
"Building Bridges with Light"
In memoriam of Yu. N. Denisyuk
10th International Symposium on Display Holography
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COMPUTER-GENERATED FOURIER HOLOGRAM IN OPTICAL DEVICES OF VISUAL OBSERVATION
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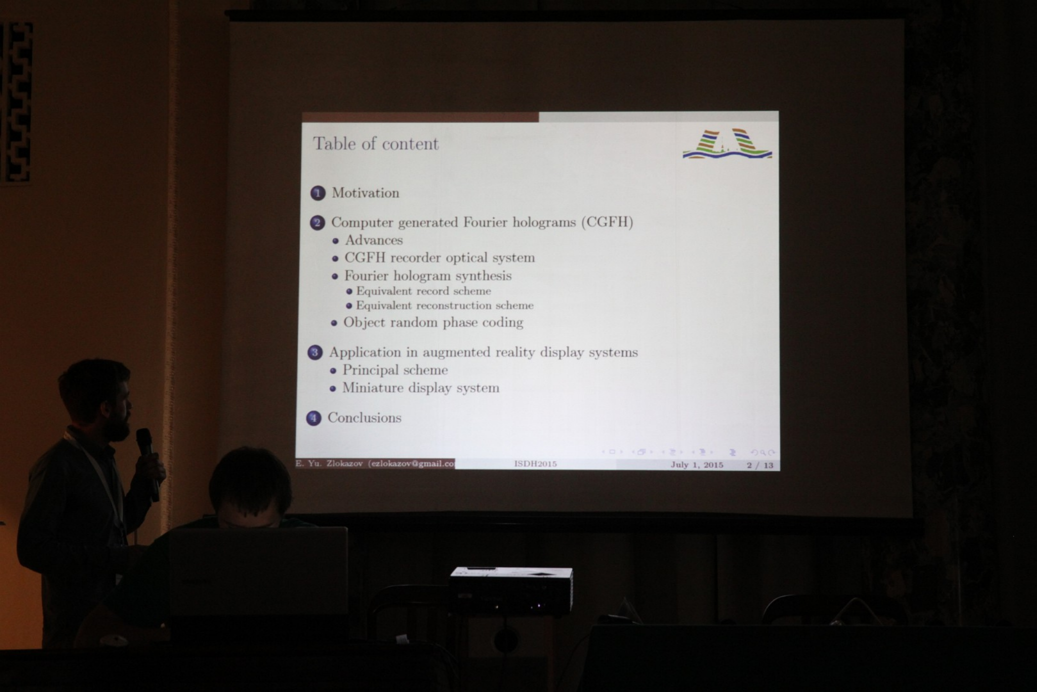
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Motivation
Motivation
Target pointing application in augmented reality aiming systems
aircraft displays
"smart glasses"
optical sights
Google search on "target sign" request:
Specific problem — target sign MUST pass the parallax test
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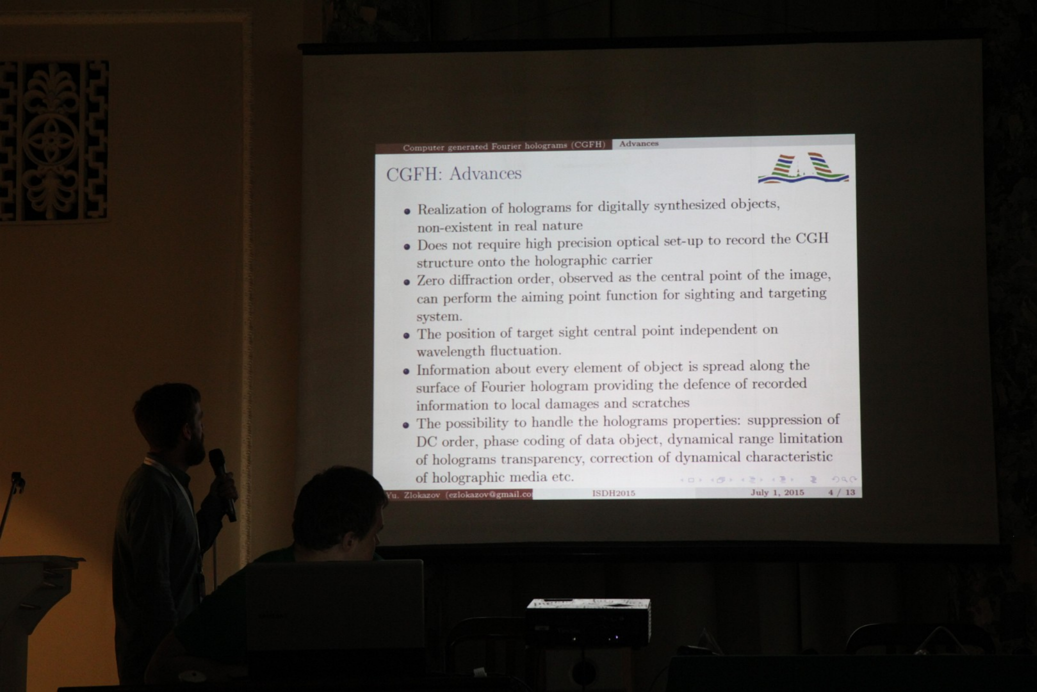
Computer generated Fourier holograms (CGFH)
Advances
CGFH: Advances
Realization of holograms for digitally synthesized objects, non-existent in real nature
Does not require high precision optical set-up to record the CGH structure onto the holographic carrier
