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Omni-Tube: A Low-Cost Portable Omnidirectional Interactive 3D Display

Che-Hao Hsu[1,2], Kai-Lung Hua[1], Wen-Huang Cheng[2]

[1]National Taiwan University of Science and Technology, Taiwan, R.O.C.; [2]Research Center for IT Innovation, Academia Sinica, Taiwan, R.O.C.

SIGGRAPH ASIA 2011 Nov. 28 - Dec. 1

Overview

- **Omni-Tube:** A novel omni-directional (360-degree) interactive 3D display.
- **Features:**
  - –Display multi-view images without the requirement of special glasses.
  - –Overcomes the general limitation of viewing distance and angles for low-cost 3D display.
- **Advantages:**
  - –Ease of use.
  - –Low production cost.
  - –High portability and mobility.
- **Design (two functional parts):**
  - –Optical device: easily mounted to any commercial micro projector.
  - –Projection image transformation algorithm: manages the optical distortions.

Omni-Tube prototype system

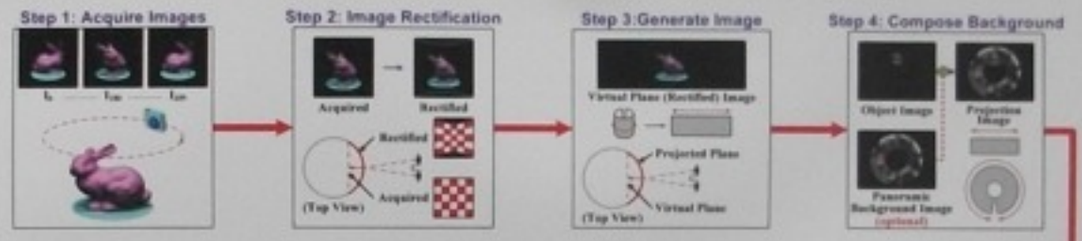
Related Works

- **High-speed rotary LED approach**
  SONY RayModeler [Ito et al. 2010]: employ 2D LED dot matrix and high-speed rotary motor to display different viewing point images.

- **Multi-projector approach**
  Osaka university [Yagi et al. 2011]: utilize three micro projectors to show three images simultaneously on a fog screen.

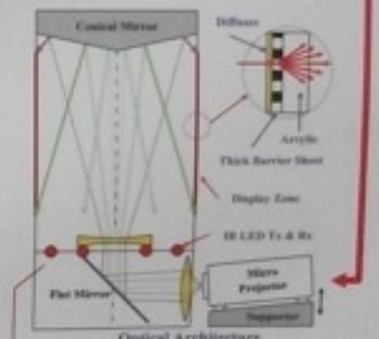
Projection Image Convert Workflow

- **Acquire Images:** acquire images from all viewing points.
- **Image Rectification:** rectify image distortion caused by the cylindrical screen.
- **Generate Position-Aware Image:** generate a display image according to users' locations.
- **Compose Background:** optionally add the background.



System Optical Architecture

- **Projection Supporter:**
  To counterbalance the inherent upward projection angle for any commercial micro projector.
- **Lens & Mirror Group:**
  Consist of convex lens, flat mirror, concave lens, and conical mirror. It bends the rays more strongly and forces them to focus on the conical mirror.
- **Display Material:**
  A special purposed diffuser and a special designed thick barrier sheet work together to produce different brightness attenuation according to different viewing angles.

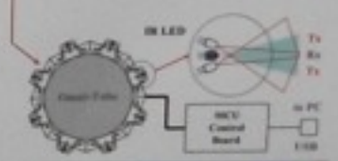


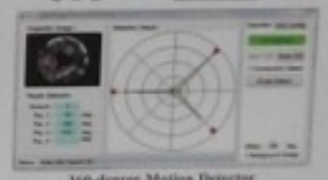
Optical Architecture

360-degree Motion Detector

- **Infrared Tx & Rx LED:**
  Eight sets of Tx/Rx IR LED were employed to measure reflection energy from cylinder surroundings.
- **MCU control board:**
  Compute users' position and distance based on eight Rx.

Function of thick barrier





360-degree Motion Detector

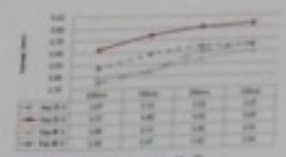
The User Study

The specification of the current **Omni-Tube** system is shown below:

- –**Tube Size:** Ø100 mm
- –**Tube Height:** 150 mm
- –**Total Height:** 210 mm
- –**Display Resolution:** 72 ppi
- –**IR Sensor:** 940 nm
- –**Motion Detection:** 360 degree, <150 cm
- –**Prototype Cost:** < $ 300 USD

Forty-five users were invited to our user study, and 89% of them were impressed with the **Omni-Tube** display and gave very positive feedback.

