Taking Augmented Reality out of the Laboratory and into the Real World

Dr Christian Sandor
Director: Magic Vision Lab

Visiting Associate Professor: Tohoku University (Japan)

Senior Lecturer:
School of Information Technology & Mathematical Sciences
University of South Australia

1975-2005: TU Munich

1975-2005: TU Munich

1975-2005: TU Munich
2004: Columbia University (7 months)

1975-2005: TU Munich
2004: Columbia University (7 months)

1975-2005: TU Munich
2004: Columbia University (7 months)
2005-2007: Canon Japan

1975-2005: TU Munich
2004: Columbia University (7 months)
2005-2007: Canon Japan
2008: TU Graz (2 months)

1975-2005: TU Munich
2004: Columbia University (7 months)
2005-2007: Canon Japan
2008: TU Graz (2 months)
since 2008: University of South Australia

1975-2005: TU Munich
2004: Columbia University (7 months)
2005-2007: Canon Japan
2008: TU Graz (2 months)
since 2008: University of South Australia
2012: Stuttgart University (6 months)

1975-2005: TU Munich
2004: Columbia University (7 months)
2005-2007: Canon Japan
2008: TU Graz (2 months)
since 2008: University of South Australia
2012: Stuttgart University (6 months)
since 2013: Tohoku University

LAB MAGIC VISION

Students

4 PhD
1 Honours
3 Research Associates
3 Interns

Research

Augmented Reality (AR)
Human-Computer Interaction
Haptics
Visualization

Current Sponsors

SAMSUNG NVIDIA

Previous Sponsors

Canon
NOKIA

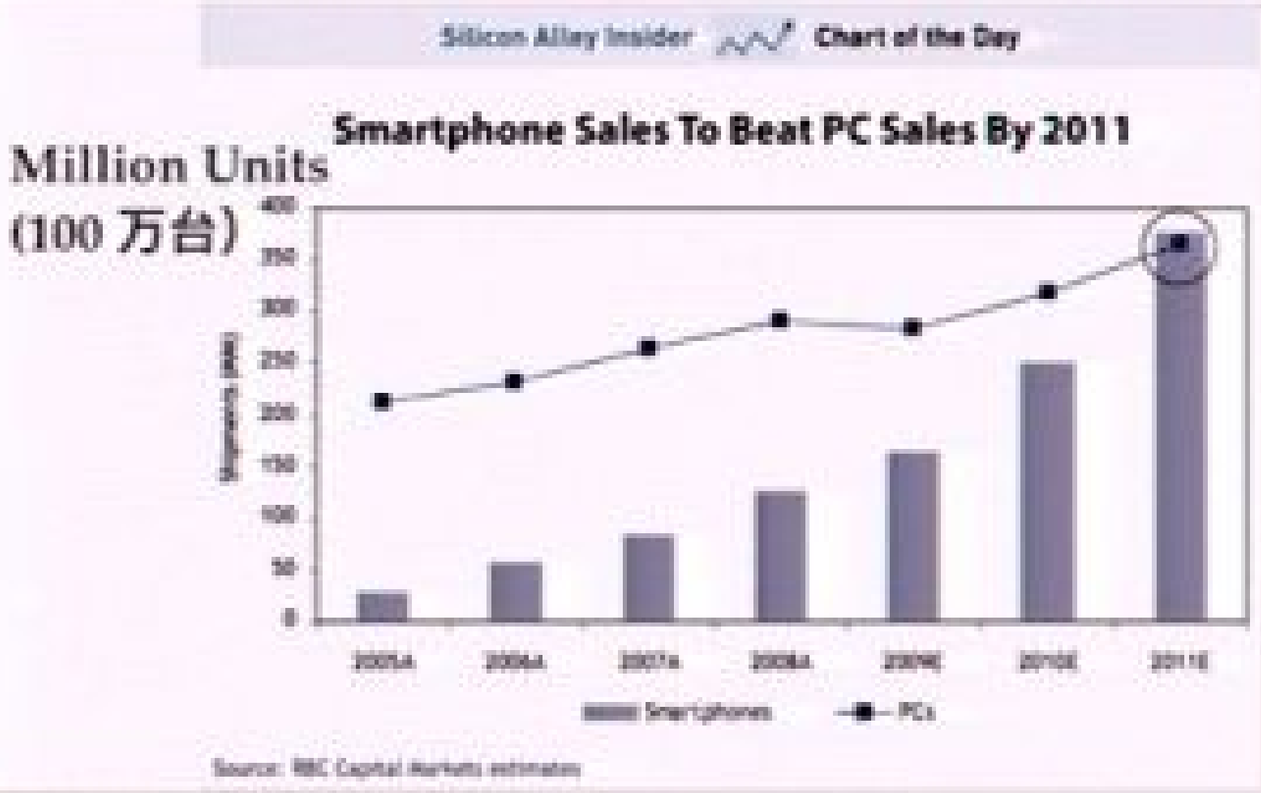
Augmented Reality Example

Demo: Tracker by Gerhard Reitmayr (TU Graz, Austria), used in:

Arindam Dey, Graeme Jarvis, **Christian Sandor**, and Gerhard Reitmayr. Tablet versus Phone: Depth Perception in Handheld Augmented Reality. *IEEE International Symposium on Mixed and Augmented Reality*, 2012. ***Best Paper Award Nominee***


2:58 PM
GPUTrace
QJulia Lite
FOV2G... Lab
Monkey
HelloApple
RayMarcher
PanoManip
MagicLens
PanoLK
PanoShader
Remote
Phone
Safari
Music
Skype

Recent AR Trends



Current State of AR:
low-level = solved!

Essential technology: tracking
(where is the camera in the real world?)

ARToolkit [Kato & Billinghurst, 1999]

Going Out [Reitmayr & Drummond, ISMAR 2006]

Parallel Tracking and Mapping for Small AR Workspaces [Klein & Murray, ISMAR 2007]

Panorama Tracker [Wagner & Mulloni et al., VR 2010]

KinectFusion [Newcombe et al., ISMAR 2011]

Model continually refined
(notice holes being filled, and details
such as keys, cables, and screwdriver)


Notice DELL logo
(just a few millimeters high)

Current State of AR: Challenge = High-Level

1. Applications

   Industrial Design (with Canon)
   AR Browser (with Nokia, Samsung, Nvidia)
   Astronautics (with DLR)
   Medical (with Prof. Navab (TU Munich))
   Games
   Other industrial applications (training, maintenance, planning, ...)
   ...

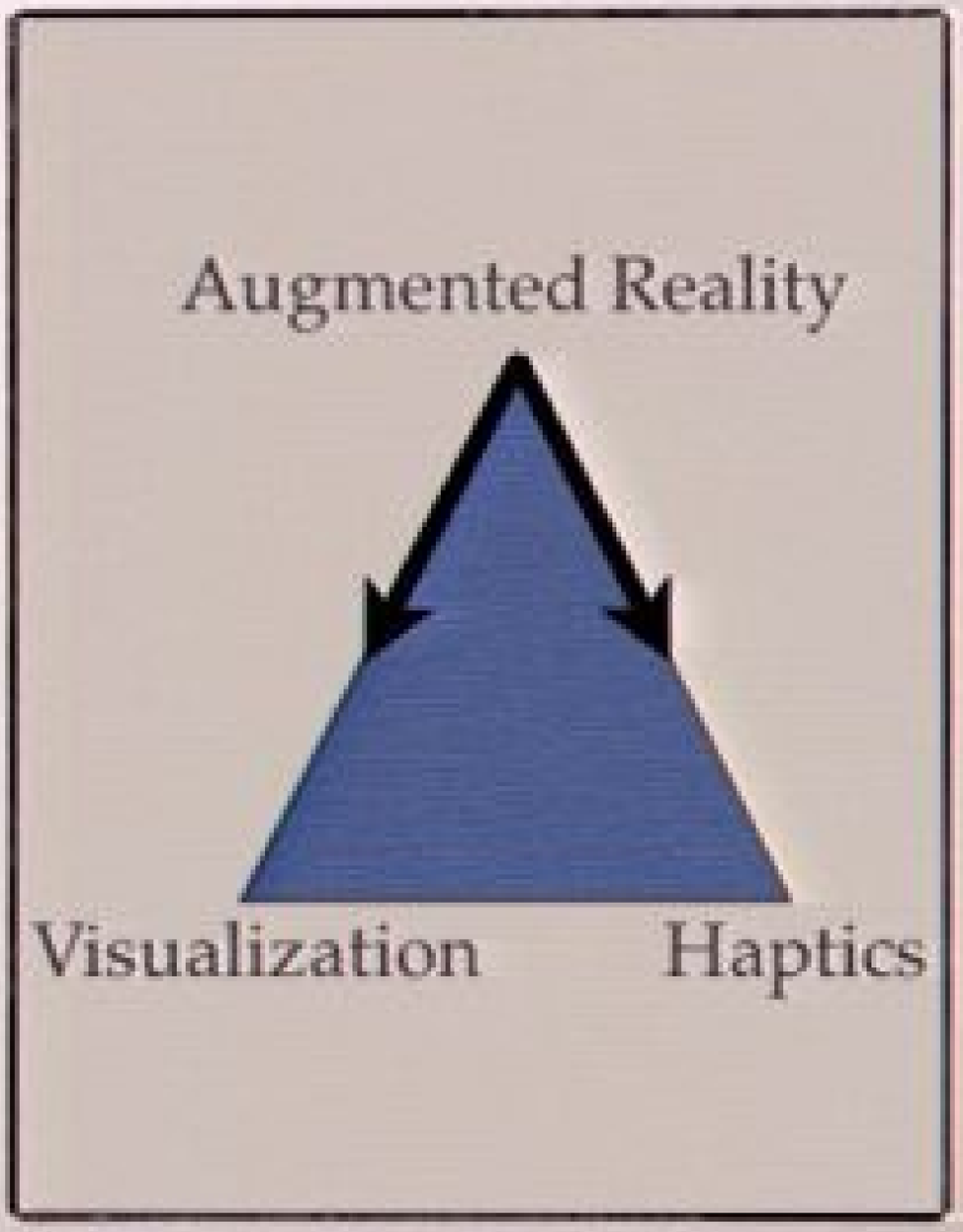
2. Human-Computer Interaction

   Human Perception of AR
   Usability
   Providing *more versatile* AR interfaces

Our Approach

Visualization:
"seeing the unseen"
[McCormick, 1988]

Haptics: AR for the sense of *touch*



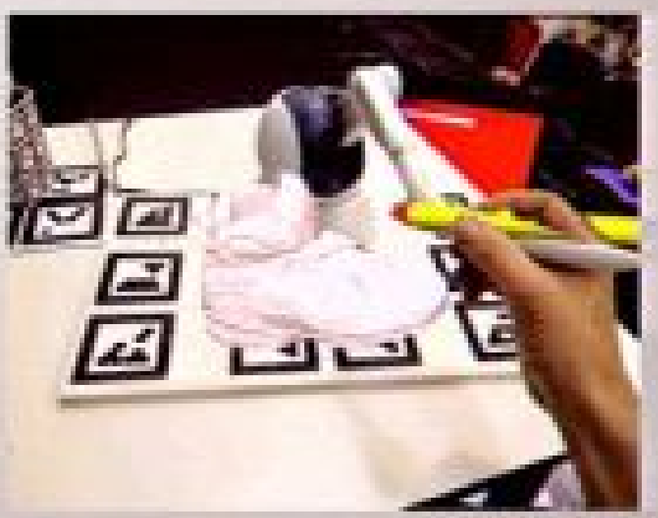
LAB MAGIC VISION

AR & Visualization

SAMSUNG NOKIA NVIDIA.

