
GML
Koç University
Optical Microsystems Laboratory
10th International Symposium on Display Holography
Holographic Image Projection with Doubled Field of View by Half-pixel Shift Alignment of Two Spatial Light Modulators
June – July 2015
Mahdi Kazempour, Deniz Mengü, Kıvanc Hedili, Erdem Ulusoy, Hakan Ürey

Image Projection Systems

United Nations Educational, Scientific and Cultural Organization

International Year of Light 2015

- Lots of applications
  - Theatre projection system
    - Using DLP/DMD based projectors

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Image Projection Systems

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    - Using DLP/DMD based projectors
  - Projection onto the car wind-shield
    - Using scanning laser projectors

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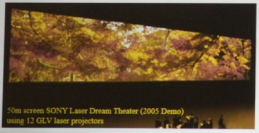
Image Projection Systems

- Lots of applications
  - Theatre projection system
    - Using DLP/DMD based projectors
  - Projection onto the car wind-shield
    - Using scanning laser projectors
  - Large screen projection
    - Using GLV laser projector



50m screen SONY' Laser Dream Theater (2005 Demo)
using 12 GLV laser projectors

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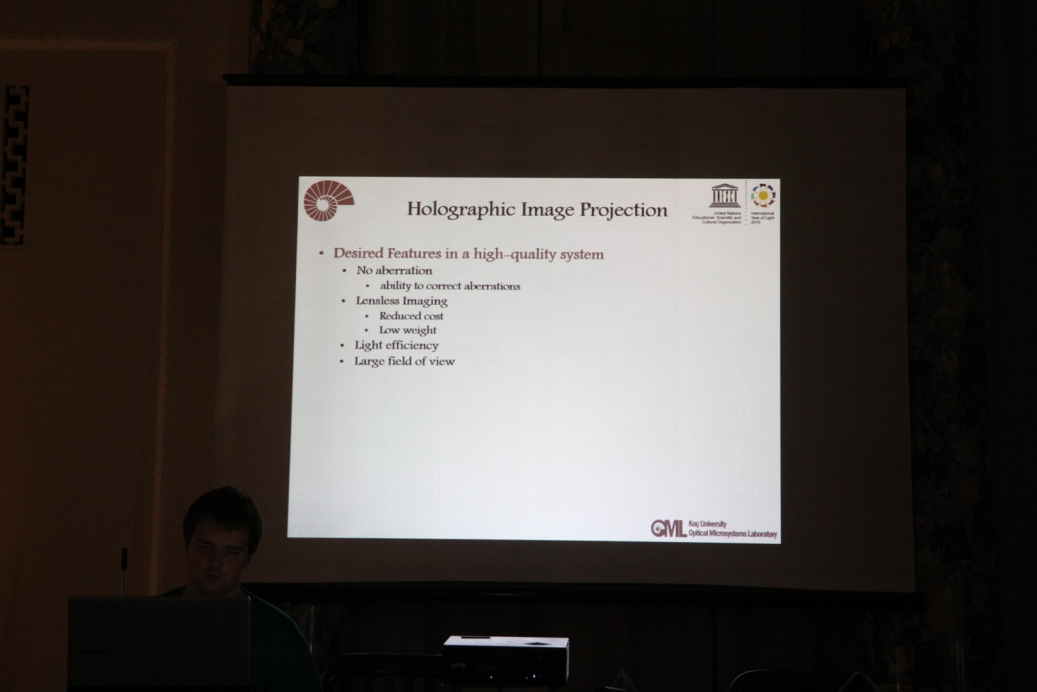
Holographic Image Projection
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Desired Features in a high-quality system
No aberration
ability to correct aberrations
Lensless Imaging
Reduced cost
Low weight
Light efficiency
Large field of view
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Holographic Image Projection

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Solution

Holographic Image Projection System

Utilizes

Spatial Light Modulator (SLM)

pixelated structure and its pixel size

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pixelated structure and its pixel size

Limits the effective field of view

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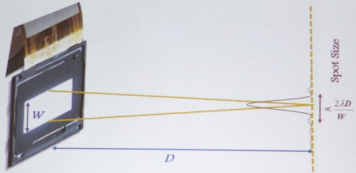
Limits of Spatial Light Modulator

- Quantization error
- Presence of zero order
- Pixelated nature and its pixel size
  - limits the effective field of view



