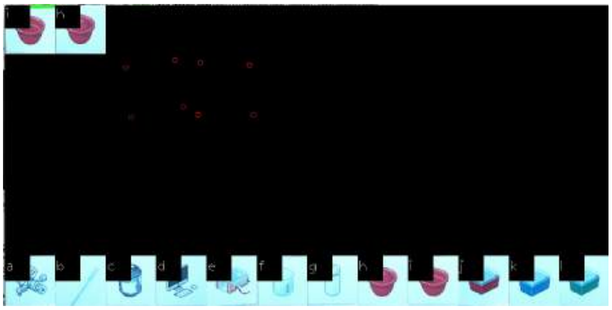
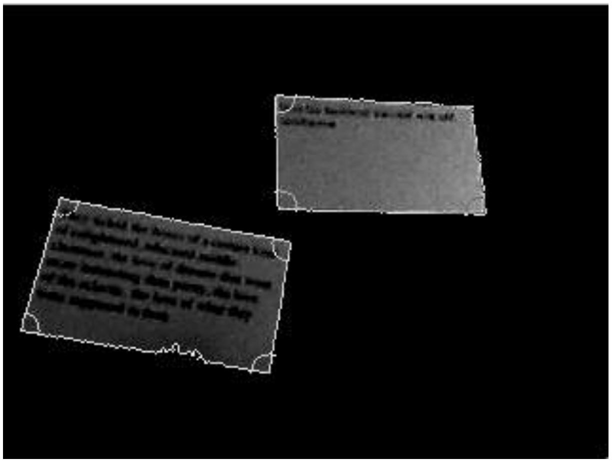
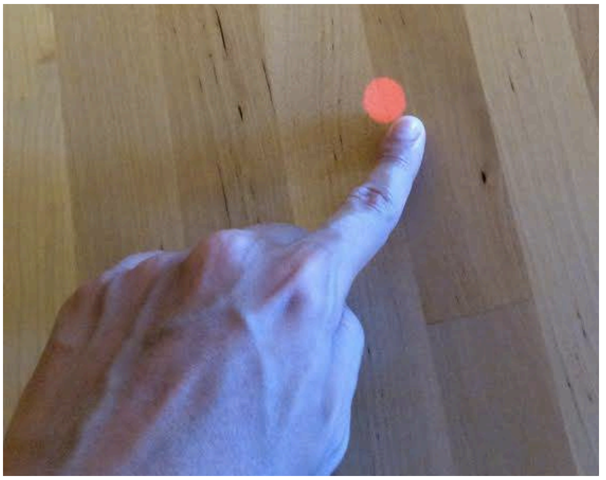


RMO: Tokens for Shawn

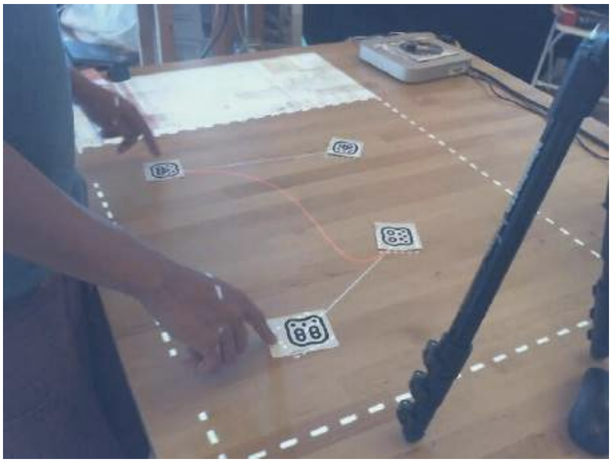


RMO: Americanah

RMO: Video Binder (Grids from a Plane)



Toby: Kinect touch
(Working with dynamic media together)



Matthias: Beziers using fiducials

Toby: Infrared PS3 Eye + LEDs +
Retroreflective tape

SurfaceFusion: Unobtrusive Tracking of Everyday Objects in Tangible User Interfaces
Alex Olwal, Andrew D. Wilson

Combines simple CV for tracking with RFID for identification.

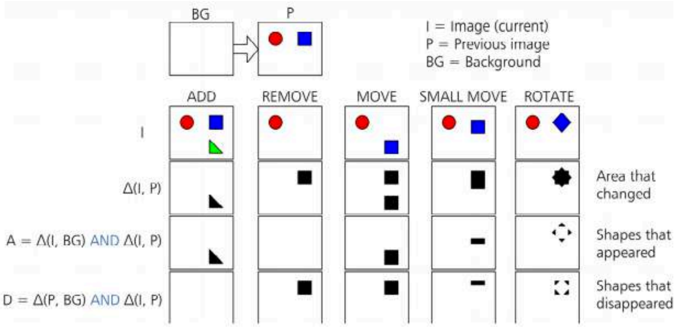


Figure 3: The Frame Difference Algebra uses absolute difference images and binary image operations for robust and fast detection of scene changes under the constraint that only one object is manipulated at a time. The background image (BG), current frame (I) and previous frame (P) are used in the calculations. By comparing the number of shapes in the resulting images with shapes that appeared (A) and disappeared (D), it is possible to infer whether an object was added, moved or removed.

