The Kinect distance sensor as human-machine-interface in audio-visual art projects

Toningenieur-Projekt

Matthias Kronlachner

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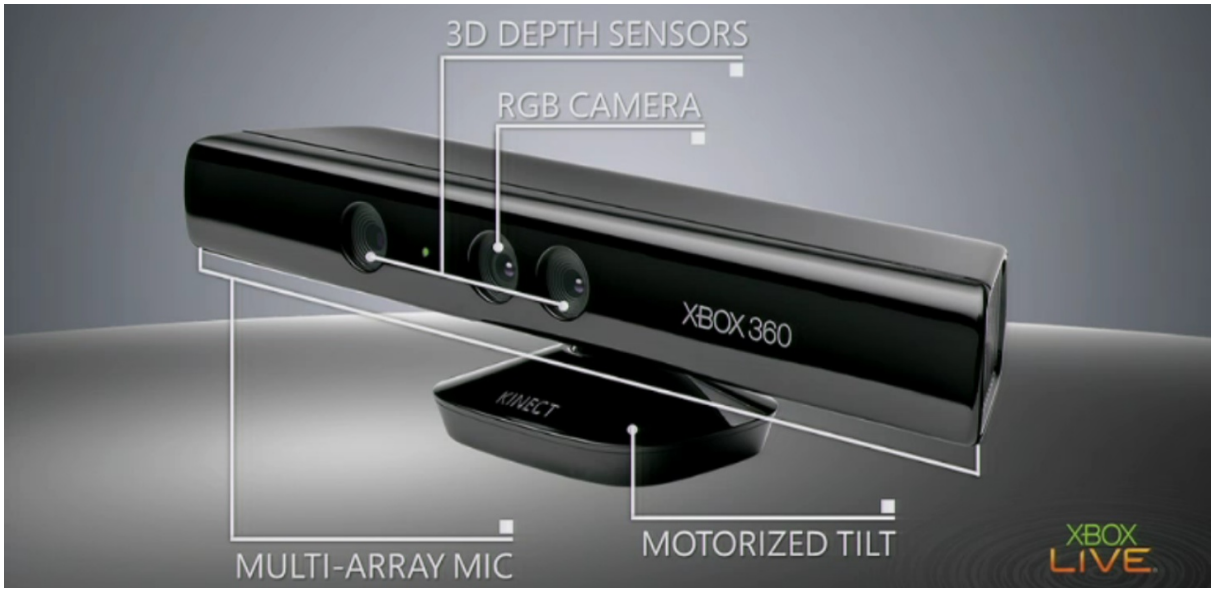
Goals of the project

- connecting Kinect device and Pure Data
- making high level functions available (Natural Interaction)
- documentation and example patches
- concrete applications in art projects

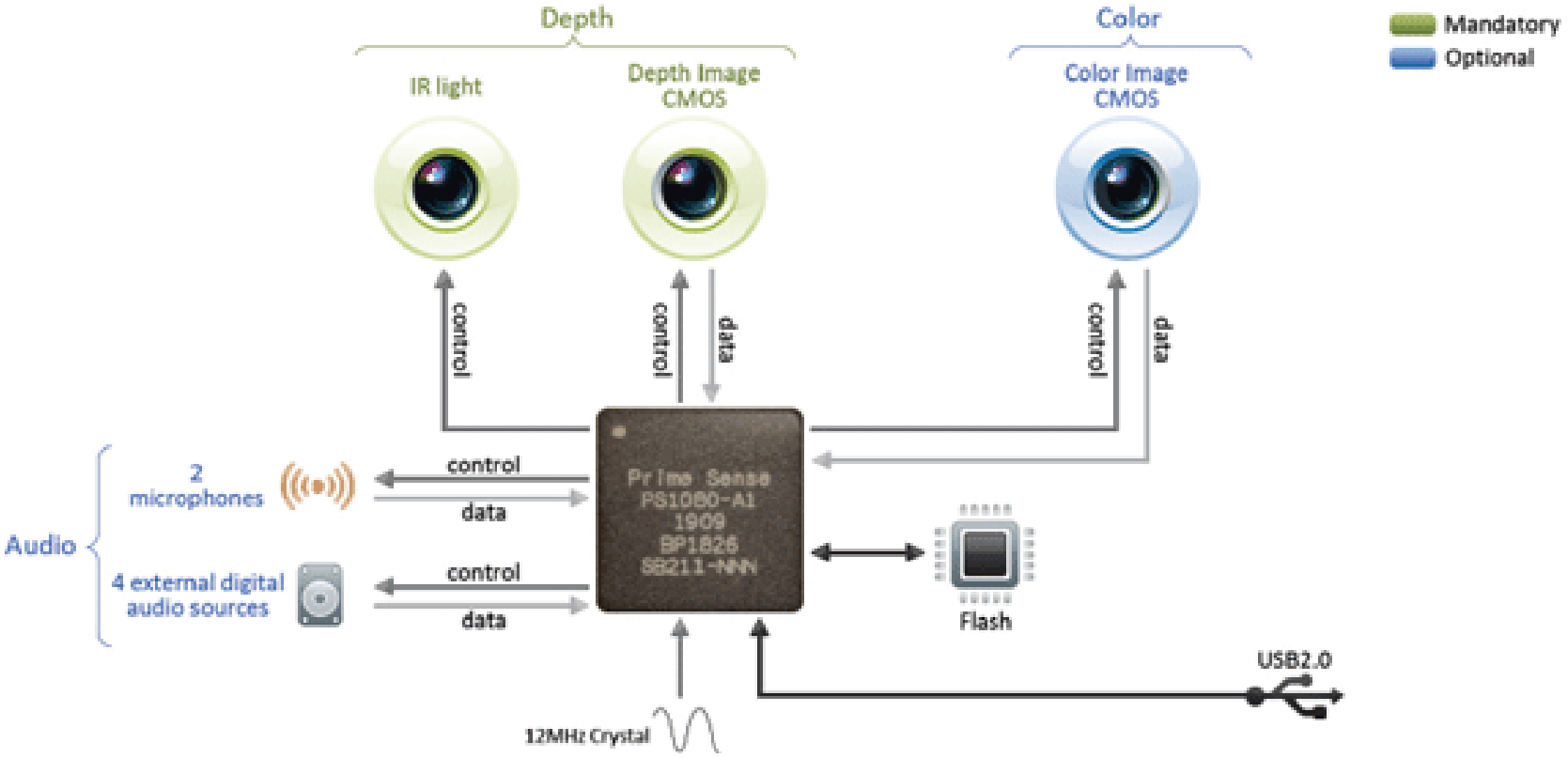
Kinect hardware



Kinect Sensor

- RGB camera
- Depth sensor
- 4 channel microphone array
- tilting head $\pm 27°$
- 3 axis accelerometer
- 3 color LED

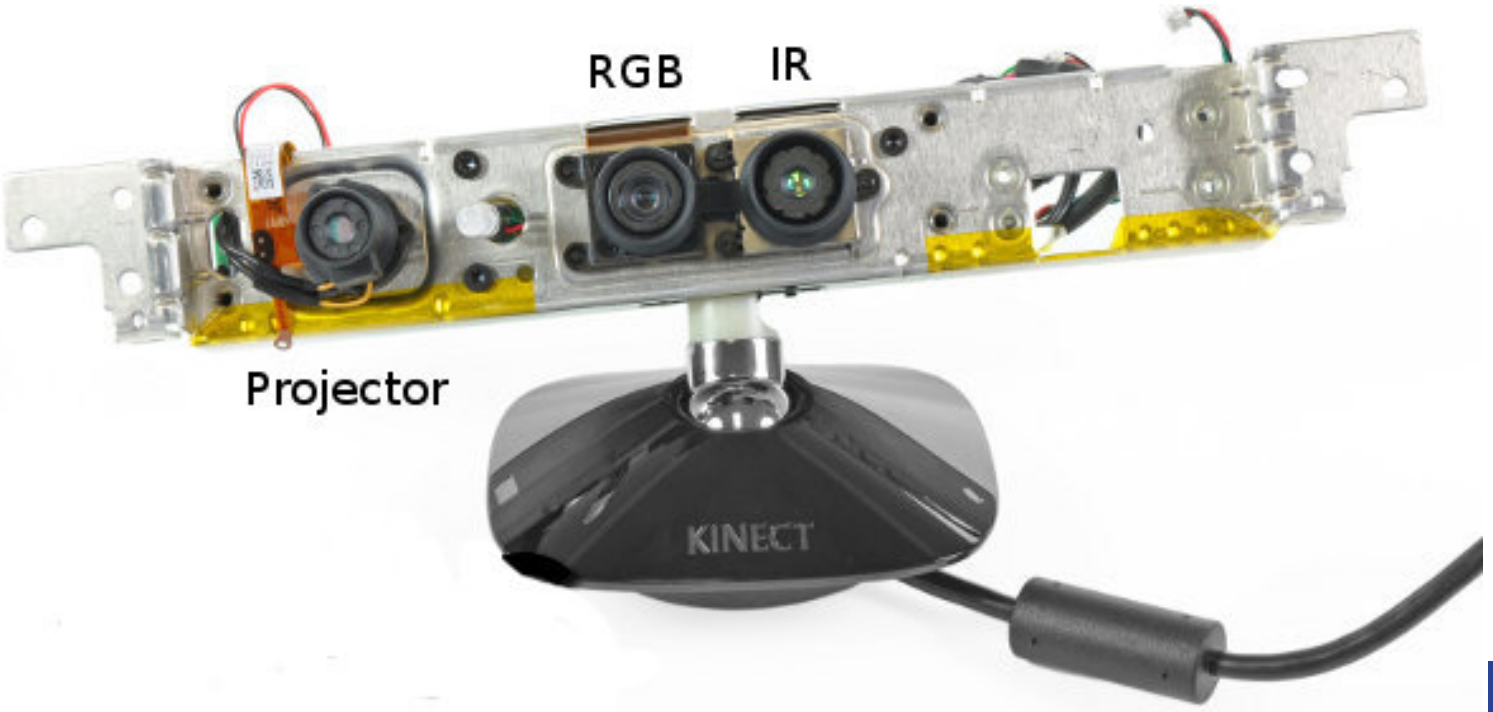
PrimeSense - block diagram reference design