Zero diffraction order, observed as the central point of the image, can perform the aiming point function for sighting and targeting system.
The position of target sight central point independent on wavelength fluctuation.
Information about every element of object is spread along the surface of Fourier hologram providing the defence of recorded information to local damages and scratches
The possibility to handle the holograms properties: suppression of DC order, phase coding of data object, dynamical range limitation of holograms transparency, correction of dynamical characteristic of holographic media etc.
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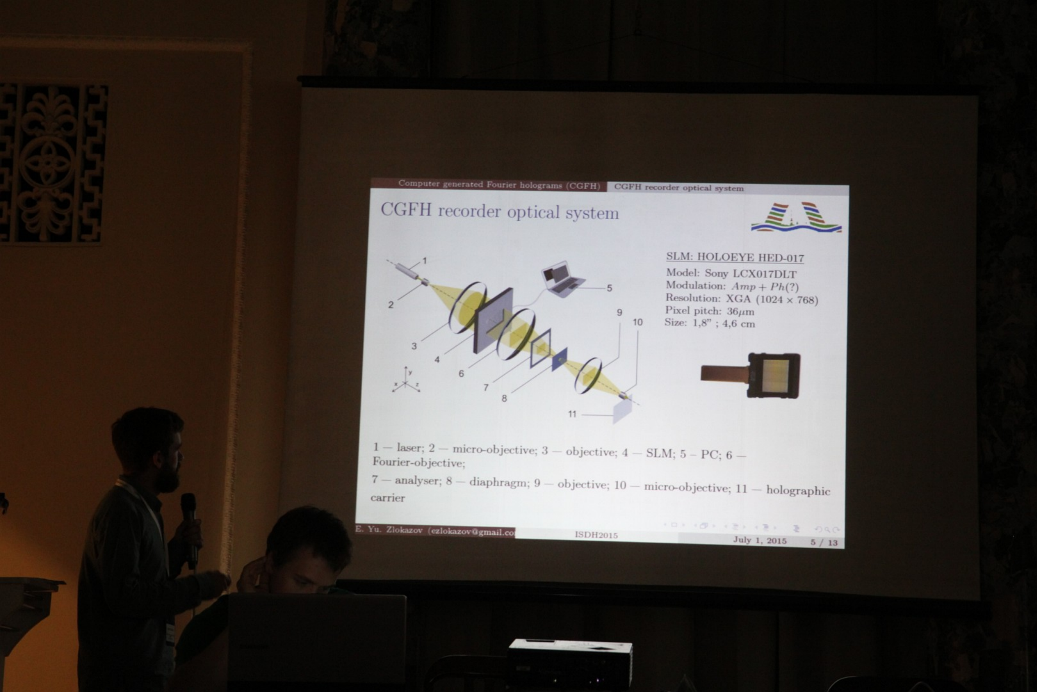
Computer generated Fourier holograms (CGFH)
CGFH recorder optical system
CGFH recorder optical system
SLM: HOLOEYE HED-017
Model: Sony LCX017DLT
Modulation: Amp + Ph(?)
