

MICROSCOPY, IN A HEARTBEAT

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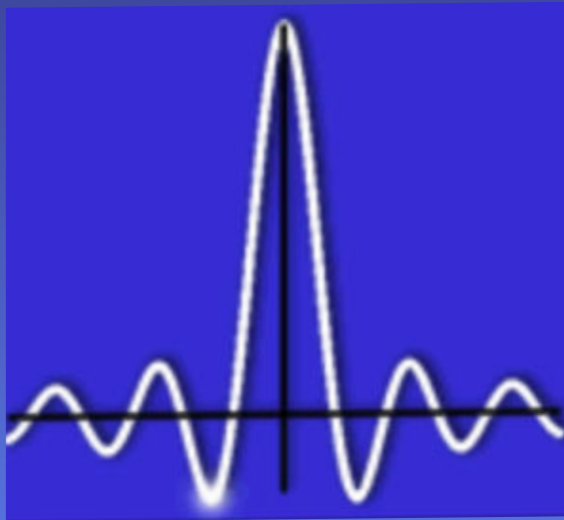
Adjunct Professor
ECE Department
University of California, Santa Barbara

Twenty Years of Biomedical Imaging and Splines

23 March 2018, EPFL, Lausanne



My first signal processing student project (1999)



THINK!



My second
student
project
in signal
processing
(diplôme 2000)



How BIG affected my hobbies...