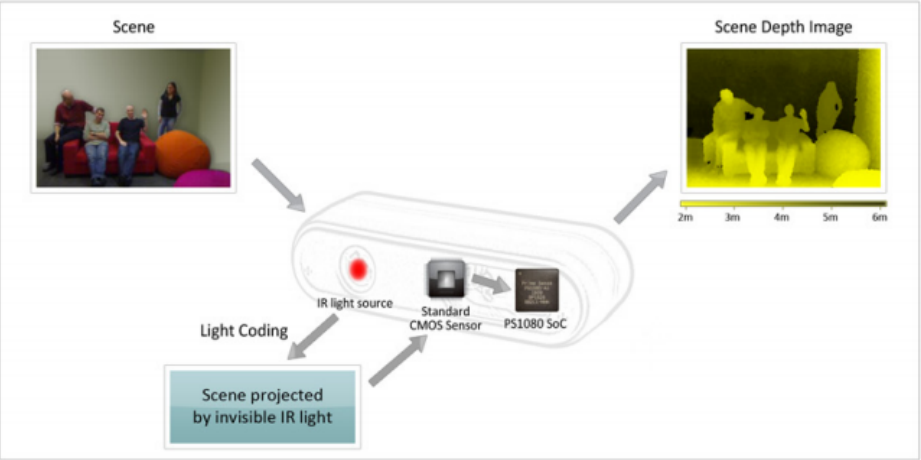
Source: http://www.primesense.com

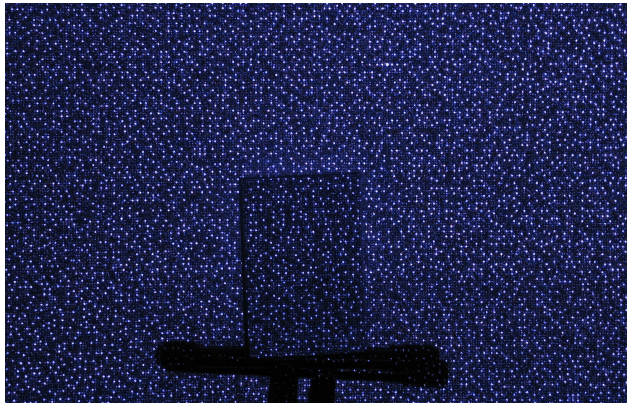
RGB Camera

- 640x480 @ appr. 30 Hz framerate
- max. 1280x1024 @ appr. 15 Hz framerate



Depth Sensor - function





Pattern of infrared dots

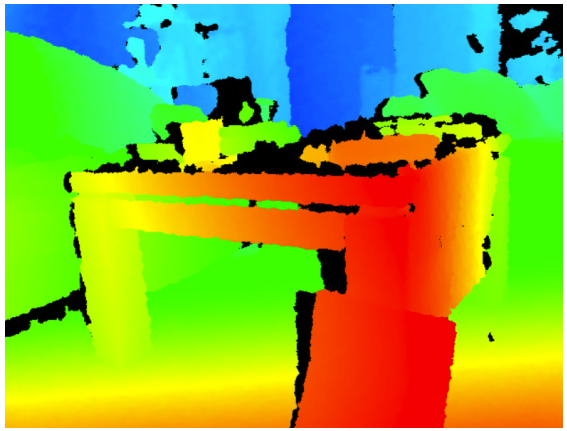
Source: http://www.futurepicture.org
http://www.anandtech.com

Depth Sensor

- 640x480 pixels, rightmost 8 columns "no data"
  usable: → 632x480
- raw: 11 bit depth value → 2047 if value cannot be estimated
- range: 0.7 to 7 m (optimum range 1.2 to 3.5 m)

