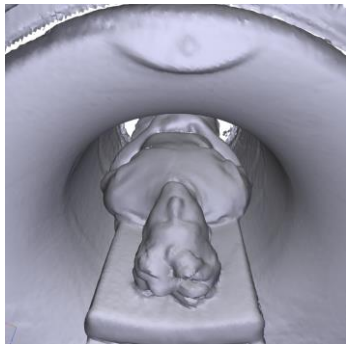
World In Motion

Phil Noonan
March, 2018

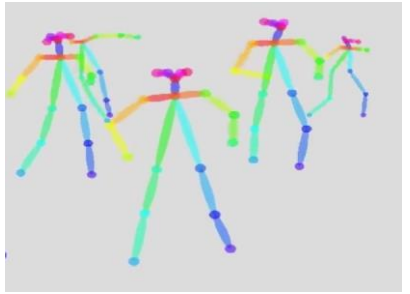
Overview

Realsense



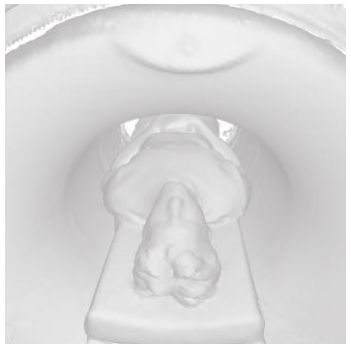
Fusion

Optical Flow

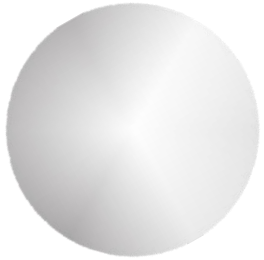


OpenPose

Realsense



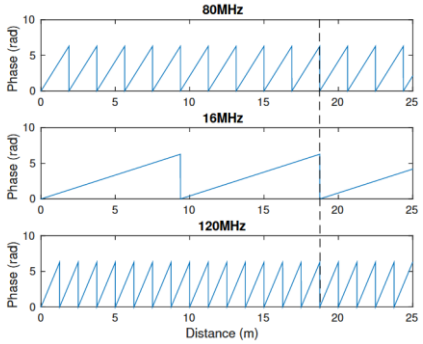
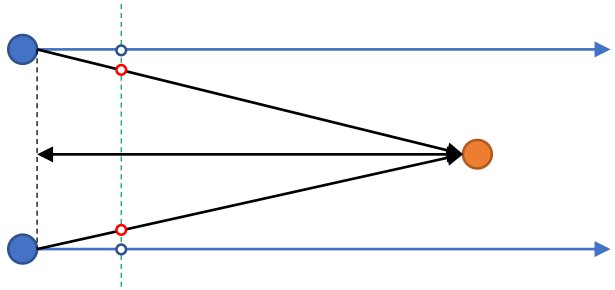
Fusion



Optical Flow

OpenPose

RGB-D

	Kinect v2	R415	R435
			
Depth Tech	Time of Flight 	Active IR Stereo 	Active IR Stereo
Depth Field of View	70.6 x 60 deg	69.4 x 42.5 deg	91.2 x 65.5 deg
Depth Range	0.5 m – 18.0 m 0.05 m – 0.5 m (mod)	0.15 m – 10.0 m	0.2 m – 10.0 m
Depth Image Resolution	512 x 424 @ 30 Hz	1280 x 720 @ 30 Hz 848 x 480 @ 90 Hz	1280 x 720 @ 30 Hz 848 x 480 @ 90 Hz

Internals

Unit can be purchased as whole or as components

MRI compatible? Stiffener contains stainless steel AISI 304

Magnetic Permeability 1.008 @ RT

Component	Wt. %
C	Max 0.08
Cr	18 - 20
Fe	66.345 - 74
Mn	Max 2
Ni	8 - 10.5
P	Max 0.045
S	Max 0.03
Si	Max 1

Depth Module

£58.30

Vision Processor

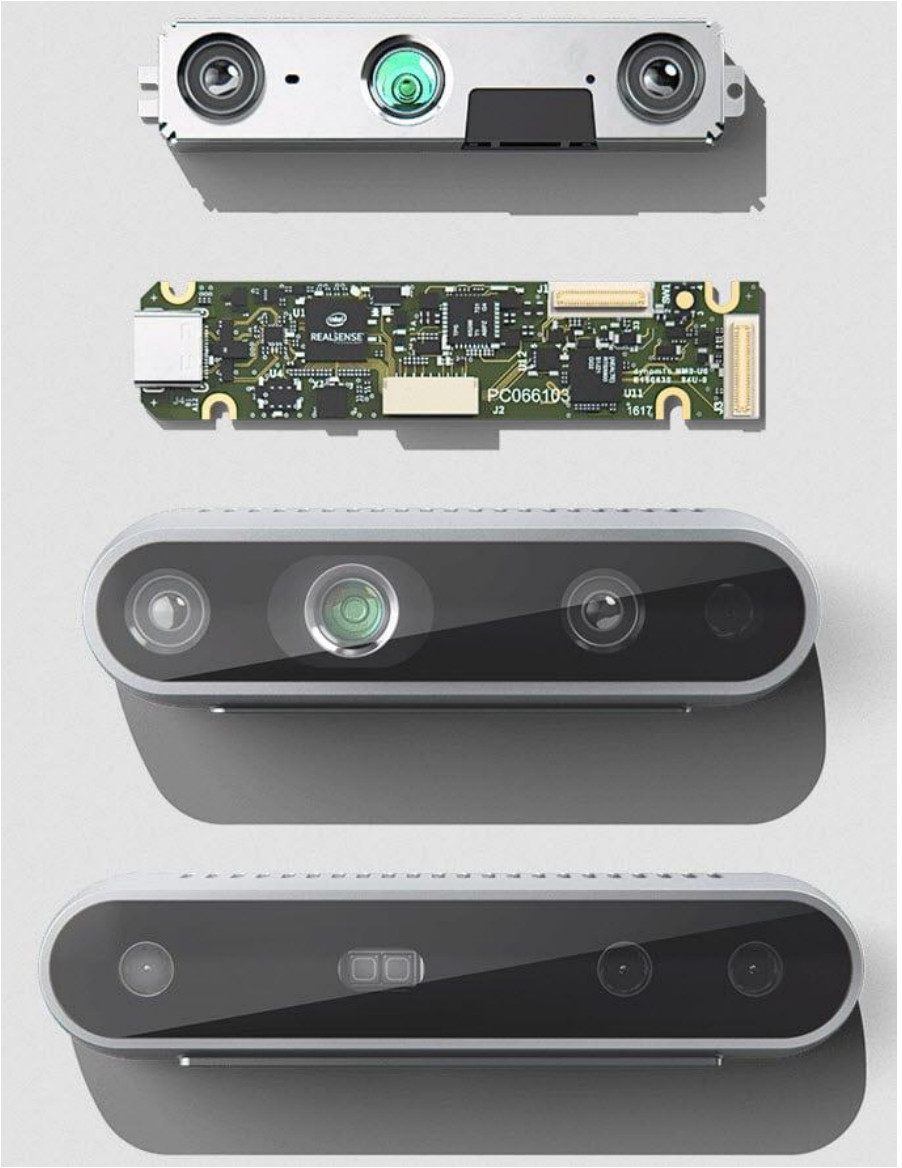
£25.85

R435

£155.42

R415

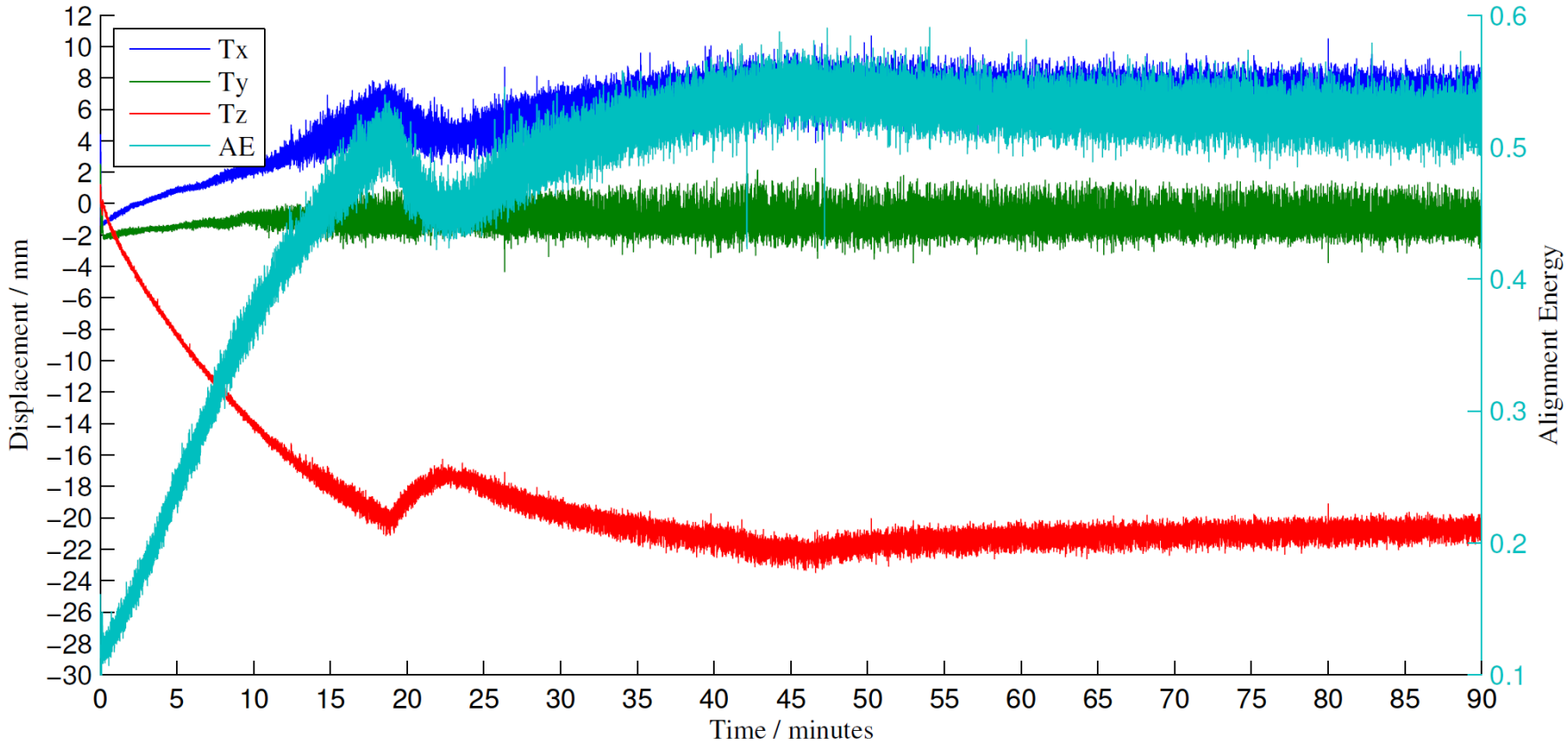
£128.56



Hands on, pass around!

