Pseudo-holographic device elicits rapid depth cues despite random-dot surface masking

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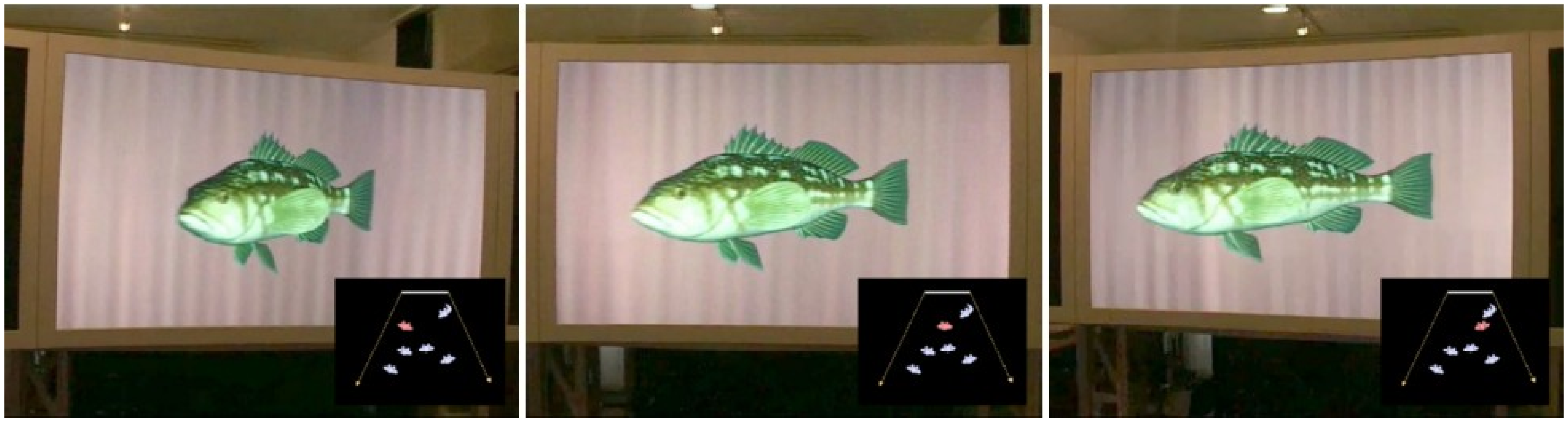
Abstract

Experiments with random-dot masking demonstrate that, in the absence of cues mundanely available to 2-D displays (object occlusion, surface shading, perspective foreshortening, and texture
gradients), Holografika's large-screen multi-projector video system (COHERENT-IST-FP6-510166) elicits useful stereoscopic and motion-parallax depth cues, and does so in under 2 s. We employed asimplified version of Julesz's (c.1971) famous spiral ramp surface: a 3-layer cylindrical wedding-cakeövia an openGL model that subjects viewed along its concentric axis. By adjusting its parameters, two sets of model-stimuli were rendered: one with a uniform large field of depth and one where the field was effectively flat. Each of eleven, pre-screened, subjects completed four experiments, each consisting of eight trials in a 2IFC design whereby they indicated in which interval they perceived the greatest field of depth. The experiments tested one-eye static, one-eye head-swaying, two-eye static, and two-eye head-swaying observationöin that order. Scores improved also in that order.