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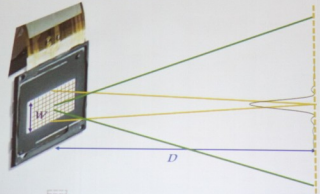

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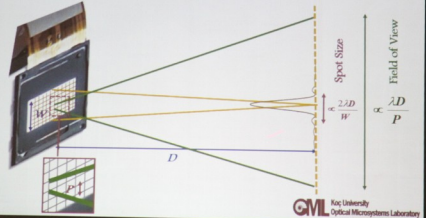

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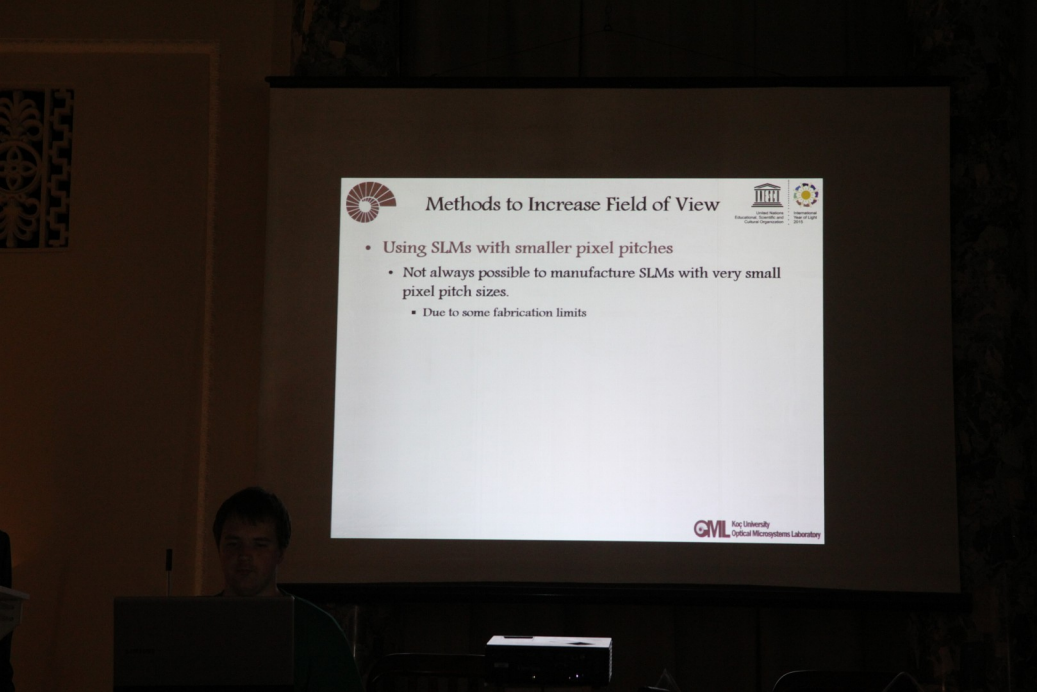
Methods to Increase Field of View
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International Year of Light 2015
Using SLMs with smaller pixel pitches
Not always possible to manufacture SLMs with very small pixel pitch sizes.
Due to some fabrication limits
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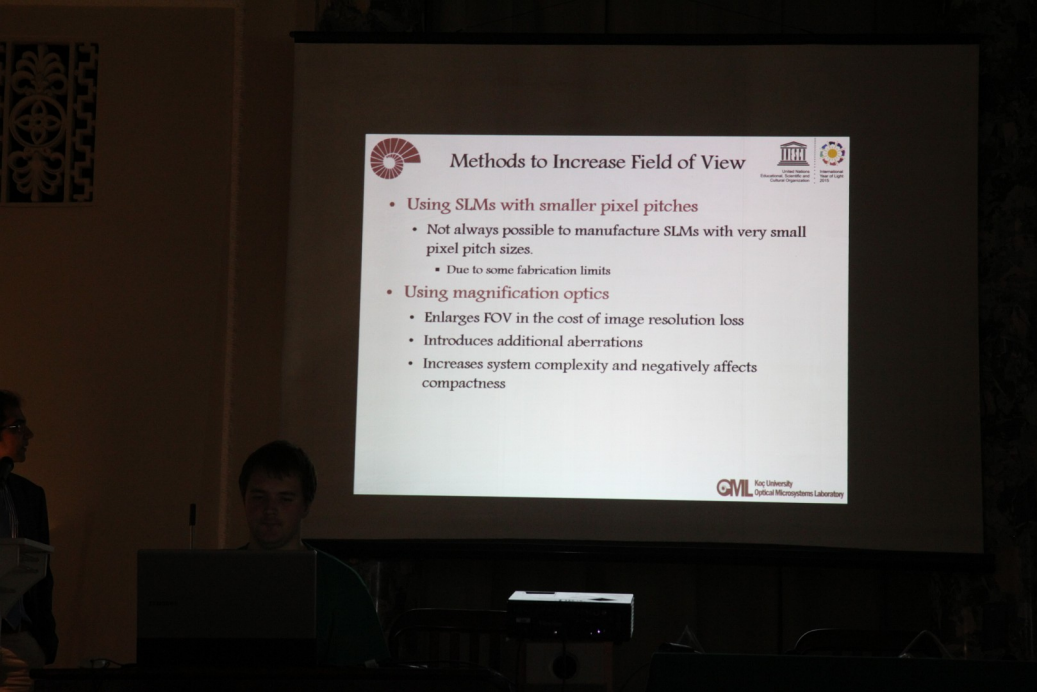
Methods to Increase Field of View
United Nations Educational, Scientific and Cultural Organization
International Year of Light 2015
• Using SLMs with smaller pixel pitches
• Not always possible to manufacture SLMs with very small pixel pitch sizes.
▪ Due to some fabrication limits
• Using magnification optics
• Enlarges FOV in the cost of image resolution loss