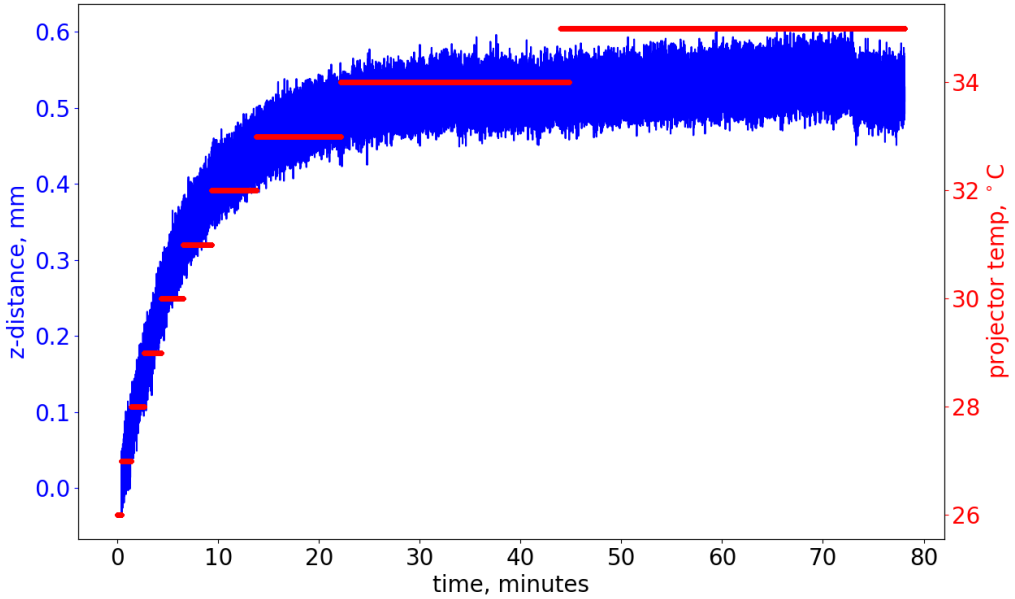
(don’t touch the lenses)

Warmup time

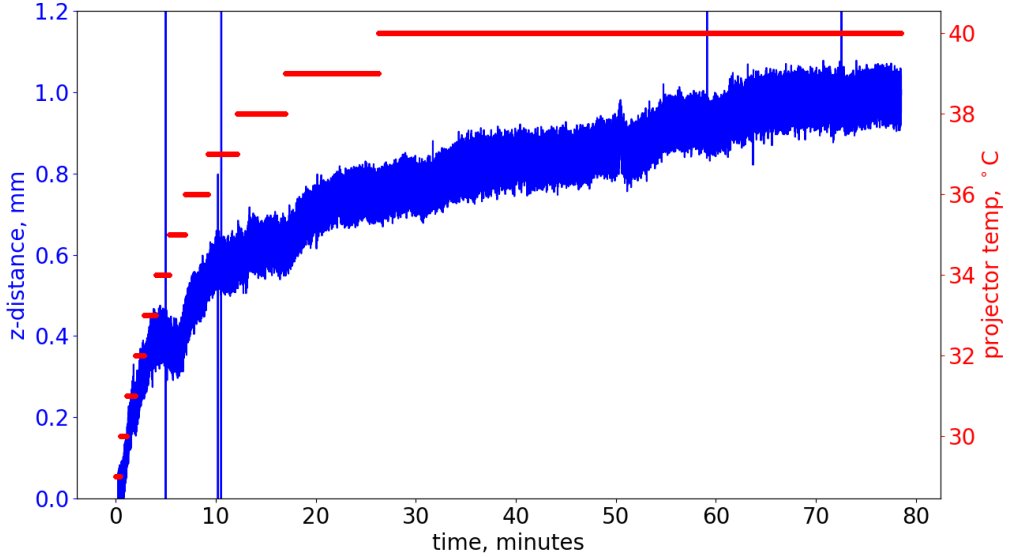


Static head phantom
Distance 20 cm

Warmup time



Static head phantom
Distance 25 cm
IR auto exposure on



Static head phantom
Distance 25 cm
IR auto exposure on

Both RS cameras have passive cooling

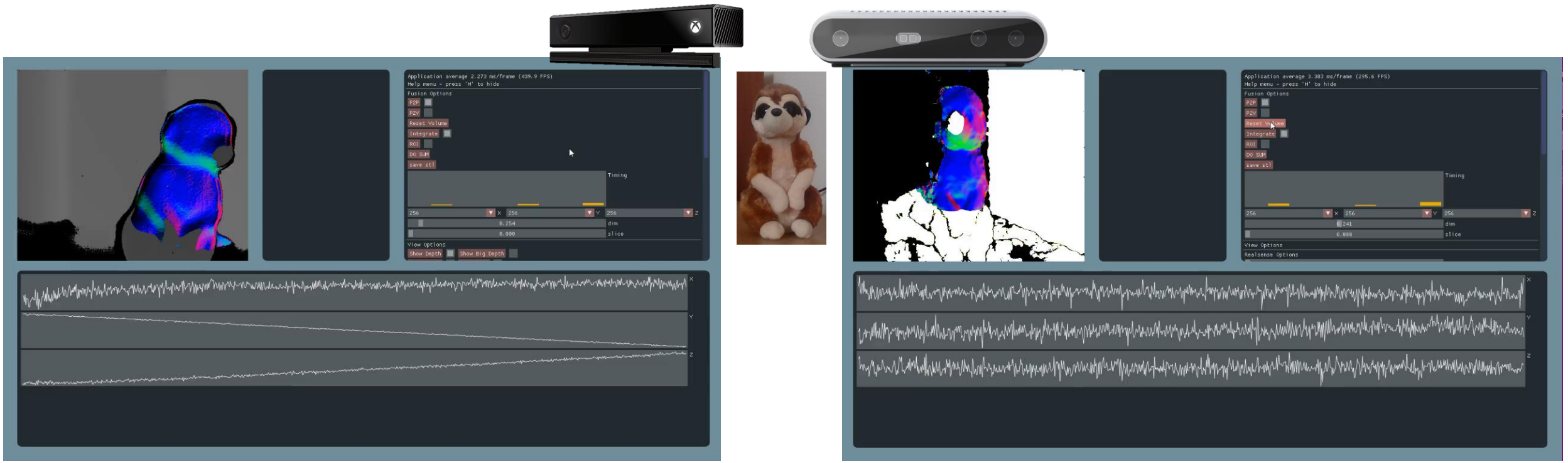
Dependent on ambient room temp

Both R415 and Kinect v2 stabilize after 20 – 30 min

R415 has varying depth of 0.6 mm vs 20+ mm for the Kinect v2 during warmup period

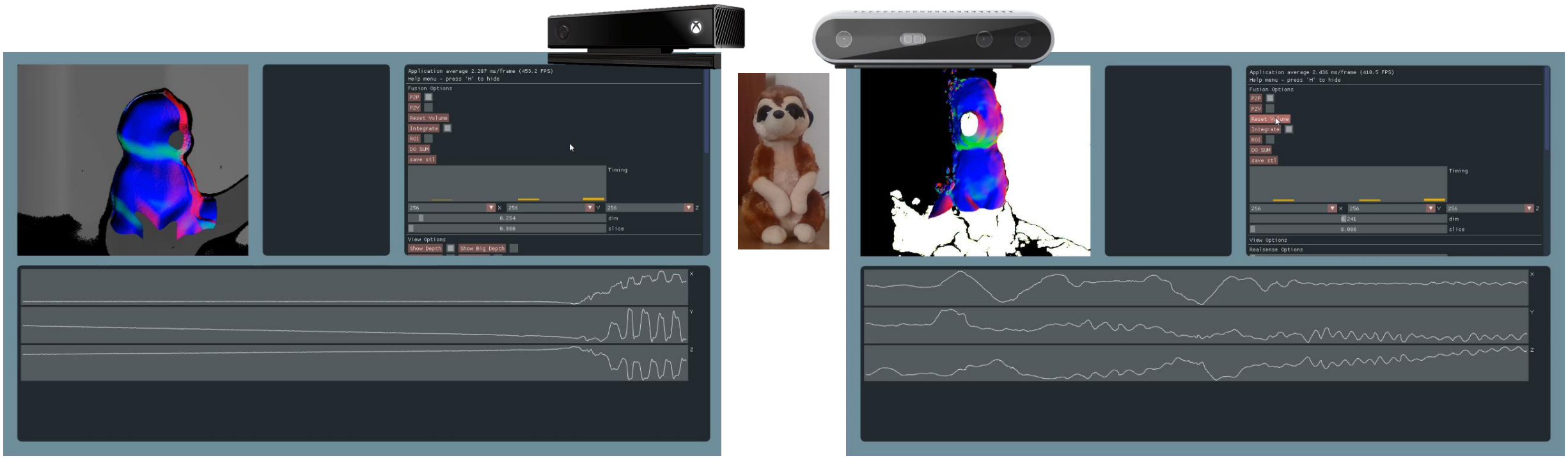
More investigations needed on the R435…

30 vs 90 Frames per Second



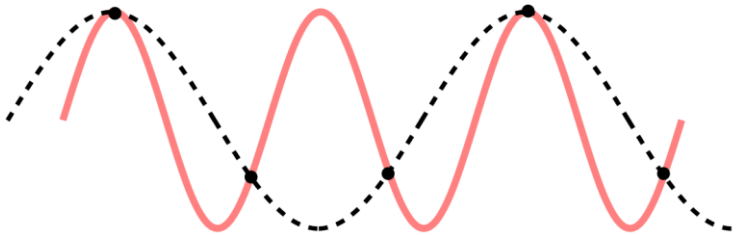
Screen captured using Nvidia shadowplay at 60 fps

30 vs 90 Frames per Second



Videos slowed down to illustrate fast twitch motion

Nyquist theorem applies!



