

TAKING AUGMENTED REALITY OUT OF THE LABORATORY AND INTO THE REAL WORLD

DR CHRISTIAN SANDOR
DIRECTOR: MAGIC VISION LAB

MAGIC VISION

VISITING ASSOCIATE PROFESSOR: TOHOKU UNIVERSITY (JAPAN)

SENIOR LECTURER:

SCHOOL OF INFORMATION TECHNOLOGY & MATHEMATICAL SCIENCES
UNIVERSITY OF SOUTH AUSTRALIA



1975-2005: TU Munich



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1975-2005: TU Munich

2004: Columbia University (7 months)



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1975-2005: TU Munich

2004: Columbia University (7 months)

2005-2007: Canon Japan



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2004: Columbia University (7 months)

2005-2007: Canon Japan

2008: TU Graz (2 months)



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2008: TU Graz (2 months)
since 2008: University of South Australia





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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)

招聘准教授



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



Previous Sponsors



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



FOV2D Lab



Monkey



HelloApple



RayMarcher



PanoManip



MagicLens



PanoLK



PanoShader



Remote



Phone



Safari



Music

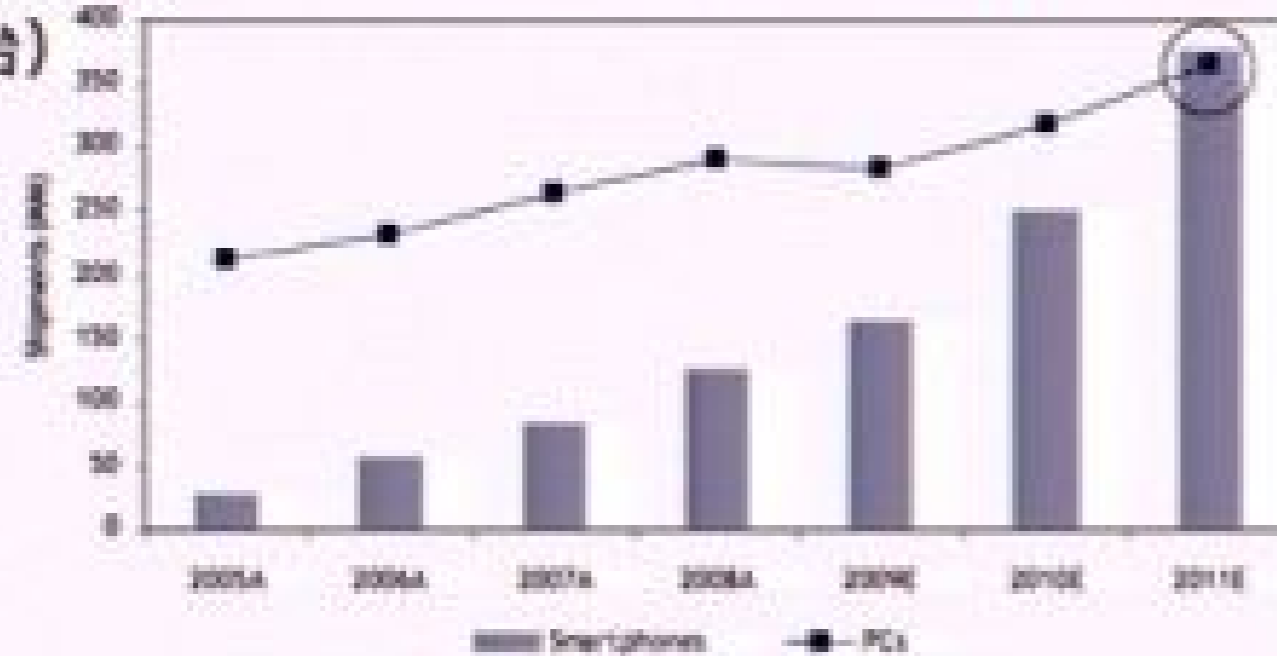


Skype

RECENT AR TRENDS

Silicon Alley Insider  Chart of the Day

Smartphone Sales To Beat PC Sales By 2011
Million Units
(100 万台)



Source: RBC Capital Markets estimates



CURRENT STATE OF AR: LOW-LEVEL = SOLVED!

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

ARToolkit [Kato & Billinghurst, 1999]

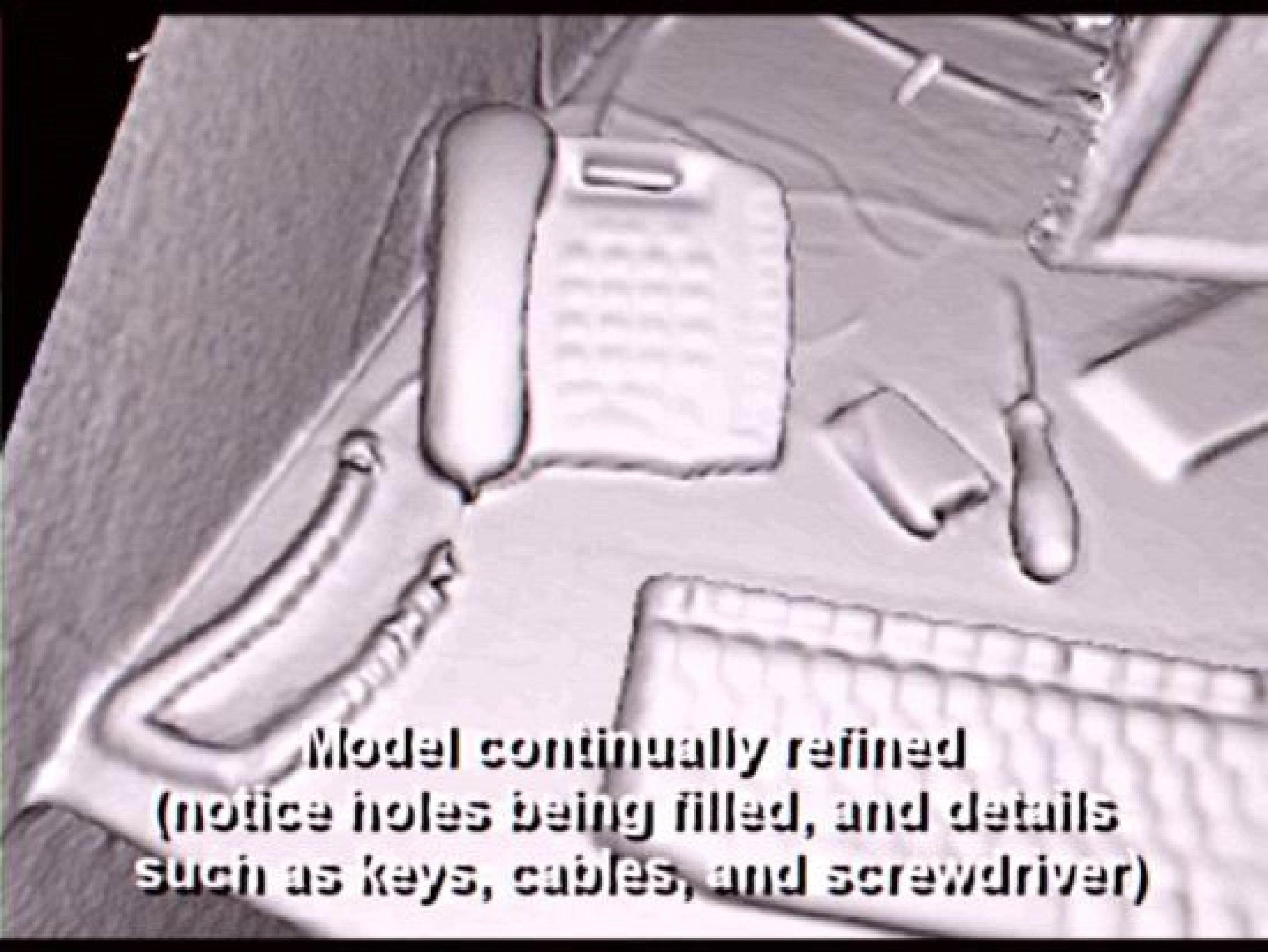
Going Out [Reitmayr & Drummond, ISMAR 2006]

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)**

A photograph of a Dell monitor on a stand. The monitor is tilted back. On the bottom bezel, there is a small, embossed logo. The text below the image points to this logo.

**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

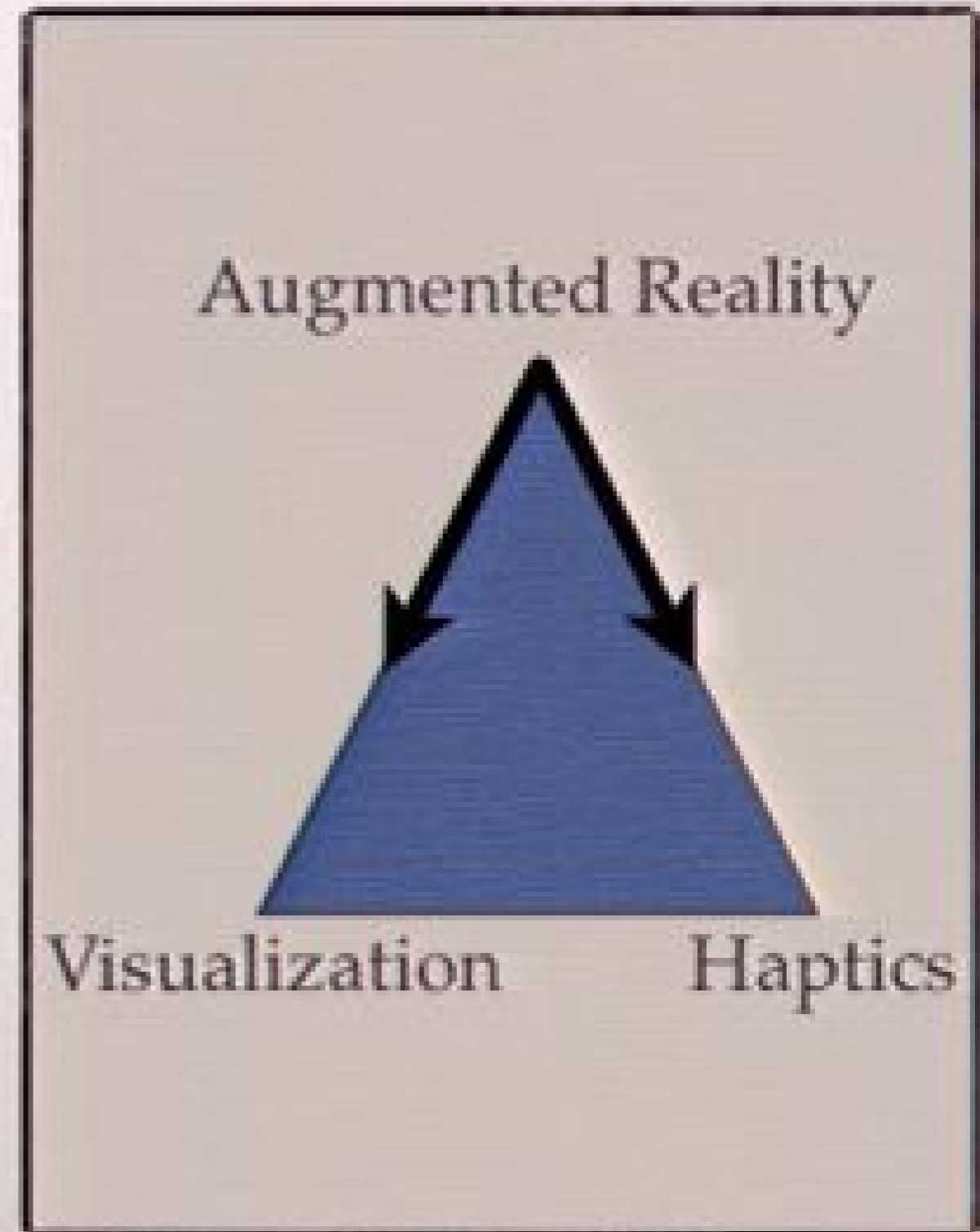
Usability

Providing *more versatile* AR interfaces

OUR APPROACH

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

Haptics: AR for the
sense of *touch*



LAB MAGIC DIVISION

AR & Visualization



AR & Haptics



MOTIVATION

Problems with most AR browsers:

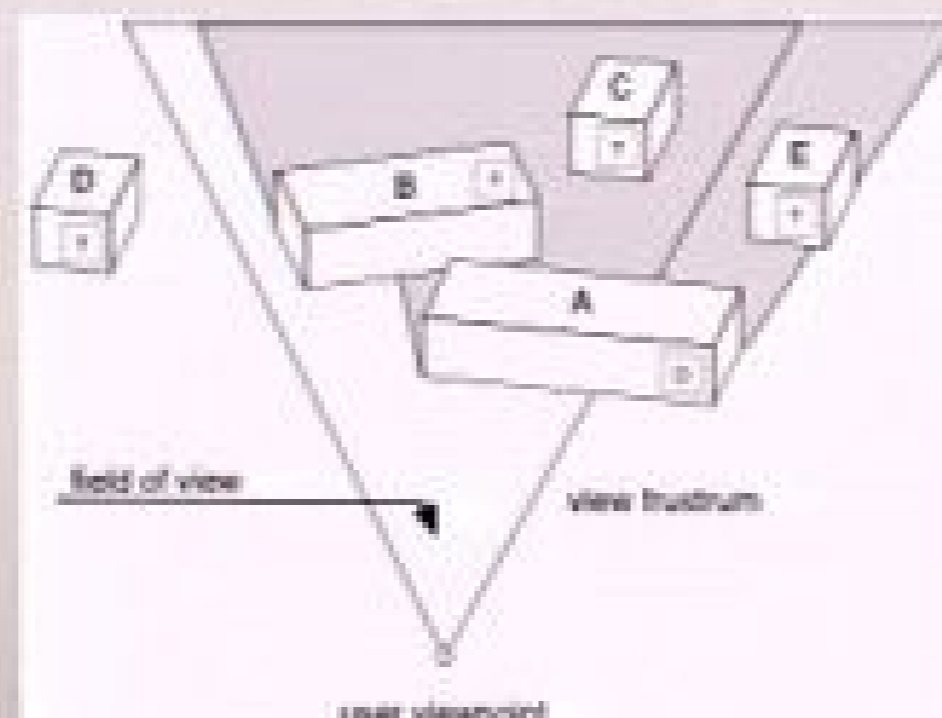
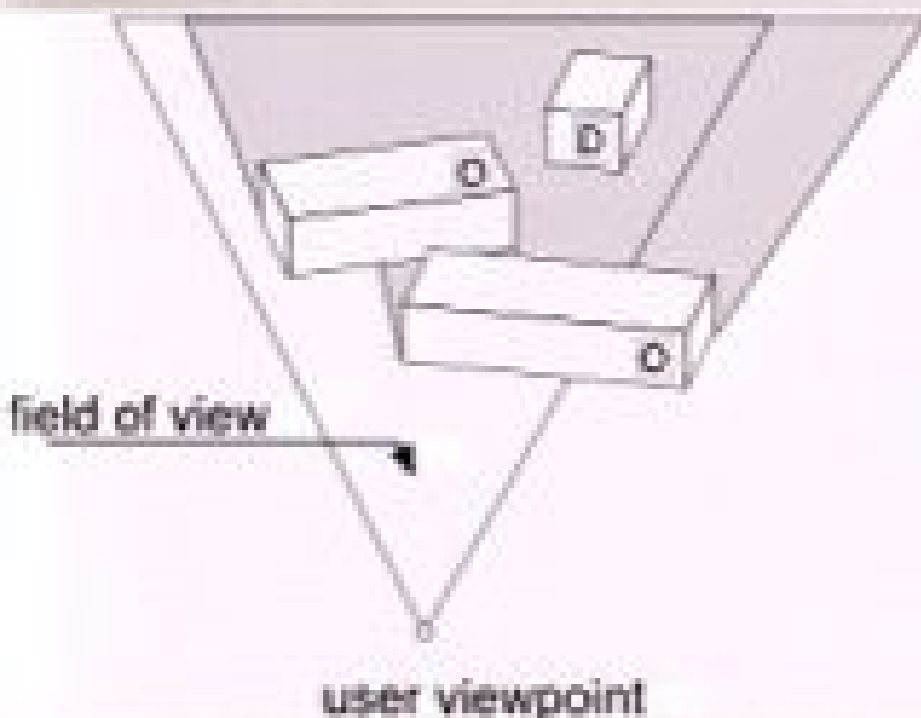
Pieces of **isolated information** instead of one **integrated visualization**