Before BIG



Playing with cool
Danish building
blocks



Enjoying
Fine Art



Taking pictures of rare
wildflowers

... and how life became 100% splines

Before BIG



Playing with cool Danish building blocks

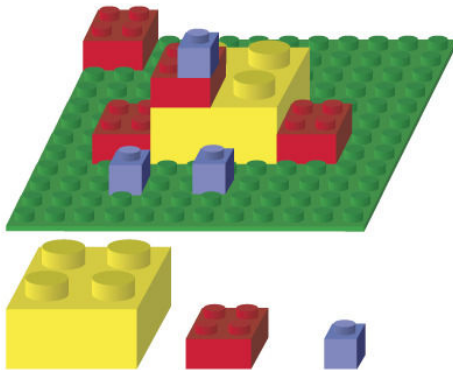


Enjoying Fine Art

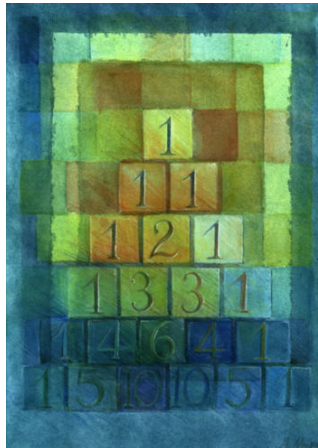


Taking pictures of rare wildflowers

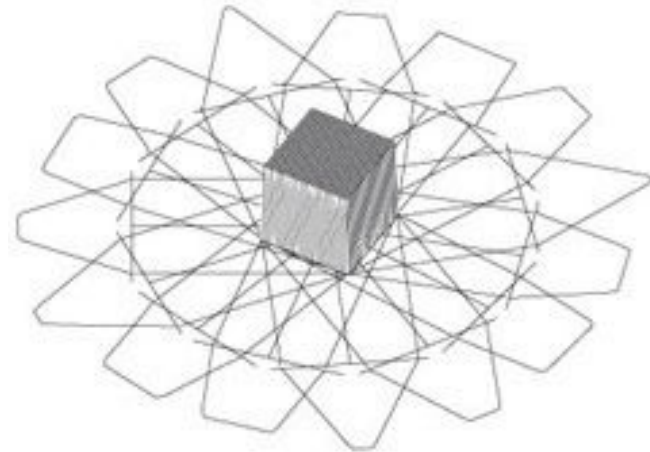
While at BIG



Playing with cool Danish building blocks



Enjoying Fine Art

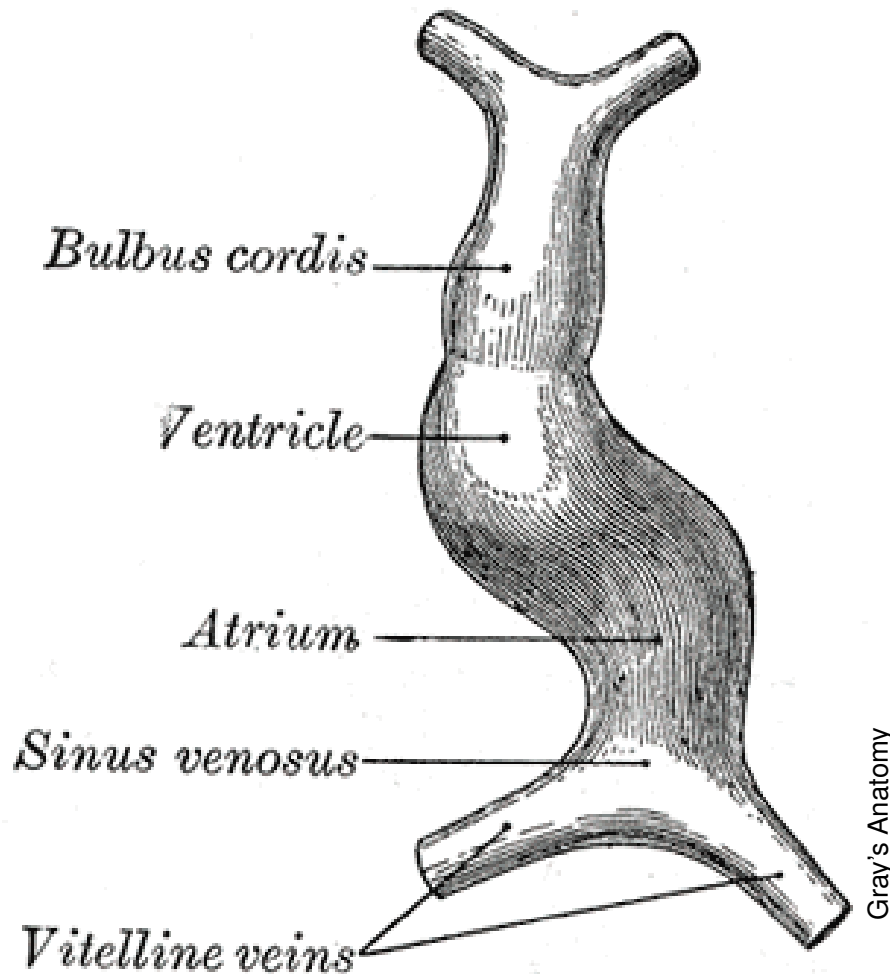


Taking pictures of rare wildflowers

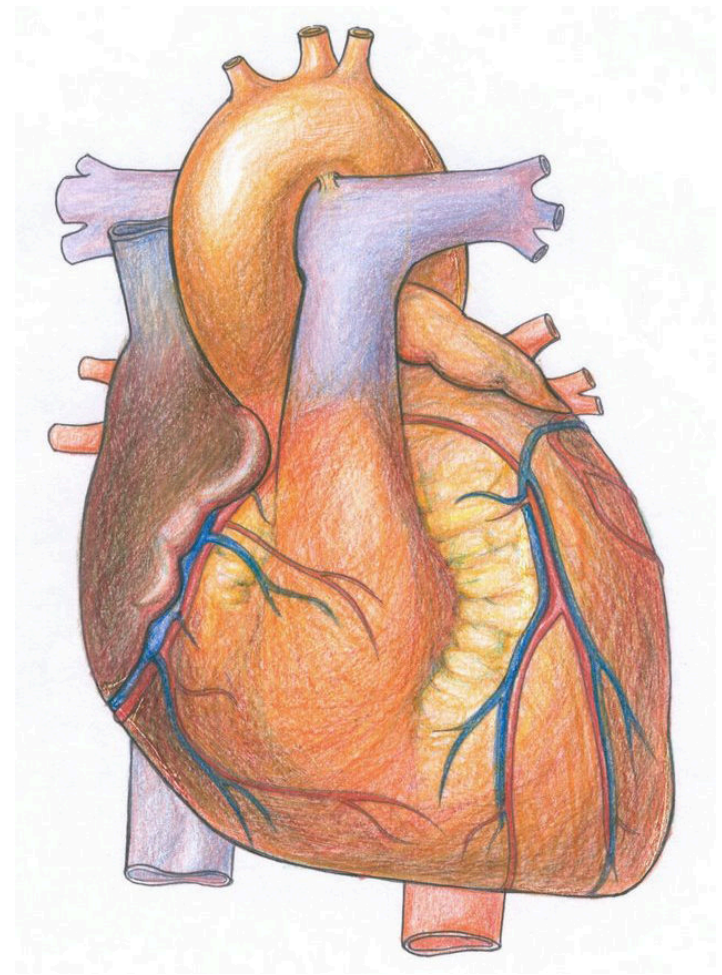
To get hired as a PhD student @ BIG, is wearing a tie required?



Hint: even if it is not necessary, you can always recycle the tie to illustrate sampling in your image processing class.



