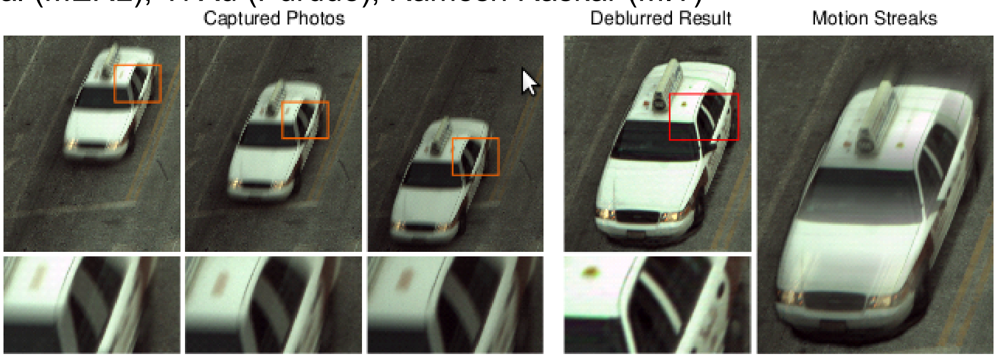
CAMERA

Invertible Motion Blur in Video

Amit Agrawal (MERL), Yi Xu (Purdue), Ramesh Raskar (MIT)



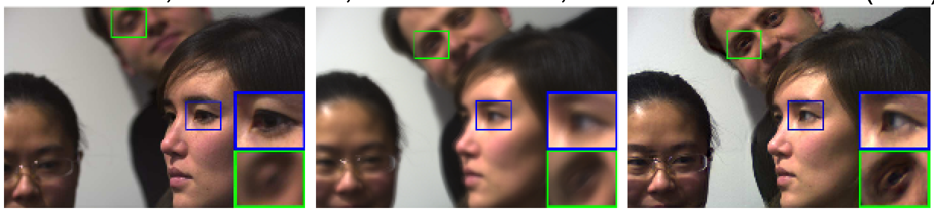
We achieve jointly-invertible blur simply by changing the exposure time of successive frames. We address the problem of automatic deblurring of objects moving with constant velocity by solving its critical components: preservation of all spatial frequencies, segmentation and motion estimation of moving parts, and non-degradation of the static parts of the scene. We demonstrate several challenging cases of object motion blur including textured backgrounds and partial occluders.

Dark Flash Photography

Dilip Krishnan, Rob Fergus (NYU)

Camera flashes produce intrusive bursts of light that disturb or dazzle. We present a prototype camera and flash that uses infra-red and ultra-violet light mostly outside the visible range to capture pictures in low-light conditions. Building on ideas from flash/no-flash photography, we capture a pair of images, one using the dark flash, other using the dim ambient illumination alone. We then exploit the correlations between images recorded at different wavelengths to denoise the ambient image and restore fine details to give a high quality result, even in very weak illumination. The processing techniques can also be used to denoise images captured with conventional cameras.

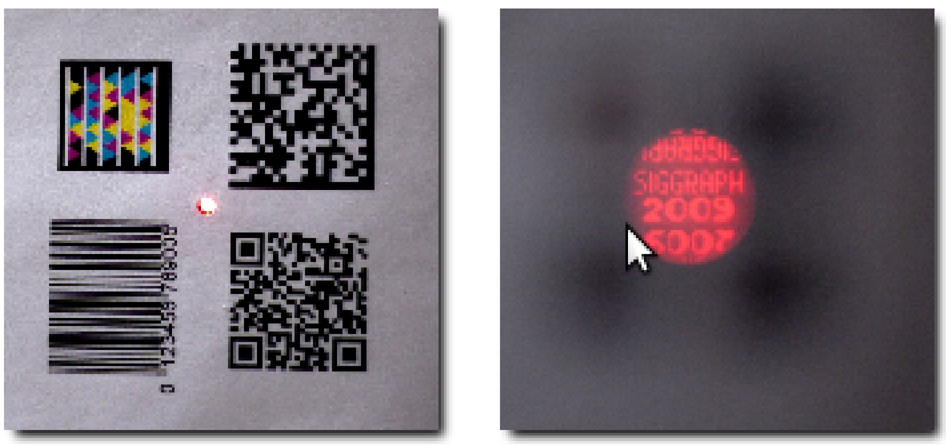
4D Frequency Analysis of Computational Cameras for Depth of Field Extension
Anat Levin, Sam Hasinoff, Paul Green, Fredo Durand, William T. Freeman (MIT)



Standard lens image | Our lattice-focal lens: input | Lattice-focal lens: all-focused output

Depth of field (DOF), the range of scene depths that appear sharp in a photograph, poses a fundamental tradeoff in photography---wide apertures are important to reduce imaging noise, but they also increase defocus blur. Recent advances in computational imaging modify the acquisition process to extend the DOF through deconvolution. Because deconvolution quality is a tight function of the frequency power spectrum of the defocus kernel, designs with high spectra are desirable. In this paper we study how to design effective extended-DOF systems, and show an upper bound on the maximal power spectrum that can be achieved. We introduce the lattice-focal lens, which concentrates energy at the low-dimensional focal manifold and achieves a higher power spectrum than previous designs.