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

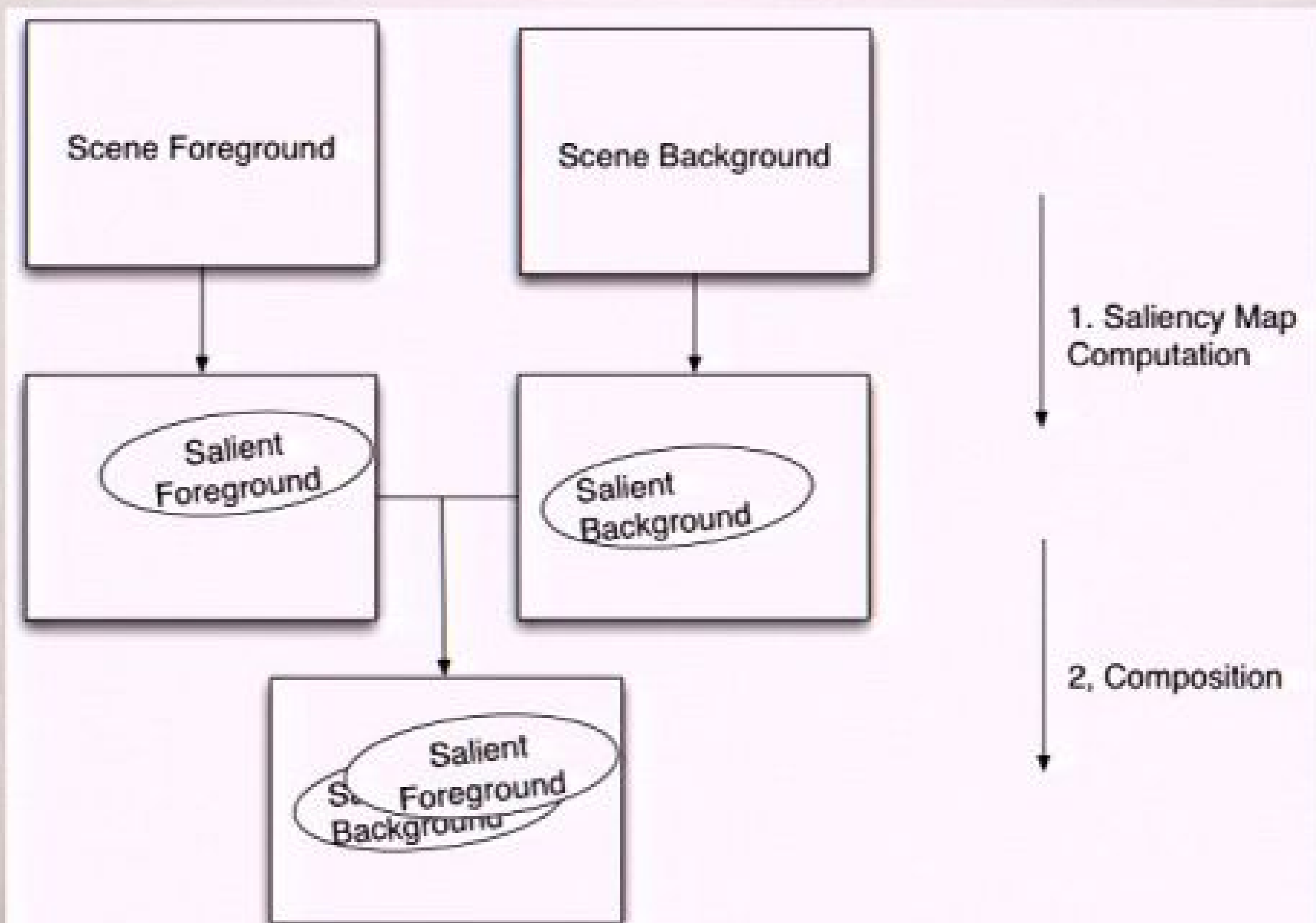
Sandor et al.
ISMAR 2010



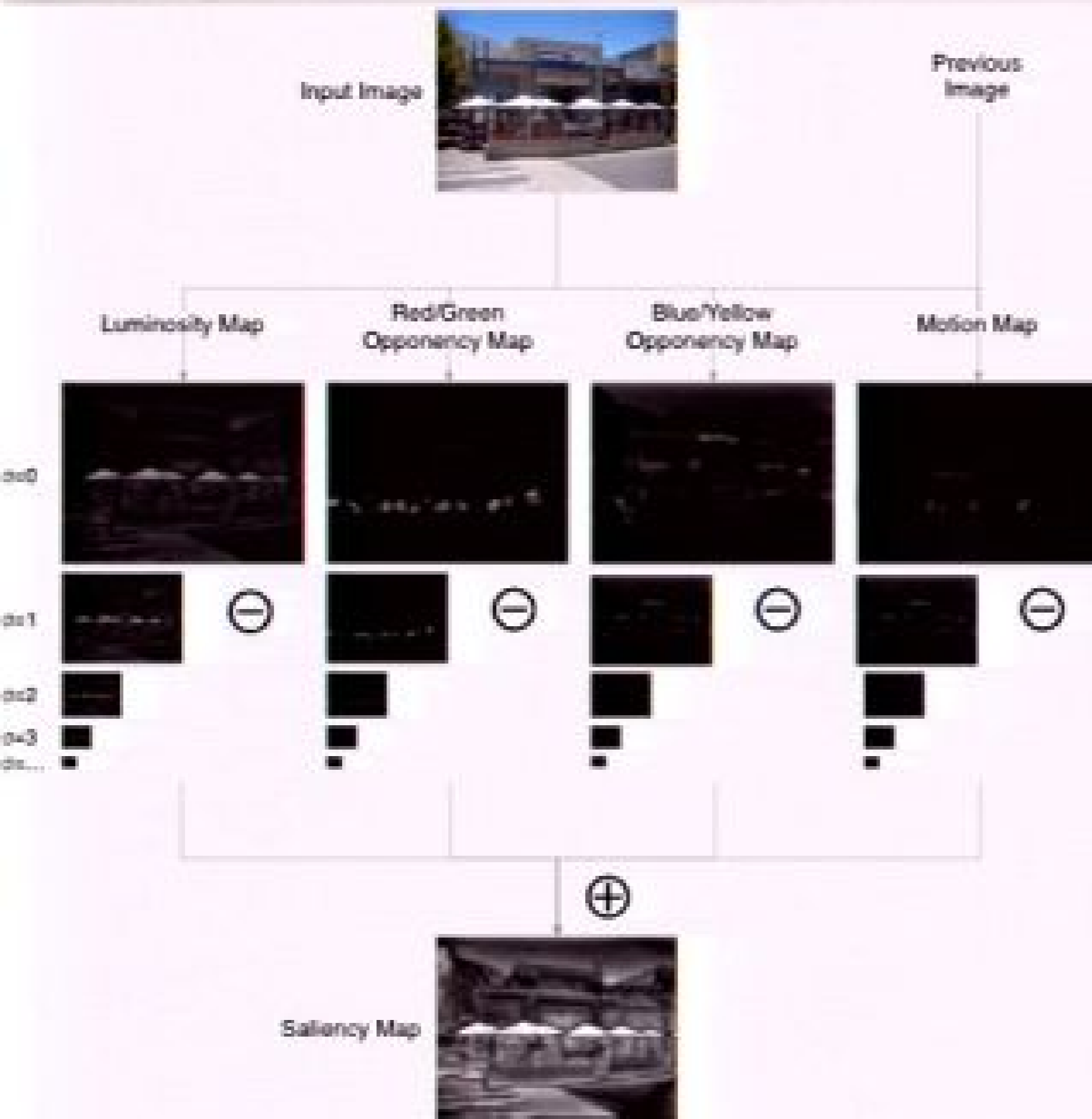
SALIENCY X-RAY

Sandor et al.
ISMAR 2010

CONCEPT: SALIENCY-BASED X-RAY



SALIENCY MAP COMPUTATION

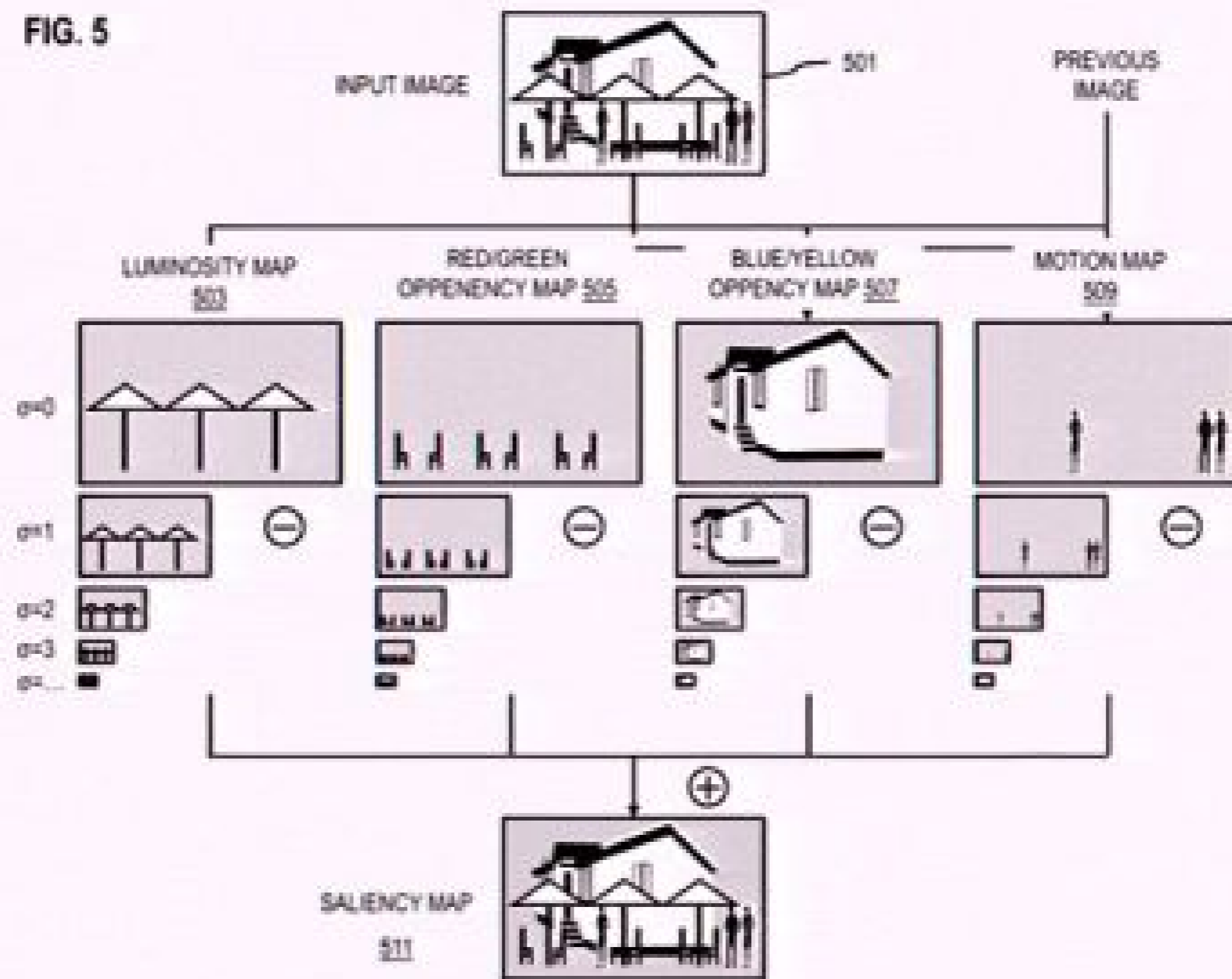


$$F_{f,p,s} = P_p \ominus P_s$$

$$l \in \{l,c,m\} \quad p \in \{2,3,4\}, s = p+S, S \in \{3,4\}$$

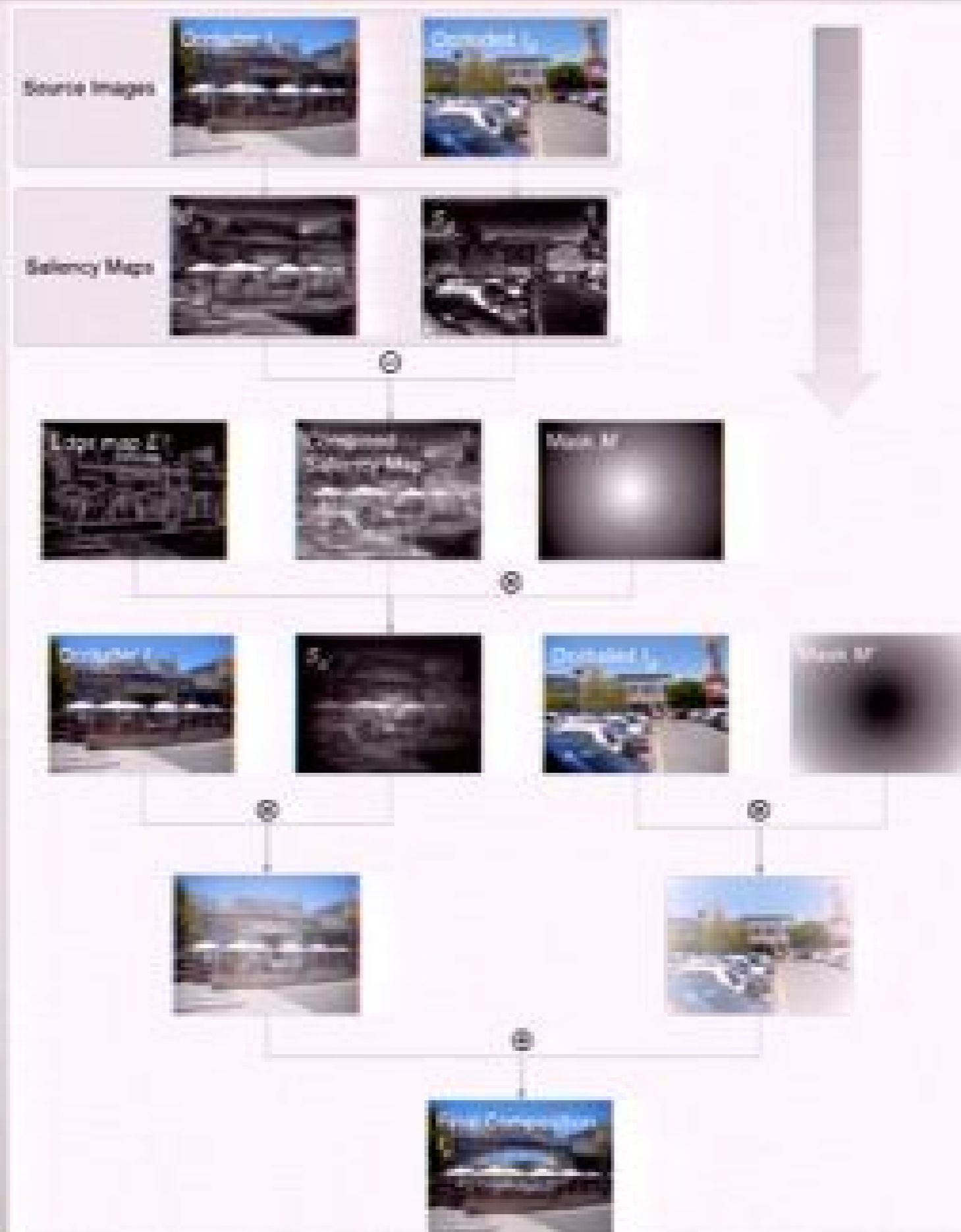
$$S = \frac{1}{3} \sum_{k \in \{l,c,l\}} C_k$$