Real views observed in three different locations



Depth perception score (1~5)

Statistics of user ratings on stereoscopicity

References

(1) Ito, K., Kimachi, H., Sakurai, H., Kobayashi, I., Yasunaga, H., Mori, H., Tokuyama, K., Ishikawa, H., Hayasaka, K., and Yanagisawa, H. "*360-degree stereoscopic display*", In *ACM SIGGRAPH 2010 Emerging Technologies*.

(2) Yagi, A., Imura, M., Kuroda, Y., and Oshiro, O. "*360-degree fog projection interactive display*", In *ACM SIGGRAPH Asia 2011 Emerging Technologies*.

Poster

Arbitrarily Focused Video Using High-Speed Liquid Lens

Hiroki Deguchi
Hiromasa Oku and Masatoshi Ishikawa

Ishikawa Oku Lab
UNIVERSITY OF TOKYO
http://www.k2.t.u-tokyo.ac.jp/

Abstract

Focusing and blurring are essential techniques employed by photographers to emphasize a given photographic subject. Recent developments on synthetic digital photography permit the manipulation of focus and depth of field after the picture has been taken off-line.

In this work, we propose a high-speed focus-scanning technique and a simple algorithm to synthesize arbitrarily refocused images using a set of differently focused images named a 'focal depth image set'. The high-speed focus-scanning is achieved by a high-speed liquid lens called Dynamorph Lens(DML). The DML has a liquid-liquid interface that works as a refractive surface and can be arbitrarily reshaped to modify the focal length in a few milliseconds. A new camera lens system including the DML prototype as a focusing component was developed and coupled with a high-speed camera. It achieved practical imaging performances and wide angle of view. High-speed capture rate of 100 focal depth image sets per a second and synthesize of arbitrarily focused video of dynamic scene with little artifact due to the high-speed capture rate were demonstrated.

Background

Motivation

- The manipulation of focus and depth of field *after* the picture has been taken

Previous Work

- Light Field Camera
  [Ng et al. 2005]
  ✕ Low resolution
  ✕ Hard to apply to wide angle lenses

- Focus-scanning Photography
  [Kodama et al. 2006]
  ✕ Hard to obtain differently focused images with high speed

Our Approach

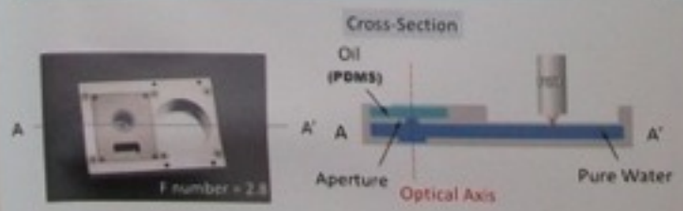
We propose

- a new focus scanning technique using a high-speed liquid lens called Dynamorph lens.

- an algorithm to synthesize arbitrarily refocused images using a set of differently focused images named 'focal depth image sets'.

- an arbitrarily refocused video by stacking synthesized images in chronological order. The high capture rate of the focal depth image sets enables us to synthesize a high frame rate video.

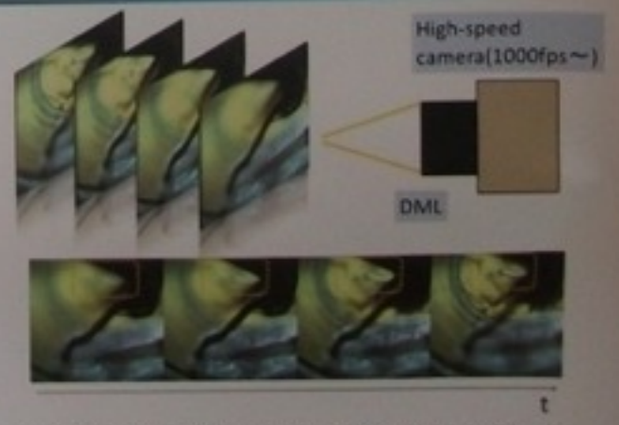
Dynamorph Lens



Aperture diameter	3mm
Liquids	Water, poly-dimethylsiloxane(PDMS)
Maximum wavefront error (rms)	80.3nm
Fastest step response time of focal length	2ms

- A high-speed liquid lens with a practical imaging performance
- Two immiscible liquids are infused in a rigid container
- Change the interface shape by liquid pressure using a piezostack actuator (PZT)

Focal Depth Image Sets



- A sequence of images captured at differently focused depth
- If the acquisition rate of the focal depth image set is relatively high, we can reduce the effect of temporal variations in illumination or object motion during the acquisition.

www.k2.t.u-tokyo.ac.jp/mvf/dof_expand/ - Email: Hiroki_Deguchi@ipc.i.u-tokyo.ac.jp

(a) (b) (c) (d)