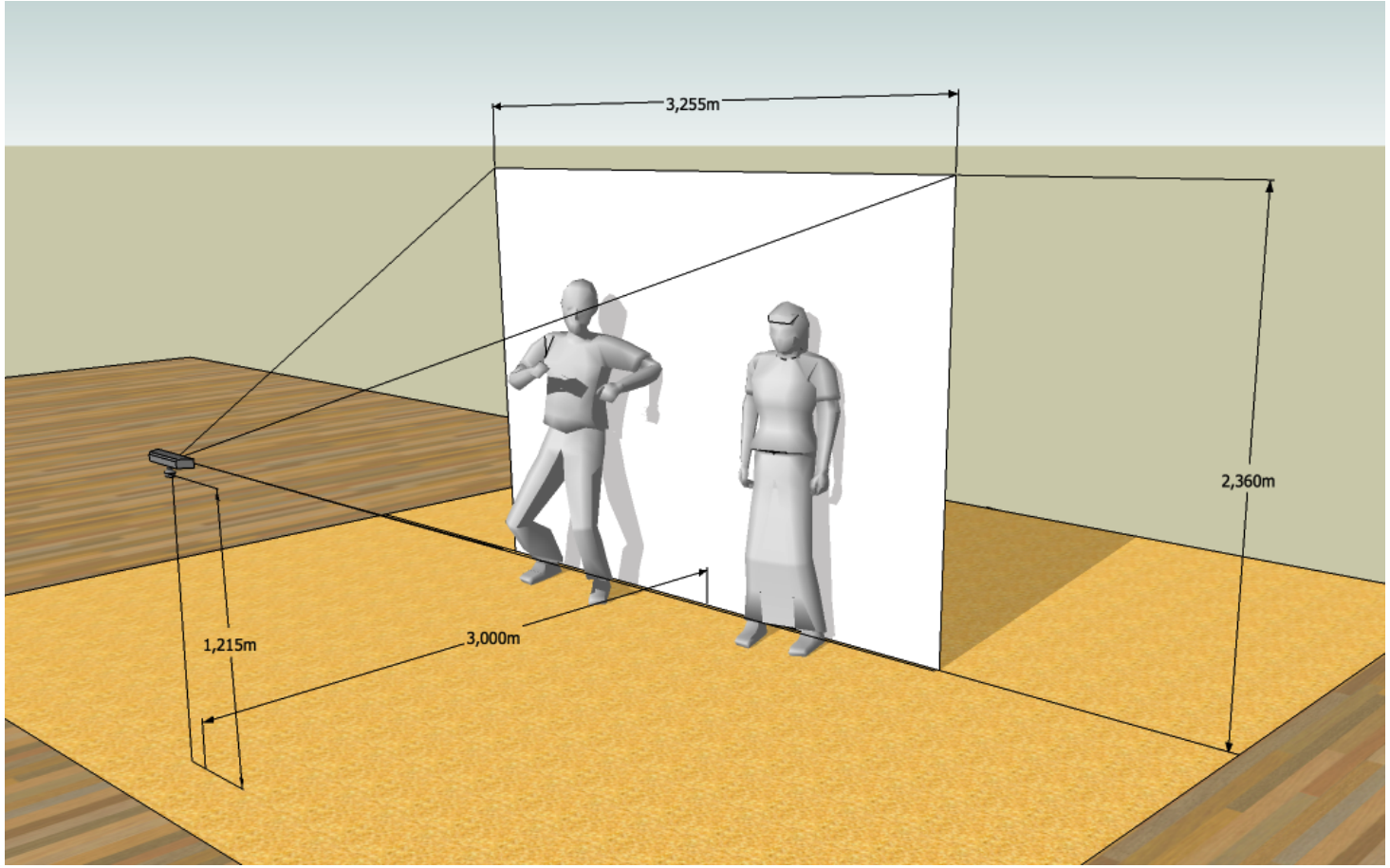
rgb image

infrared image



colorized depth image

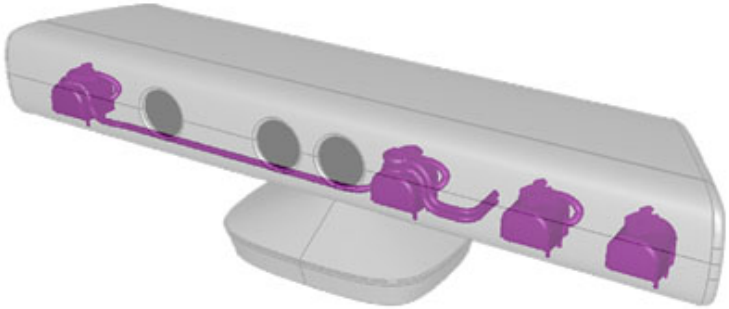
Depth Sensor - Field of view



Field of view 58° H, 45° V, 70° D

Microphone Array

- 4 channels
- 16 bit @ approximately 16 kHz
- 1 mics on the left, 3 mics on the right side
- send 5.1 signal to Kinect for echo cancellation



Access the Kinect

libfreenect

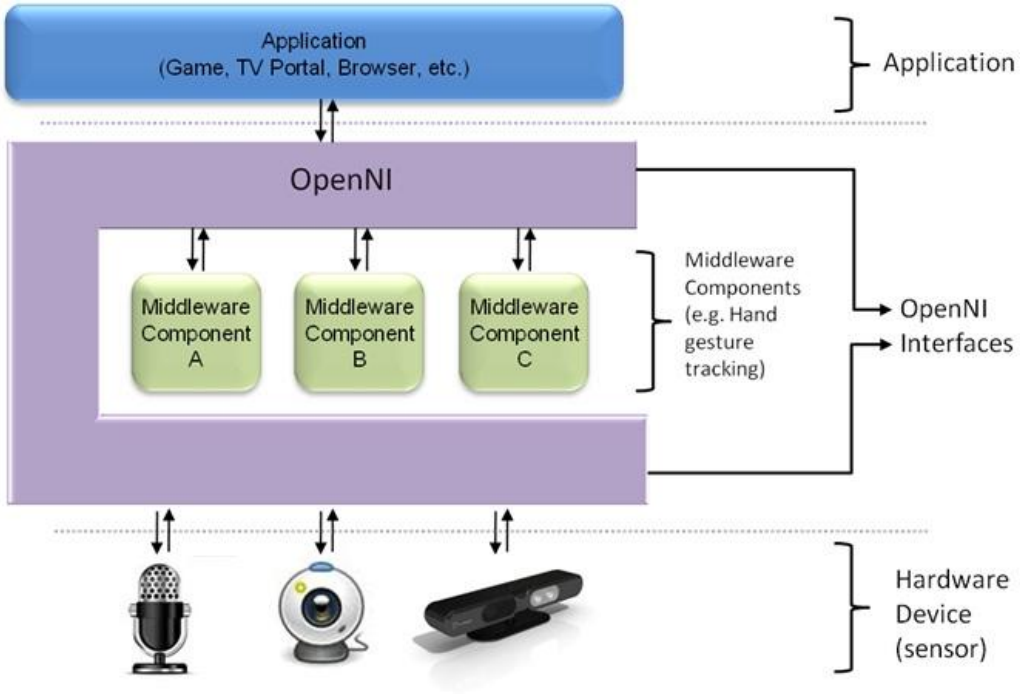
- Open Source (Apache v2/GPL v2 license)
- Windows, OSX, Linux

✓ RGB/IR and Depth Image
✓ multiple devices by serial number
✓ Audio streams
✓ LED and Motor tilt control
✓ get Accelerometer data
✗ no higher level functions (tracking, ...)

→ pix_freenect, freenect is based on libfreenect

OpenNI - Open Natural Interaction

- industry-led, not-for-profit organisation ? (PrimeSense)
  "certify and promote the compatibility and interoperability of Natural Interaction (NI) devices"



Source: http://www.openni.org

OpenNI - Open Natural Interaction

- ✓ Open Source
- ✓ device independent
- ✓ Record and playback streams
- ✗ Kinect driver without audio, accelerometer, LED and motor tilt access

Primesense NITE Middleware

- ✓ Binaries for Windows, Mac OS, Linux
- ✓ Scene analysis/segmentation (User tracking)
- ✓ Hand and Skeleton tracking
- ✗ high level function just with one device
- ✗ closed source

→ pix_openni is based on OpenNI and NITE middleware

Microsoft Kinect for Windows SDK

- ✓ all functions of Kinect supported
- ✓ commercial license since final version, easy to use
- ✓ Face and Skeleton (standing and sitting) tracking
- ✓ sound source localization, beam forming
- ✓ speech recognition
- ✗ Windows only, closed source!

Source: www.microsoft.com

PD/Gem externals

representation of depth data

- ✗ no colorspace for depth values in Gem
- ✓ visual representation → RGB or Gray mapping

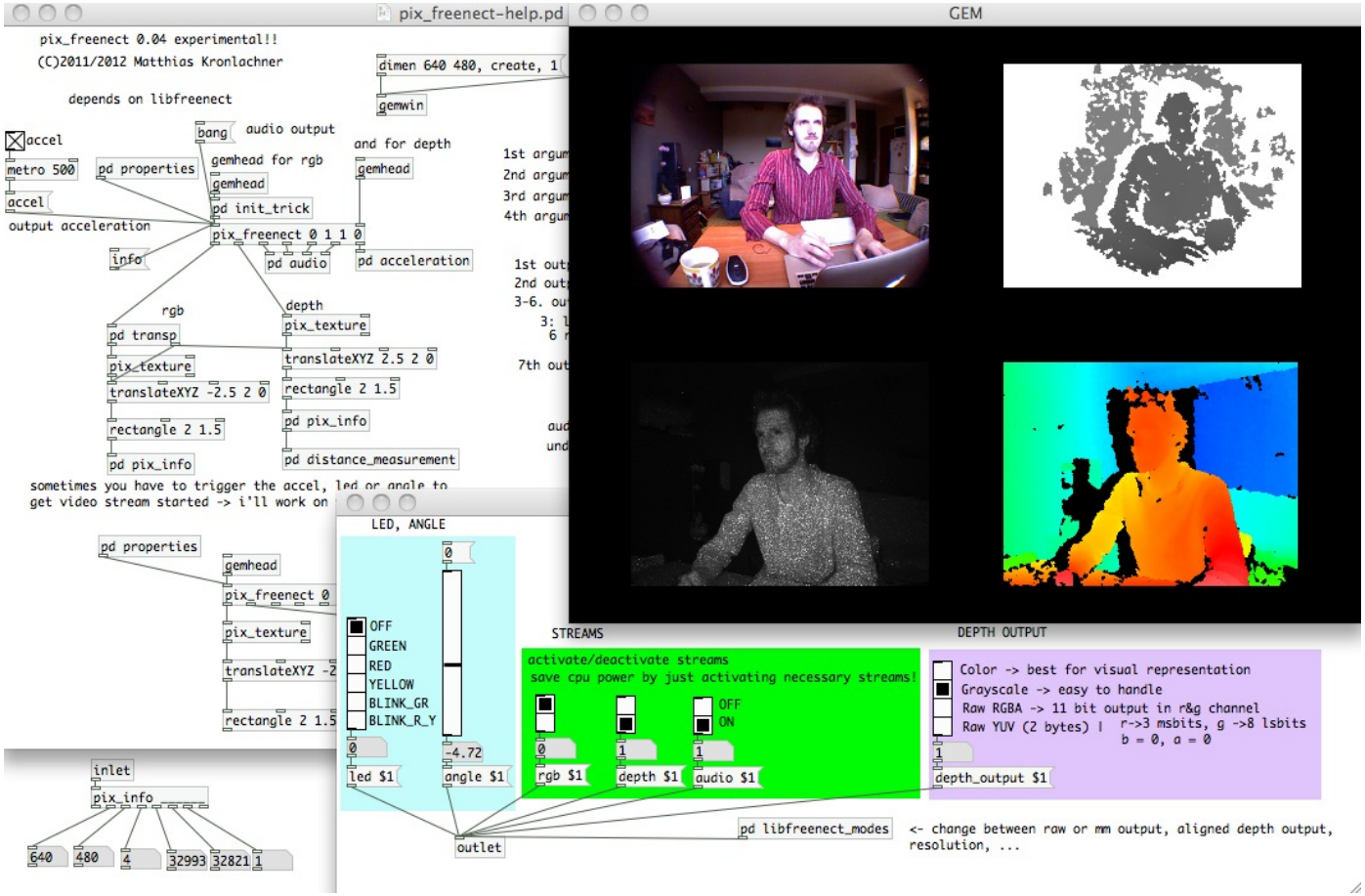
- ✓ current raw output solutions
  - RGBA
  - YUV422

