
APPLICATION
SETTLING PARICLES
BLOOD CELLS
OTHER...
COMBUSTION PRODUCTS


PLANKTON PARTICLES INVESTIGATION
a
b
c
d

EXTRACTING INFORMATION FROM HOLOGRAPHIC DATA

- Information about shape, size, location of each particle of the volume

- Information about particles ensemble:

a. Particles concentration in volume/layer

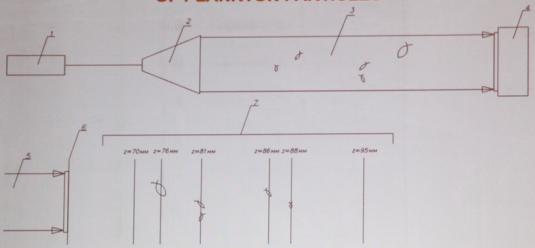
b. Particles size distribution

c. Distribution of the particles in volume

The choice of calculating parameters depends on the scientific problem and the object of investigation

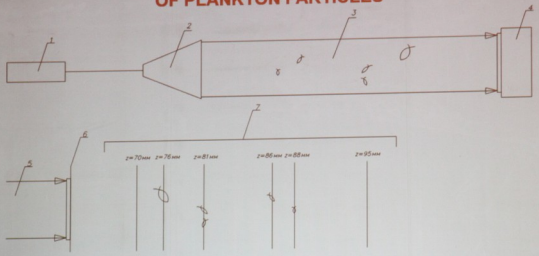
The aim of this work is automation the process of creation a video from a time sequence of digital holograms of particles

RECORDING AND RECONSTRUCTION OF DIGITAL HOLOGRAMS OF PLANKTON PARTICLES



1 – laser source, 2 – collimator, 3 – investigating volume with particles, 4 – CCD camera
5 – reconstructing reference beam, 6 – hologram, 7 – reconstructed images

RECORDING AND RECONSTRUCTION OF DIGITAL HOLOGRAMS OF PLANKTON PARTICLES



1 – laser source, 2 – collimator, 3 – investigating volume with particles, 4 – CCD camera
5 – reconstructing reference beam, 6 – hologram, 7 – reconstructed images

Method of the best focusing plane determination

№	Method	short description	requirement of ROI detection / preprocessing	speed	error, mm
1	Boundary contrast	Boundary contrast calculation for a number of reconstructed planes	+/+	3/5 (not more then 10 sec.)	0,2
2	Tenengrad	Based on calculation of intensity gradient for a number of reconstructed images using Sobel filter	+/-	4/5	1
3	Longitudinal intensity	Determination the minimal intensity for every transverse coordinate of reconstructed images	- / -	5/5	2
4	Entropy	Calculation the entropy for a number of reconstructed planes	+ / -	4/5	3
5	Variance	Calculation the variance for a number of reconstructed planes	+ / -	4/5	3
6	Brenner	Calculation the average values of intensity gradient (through one pixel) for a number of reconstructed planes	+ / -	4/5	2
7	Correlation	Calculation the correlation coefficients between two specially selected reconstructed images	+ / -	3/5 (depend on the number of rec. planes)	3

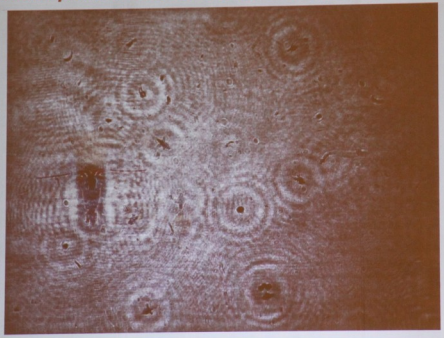
TRADITIONAL METHOD OF CREATION VIDEO BASED ON HOLOGRAPHIC DATA

1. Recording a time sequence of digital holograms
2. Reconstruction particles images from the hologram at various distances with adjusted step
3. **Region of interest (RoI) determination**
4. Determination the position of best focusing plane for every hologram of video sequence
5. Combining the reconstructed images in video
6. The analysis of the video (particles shape, size, concentration and so on)