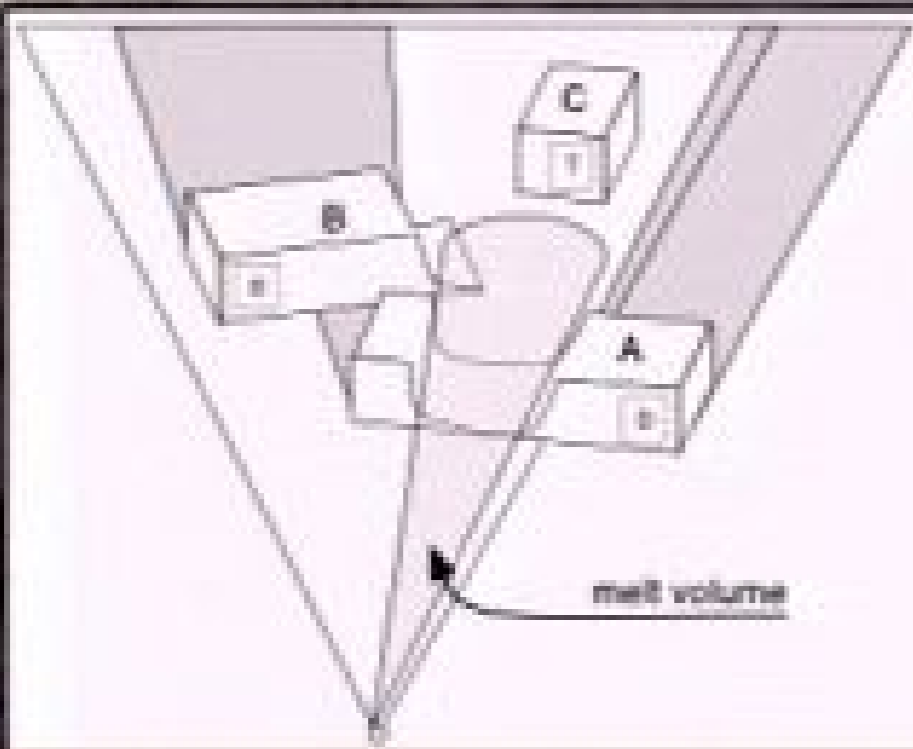
FIG. 5



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



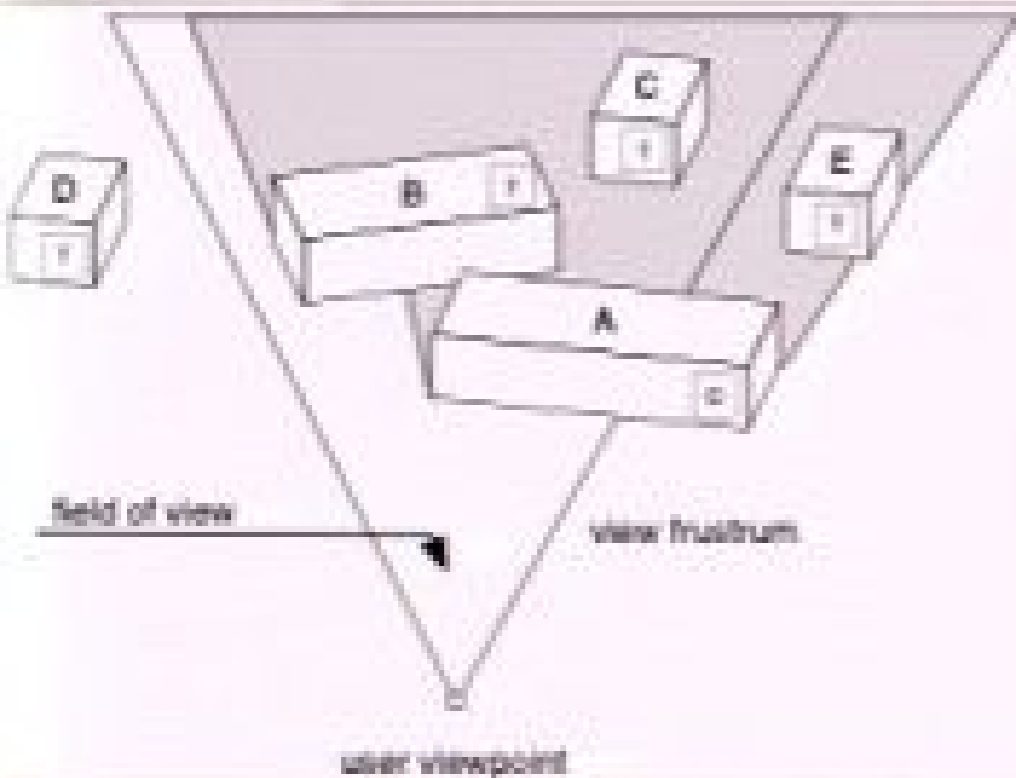


MELTING

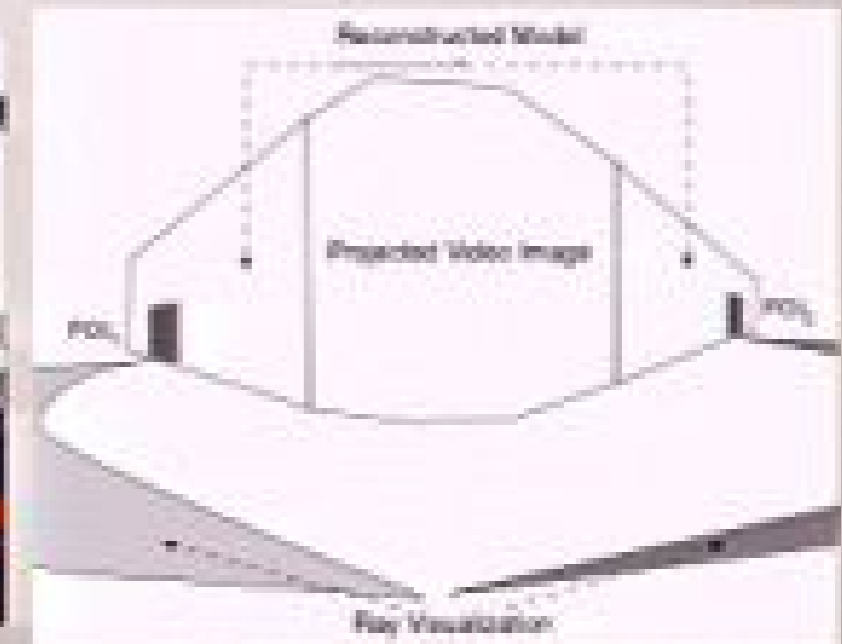
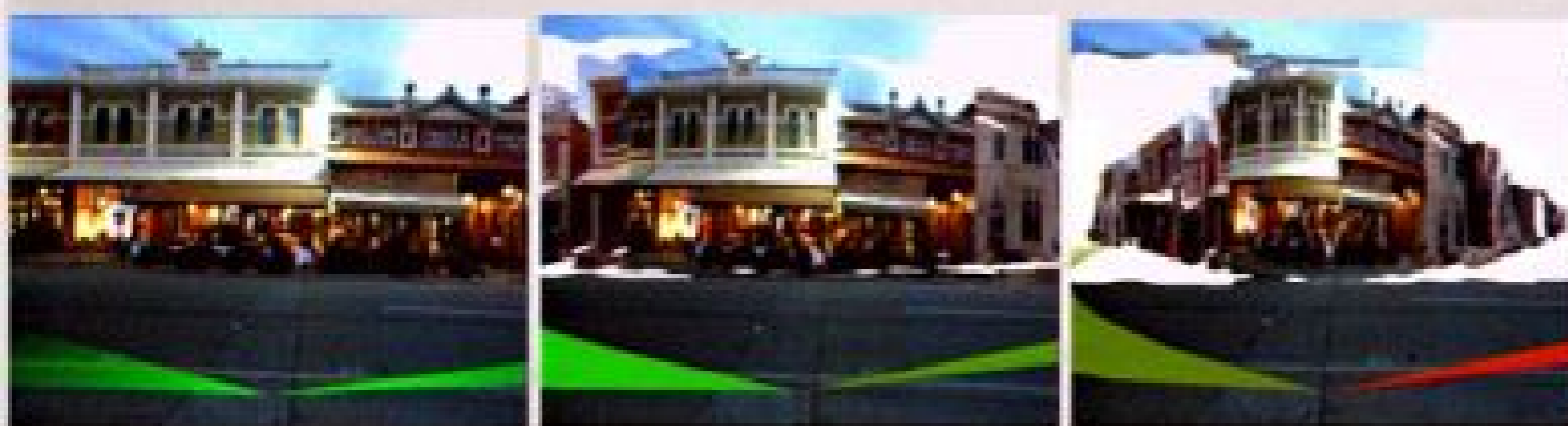
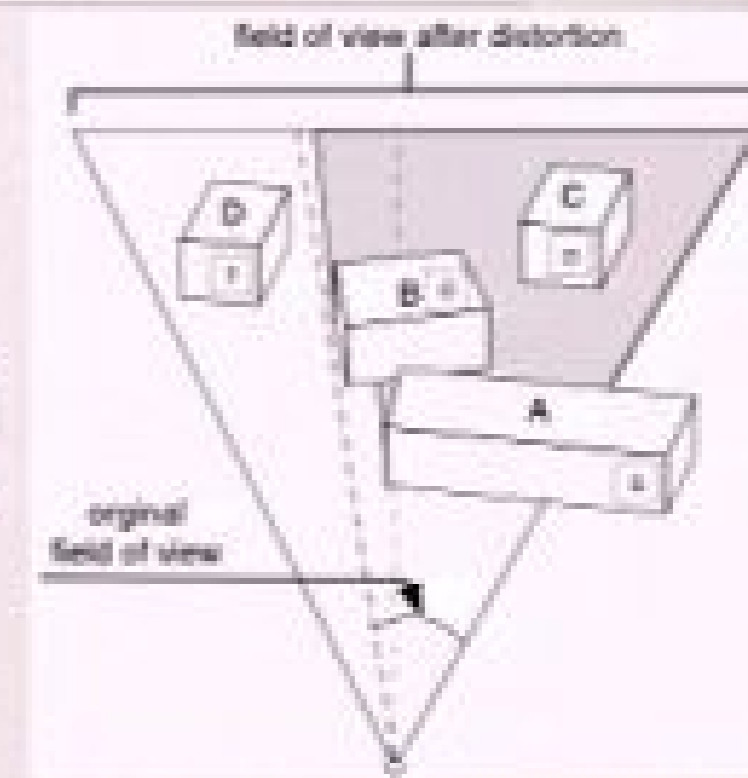
Sandor et al.
ISMAR 2009, VR 2010