Day 22 (Human)



Adult (Human)

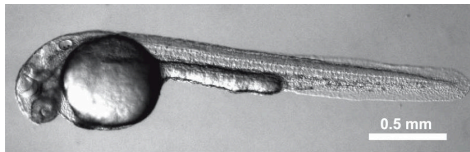
Why it matters:

Congenital heart defects occur in 0.8% of newborn infants and are the leading cause of birth defect-related deaths

Imaging the developing heart: challenging requirements...

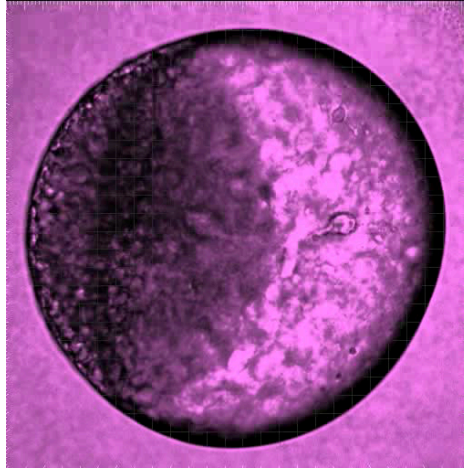
It's small:

heart is a few hundred μm ,
cells few μm ;
 \Rightarrow requires magnification



It's slow:

Development over
hours, days

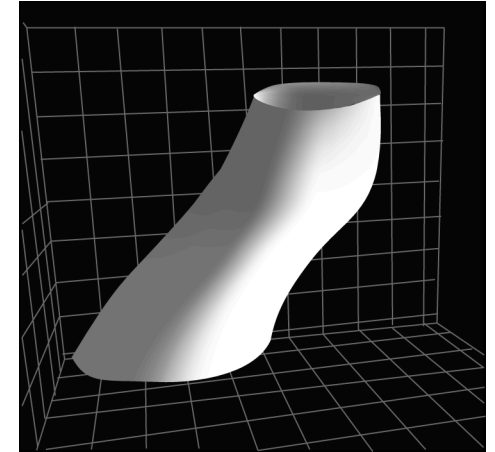


It's fast:

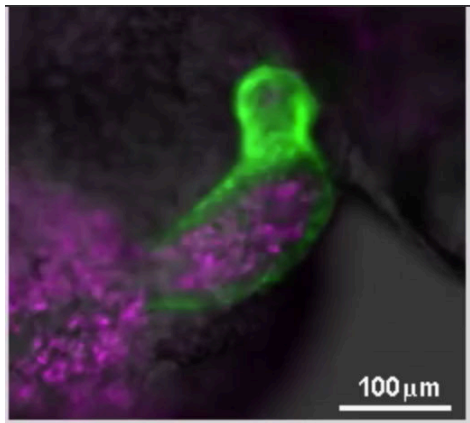
2-3 Heart beats
per second



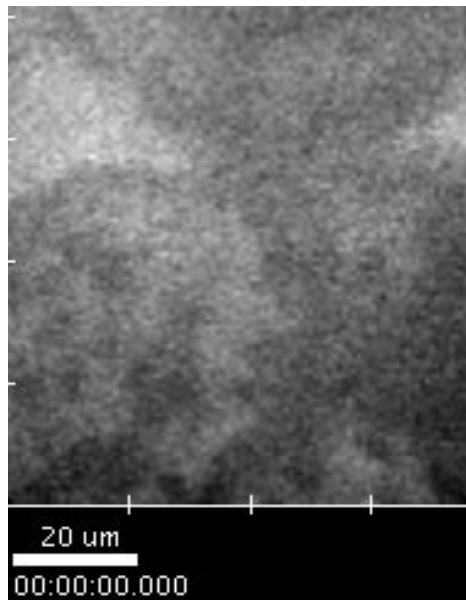
It's 3D (when most
microscopes are
fast only in 2D)