Resolution: XGA (1024 × 768)
Pixel pitch: 36μm
Size: 1,8" ; 4,6 cm
1 — laser; 2 — micro-objective; 3 — objective; 4 — SLM; 5 – PC; 6 — Fourier-objective;
7 — analyser; 8 — diaphragm; 9 — objective; 10 — micro-objective; 11 — holographic carrier
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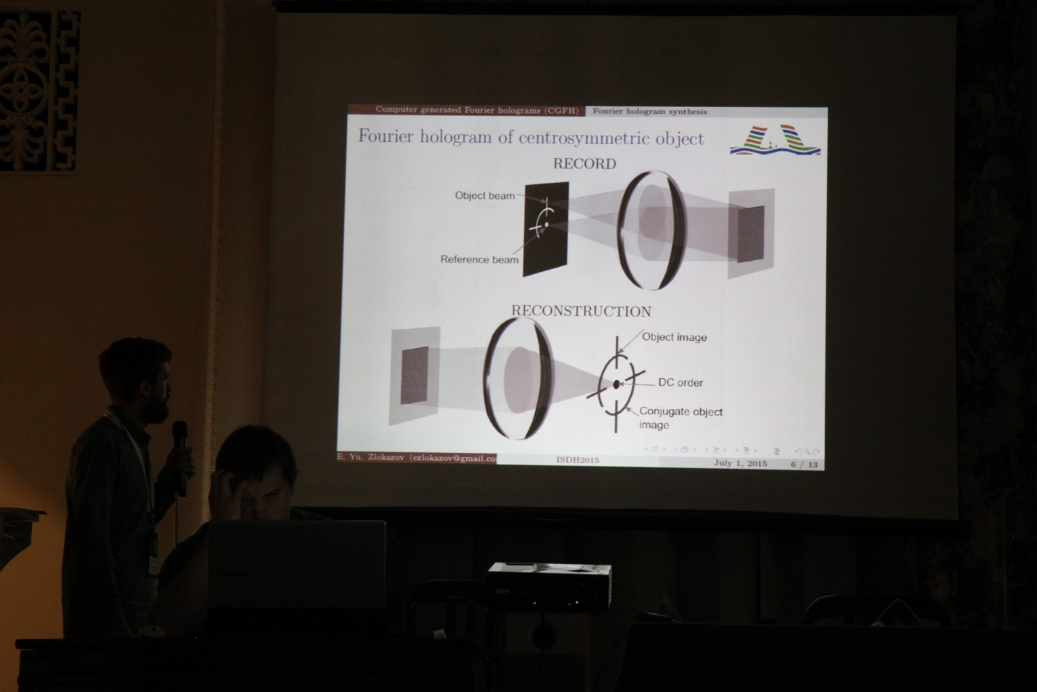
Computer generated Fourier holograms (CGFH)
Fourier hologram synthesis
Fourier hologram of centrosymmetric object
RECORD
Object beam
Reference beam
RECONSTRUCTION
Object image
DC order
Conjugate object image
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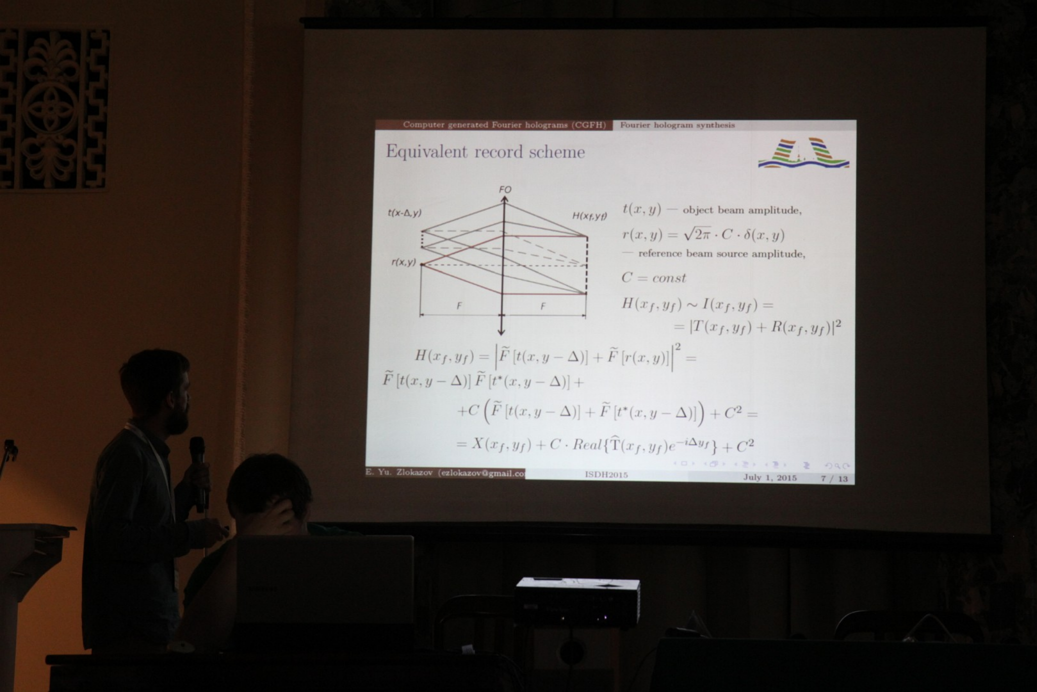

Computer generated Fourier holograms (CGFH)