SPACE-DISTORTING VISUALIZATIONS

RADIAL DISTORTION

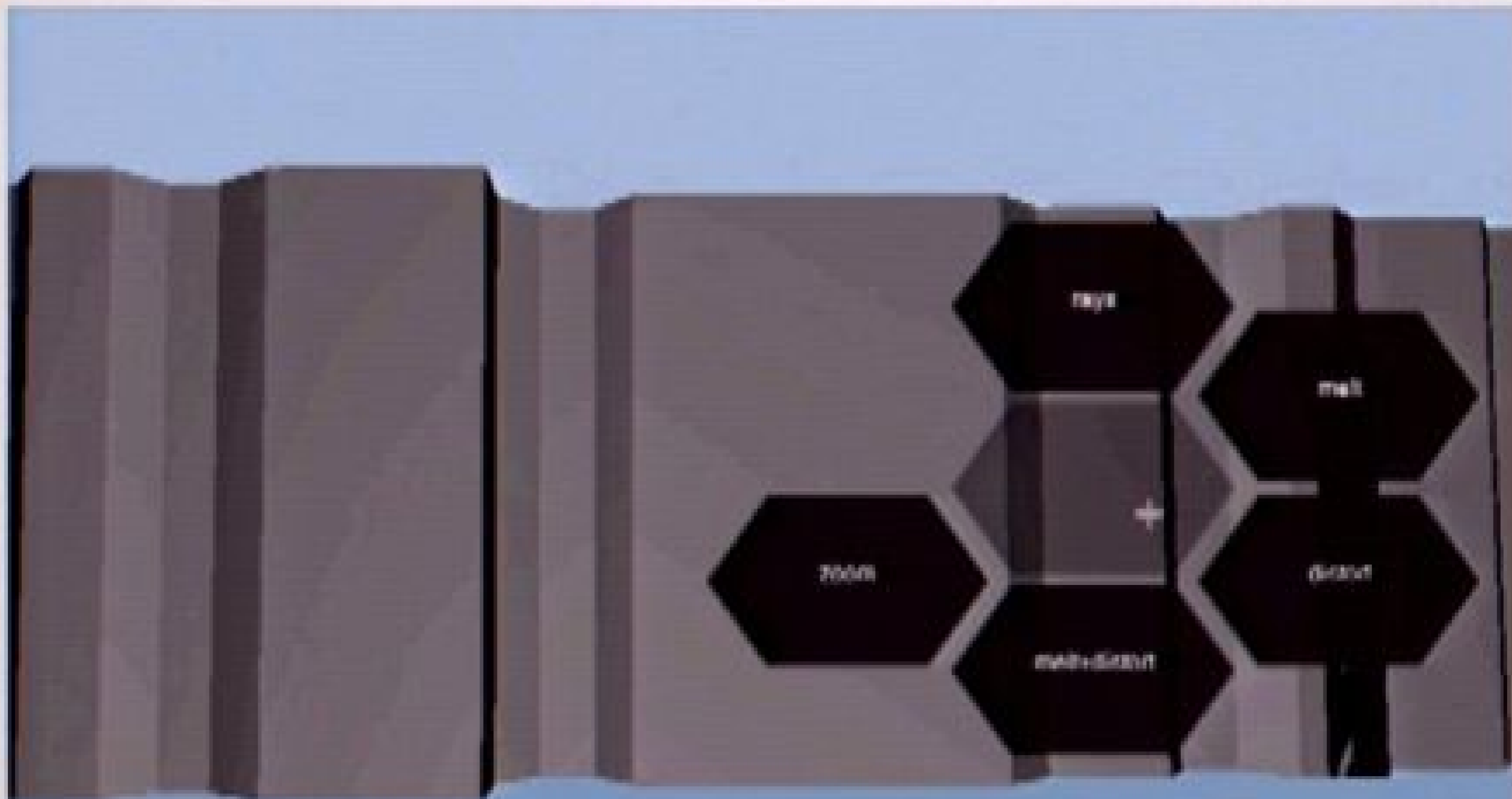


$$r = \begin{cases} \frac{\frac{1}{2}FOV}{\arg \min(p_{angle_min} | p \in P)} & \text{for } \gamma \leq 0, \\ \frac{\frac{1}{2}FOV}{\arg \max(p_{angle_max} | p \in P)} & \text{for } \gamma \geq 0. \end{cases}$$



SPACE-DISTORTING VISUALIZATIONS

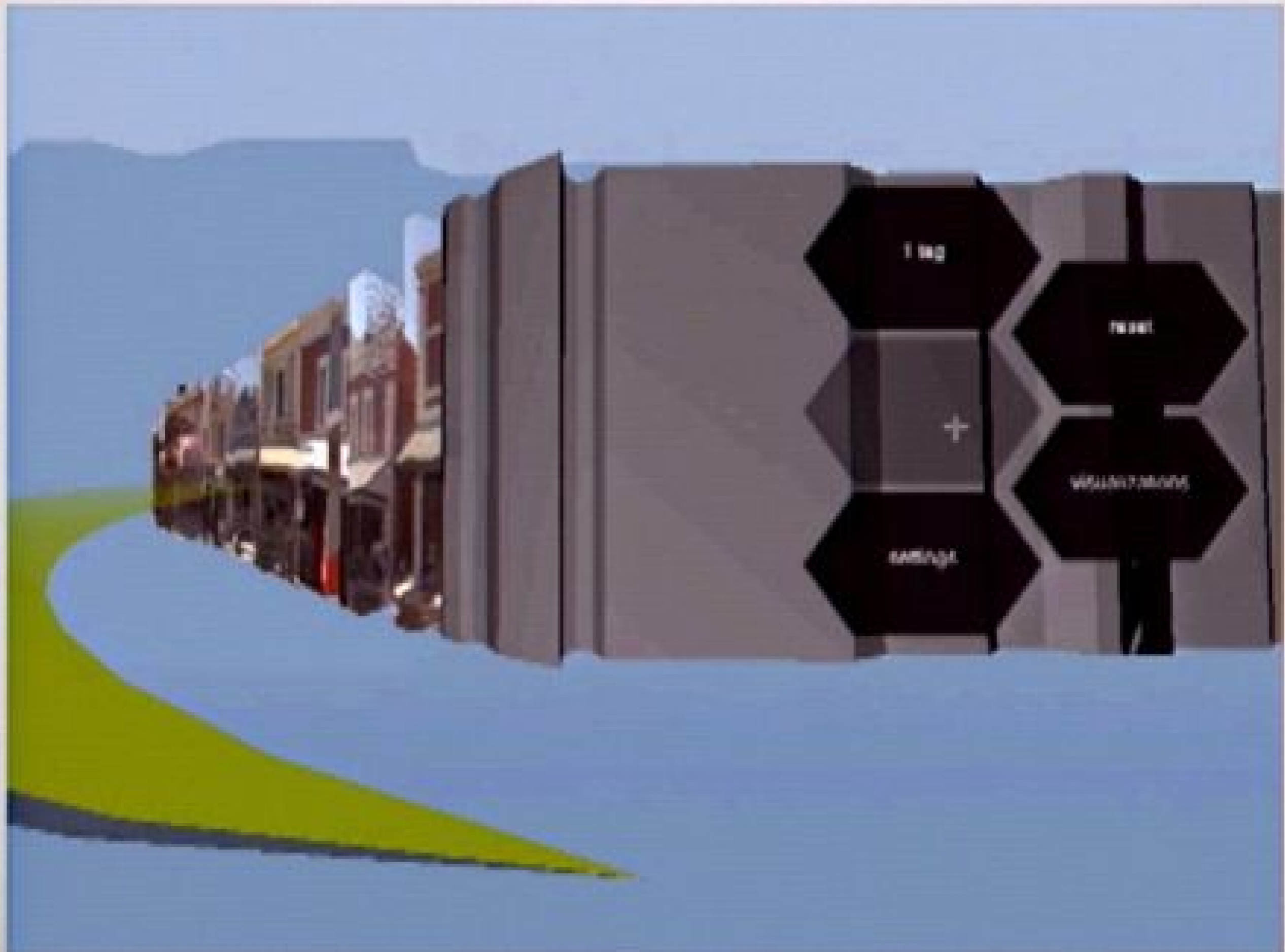
RADIAL DISTORTION



The center of the FOV is compressed accordingly.

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



TED^x
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
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Research Centre**

NEXT ITERATION

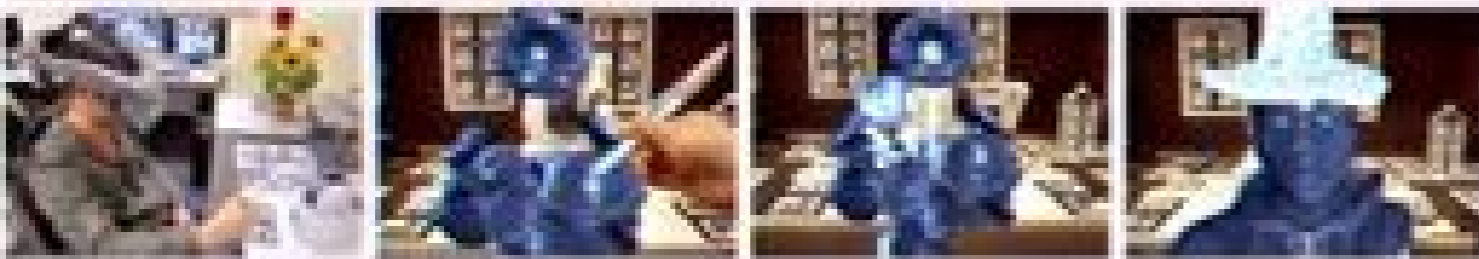
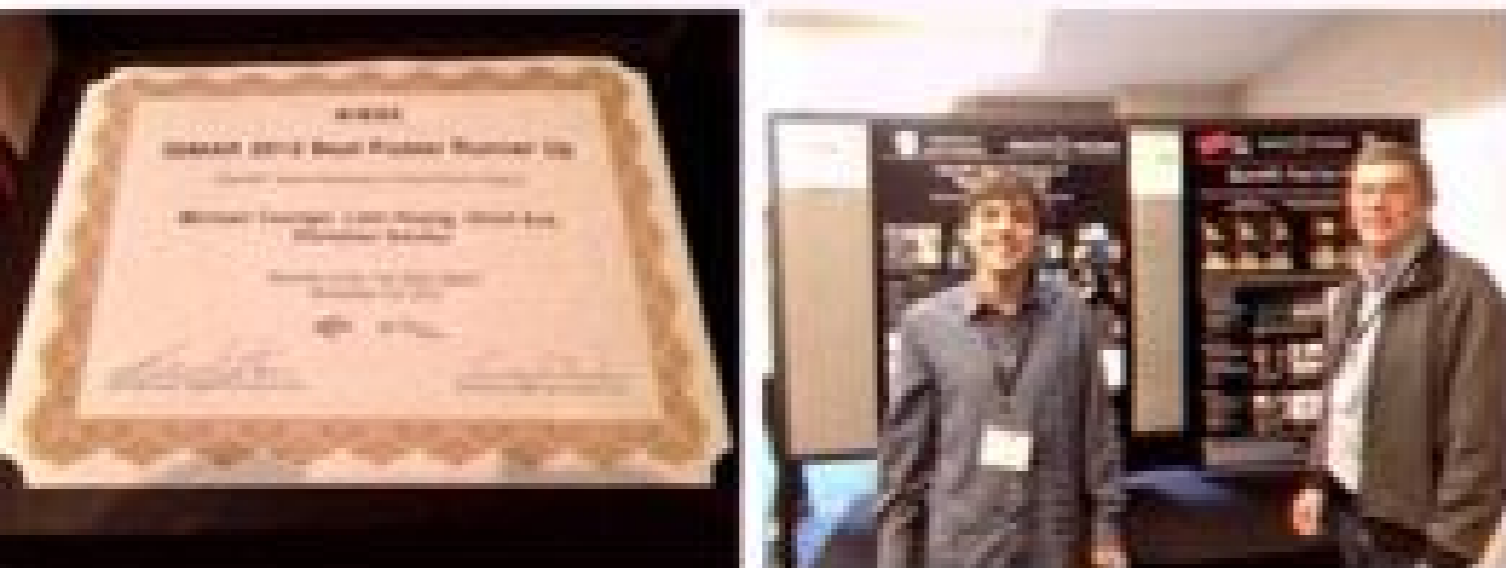