AR & Haptics

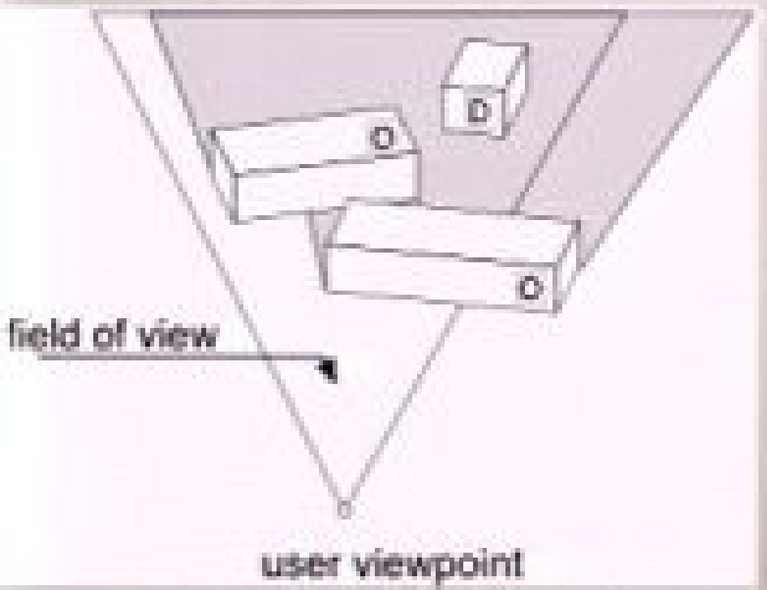
Canon DLR

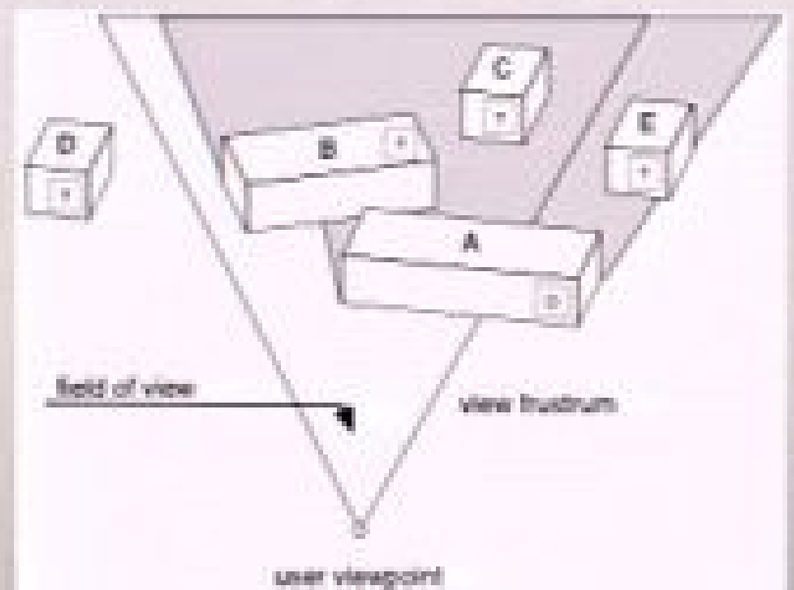


Motivation

Problems with most AR browsers:

- Pieces of **isolated information** instead of one **integrated visualization**
  - Bad ergonomics
  - Small screen problem becomes even worse
  - Extremely limited visualizations
- Challenging: occlusions, small field of view





EDGE-BASED X-RAY

Ben Avery, Christian Sandor,
Bruce Thomas.
VR 2009.