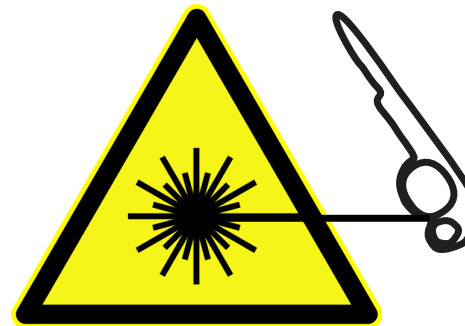
One channel
is rarely enough



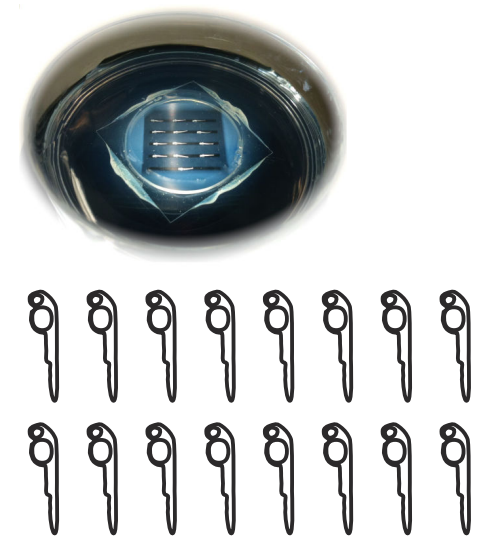
Signal is weak



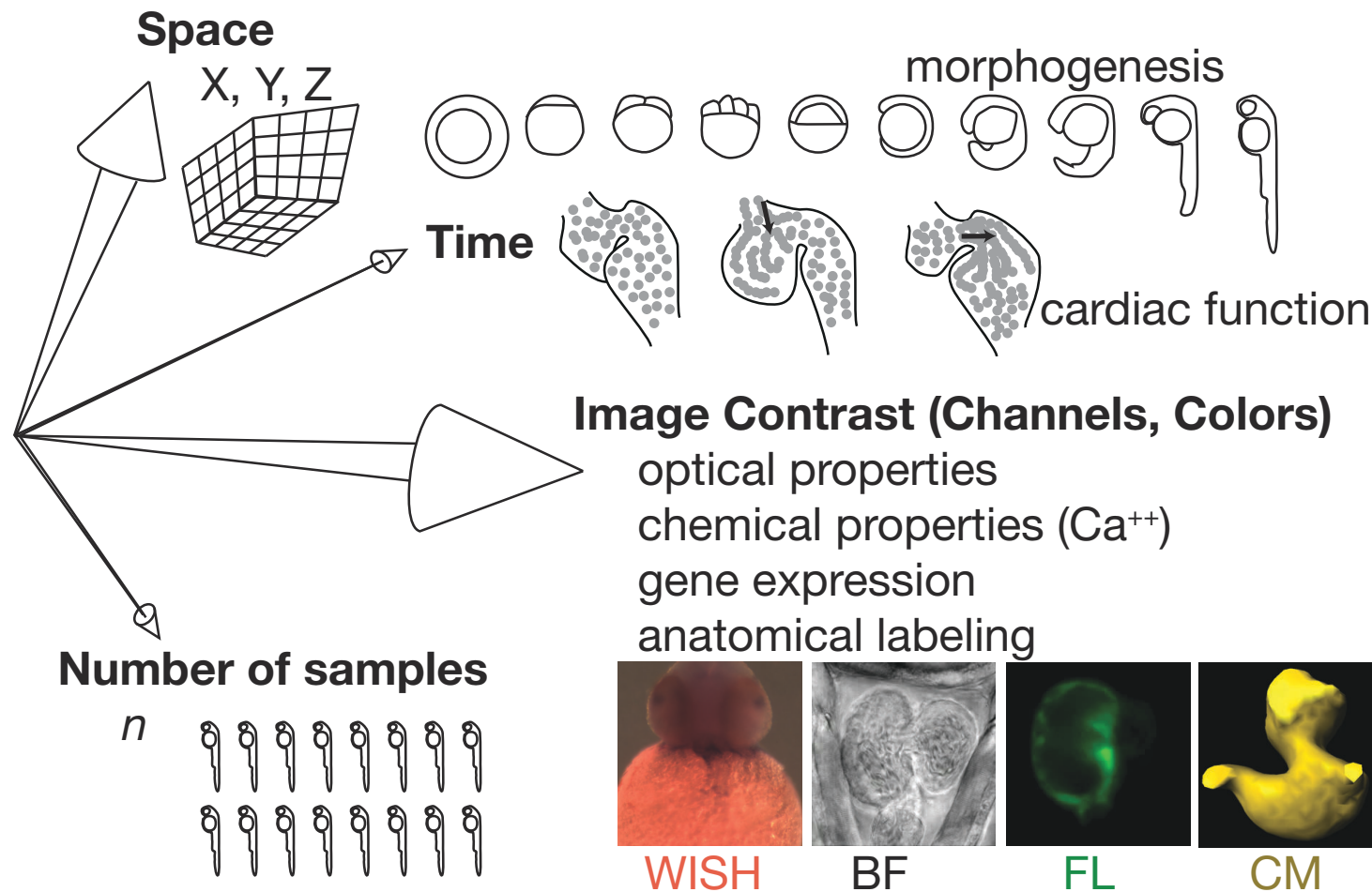
Sample is fragile



No statistics
with $n = 1$



... dimensions are too many for naïve imaging

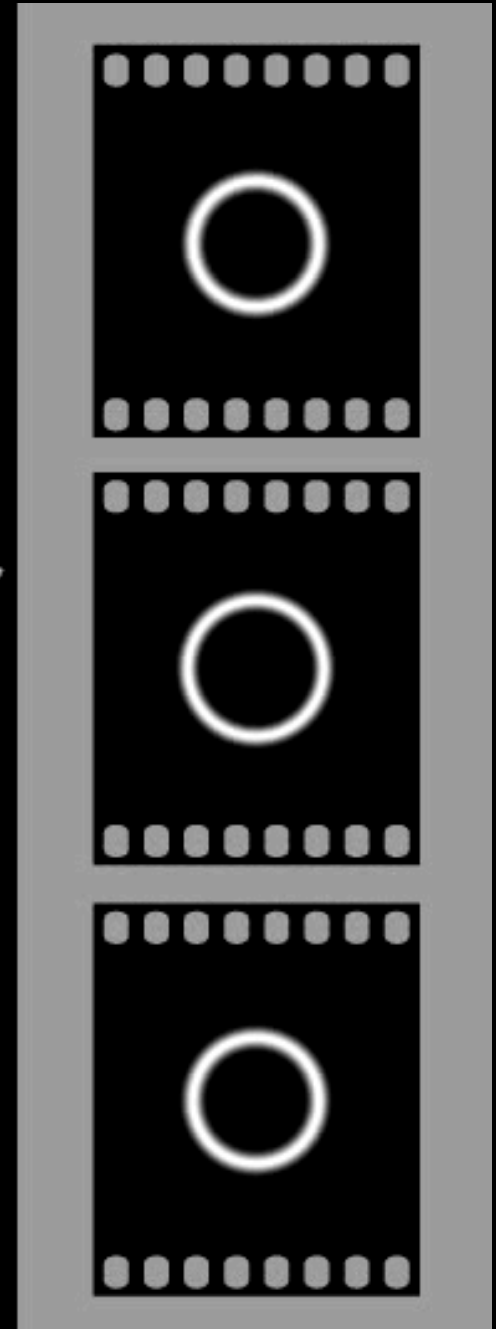
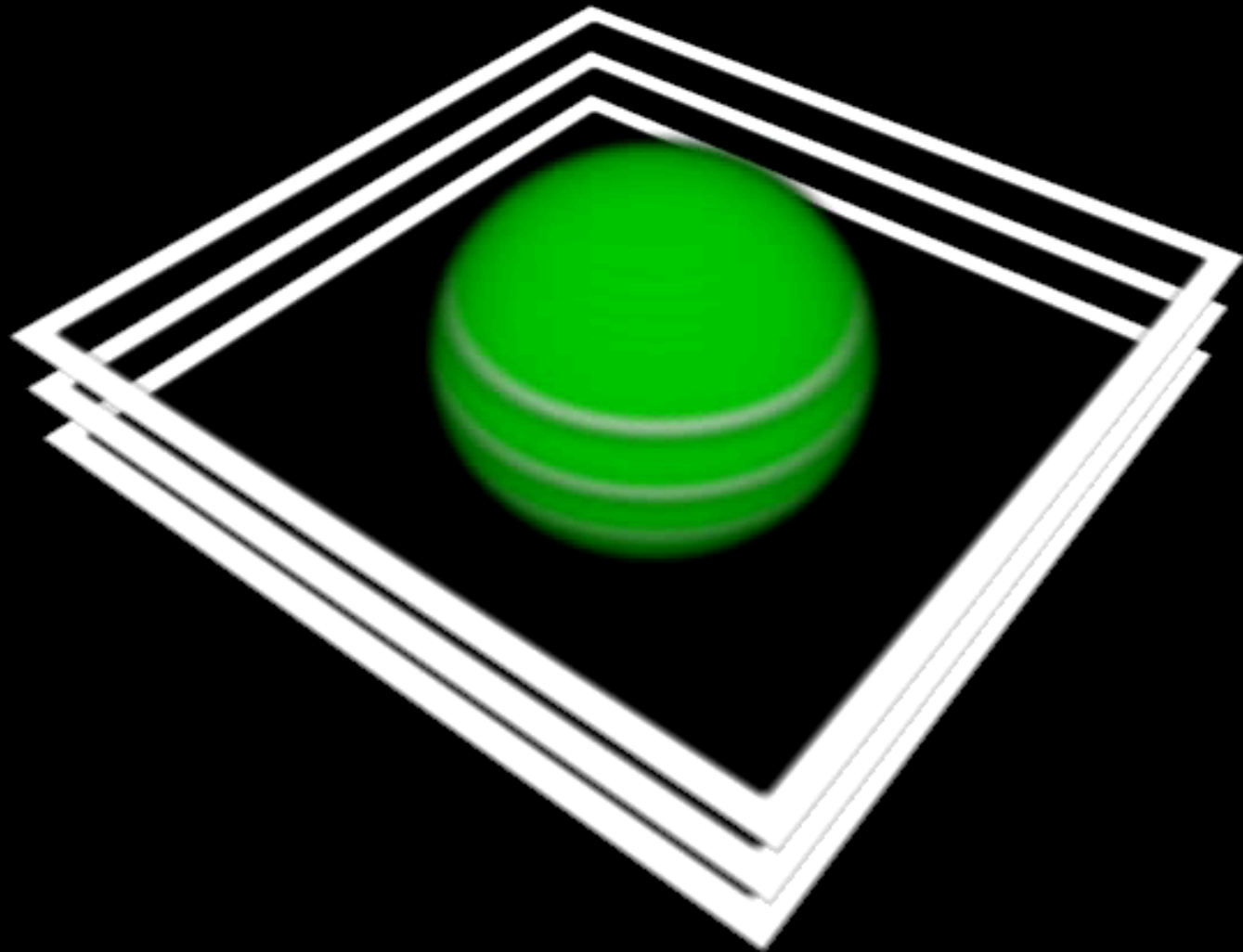