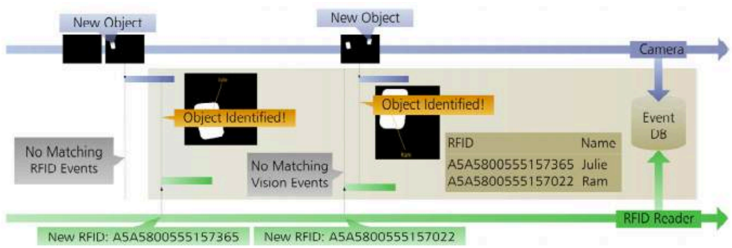


Figure 6: The fusion pipeline. As new events appear, the system tries to match them with previously unmatched events in order to associate localize and identify shapes on the surface.

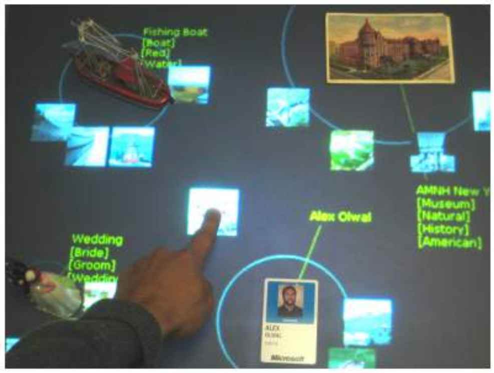


Figure 1: Our tangible user interface allows a user to intuitively interact with physical objects and their associated digital information. The system fuses RFID sensing and activities detected by simple computer vision techniques to identify and locate objects on the table.

"We employ a database of events where detected vision and RFID events are continuously stored. When a new object appears, disappears or is moved, as detected by our image processing techniques, we add a timestamped entry, with a reference to the corresponding still image in the FDA. Similarly, we store a timestamped event when an RFID tag appears or disappears. Our database thus contains all state changes that have occurred, such that the state of objects on the surface may be retrieved at any time."

Sensetable: A Wireless Object Tracking Platform for Tangible User Interfaces
James Patten, Hiroshi Ishii, Jim Hines, Gian Pangaro

Each object emulates a pointer on a Wacom Intuous sensing tablet. (Paper is more about interaction possibilities, not implementation.)

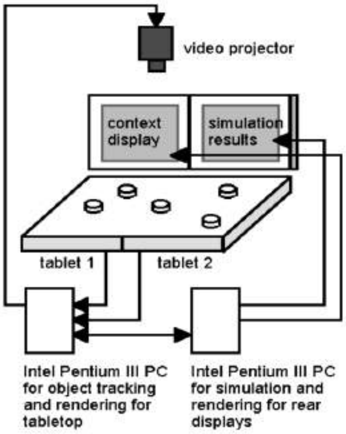


Figure 5: System Architecture of Sensetable for System Dynamics Simulation

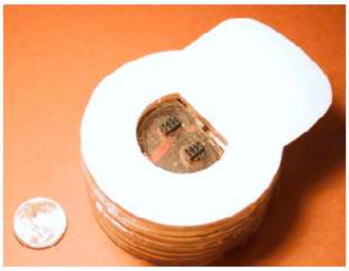


Figure 3: A Sensetable puck, with a socket for attaching a dial or modifier. A US quarter is shown for scale.