Figure 1: *(a)One of synthesized images. (b),(c)and(d) are magnified views of synthesized image. (b)is a close-up of(a), focused on the ball. (c)is focused on the ant. (d)has a wide range of depth of field.*

Poster +
emerging technology

Fuwa-Vision

An auto-stereoscopic floating-image display

email: h-nii@iij.ad.jp movie: http://vimeo.com/45167701

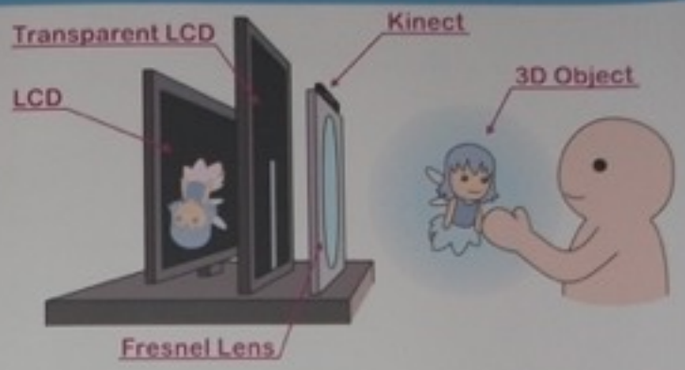
Hideaki Nii*1, Kening Zhu*2, Hiromi Yoshikawa*3, Nyan Lin Htat*2, Roland Aigner*4, Ryohei Nakatsu*5

*1 IIJ Innovation Institute, Tokyo, Japan, *2 KEIO-NUS CUTE-Center, National University of Singapore
*3 The University of Electro-Communications Japan, *4 Ars Electronica GmbH,
*5 Interactive and Digital Media Institute NUS Singapore

IIJ INNOVATION INSTITUTE

Abstract

Fuwa-Vision is a simple interactive auto-stereoscopic display for multiple users without glasses or mechanical moving components. This system can project the 3D object as if it floating in midair.



System Description

Theoretical Principle of Fuwa-Vision

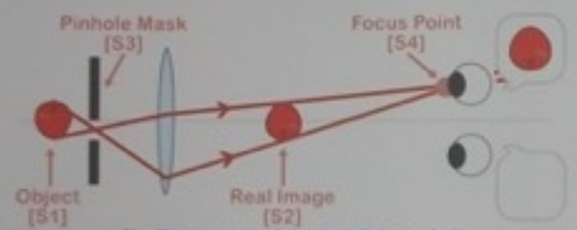


Fig. The concept of the light field control

Basic Idea

The **object** is installed at point **S1**, **the real image** appear at point **S2**. The **pinhole mask** is installed at point **S3**, the light ray of the object goes through the pinhole and makes the real image, and finally intersects at **S4**. Therefore viewer can see the real image at S4.

Auto Stereoscopic

The projection area will be moved according to the position of pinhole mask. Therefore this system projects different images to viewer's left and right eyes alternetively. By swtichting shutter pattern at the point S3, the auto-stereoscopic image aprears.

Design of the System

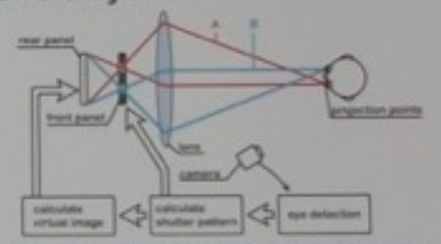


Fig. The simple block diagram of the 3D display

Two LCD panels

The rear LCD panel shows the auto-stereoscopic image and the front transparent LCD panel shows the slit image.

Lens

The lens makes the projected real image by merging the images on these LCD panels.