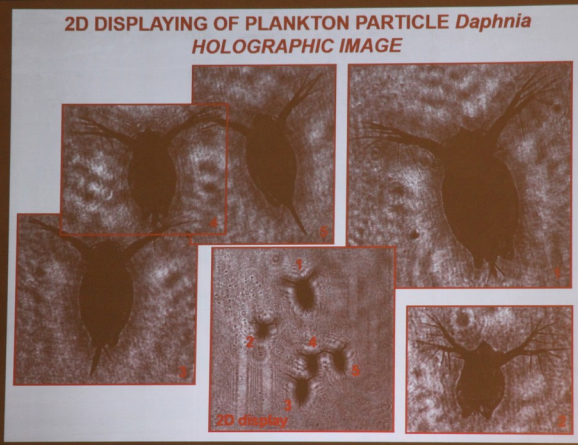
- Such way is not useful for ensemble of small particles

To automate the process of holographic video creation we suggest to exclude the RoI determination

VIDEO BASED ON HOLOGRAPHIC DATA OF PLANKTON PARTICLE *Epishura Baicalensis* USING TRADITIONAL METHOD

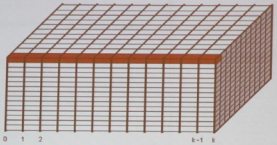


Position of the best focusing plane attached to the marked particle


2D DISPLAYING OF PLANKTON PARTICLE *Daphnia*
HOLOGRAPHIC IMAGE
4
5
3
1
2
4
5
3
2D display
1
2

THE ALGORITHM OF 2D MAPPING OF HOLOGRAPHIC IMAGE OF THE VOLUME

Plankton digital hologram



Sections of the volume

Tenengrad

$$T = \frac{1}{N_x \cdot N_y} \sum_{i=0}^{Nx-1} \sum_{j=0}^{Ny-1} G_{i,j}$$

Sobel masks

$$G_{i,j} = \sqrt{S_x^2(i,j) + S_y^2(i,j)}$$

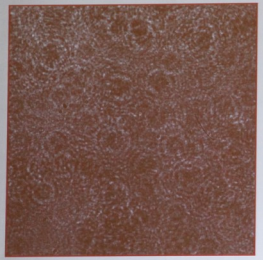
$$S_{XM} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad S_{YM} = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

VIDEO BASED ON HOLOGRAPHIC DATA OF PLANKTON USING SUGGESTED METHOD

All images of particles of the registered volume are focused!

"LAYER BY LAYER" INVESTIGATION OF THE REGISTERED VOLUME WITH AIR BUBBLES IN WATER

Hologram of air bubbles in water



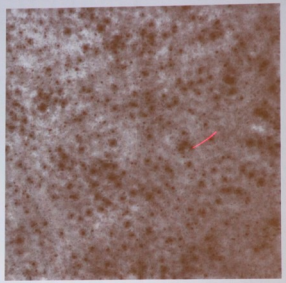
The refocusing from one plane to another