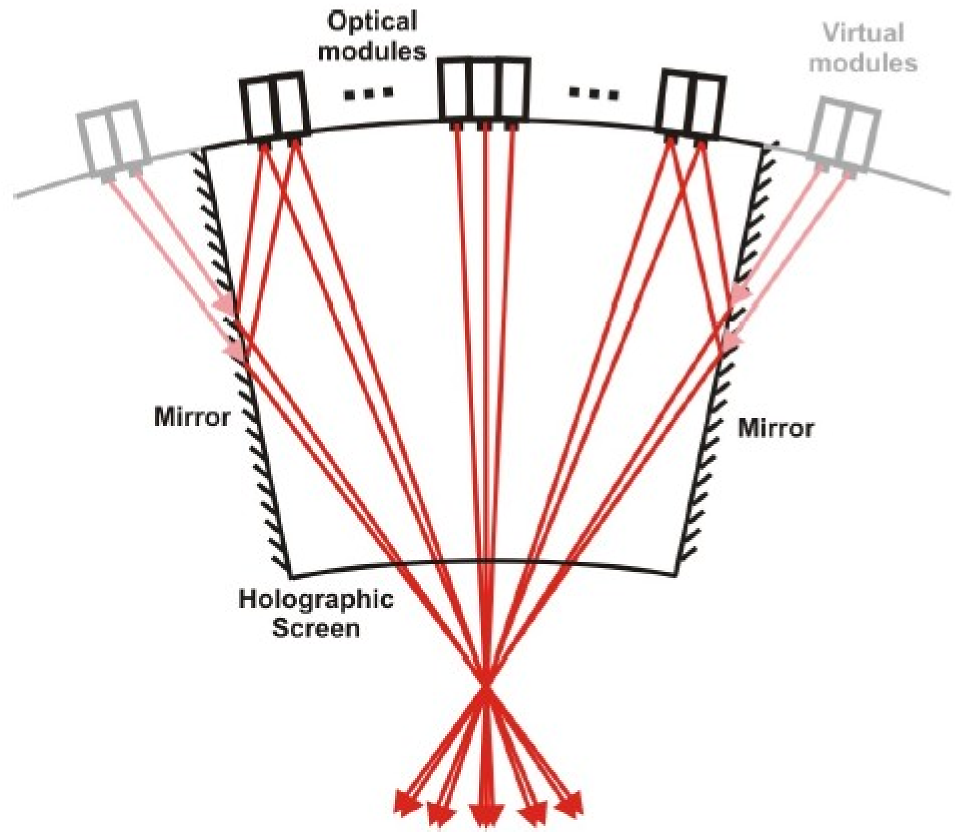
Large scale interactive multi-user “holographic” display
developed by Holografika Hungary.



The display allows freely moving naked-eye participants to share a three-dimensional scene with fully continuous, observer-independent, parallax (*horizontal for now*).
Field of view: ~45 deg horizontally; Luminance ~5000 lumen.

Tibor Balogh, Tamas Forgacs, Tibor Agocs, Olivier Balet, Eric Bouvier, Fabio Bettio, Enrico Gobbetti, and Gianluigi Zanetti. A scalable hardware and software system for the holographic display of interactive graphics applications. In *EUROGRAPHICS 2005 Short Papers Proceedings*, Conference, 2005.

Display concept



The **50M-pixel** display prototype uses a specially arranged array of **64 XGA commodity projectors** and a pseudo-holographic screen with a diagonal of **1.8m**. The projection modules project their specific image onto the screen to build up the 3D scene. The applied distributed image organization makes it **fundamentally different** from other multi-view solutions. The module views are not associated with specic view directions. Instead, the light beams to be emitted by the projection modules, (images generated by the projectors), are determined by geometry. Each module emits light beams toward a subset of the points of the holographic screen. At the same time, each point of the holographic screen is hit by more light beams arriving from different modules. The light beams propagate to address fixed spatial positions that are independent from the viewer's position. Many modules contribute to each view of the 3D image, thus no sharp boundary occurs between views, and the display offers continuous and smooth change at different image areas.

Medical context

Anatomy Perception:

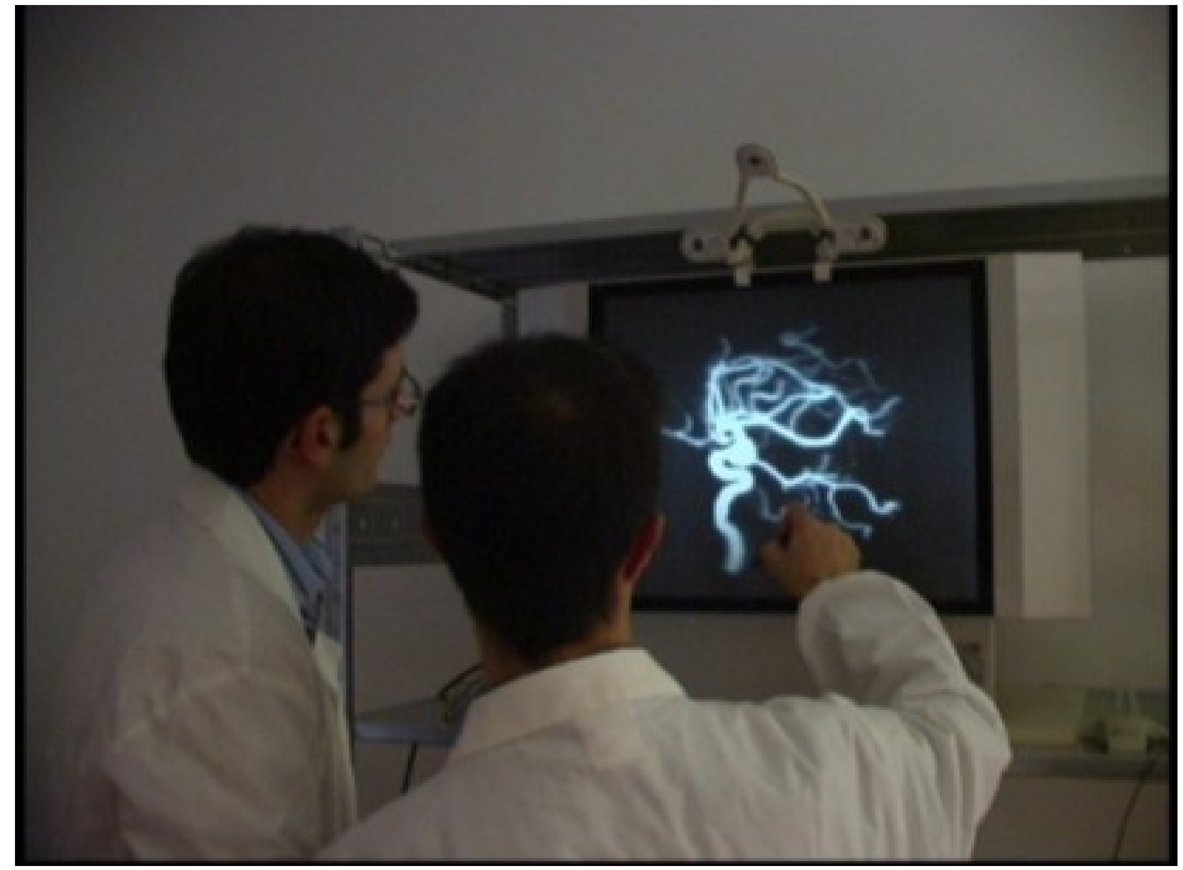
– Assist in disambiguating complex clinical images.
– "Depth oblivious" direct volume rendering techniques:

Maximum Intensity Projection:

– Volume render the maximum value encountered along a ray instead of its optical value. E.g. for MRI & CT data.

X-ray volume rendering:

– Volume render the line integral value along a ray – classical way to show internal structure.



Evaluation sessions:

– Brotzu Hospital medics (Cagliari,Sardinia)
– Two radiologist + one head of the stroke unit
– The <u>small</u> HOLO display

Random-dot sprial-ramp

- Julesz's Spiral-ramp random-dot-stereogram (c.1971) can take over a *minute* to *free-fuse* binocularly – because the texture masks out non-disparity-based depth cues such as shading, texture gradients, perspective and overlap-occlusion (see figure).

- Yet such a spiral ramp should be *immediately perceived* when rendered by the pseudo-holographic display. Test: 2AFC reaction times of subject differentiating ramp seen from front and back.

- We modified the open-GL GLE extrusion library to coat helicoid surface in random-dot textures in order to implement our 3D version of Julesz's figure (see figures).