• Introduces additional aberrations
• Increases system complexity and negatively affects compactness
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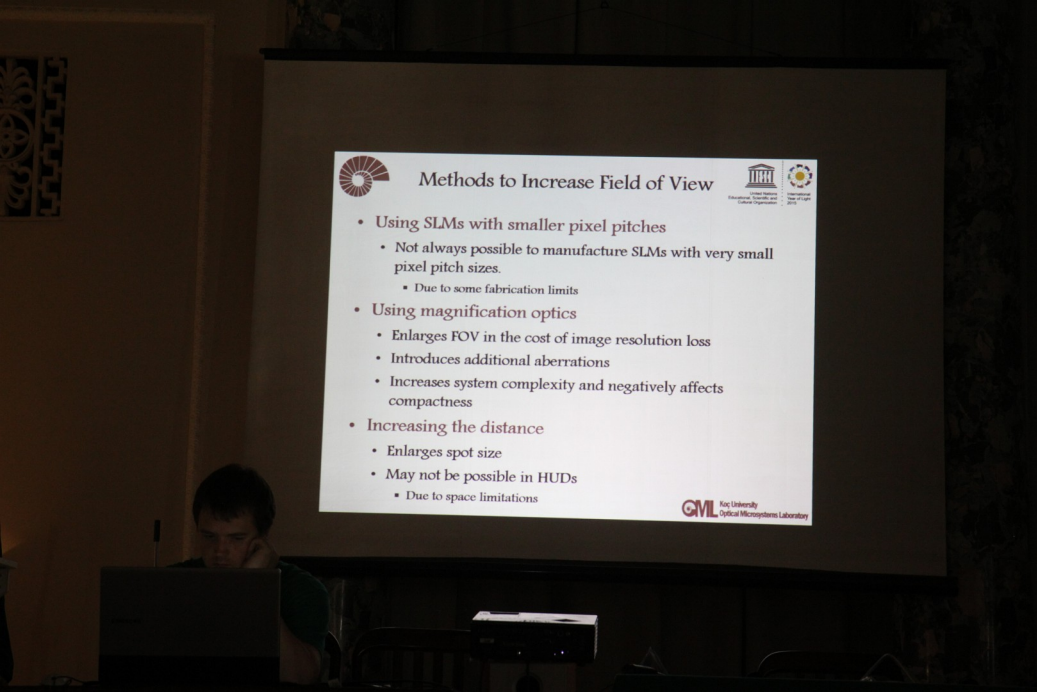
Methods to Increase Field of View
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International Year of Light 2015
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▪ Due to some fabrication limits
• Using magnification optics
• Enlarges FOV in the cost of image resolution loss
• Introduces additional aberrations
• Increases system complexity and negatively affects compactness
• Increasing the distance
• Enlarges spot size
• May not be possible in HUDs
▪ Due to space limitations
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Our Proposed Method

- Obtain a new SLM with a halved-pixel pitch (in one direction) out of two identical SLMs
- What do we achieve?
  - Same pixel size (spot size) on the image plane
  - Doubled field of view
  - This sounds as if we use only one SLM.