The refocusing from 110 to 200 mm

AUTOMATICALLY CREATED VIDEO RECIVED FROM TIME SEQUENCE OF AIR BUBBLES DIGITAL HOLOGRAMS

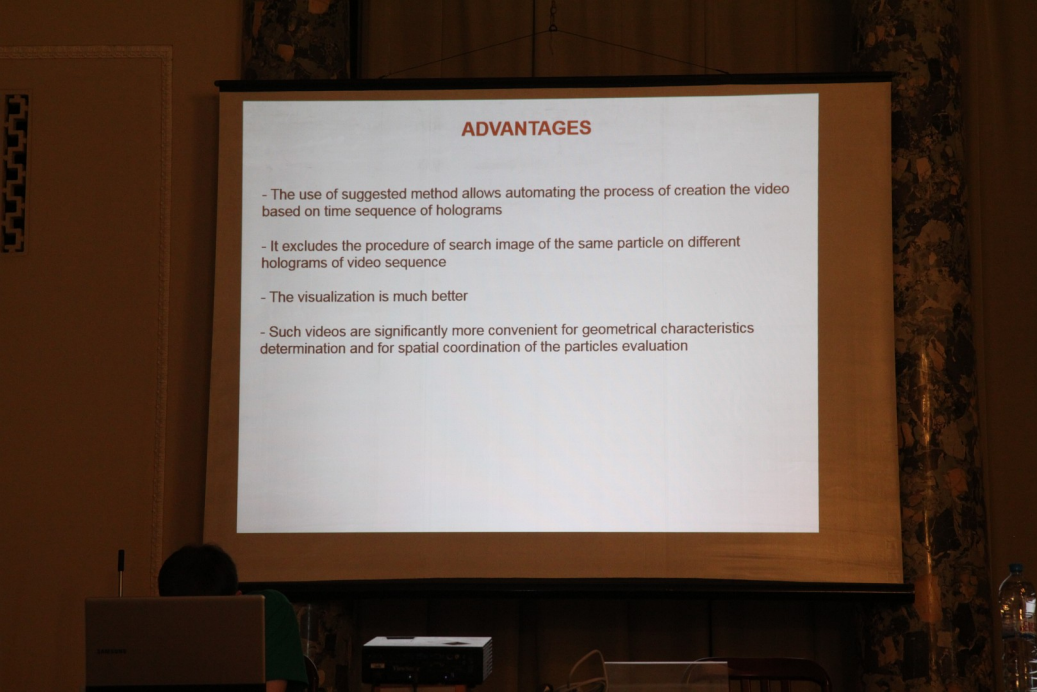
For fixed single reconstructing distance

(150 mm)



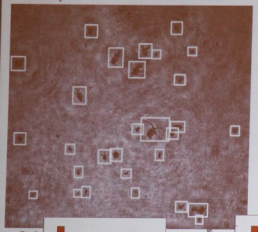
For all particles in registered volume

(depth 110-200 mm)

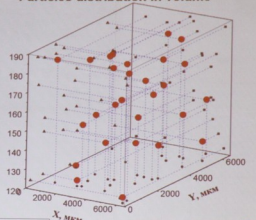

ADVANTAGES
- The use of suggested method allows automating the process of creation the video based on time sequence of holograms
- It excludes the procedure of search image of the same particle on different holograms of video sequence
- The visualization is much better
- Such videos are significantly more convenient for geometrical characteristics determination and for spatial coordination of the particles evaluation

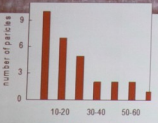
RESULTS OF AUTOMATIC PLANKTON PARTICLES HOLOGRAMS PROCESSING

Depth of the volume is 70 mm

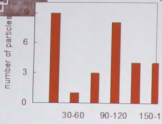


Particles distribution in volume

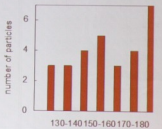




particles square, x1000 μm2



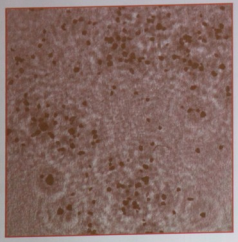
particles orientation, grad.



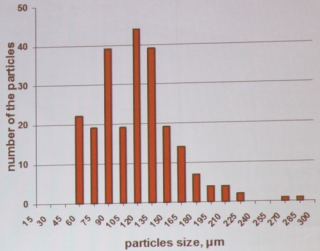
layers of the volum e, m m

Automatic estimation of sand particles concentration and evaluation of particles size distribution

Reconstructed image of sand particles monolayer



Particles size distribution



THANKS FOR YOUR ATTENTION

WELCOME TO OUR WORKSHOPS ON FRIDAY

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