Figure 1: Users of our system can rapidly clone and edit real-world objects in our virtual/augmented Reality environment. (a) Initial view (b) view through the head worn display - cloned flowers are being edited through a haptic device. (c) final model after deformation. (d) further example: a virtual 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*

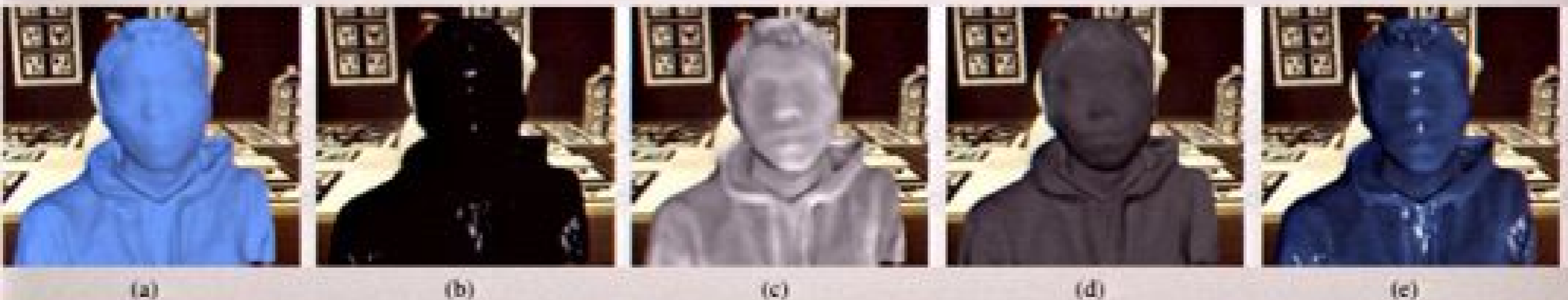


Figure 3: The different lighting components used in our raymarcher: (a) diffuse, (b) specular, (c) soft shadows, (d) ambient occlusion, and (e) the final result.

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...



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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

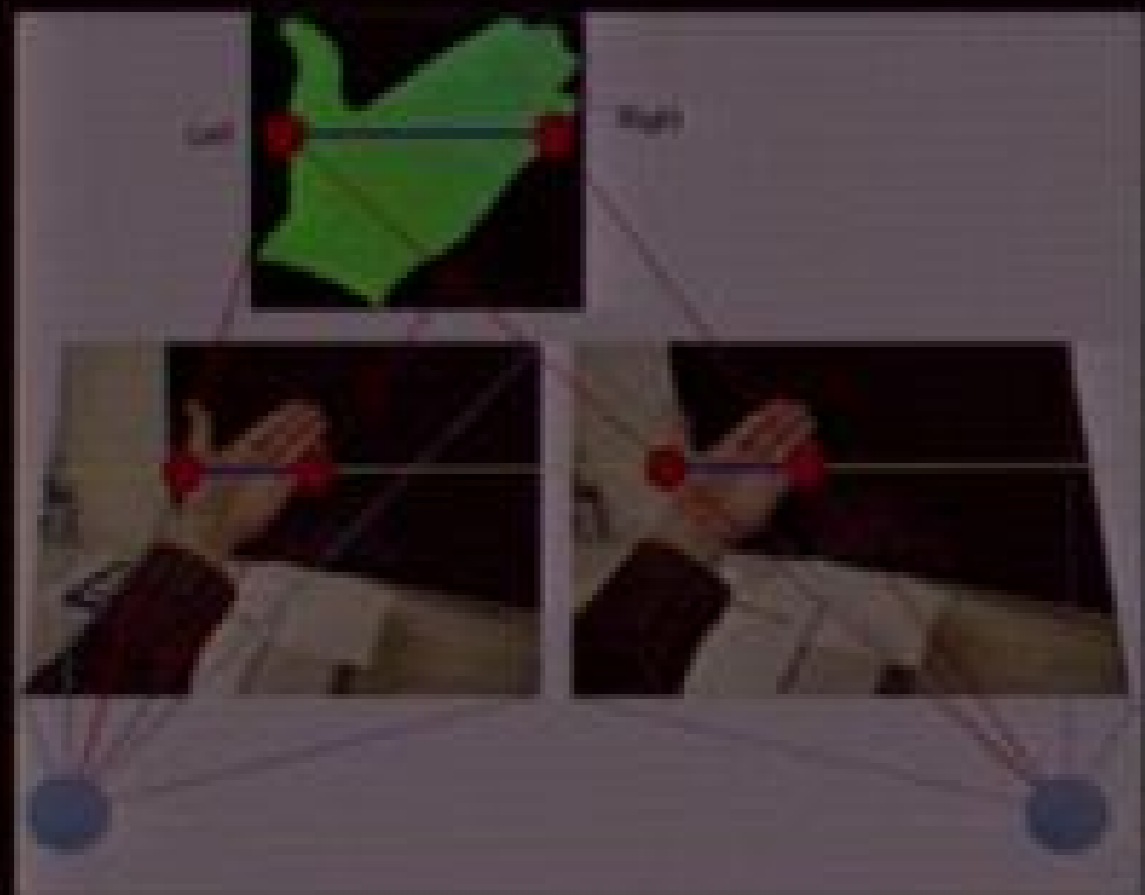




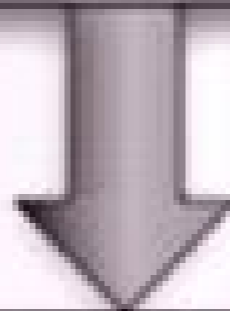
Hand Reconstruction: Depth Map and Optical Flow

Depth Map

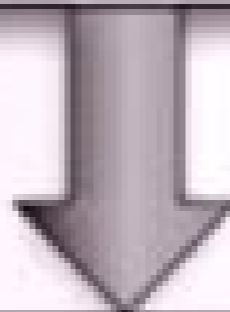
0.5x



**Input converted
to 3D Voxel Grid**



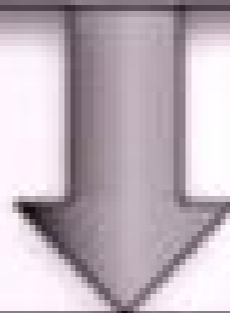
**3D Navier Stokes
Fluid Solver**



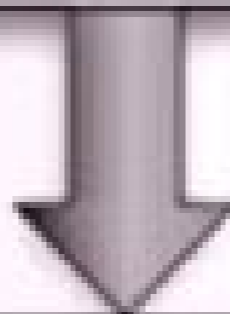
**Color Mapping and
Image Composition**



**Input converted
to 3D Voxel Grid**



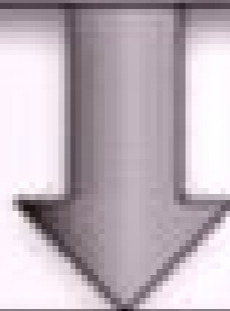
**3D Navier Stokes
Fluid Solver**



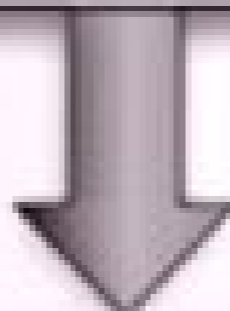
**Color Mapping and
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**Input converted
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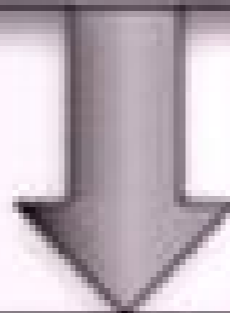
**3D Navier Stokes
Fluid Solver**



