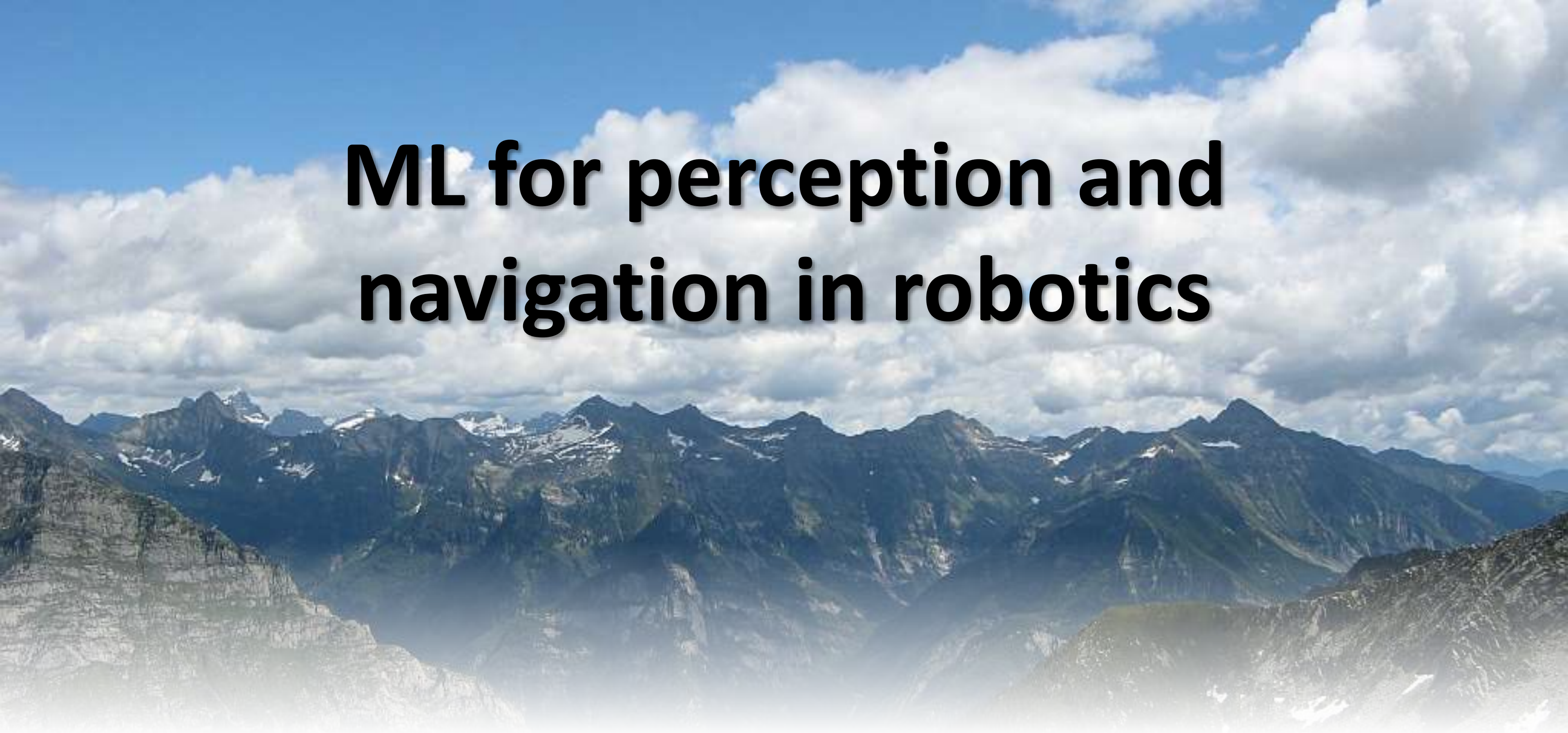


ML for perception and navigation in robotics

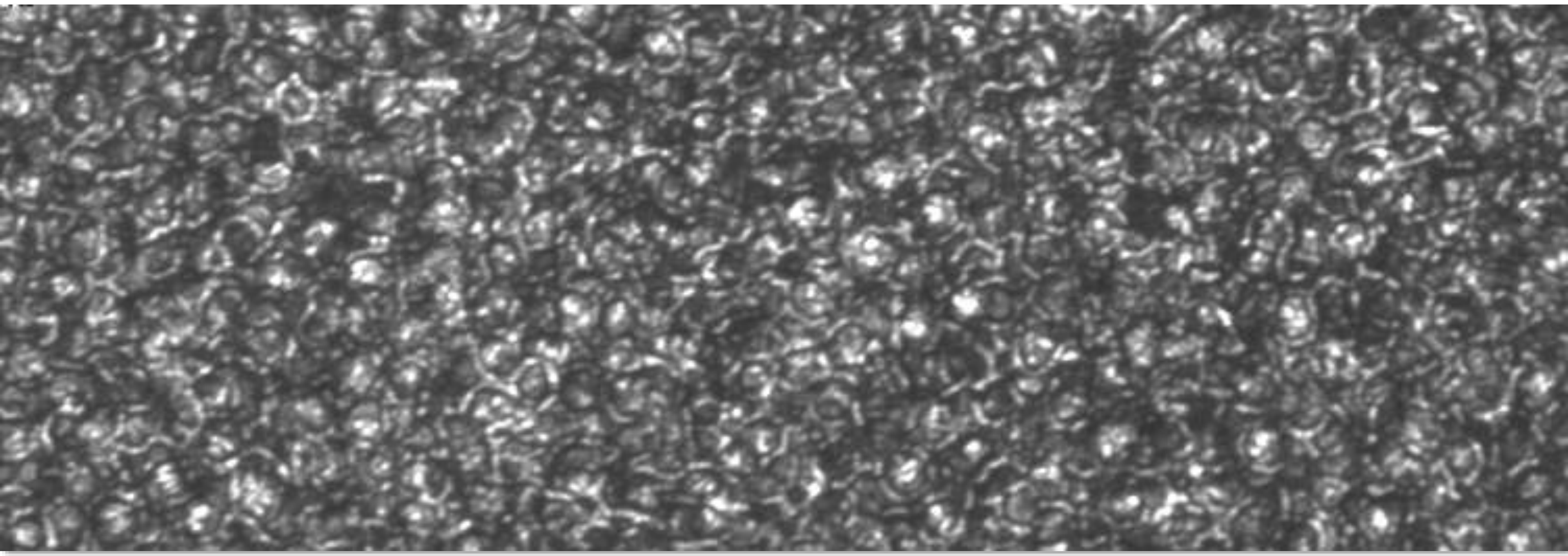
Alessandro Giusti

Dalle Molle Institute for Artificial Intelligence
Lugano, Switzerland

USI - SUPSI

Outline

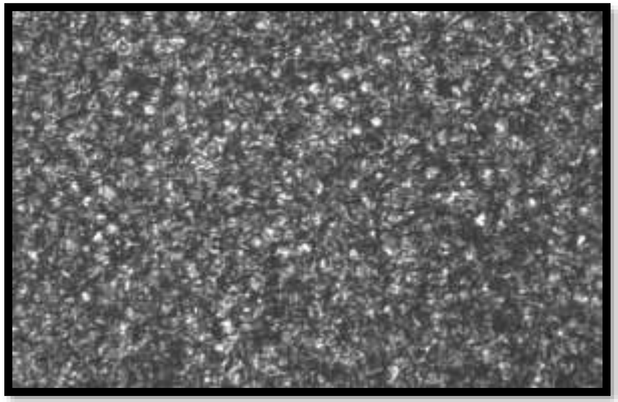
1. Vision-based roughness estimation of metal surfaces
2. Vision-based proximity Human-Drone Interaction
3. Augmented reality for microscopy applications



With GF Machining Solutions – AGIE Charmilles

1. VISION-BASED ROUGHNESS ESTIMATION OF METAL SURFACES

Visual measurement of surface roughness



$Ra = 0.98 \pm 0.13\ \mu m$

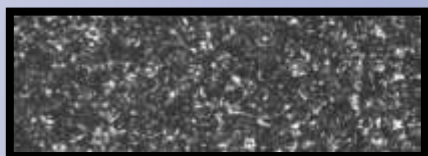
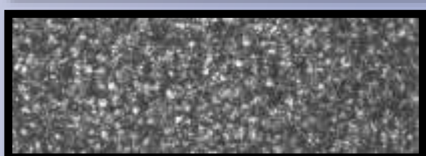
Image

Image Processing Software

Results

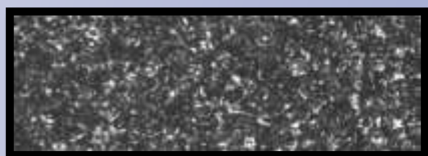
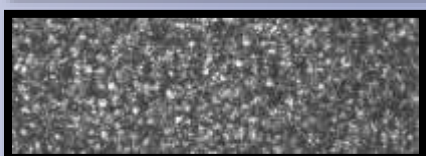
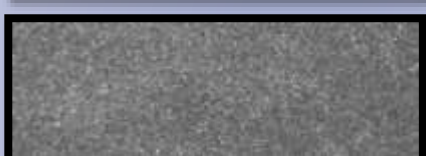
Machine Learning Approach (1)

Training set

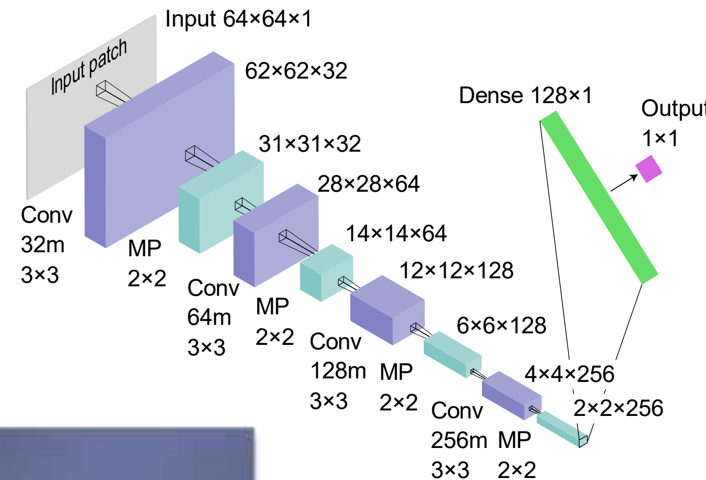
Image	Known Ra
	2.09
	1.21
	0.64
	0.37
	0.17

Machine Learning Approach (2)

Training set

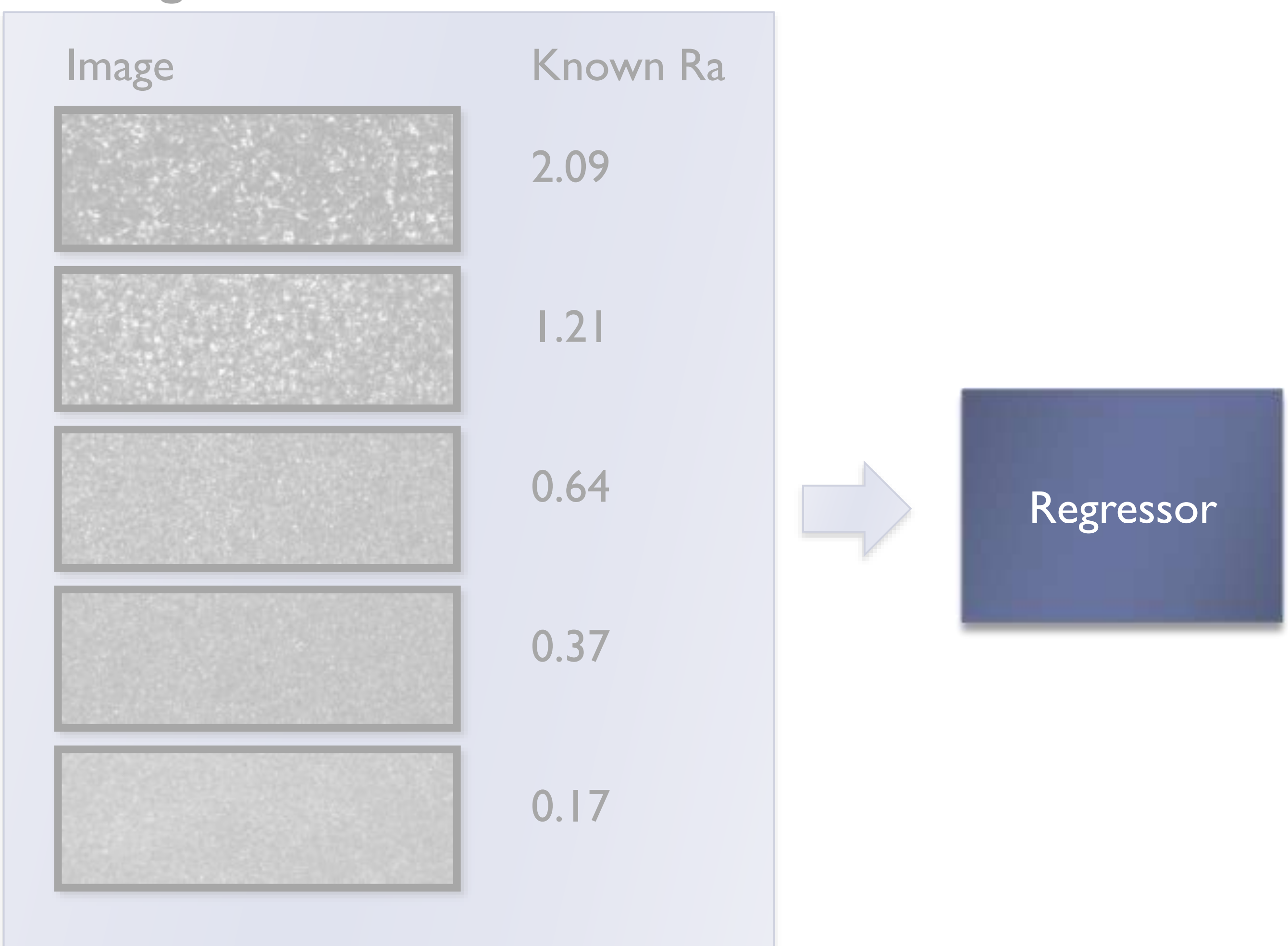
Image	Known Ra
	2.09
	1.21
	0.64
	0.37
	0.17

Regressor

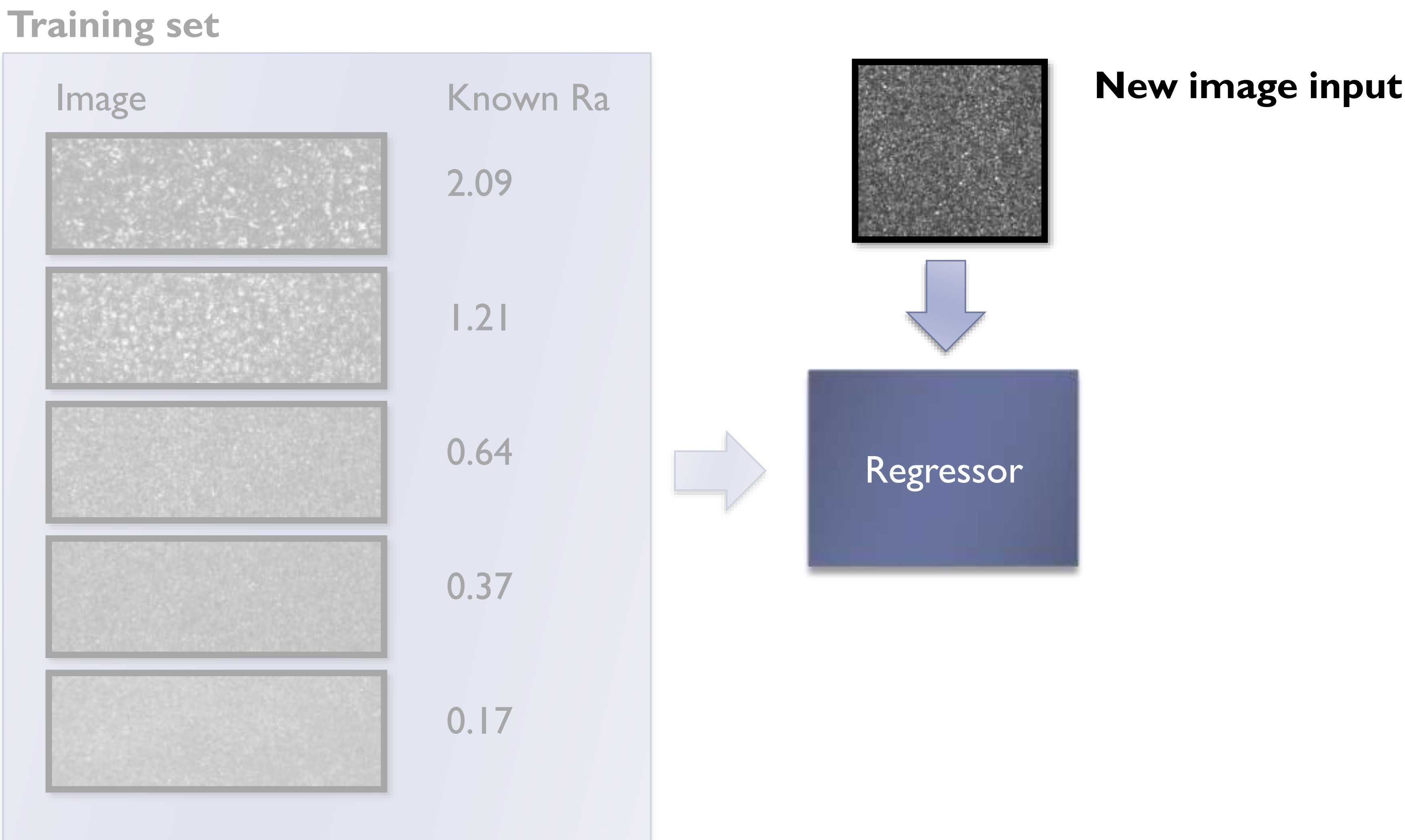


Machine Learning Approach (3)