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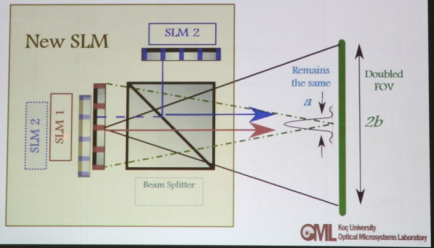
Setup Details

- The two SLMs (with $M \times N$ pixels of pitch $P \times P$) are aligned except for a shift in horizontal direction by a half pixel to obtain a new SLM (with $M \times 2N$ pixels of pitch $P \times P/2$).



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Hologram Computation

- An $M \times 2N$ phase-only hologram is computed according to the new SLM.
- The even and odd columns of the hologram are fed in a de interlaced manner into the SLM 1 and 2, respectively.

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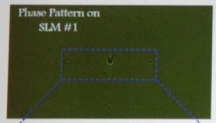

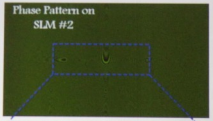

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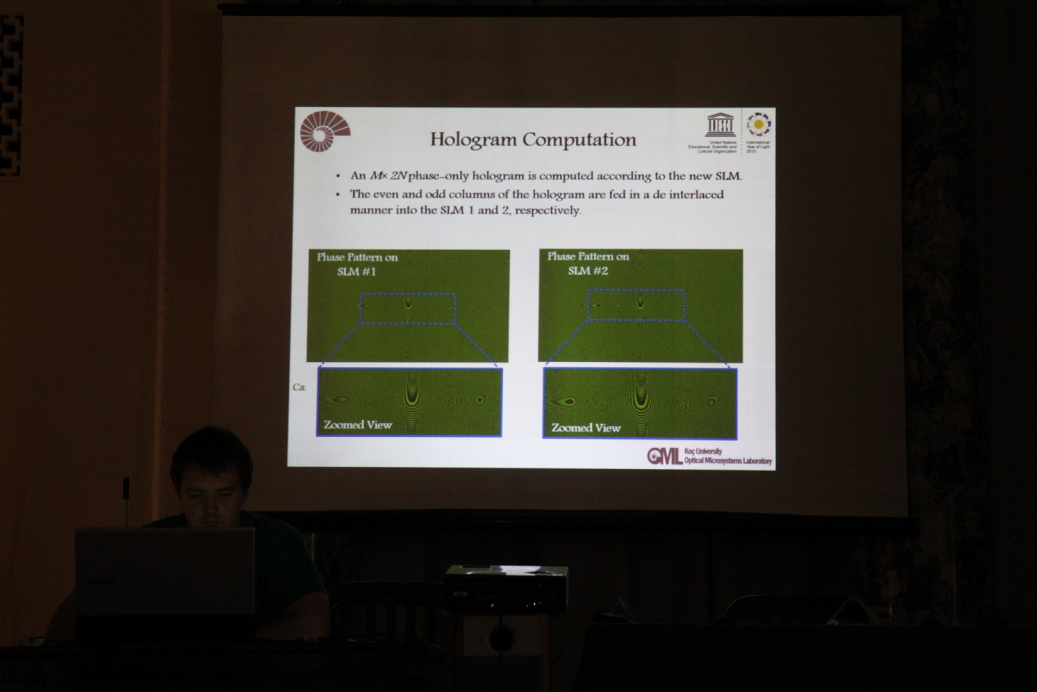
Hologram Computation
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An M× 2N phase-only hologram is computed according to the new SLM.
The even and odd columns of the hologram are fed in a de interlaced manner into the SLM 1 and 2, respectively.
Phase Pattern on SLM #1
Phase Pattern on SLM #2
Zoomed View
Zoomed View
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Simulation Results

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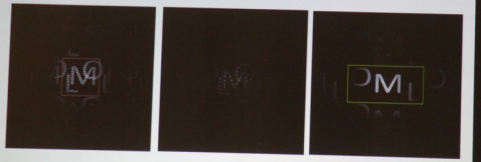
- Before Proper Alignment
- After Proper Alignment



*The results are obtained using MATLAB simulations.