→ need for pix_expr

R	G	B	A
3/8 msb	8 lsb	0 or userid	255

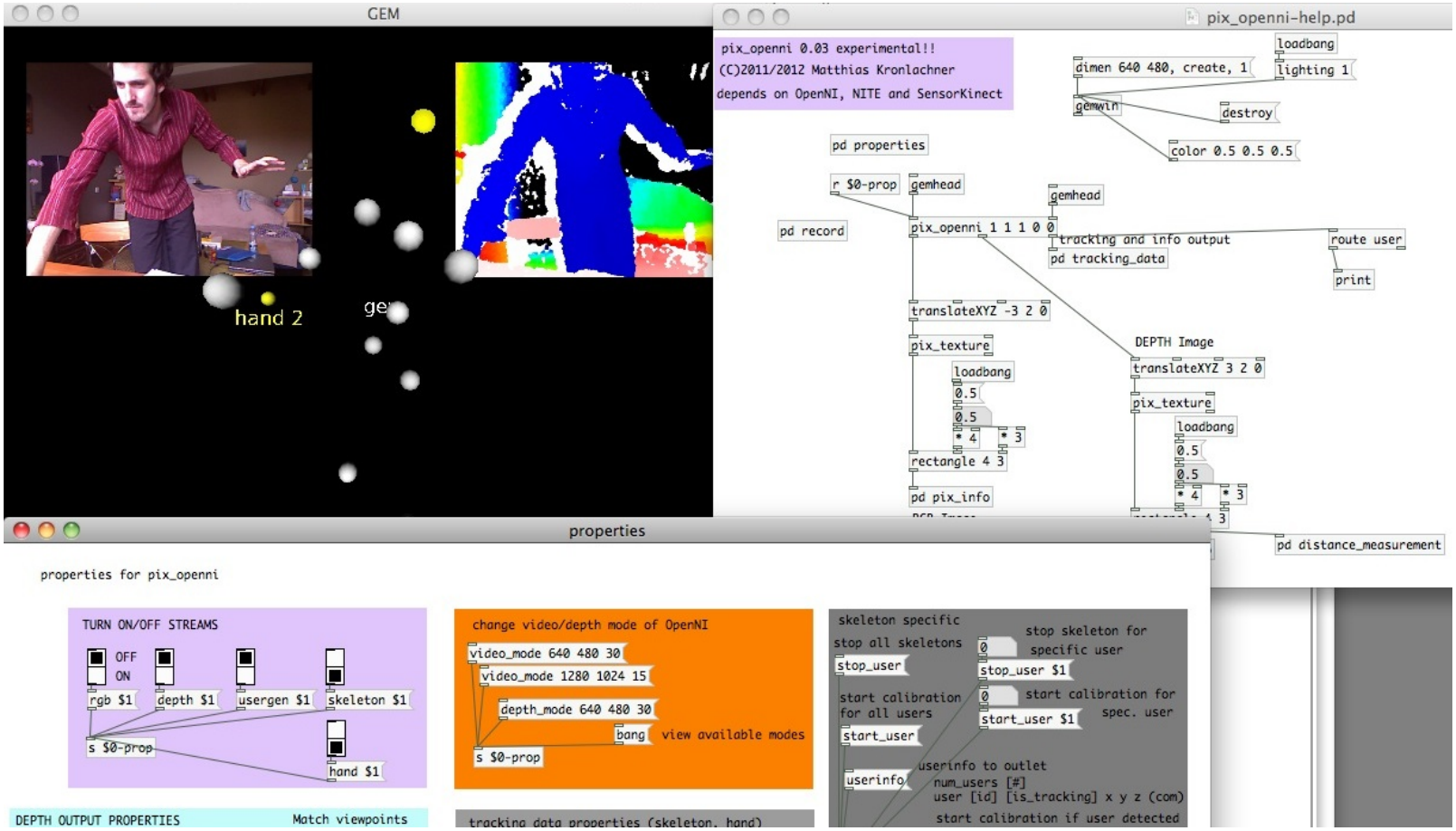
YUV422 (2 bytes per pixel)
11 bit/16bit depth values