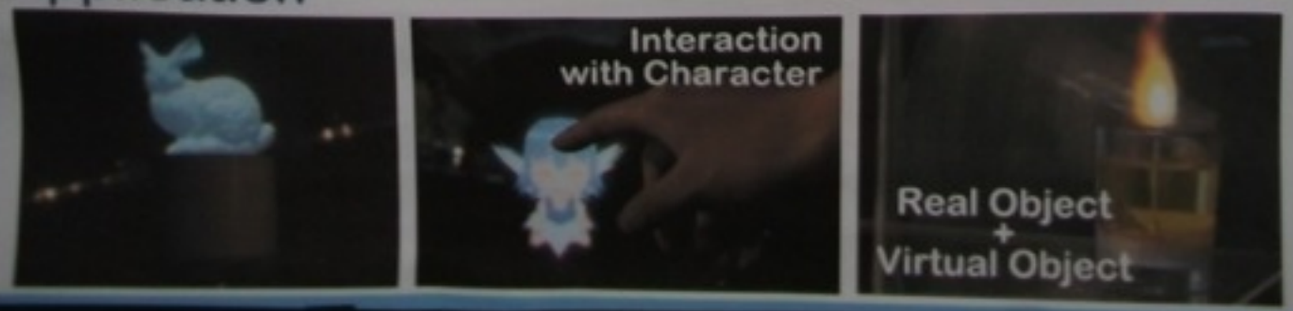
The shutter pattern of the front LCD

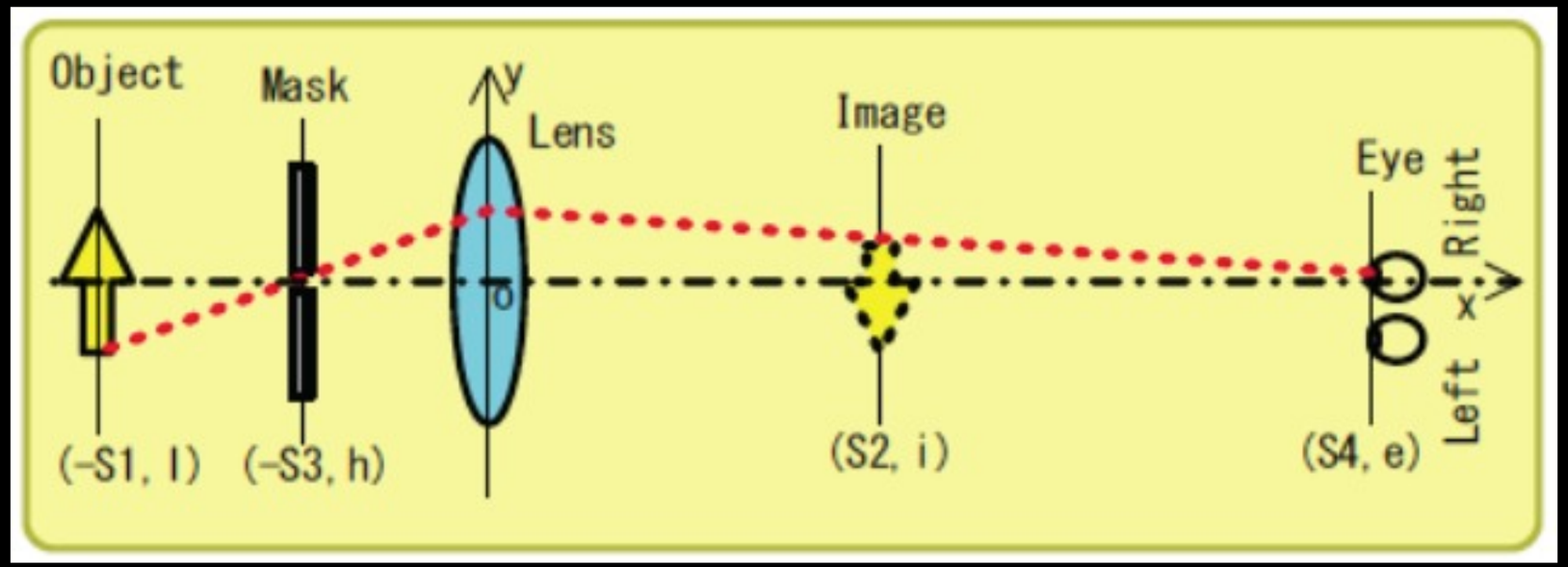
The shutter pattern controls the projection area of the auto-stereoscopic image, like the 3D shutter glasses.

Eye Tracking System

Viewer's head position is detected by Kinect, so the suitable position of the slit and the viewing angle of the auto-stereoscopic image can be calculated.