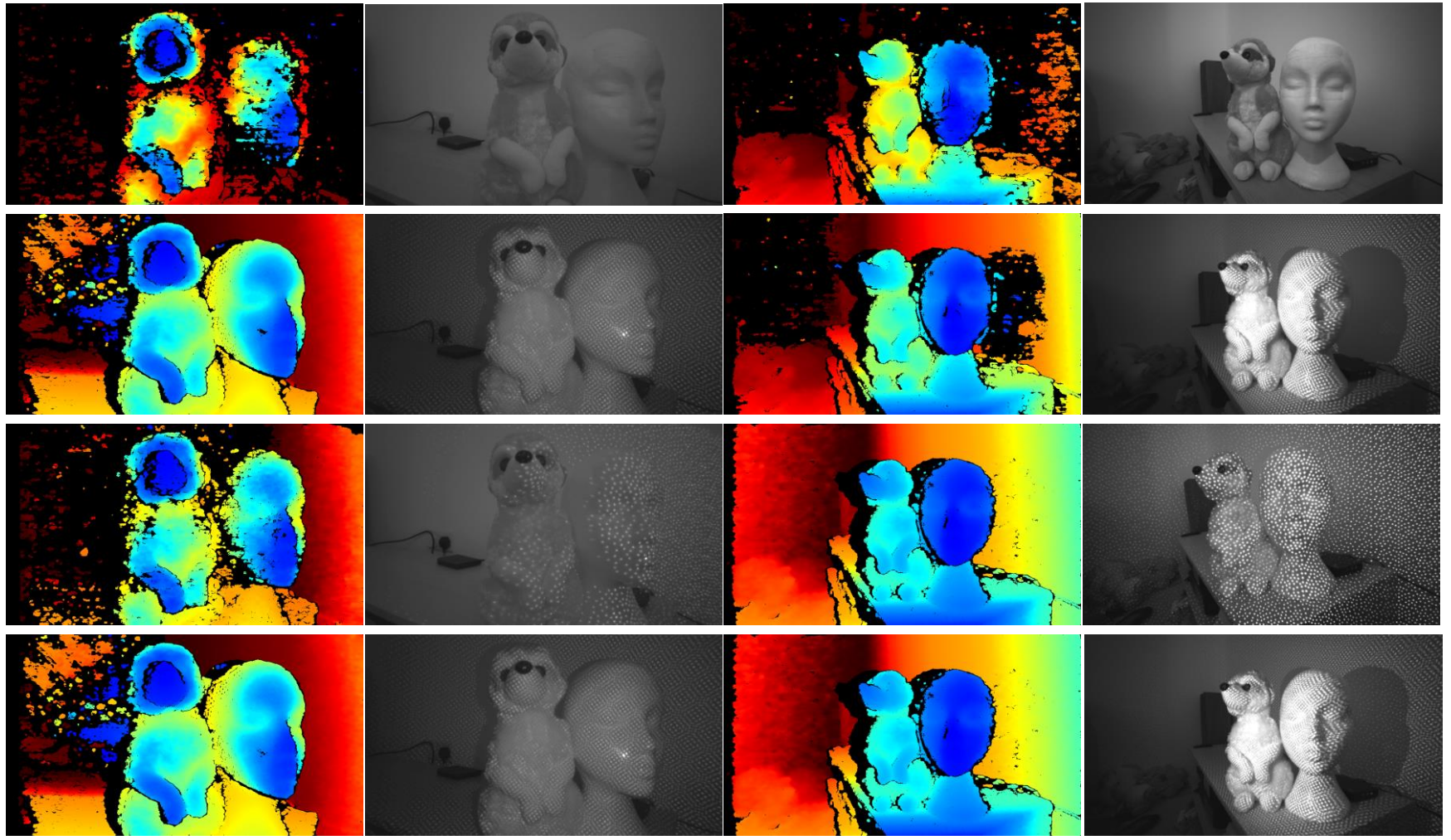
Interference

Every 15 minutes 1 minute of destructive interference

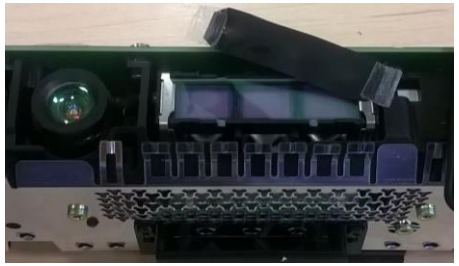
Light from one Kinect is erroneously detected by the other

Careful setup can minimize this effect

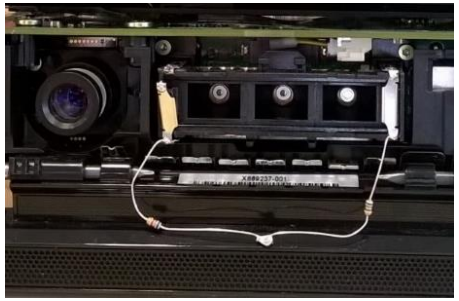
Multipath reflections are a big issue for ToF RGB-D



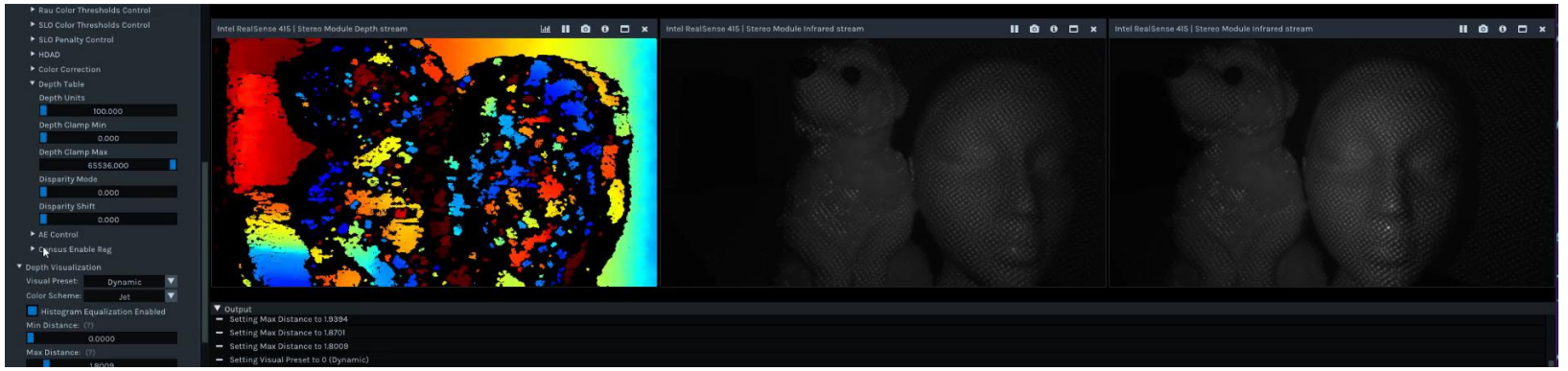
Range Modifications



Near mode – IR filter, lens refocus



Far mode – remove IR disperser, replace wide angle lens for zoom lens

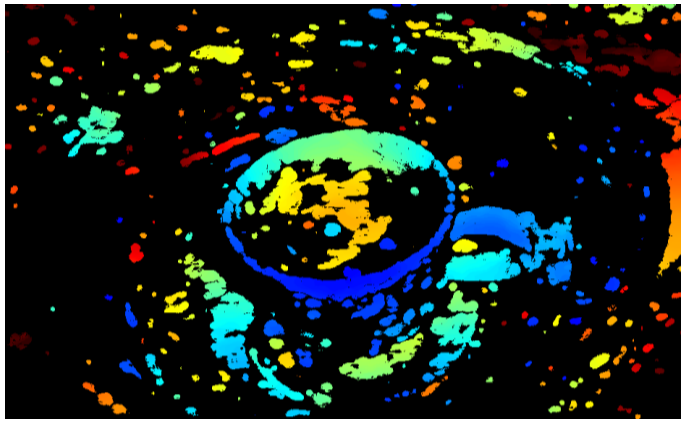


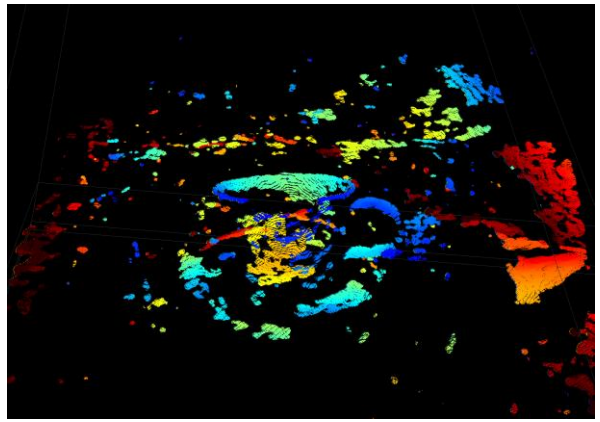
Move a slider

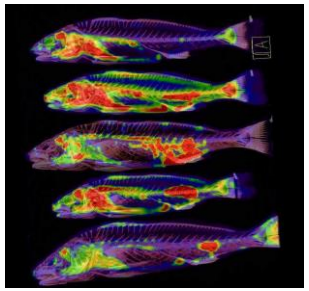
Other Use Scenarios

Under water

Phantoms with non-rigid internal spheres







Fish PET

Salmon fMRI

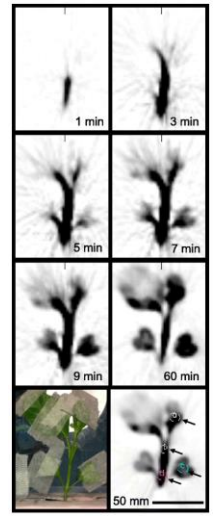
Browning et al. *Using PET/CT imaging to characterize 18 F-fluorodeoxyglucose utilization in fish*. Journal of Fish Diseases 2013

Outdoor use

Medical imaging applications currently unclear

Plant PET?