pix_freenect



two Kinects, upper pair with Zoom lense

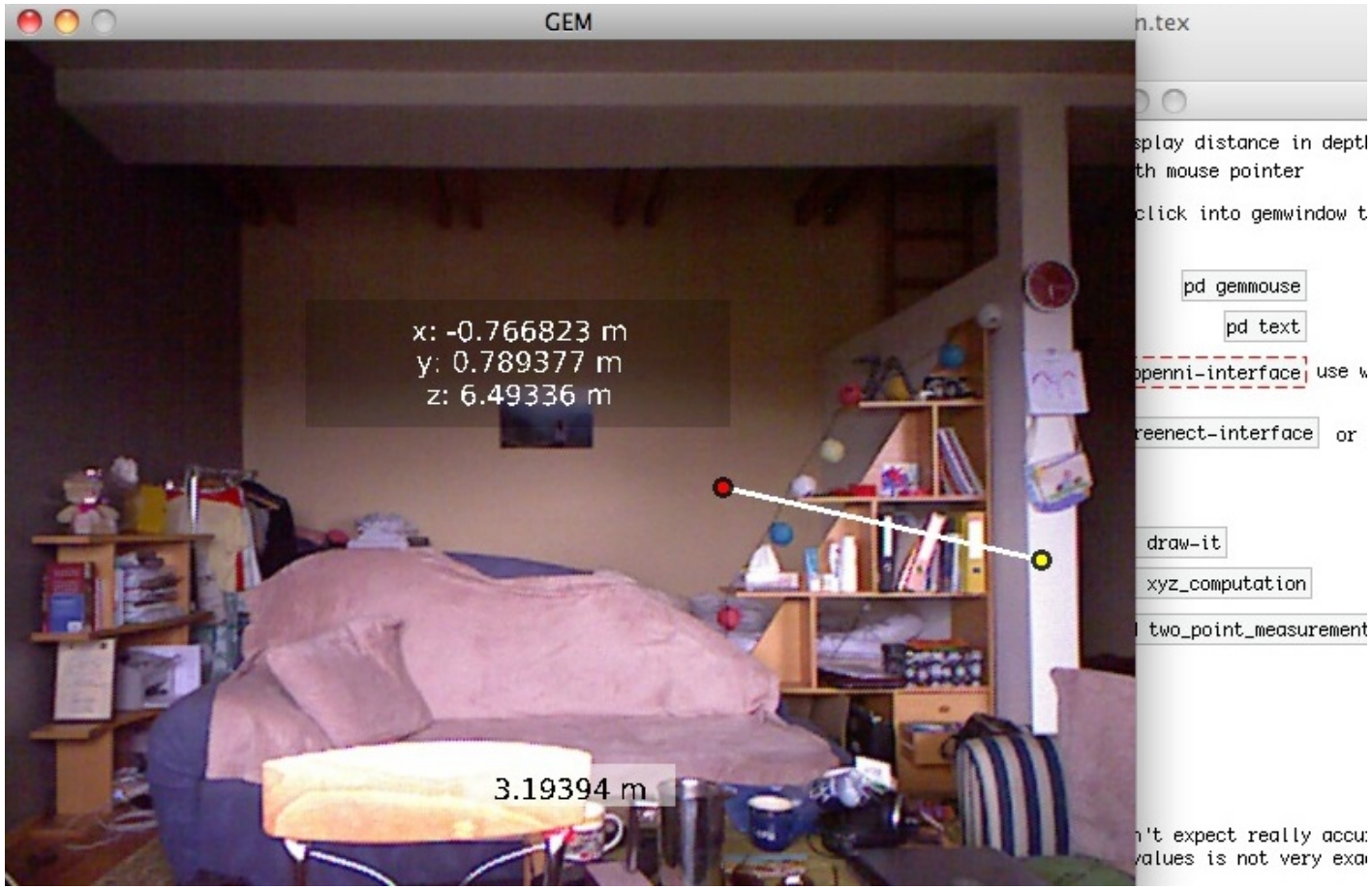
pix_openni



pix_openni with skeleton tracking, hand tracking and usercoloring

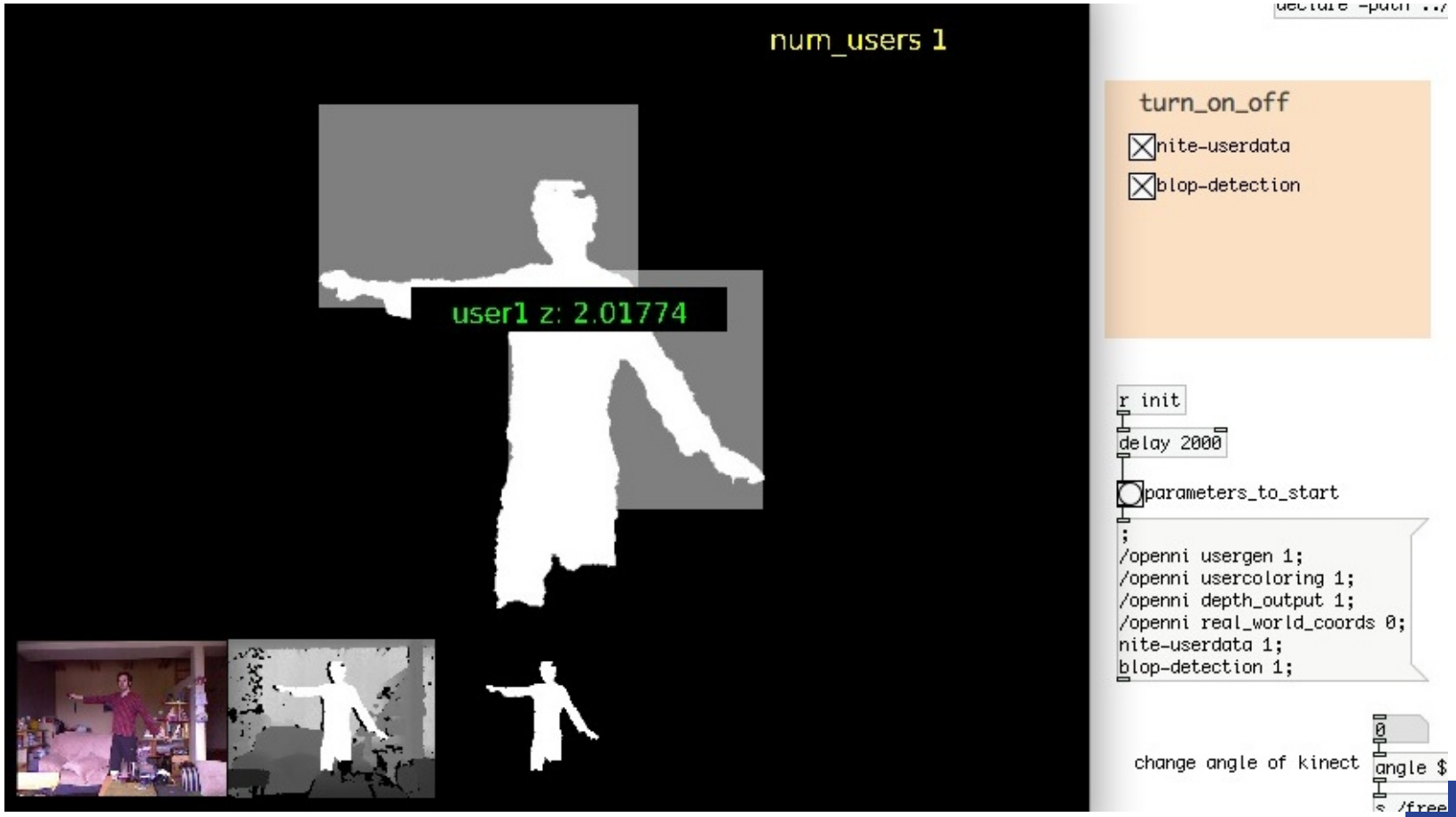
Application

Distance measurement

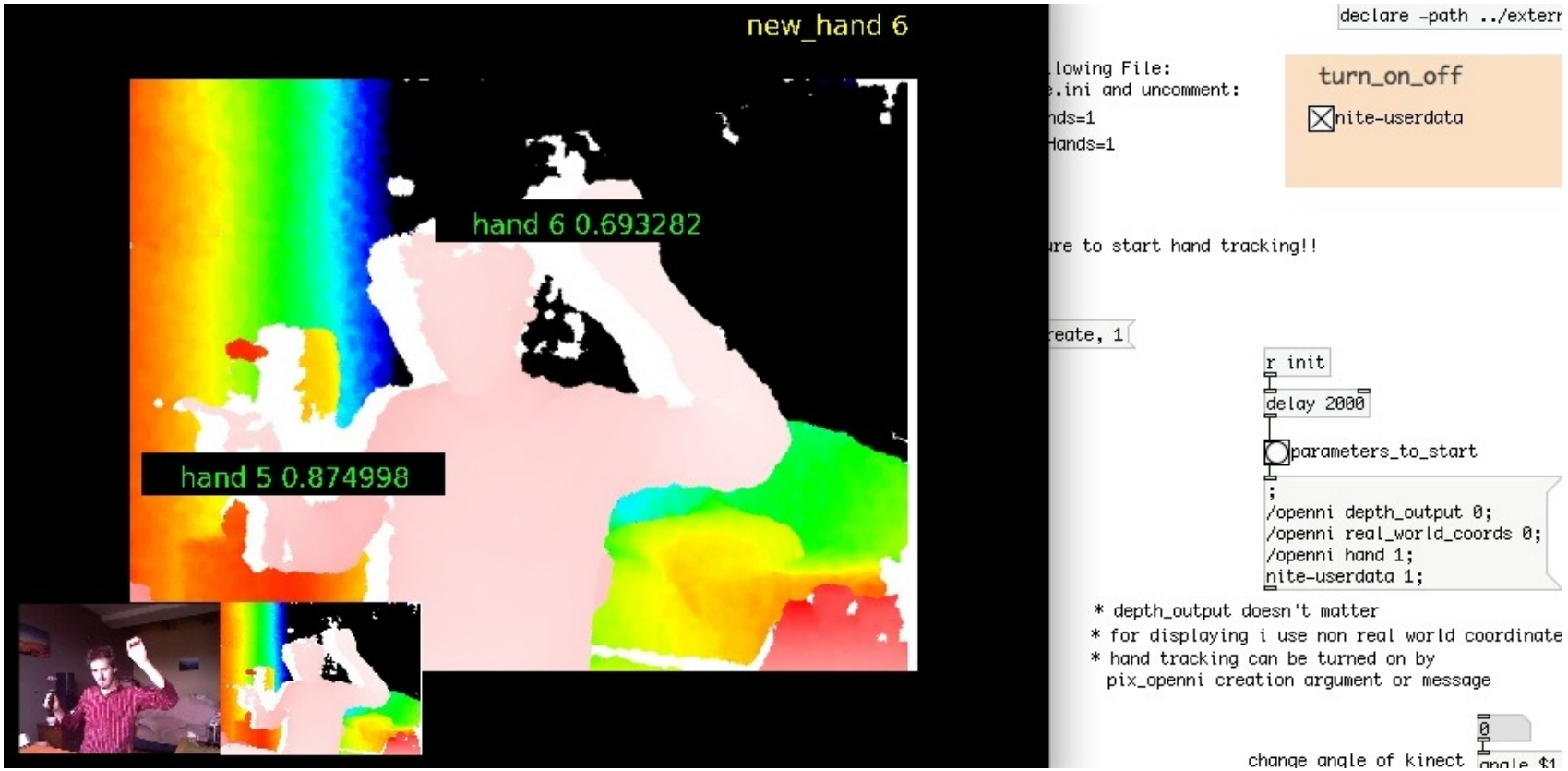


Background subtraction