Bokode: Imperceptible Visual Tags for Camera-based Interaction from a Distance
Ankit Mohan, Grace Woo (MIT), Shinsaku Hiura (Osaka University), Quinn Smithwick, Ramesh Raskar (MIT)



In Focus Photograph | Out of Focus Photograph

We show a new camera based interaction solution where an ordinary camera can detect small optical tags from a relatively large distance. Current optical tags, such as barcodes, must be read within a short range and the codes occupy valuable physical space on products. We present a new low-cost optical design so that the tags can be shrunk to 3mm visible diameter, and unmodified ordinary cameras several meters away can be set up to decode the identity plus the relative distance and angle. The design exploits the bokeh effect of ordinary cameras lenses, which maps rays exiting from an out of focus scene point into a disk like blur on the camera sensor. This bokeh-code or Bokode is a barcode design with a simple lenslet over the pattern. We show that an off-the-shelf camera can capture Bokode features of 2.5 microns from a distance of over 4 meters. We use intelligent binary coding to estimate the relative distance and angle to the camera, and show potential for applications in augmented reality and motion capture.

STEREO

The Graph Camera

Voicu Popescu, Paul Rosen, Nicoletta Adamo-Villani (Purdue)

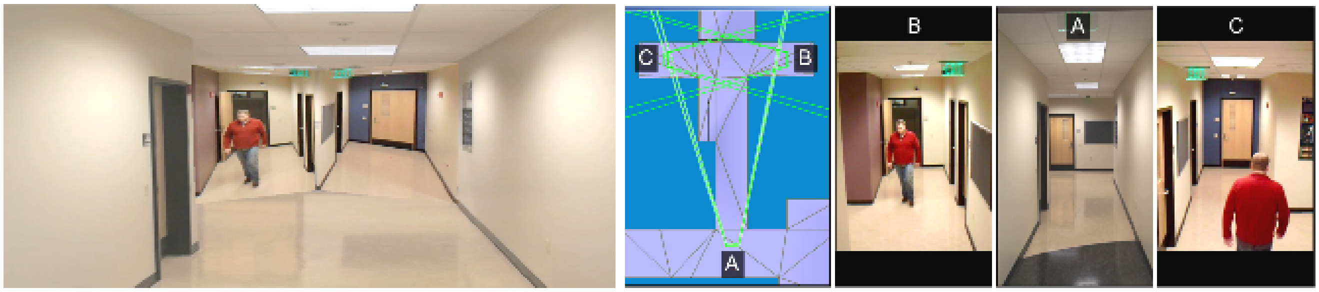


Figure 2 Single-image comprehensive visualization of real-world scenes. The graph camera image (*left*) seamlessly integrates 3 video feeds (*right*) and shows all 3 branches of the T corridor intersection.

The Graph Camera is a tool for generating multi-perspective views of a complex 3-D environment. The Graph Camera begins as a standard planar pinhole camera frustum. That frustum then undergoes a series of bending, splitting, and merging operations. The resulting images are mostly continuous and allow for comprehensive views of 3-D space.

REDUCED PHYSICS

Enrichment Textures for Detailed Cutting of Shells

Peter Kaufmann Sebastian Martin, (ETH Zurich), Mario Botsch (Bielefeld Univ), Eitan Grinspun (Columbia), Markus Gross (ETH Zurich)