Converse et al. *Mathematical modeling of positron emission tomography (PET) data to assess radiofluoride transport in living plants following petiolar administration*. Plant Methods 2015

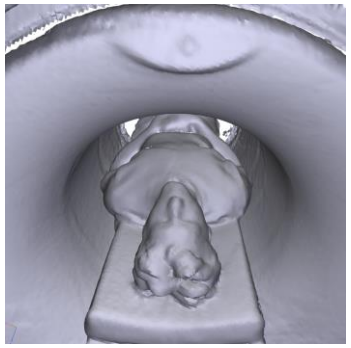


Using Mirrors

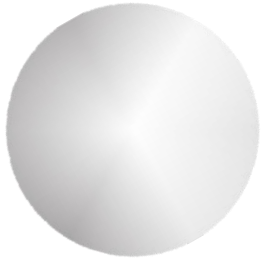
Multiple viewpoints of objects obtained

Enable views around head coil obstructions

Realsense



Fusion



Optical Flow

OpenPose

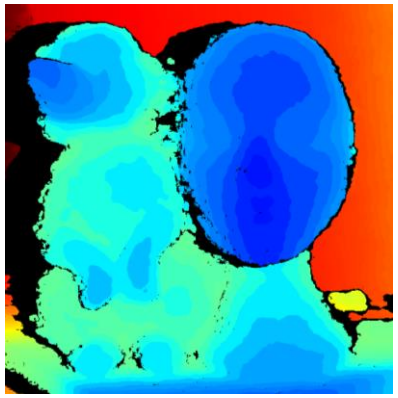
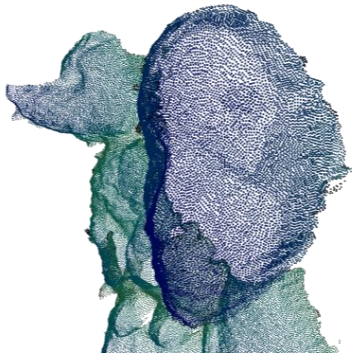
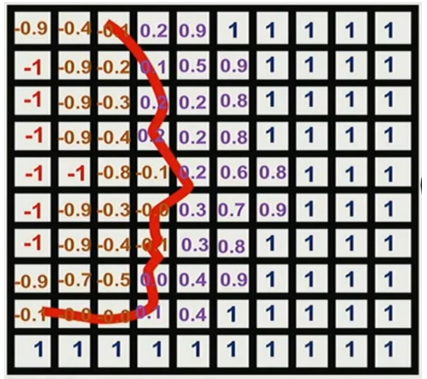
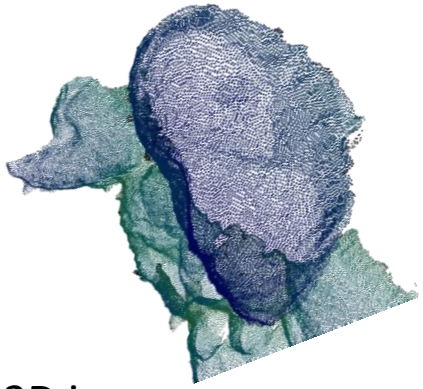
Iterative Closest Point

Combine sequentially obtained noisy 2.5D images into a global 3D volume

Motion between frames is small @ 30 Hz

Only few iterations needed to estimate rigid body type motion

Depth to Point

Input Data Type	Process	Output Data Type
 2D image Image pixel = float(z)	Back projection	 2D image Image pixel = float3(x, y, z)
 3D Volume Volume voxel = float(TSDF)	Raycasting	 2D image Image pixel = float3(x, y, z)

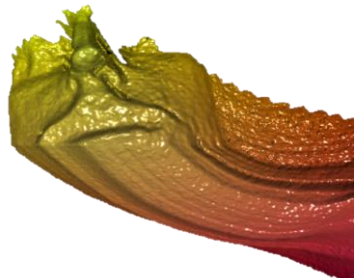
Registration

ICP is performed quickly using corresponding pixels in both float3 images

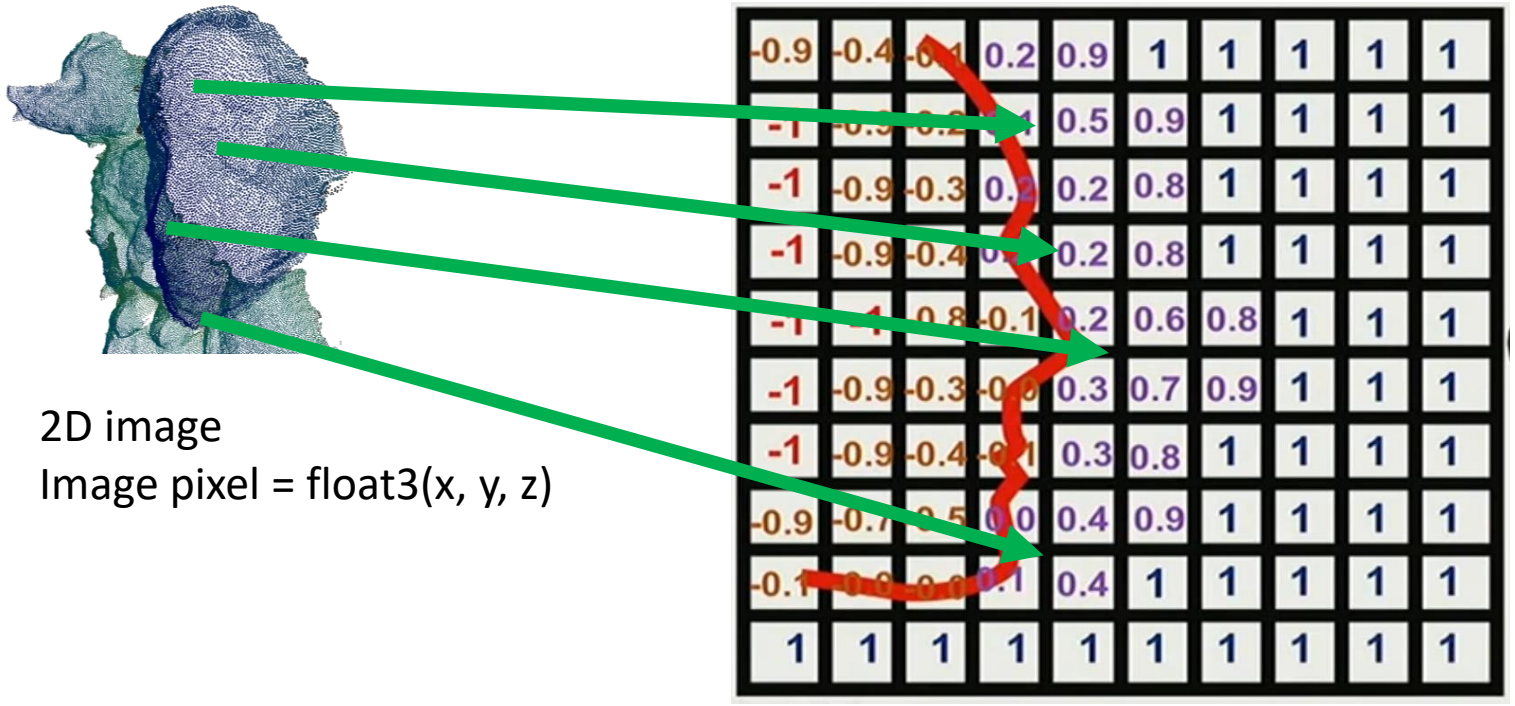
Integration

If residual error < threshold, the new depth frame is integrated into the 3D TSDF volume

Integration can be suspended to prevent small errors accumulating and causing drift



Depth to Volume



2D image
Image pixel = float3(x, y, z)

Registration

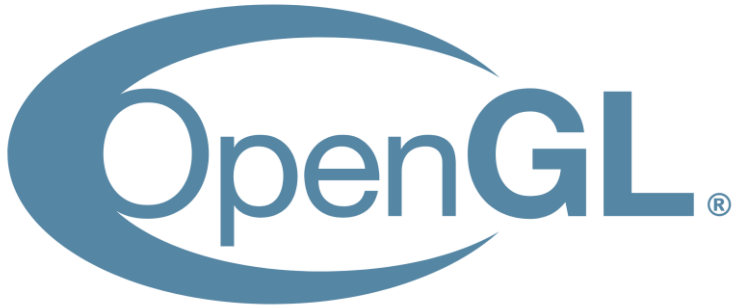
The TSDF is read for each 3D vertex
(potentially up to 848 x 480 x 90 texture reads per second ~ 1.1 GB s^{-1})

No need to find corresponding vertices

No need to raycast

Need to perform bilinear interpolation from the 3D texture read

OpenGL



Widely used and supported

Developed by the Khronos Group

Industry standard for multiplatform graphics

Contains methods for hardware accelerated processes

- Interpolation
- Texture/Image read+write access
- Rendering
- Plus many more …

New API from Khronos …

oglFusion

Aims

Opensource

Fast

Multiplatform

Upgradeable

Current Version

OpenGL 4.3 (Released August 2012)

Linux and Windows supported

CPU or GPU supported (if 4.3 compatible)

Depth to Point

Depth to Volume

Kinect v2

Realsense R415/R435

In progress

Optimisation for lower end CPU/GPU devices

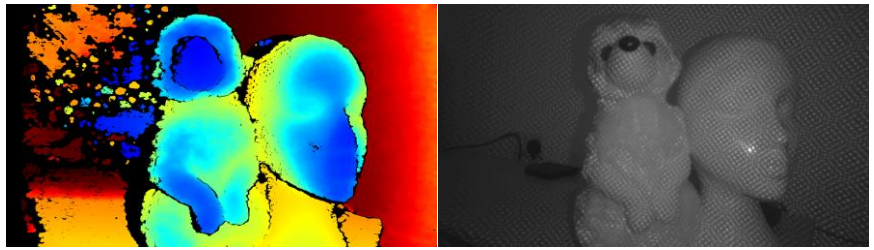
Multiple camera inputs

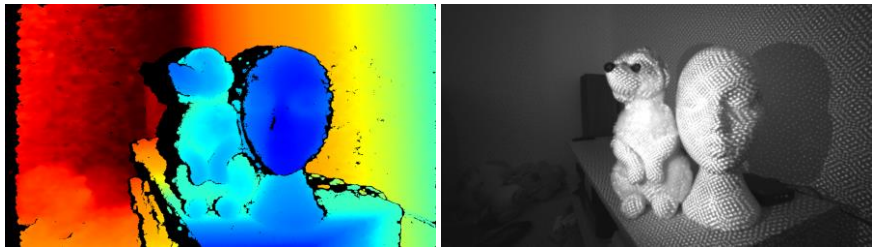
Integrate optical flow to investigate non-rigid tracking