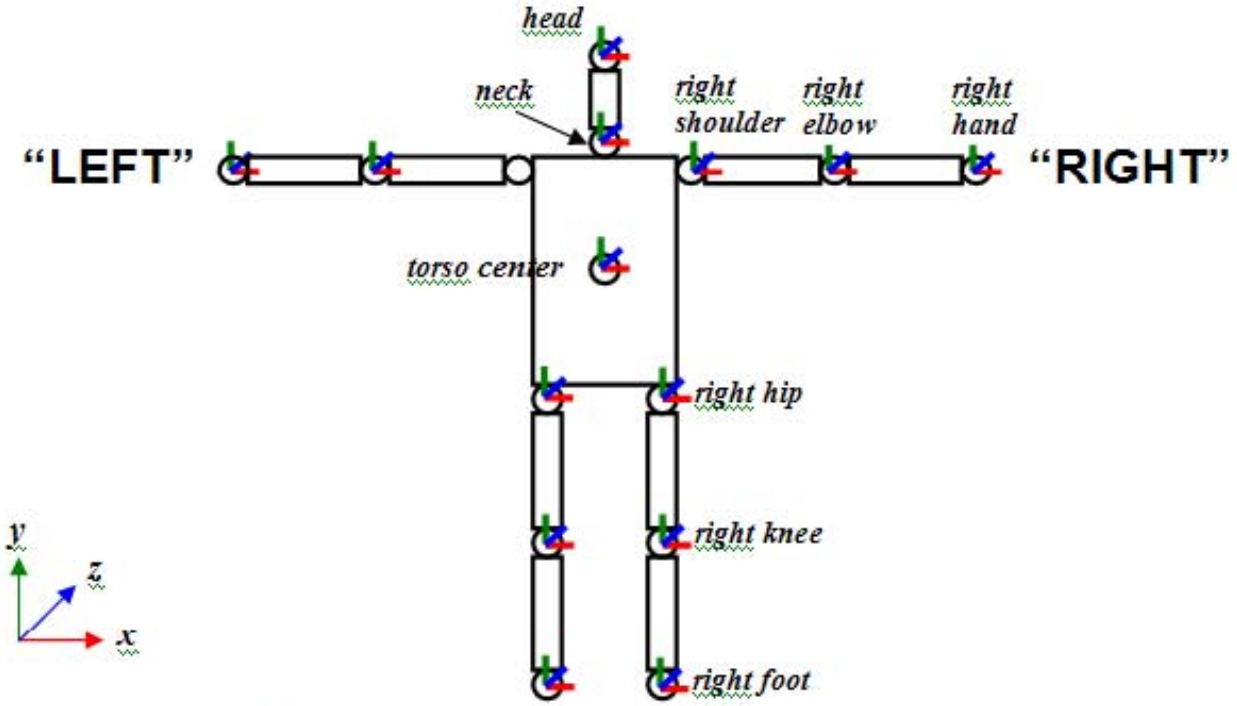
User tracking with pix_openni



Hand tracking with pix_openni



Skeleton tracking with pix_openni

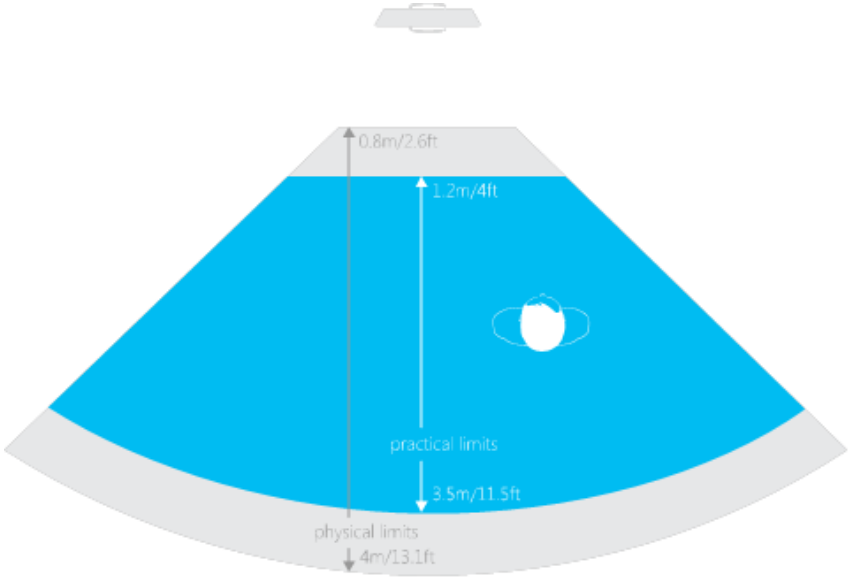


NOTE 1: Skeleton's front side is seen in this figure
NOTE 2: Upper arm is twisted such that if elbow is flexed the lower arm will bend forwards towards sensor.