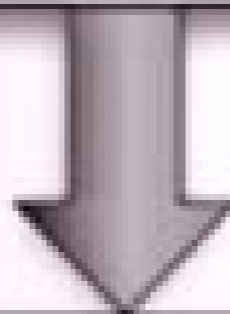
**Color Mapping and
Image Composition**



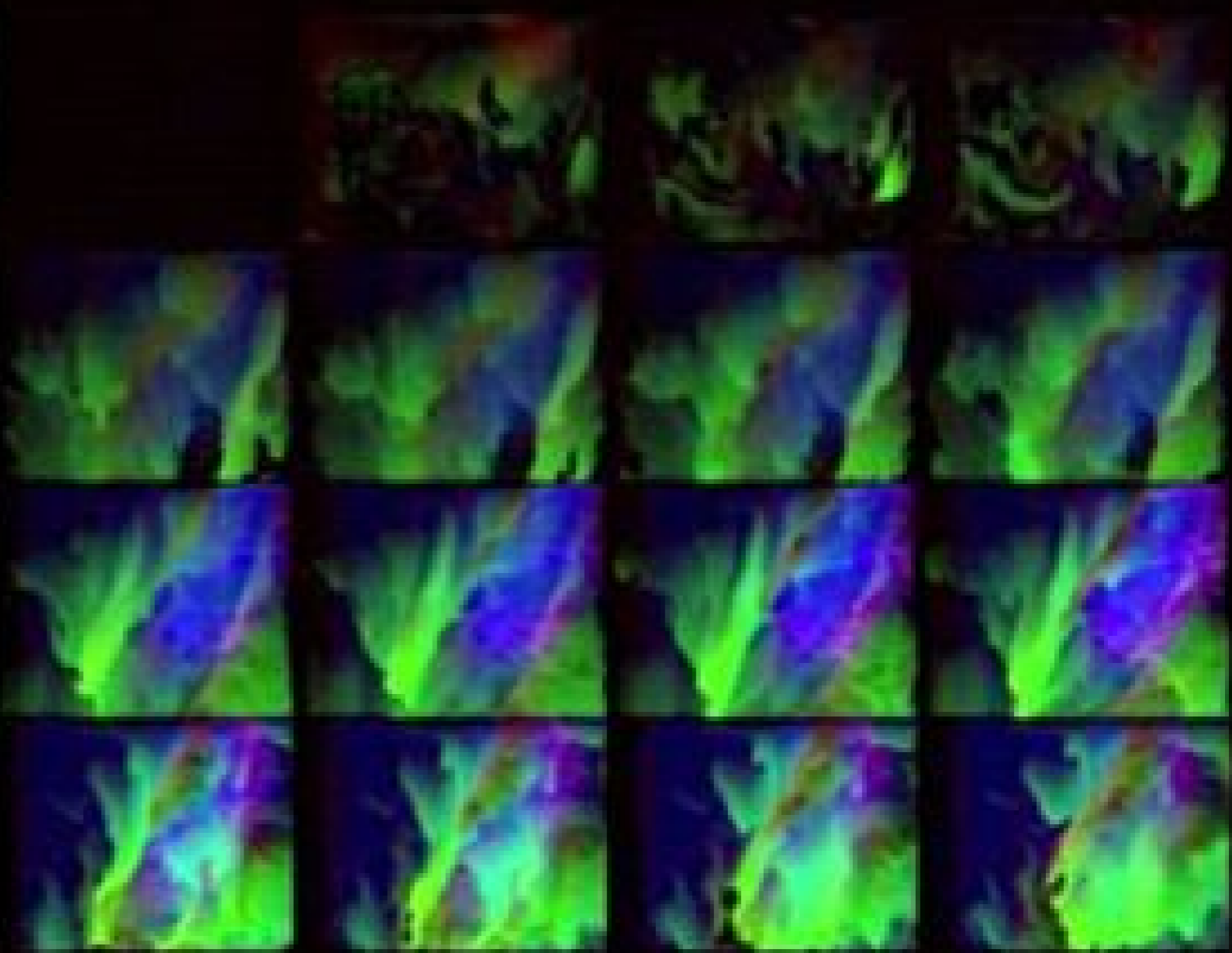
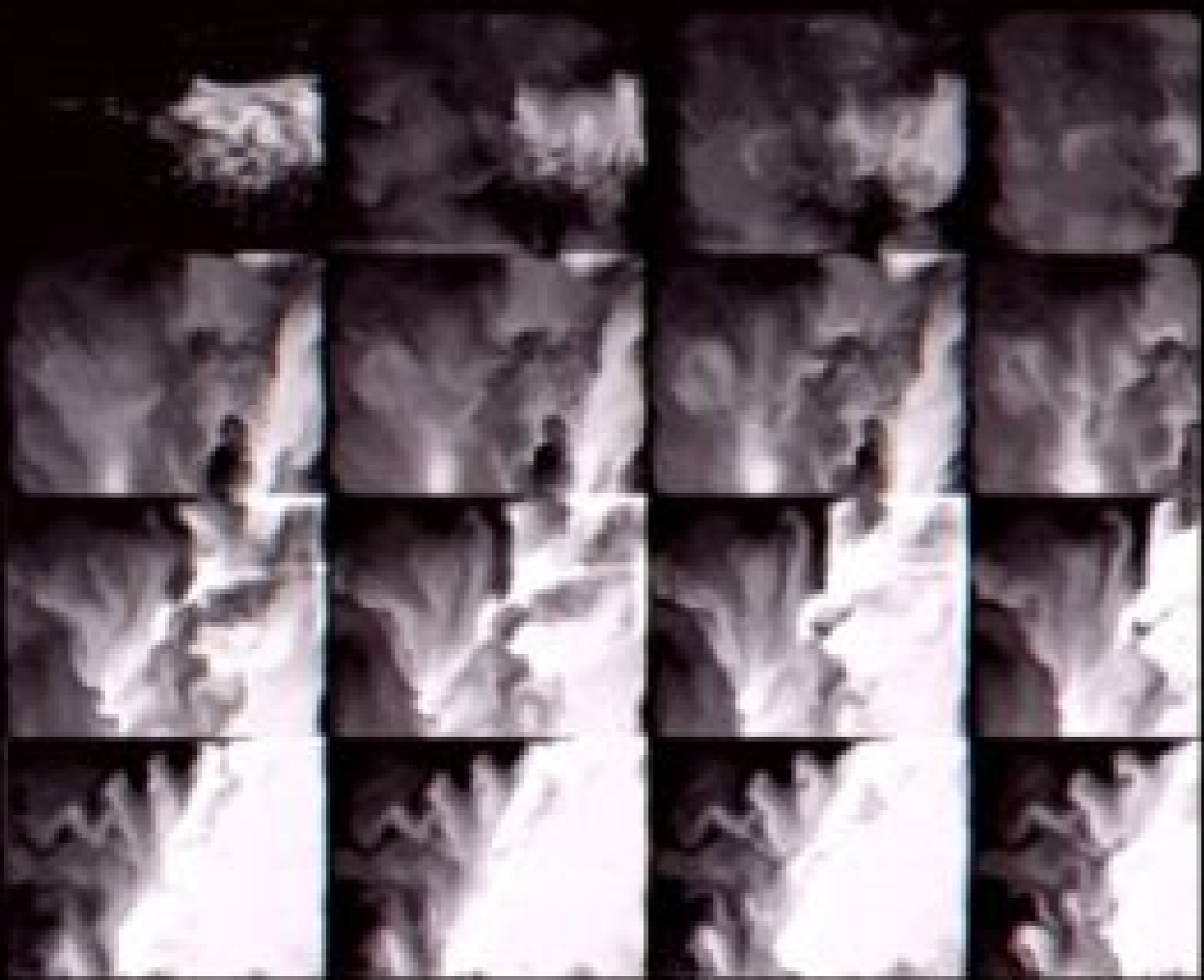
**Input converted
to 3D Voxel Grid**

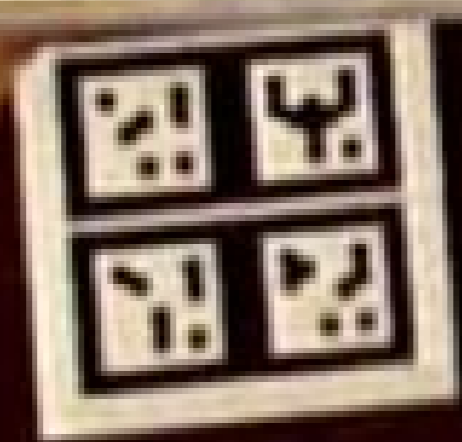
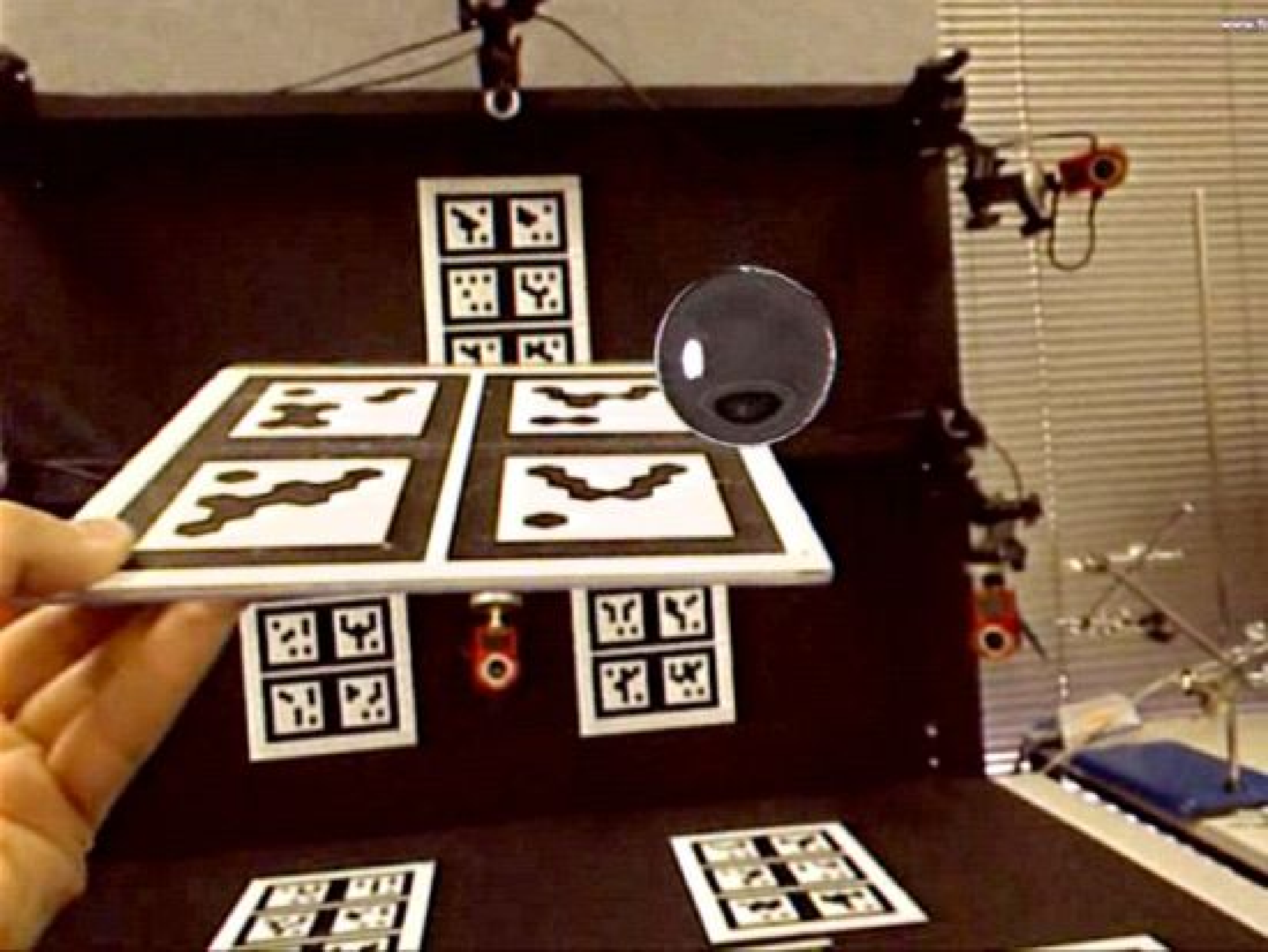


**3D Navier Stokes
Fluid Solver**



**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)

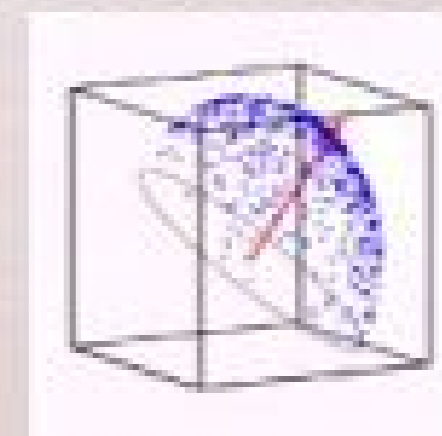
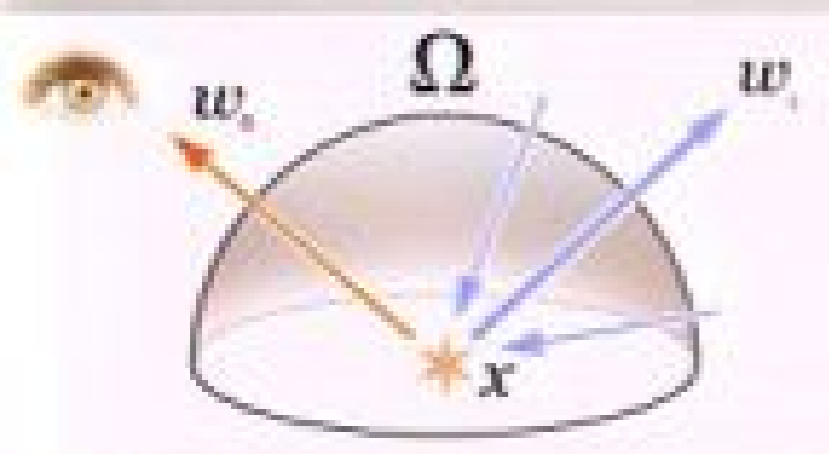
(b)

(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



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

CONCLUSIONS: SCIENTIFIC CONTRIBUTION

We have co-pioneered:

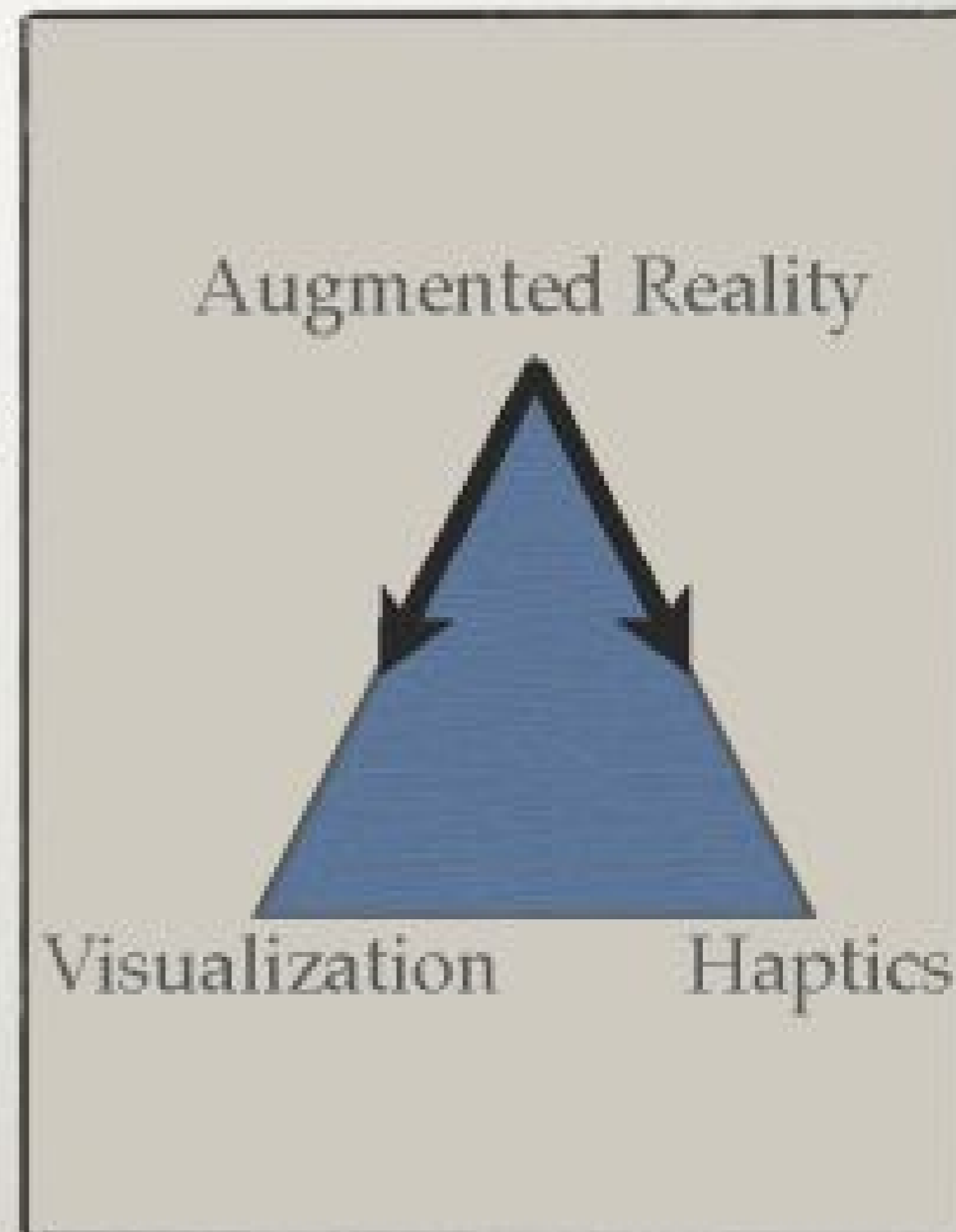
AR & Visualization

White, Feiner (Columbia University)

Kalkofen, Mendez, Schmalstieg (TU Graz)

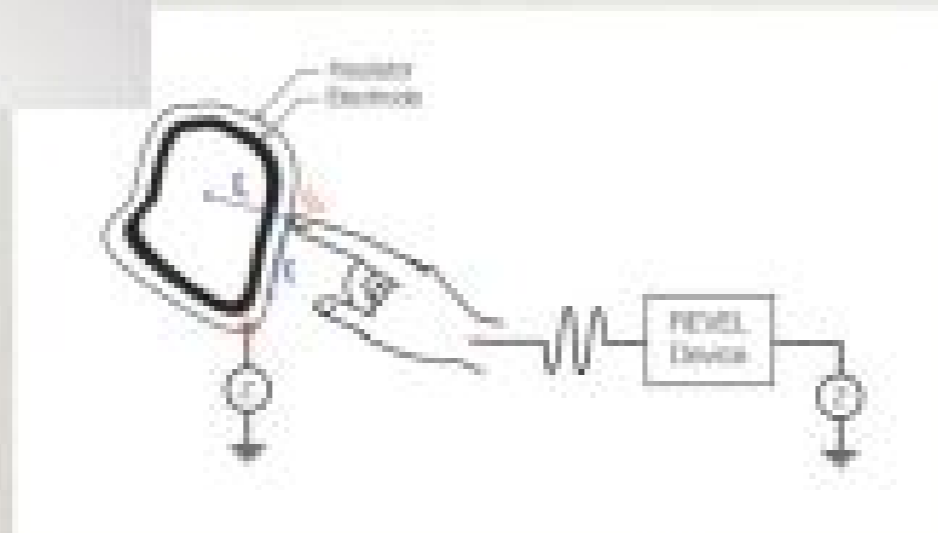
AR & Haptics

Knörlein, Harders (ETH Zurich)

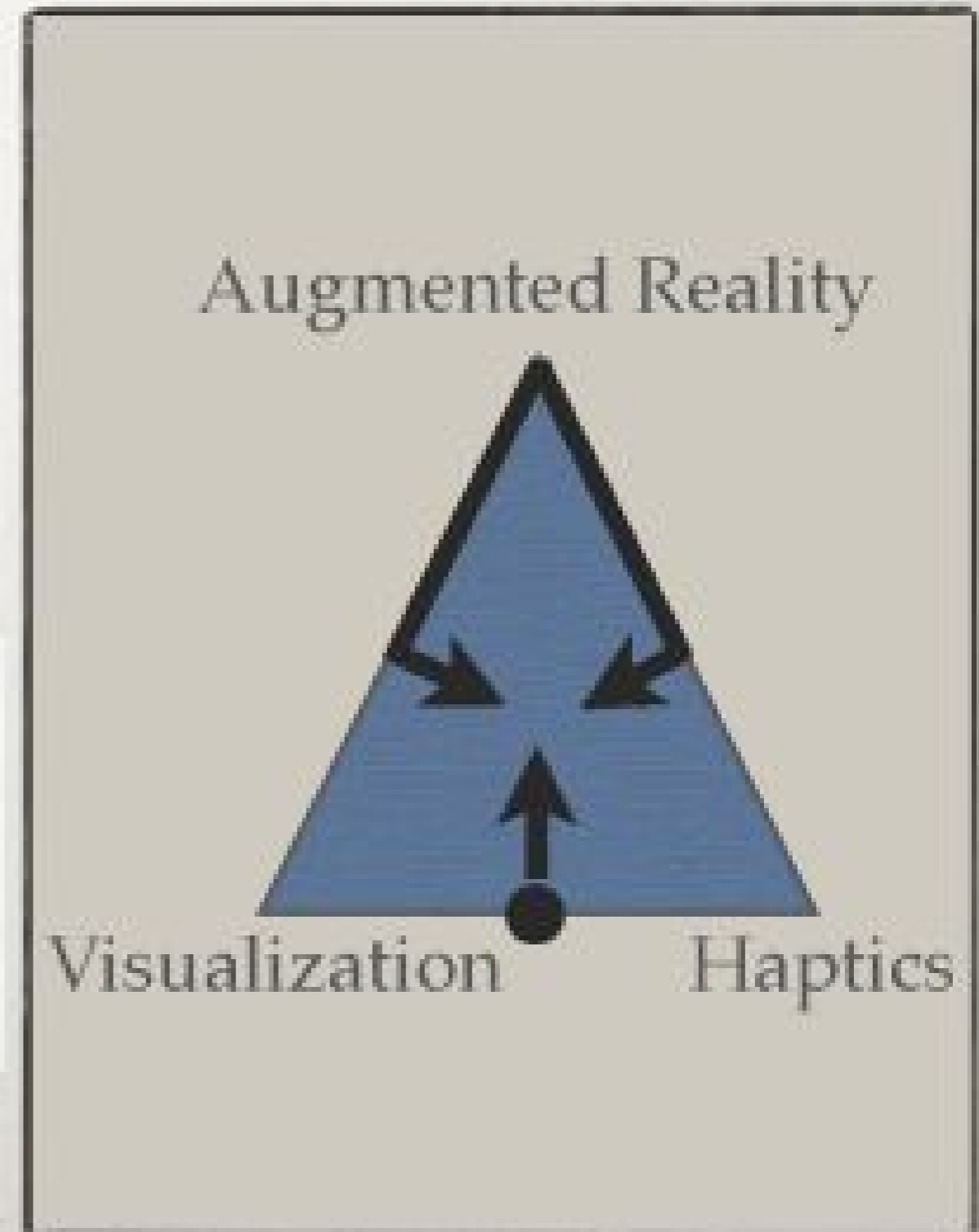


CONCLUSIONS: FUTURE WORK

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



[Bau & Poupyrev, SIGGRAPH 2012]



MORE INFORMATION: WWW.MAGICVISIONLAB.COM

MAGIC VISION

Any sufficiently advanced technology is indistinguishable from magic.
- Arthur C. Clarke's Third Law

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Welcome to the Magic Vision Lab. We enjoy creating tomorrow's user interfaces today!

Humans perceive their environment primarily through vision. Our goal is to enhance human vision with computer generated graphics in order to bring human intelligence to a whole new level. Our vision is shared by a large and growing community from industry, academia, and research.

We are part of the [Microsoft Research](#) and [Intel Labs](#).

Learn more about our research and the [Magic Vision Lab](#) and the [Magic Vision](#) series.

Video Player 1: A person wearing a VR headset looking at a virtual interface.

Video Player 2: A person using a VR controller to interact with a virtual environment.

Video Player 3: A person using a VR headset to view a virtual scene.

Sponsors: SAMSUNG, Canon, NOKIA, Intel Labs, NVIDIA.

BS1 4:30PM-5:00PM
BS1 7:30PM-8:00PM

BS1 4:30PM-5:00PM
BS1 7:30PM-8:00PM

PARTNER VOICE

音声がわかる?

A man in a suit stands next to a woman wearing a VR headset. A person in a VR headset is visible in the background. The text '音声がわかる?' (Can you hear the voice?) is displayed on the screen.

LAVAL VIRTUAL

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The Experience | VR Mix | News | Innovation Showcase | VRU 2012 | Registration | Virtual Partners | More

VR Mix keynote speakers

March 28, 10:00am
Christian Sander
Director of the Magic Vision Lab,
University of North Carolina

March 28, 2:00pm
Bernard Ourghanlian
CTO of Microsoft France

March 28, 3:00pm
Prof. Masahiko Inami
from the School of Media Design
at the Keio University, JAPAN

Three portrait photos of the keynote speakers: Christian Sander, Bernard Ourghanlian, and Prof. Masahiko Inami.

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!