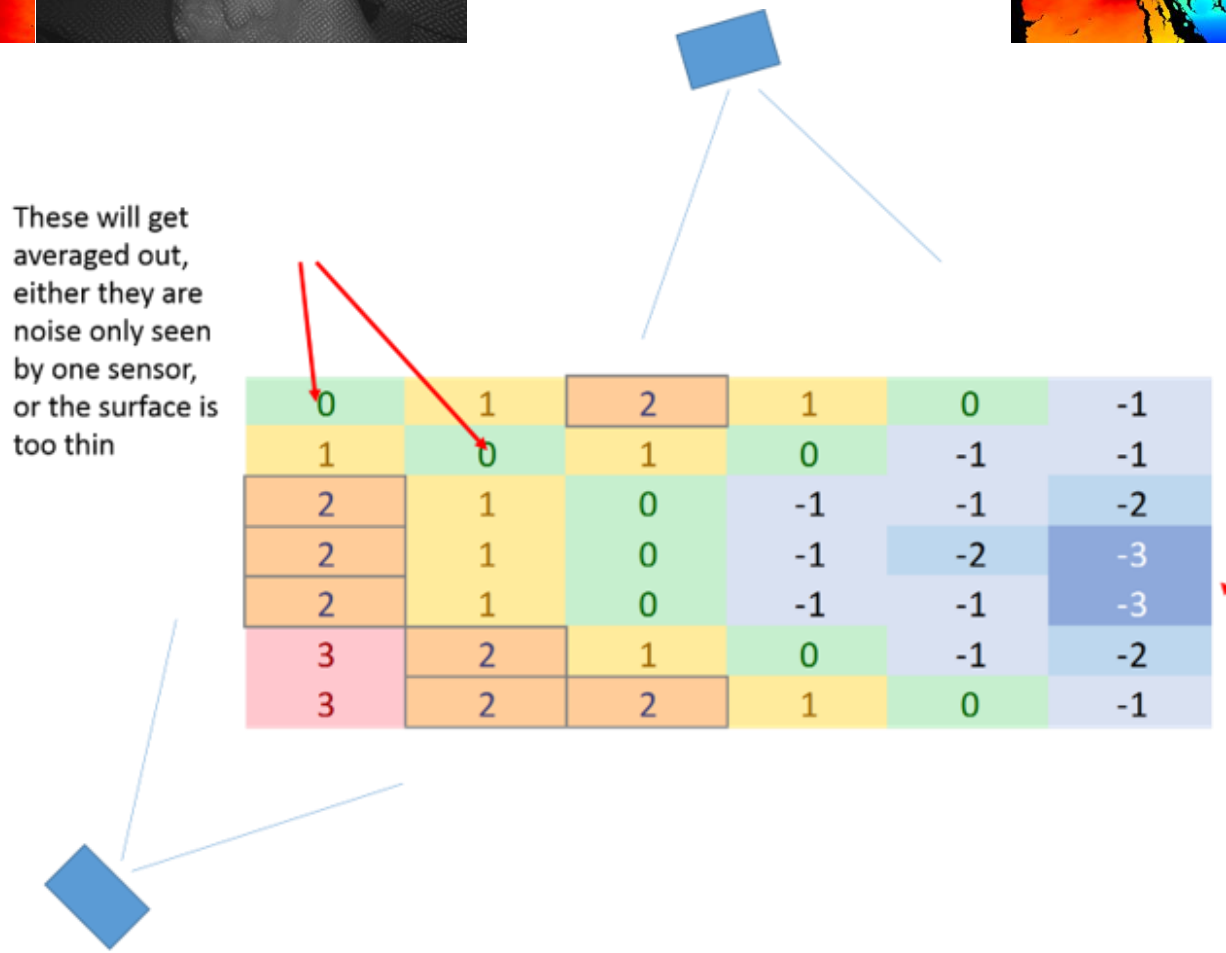
Long term goals

Switch to Vulkan (enabling macOS/iOS)