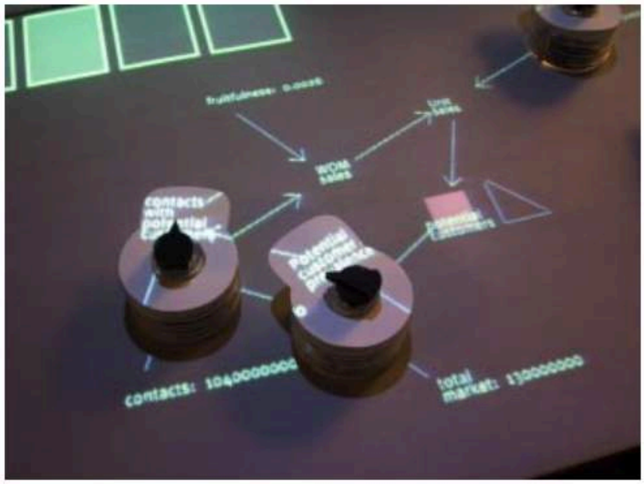
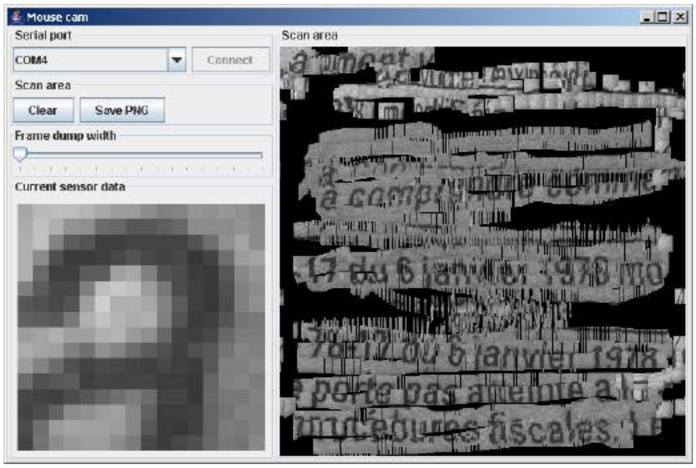
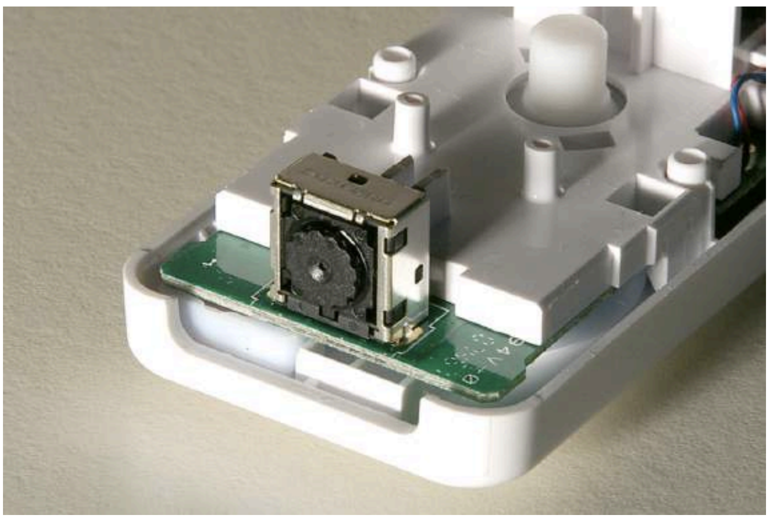


Figure 1: A system dynamics application running on top of Sensetable



An **optical mouse** uses a low resolution (18x18) grayscale camera with optical flow to pick up relative motions on a surface.

An **anoto pen** uses a small camera (optical mouse cam?) to read dot patterns on specially printed paper to give absolute position of the pen on the paper.



A **wiimote** has a 1024x768 infrared camera which outputs the x, y, and size of the four brightest spots it sees.

Automatic Projector Calibration with Embedded Light Sensors
Lee, J.C.; Dietz, P.H.; Maynes-Aminzade, D.; Raskar, R.; Hudson, S.

Projector projects gray codes. Light sensors in the environment register when they see light, thus calibrating pixels in projection space to points in the environment.

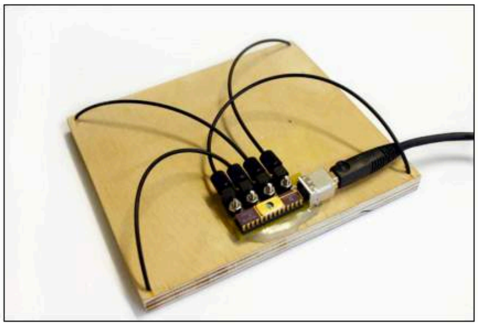


Figure 2. Back side of a projection target with optical fibers at each corner and a USB sensor board.

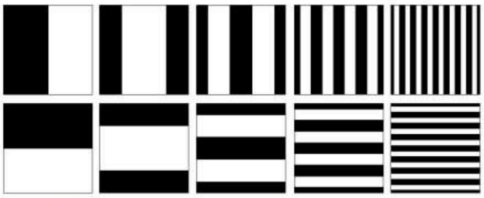


Figure 3. Horizontal and vertical Gray-coded binary patterns

Figure 5. Top: Shader Lamps demo of decorating physical objects. Bottom: multi-projector stitching

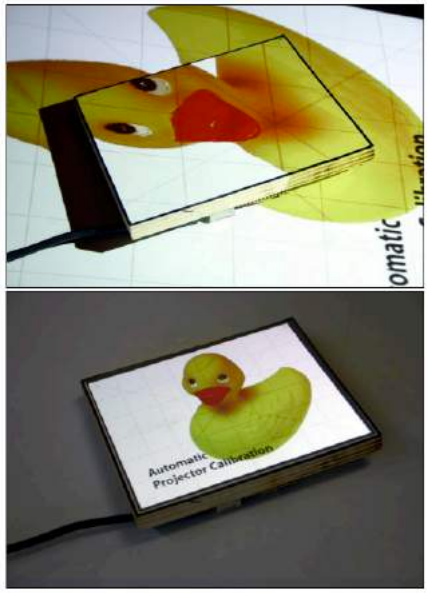


Figure 1. Screen calibration: before and after.

RFIG Lamps: Interacting with a Self-Describing World via Photosensing Wireless Tags and Projectors
Ramesh Raskar, Paul Beardsley, Jeroen van Baar, Yao Wang, Paul Dietz, Johnny Lee, Darren Leigh, Thomas Willwacher

Projector projects gray codes. Photosensors determine their relative position and send it out via "Active RFID". Authors claim that it would be feasible to power the tags via RF (like passive RFID).