Fourier hologram synthesis
Equivalent record scheme
FO
t(x-Δ,y)
H(xf,yf)
r(x,y)
F
F
$t(x, y)$ — object beam amplitude,
$r(x, y) = \sqrt{2\pi} \cdot C \cdot \delta(x, y)$
— reference beam source amplitude,
$C = const$
$H(x_f, y_f) \sim I(x_f, y_f) =$
$= |T(x_f, y_f) + R(x_f, y_f)|^2$
$H(x_f, y_f) = \left| \widetilde{F}\left[t(x, y-\Delta)\right] + \widetilde{F}\left[r(x, y)\right] \right|^2 =$
$\widetilde{F}\left[t(x, y-\Delta)\right] \widetilde{F}\left[t^*(x, y-\Delta)\right] +$
$+C\left(\widetilde{F}\left[t(x, y-\Delta)\right] + \widetilde{F}\left[t^*(x, y-\Delta)\right]\right) + C^2 =$
$= X(x_f, y_f) + C \cdot Real\{\widehat{\mathrm{T}}(x_f, y_f) e^{-i\Delta y_f}\} + C^2$
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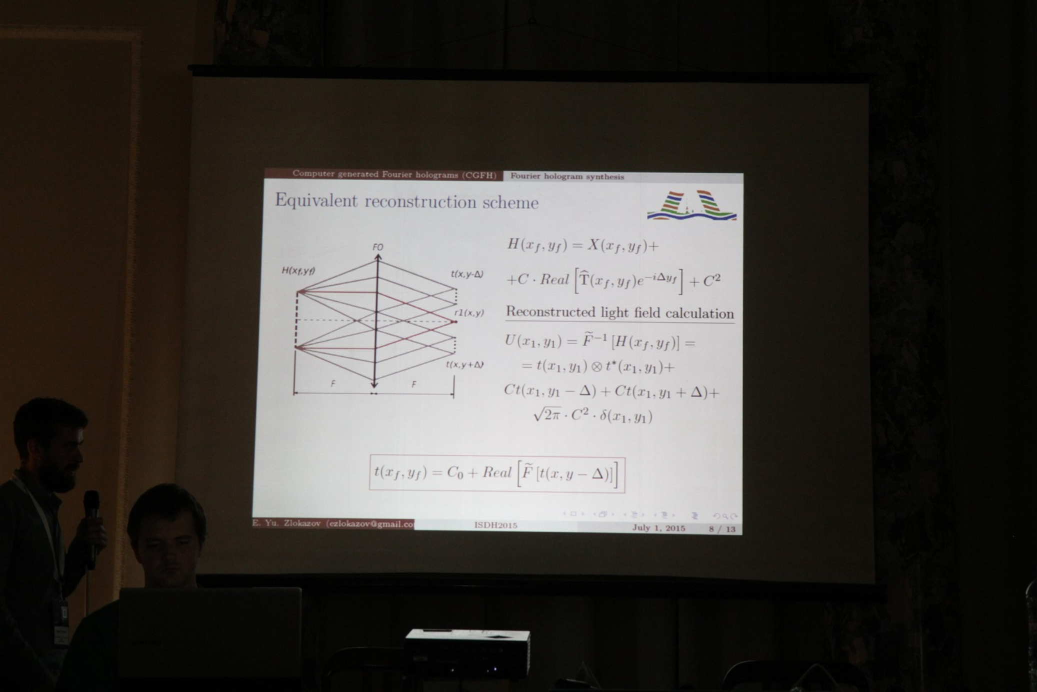
Computer generated Fourier holograms (CGFH)
Fourier hologram synthesis
Equivalent reconstruction scheme
FO
H(xf,yf)
t(x,y-Δ)
r1(x,y)
t(x,y+Δ)
F
F
$H(x_f, y_f) = X(x_f, y_f) +$
$+C \cdot Real\left[\widehat{\mathrm{T}}(x_f, y_f) e^{-i\Delta y_f}\right] + C^2$
Reconstructed light field calculation
$U(x_1, y_1) = \widetilde{F}^{-1}\left[H(x_f, y_f)\right] =$
$= t(x_1, y_1) \otimes t^*(x_1, y_1) +$
$Ct(x_1, y_1 - \Delta) + Ct(x_1, y_1 + \Delta) +$
$\sqrt{2\pi} \cdot C^2 \cdot \delta(x_1, y_1)$
$\boxed{t(x_f, y_f) = C_0 + Real\left[\widetilde{F}\left[t(x, y - \Delta)\right]\right]}$
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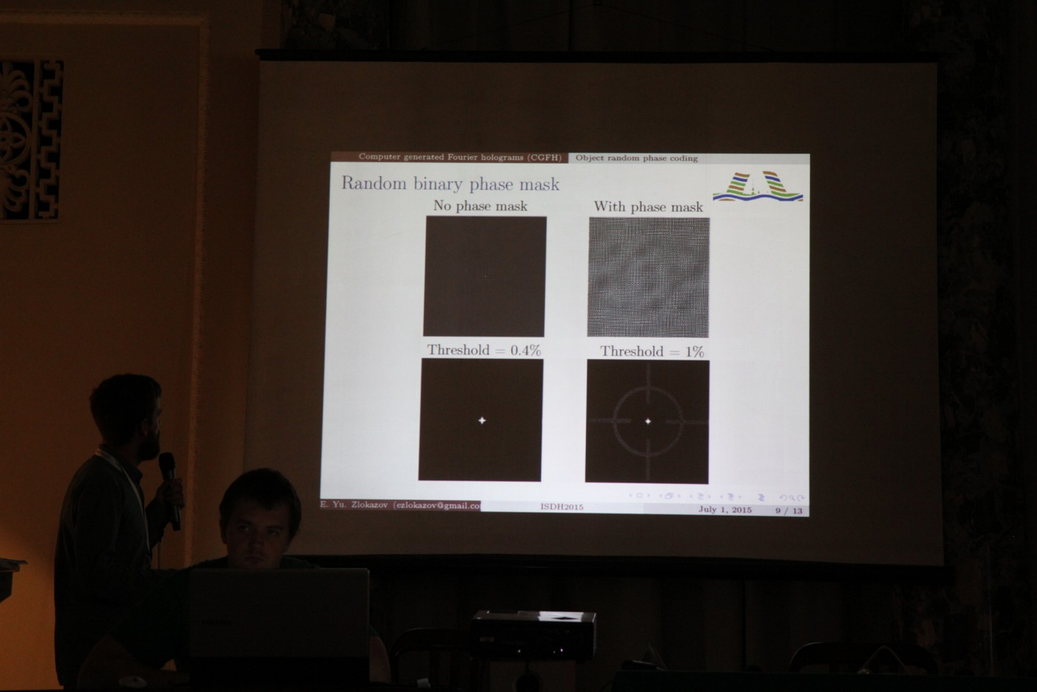