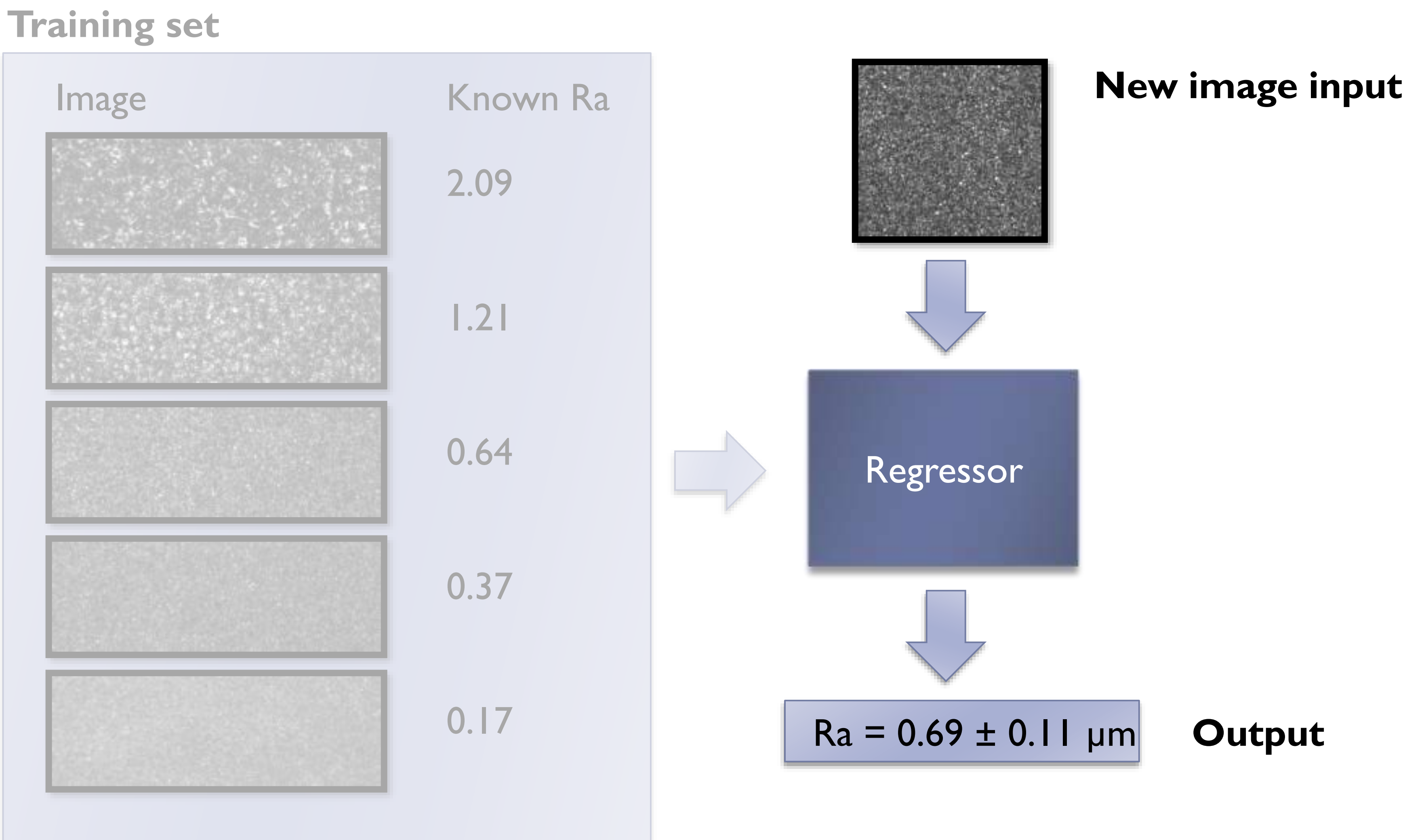
Training set



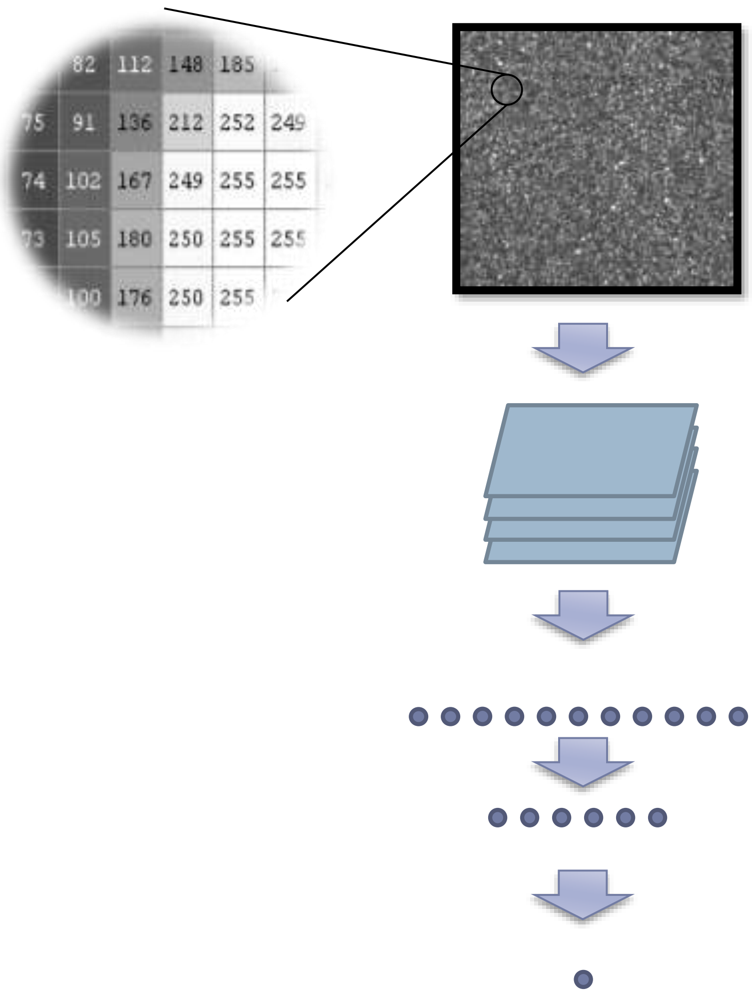
Machine Learning Approach (4)



Machine Learning Approach (5)



Deep Neural Networks as Regressors



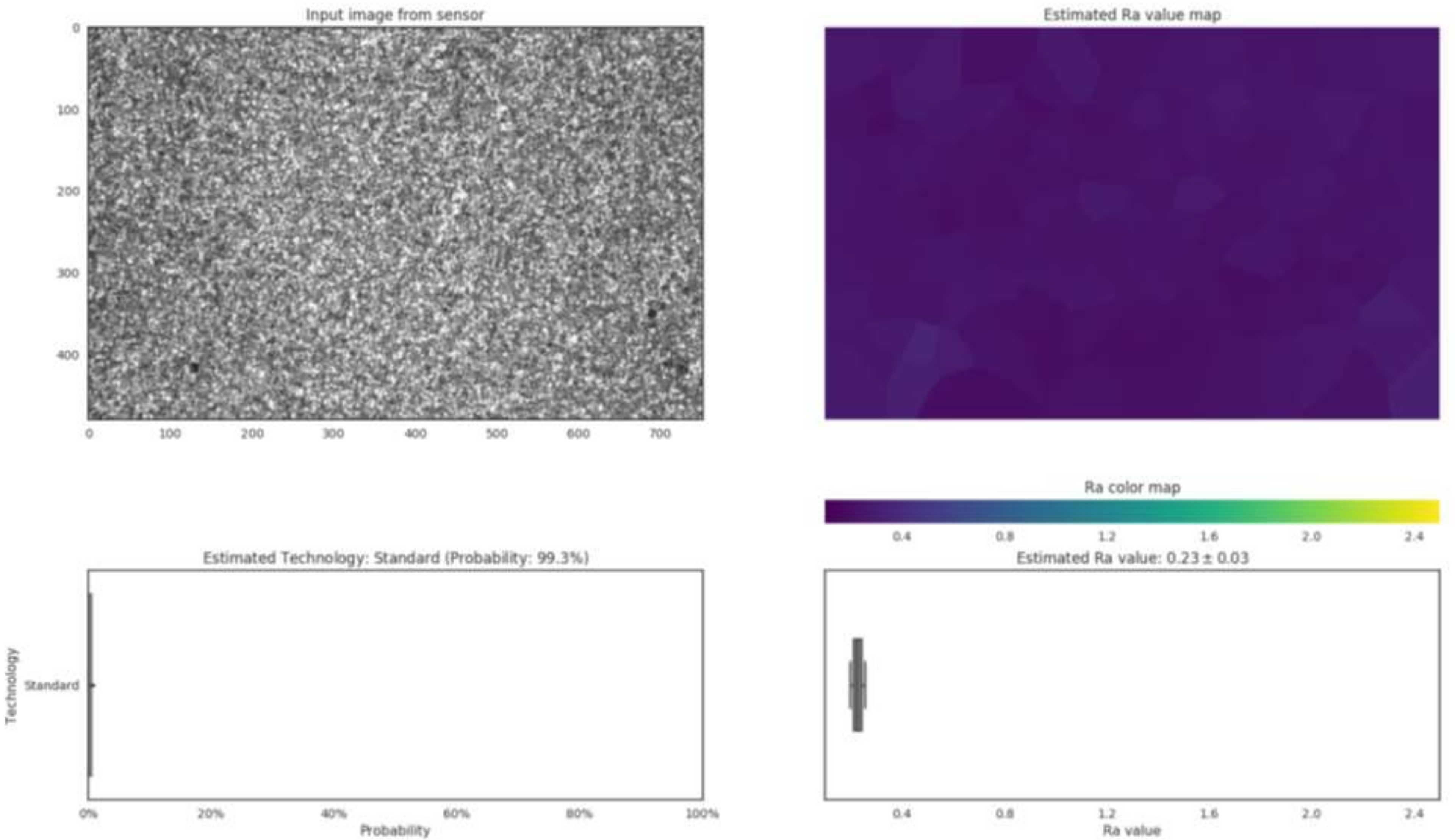
Input layer
a grid of 64x64 neurons
(raw image pixel intensities)

Convolutional and Max-pooling layers
a standard lenet-like architecture
for feature extration

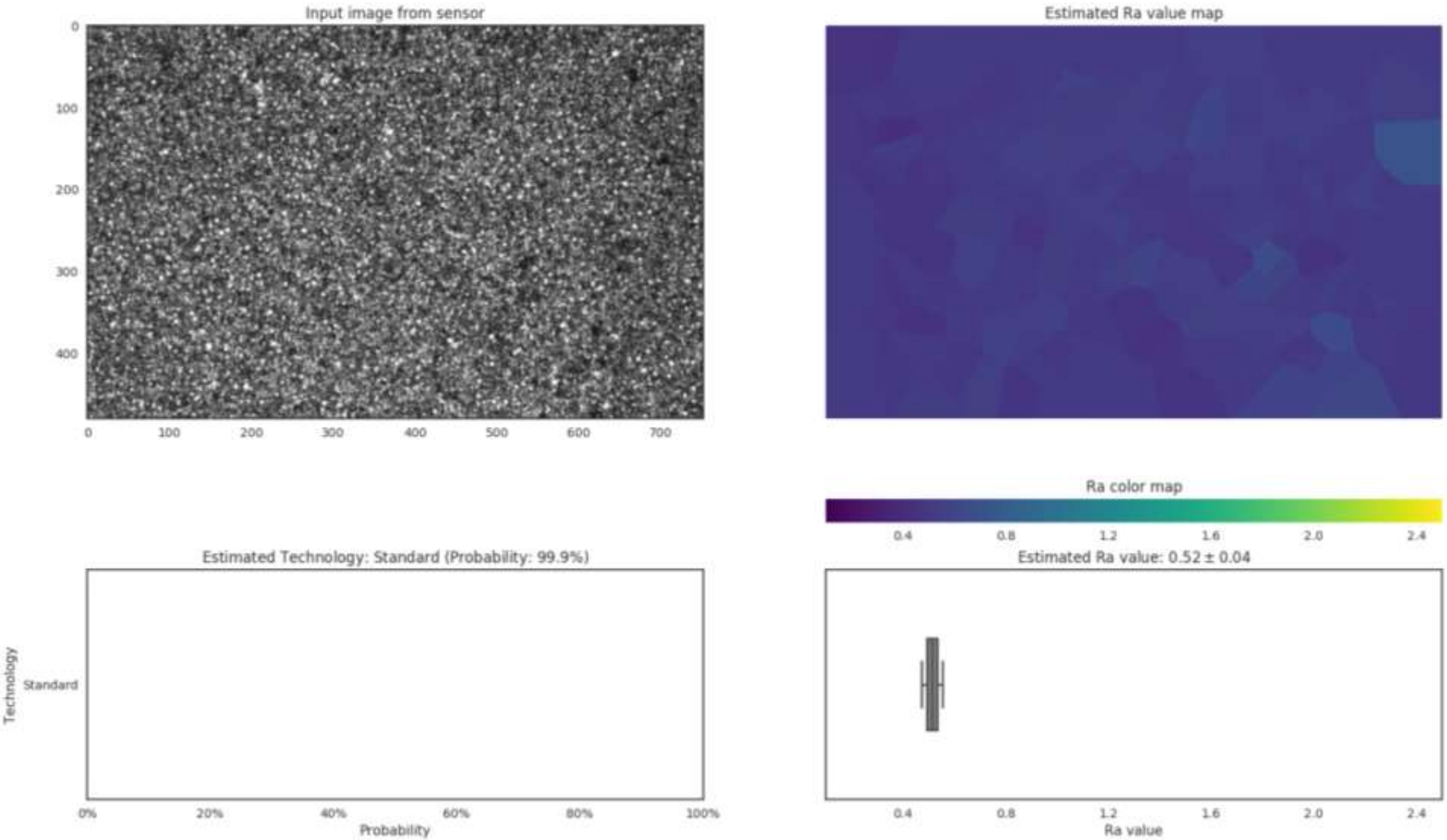
Two fully-connected layers
as a regressor