Bottlenecks that limit resolution and breadth

- optical resolving power, data bandwidth
- available time
- sample integrity

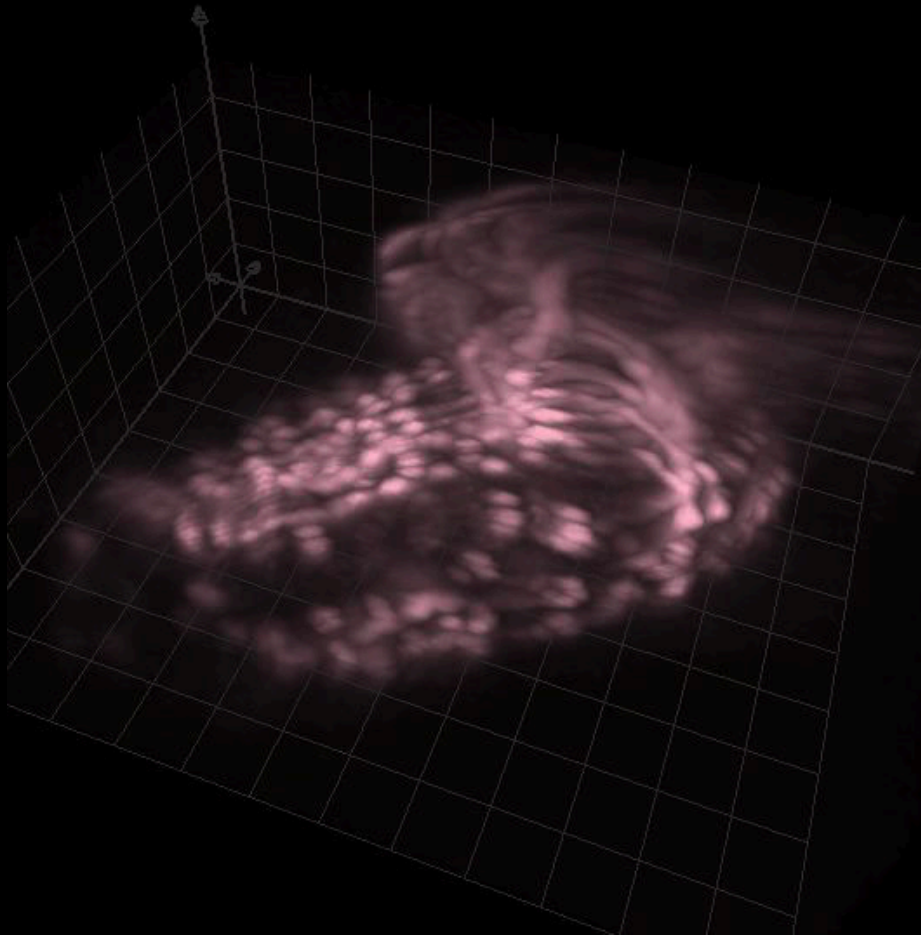
Can we perform high-dimensional imaging without sacrificing resolution or image quality?