Also elaborates interactions with a hand-held projector.

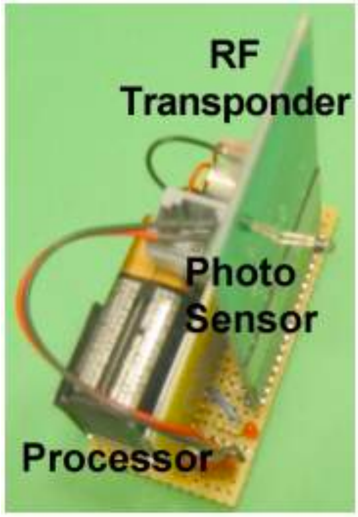


Figure 4: (a) A tagged surface, (b) One frame during Gray-code projection, (c) Correctly-placed projected augmentation.

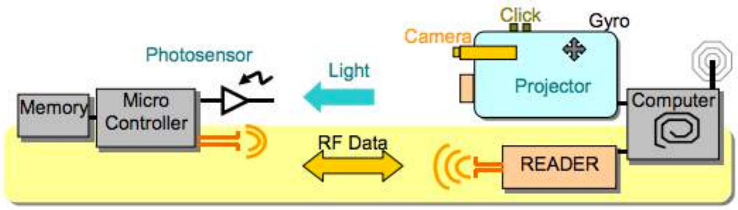


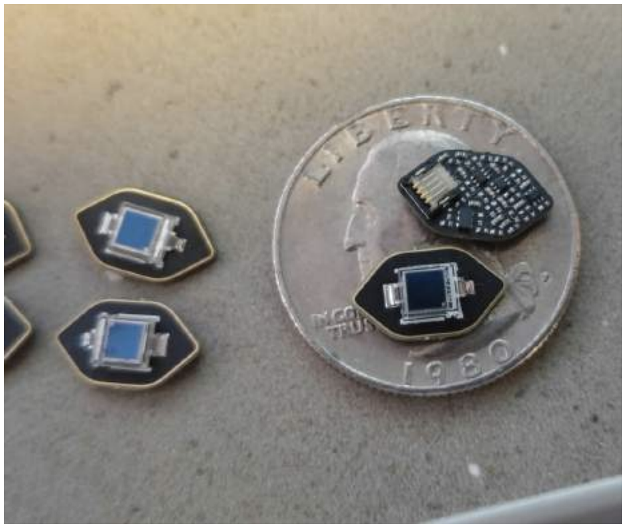
Figure 3: Communication between the photosensing tag (left) and handheld projector system (right).

Figure 10: Projected augmentation on the box is attached to tags at the vertices, and so adapts automatically to the opening of the lid.

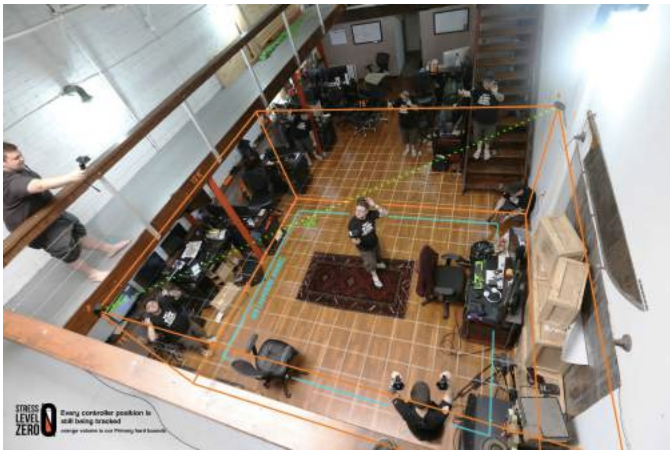
Vive Lighthouse
Alan Yates

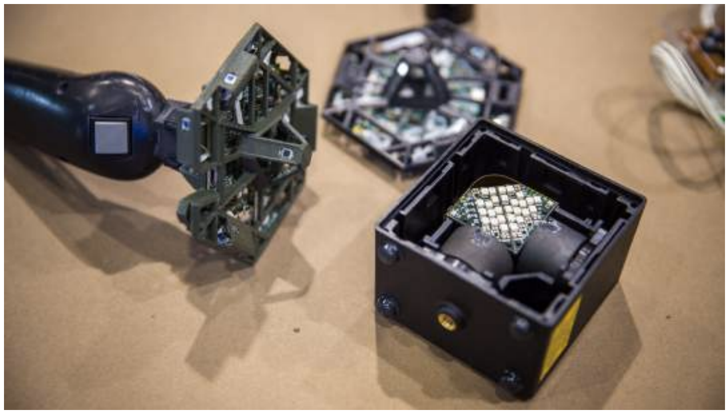
Beacons sweep timed IR laser planes. Tracked objects have photocells which measure when they see the IR light. They use timing information to determine their x-y position with respect to the beacon. Usual setups use two beacons and each device has several photocells.