One output neuron
activation representing
the Ra value directly

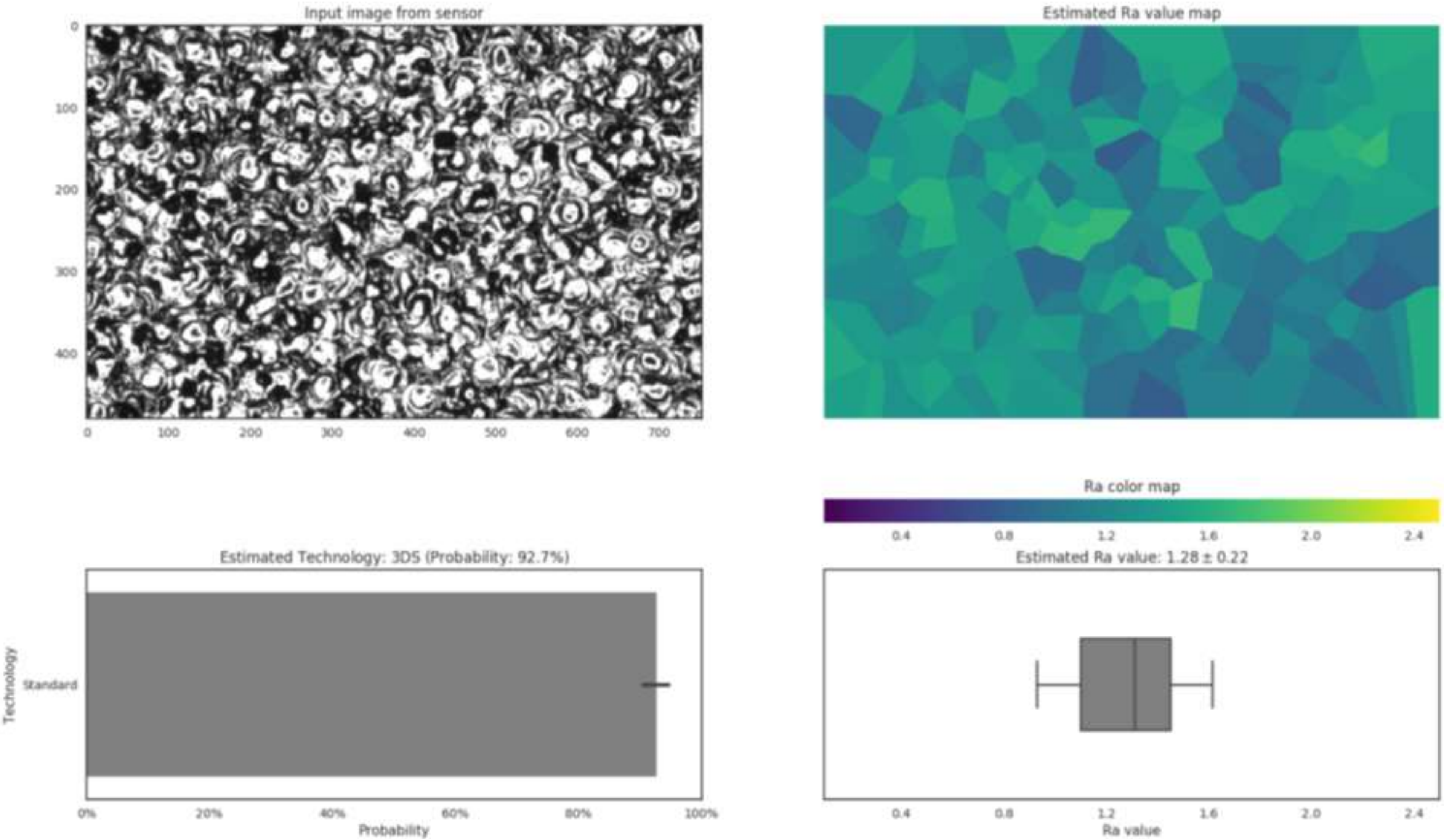
Example results



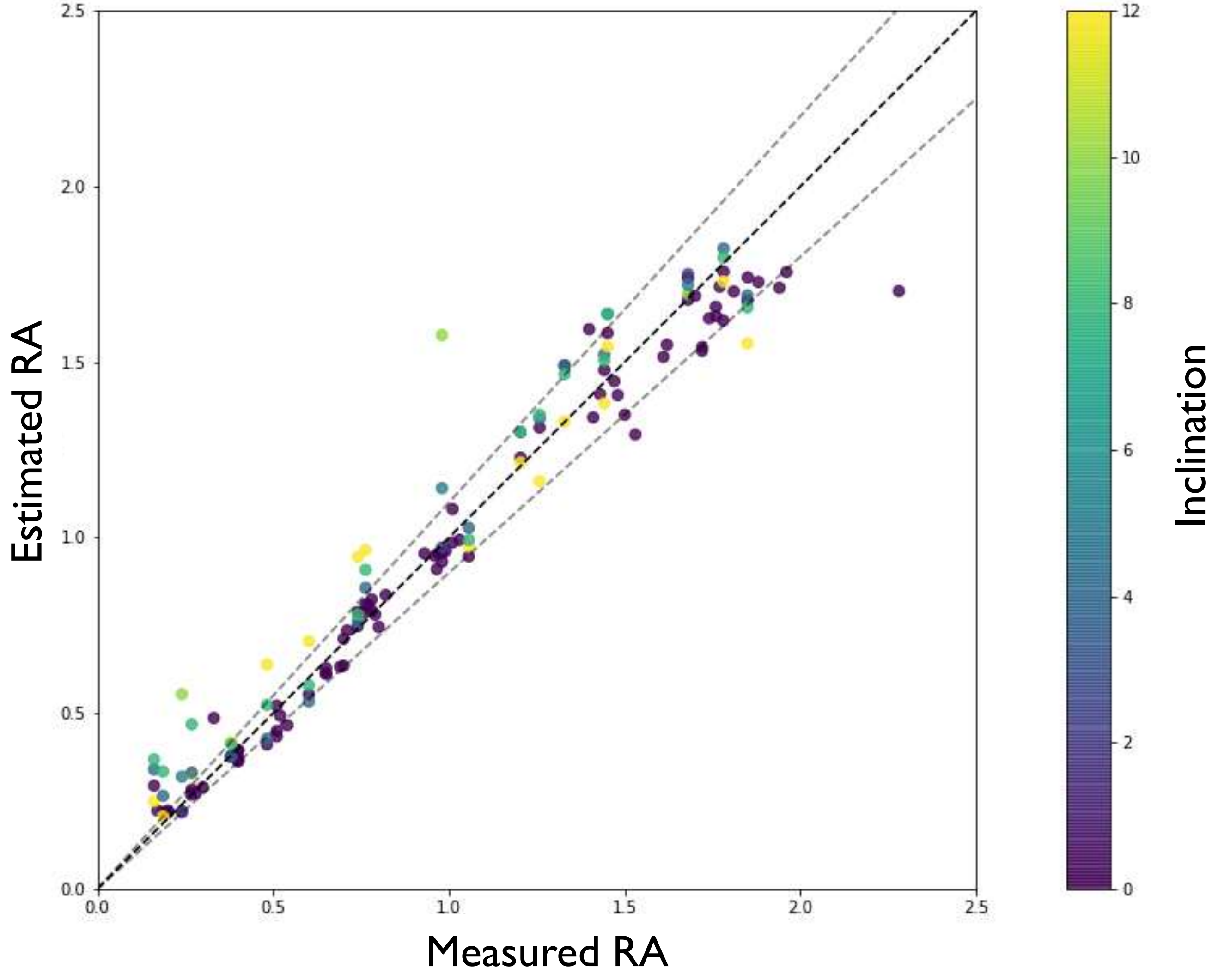
Example results

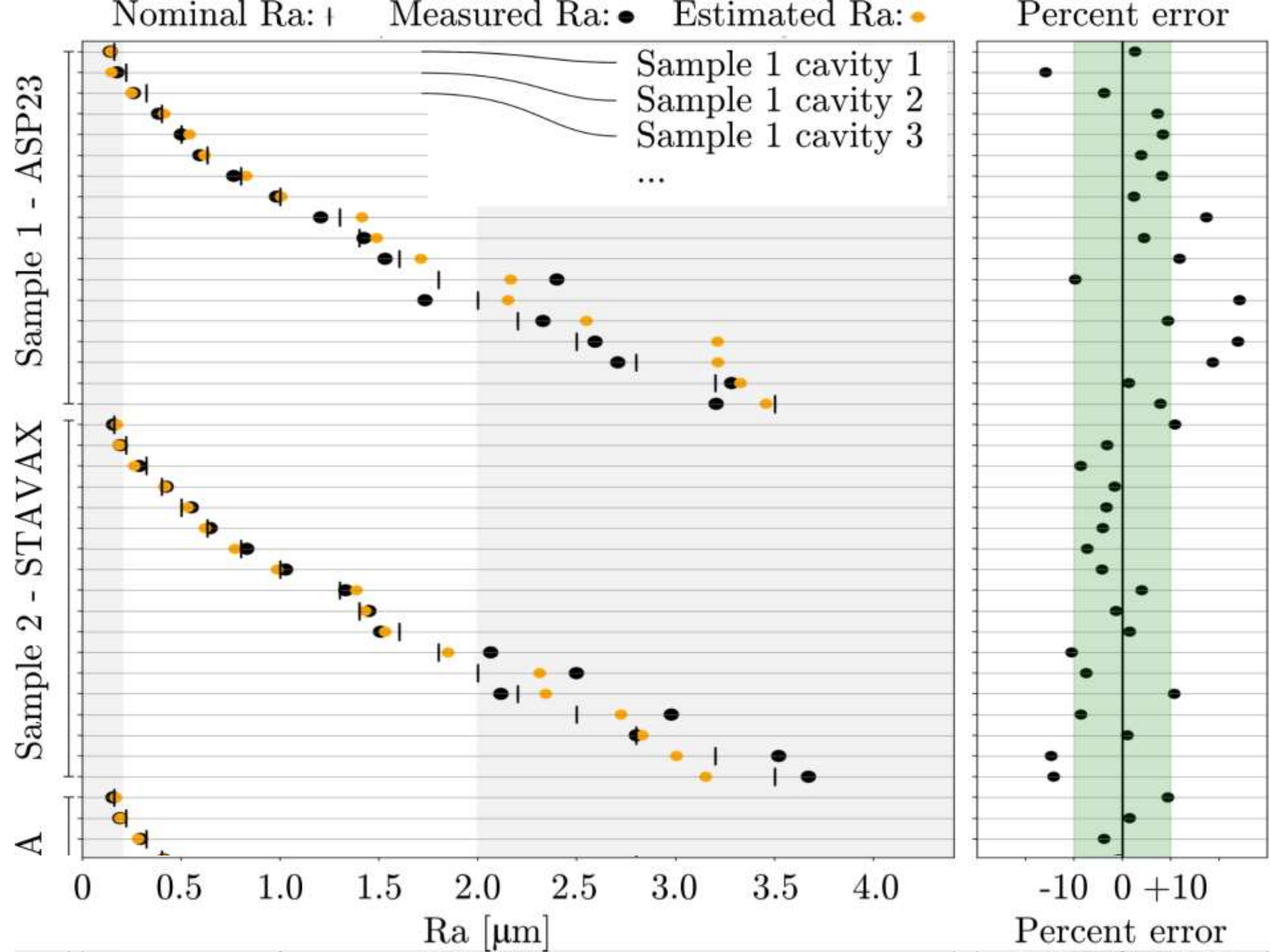


Example results



Cross validated results on cavities



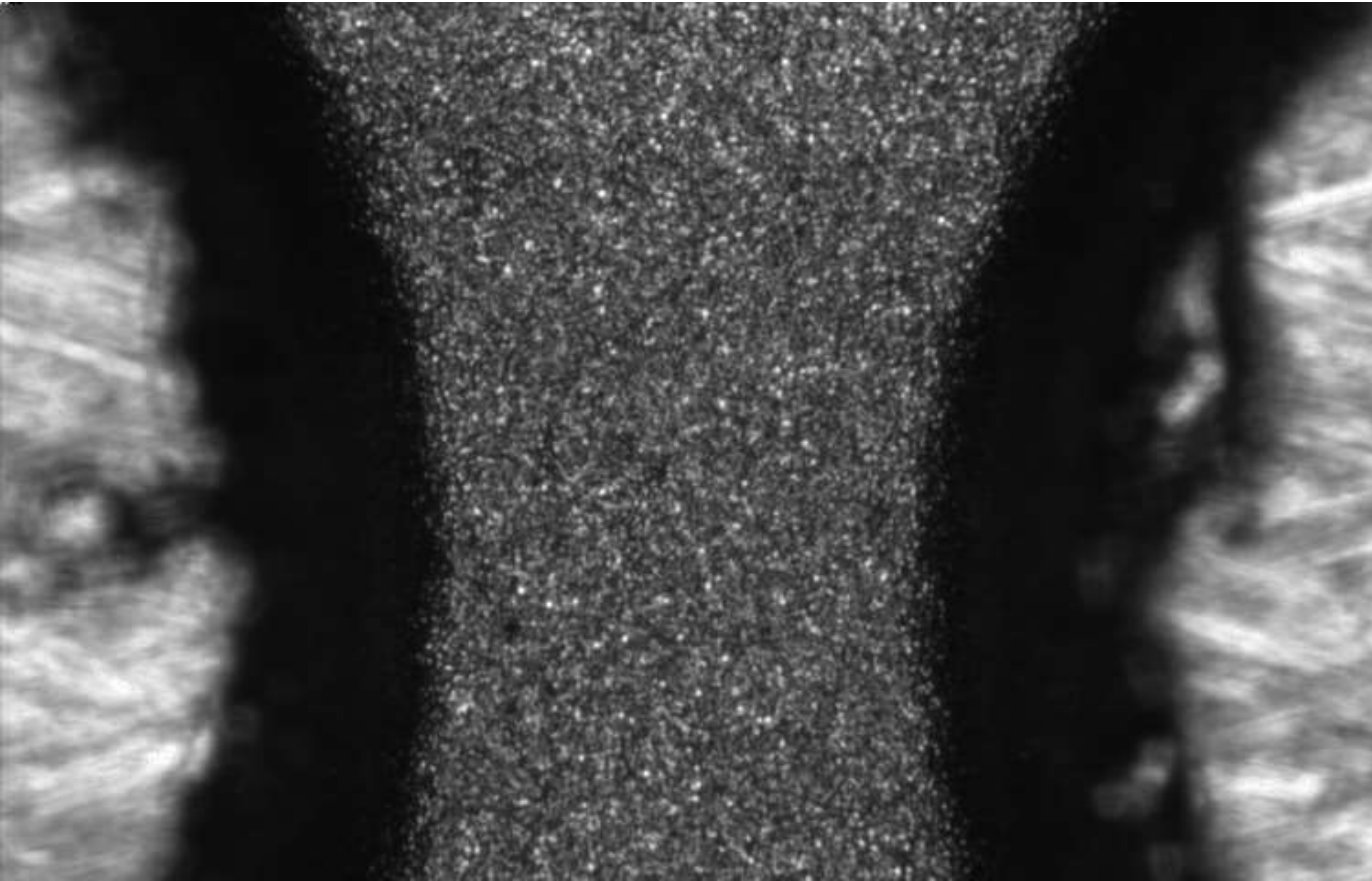


Nominal Ra:
Measured Ra:
Estimated Ra:
Percent error
Sample 1 cavity 1
Sample 1 cavity 2
Sample 1 cavity 3
...
Sample 1 - ASP23
Sample 2 - STAVAX
A
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Ra [μm]
-10
0
+10
Percent error

Anomaly Detection Approaches

- Large defect-free datasets for various Ra
- No annotated data available for defects
- Wide variability of possible anomalies:
  - imaging issues (focus/illumination)
  - surface defects