Reconstruction

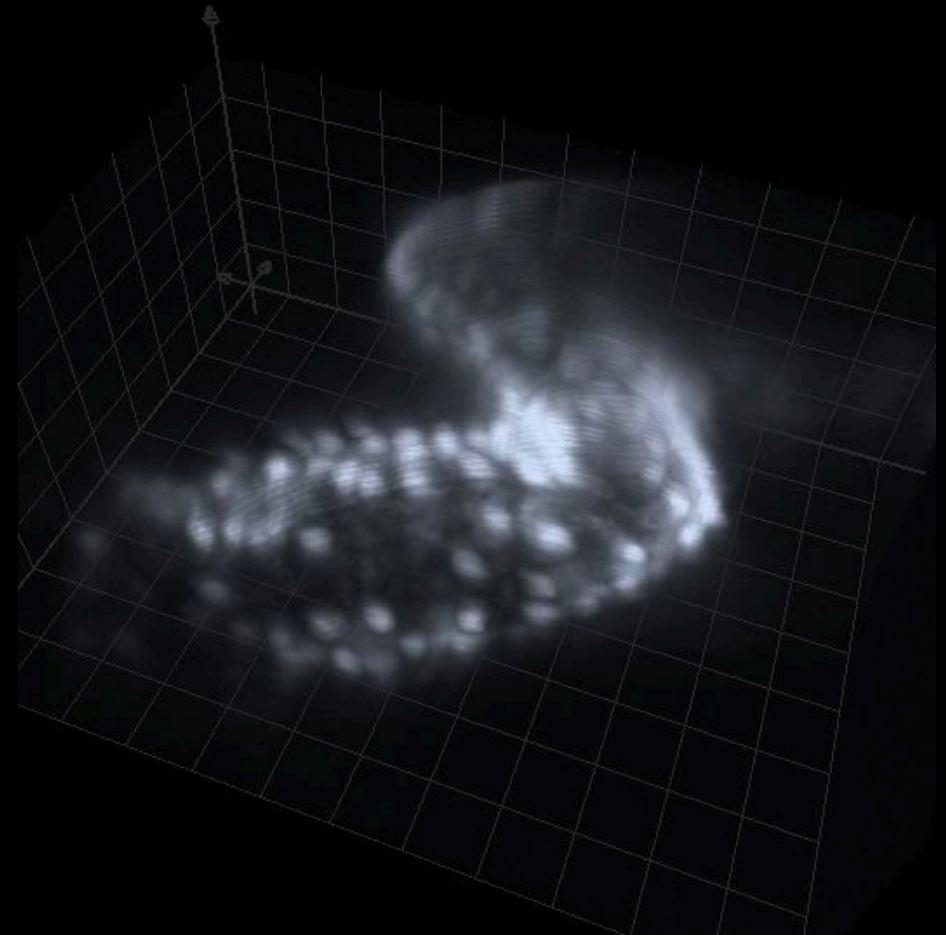


4D, in vivo, and fast microscopy becomes possible

Before synchronization



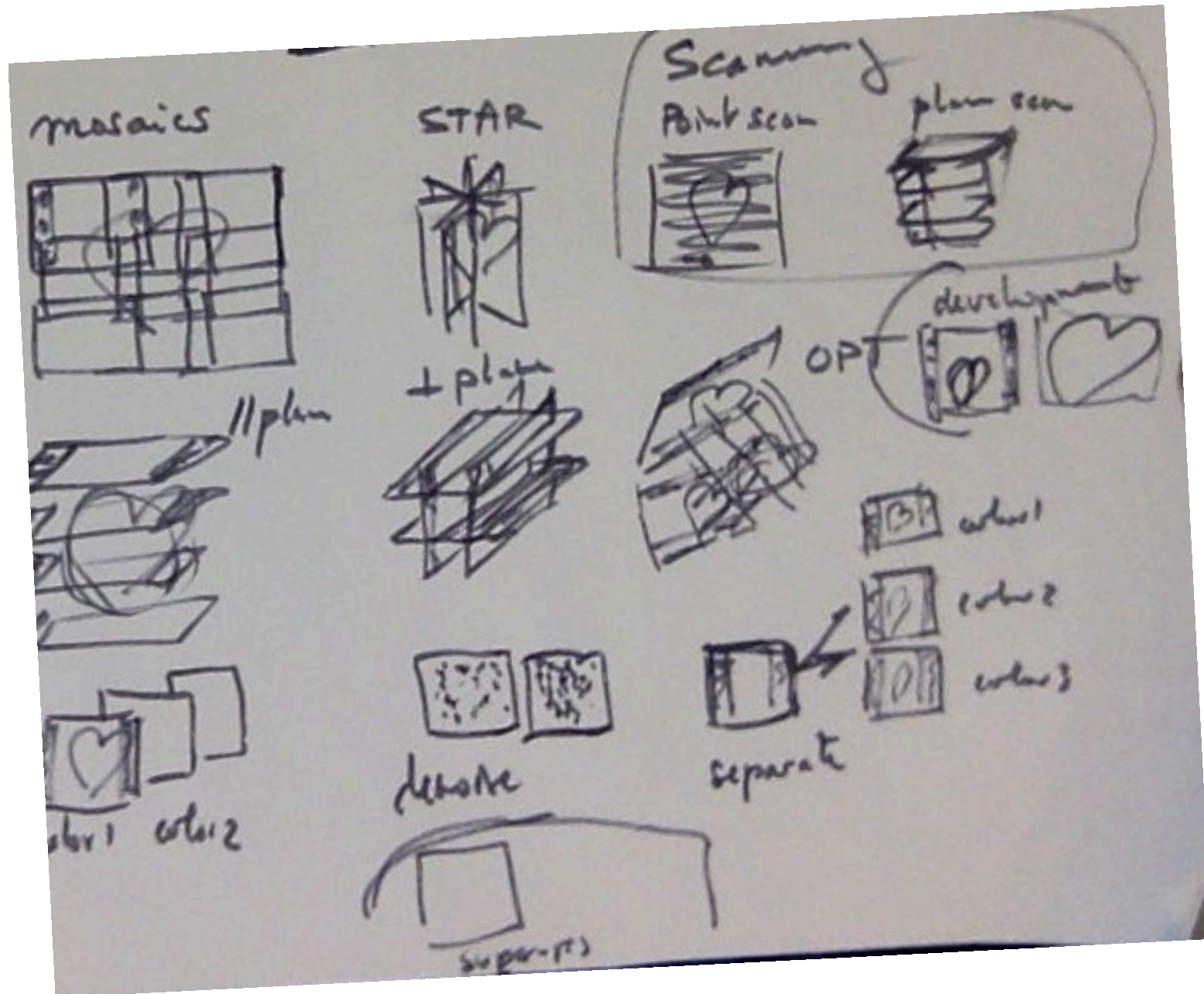
After synchronization



A.S. Forouhar, **ML**

[Tg(*cmlc2*:GFP) 38 hpf zebrafish, Huai-Jen Tsai, National Taiwan University]

Many variations on the same theme over the years...



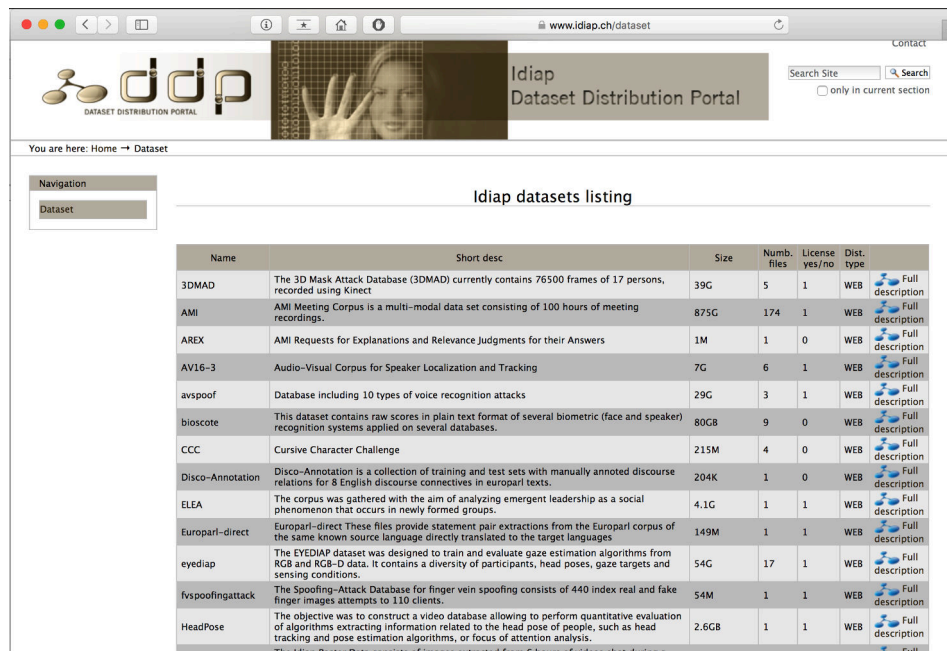
... still many configurations that remain to be cracked!