Computer generated Fourier holograms (CGFH)
Object random phase coding
Random binary phase mask
No phase mask
With phase mask
Threshold = 0.4%
Threshold = 1%
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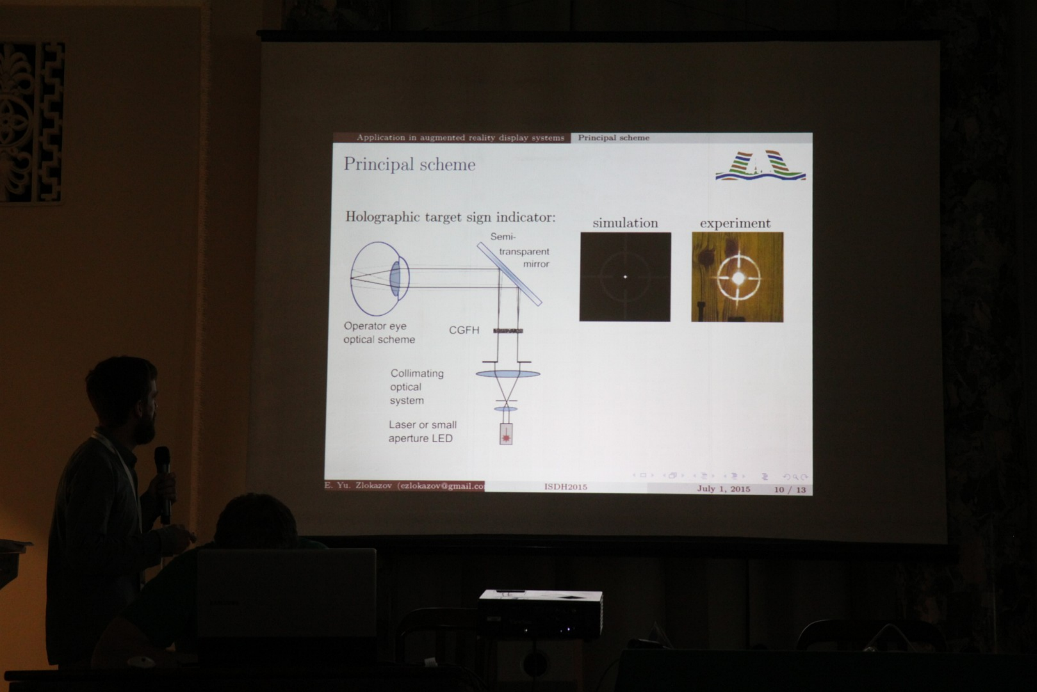
Application in augmented reality display systems
Principal scheme
Principal scheme
Holographic target sign indicator:
Semi-
transparent
mirror
Operator eye
optical scheme
CGFH
Collimating
optical
system
Laser or small
aperture LED
simulation
experiment
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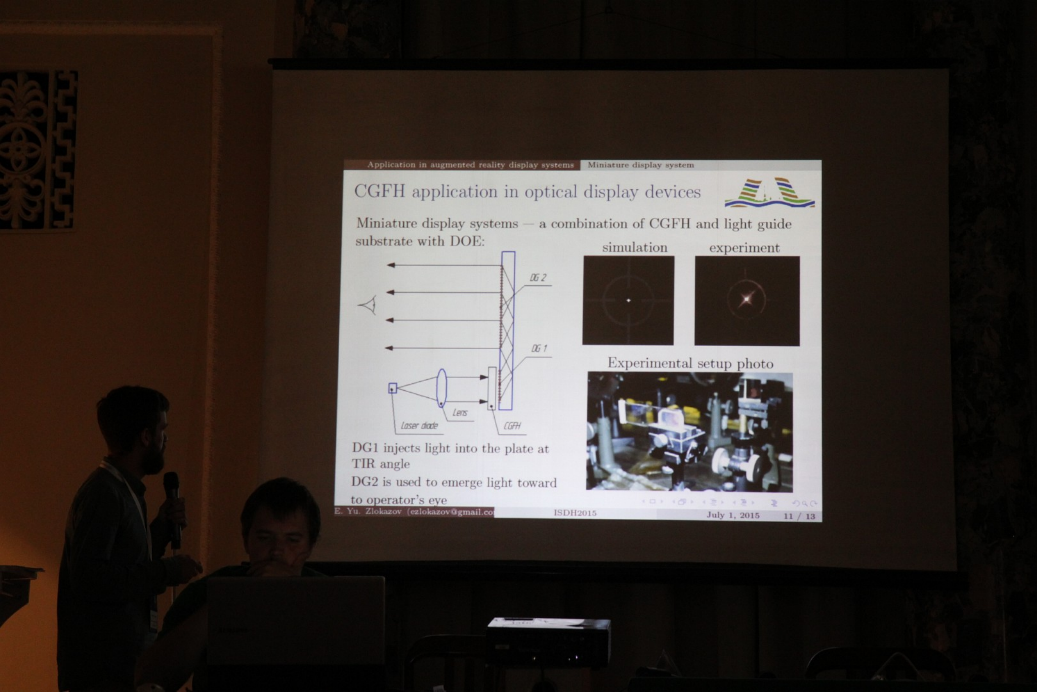
Application in augmented reality display systems