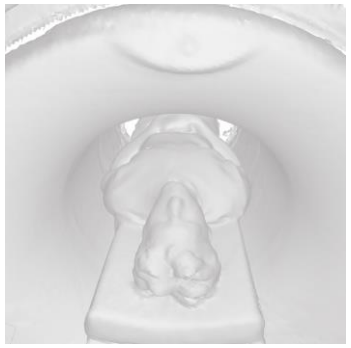
Multiple Camera D2V







Realsense

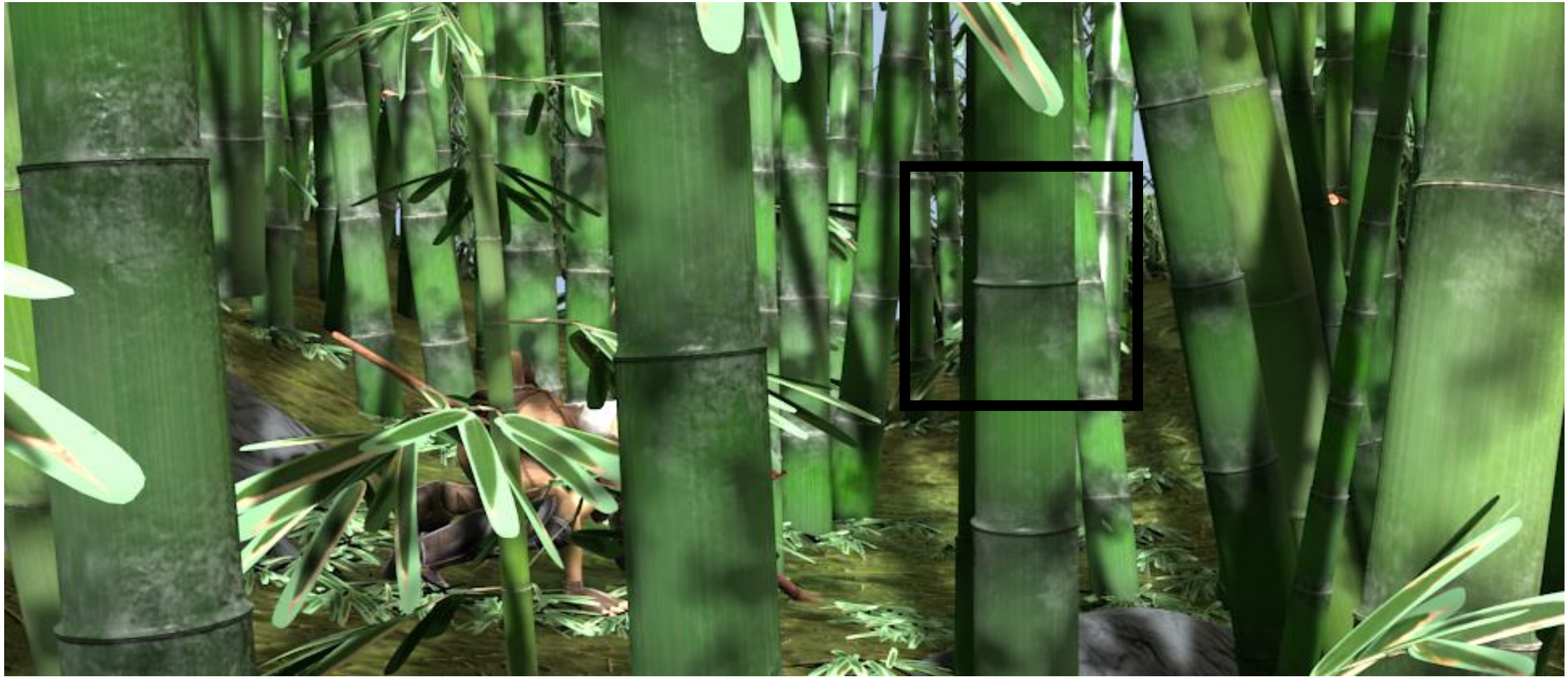


Fusion

Optical Flow

OpenPose

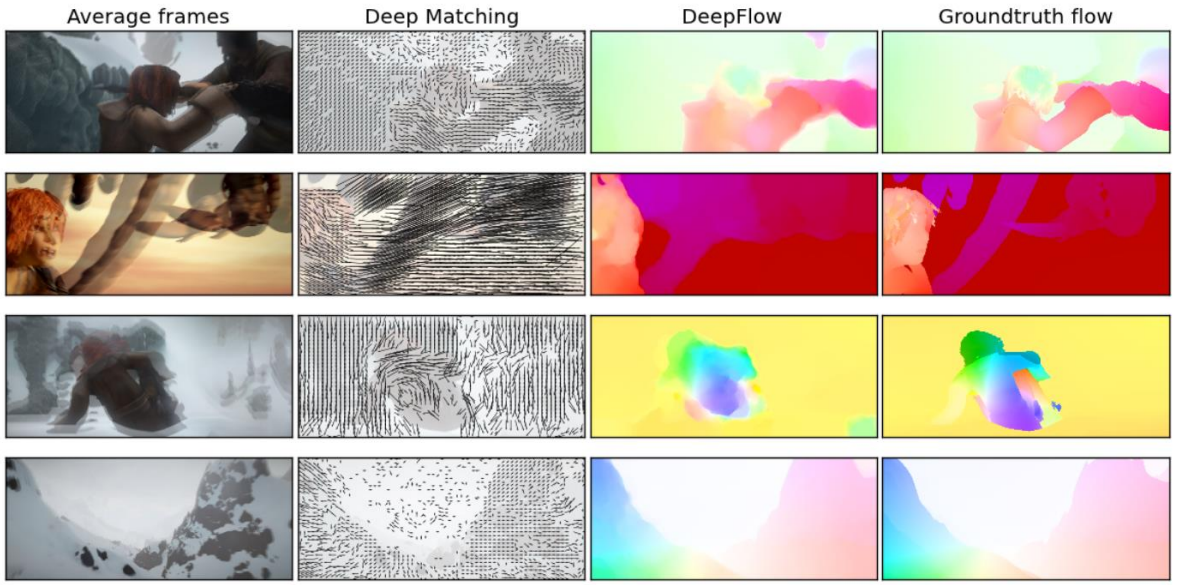
Optical Flow

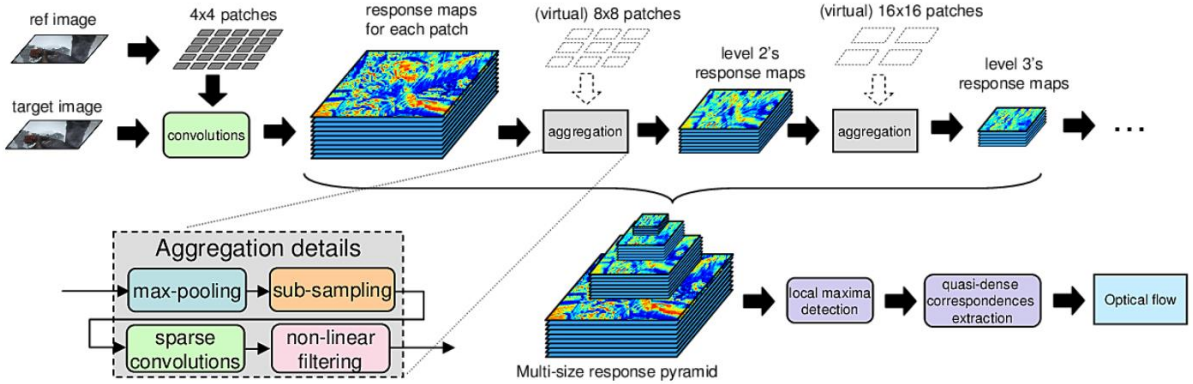


Dense Optical Flow

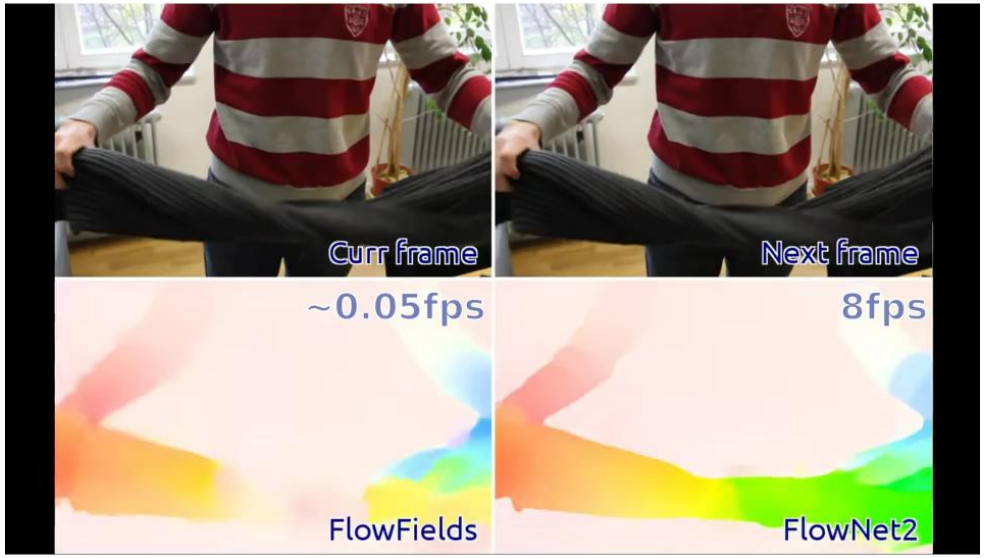
Dense Optical Flow

Deepflow2



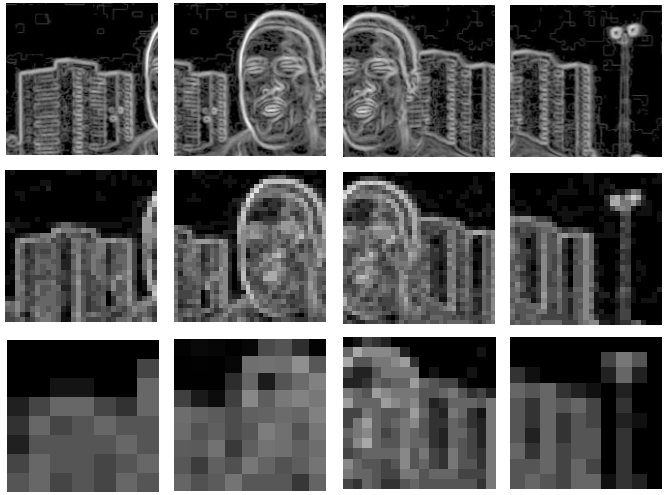


Flownet2 – neural net



Fast Dense Optical Flow

Im_0 **Im_0 PyrArray** **Im_0 PyrArray Gradient** **Im_0 PyrArray Gradient Patches**



Im_1 **Im_1 PyrArray**

Operate coarse to fine

Compute SSD from patches to Im_1

Use Hessian to converge to optimal displacement

Use previous Pyr level to initialize next level

Patch size limits resolution

Image resolution limits speed

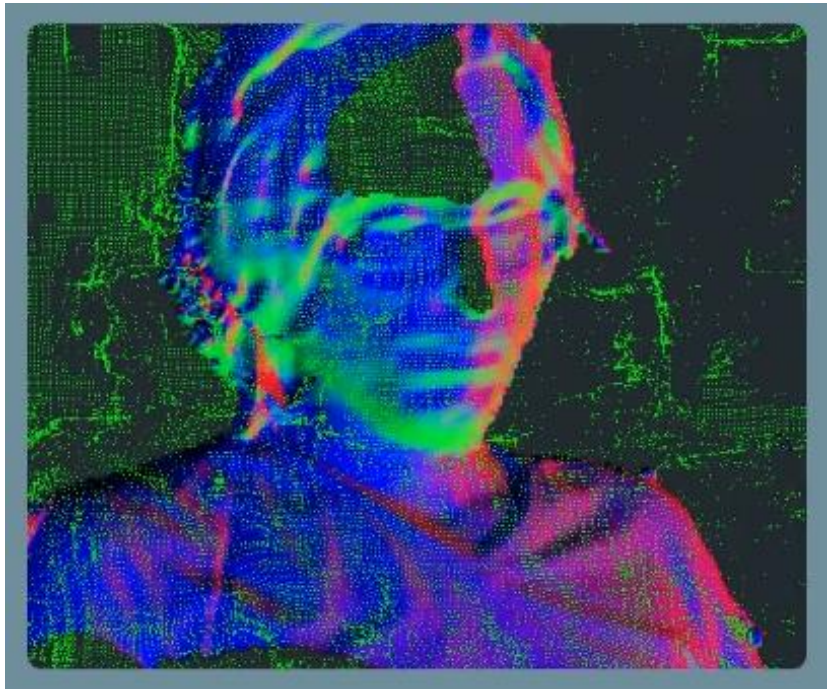
Fast Optical Flow using Dense Inverse Search
T. Kroeger, R. Timofte, D. Dai, L. Van Gool., ECCV 2016.

oglFlow

openGL re-interpretation of Dense Inverse Search

Targeting non-rigid fusion

Green dots = grid of tracking points



oglFusion requires rigid body otherwise model blurs due to erroneous integration

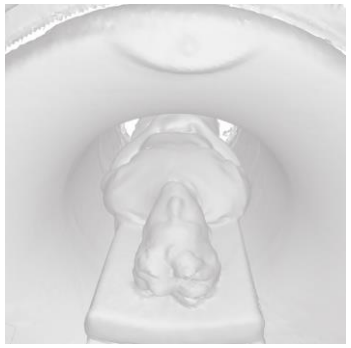
With fast dense optical flow, we can acquire knowledge of non-rigid motion before fusion begins