Reproducible research: different ways to share (or not to share) data

Distribute the data:

Over 30 databases are distributed by Idiap:

www.idiap.ch/dataset



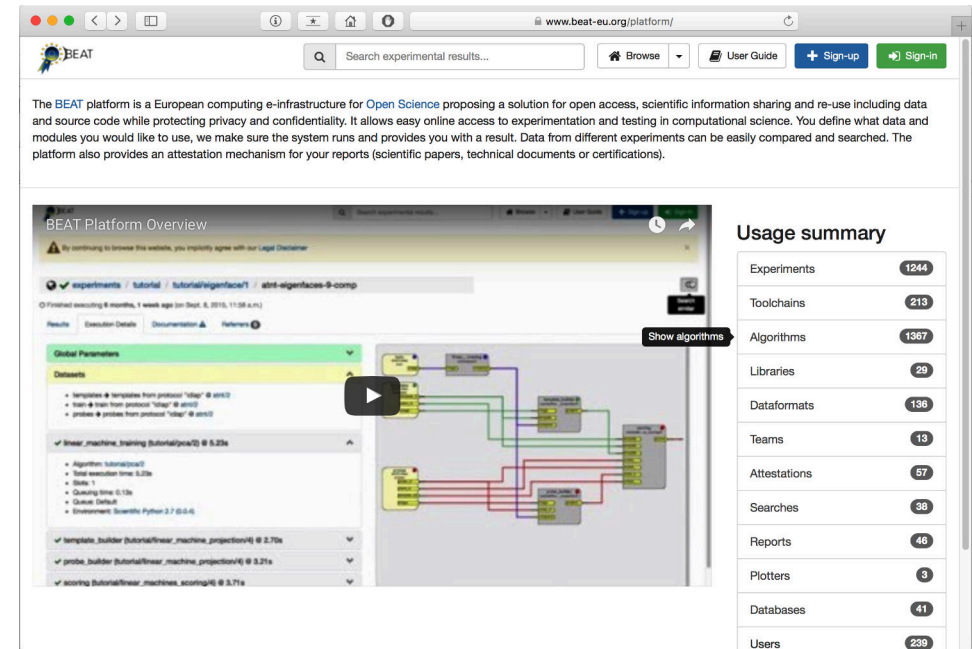
The screenshot shows the Idiap Dataset Distribution Portal. It features a navigation bar with 'Home' and 'Dataset' links. Below the navigation bar is a table titled 'Idiap datasets listing'. The table has columns for Name, Short desc, Size, Numb. files, License yes/no, Dist. type, and a link to the full description. The table lists 15 datasets, including 3DMAD, AMI, AREX, AV16-3, avspoof, bioscope, CCC, Disco-Annotation, ELEA, Europarl-direct, eyediap, fvs spoofing attack, and HeadPose.

Name	Short desc	Size	Numb. files	License yes/no	Dist. type	Full description
3DMAD	The 3D Mask Attack Database (3DMAD) currently contains 76500 frames of 17 persons, recorded using Kinect	39G	5	1	WEB	Full description
AMI	AMI Meeting Corpus is a multi-modal data set consisting of 100 hours of meeting recordings.	875G	174	1	WEB	Full description
AREX	AMI Requests for Explanations and Relevance Judgments for their Answers	1M	1	0	WEB	Full description
AV16-3	Audio-Visual Corpus for Speaker Localization and Tracking	7G	6	1	WEB	Full description
avspoof	Database including 10 types of voice recognition attacks	29G	3	1	WEB	Full description
bioscope	This dataset contains raw scores in plain text format of several biometric (face and speaker) recognition systems applied on several databases.	80GB	9	0	WEB	Full description
CCC	Cursive Character Challenge	215M	4	0	WEB	Full description
Disco-Annotation	Disco-Annotation is a collection of training and test sets with manually annotated discourse relations for 8 English discourse connectives in europarl texts.	204K	1	0	WEB	Full description
ELEA	The corpus was gathered with the aim of analyzing emergent leadership as a social phenomenon that occurs in newly formed groups.	4.1G	1	1	WEB	Full description
Europarl-direct	Europarl-direct These files provide statement pair extractions from the Europarl corpus of the same known source language directly translated to the target languages	149M	1	1	WEB	Full description
eyediap	The EYEDIAP dataset was designed to train and evaluate gaze estimation algorithms from RGB and RGB-D data. It contains a diversity of participants, head poses, gaze targets and sensing conditions.	54G	17	1	WEB	Full description
fvs spoofing attack	The Spoofing-Attack Database for finger vein spoofing consists of 440 index real and fake finger images attempts to 110 clients.	54M	1	1	WEB	Full description
HeadPose	The objective was to construct a video database allowing to perform quantitative evaluation of algorithms extracting information related to the head pose of people, such as head tracking and pose estimation algorithms, or focus of attention analysis.	2.6GB	1	1	WEB	Full description

Sequester the data:

BEAT platform (evaluation of biometry algorithms on sequestered data)

S. Marcel *et al.*



The screenshot shows the BEAT platform interface. It features a search bar, a 'Browse' button, and a 'Sign-up' button. Below the search bar is a description of the BEAT platform. The main content area shows a workflow diagram with a play button. On the right side, there is a 'Usage summary' table.

The BEAT platform is a European computing e-infrastructure for Open Science proposing a solution for open access, scientific information sharing and re-use including data and source code while protecting privacy and confidentiality. It allows easy online access to experimentation and testing in computational science. You define what data and modules you would like to use, we make sure the system runs and provides you with a result. Data from different experiments can be easily compared and searched. The platform also provides an attestation mechanism for your reports (scientific papers, technical documents or certifications).