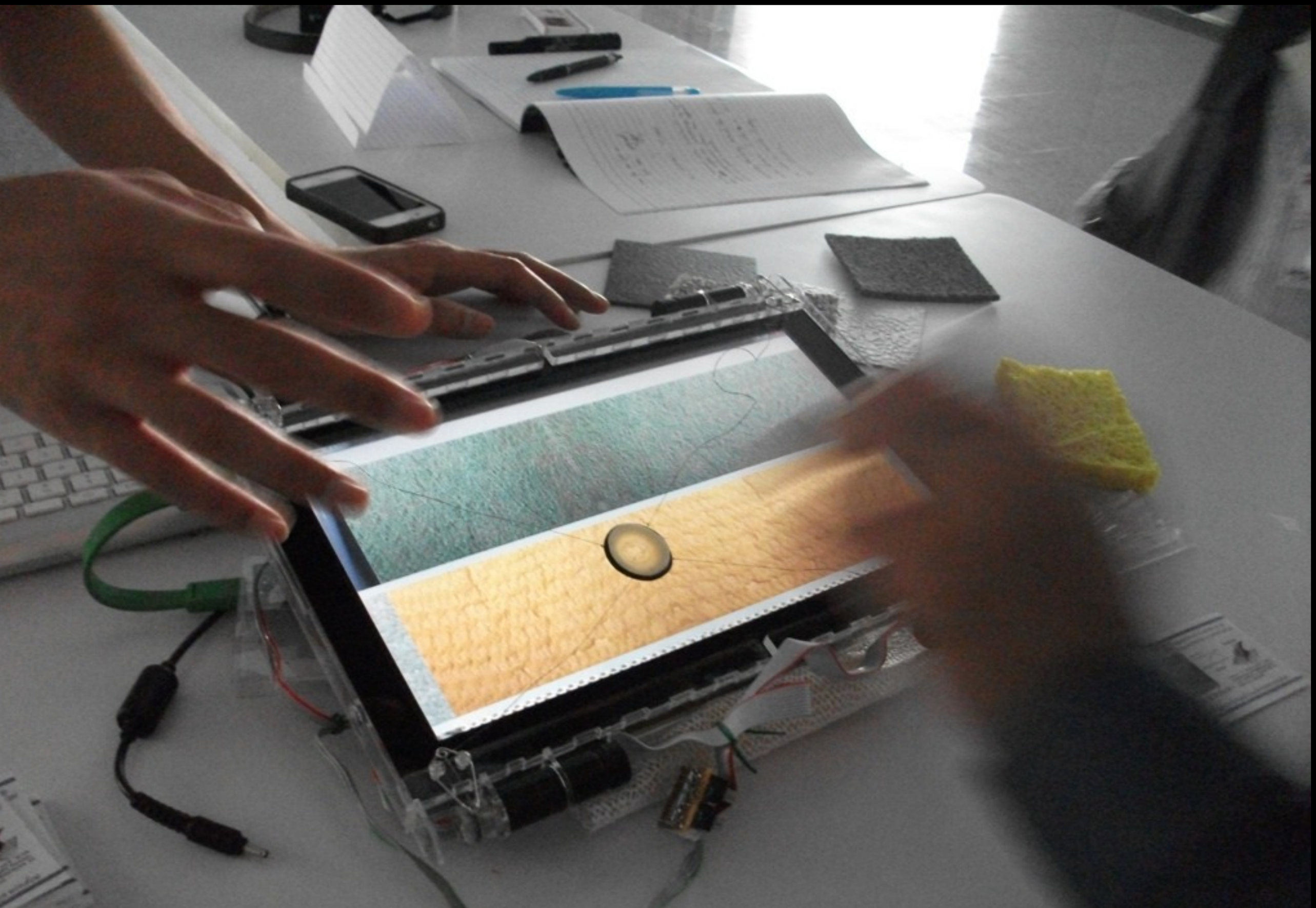
Application

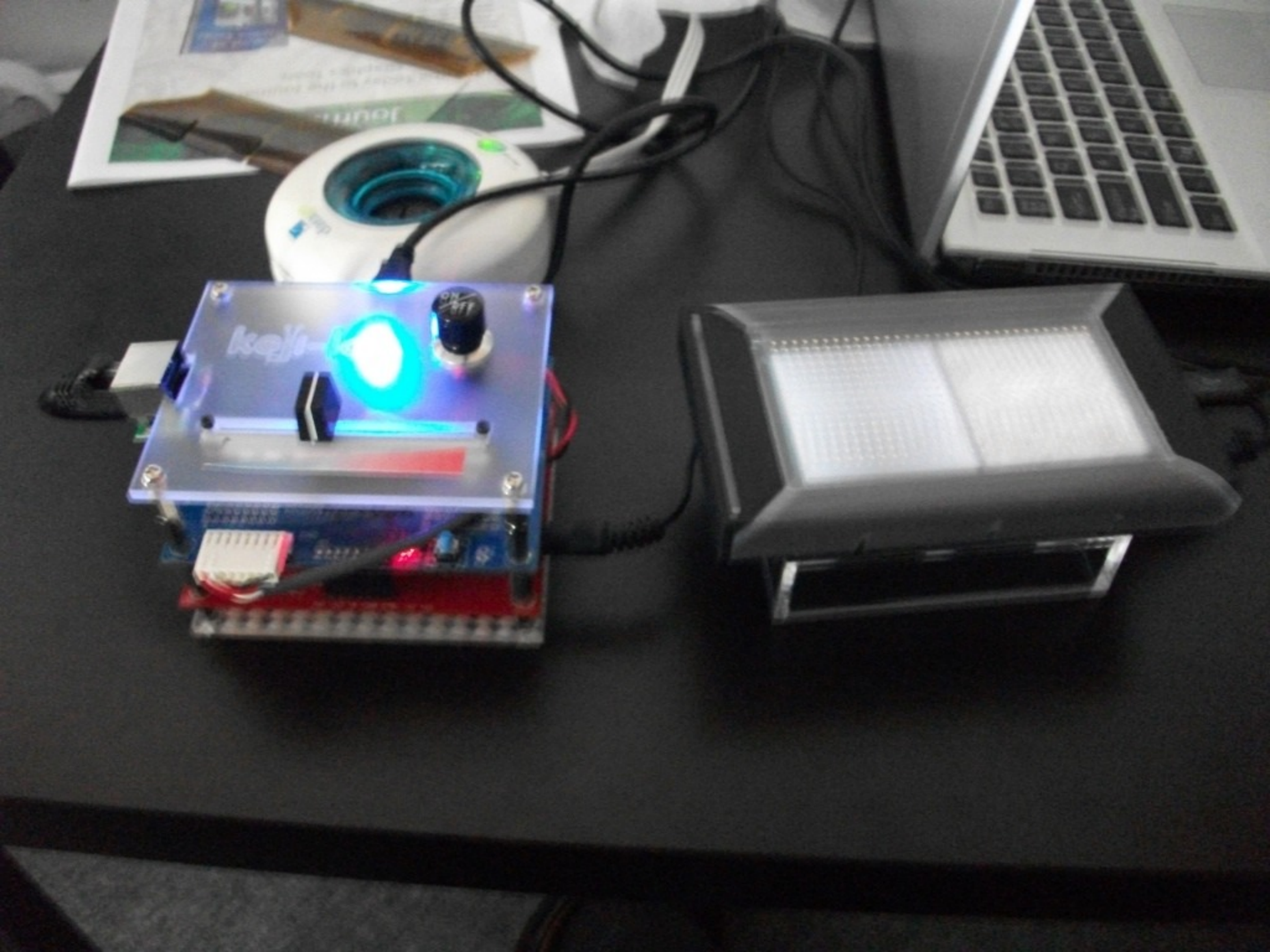



Object
Mask
y
Lens
Image
Eye
Right
x
Left
(-S1, I)
(-S3, h)
o
(S2, i)
(S4, e)

Poster +
Emerging technology

Emerging technology “theme”: touch





Papers: Video Enhanced Gigapixel Panoramas

- Add localised motion to gigapixel images.
- Video region may move across the image.
- Best of both worlds:
  - video has poor spatial resolution
  - gigapan images have poor temporal resolution.
- Key to the work is the video registration/blending, and their interactive viewer.