Edge-based X-Ray: Limitations

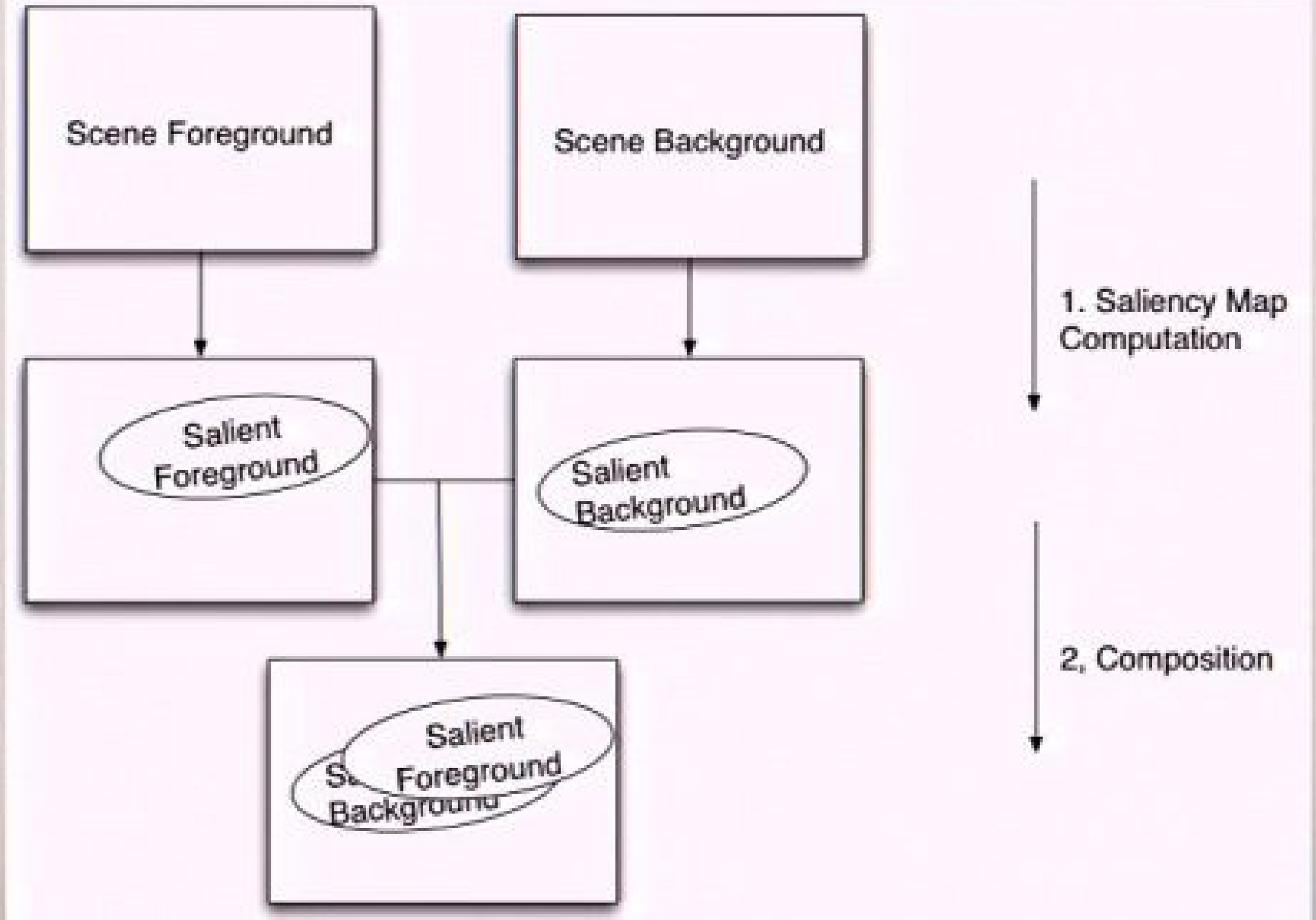
Saliency X-Ray

Sandor et al.
ISMAR 2010

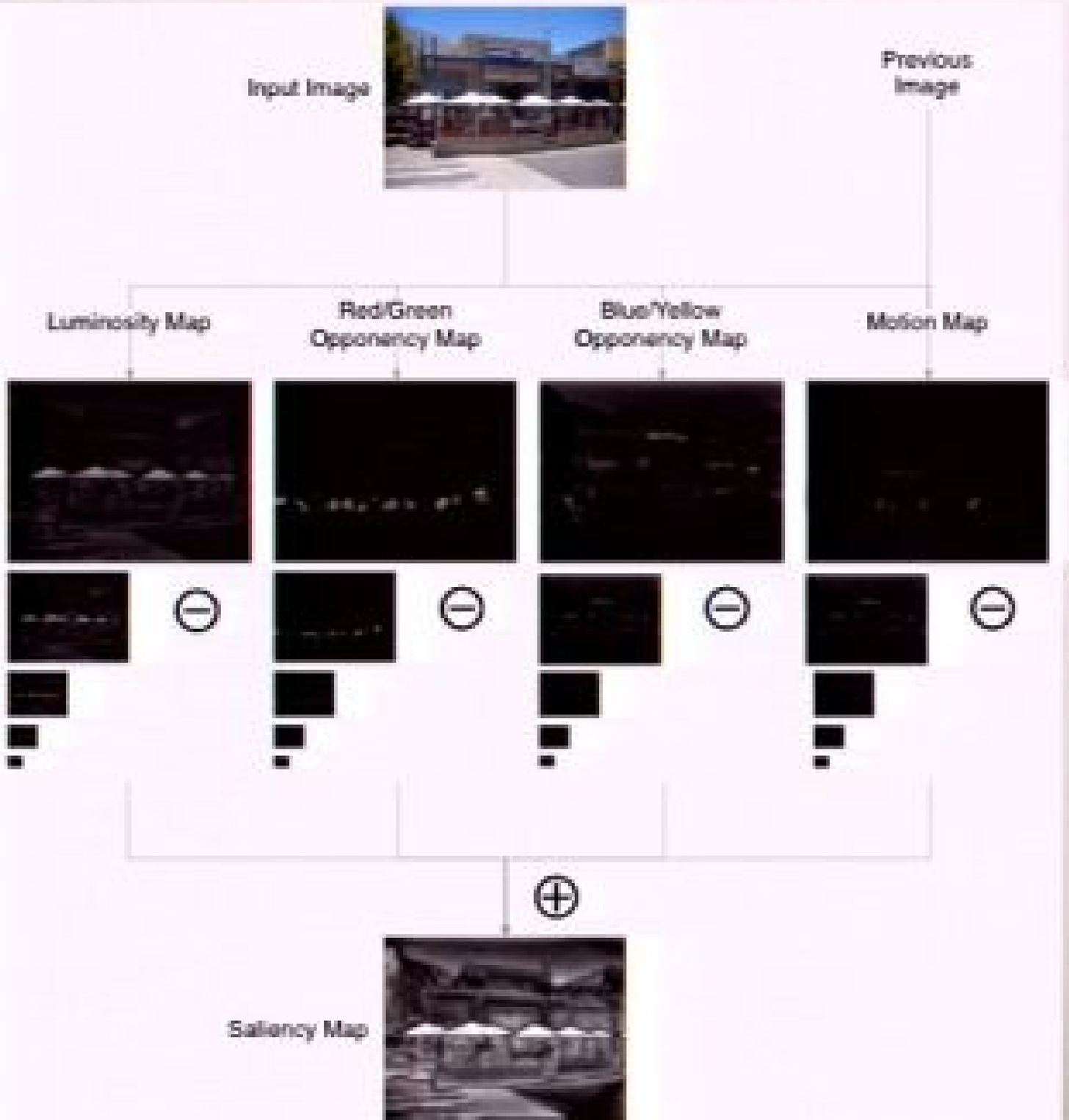
Saliency X-Ray

Sandor et al.
ISMAR 2010

Concept:
Saliency-based X-Ray



Saliency Map Computation

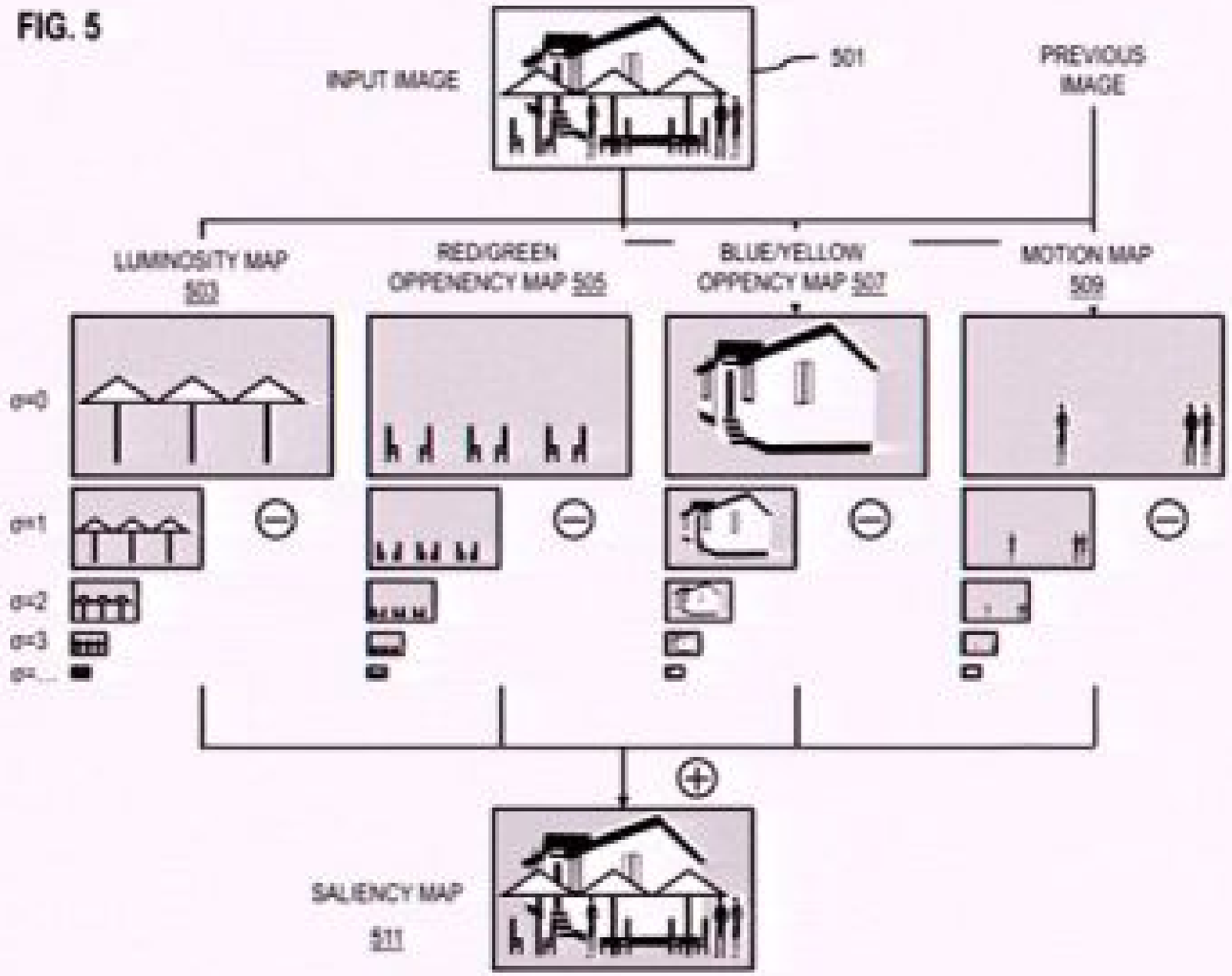


$$F_{f,p,s} = P_p \ominus P_s$$

f ∈ {I,c,m} p ∈ {2,3,4}, s = p+S, S ∈ {3,4}

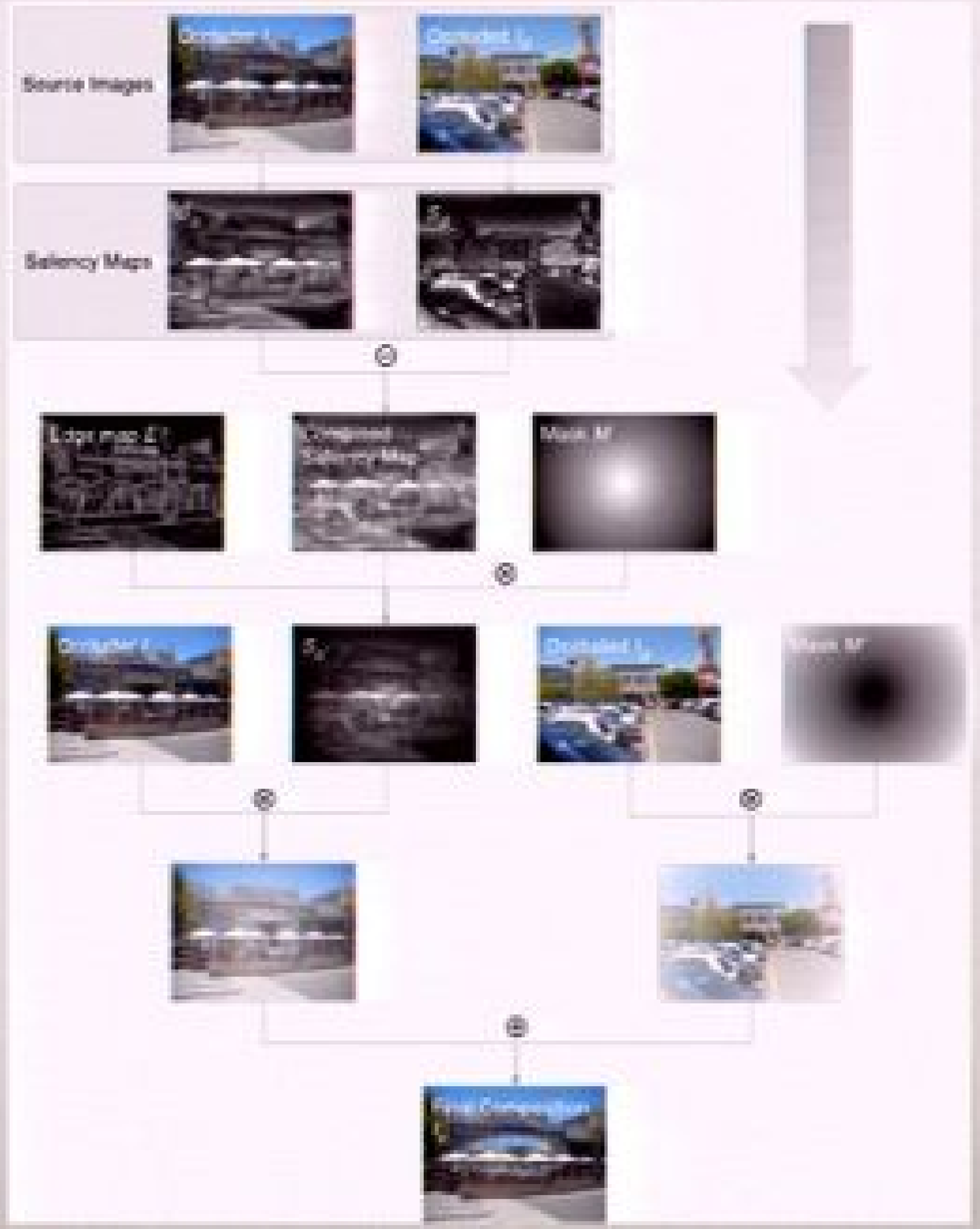
$$S = \frac{1}{3} \sum_{k \in \{I,c,I\}} C_k$$

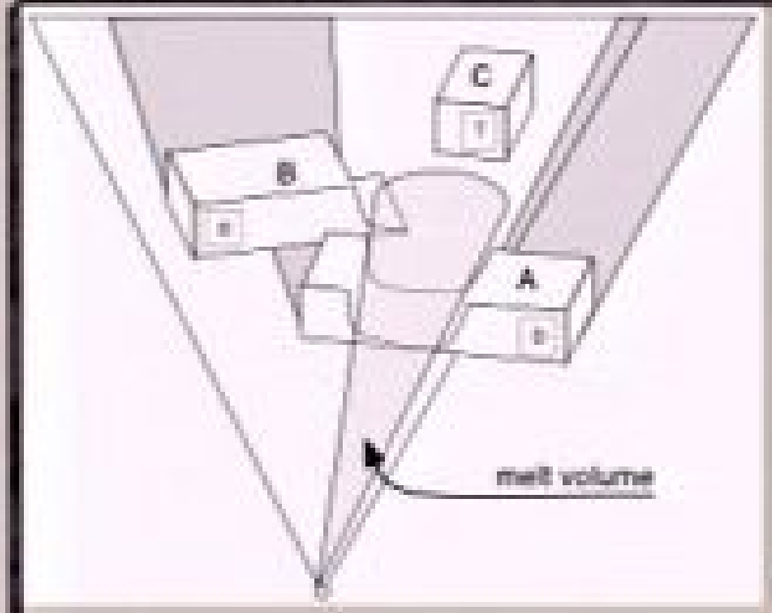
FIG. 5



Christian Sandor, Andrew Cunningham, and Mattila Ville-Veikko. **Method and Apparatus for an** Augmented Reality X-Ray. *US Patent application 12/785,170 (Filed 21 May 2010).* Available online at google patent search: http://goo.gl/ncVzj

Composition

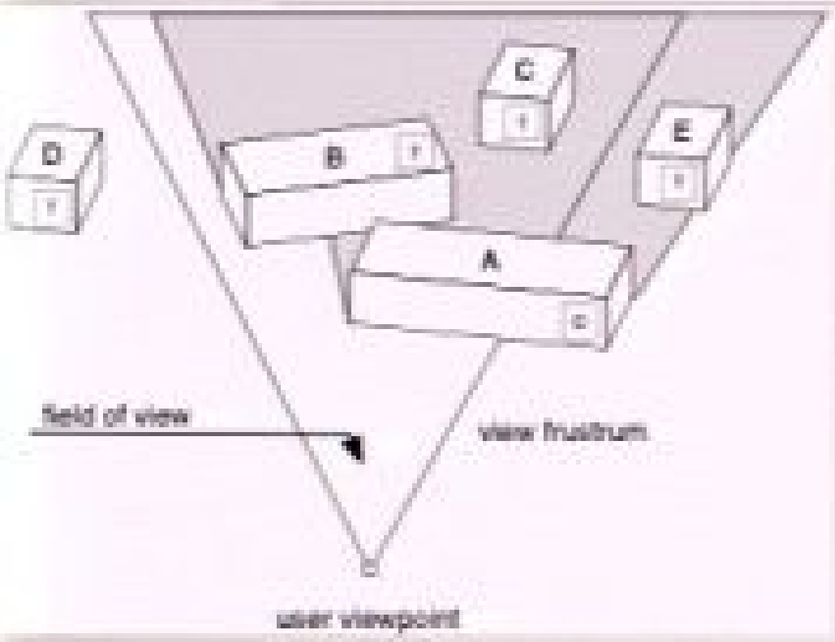




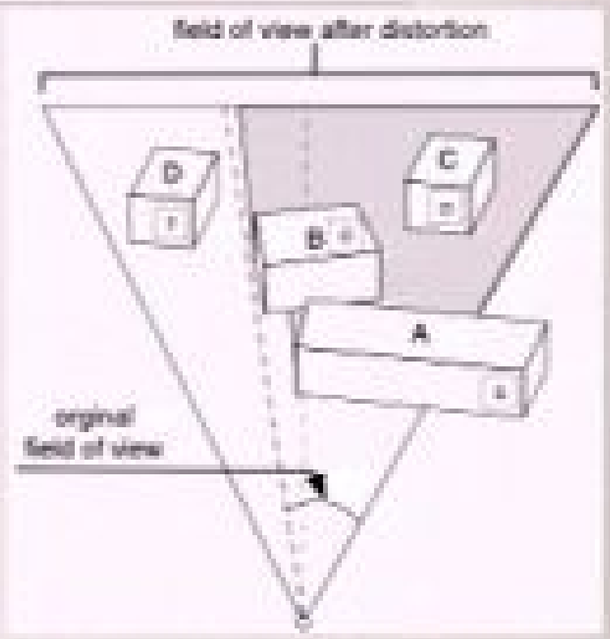
MELTING

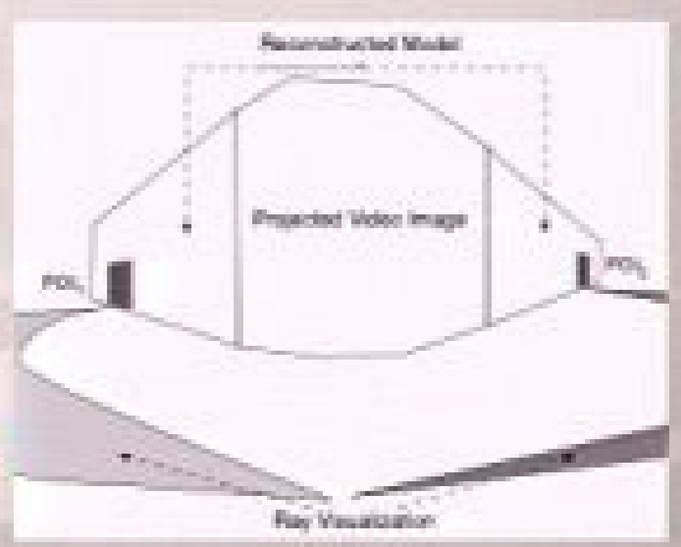
Sandor et al.
ISMAR 2009, VR 2010

Space-Distorting Visualizations
Radial Distortion

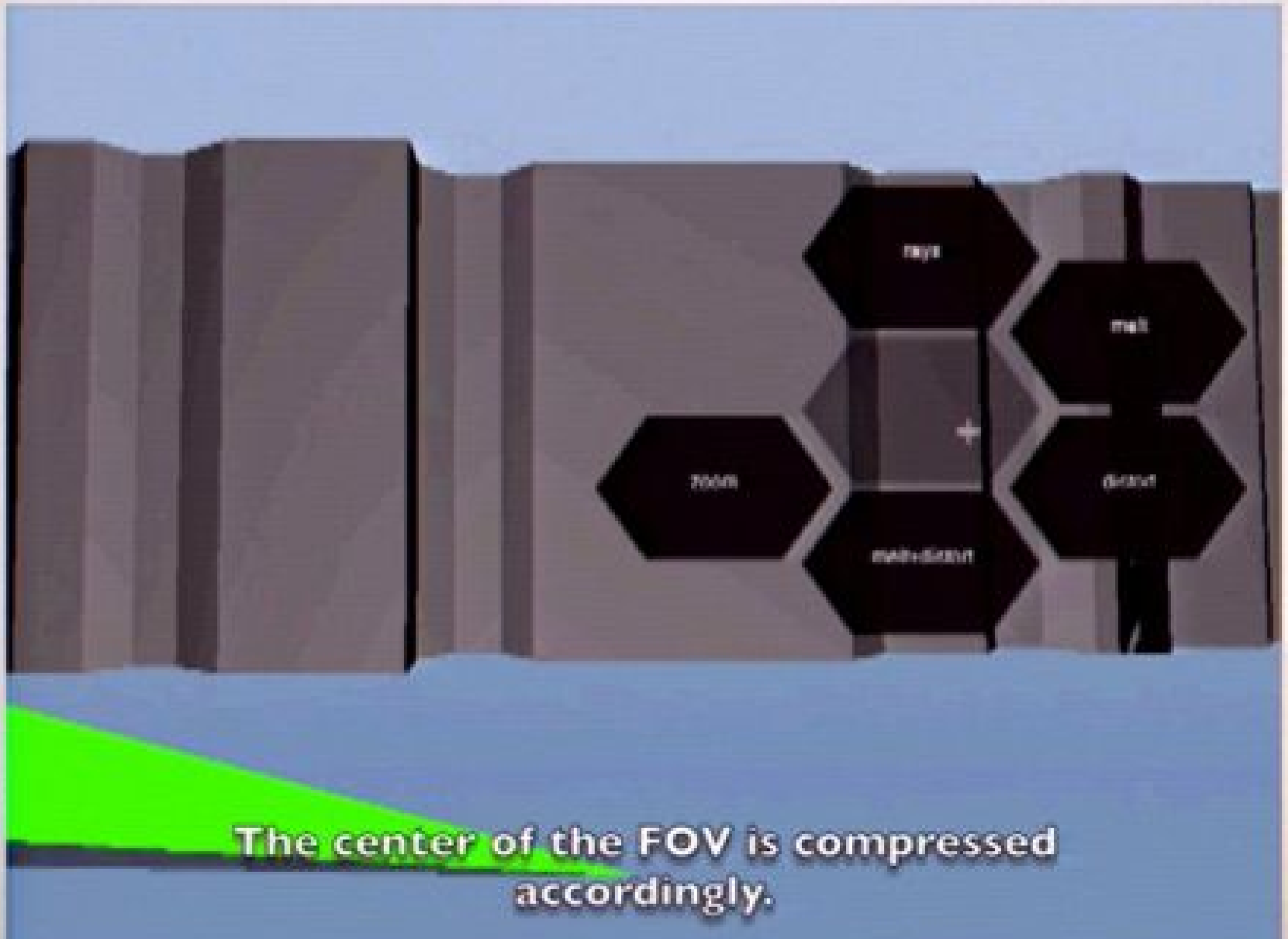


$$r = \begin{cases} \dfrac{\frac{1}{2}FOV}{\arg\min(p_{angle\_min} \mid p \in P)} & \text{for } \gamma \leq 0, \\ \dfrac{\frac{1}{2}FOV}{\arg\max(p_{angle\_max} \mid p \in P)} & \text{for } \gamma \geq 0. \end{cases}$$