Example input

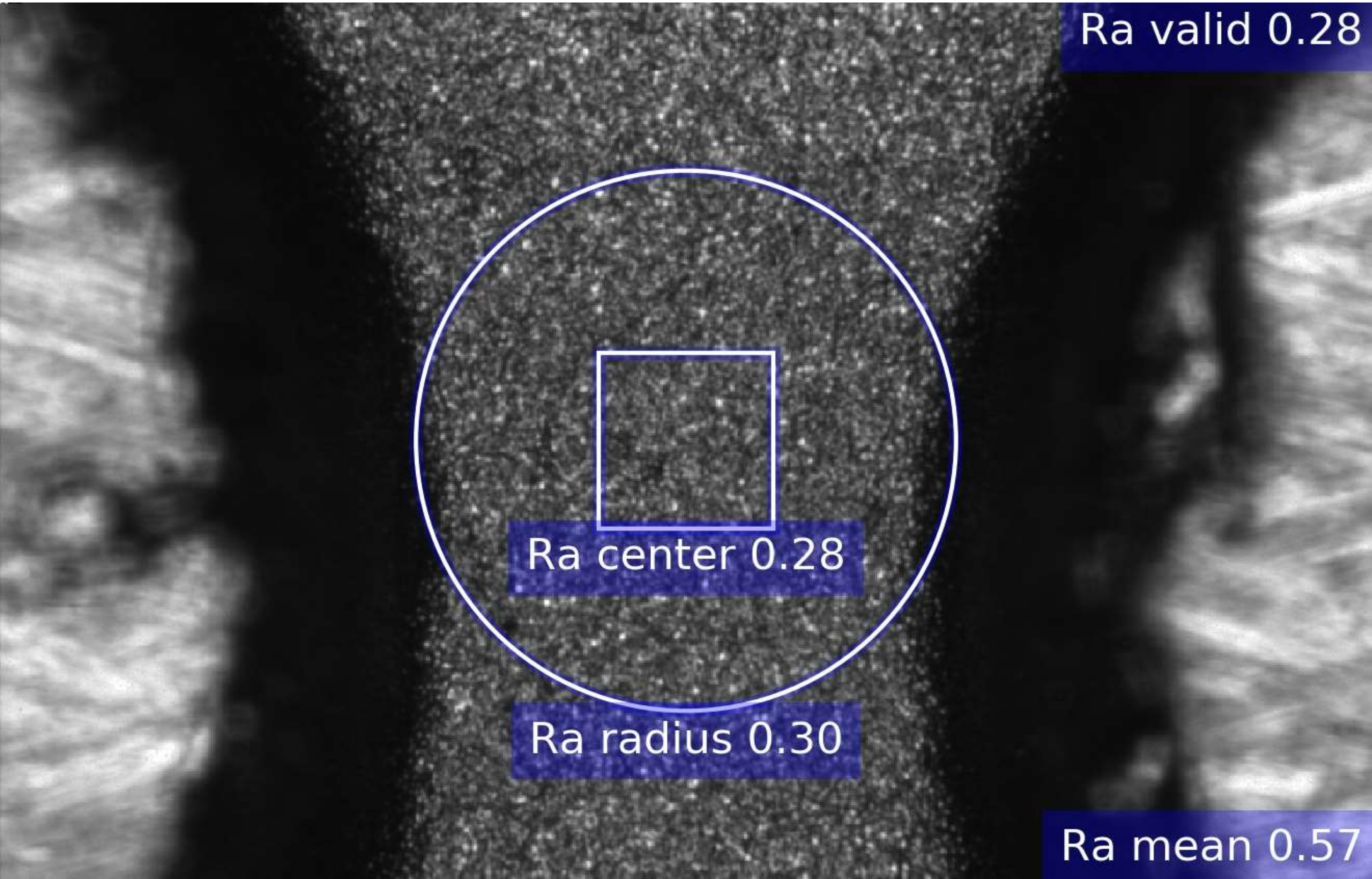


Anomaly map

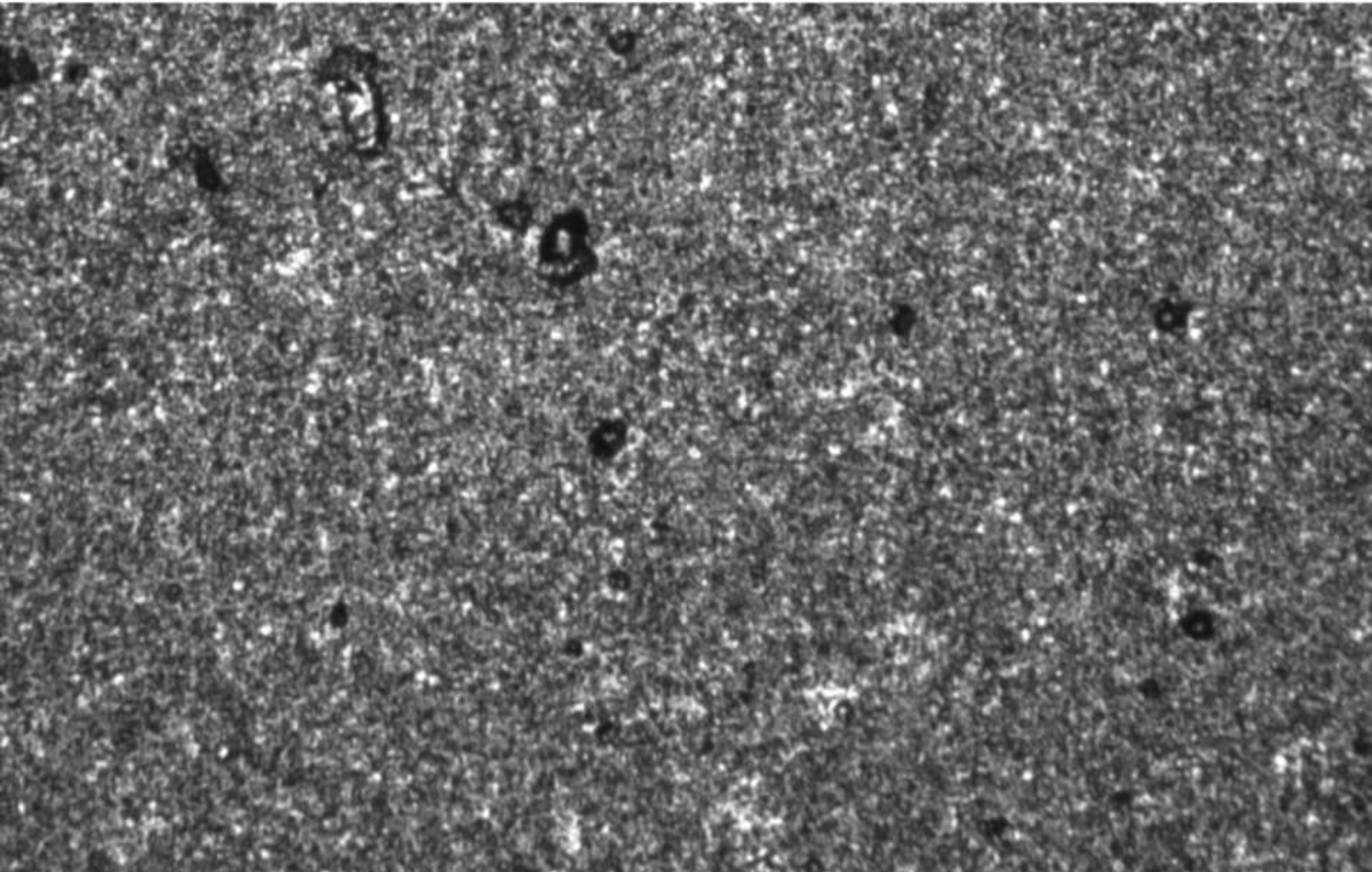
Estimated Ra map

Estimated Ra map in non-anomaly regions

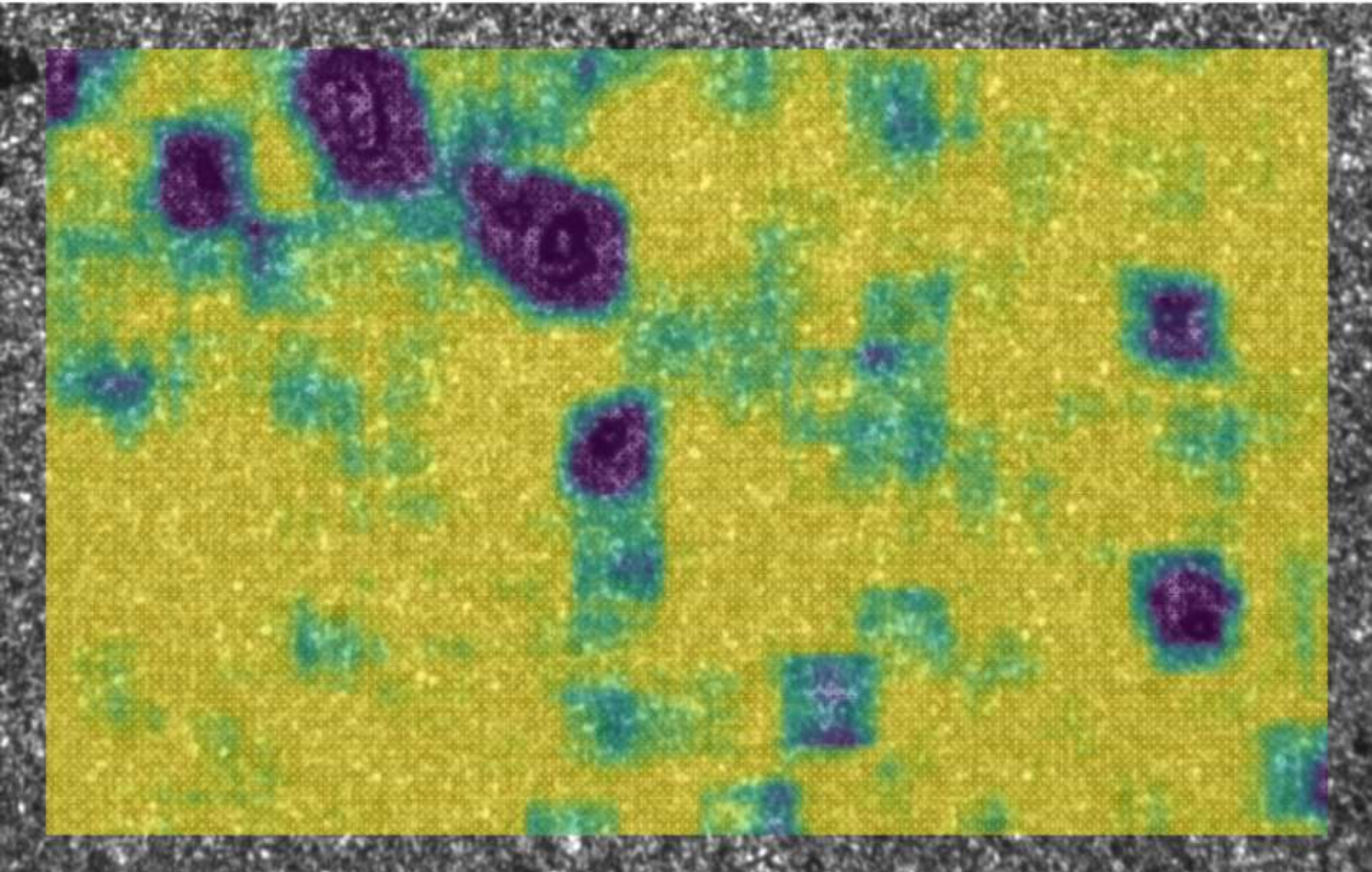
Output, user-facing interface



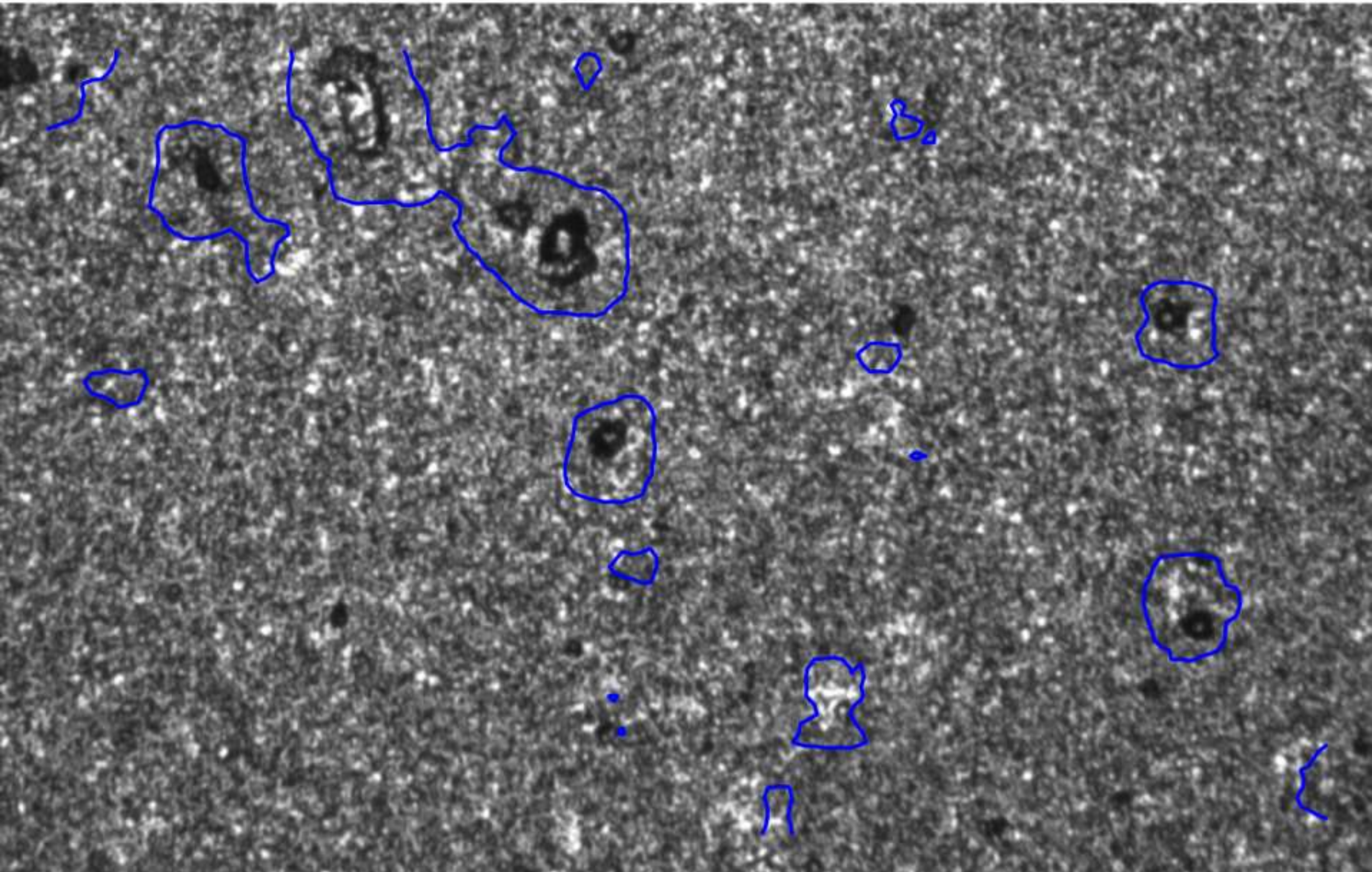
Detection of localized defects



Detection of localized defects



Detection of localized defects

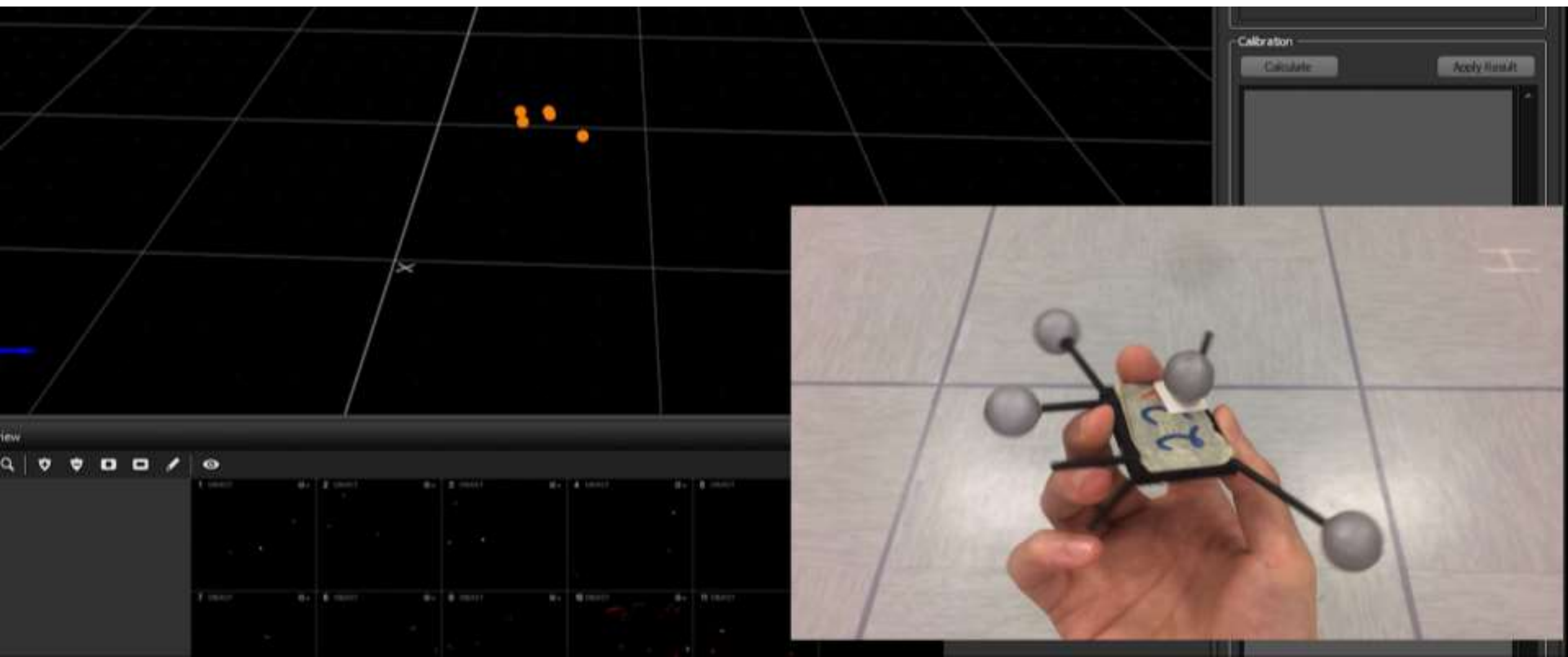


Videos, links, publications and code:
https://github.com/idsia-robotics/proximity-quadrotor-learning

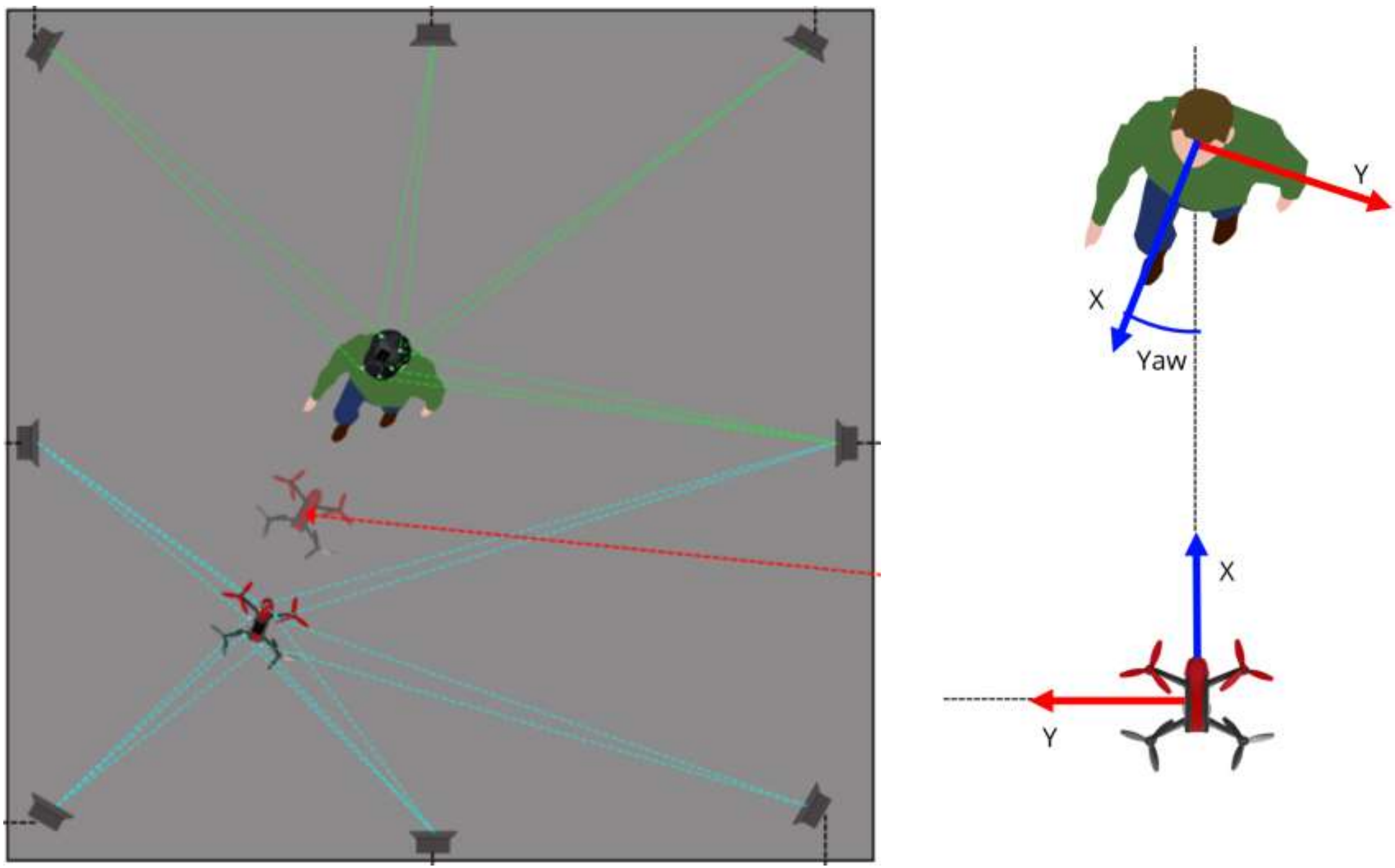
2. VISION-BASED PROXIMITY HUMAN-ROBOT INTERACTION

Control a drone flying close to humans

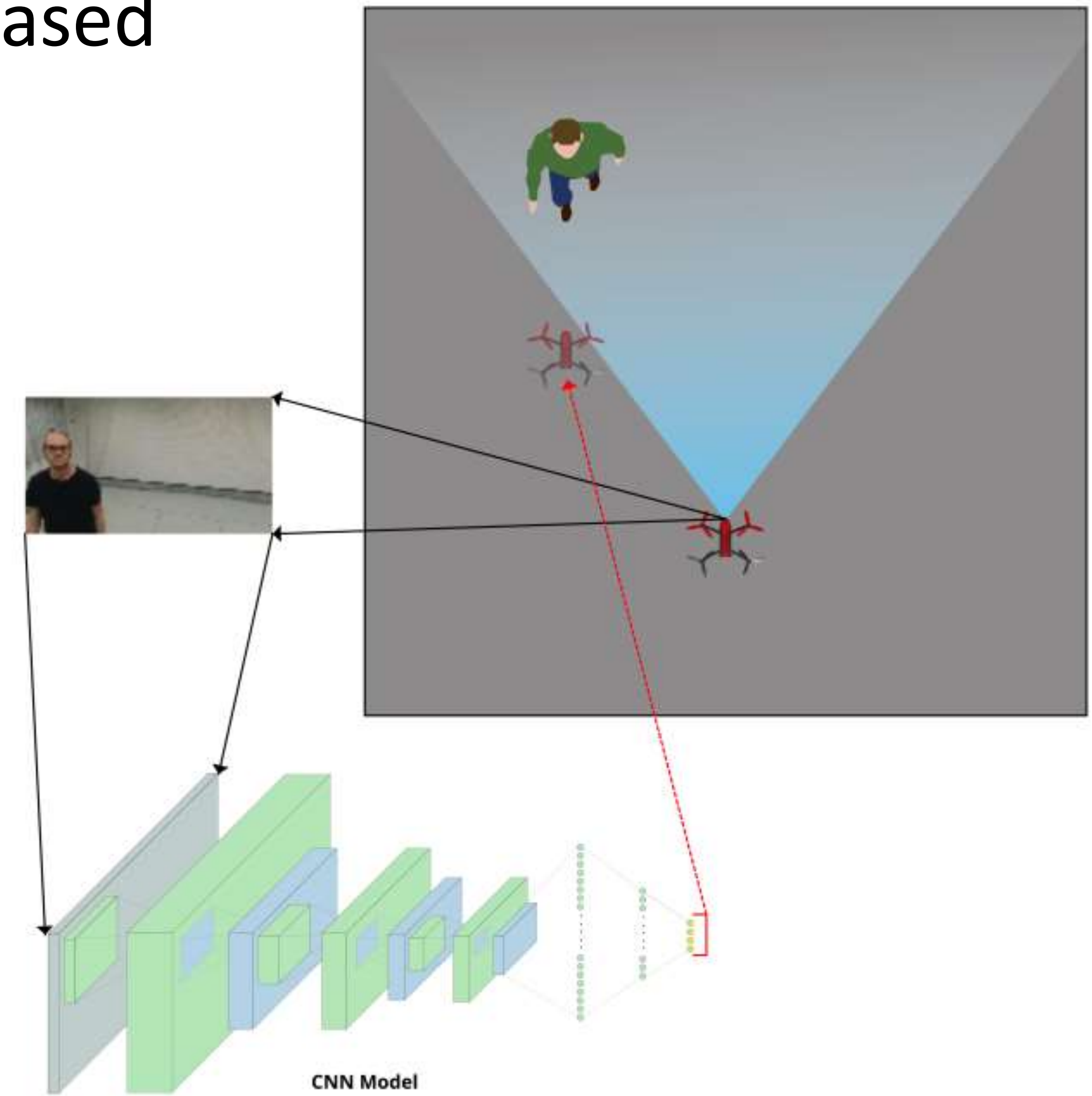
Easy! (using motion tracking)