Sören Pirk
University of Konstanz

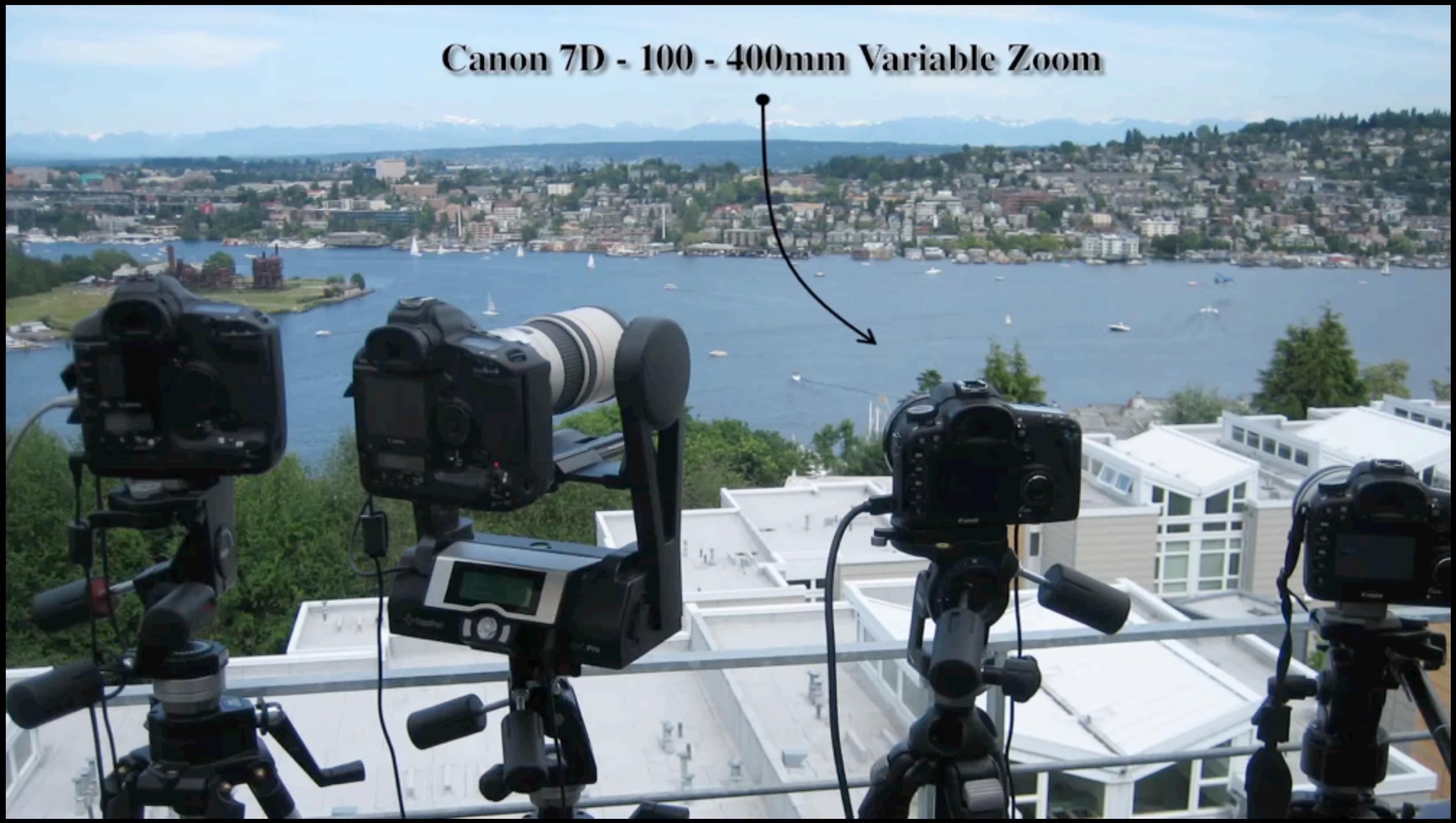
Michael F. Cohen
Microsoft Research

Oliver Deussen
University of Konstanz

Matt Uyttendaele
Microsoft Research

Johannes Kopf
Microsoft Research

Figure 1: *A gigapixel image with integrated sparse video clips. Combining high-resolution images with embedded video (example frames in the top row) allows users to explore complex scenes in a new way.*


Canon 7D - 100 - 400mm Variable Zoom

Papers: Real or Fake? Human Judgments about Photographs and Computer-generated Images of Faces

- Determine factors that cause people to to perceive images as real or CG.
- Concentrated on faces
- Outcomes
  - help cognitive scientists discover the mechanisms that underlie judgements of realism