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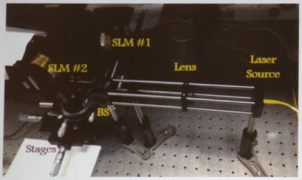
Experimental Setup & Alignment

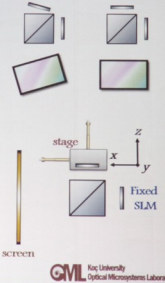
- Some efforts have been done in the lab.



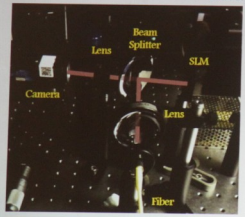
- However the alignment is not easy to achieve!
- There exist only one proper location.
  - We need computer controlled nano-precision stages.
  - Experiment are ongoing.

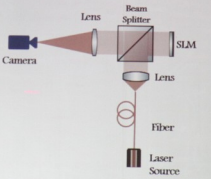
Alignment Procedure

- Converging Beam
  - Match zero order
    - With out-of-plane rotation adjustment
  - Match other orders
    - With in-plane rotation adjustment
- Collimated Beam
  - Eliminate circular fringing patterns
    - Play with z axis
- Final Step
  - Try to match pixel-by-pixel
    - Use checker boards
    - Play only with x and y axis



Proof of Concept Setup





The SLM has 8 micron pixel pitch.
We can use 16 micron pitches for demo.