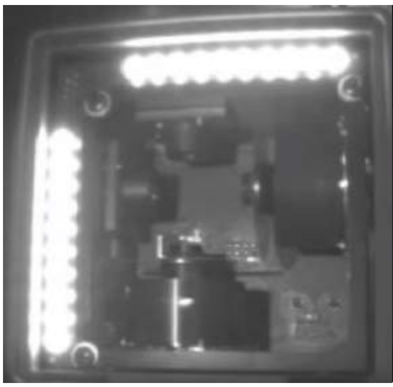
Vive claims they will be supporting this technology as a standalone product, perhaps after the Vive VR system hits the market (May?).



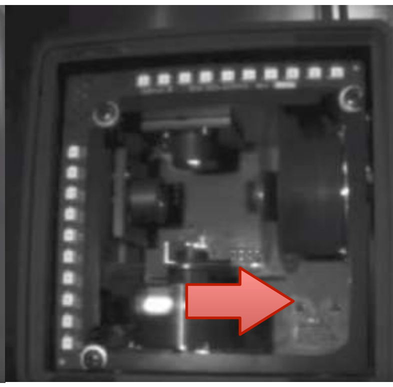
Lighthouse photosensors



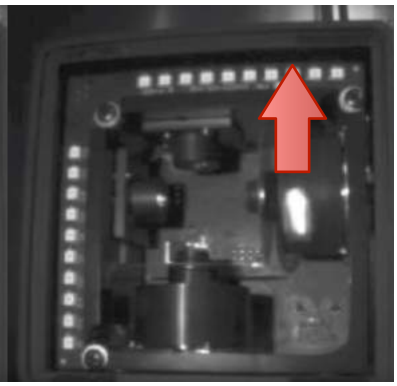




1. Timing Flash



2. Horizontal Sweep



3. Vertical Sweep

Prakash: Lighting Aware Motion Capture using Photosensing Markers and Multiplexed Illuminators
Ramesh Raskar et al

Uses IR "projectors" (which are LEDs mounted behind optics and gray code masks) to project structured light. Tracked objects have photosensors which decode timing information to determine their position.

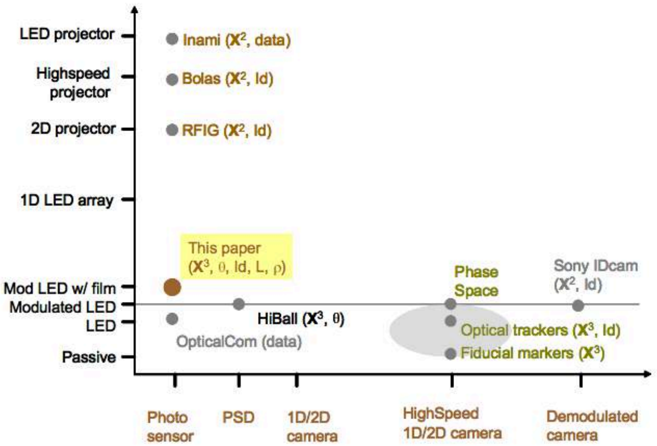


Figure 2: *Communication choices between light sources and receivers plotted as complexity of receivers (X-axis) versus complexity of transmitters (Y-axis).*

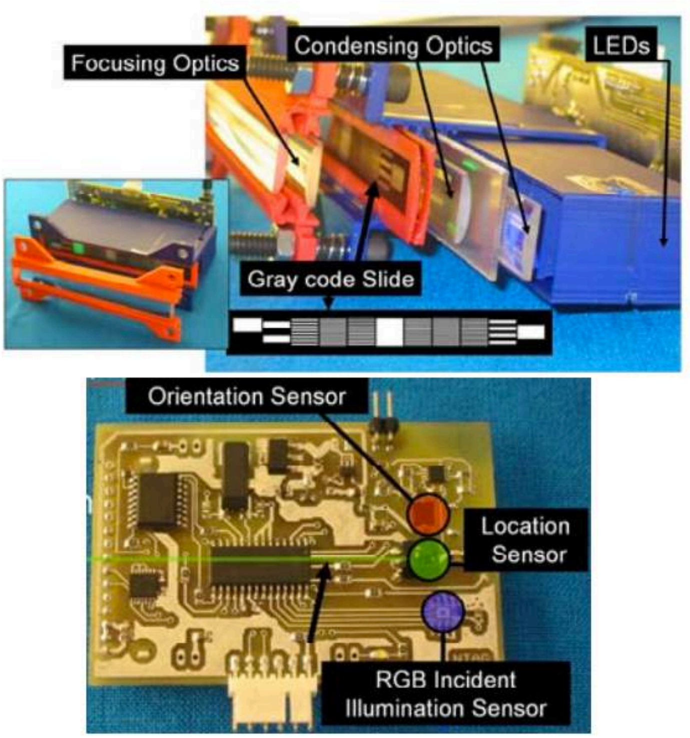


Figure 3: *Our prototype (Top) projector (a multi-beamer array), and (Bottom) tag receiver.*

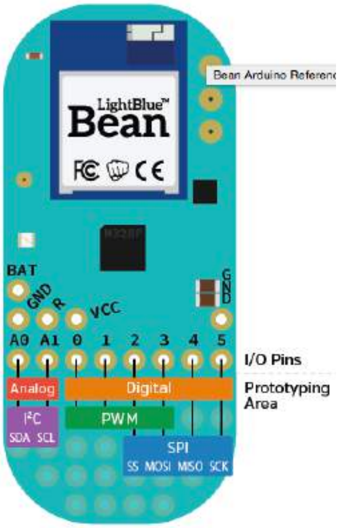
Bluetooth Low Energy (BLE) is probably ideal for us. (It is different than the Bluetooth you're used to, e.g. for wireless keyboards.)