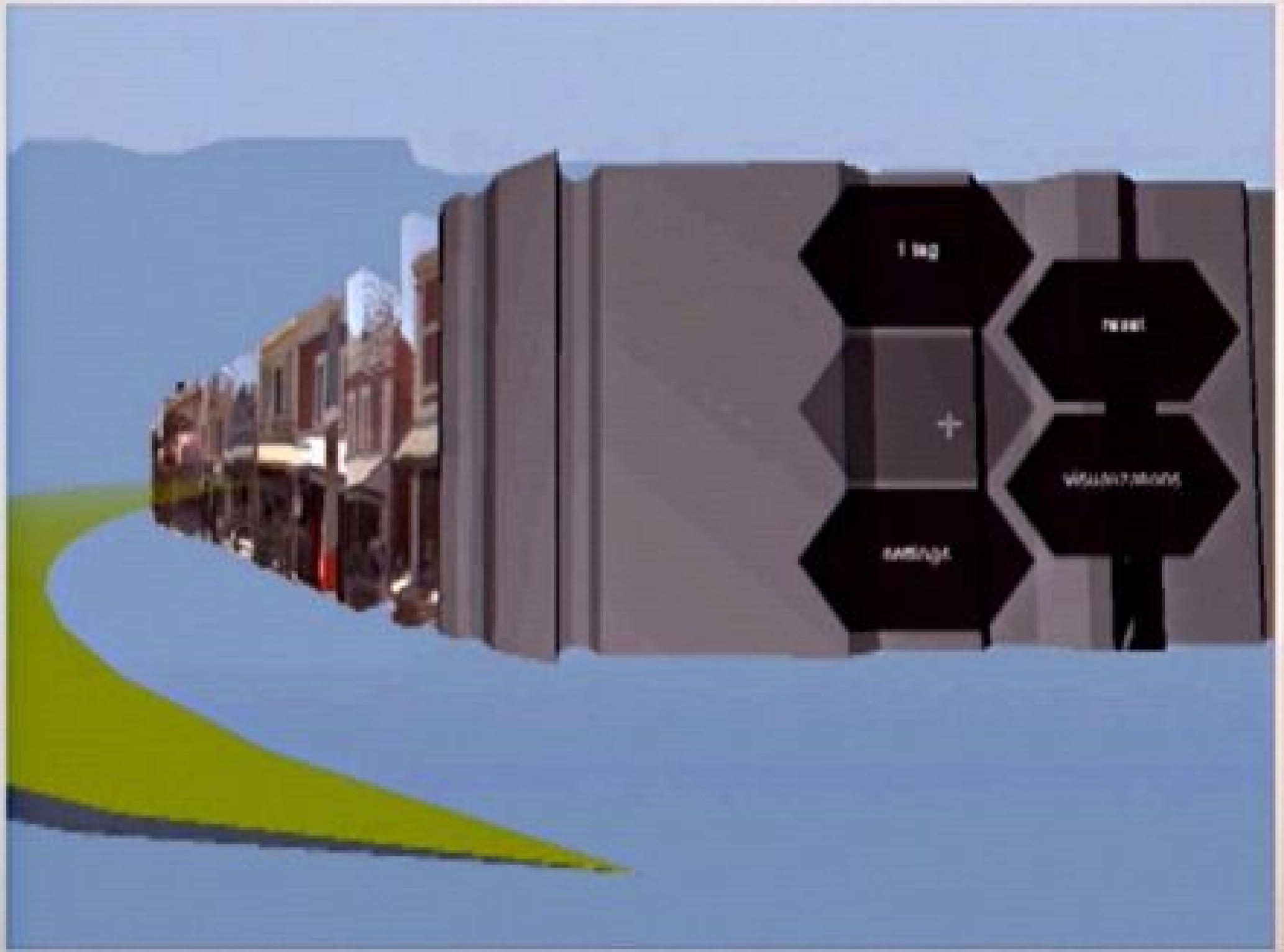




Space-Distorting Visualizations
Radial Distortion



Space-Distorting Visualizations
Radial Distortion

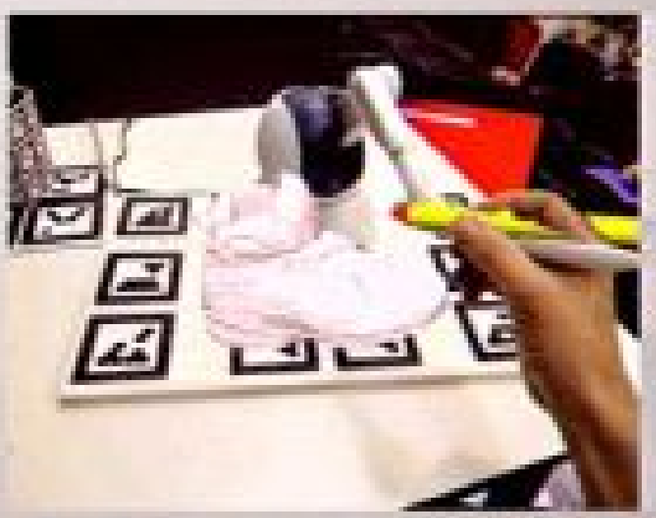


Space-Distorting Visualizations
Radial Distortion

LAB MAGIC VISION

AR & Visualization

AR & Haptics



LAB MAGIC VISION

www.magicvisionlab.com

University of South Australia

School of Computer and Information Science

Advanced Computing Research Centre

courtesy of

Ri Aus

TEDx Adelaide

x = independently organized TED event

Visuo-Haptic Augmented Reality Demo for TEDx

Team: Christian Sandor – Ulrich Eck
Quang Le – Peter Weir
Donald Urquhart

LAB MAGIC VISION

www.magicvisionlab.com

University of South Australia

School of Computer and Information Science

Advanced Computing Research Centre

Next Iteration

Figure 1: Users of our system can rapidly clone and edit real-world objects in our visual-haptic Augmented Reality environment. (a) outside view (b) view through the head-worn display: cloned flowers are being edited through a haptic device. (c) final model after deformation. (d) further example: a virtual hat was added to a cloned person.

Michael Csongei, Liem Hoang, Ulrich Eck, and **Christian Sandor**. ClonAR: Rapid Redesign of Real-World Objects. Poster in *Proceedings of IEEE International Symposium on Mixed and Augmented Reality*, pages 277–278, Atlanta, GA, USA, November 2012. ***Best Poster Runner Up***

Figure 3: The different lighting components used in our raymarcher: (a) diffuse, (b) specular, (c) soft shadows, (d) ambient occlusion, and (e) the final result.

Our ISMAR 2011 Best Demo Award

Collaboration with

Gerhard Reitmayr (TU Graz, Computer Vision)

Matt Swoboda (Sony London, Computer Graphics)

We won against 40 other demos

Top labs: INRIA, Georgia Tech, TU Graz

Top companies: Volkswagen, Sony, Nokia...

Our ISMAR 2011 Best Demo Award

Collaboration with

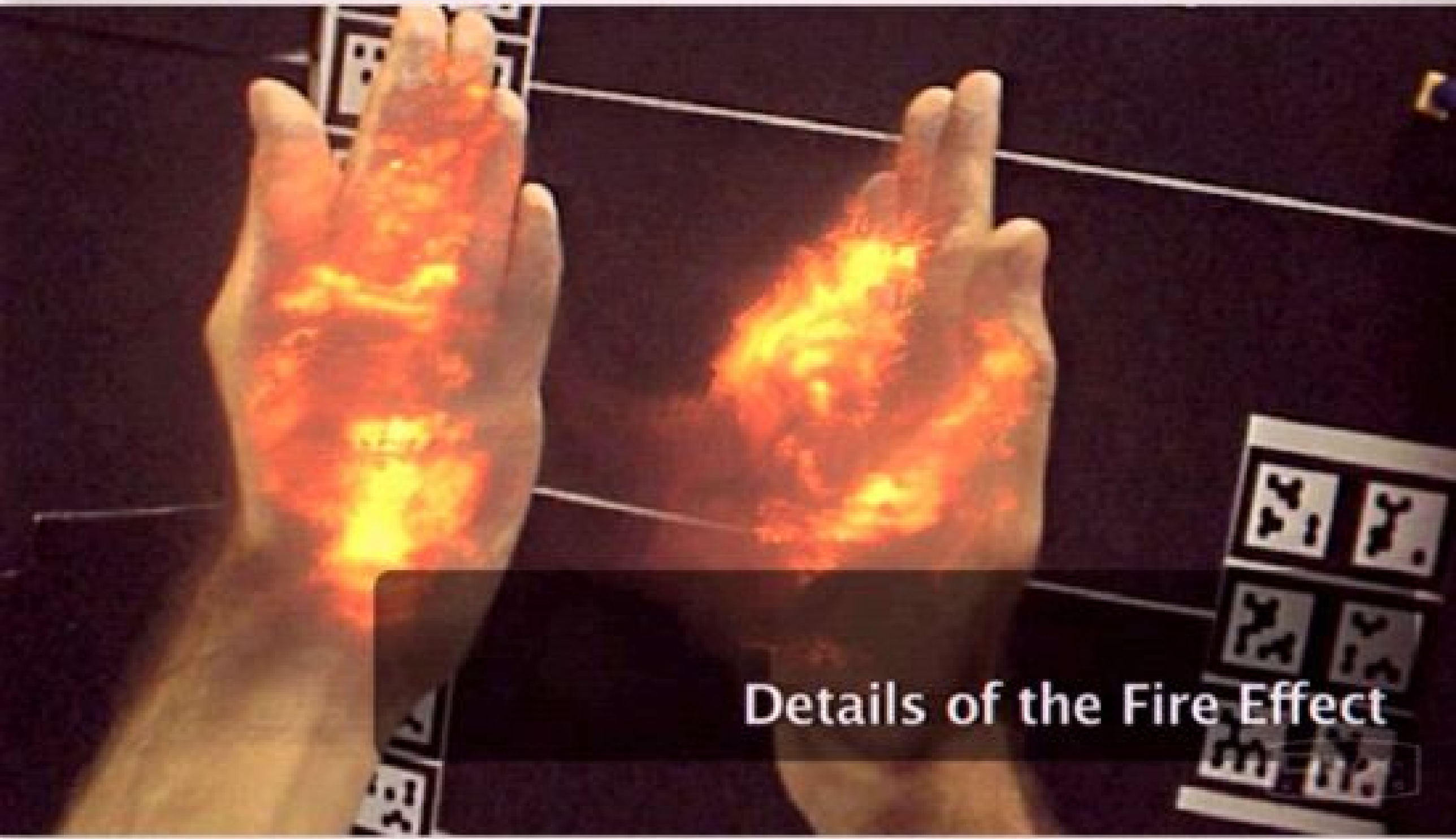
Gerhard Reitmayr (TU Graz, Computer Vision)