Miniature display system
CGFH application in optical display devices
Miniature display systems — a combination of CGFH and light guide substrate with DOE:
DG 2
DG 1
Lens
Laser diode
CGFH
simulation
experiment
Experimental setup photo
DG1 injects light into the plate at TIR angle
DG2 is used to emerge light toward to operator's eye
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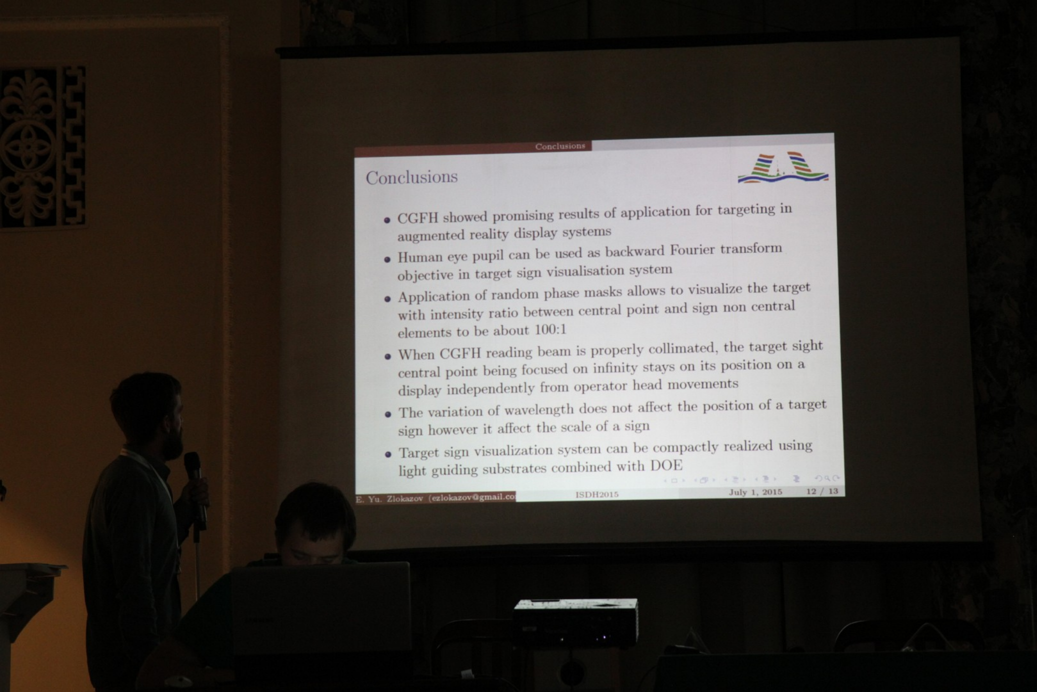
Conclusions
Conclusions
CGFH showed promising results of application for targeting in augmented reality display systems
Human eye pupil can be used as backward Fourier transform objective in target sign visualisation system