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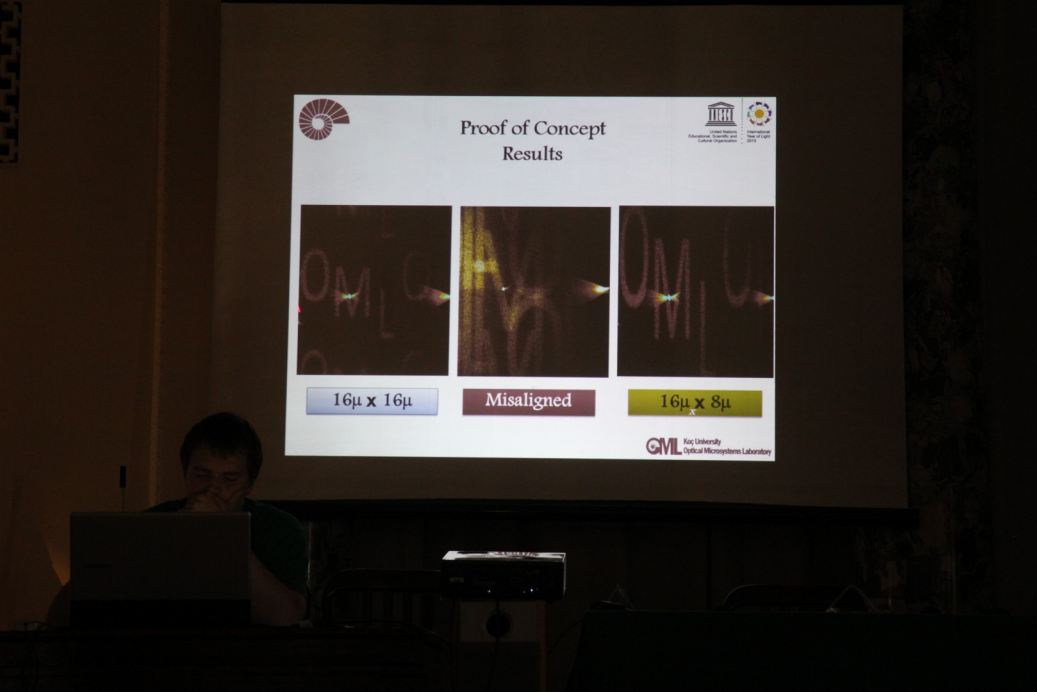
Proof of Concept
Results
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16μ x 16μ
Misaligned
16μ x 8μ
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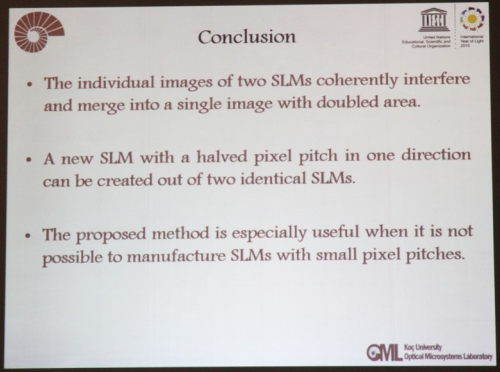
Conclusion
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• The individual images of two SLMs coherently interfere and merge into a single image with doubled area.
• A new SLM with a halved pixel pitch in one direction can be created out of two identical SLMs.
• The proposed method is especially useful when it is not possible to manufacture SLMs with small pixel pitches.
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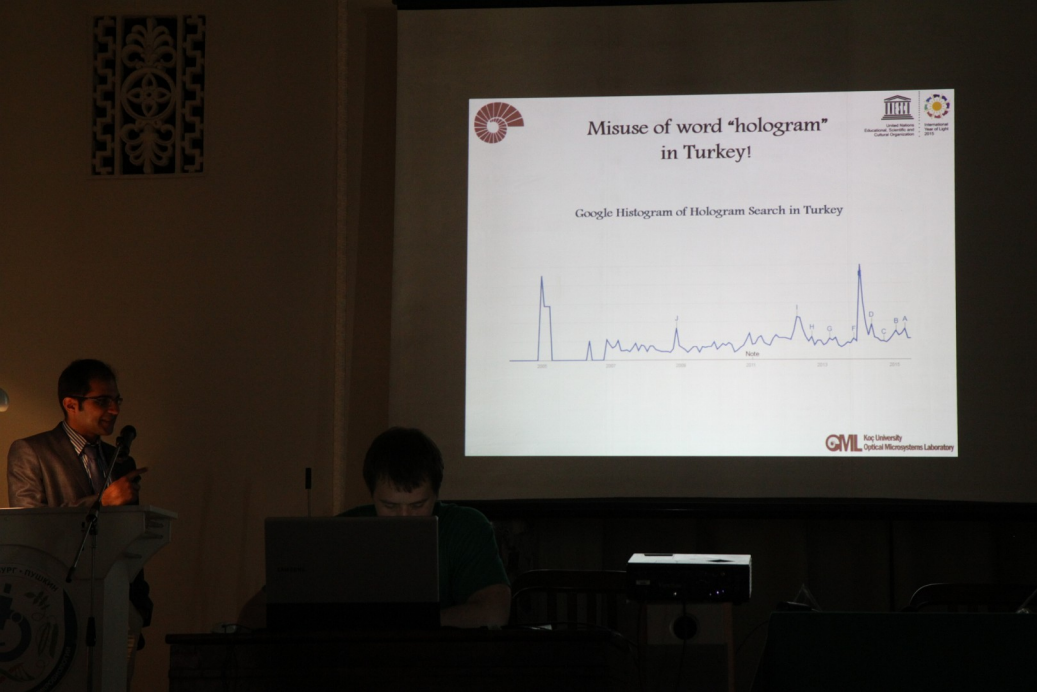
Misuse of word "hologram" in Turkey!
Google Histogram of Hologram Search in Turkey
Note