oglFlow ~ 6-10 ms per frame @ 512 x 424 resolution

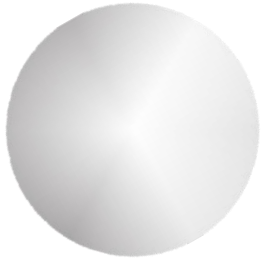
oglFusion ~ 1 ms per frame

90 Hz achievable in real time

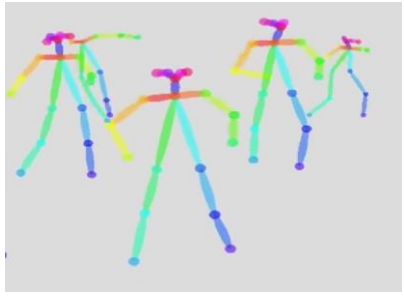
Realsense



Fusion



Optical Flow



OpenPose

OpenPose

Suggested: Mark Ronson - Uptown Funk ft. Bruno Mars

Real-time Multi-Person 2D Pose Estimation Using Part Affinity Fields

Zhe Cao, Tomas Simon, Shih-En Wei, Yaser Sheikh
Carnegie Mellon University

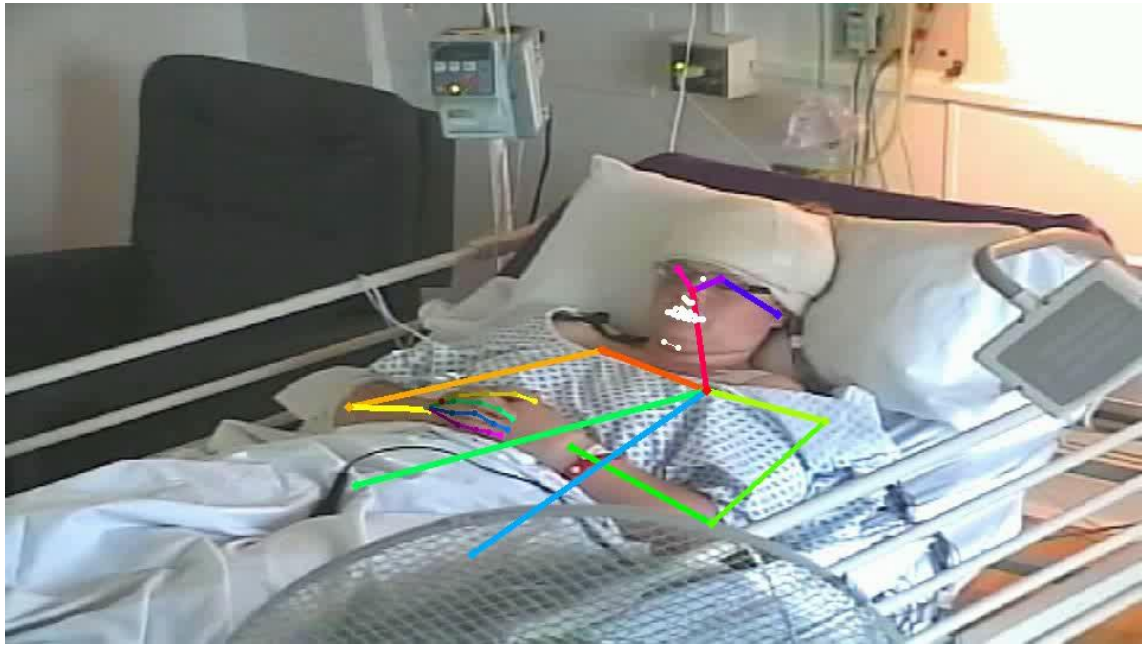
Epilepsy

Patient is monitored during hospital stay

Large amounts of video sequences

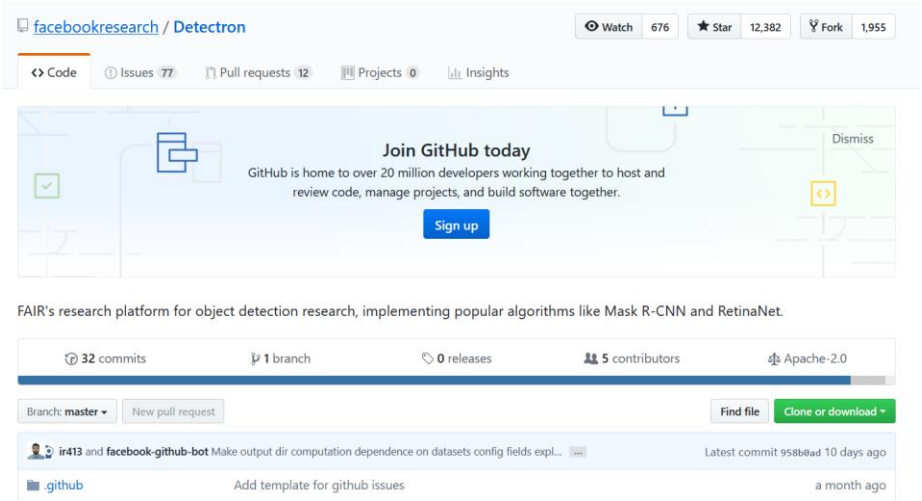
Manual annotation required

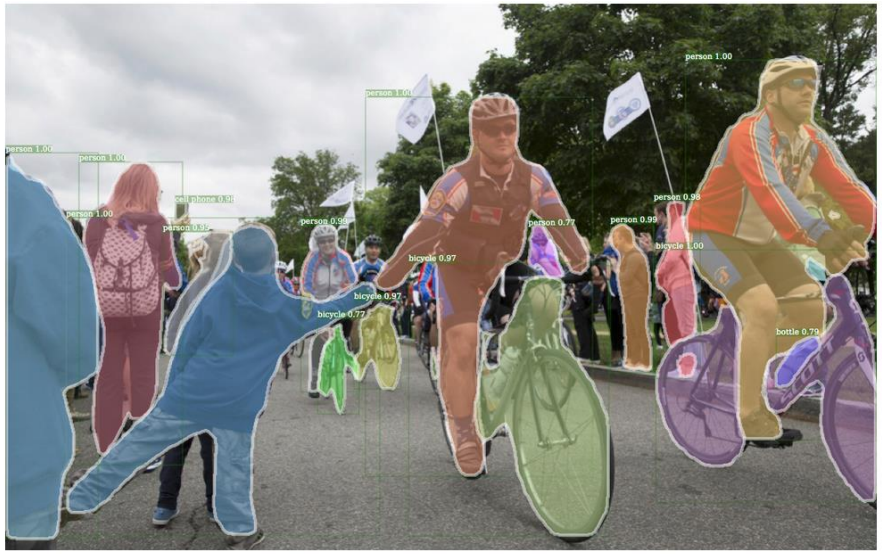
No pose quantification generally available



Patient has given approval for use of data

Detectron and DensePose





Example Mask R-CNN output.

DensePose: Dense Human Pose Estimation In The Wild

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nneverova@fb.com

Iasonas Kokkinos
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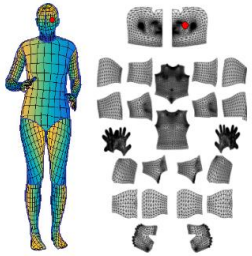
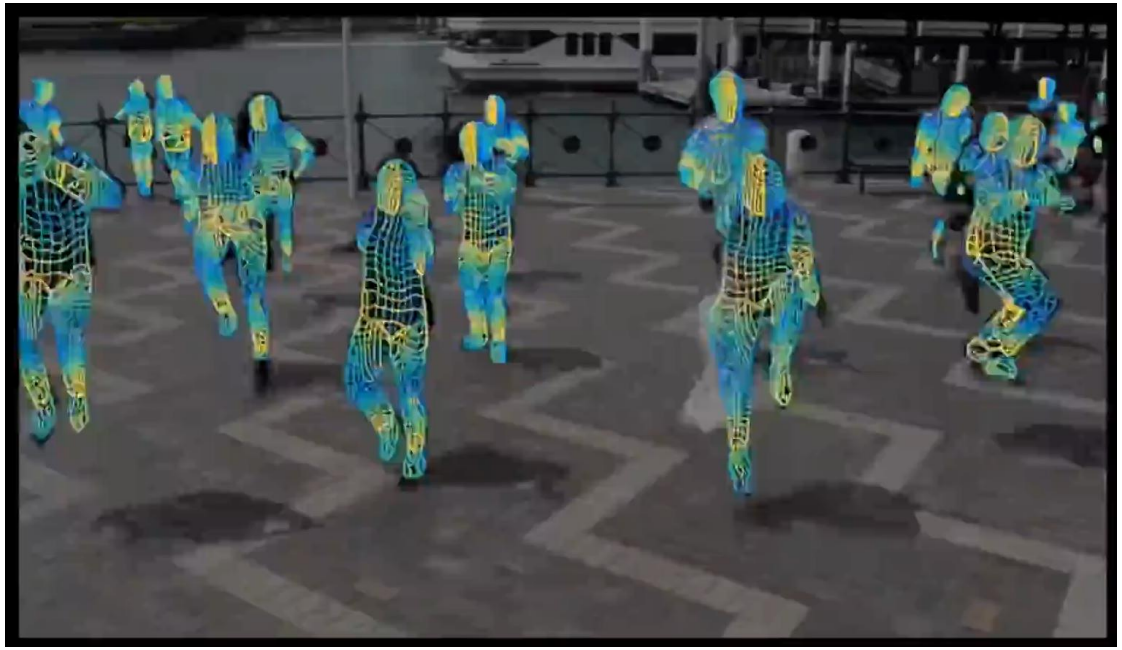
DensePose-RCNN Results

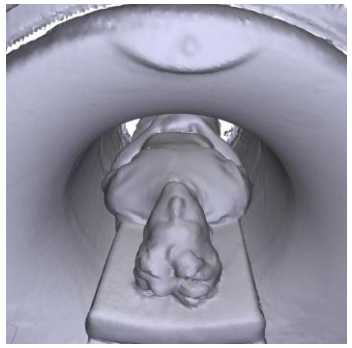
DensePose COCO Dataset





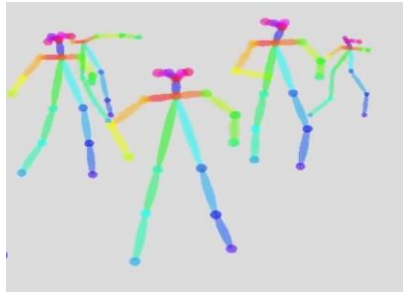
Questions?