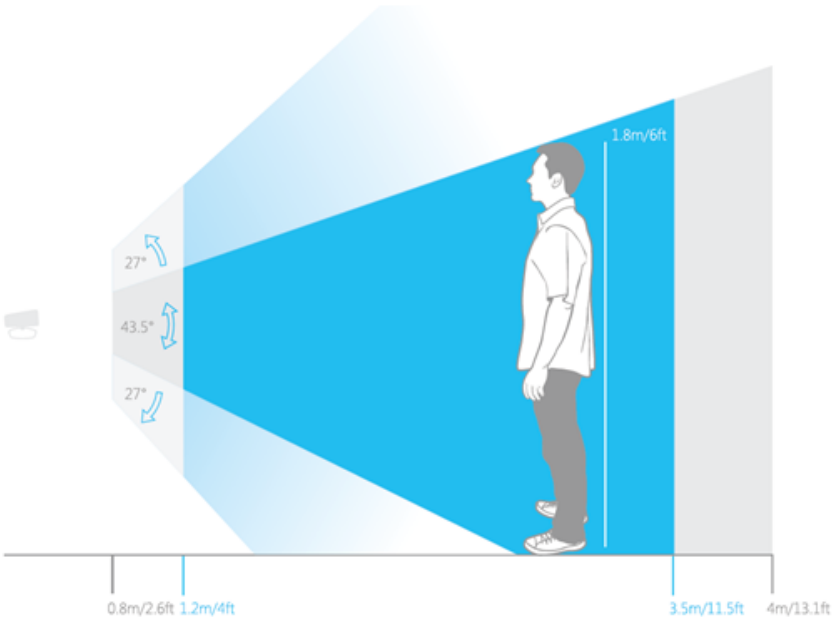
Skeleton joints

Source: http://www.primesense.com

Skeleton tracking with pix_openni



horizontal field of view

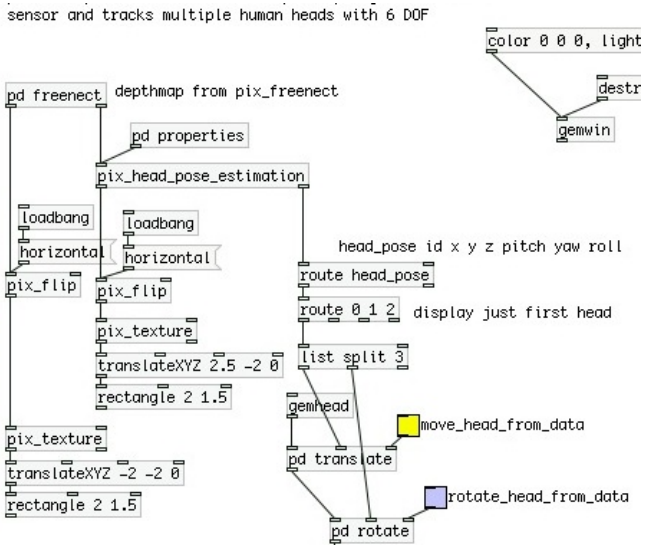


vertical field of view

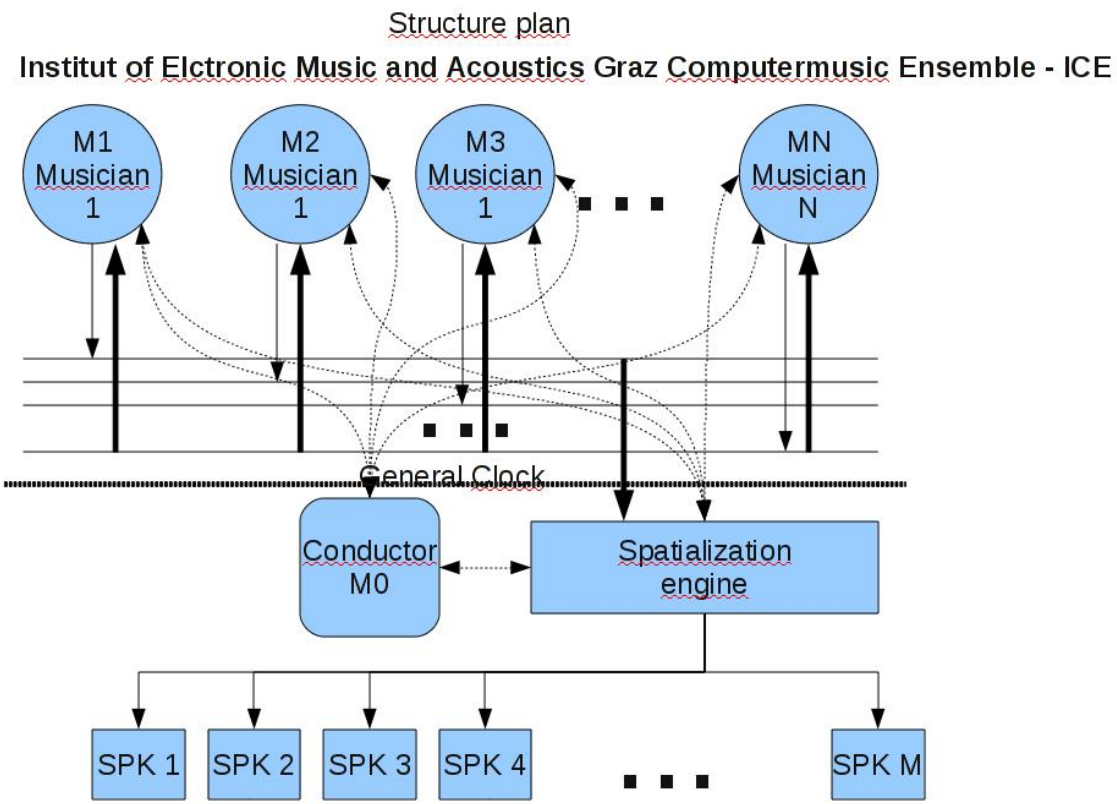
Source: www.microsoft.com

pix_head_pose_estimation

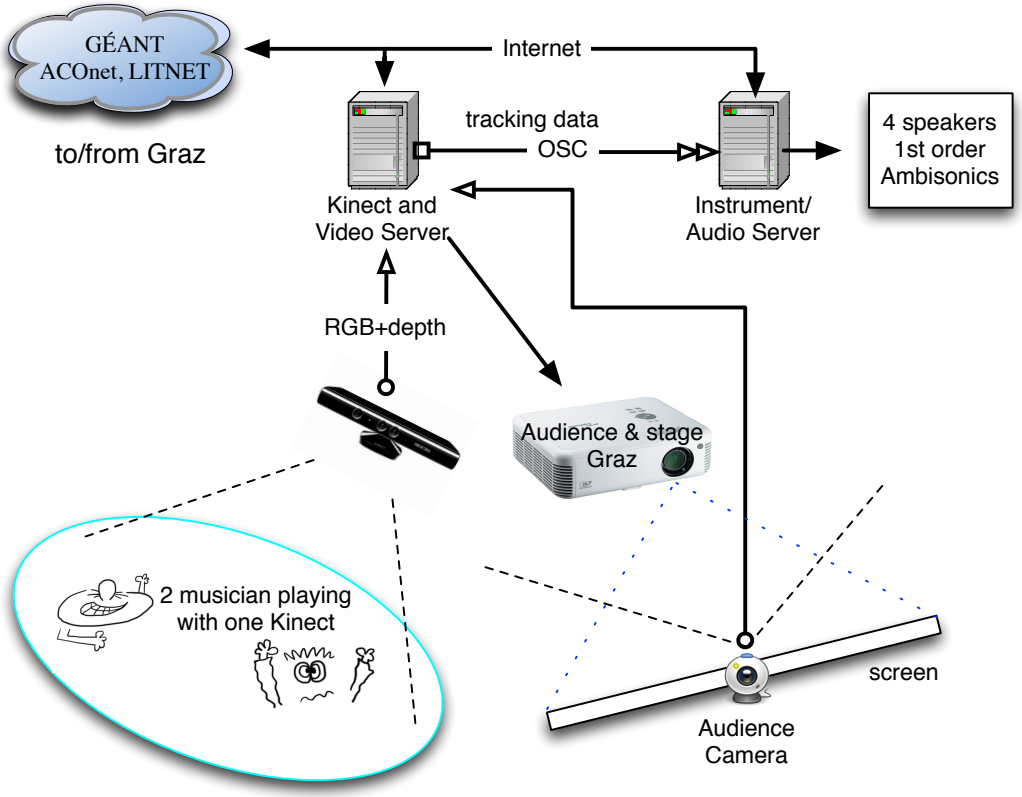
- Standalone application by Gabriele Fanelli, ETH Zurich
- ✓ multiple users
- ✓ depends on OpenCV
- ✗ 6 DOF, can detect angles about ±75° yaw, ±60° pitch and ±50° roll