Julesz Spiral Ramp Random Dot Stereogram (C.Tyler)

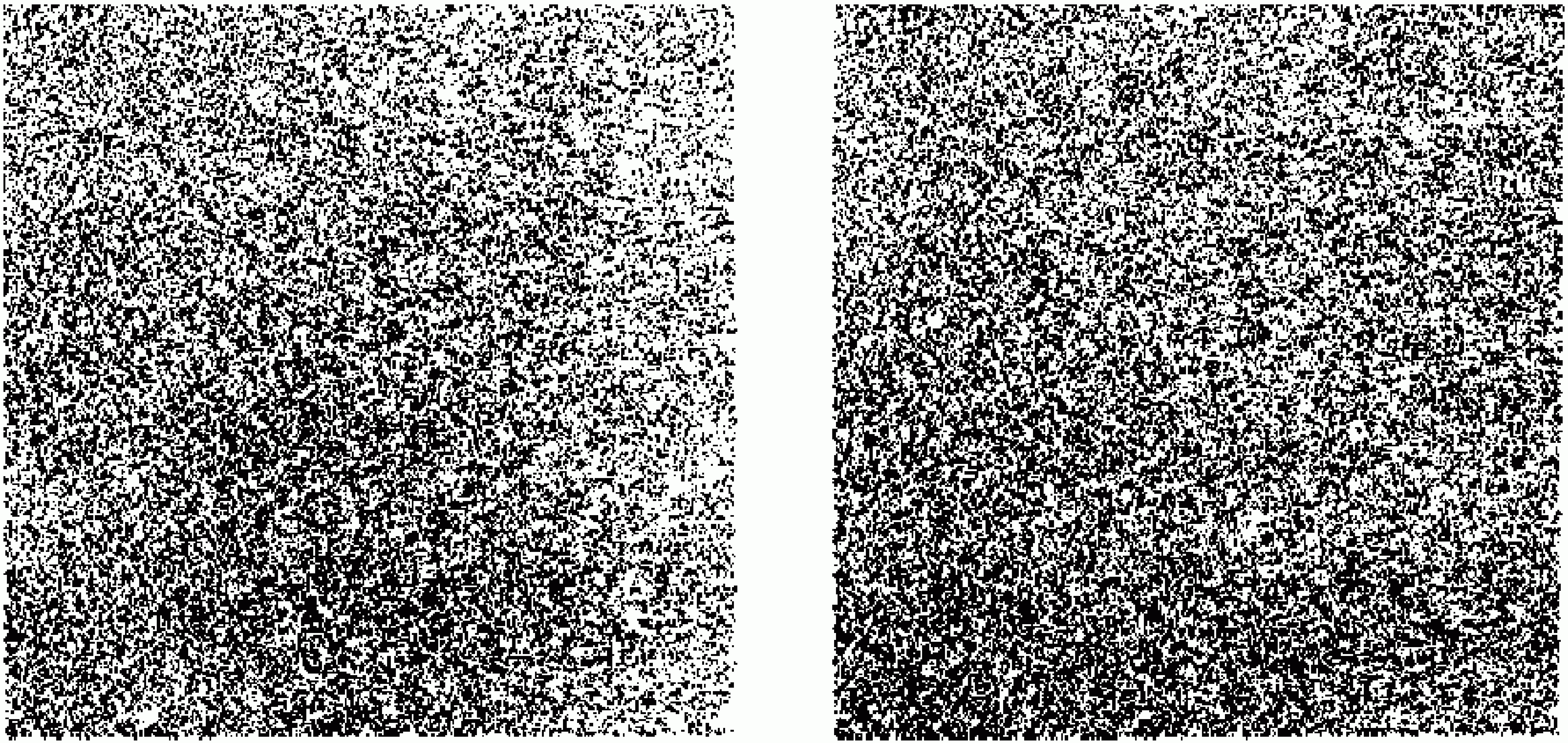
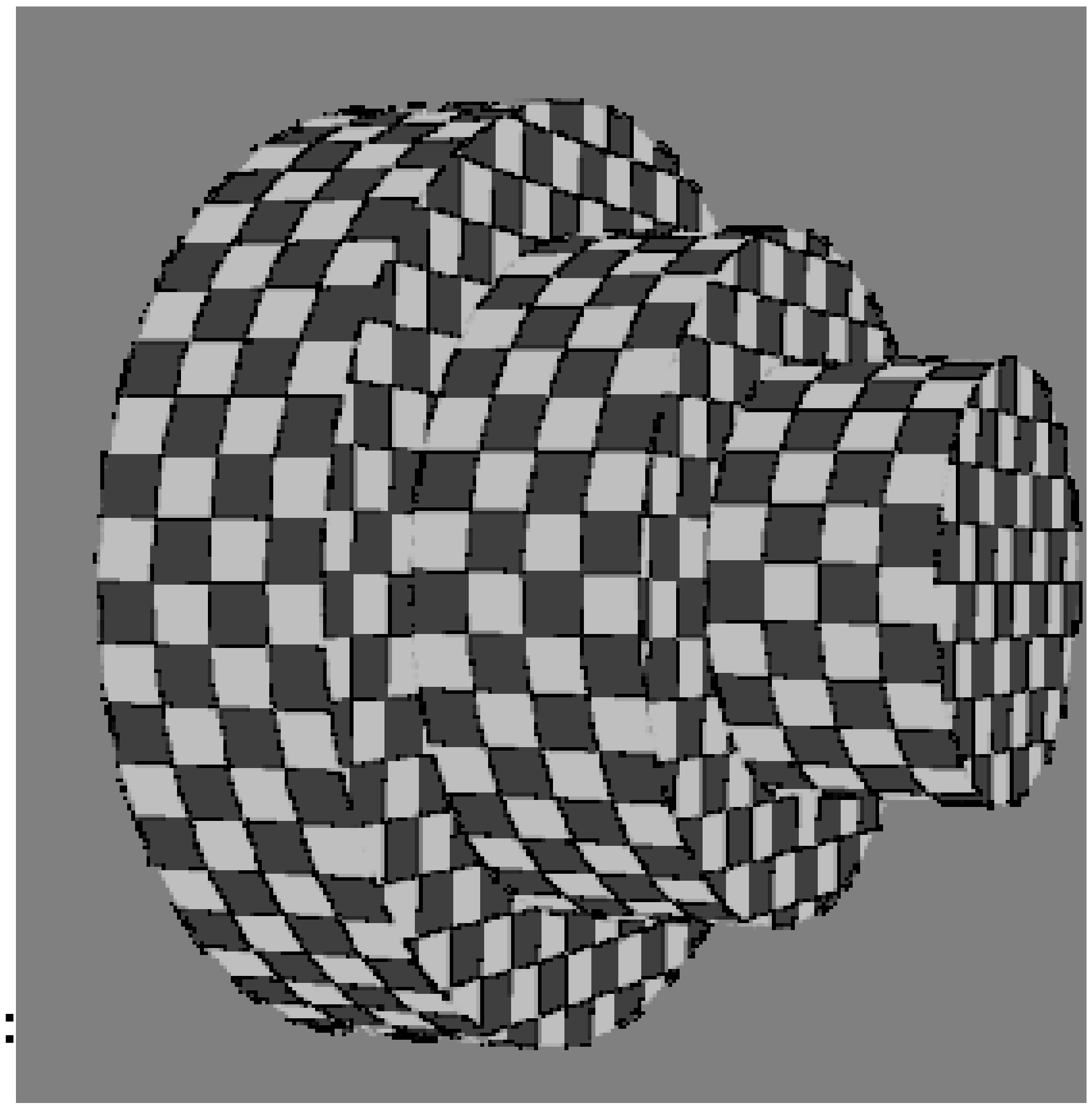