Realsense



Fusion

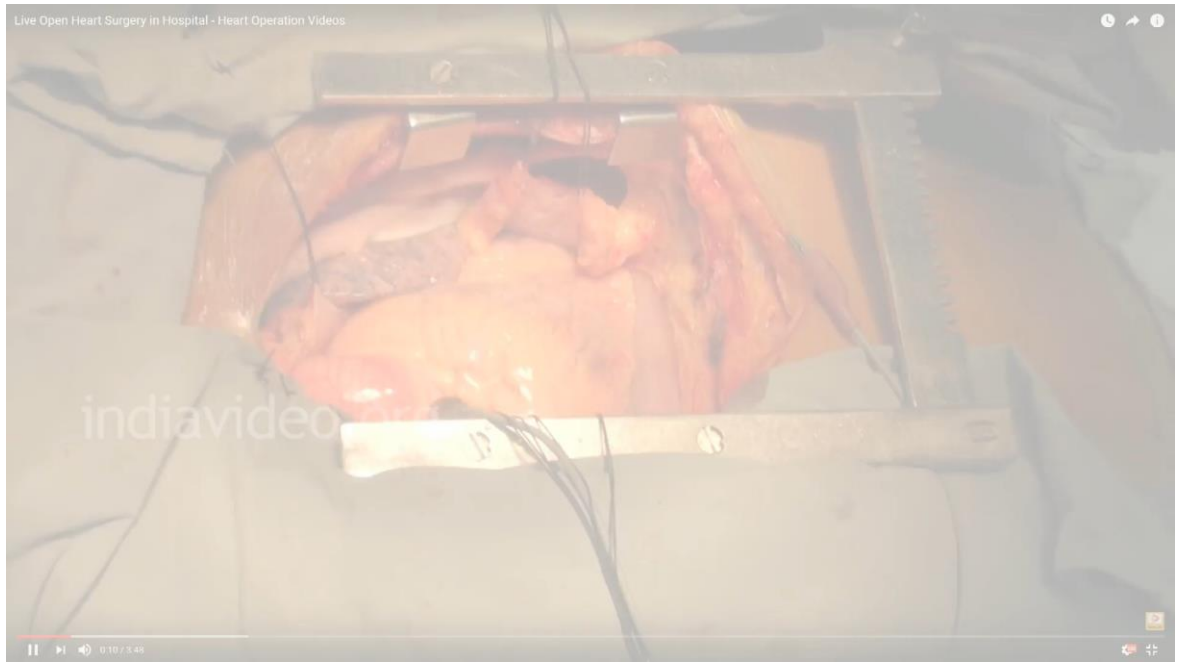
Optical Flow



OpenPose

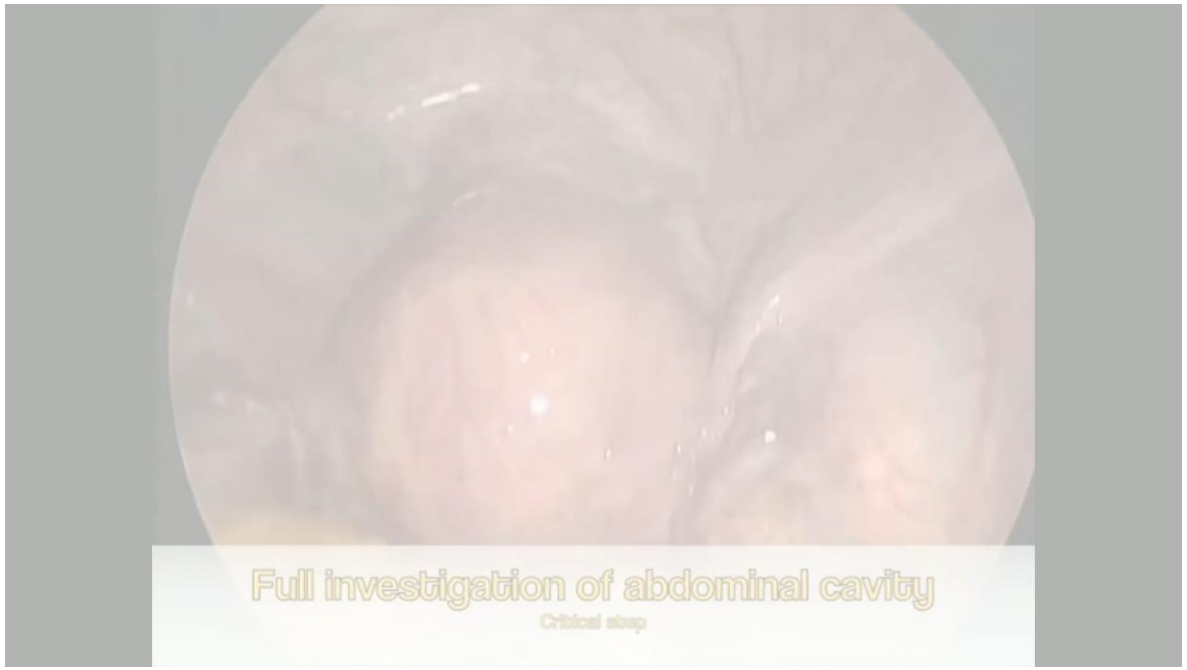
Thanks

Misc



Open Heart

Misc



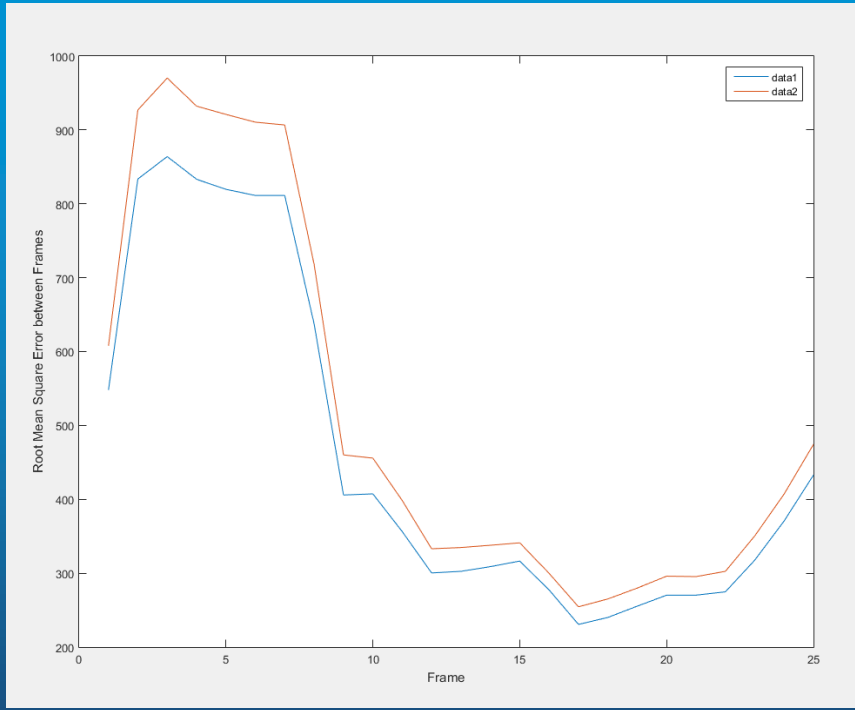
Laparoscopy

Example of Dynamic Imaging With PBR28

Imperial College London

imanova Centre for Imaging Sciences

Analysis



Uncorrected			
Region			
Caudate	Putamen	Whole Brain	Striatum
6.80E+03	1.85E+03	118.556	1.59E+03

MIAKAT™

wRSSQ using SRTM

Kinect Based							
Region							
Caudate	% Decrease	Putamen	% Decrease	Whole Brain	% Decrease	Striatum	% Decrease
4.77E+03	29.90	1.24E+03	32.83	9.20E+01	22.37	7.56E+02	52.52
Image Based							
Region							
Caudate	% Decrease	Putamen	% Decrease	Whole Brain	% Decrease	Striatum	% Decrease
4.92E+03	27.71	1.28E+03	30.79	9.36E+01	21.04	9.20E+02	42.21

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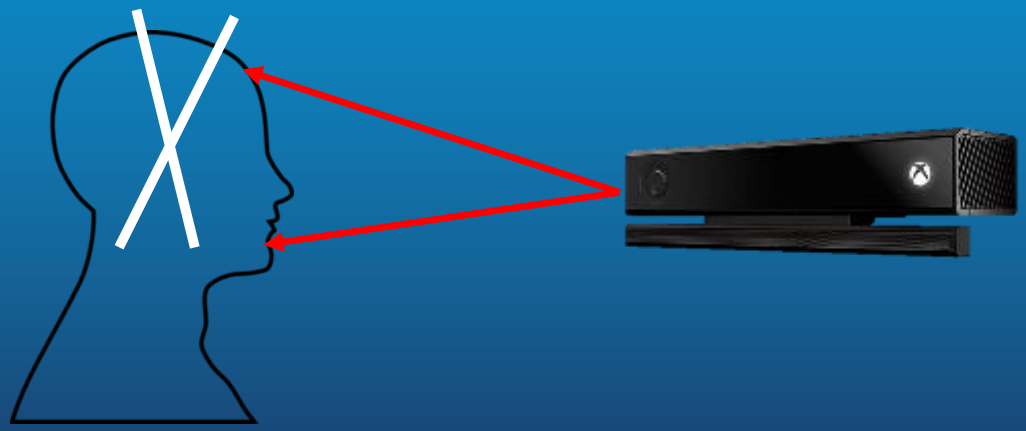
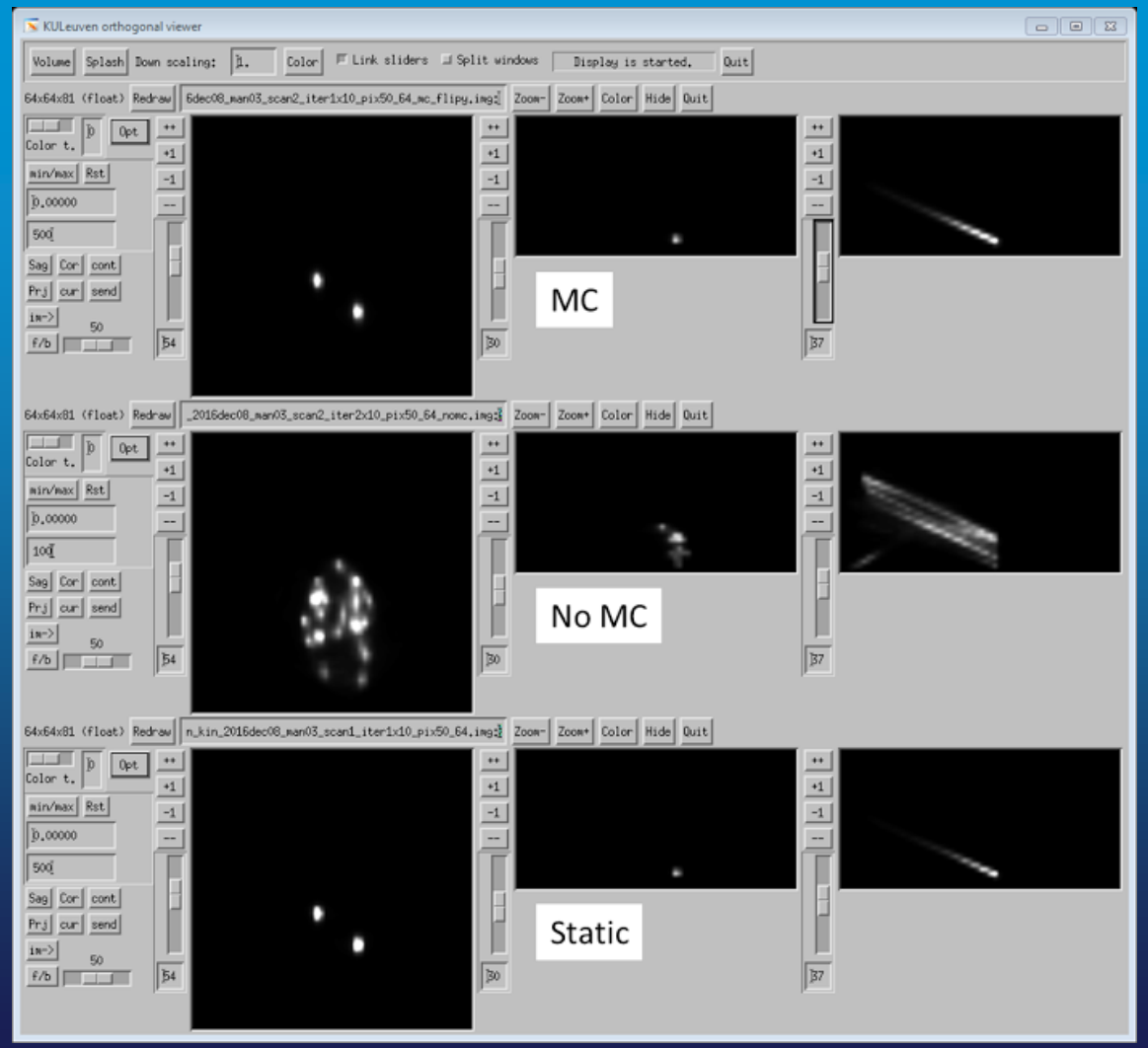
Event by Event

Pilot data using head phantom
2 internal linesource
2 minutes PET (Siemens HiRez)
Constant, handheld motion
Step changes every 5 seconds



In collaboration with
Johan Nuyts,
Matthew Bickell,
Anna Turco



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