  - help CG artist create more realistic characters
  - improve computational models in image forensics
- “One key finding was that participants discriminated between photos and CG images best for original images, less well for grayscale images, and worst for reflectance images. This suggests that shading may be more important than colour for judgments about visual realism.“
- Also experts outperformed non-expert but only for greyscale images.

Shaojing Fan
Ningbo University

Tian-Tsong Ng *
I^{2}R, A*STAR

Jonathan S. Herberg
IHPC, A*STAR

Bryan L. Koenig
IHPC, A*STAR

Shiqing Xin
Ningbo University

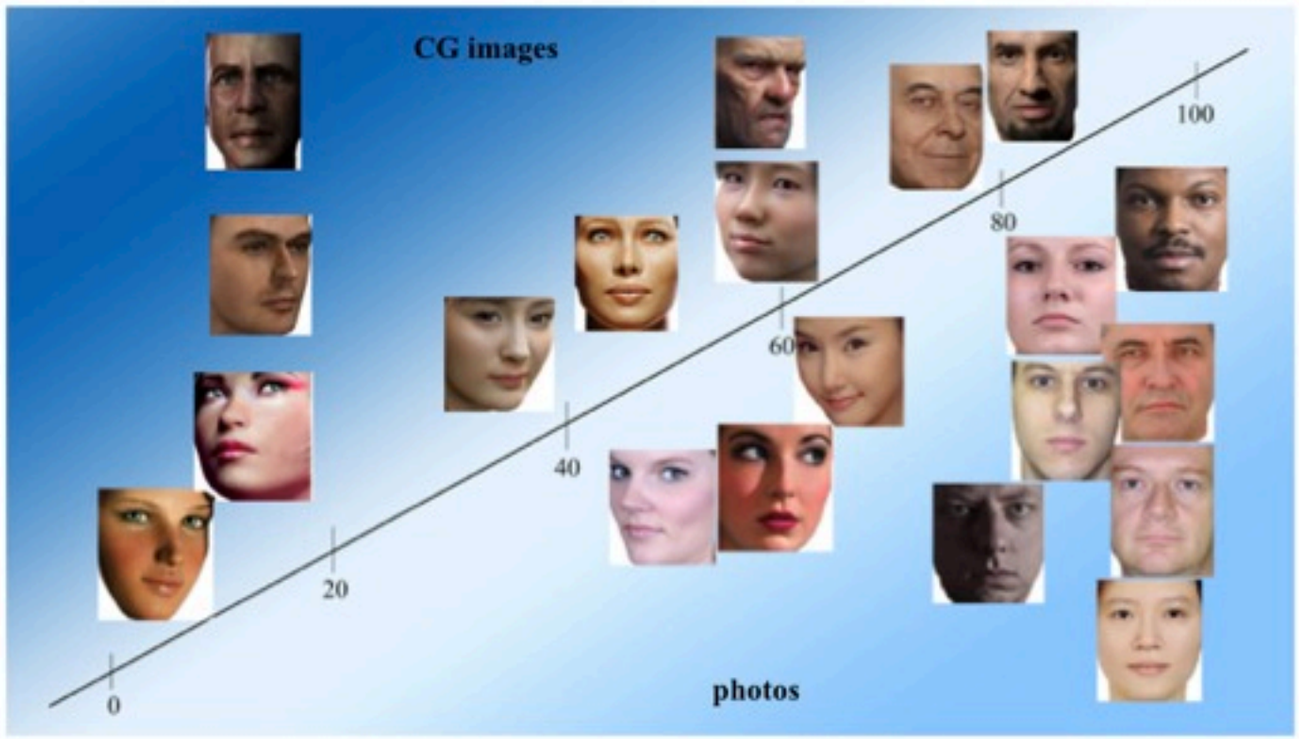
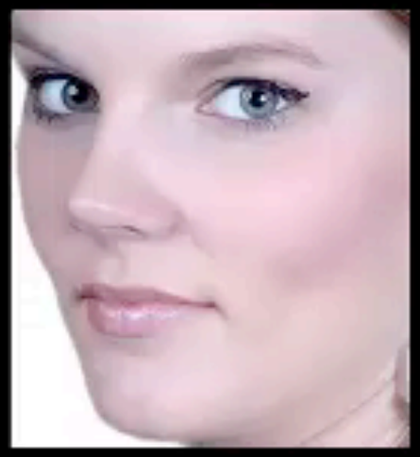
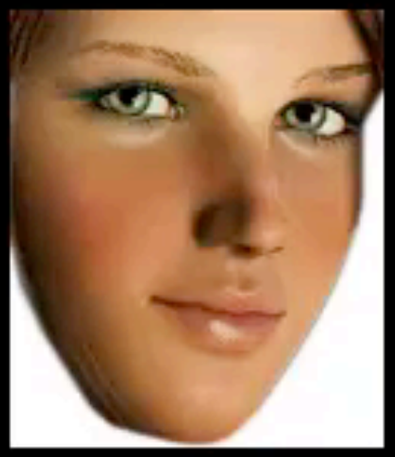