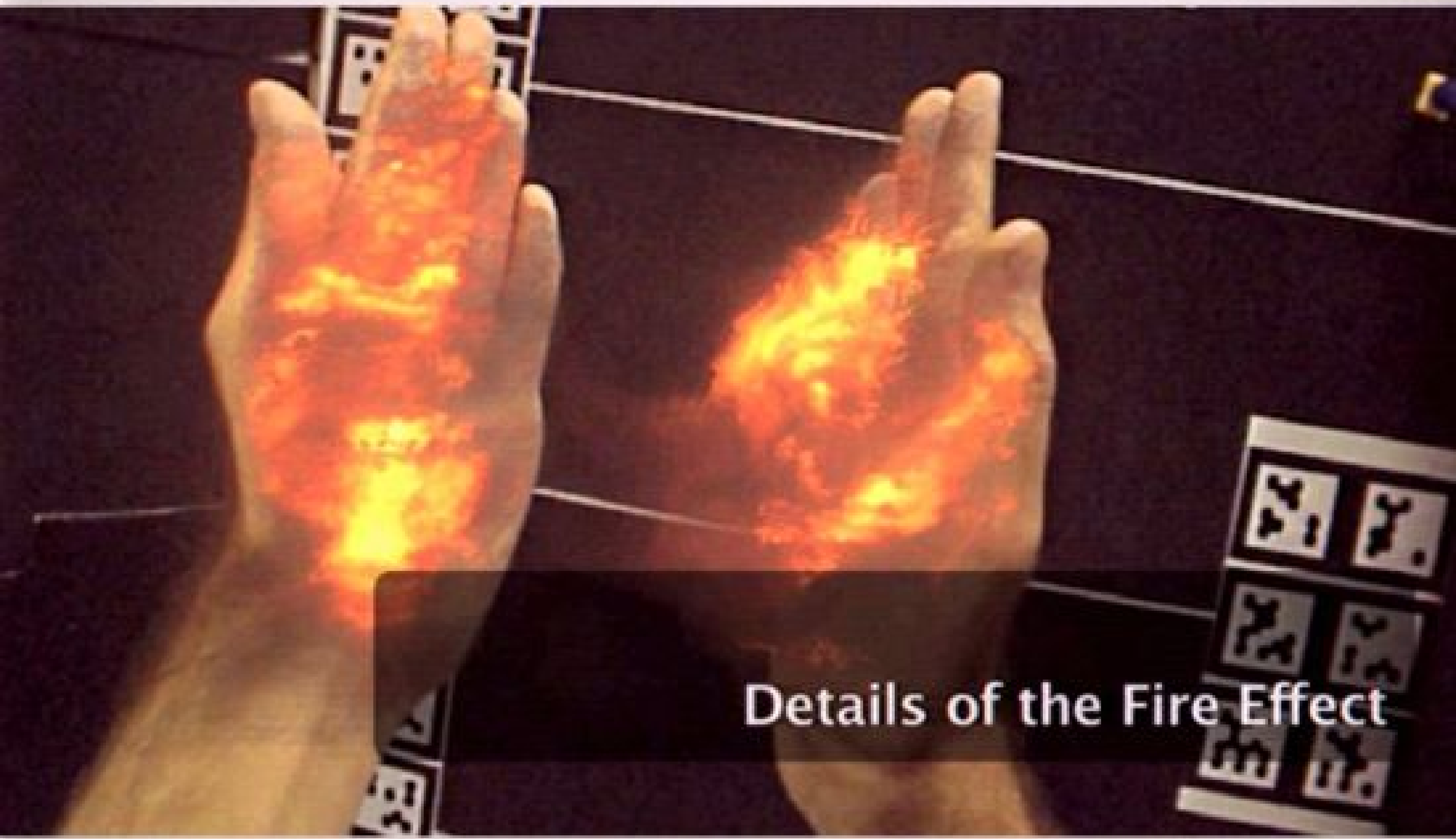
Matt Swoboda (Sony London, Computer Graphics)

We won against 40 other demos

Top labs: INRIA, Georgia Tech, TU Graz

Top companies: Volkswagen, Sony, Nokia...


Details of the Fire Effect


Details of the Fire Effect

Evaluation

At ISMAR, we got very unexpected feedback from users:

20% reported a *heat sensation*

5% reported *smelling fire*

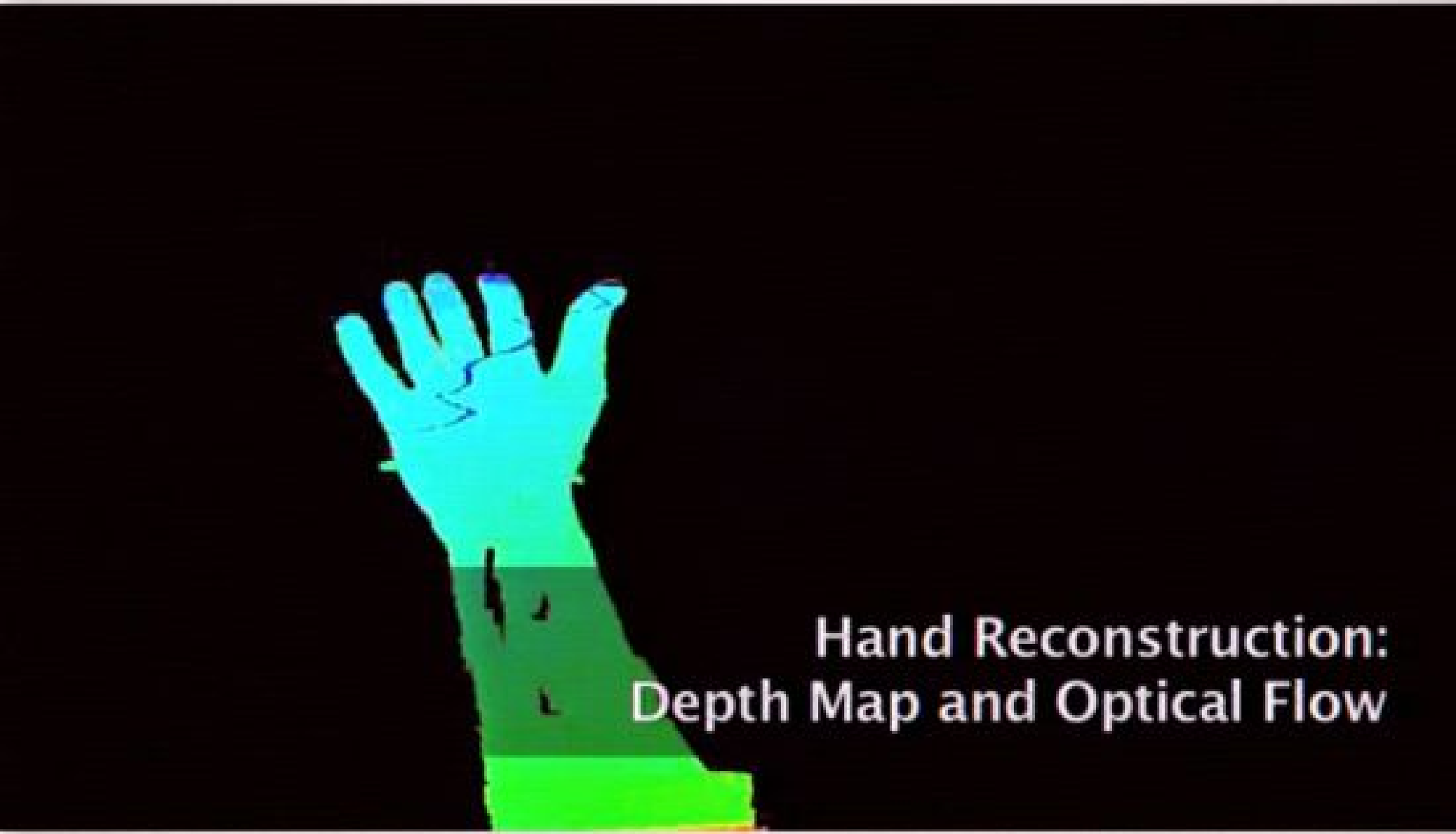
Next: formal evaluation to validate this effect [Weir, Sandor, et al. IEEE VR 2013]

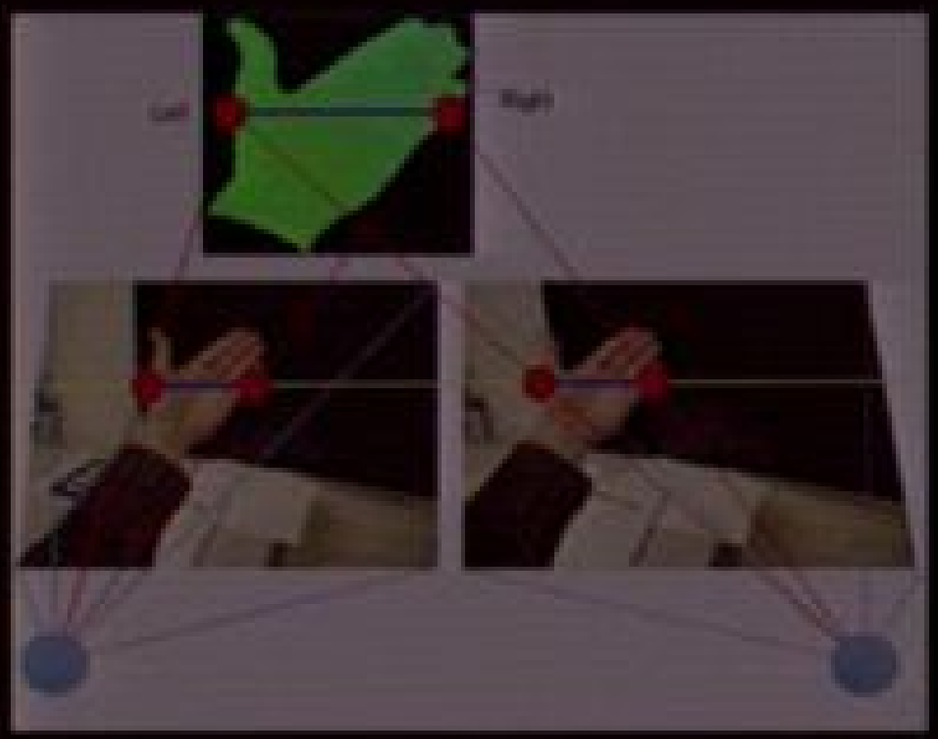
Participant T.:
"fire moves as I move my hands"