Fig. 7. Random-dot stereogram of a spiral depth figure. When the left and right images are fused stereoscopically, a spiral in depth will appear. These arrays are arranged so that the reader may free-fuse by crossing the eyes to see the spiral pointing upward. (Julesz B:

Stimulus: 3D test-card

Evaluate depth cues:

- **Binocular stereo via both eyes**
- **Motion parallax by swaying head**



Model stimulus:

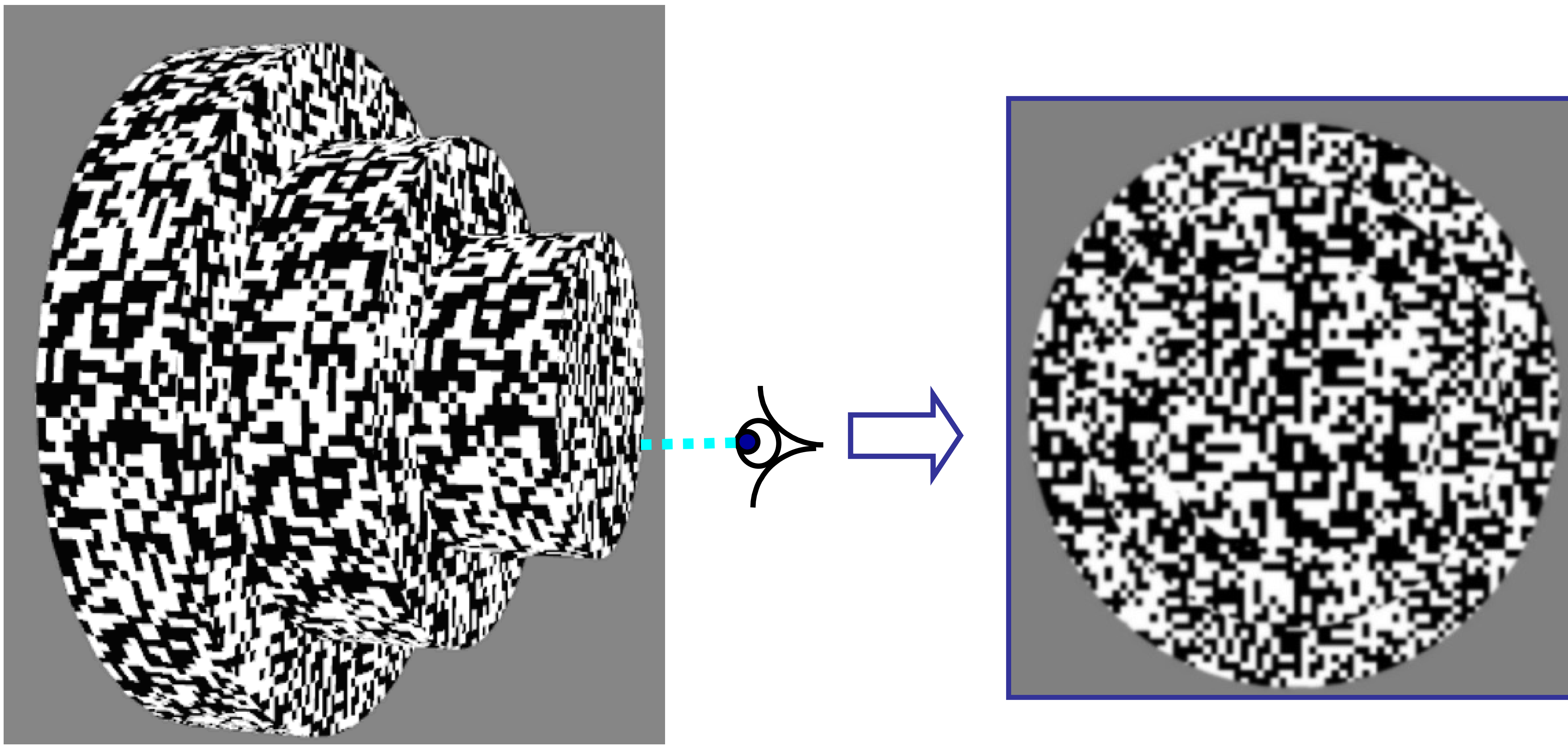
- **Fill up view volume: with a rich set of depth variations**
- **Easy to control: parameterised**
- **Diagnostic value: 3D test-card**

Mask non-disparity cues:

- **those mundanely available to 2D displays: occlusion, shading, perspective, texture gradient, etc**

- **Random dot surface texture …**

Disparity-based cues



Appearance seen centrally standing still with only one eye open.