Application of random phase masks allows to visualize the target with intensity ratio between central point and sign non central elements to be about 100:1
When CGFH reading beam is properly collimated, the target sight central point being focused on infinity stays on its position on a display independently from operator head movements
The variation of wavelength does not affect the position of a target sign however it affect the scale of a sign
Target sign visualization system can be compactly realized using light guiding substrates combined with DOE
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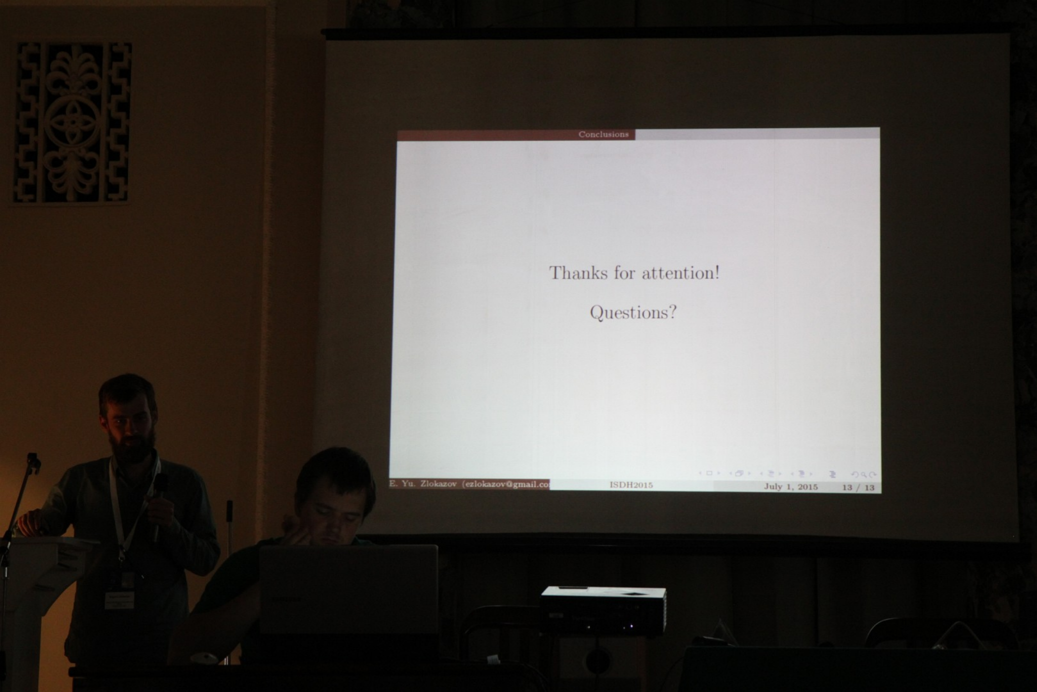
Conclusions
Thanks for attention!
Questions?
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