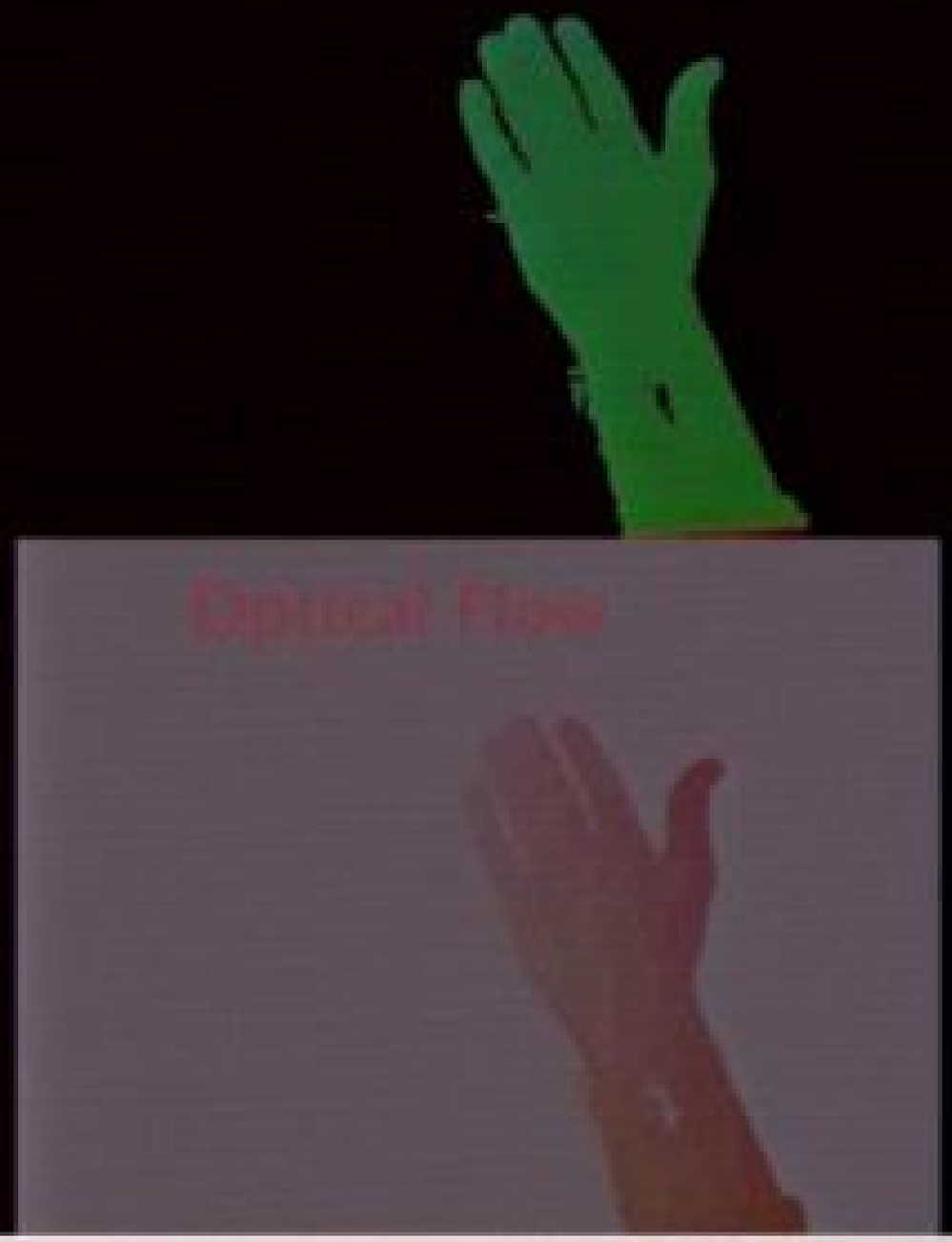
Computer

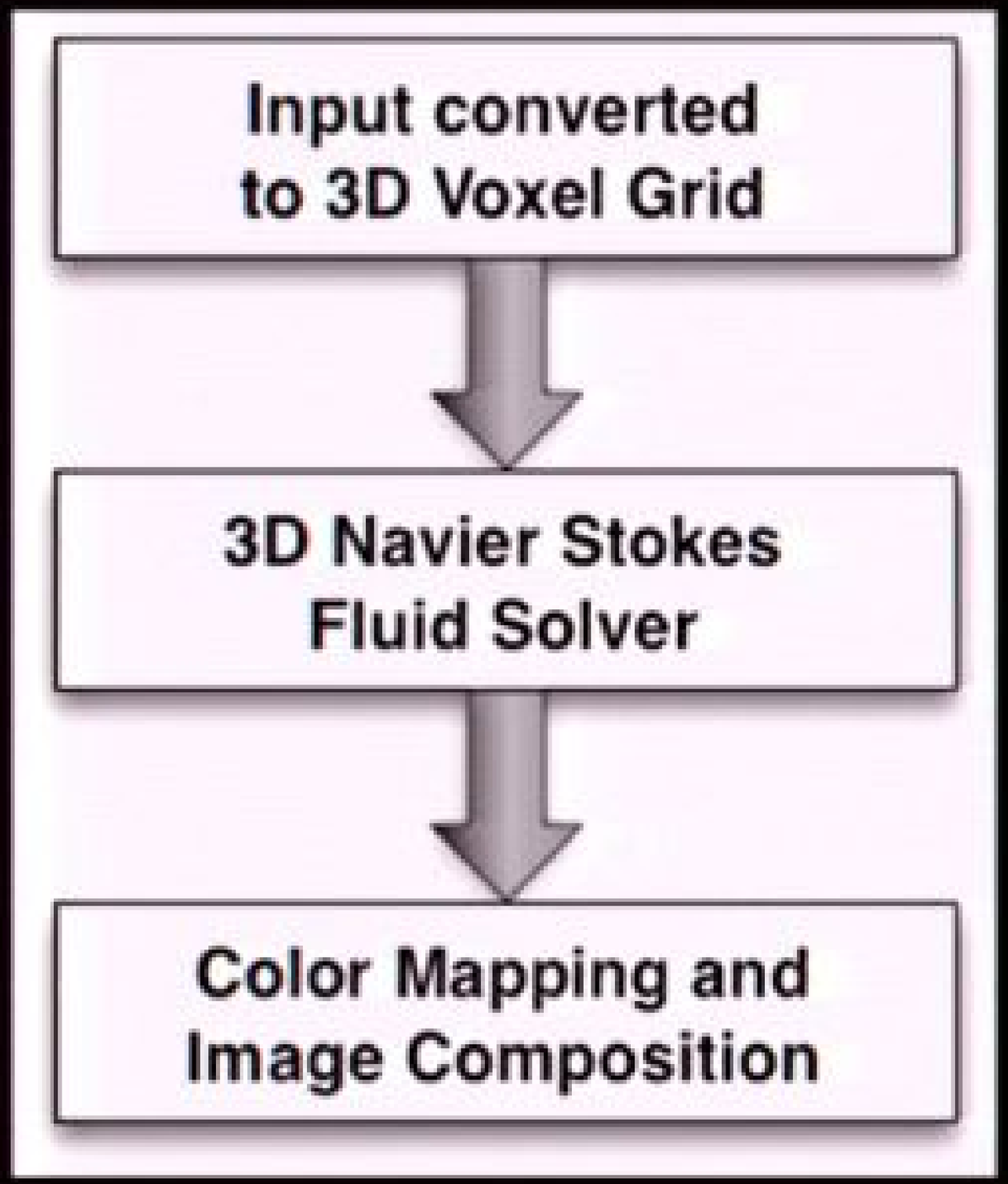
Vision

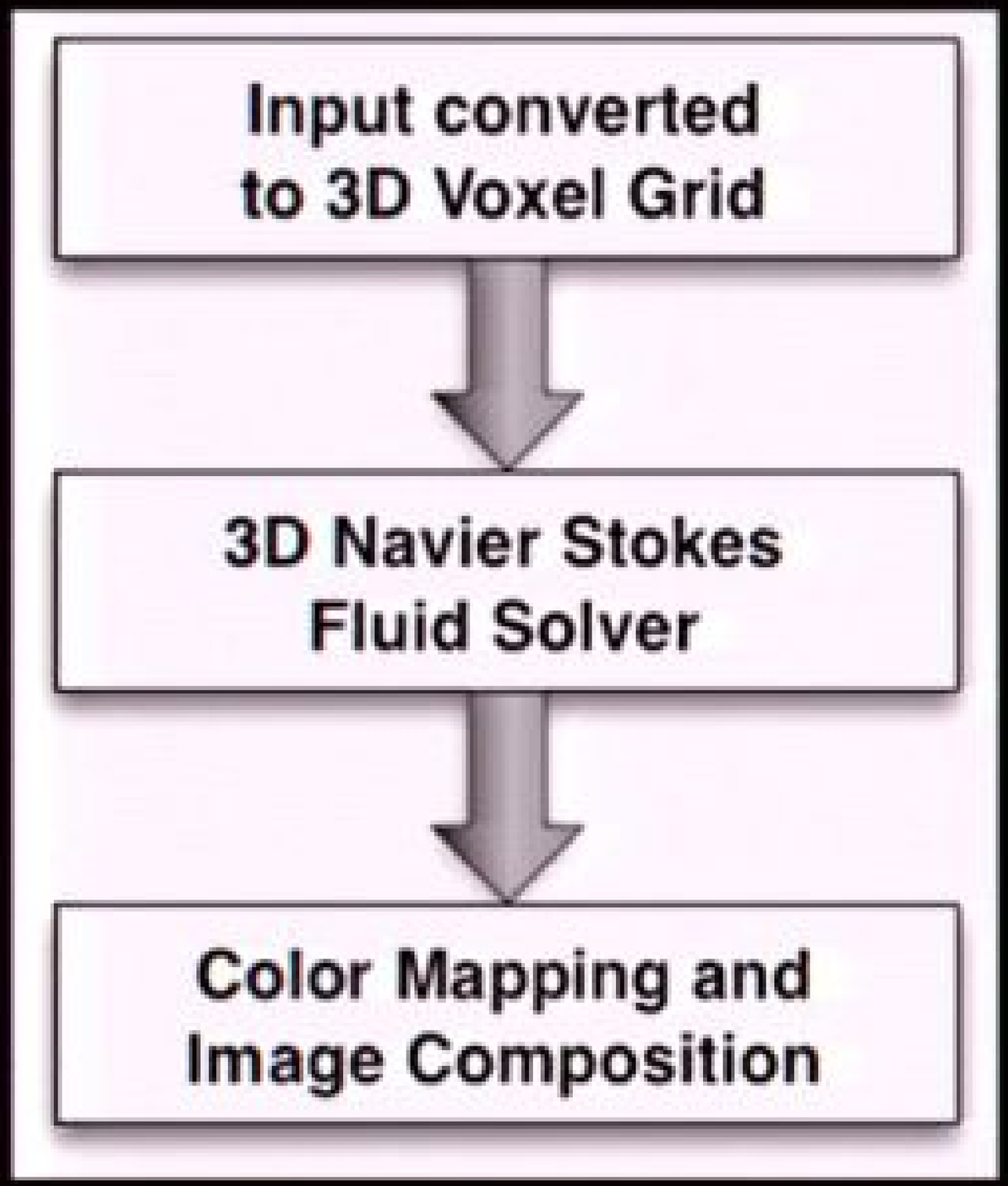

Hand Reconstruction:
Hand Mask Refinement

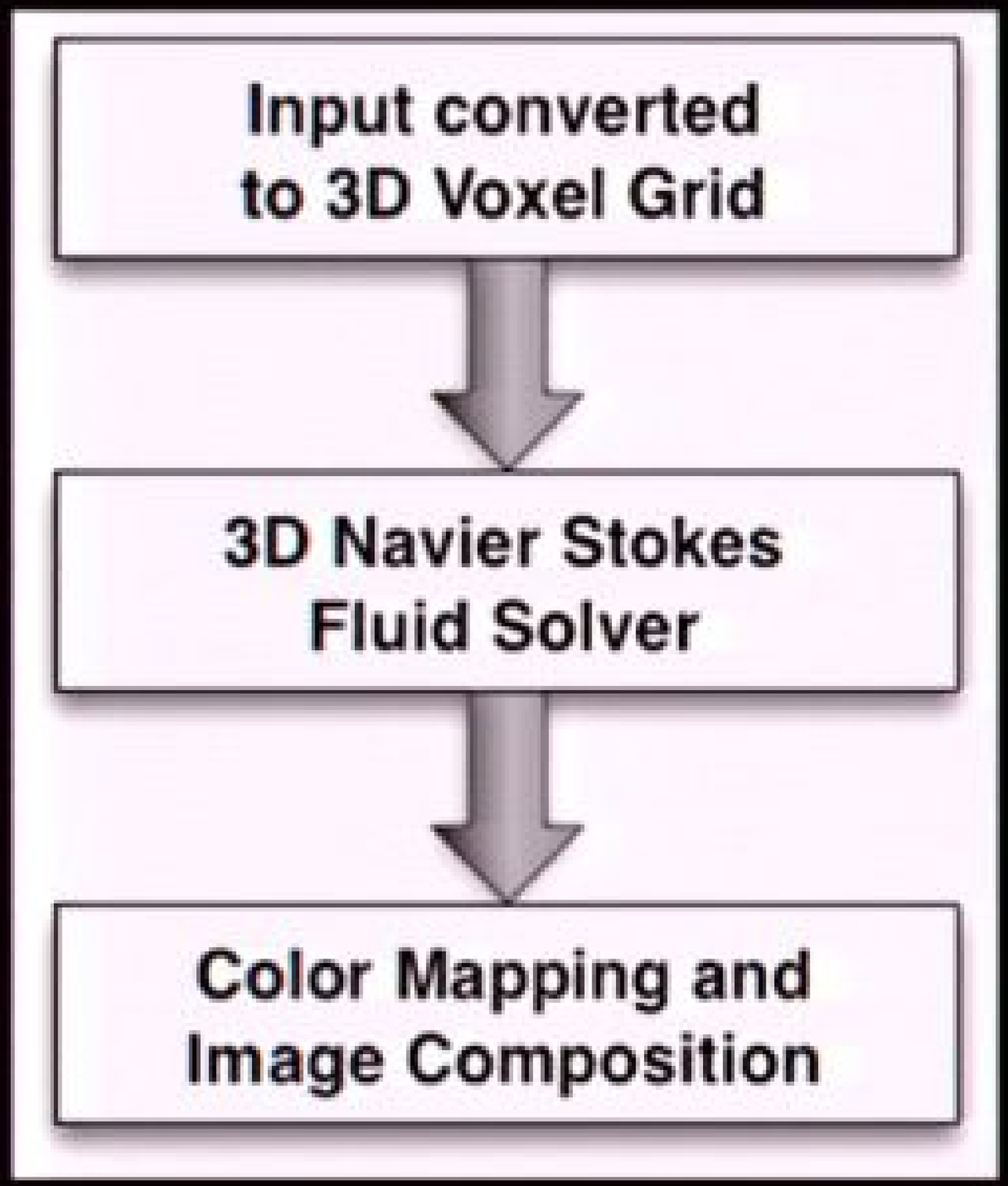

Hand Reconstruction:
Depth Map and Optical Flow

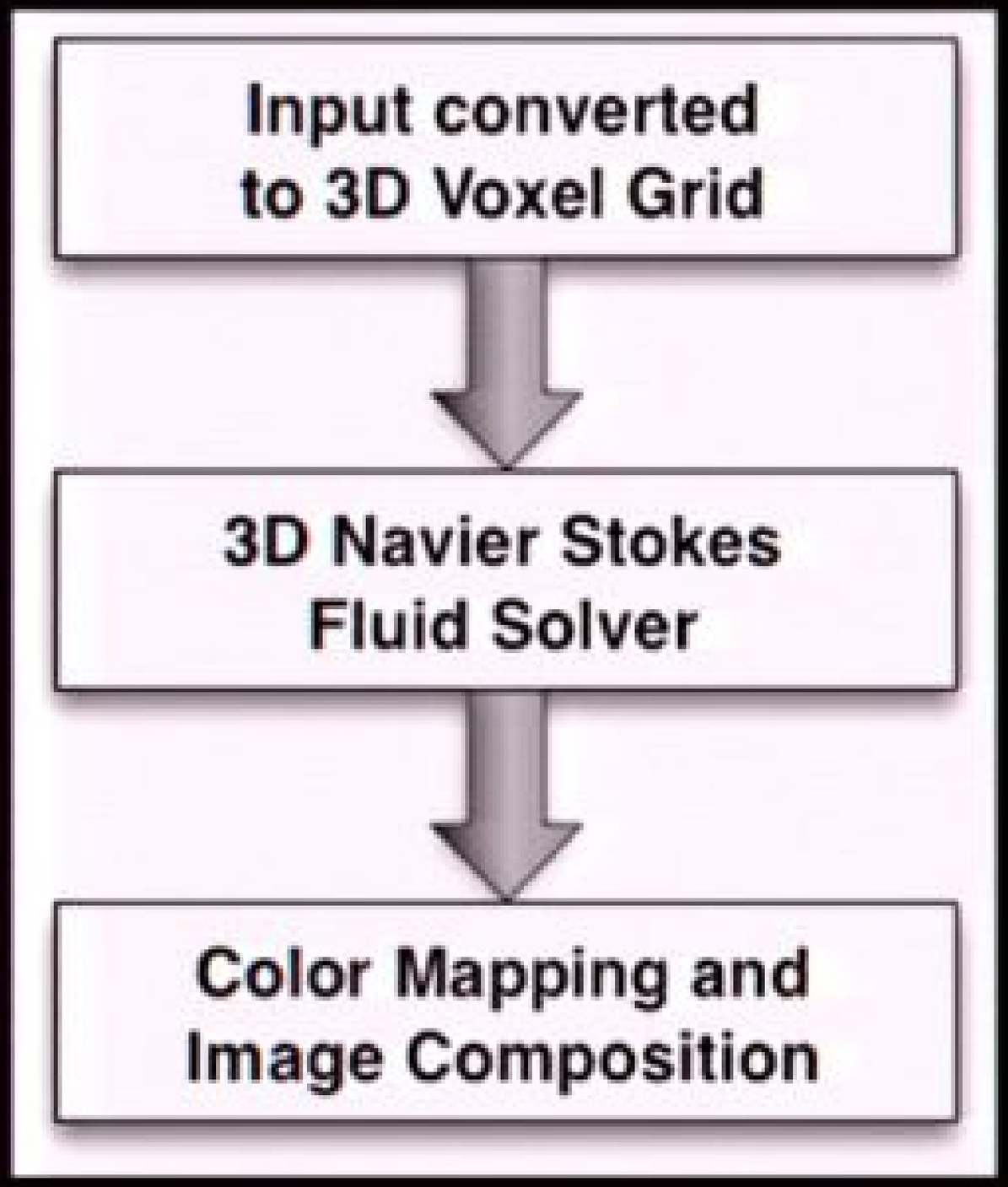


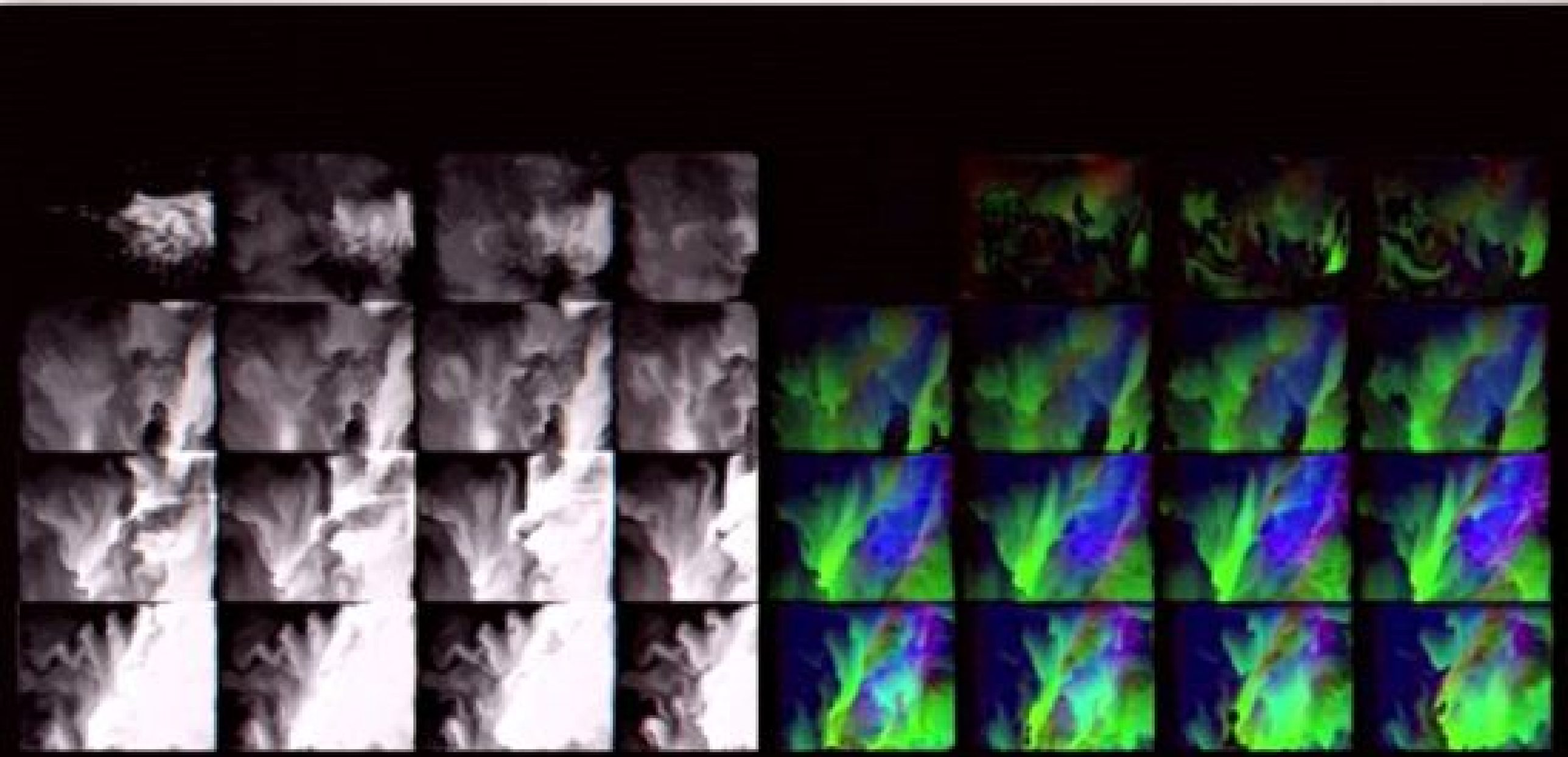

Depth Map
0.5x
Optical Flow

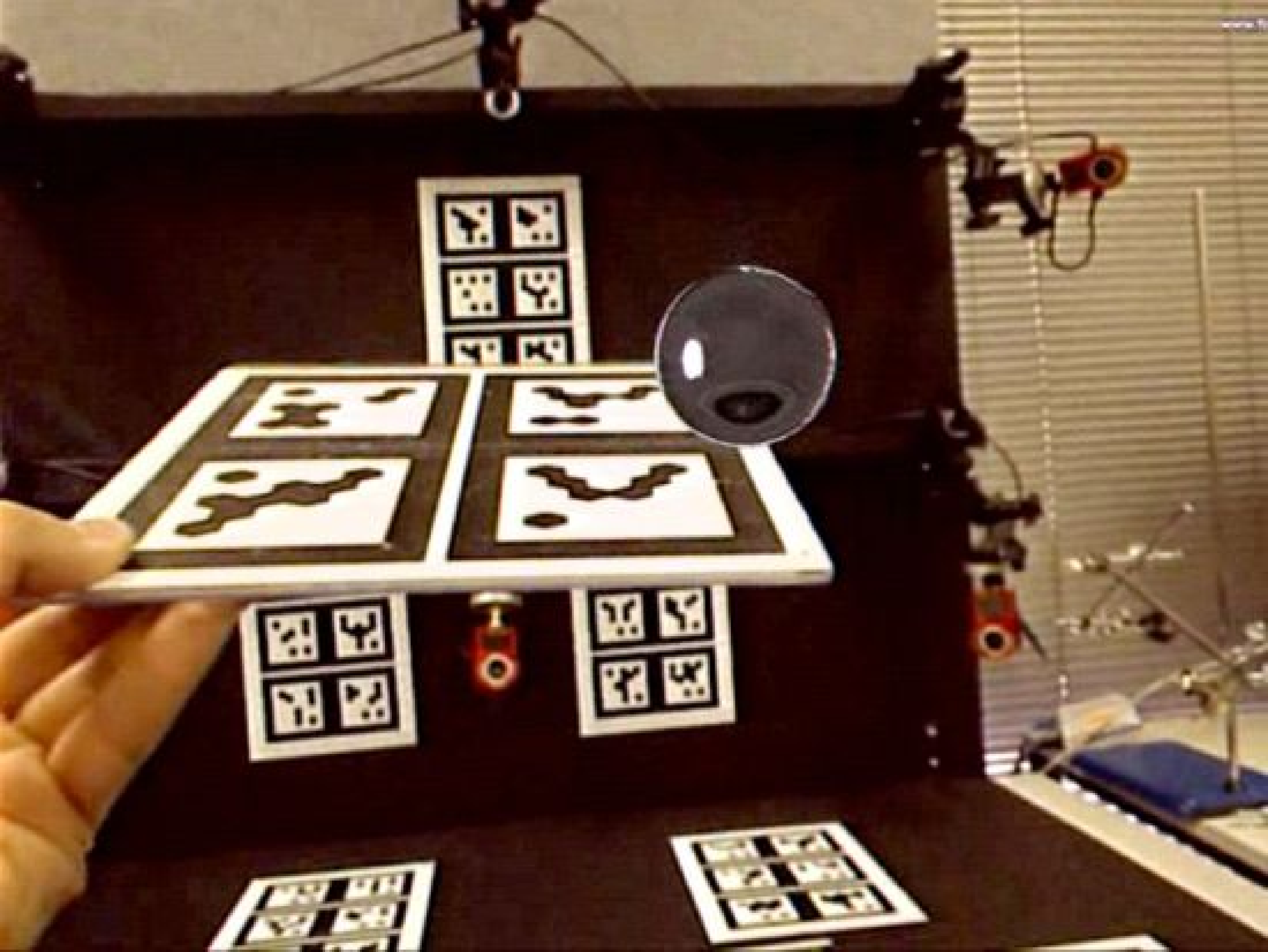

Input converted
to 3D Voxel Grid
3D Navier Stokes
Fluid Solver
Color Mapping and
Image Composition


Input converted
to 3D Voxel Grid
3D Navier Stokes
Fluid Solver
Color Mapping and
Image Composition


Input converted
to 3D Voxel Grid
3D Navier Stokes
Fluid Solver
Color Mapping and
Image Composition


Input converted
to 3D Voxel Grid
3D Navier Stokes
Fluid Solver
Color Mapping and
Image Composition





Realtime Raymarching for Mobile Augmented Reality