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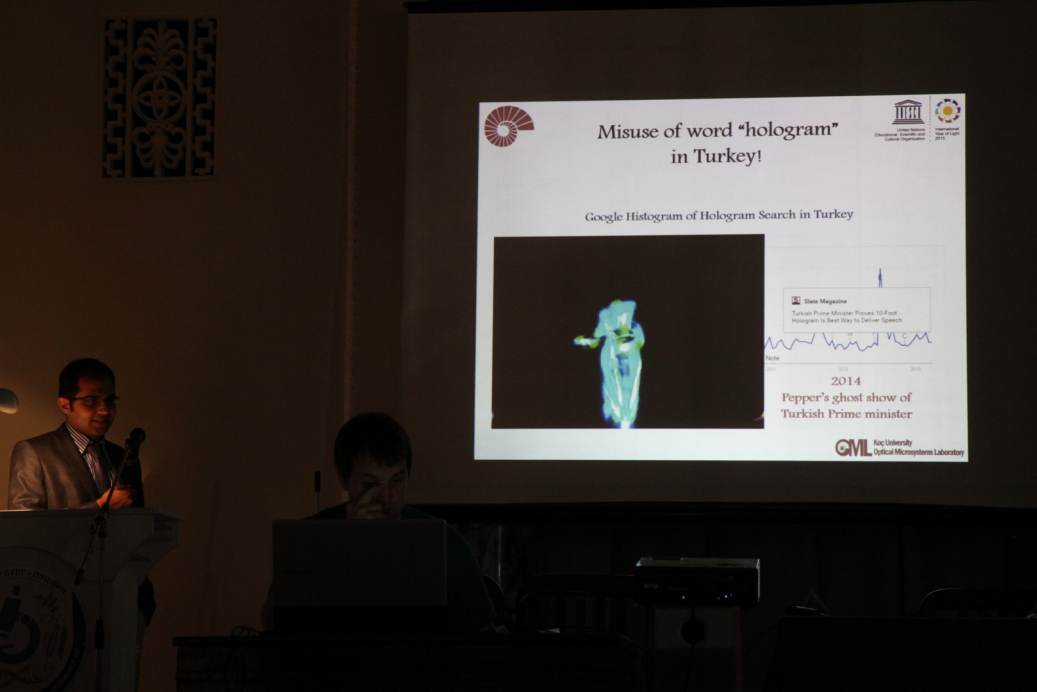
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Slate Magazine
Turkish Prime Minister Proves 10-Foot Hologram Is Best Way to Deliver Speech
Note
2004
2010
2015
2014
Pepper's ghost show of
Turkish Prime minister
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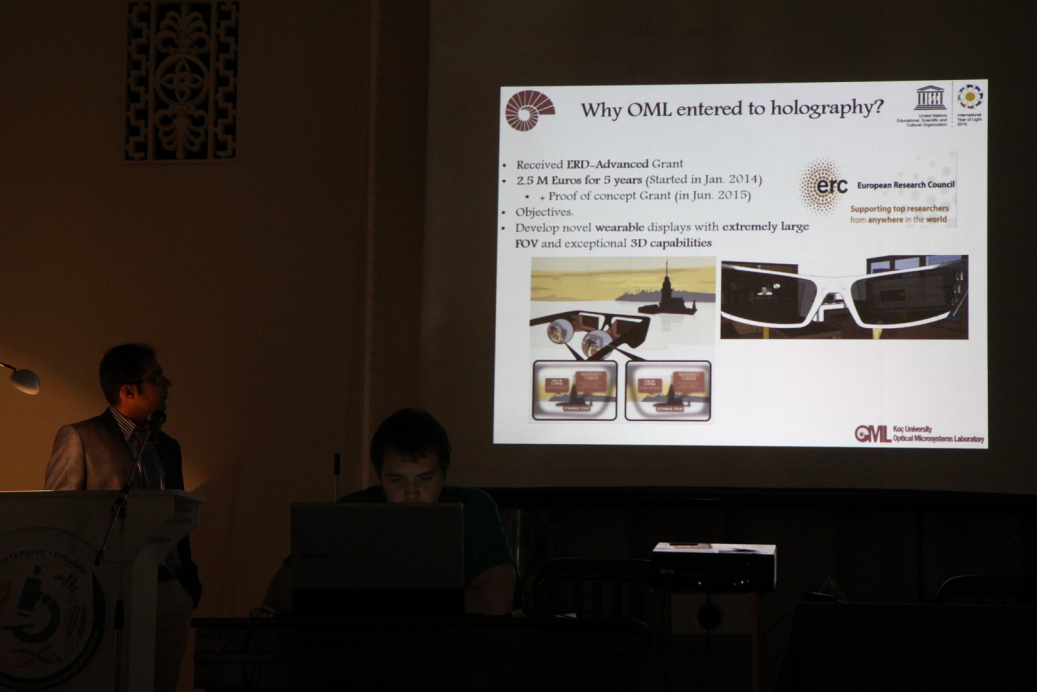
Why OML entered to holography?
United Nations Educational, Scientific and Cultural Organization
International Year of Light 2015
Received ERD-Advanced Grant
2.5 M Euros for 5 years (Started in Jan. 2014)
+ Proof of concept Grant (in Jun. 2015)
Objectives.
Develop novel wearable displays with extremely large FOV and exceptional 3D capabilities
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Thanks for your attention...

Q & A ?

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