Usage summary

Category	Count
Experiments	1244
Toolchains	213
Algorithms	1367
Libraries	29
Dataformats	136
Teams	13
Attestations	57
Searches	38
Reports	46
Plotters	3
Databases	41
Users	239

Still a need:

dynamic image data sets for computational imaging problems are nice to have but there are too few available

Proposal (2015):

Set up an image acquisition platform to collect and share dynamic images over a broad range of scales and applications

2018: A platform in support of dynamic computational imaging

Two 7-axis backdrivable robotic arms (Panda, Franka Emika)

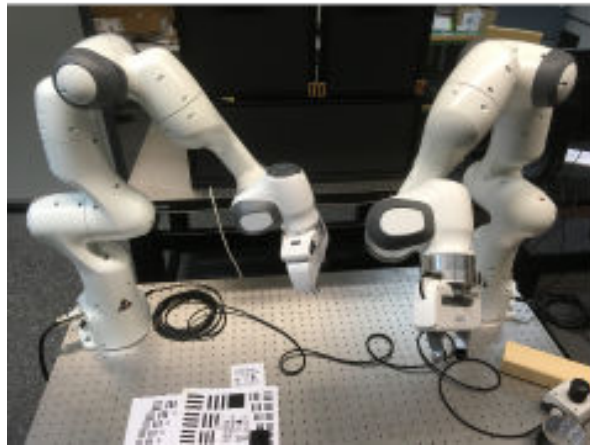
Come in We're
OPEN

Two-color Light-sheet microscope (Open-SPIM)

ML, S. Calinon, S. Marcel, SNSF 206021_164022

Imaging Motion: Explore, Constrain, Reproduce

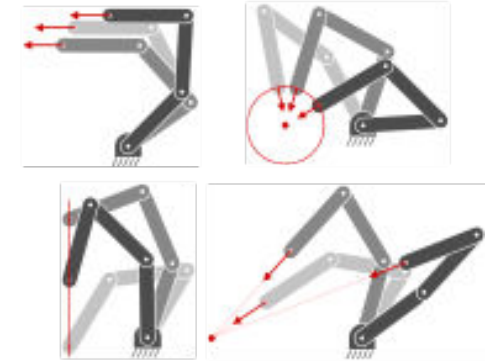
One Platform to ...



... explore motion space systematically...



... constrain motion or view...



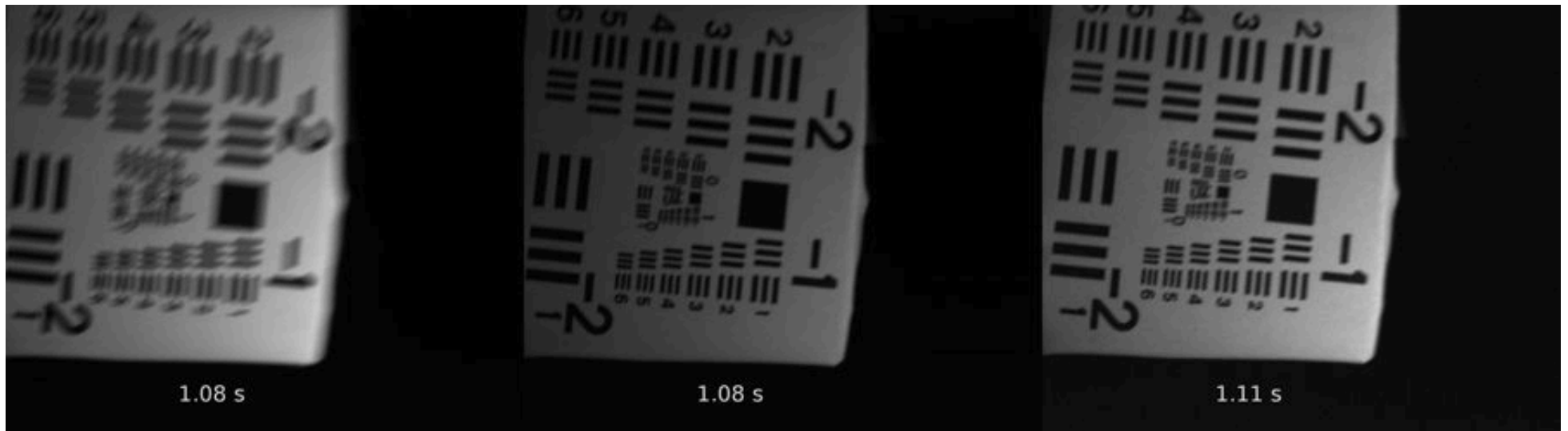
... and reproduce arbitrary motion:

Example: *Comparing performance of acquisition and/or reconstruction methods*

Long exposure

Strobed exposure

Temporal super-resolution



Christian Jaques, Adrian Shajkofci, Emmanuel Pignat, S. Calinon, *MI*

Summary

- Imaging the developing heart
 - Imaging is a key component but constraints are challenging
 - Proposed solution: sequential sampling of the data space (over multiple heart beats) with post-processing
 - Many variations, still many open problems
- Computational imaging
 - Need more quality data to work with
 - Developed an imaging platform at Idiap
 - Platform is open for collaborators!



Acknowledgments

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Mary E. Dickinson

U. Houston (OCT)

Kirill Larin

a*star, Singapore

(Heart transgenics)

Kar Lai Poon, Vlad Korzh

Hard- and Software

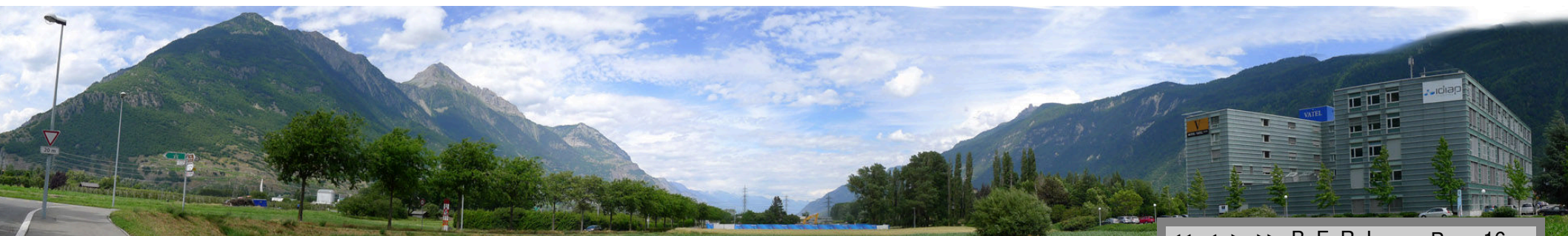
Imaris (Bitplane AG)
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Zebrafish

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