Graeme Jarvis*
Magic Vision Lab
University of South Australia

Christian Sandor†
Magic Vision Lab
University of South Australia

Sean White‡
Nokia Research Center
Nokia

(a)

(b)

Glass Sphere with Refractions

Glass Sphere with Refractions

Global Illumination for Augmented Reality on Mobile Phones

Michael Csongei*
Magic Vision Lab
University of South Australia

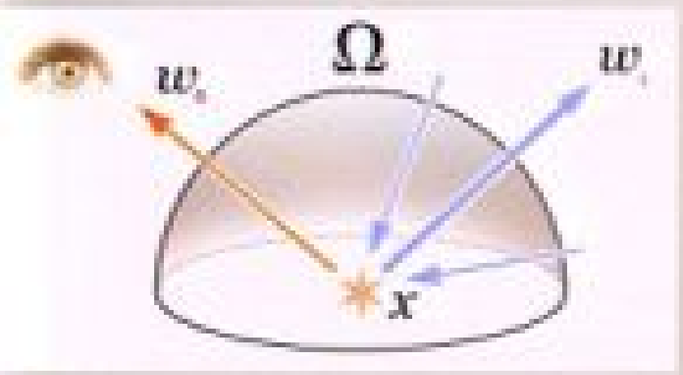
Christian Sandor†
Magic Vision Lab
University of South Australia

Yong Beom Lee‡
Samsung Advanced Institute of Technology
Samsung

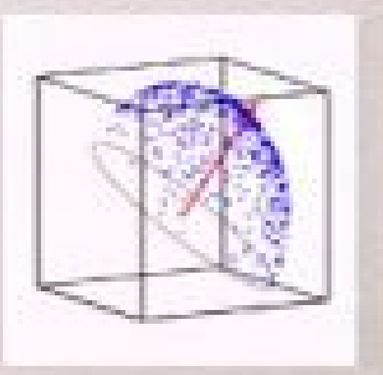
(a) (b) (c)

Figure 1: (a) Our prototype achieves Global Illumination for Augmented Reality scenes on mobile phones by realtime pathtracing. (b,c) show three apples for comparison: (left) our result, (center) reference rendering created offline, and (right) a real apple.