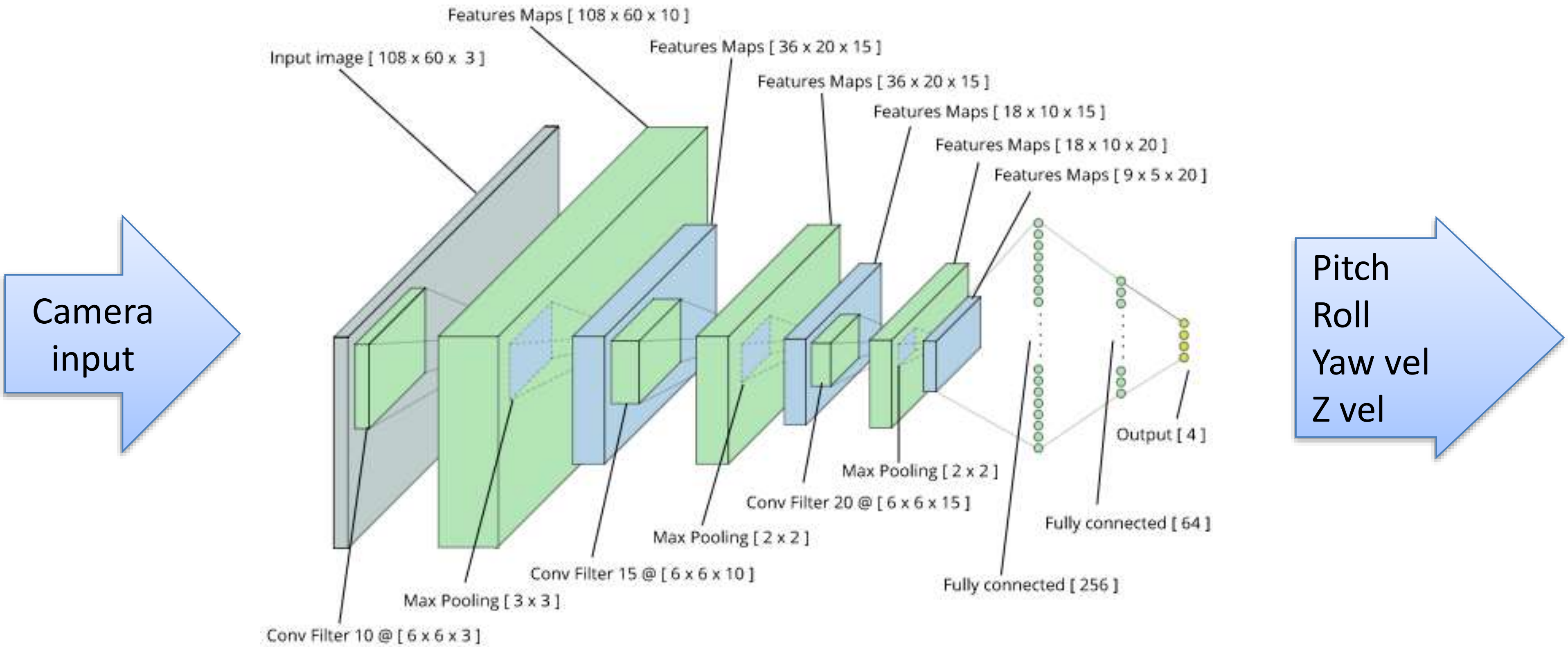
Proximity control using motion tracking



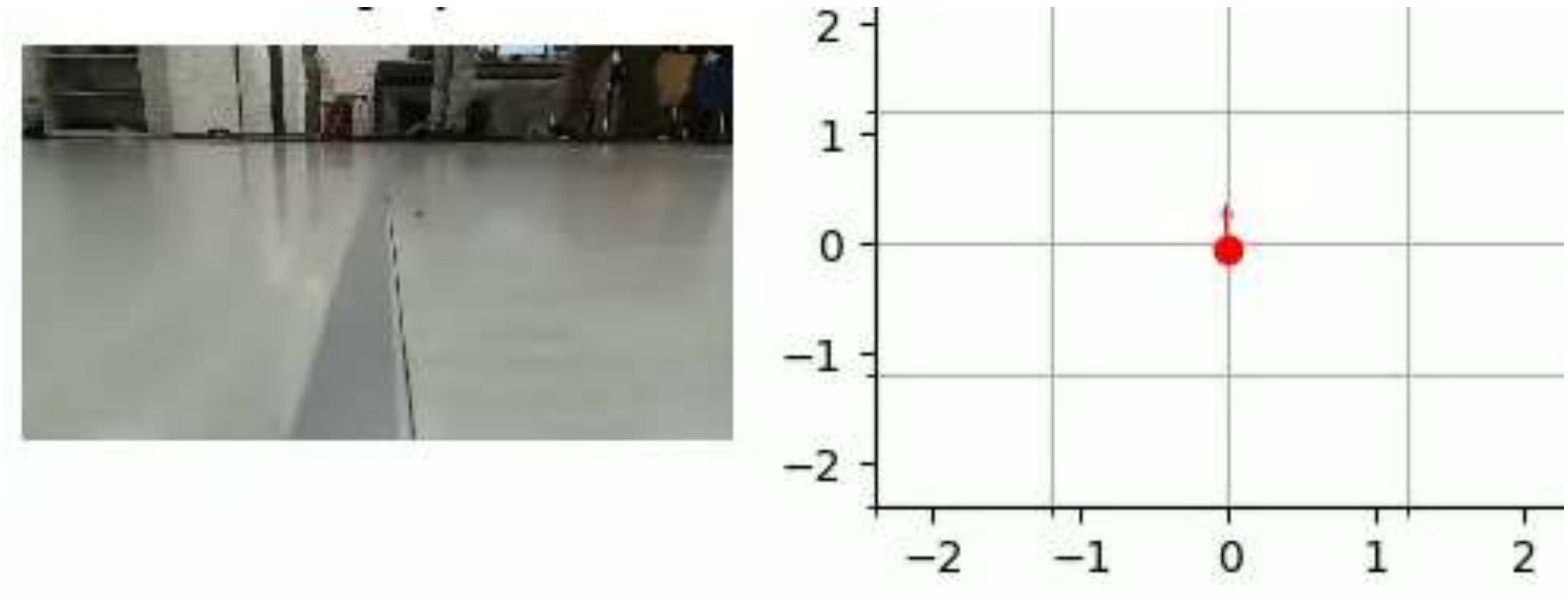
Goal: vision-based control

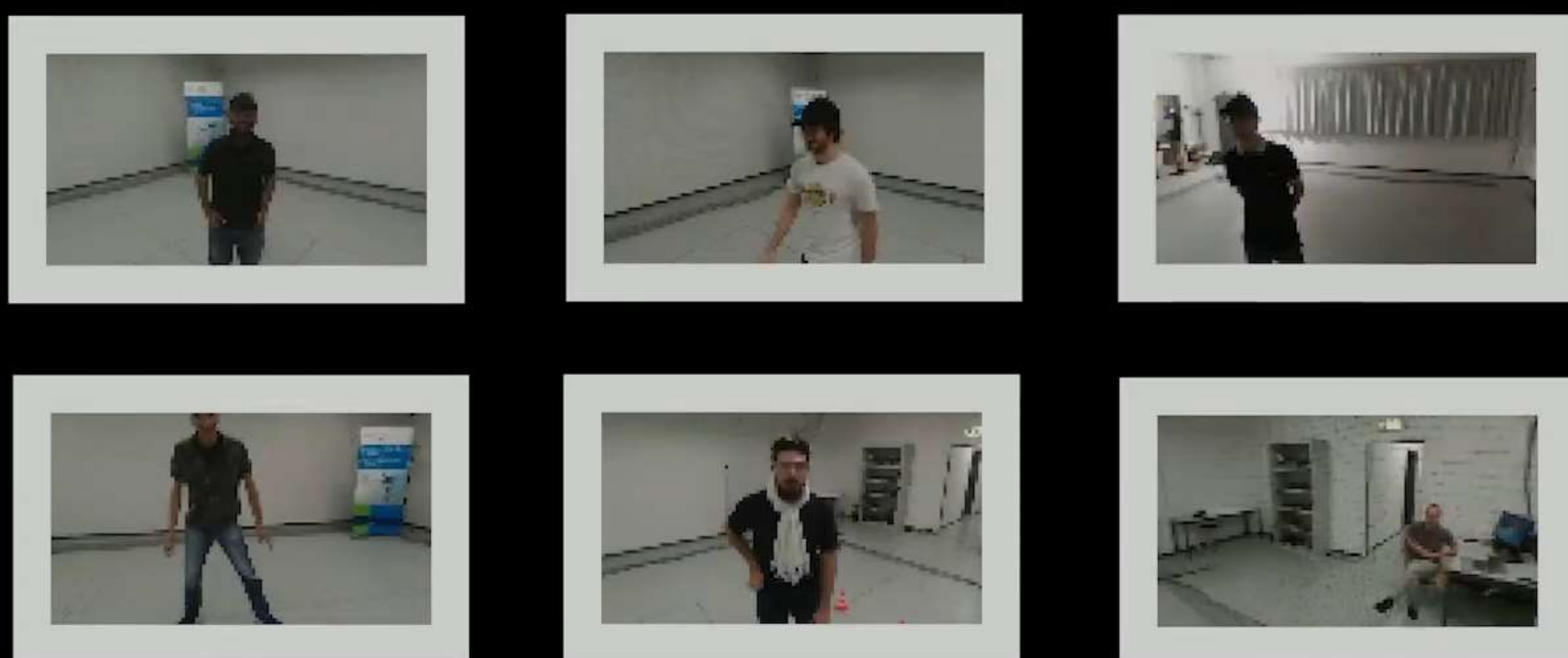


A deep net for end-to-end visual control

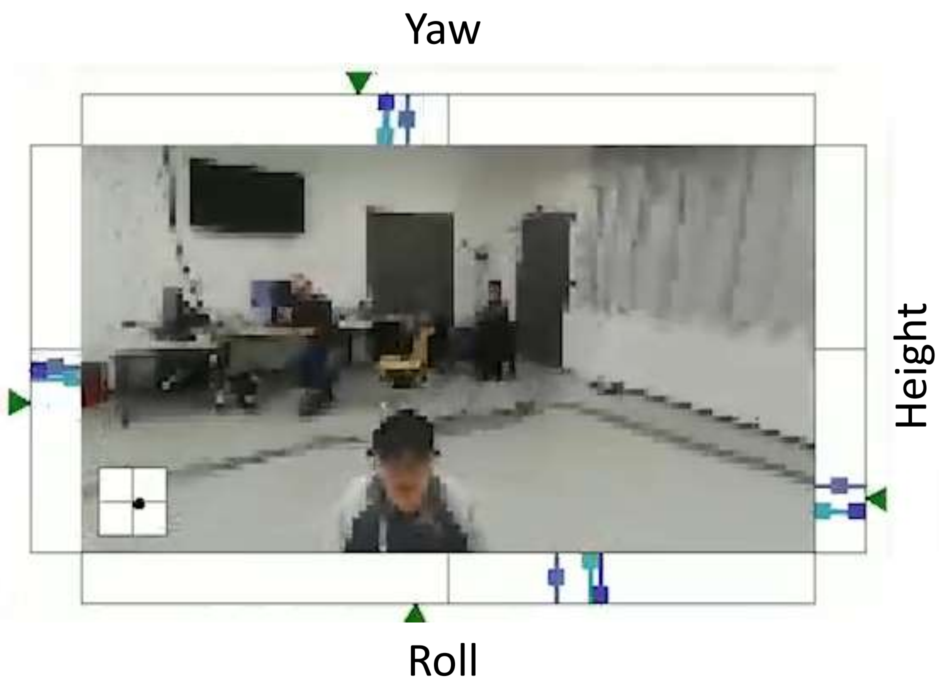


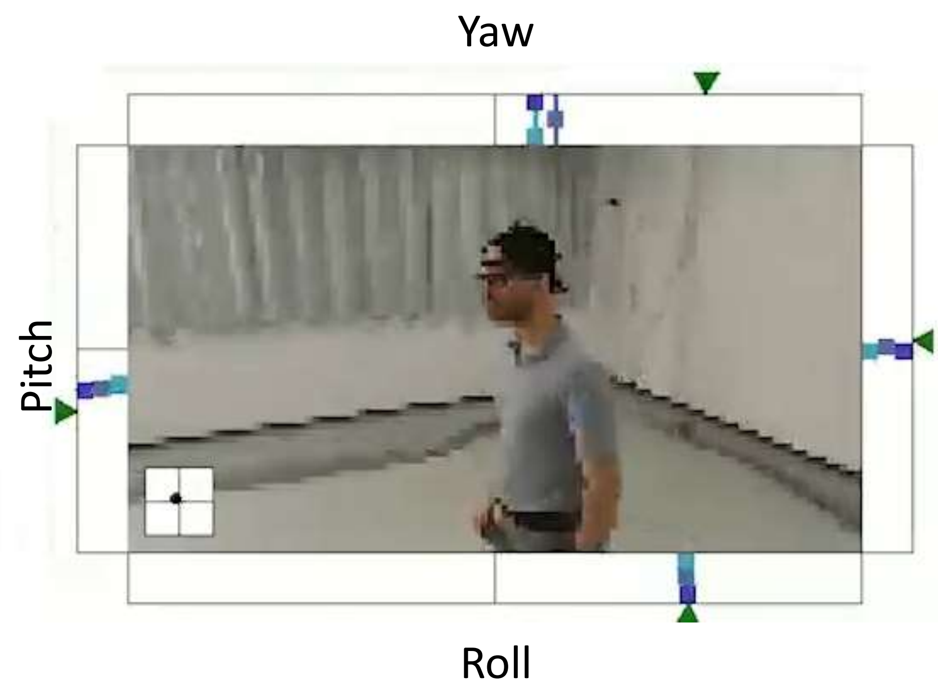
Datasets





Prediction performance



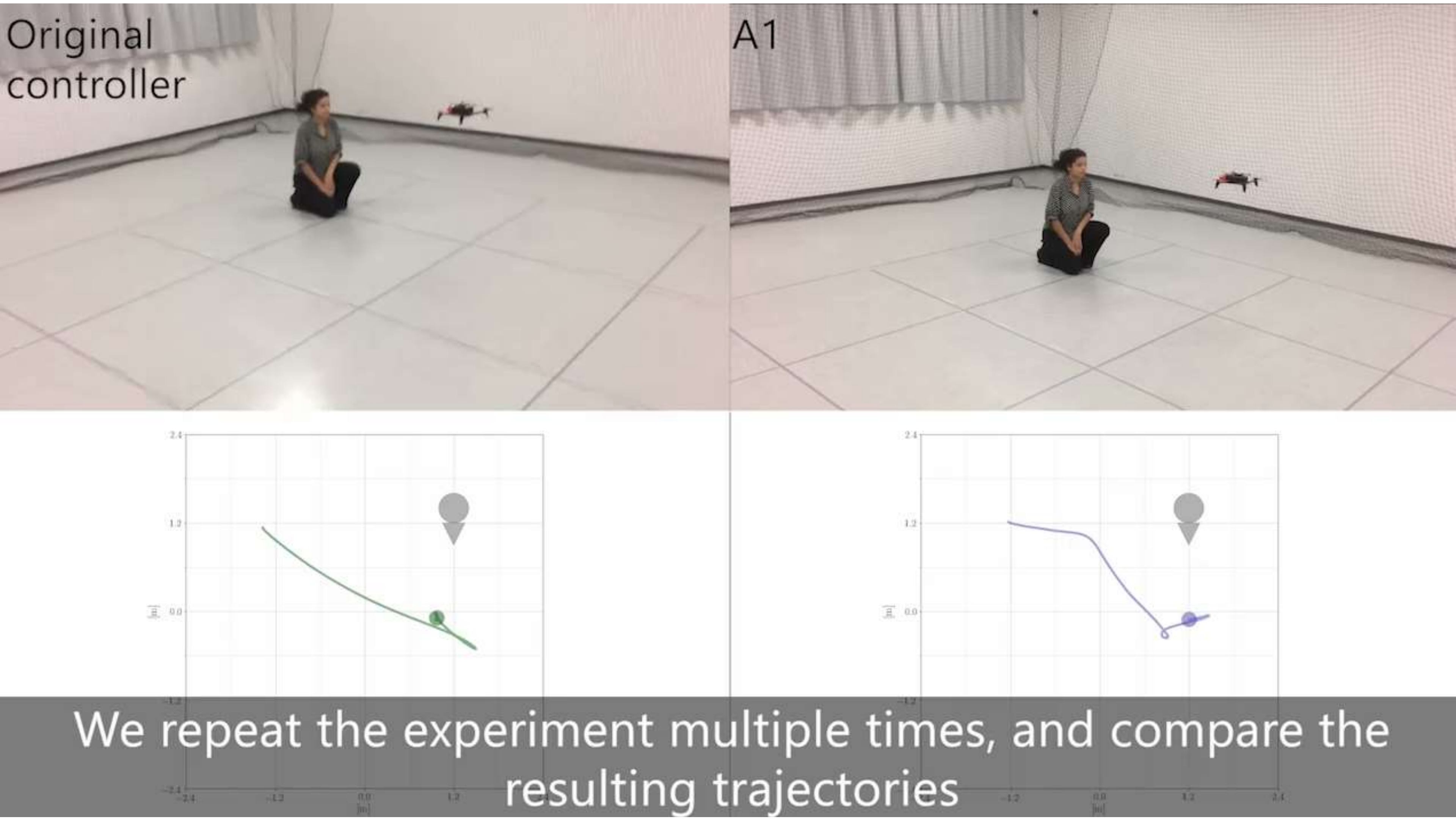


▲ ground truth control

■ predicted values (by three different models)