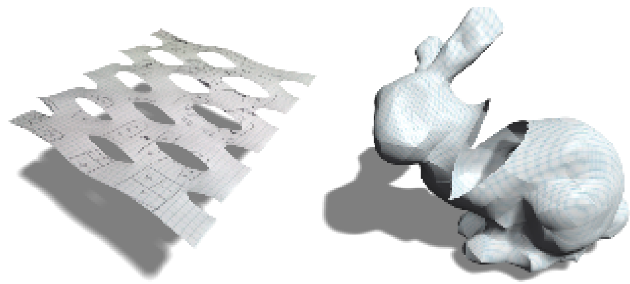
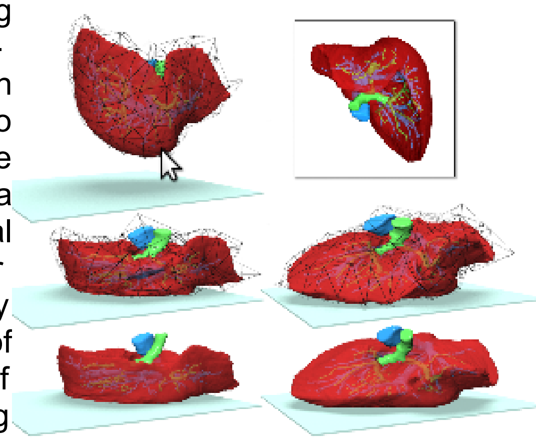


Figure 1: *Starting from a single 8-node quad shell element, our method is able to capture complex deformations and topological changes by simply enriching the element's basis functions through texture maps (left). Fracturing a bunny triangle mesh (right).*

We present a method for simulating highly detailed cutting and fracturing of thin shells using low-resolution simulation meshes. Instead of refining or remeshing the underlying simulation domain to resolve complex cut paths, we adapt the extended finite element method (XFEM) and enrich our approximation by custom-designed basis functions, while keeping the simulation mesh unchanged. The enrichment functions are stored in enrichment textures, which allows for fracture and cutting discontinuities at a resolution much finer than the underlying mesh, similar to image textures for increased visual resolution. Furthermore, we propose harmonic enrichment functions to handle multiple, intersecting, arbitrarily shaped, progressive cuts per element in a simple and unified framework.

Numerical Coarsening of Inhomogeneous Elastic Materials

Lily Kharevych, Patrick Mullen, Houman Owhadi, Mathieu Desbrun (CIT)



We propose an approach for efficiently simulating elastic objects made of non-homogeneous, non-isotropic materials. Based on recent developments in homogenization theory, a methodology is introduced to approximate a deformable object made of arbitrary fine structures of various linear elastic materials with a dynamically-similar coarse model. This numerical coarsening of the material properties allows for simulation of fine, heterogeneous structures on very coarse grids while capturing the proper dynamics of the original dynamical system, thus saving orders of magnitude in computational time. Examples including inhomogeneous and/or anisotropic materials can be realistically simulated in real time with a numerically-coarsened model made of a few mesh elements.

Preserving Topology and Elasticity for Embedded Deformable Models

Matthieu Nesme (McGill University, Grenoble Universites, INRIA and LJK-CNRS), Paul G. Kry (McGill University), Lenka Jeřábková (INRIA and LJK-CNRS), François Faure (Grenoble Universites, INRIA and LJK-CNRS)

In this paper we introduce a new approach for the embedding of linear elastic deformable models. Our technique results in significant improvements in the efficient physically based simulation of highly detailed objects. First, our embedding takes into account topological details, that is, disconnected parts that fall into the same coarse element are simulated independently. Second, we account for the varying material properties by computing stiffness and interpolation functions for coarse elements which accurately approximate the behaviour of the embedded material. Finally, we also take into account empty space in the coarse embeddings, which provides a better simulation of the boundary. The result is a straightforward approach to simulating complex deformable models with the ease and speed associated with a coarse regular embedding, and with a quality of detail that would only be possible at much finer resolution.

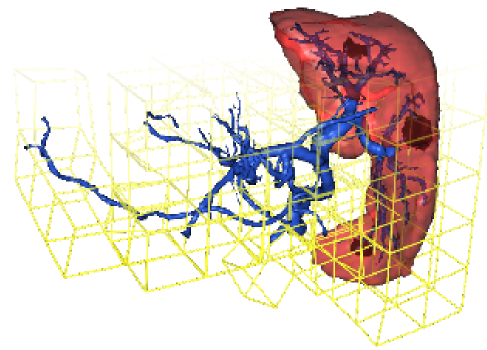


Figure 1: *A model of a liver with attached vascular system simulated with coarse resolution hexahedra. Our technique models the behaviour of the soft liver tissue, stiffer veins, and much stiffer tumors by taking into account a distribution of materials and the presence of empty regions in the embedding. The complex topological branching of the vascular system is preserved by superimposing elements.*

Deformable Object Animation Using Reduced Optimal Control

Jernej Barbic, Marco da Silva (MIT), Jovan Popovic (MIT and Adobe Systems, Inc.)

We present a fast space-time optimization method to author physically based deformable object simulations that conform to animator-specified keyframes. We demonstrate our method with FEM deformable objects and mass-spring systems.