It is very low power and connection is fast.

The range is a few meters, so we would set up "hosts" (Rasp Pi's) throughout the space (e.g. on every column) which would auto-connect to our wireless devices and proxy the communication into the Room system.

Alternatives are Zigbee which has a longer range but perhaps less ideal interference characteristics. And wifi which is probably too high power for battery powered devices.

This is a **LightBlue Bean** by PunchThrough Design. Check out how light it is! It runs on a CR2032 coin cell battery and should last for months or years.



It includes a built-in accelerometer. This is nice because we can e.g. make it sleep until the object is moved, then have it ping the system.

For example, a protocol might be:

1. Object moves, Bean pings the system "I'm Object 4. I've been moved!"
2. System responds, "Object 4: Show where you are at time t."
3. At time t, object blinks its LED.
4. Cameras know to look for a blinked LED at time t and associate it to Object 4.

1 Bean	$30.00 per Bean
4 Beans	$28.50 per Bean
10 Beans	$27.00 per Bean
100 Beans	$25.50 per Bean
500 Beans	$24.00 per Bean

3D Puppetry: A Kinect-based Interface for 3D Animation
Robert T. Held, Ankit Gupta, Brian Curless, Maneesh Agrawala

Tracks the position and pose of 3D "puppet" objects. Objects must be added to a database with a 3D model and several RGB template images of the object from different angles. RGB with SIFT features are used to identify an object to a template and get a rough pose. Then this pose estimate is refined by matching against the 3D model.

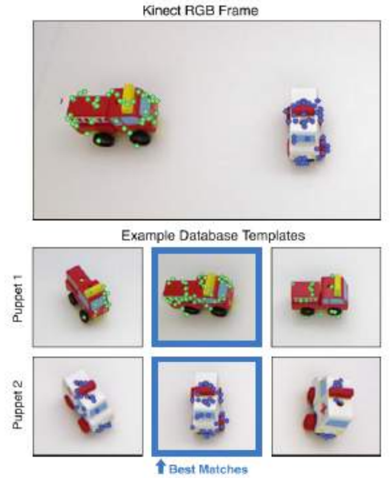


Figure 5. SIFT-based puppet identification. The RGB frame contains two physical puppets that our system has matched to the template images below it. We use color-coded dots to indicate the coordinates of the matched SIFT features. For each puppet, the best-matched template contains the most SIFT matches to the frame.

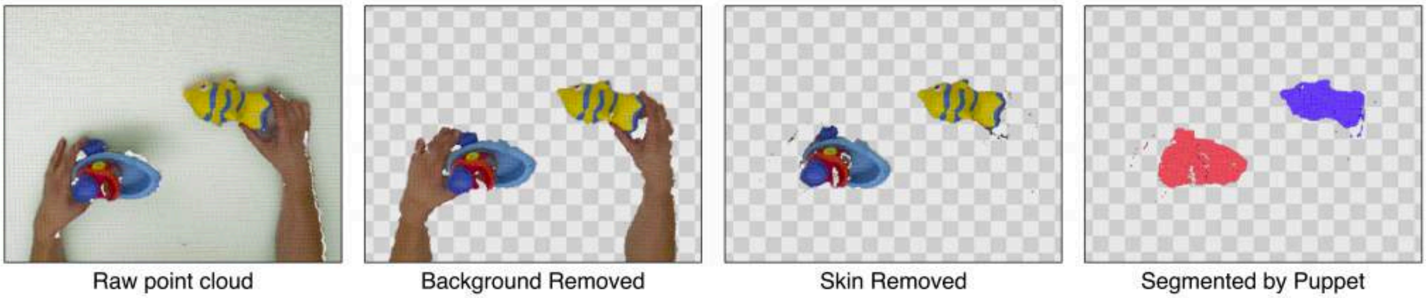


Figure 6. Steps of point-cloud segmentation. Beginning with the raw point cloud from the Kinect, our segmenter removes the background and the puppeteer's skin, and finally produces separate point clouds associated with each puppet.

