General Examinations Proposal

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Introduction

Display and photographic technologies currently being developed at the Media Lab and elsewhere offer new tools for capturing and displaying images. When sensing and display technologies are combined, these tools also offer the promise of allowing people to instantaneously perceive and react to their surroundings in ways not previously possible. The areas below examine tools for enabling people to understand, in real time, parts of the physical world that are unavailable to our unaided senses.

Tools already exist for extending human perceptual ability. In many cases however, information is transformed in a way that does not take full advantage of our sensory capabilitiy. For example, night-vision goggles allow us to see when we could normally not, but the systems in common use only display a monochrome image to the wearer. This leaves our color-processing capabilities unused, and potentially available for other related information like compass heading, or even acoustic visualization. Areas for this exam will cover methods for both acquiring and displaying extra-sensory information, as well as examination of limits on human capability constraining sensory extension. Together, these areas will pave the way for sensory augmentation designs that maximize the information available to their users.

Possible applications enabled by these designs include:

- Tools for displaying volumetric variation of refractive index within transparent objects.
- Tools for visualizing evolution of volumetric information over time, such as the viewing of air movement in 3D weather data, or the spatiotemporal patterns in ultrasound measurements of a beating heart.
- Medical diagnostic tools employing the visualization of image or other data from many past cases concurrently with a current case.
- Tools for visually finding patterns in arbitrary high-dimensional data sets.

Main Area: 3D Information Visualization

Examiner

V. Michael Bove, Jr.
Principal Research Scientist
Director of the Object-Based Media Group
MIT Media Laboratory

Description

This research area will review literature on designing visual representations of high-dimensional data sets, including volumetric and spatio-temporal data. Holographic presentation can place light emitters at arbitrary distances from the display surface, and can give these emitters arbitrary appearance over a range of viewing directions. These additional capabilities have the potential to extend the bandwidth available between human and computer for information display. This area will additionally examine how the addition of depth and anisotropy might be used to present richer displays for data visualization.

Requirement

The completion requirement for this area will be a publishable paper, evaluated by Dr. Bove.

Examiner's signature: _____

Reading List

Bederson, B. and Shneiderman, B. (2003). *The Craft of Information Visualization*. MK Publishers.

Bertin, J. (1983). *Semiology of graphics*. University of Wisconsin Press.

Freeman, W. and Zhang, H. (18-20 June 2003). Shape-time photography. *Computer Vision and Pattern Recognition, 2003. Proceedings. 2003 IEEE Computer Society Conference on*, 2:II–151–II–157 vol.2.

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Zettl, H. (2008). *Sight, Sound, Motion: Applied Media Aesthetics, 5th Edition*. Wadsworth Publishing.

Technical Area: Computational Cameras

Examiner

Ramesh Raskar
Associate Professor of Media Arts and Sciences
Director of the Camera Culture Group
MIT Media Laboratory

Description

This area looks into advances in our ability to measure the physical world using techniques for sensing phenomena that lie outside direct perceptual experience. Techniques will include those for measuring structure of objects in the presence of visual obstructions, including tomography, as well as methods for capturing multi-spectral images. Additionally, when creating representations of the world for live interpretation by human observers, it is important to prioritize the collection of information relevant to the observer. This area will therefore also examine information flow through imaging systems for optimization for real-time operation and processing, both by cameras themselves, and by image processing systems that prepare their output for display. This will include review of Compressed Sensing literature.

Requirement

The completion requirement for this area will be 24-hour written exam, administered by Prof. Raskar.

Examiner's signature: _____

Reading List

Atcheson, B., Ihrke, I., Heidrich, W., Tevs, A., Bradley, D., Magnor, M., and Seidel, H.-P. (2008). Time-resolved 3d capture of non-stationary gas flows. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia)*, 27(5):?

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Caroli, E., Stephen, J. B., Cocco, G., Natalucci, L., and Spizzichino, A. (1987). Coded aperture imaging in x- and gamma-ray astronomy. *Space Science Reviews*, 45(3):349–403.

Cathey, W. T. and Dowski, E. R. (2002). New paradigm for imaging systems. *Applied Optics*, 41:6080–6092.

Gu, J., Nayar, S. K., Grinspun, E., Belhumeur, P. N., and Ramamoorthi, R. (2008). Compressive Structured Light for Recovering Inhomogeneous Participating Media. In *Europian Conference on Computer Vision (ECCV)*.

Kuthirummal, S. and Nayar, S. K. (2006). Multiview radial catadioptric imaging for scene capture. In *SIGGRAPH '06: ACM SIGGRAPH 2006 Papers*, pages 916–923, New York, NY, USA. ACM.

Lanman, D., Raskar, R., Agrawal, A., and Taubin, G. (2008). Shield fields: Modeling and capturing 3d occluders. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia)*, 27(5).

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Liang, C.-K., Lin, T.-H., Wong, B.-Y., Liu, C., and Chen, H. (2008). Programmable aperture photography: Multiplexed light field acquisition. *ACM Transactions on Graphics*, 27(3).

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Mohan, A., Raskar, R., and Tumblin, J. (2008). Agile spectrum imaging: Programmable wavelength modulation for cameras and projectors. *Computer Graphics Forum*, 27(2):709–717.

Nayar, S., Branzoi, V., and Boult, T. (27 June-2 July 2004). Programmable imaging using a digital micromirror array. *Computer Vision and Pattern Recognition, 2004. CVPR 2004. Proceedings of the 2004 IEEE Computer Society Conference on*, 1:I–436–I–443 Vol.1.

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Nayar, S. and Nakagawa, Y. (Aug 1994). Shape from focus. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, 16(8):824–831.

Nayar, S. K. (2006). Computational cameras: Redefining the image. *Computer*, 39(8):30–38.

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Zomet, A. and Nayar, S. K. (2006). Lensless imaging with a controllable aperture. *cvpr*, 1:339–346.

Contextual Area: Human Sensory Substitution

Examiner

Pawan Sinha
Associate Professor of Vision and Computational Neuroscience
MIT

Description

This area examines fundamental human visual capability in the context of sensory substitution. Much of existing sensory substitution research focuses on compensating for a loss in visual or auditory ability by translating information into formats readily processable by other senses. Readings will cover historical and recent research into the limits of human spatial and temporal perception through innate as well as technology-assisted capabilities.

Requirement

The completion requirement for this area will be 24-hour written exam, administered by Prof. Sinha.

Examiner's signature: _____

Reading List

T. Akinbiyi, C. E. Reiley, S. Saha, D. Burschka, C. J. Hasser, D. D. Yuh, and A. M. Okamura. Dynamic augmented reality for sensory substitution in robot-assisted surgical systems. *Conf Proc IEEE Eng Med Biol Soc*, 1:567–570, 2006.

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