Figure 1: *A psychophysical experiment explored factors underlying human judgments of visual realism for face images. The figure shows subjective realism score of 10 photo-realistic computer-generated (CG) images and 10 photos of faces. CG images are above the scale and photos below it. Overall, photos were judged to be more realistic than CG images.*

Our aim is to identify factors that influence visual realism for images of faces

Which of them are real? Which are fake?

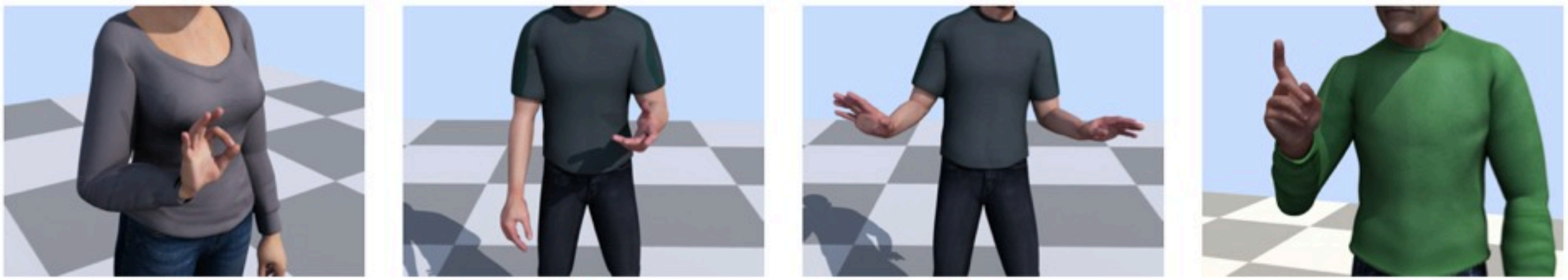
Paper: Data driven finger motion synthesis for gesturing characters

- "In a controlled environment, we carefully captured and post-processed finger and body motions from multiple actors. To augment the body motions of virtual characters with plausible and detailed finger movements, our method selects finger motion segments from the resulting database taking into account the similarity of the arm motions and the smoothness of consecutive finger motions."
- "Our key observation is that plausible finger motions can be inferred from the wrist motion."

Sophie Jörg*
Carnegie Mellon University
Clemson University

Jessica Hodgins†
Carnegie Mellon University
Disney Research, Pittsburgh

Alla Safonova‡
Disney Research, Pittsburgh



(a) (b) (c) (d)

Figure 1: *Animations with synthesized finger motions: (a) ok gesture, (b)-(c) extracts from a conversation, (d) attention gesture.*

Art + emerging technology

Siggraph Asia in Hong Kong in 2013

Tuesday November 19 - Friday November 22