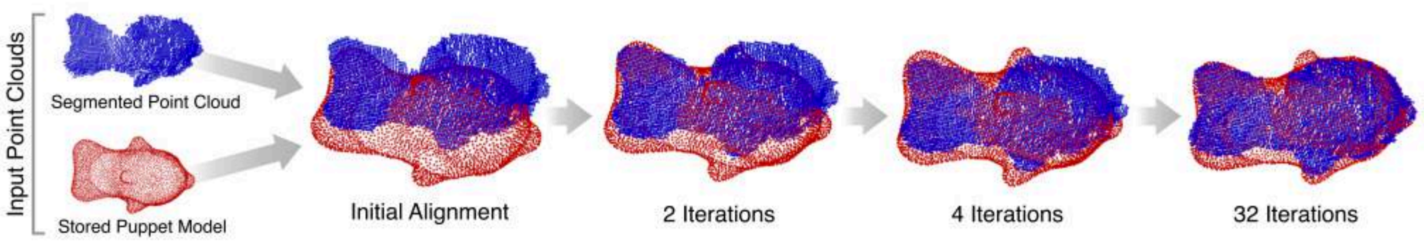


Figure 7. Progression of ICP alignment between a segmented point cloud and a Puppet Database model. Our ICP algorithm begins by transforming the puppet model using its last known pose (if available; otherwise it uses the rough pose estimate from the Puppet Identifier). Then each ICP iteration brings the clouds into closer alignment until the root mean square distance between their points meet an error threshold.

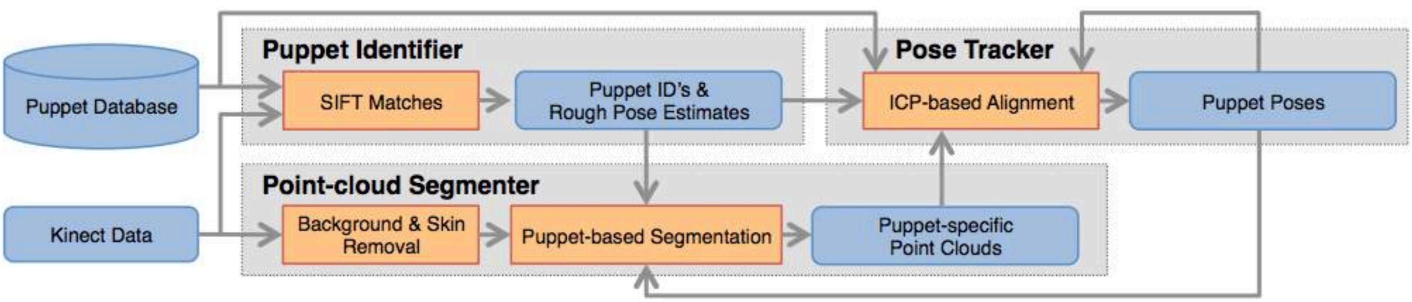
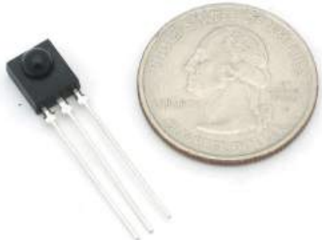
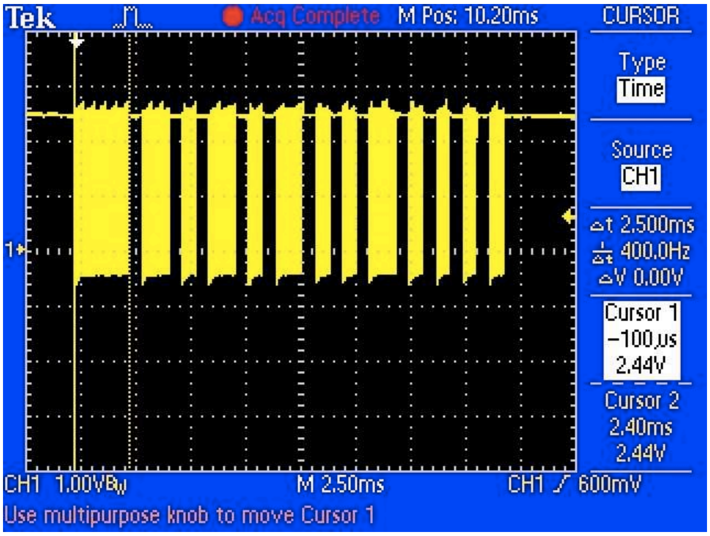


Figure 3. Overview of our system's Capture module. With each frame, the Kinect provides an RGB image and depth map. The puppet identifier compares SIFT features in those data to the features found in a database of image templates to identify puppets and roughly estimate their poses. The RGB and depth information are also combined into point clouds, which are processed to remove the background and the puppeteer's hands, and then matched to stored 3D models using ICP to estimate the puppets' 6D poses.