IEM Computermusic Ensemble (ICE) structure

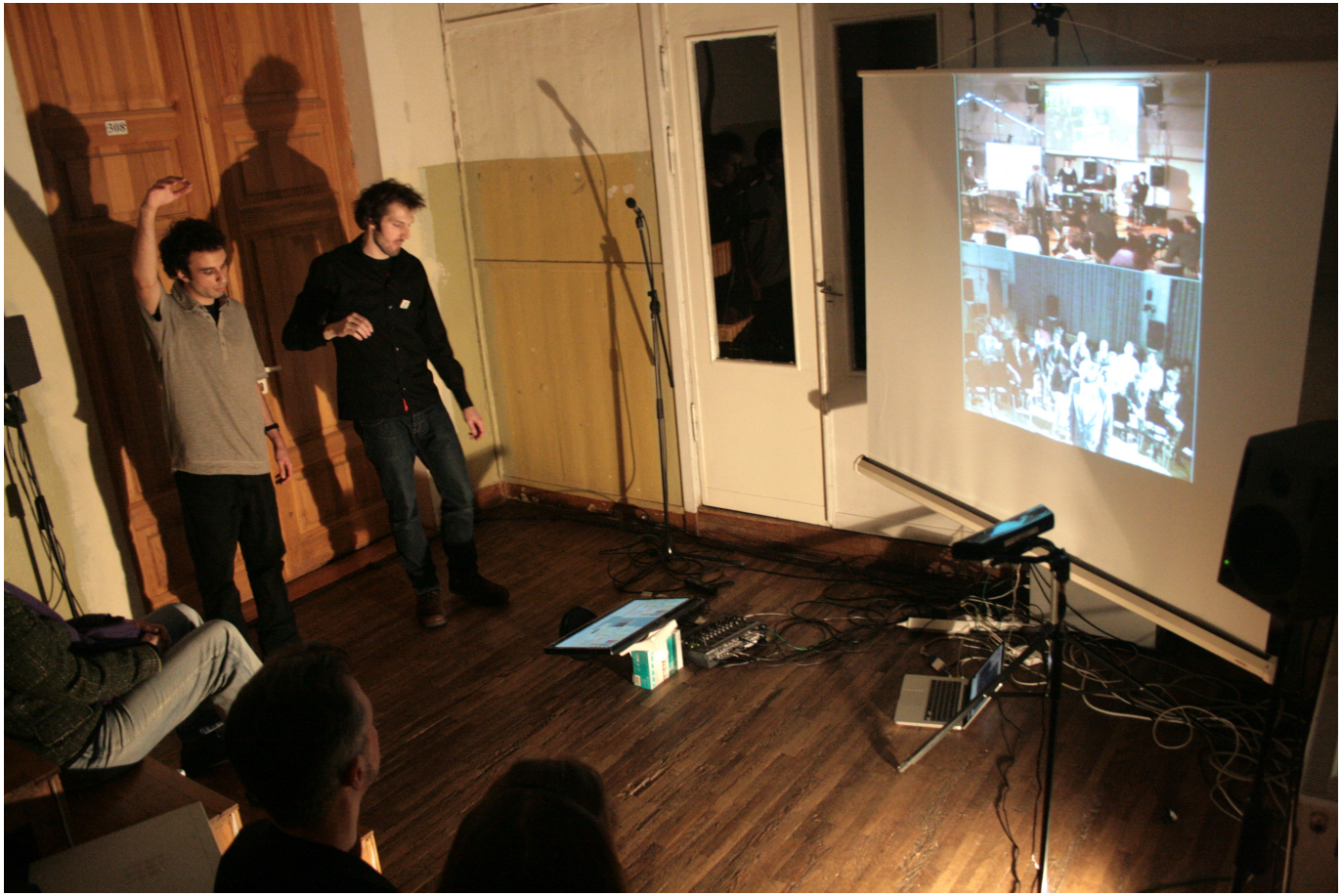


ICE Network concert - Graz - Vilnius -



ICE - Stage Setup Vilnius 20.3.2012

ICE Network concert - Graz - Vilnius



ICE @ Vilnius 20.3.2012

stage setup - vertimas

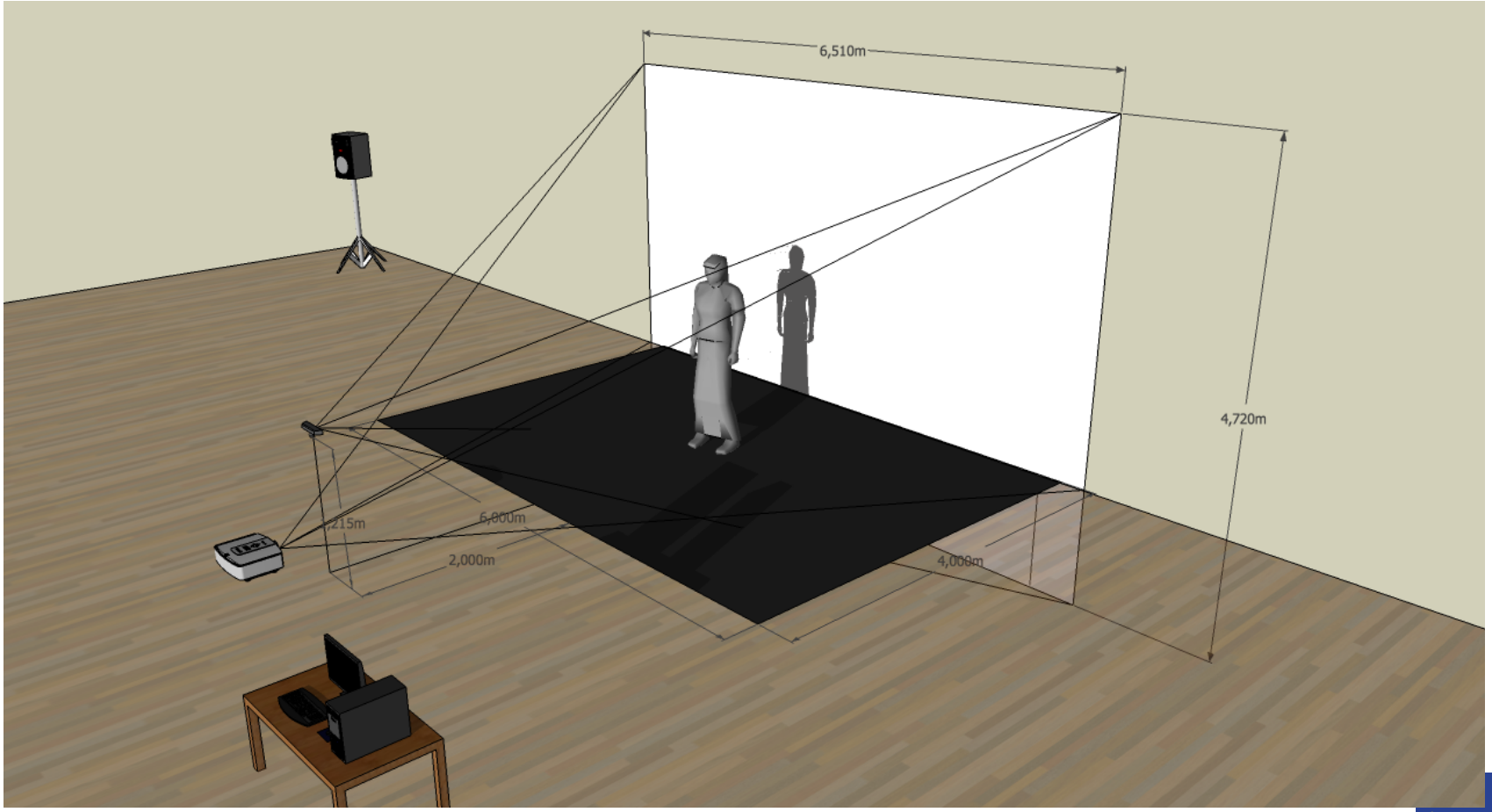
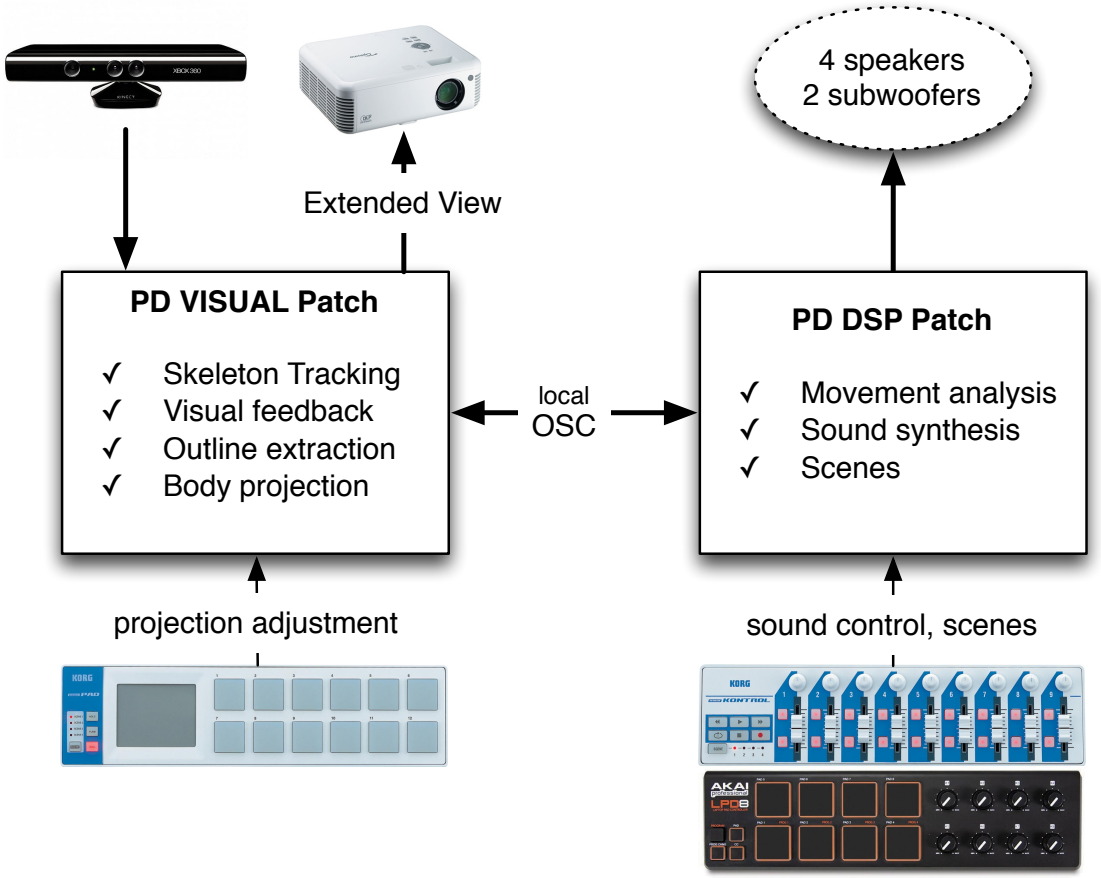


diagram - vertimas



vertimas - übersetzen

demonstration

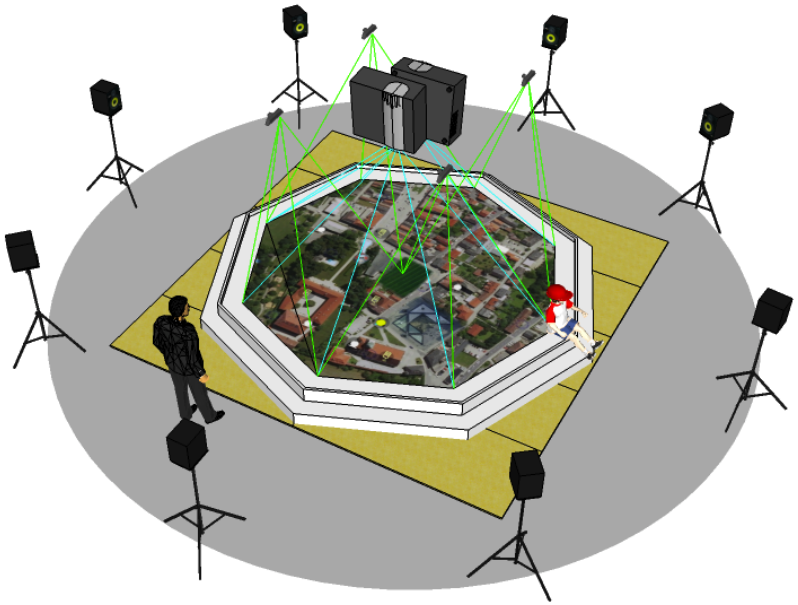
video - trailer

Pros and cons

- ✓ price, availability
- ✓ ease of use
- ✓ multifunctional
- ✗ range, resolution
- ✗ multiple devices
- ✗ high level functions dependent on big companies

Outlook

- maintaining externals
- external for Microsoft Kinect SDK
- freenect~ dsp plugin
- performances, installations, ...



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Questions...?

Thank you...