Comparison with ground truth control

ground truth control | vision-based control

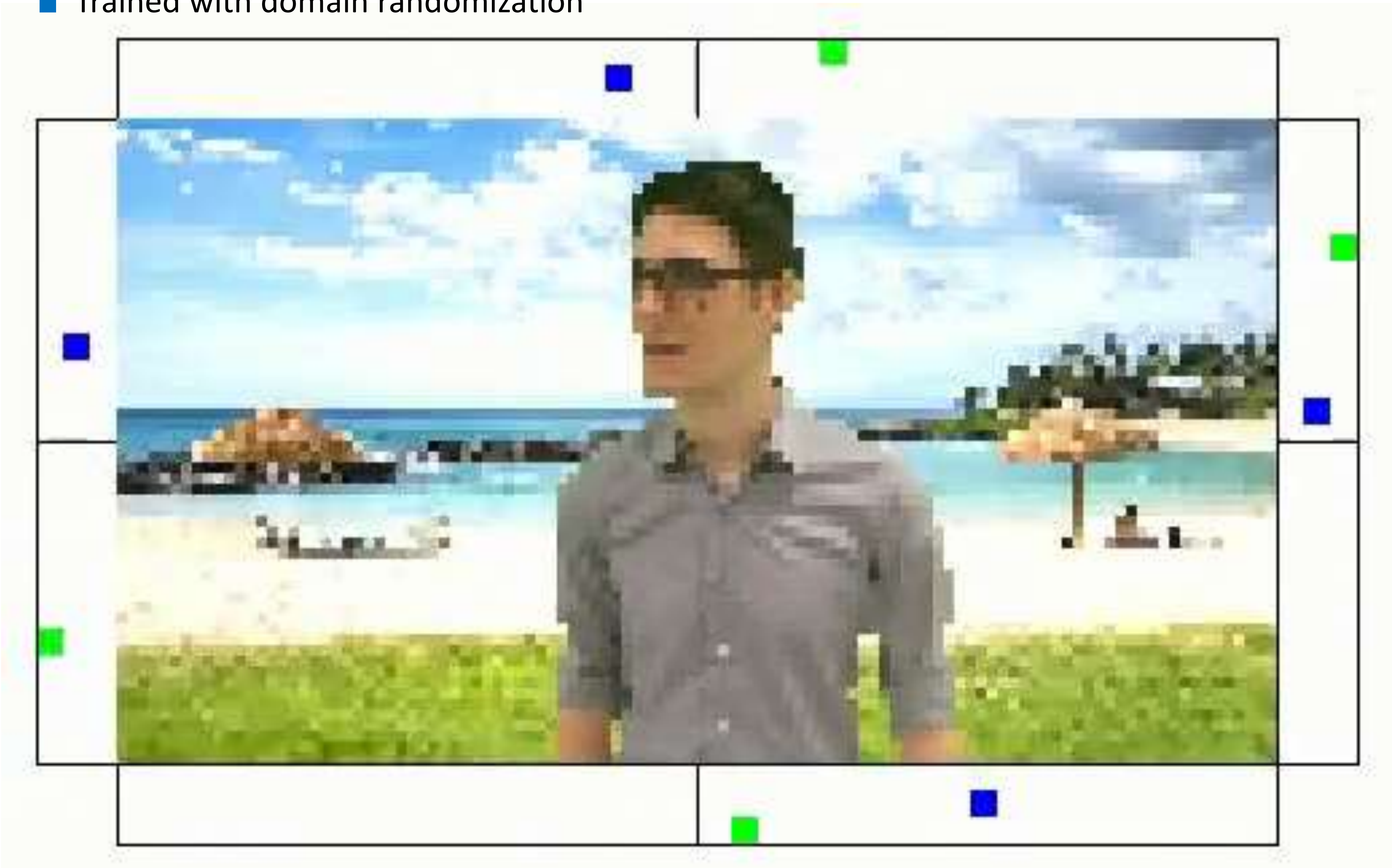


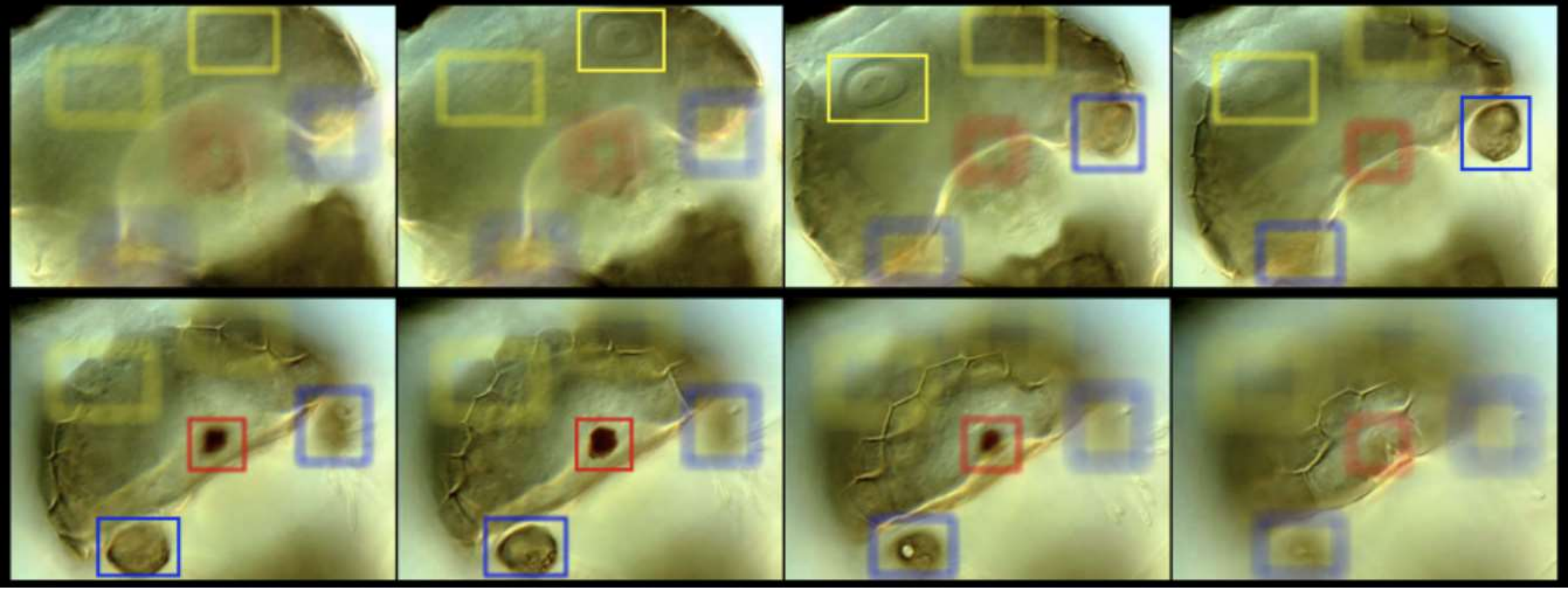
Control performance and robustness

Domain randomization for generalization

Preliminary Results

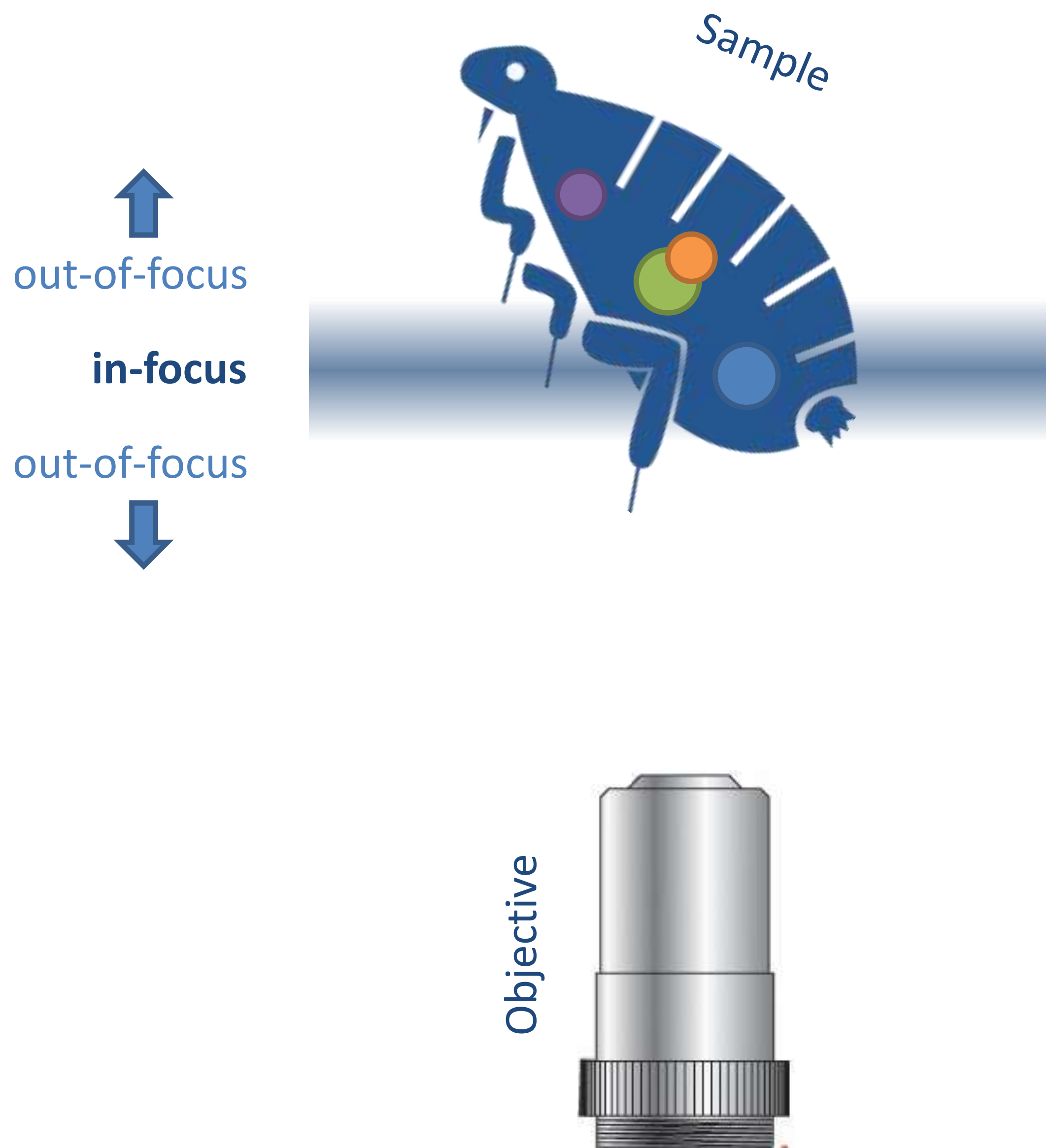
- Trained without domain randomization
- Trained with domain randomization

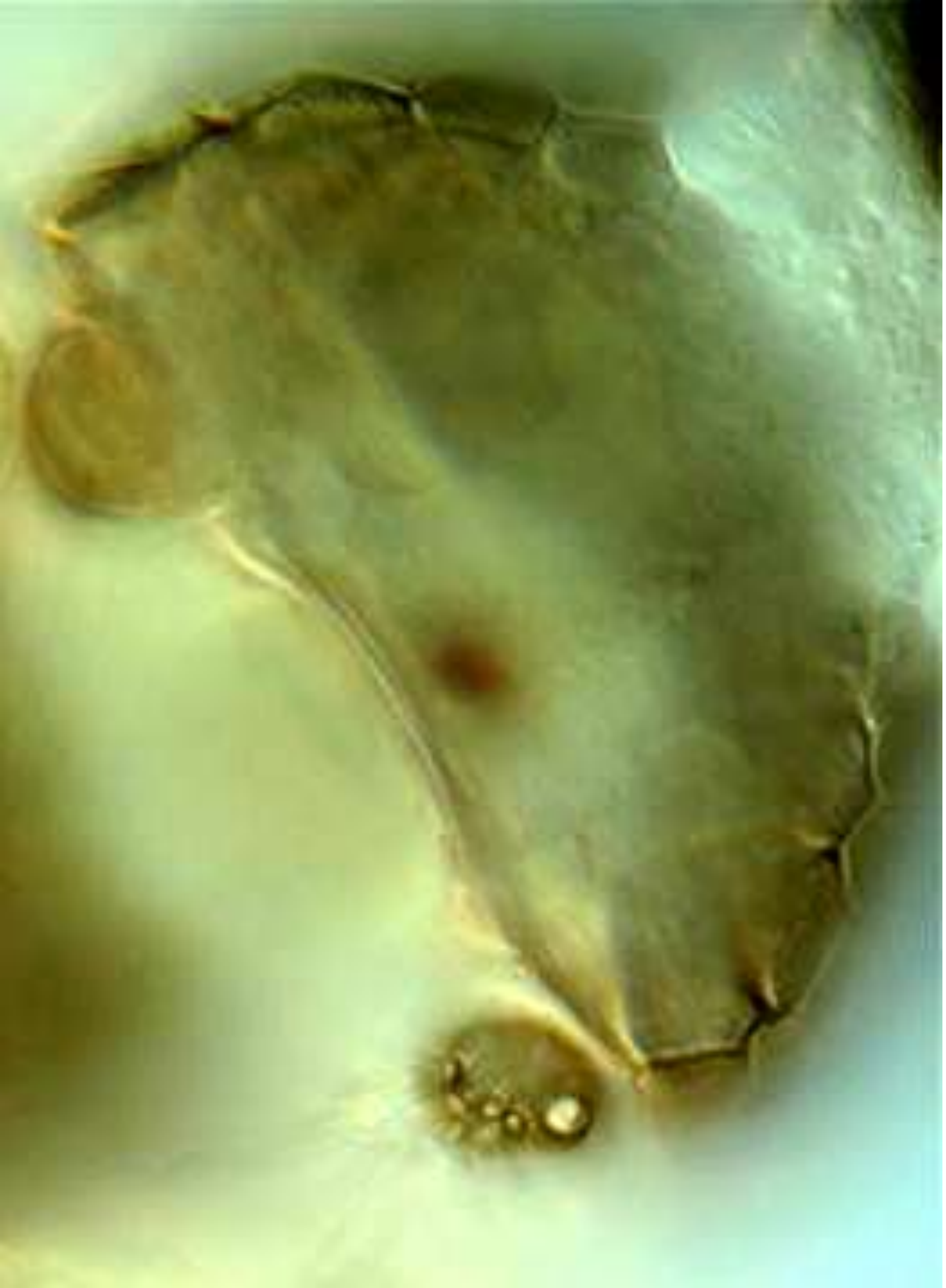
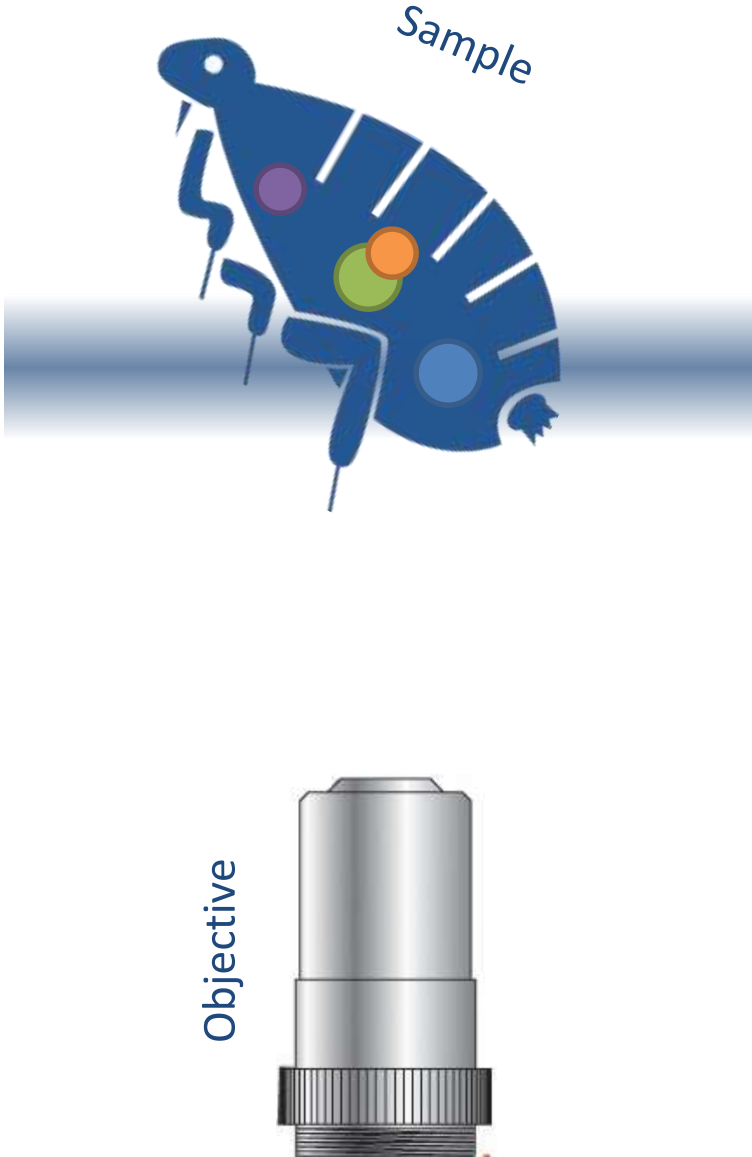


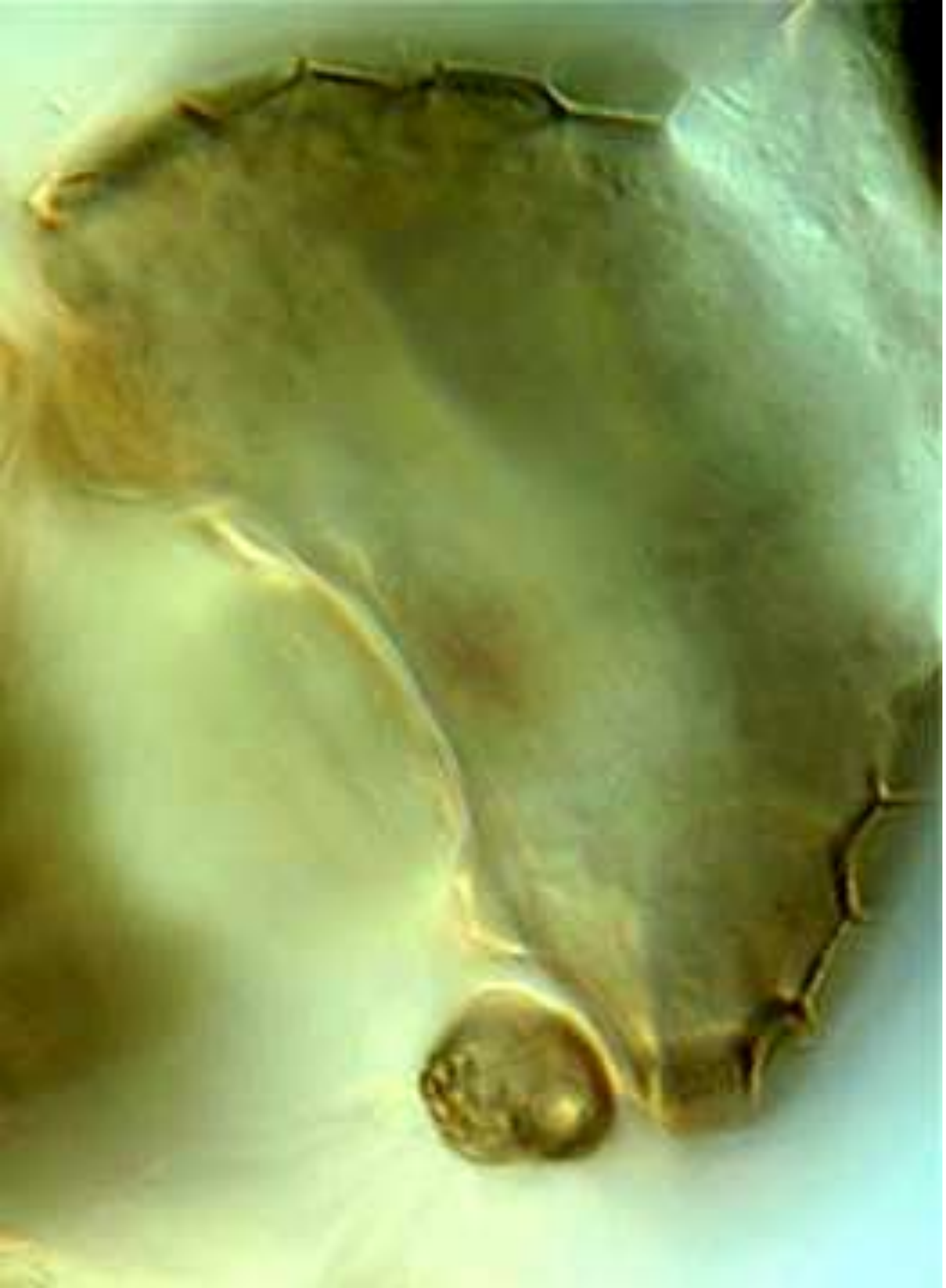


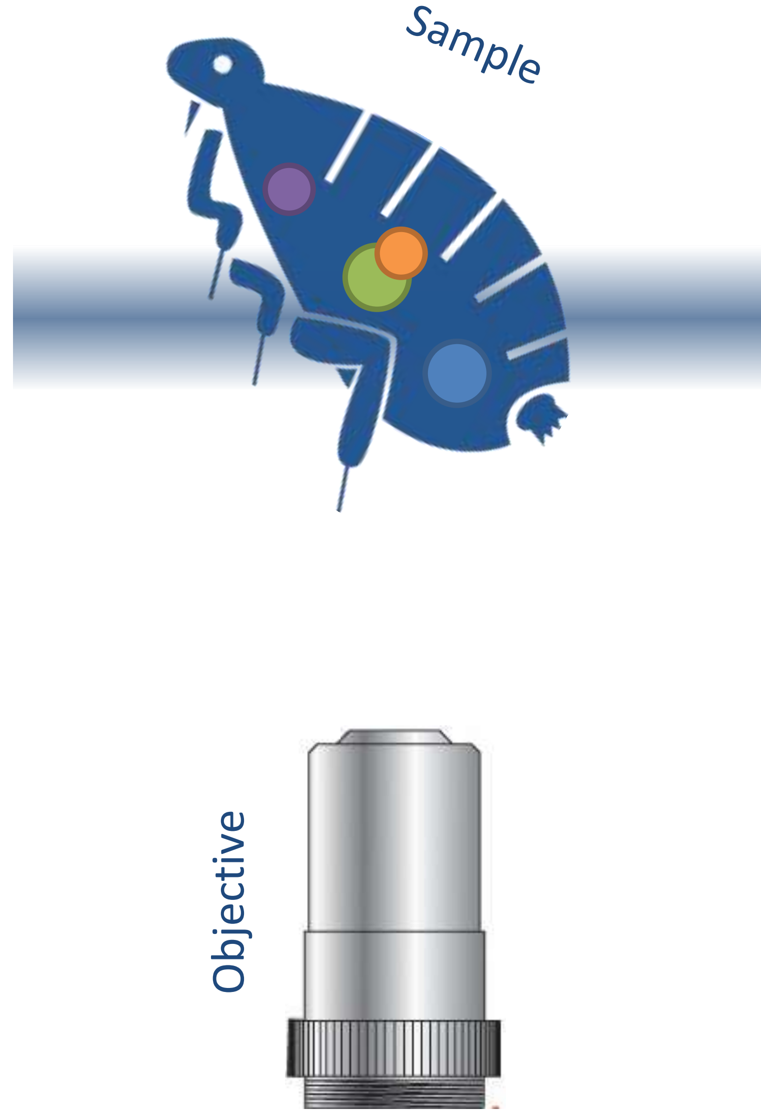
Videos, links, publications and code:
http://bit.ly/stackviz