Experiment & results

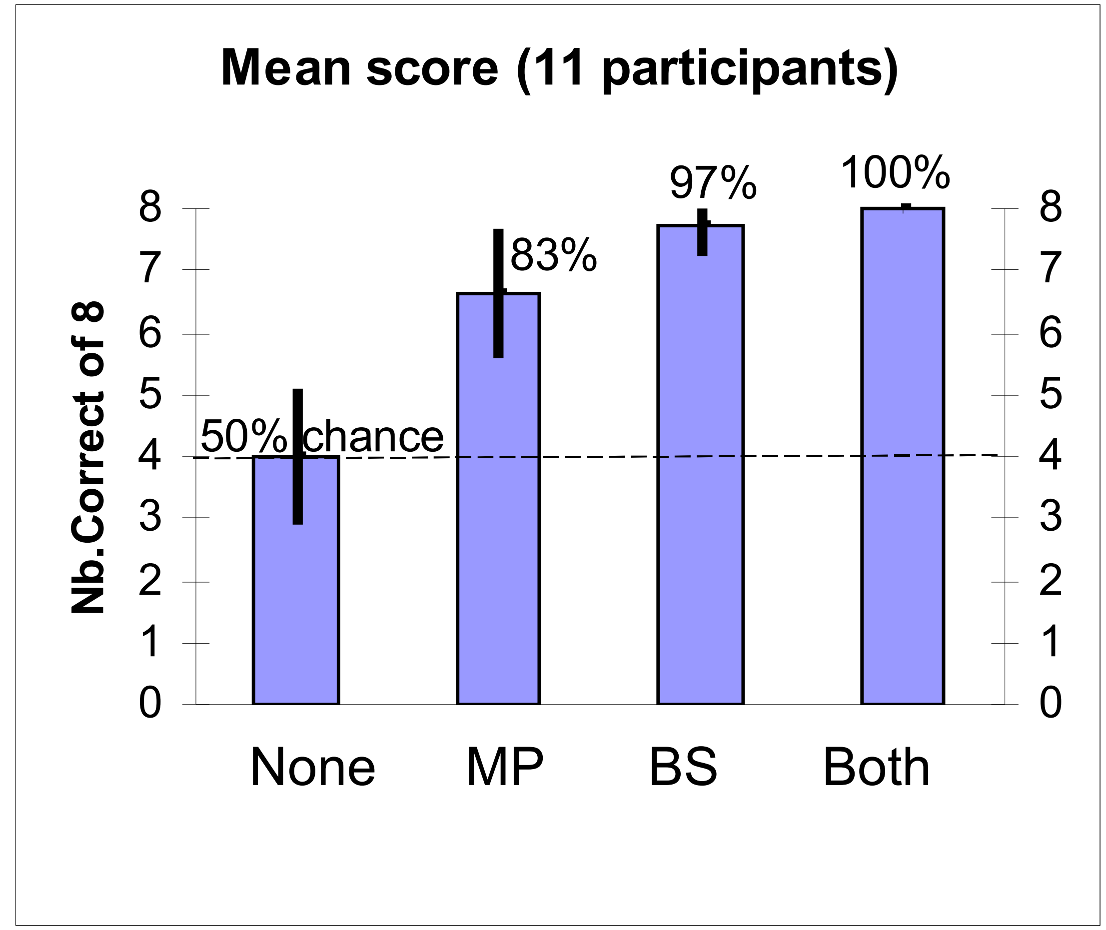
Task: distinguish 2D v.3D

- **<u>3D model</u> v.**
- **<u>2D version</u> -flattened & adjusted to appear indistinguishable under monocular static viewing**

- **11 participants, normal eyesight, familiar with our 3D test-card.**
- **Viewing distance: 1m.**
- **Presentation time: 2s**

2IFC design:

- **Two interval forced choice: whereby particpants specify:**
- **if 1st or 2nd interval "contains greatest depth of field".**
- **Interstimulus interval: 1s**
- **Priming by audio beeps**
- **8 trials per experiment.**



Four expts /conditions:

None: - No explicit cues: ***one eye, still***
MP: - <u>Motion Parallax</u> – ***head swaying***
BS: - <u>Binocular Stereo</u> – ***both eyes, still***
Both: - ***both eyes + head swaying***

Conclusion

– The disparity-based cues delivered by the small HOLO display, even in the absence of pictorial context, are usefully perceived by the observer in under 2s.