16 seconds



0.05 seconds



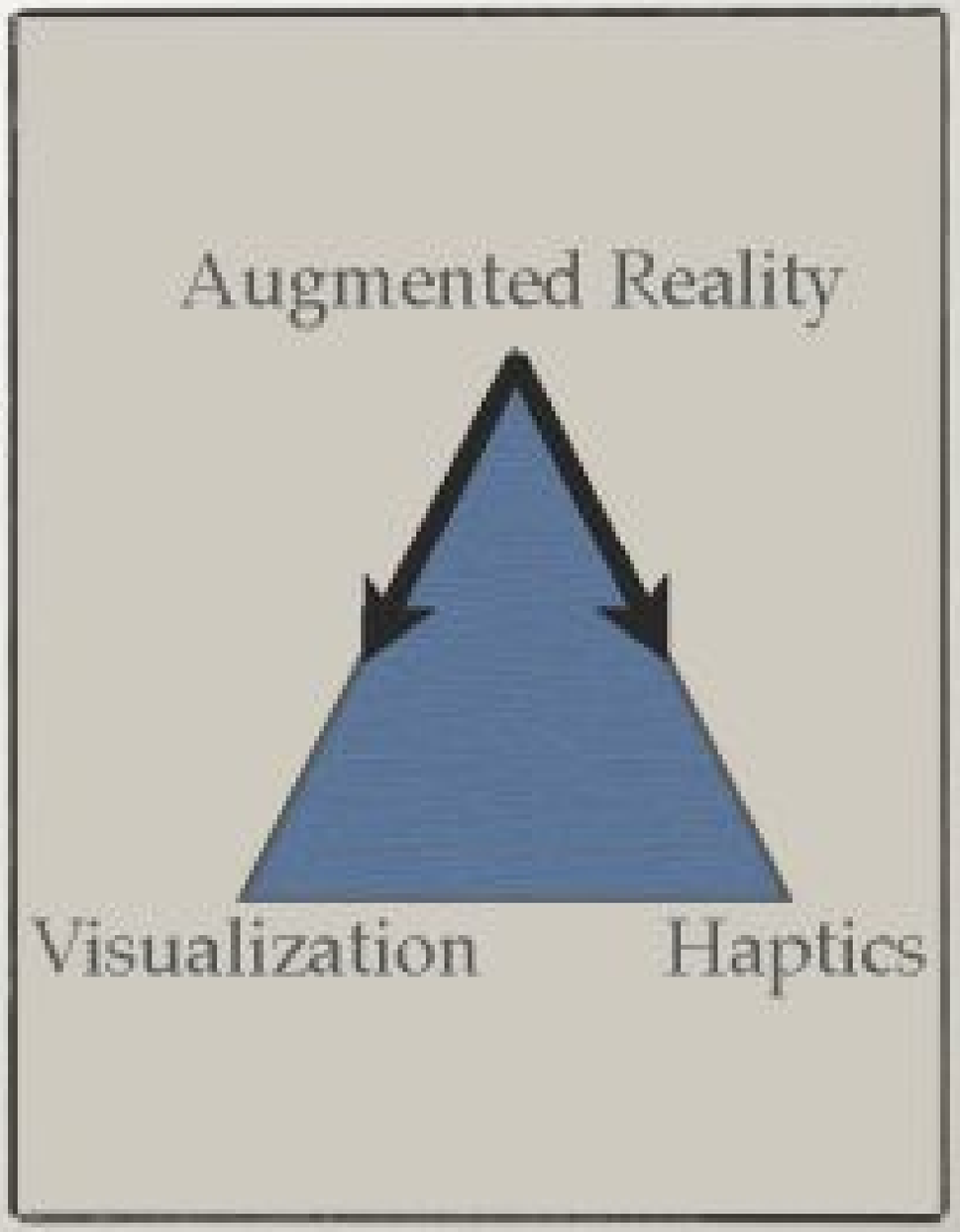
$$L_o(\mathbf{x}, \omega_o, \lambda, t) = L_e(\mathbf{x}, \omega_o, \lambda, t) + \int_\Omega f_r(\mathbf{x}, \omega_i, \omega_o, \lambda, t)\, L_i(\mathbf{x}, \omega_i, \lambda, t)\, (\omega_i \cdot \mathbf{n})\, \mathrm{d}\,\omega_i$$

Conclusions: Scientific Contribution

We have co-pioneered:

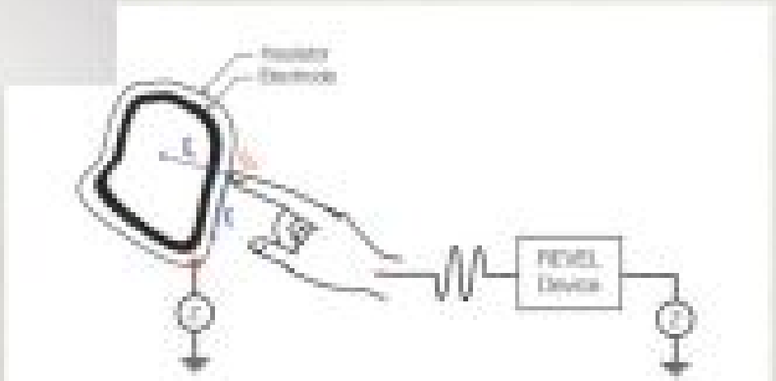
AR & Visualization
White, Feiner (Columbia University)
Kalkofen, Mendez, Schmalstieg (TU Graz)

AR & Haptics
Knörlein, Harders (ETH Zurich)

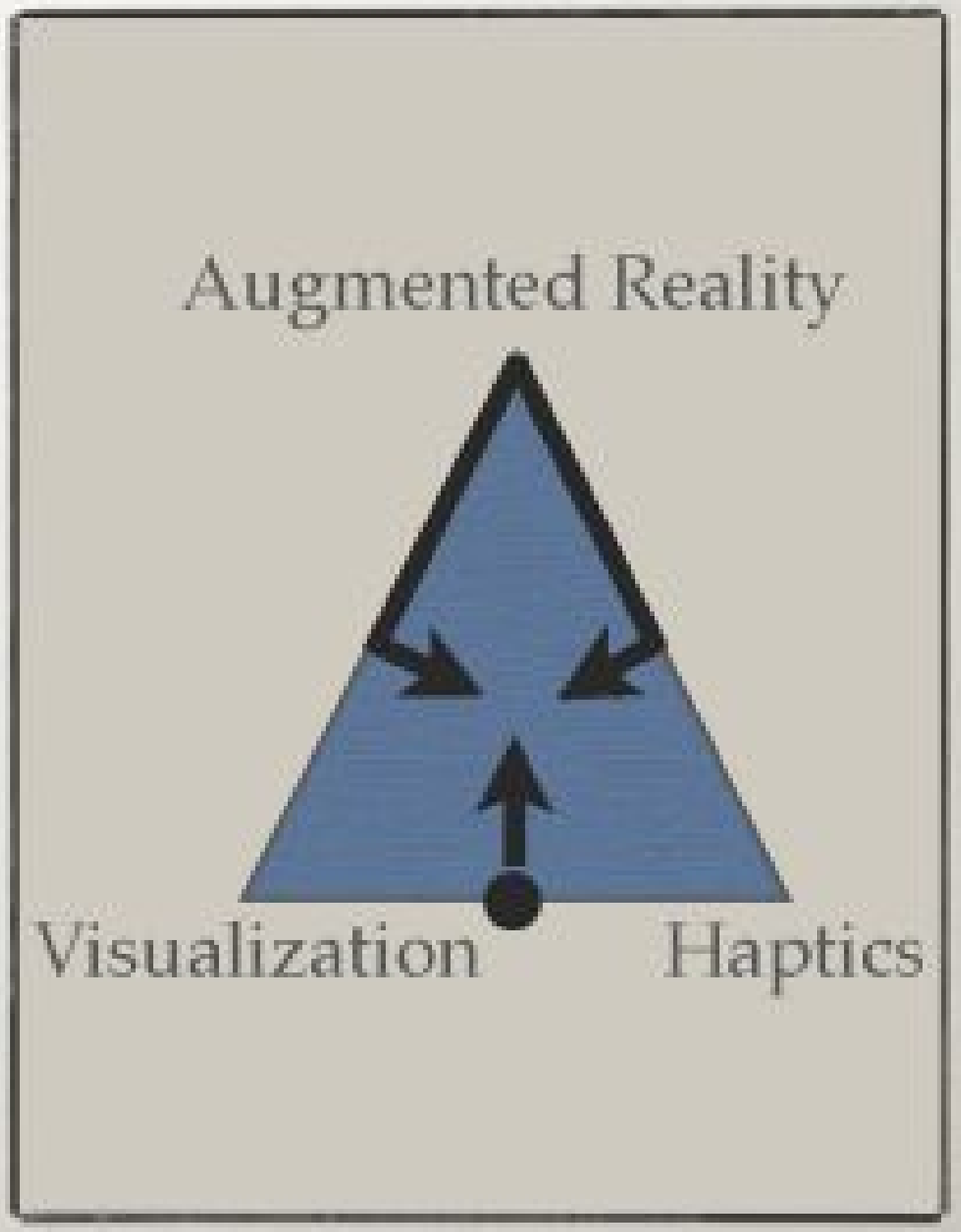


Conclusions: Future Work

Full combination =>
Startrek's Holodeck, *however* everywhere

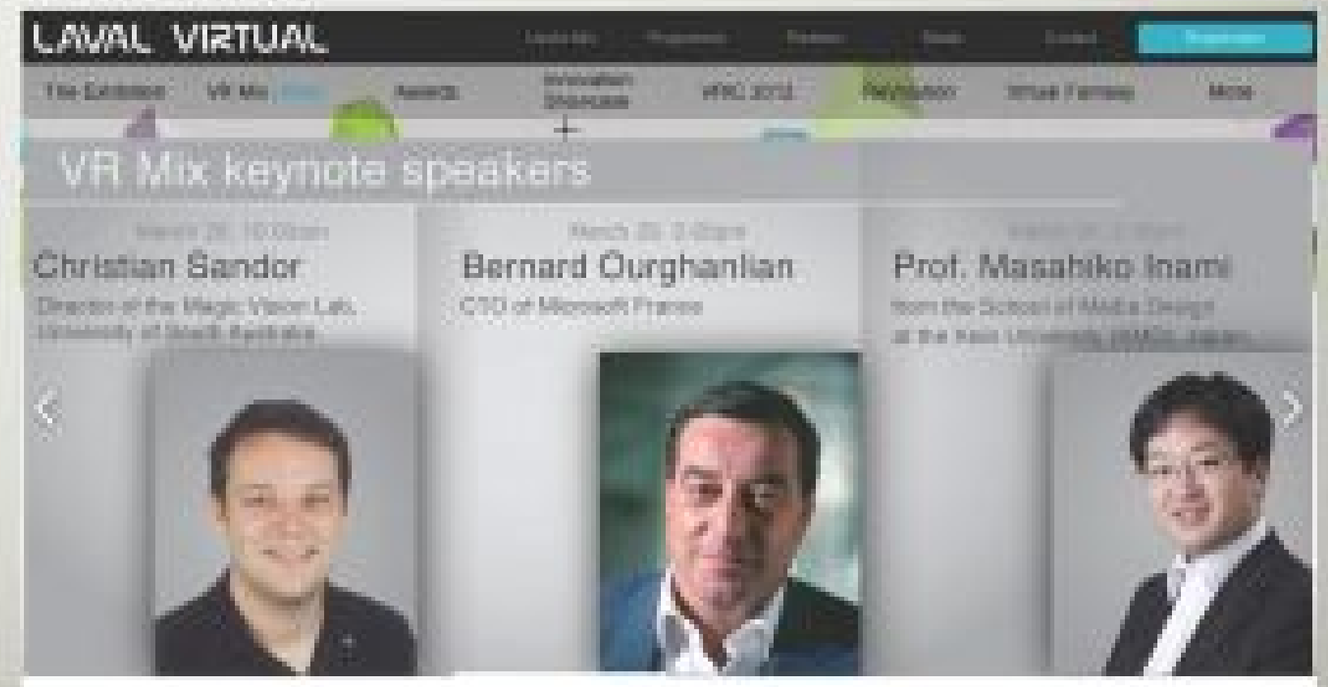


[Bau & Poupyrev, SIGGRAPH 2012]



More Information:

www.magicvisionlab.com



Key Points For Taking AR into the Real World

Tracking: practically solved

Challenges:

1. Applications

   Industrial Design (with Canon)
   AR Browser (with Nokia, Samsung, Nvidia)
   Astronautics (with DLR)
   Medical (with Prof. Navab (TU Munich))
   Games
   Other industrial applications (training, maintenance, planning, ...)
   ...

2. Human-Computer Interaction

   Human Perception of AR
   Usability
   Providing *more versatile* AR interfaces

Thank You!