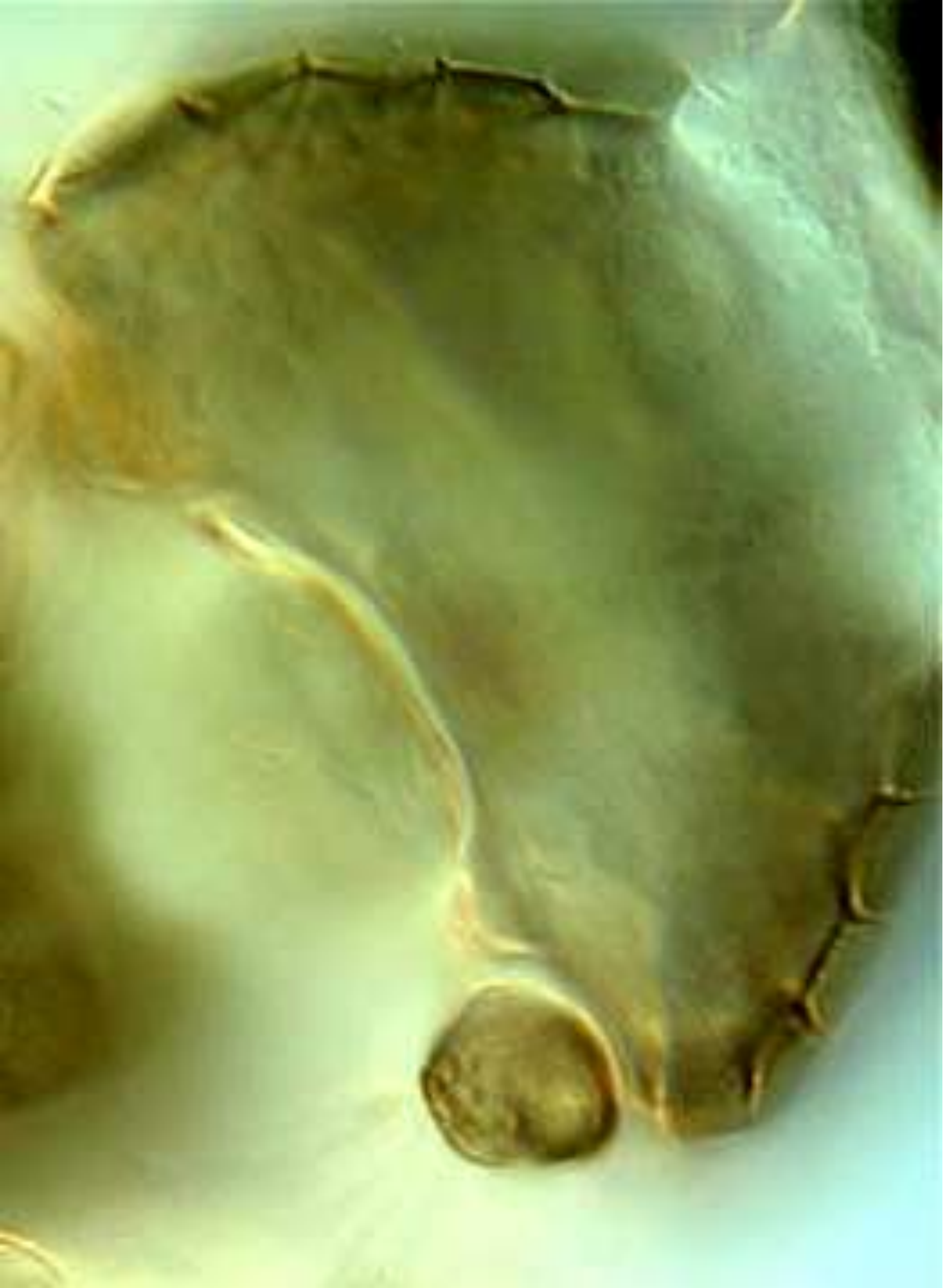
3. ARTIFICIAL DEFOCUS FOR DISPLAYING MARKERS IN MICROSCOPY Z-STACKS

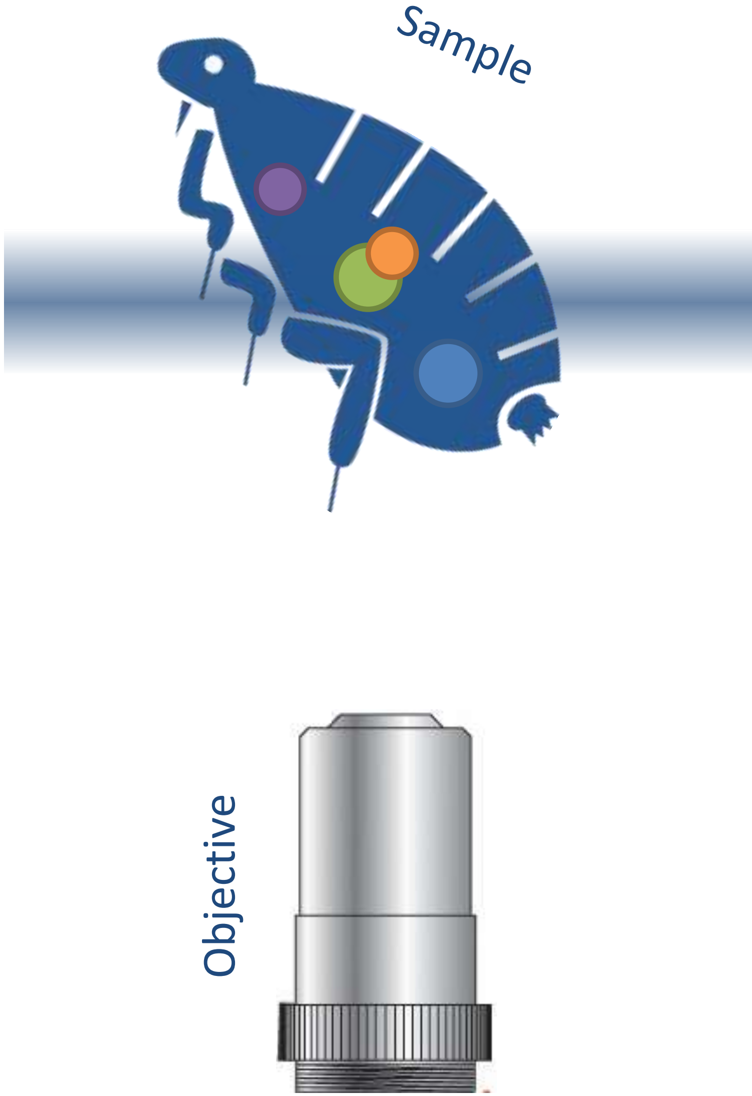

Sample
out-of-focus
in-focus
out-of-focus
Objective

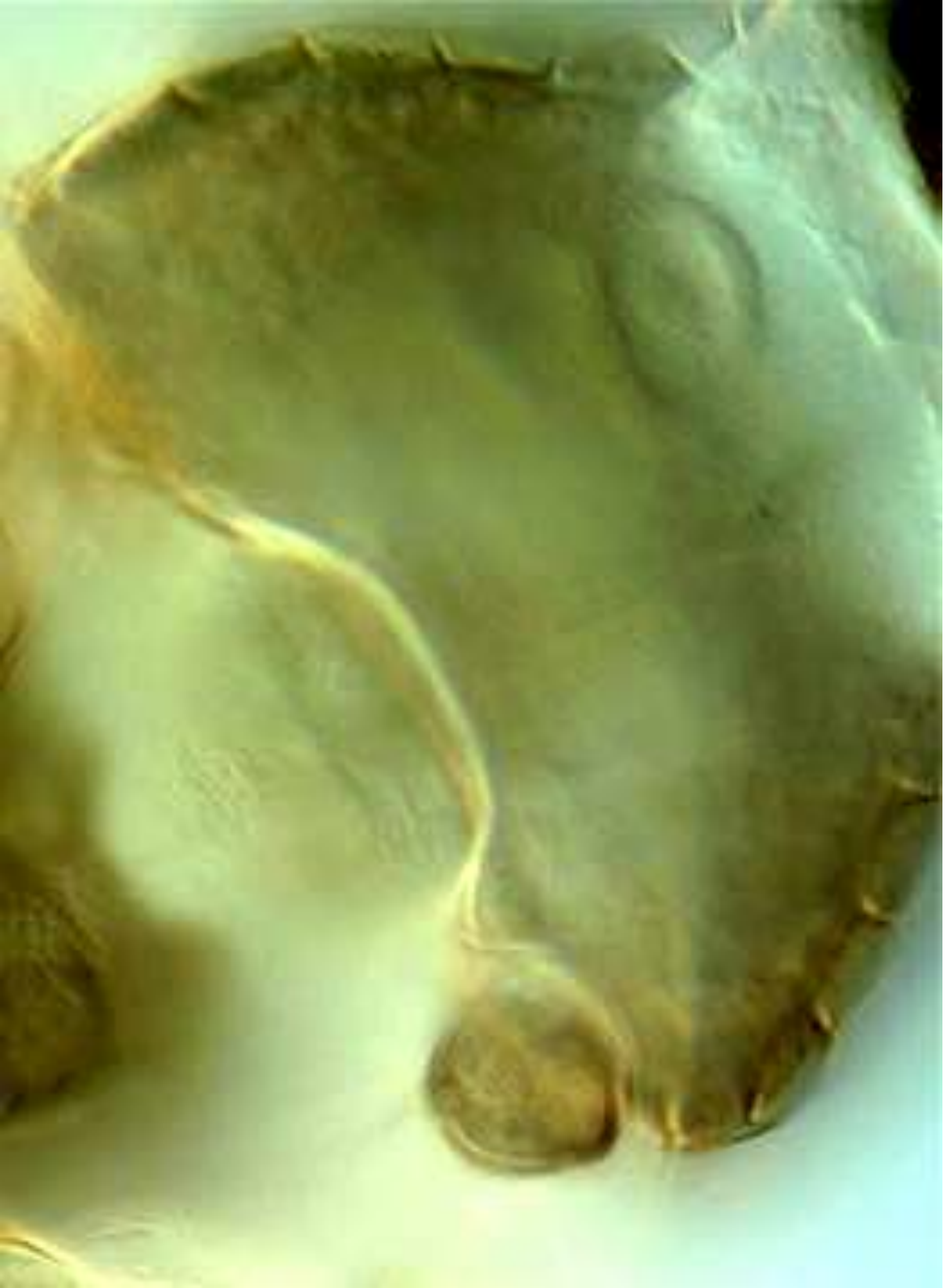


Sample
Objective

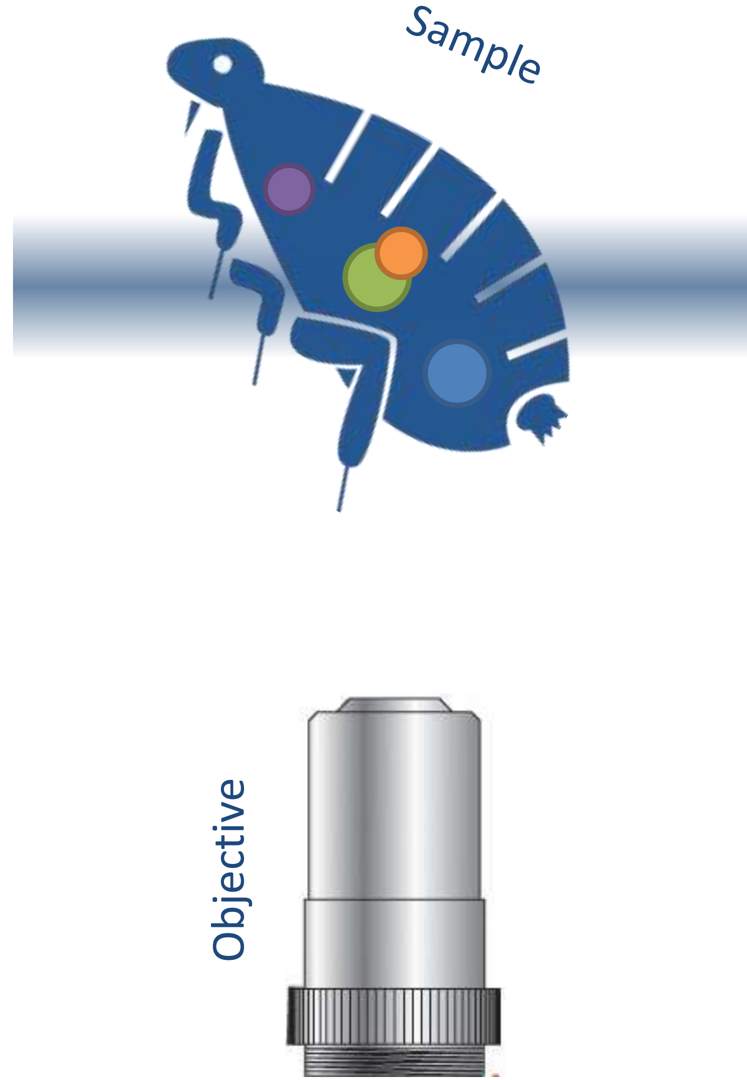


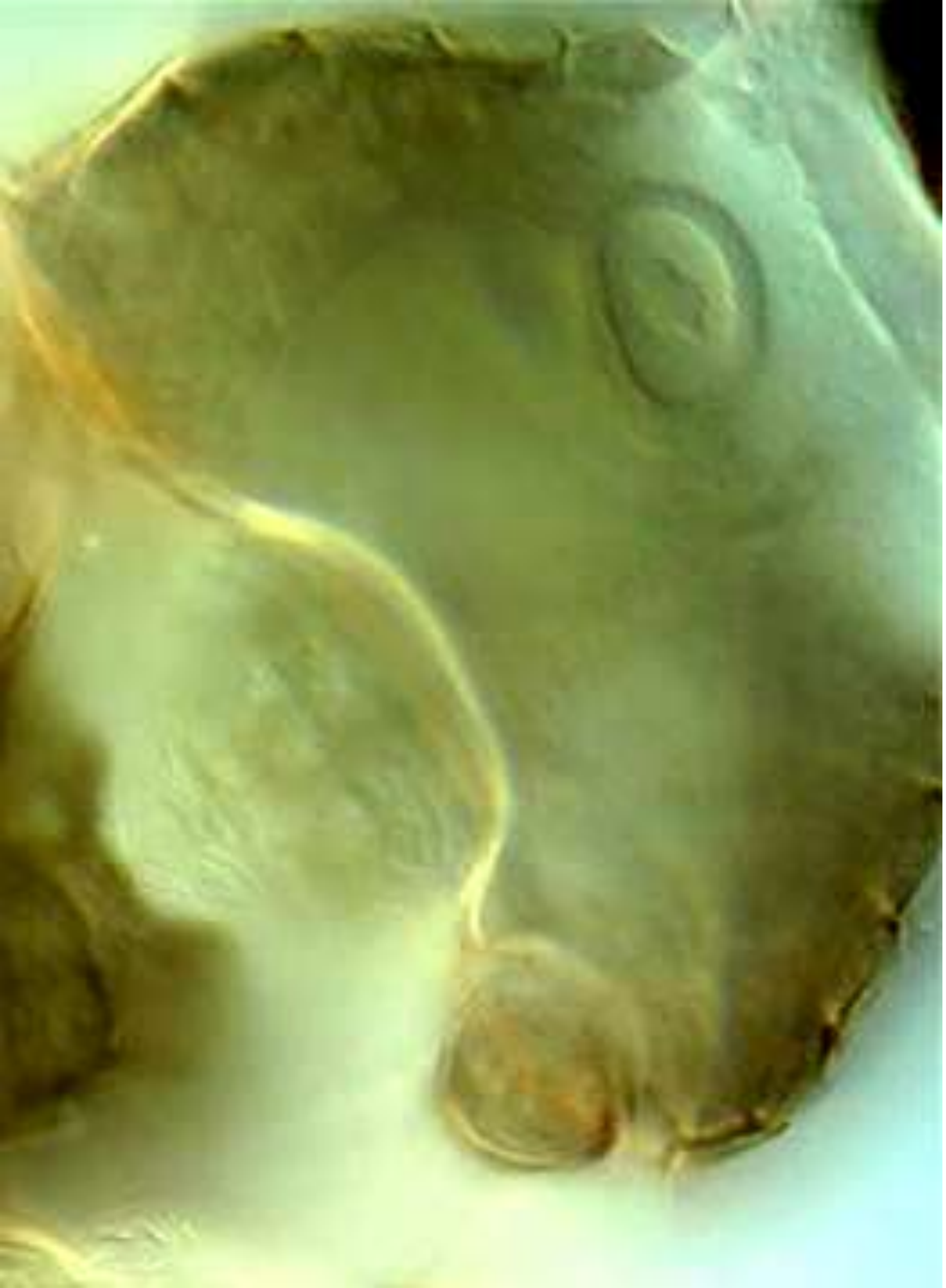

Sample
Objective

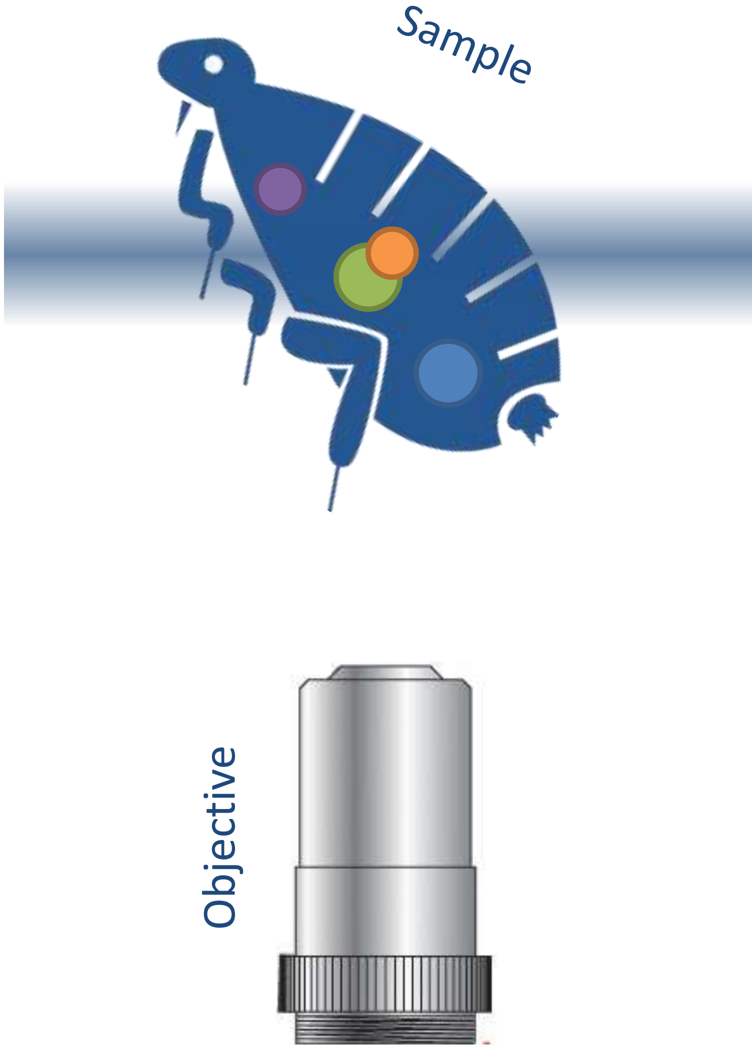


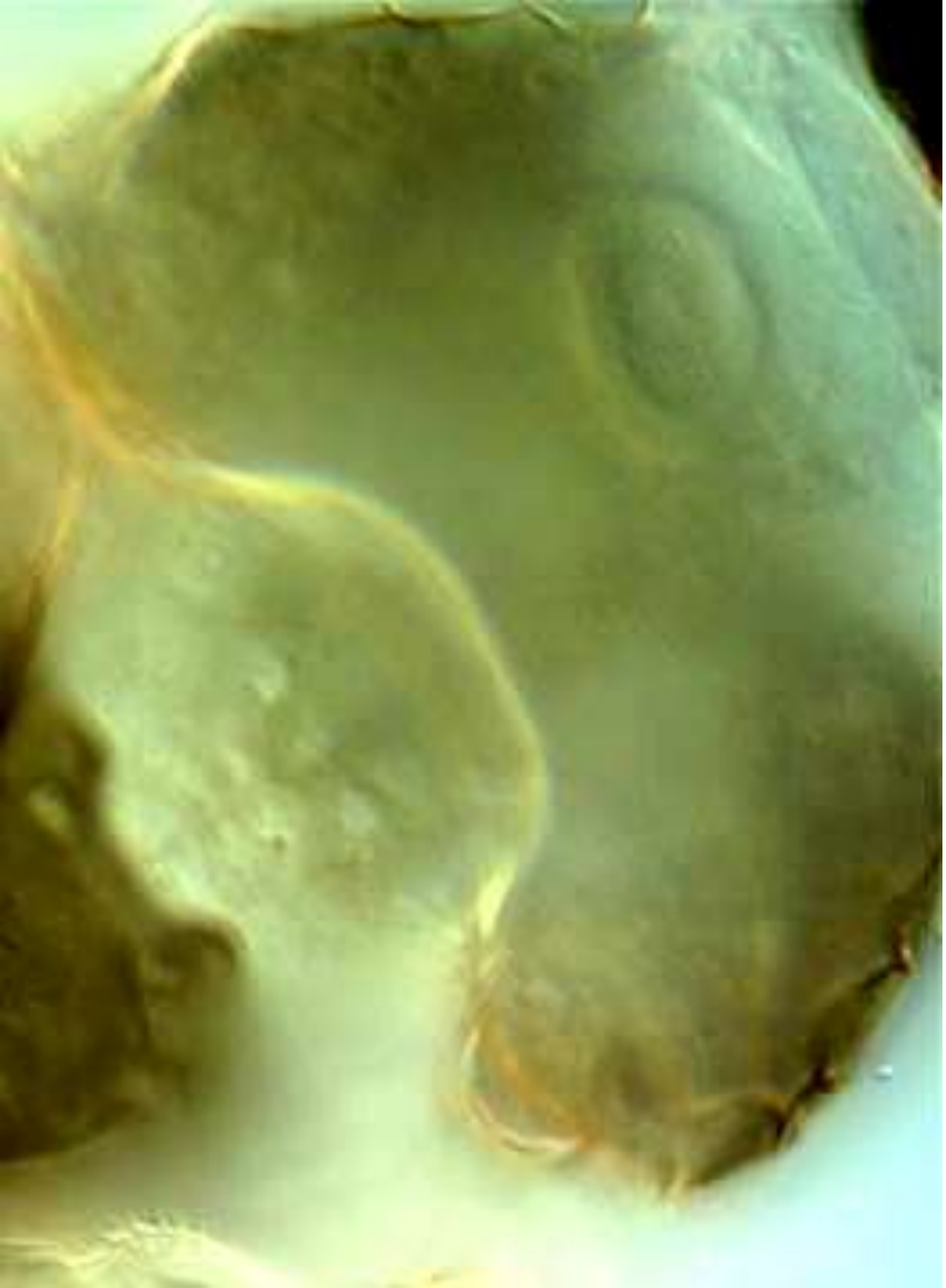

Sample
Objective

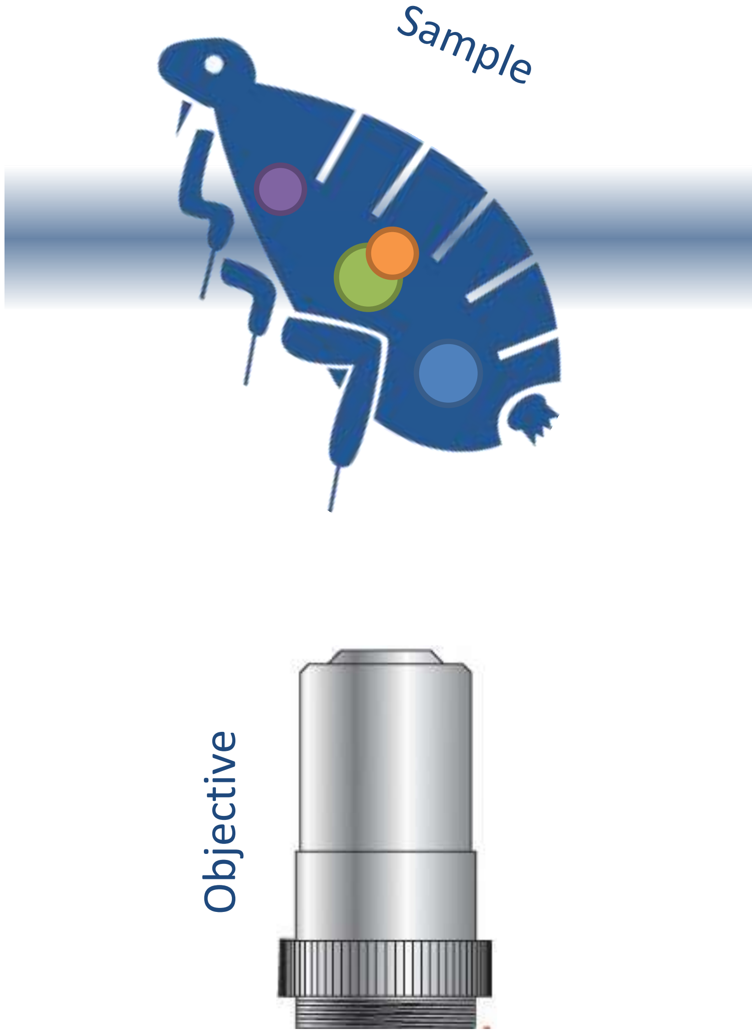


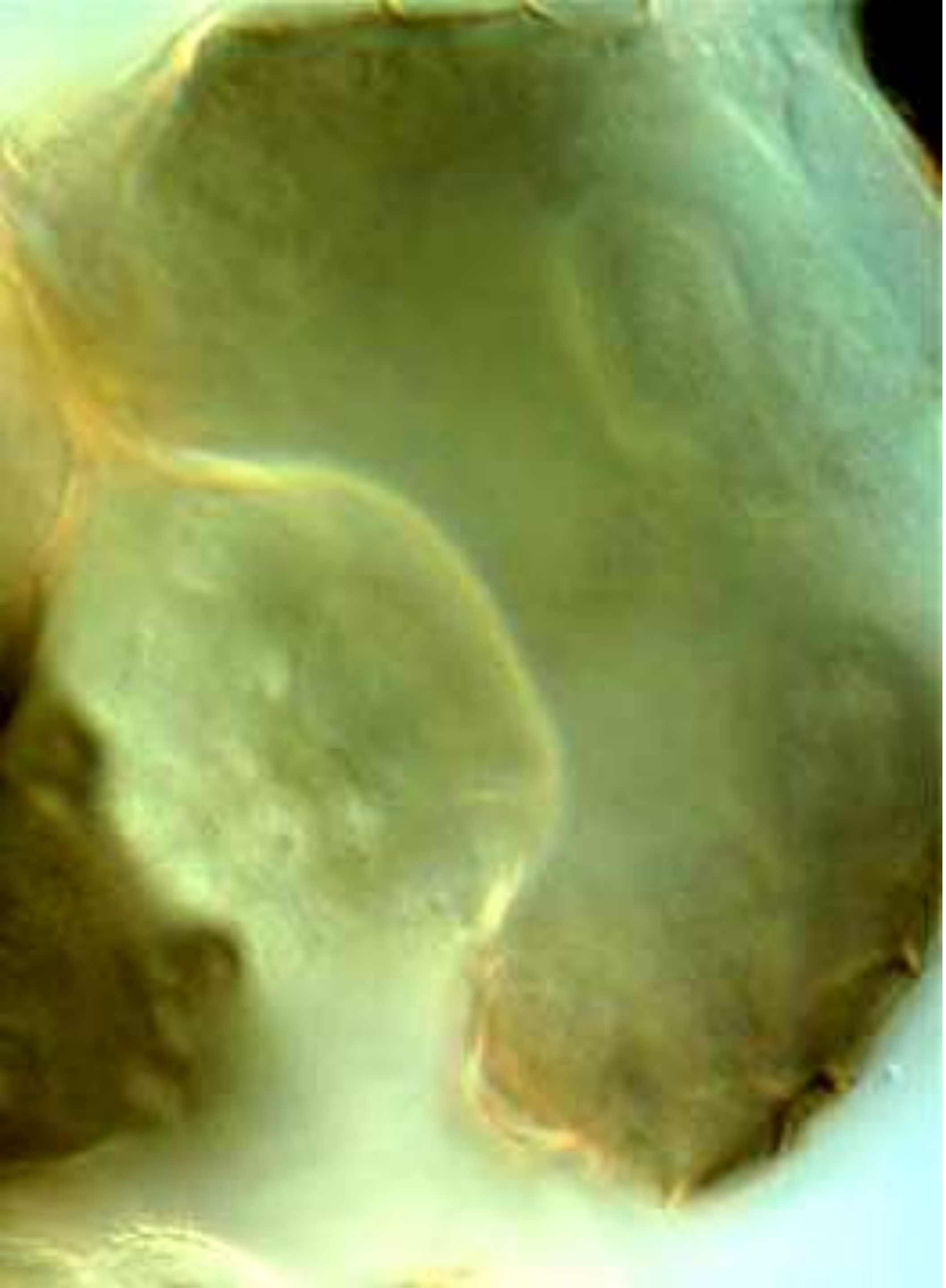

Sample
Objective

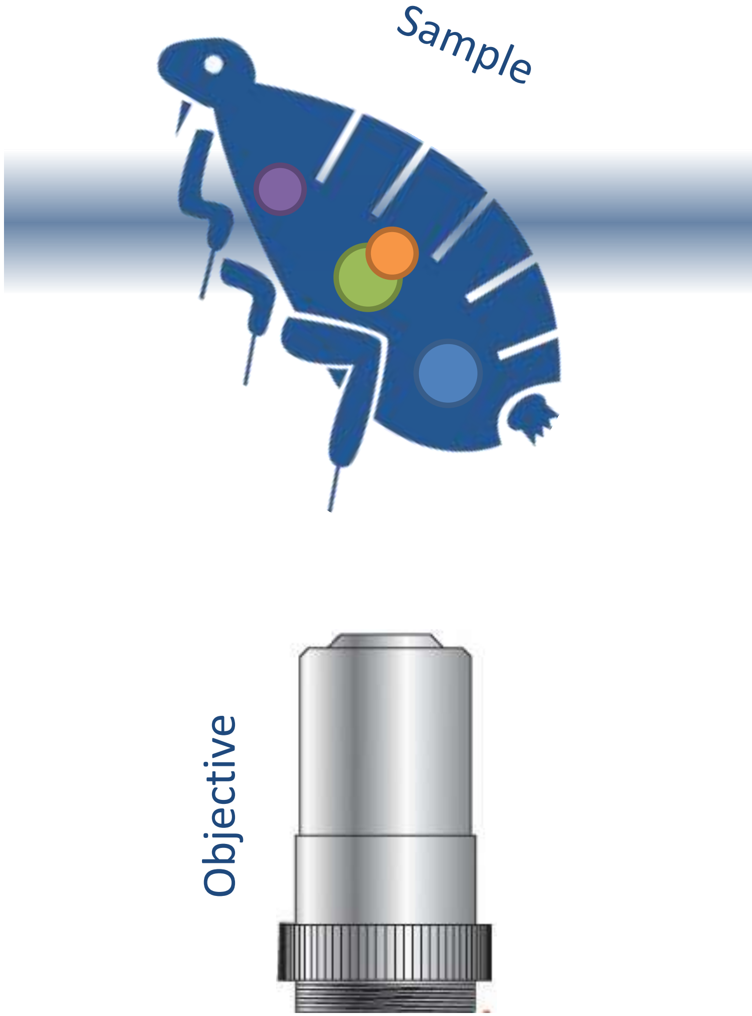


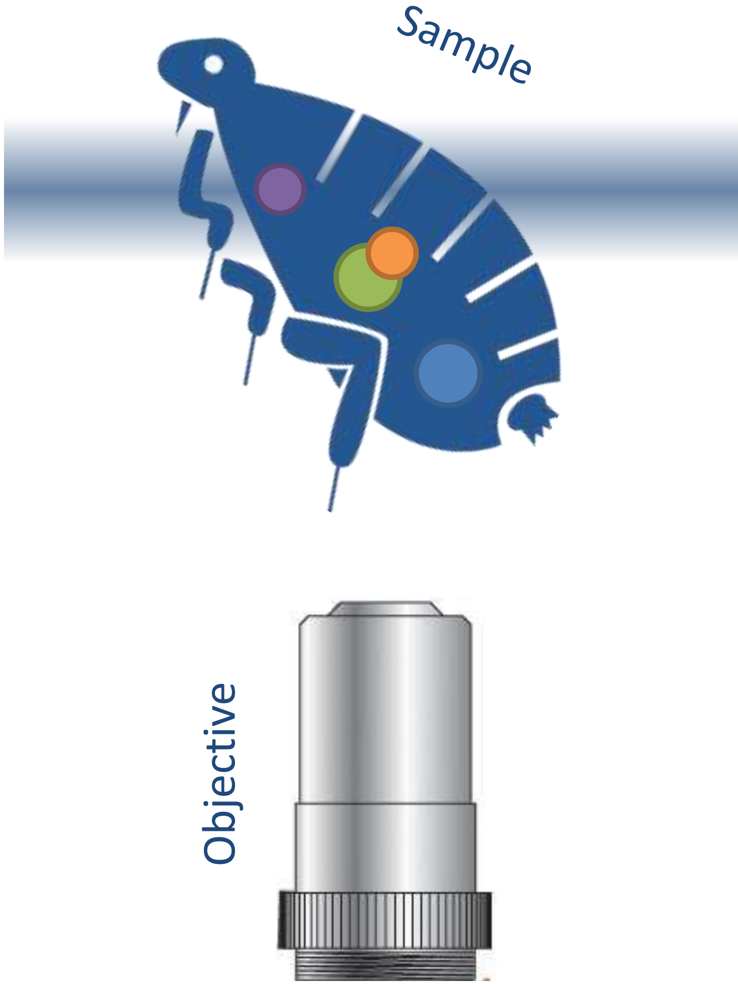

Sample