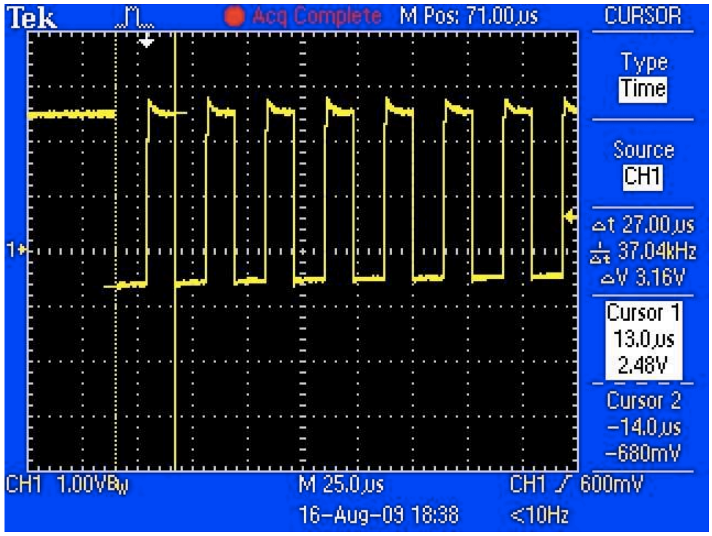
IR Sensor

Standard used for e.g. TV remote controls. Detects IR light (peak 940nm) at a 38KHz carrier frequency. $2 on Adafruit. Adafruit has a great guide (where these images are from).



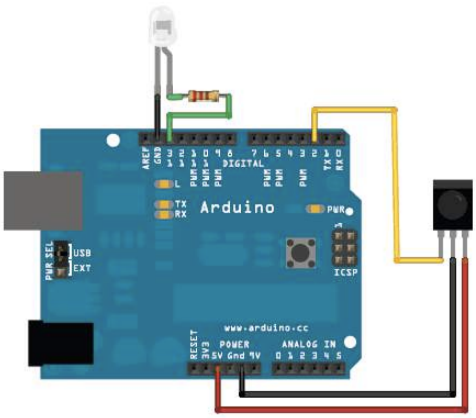


Using an IR photosensor and a fancy oscilloscope to look at the signal from a Sony remote control.



Zoomed in view showing the 38KHz carrier wave.

PWM ON	OFF
2.4 ms	0.6 ms
1.2 ms	0.6 ms
0.6 ms	0.6 ms
1.2 ms	0.6 ms
0.6 ms	0.6 ms
1.2 ms	0.6 ms
0.6 ms	0.6 ms
0.6 ms	0.6 ms
1.2 ms	0.6 ms
0.6 ms	0.6 ms
0.6 ms	0.6 ms
0.6 ms	0.6 ms
0.6 ms	270 ms



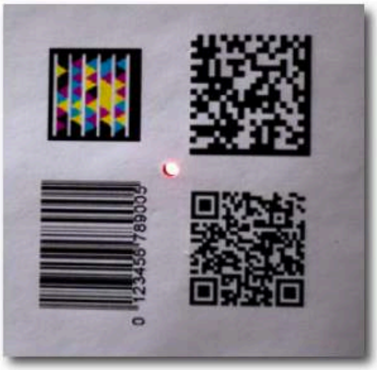
You can send signals with an IR LED (940nm) and an Arduino. (It's fast enough to make the 38KHz pulse.)

Vicon is a motion capture company that provides high speed (~250 fps) IR cameras with IR LEDs for tracking retroreflective markers, along with dedicated hardware for processing the data. Expensive ($3200/ camera, plus extras), but robust solution. It is what Ken Perlin's lab uses (I think) to track their VR space.

Bokode: Imperceptible Visual tags for Camera Based Interaction from a Distance

Ankit Mohan, Grace Woo, Shinsaku Hiura, Quinn Smithwick, Ramesh Raskar

Tiny fiducials by putting tiny codes behind a special lens. When a camera focused at infinity sees them, the bokeh produced has the code.



In Focus Photograph

Out of Focus Photograph

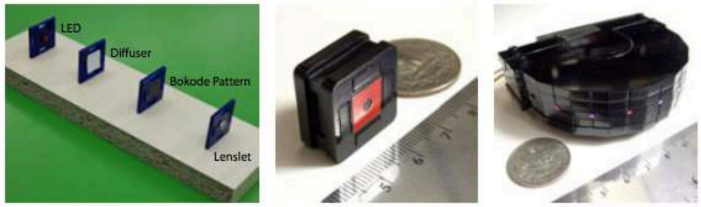


Figure 4: *Photos of Bokode prototypes discussed in the paper: (left) exploded view of our active illumination prototype, (center) an assembled Bokode, and (right) our compound superposition eye (Antarctic Krill) prototype for an ultra wide angular range.*

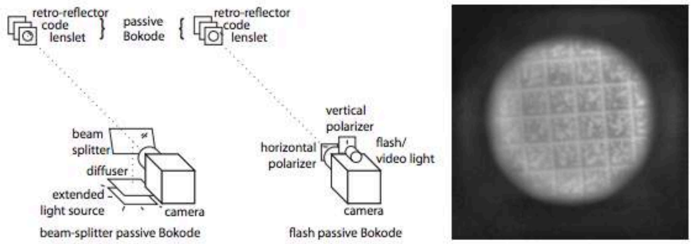


Figure 5: *Passive Bokodes replace the LED behind the Bokode pattern with a retroreflector and use the camera flash as the illumination source. (Left) Beamsplitter and cross-polarizer arrangements to illuminate the Bokode. (Right) Image of a passive Bokode captured with a camera and a light source behind a beamsplitter.*