Objective



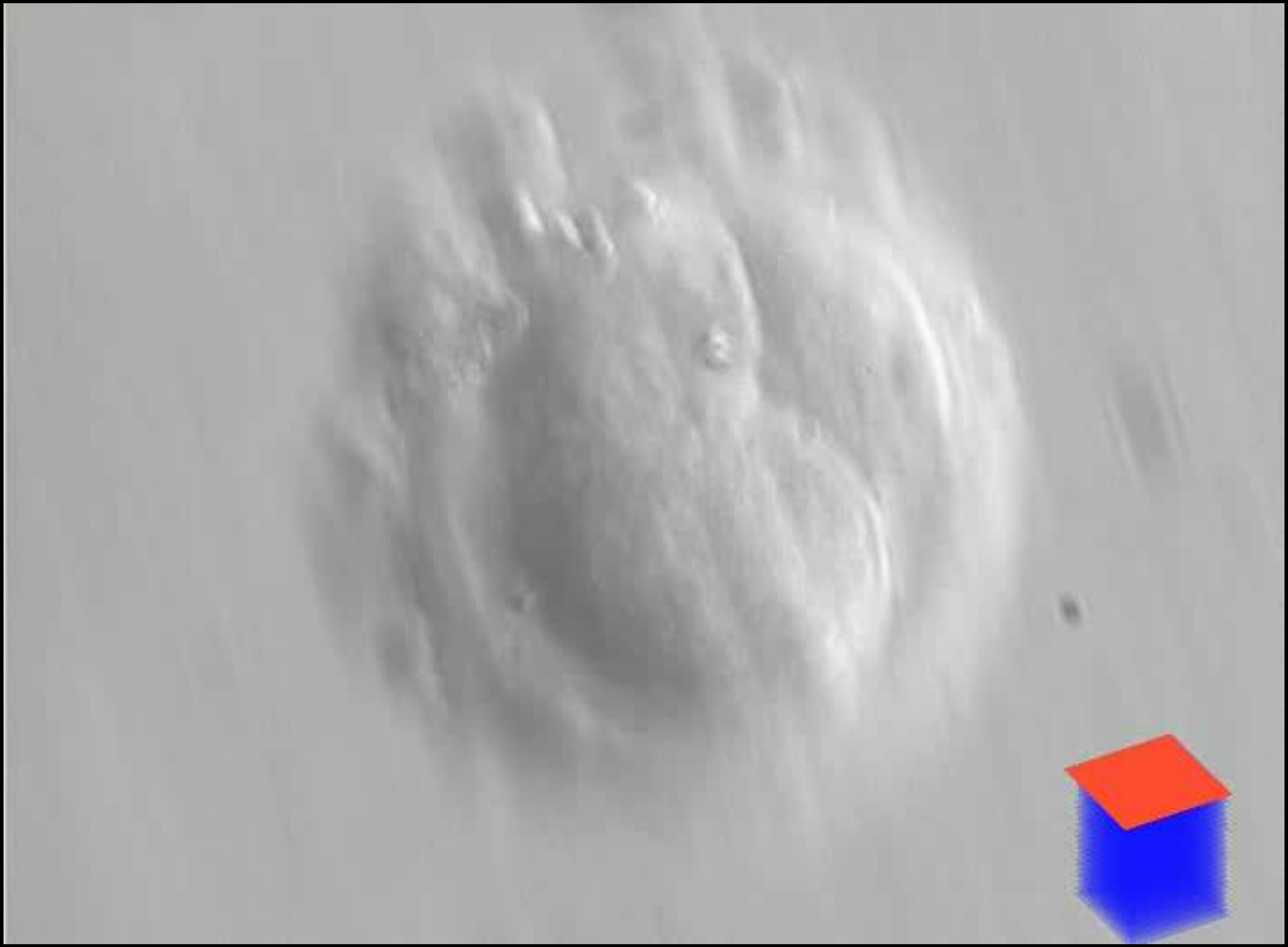

Sample
Objective



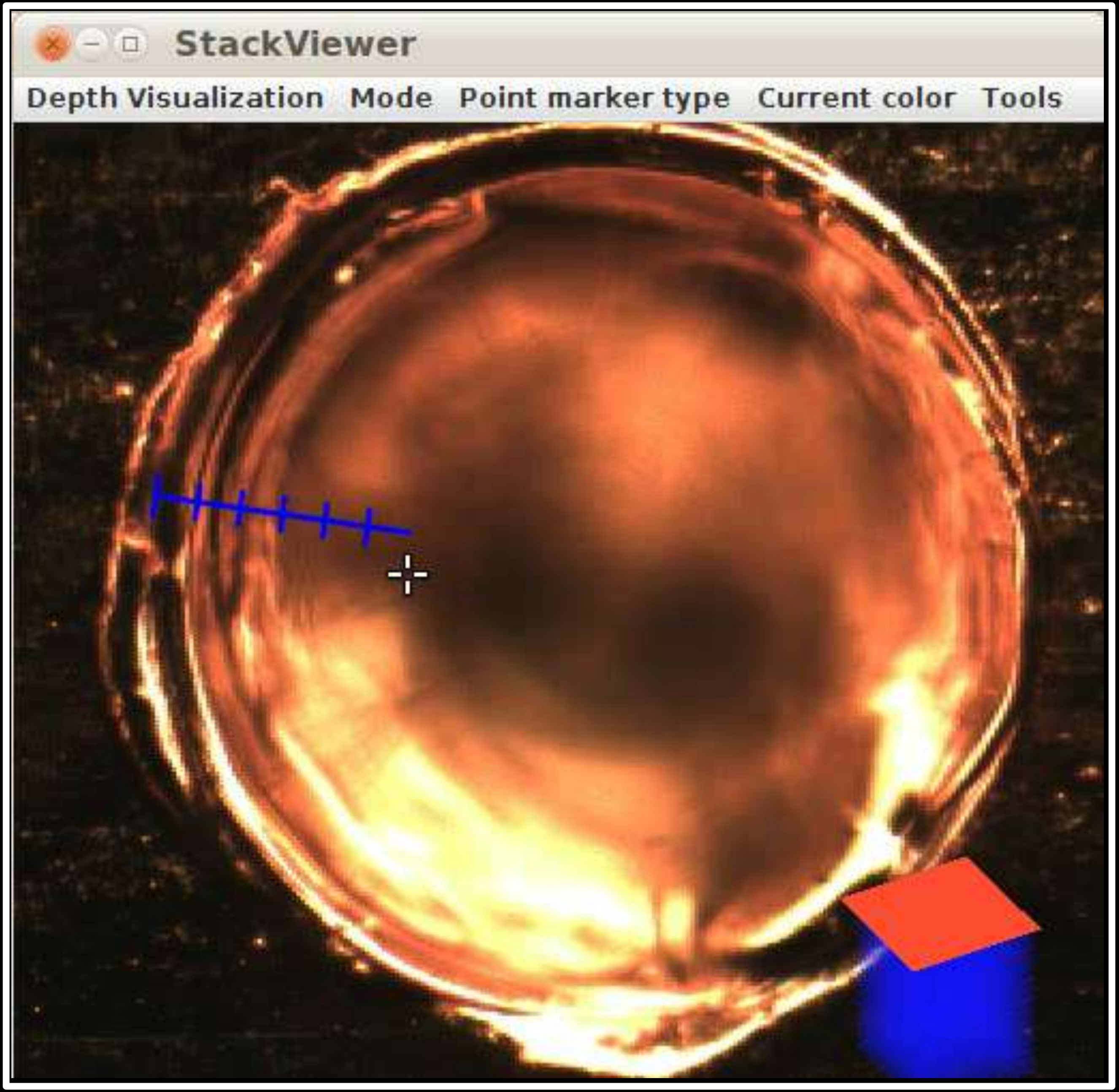

Sample
Objective


Sample
Objective

Flea chest – original image stack courtesy Daniel Stoupin – Used with permission



Human embryo at 4-cell stage – validation and correction of automated segmentation


StackViewer
Depth Visualization
Mode
Point marker type
Current color
Tools

Summary

The talk covered three topics

1. Vision-based roughness estimation of metal surface
2. Vision-based proximity Human Robot Interaction
3. Augmented reality for microscopy applications

Contact: `alessandrog@idsia.ch`

`https://idsia-robotics.github.io/`