Automated and flexible measuring of grain size and shape in images of sediment with deep learning

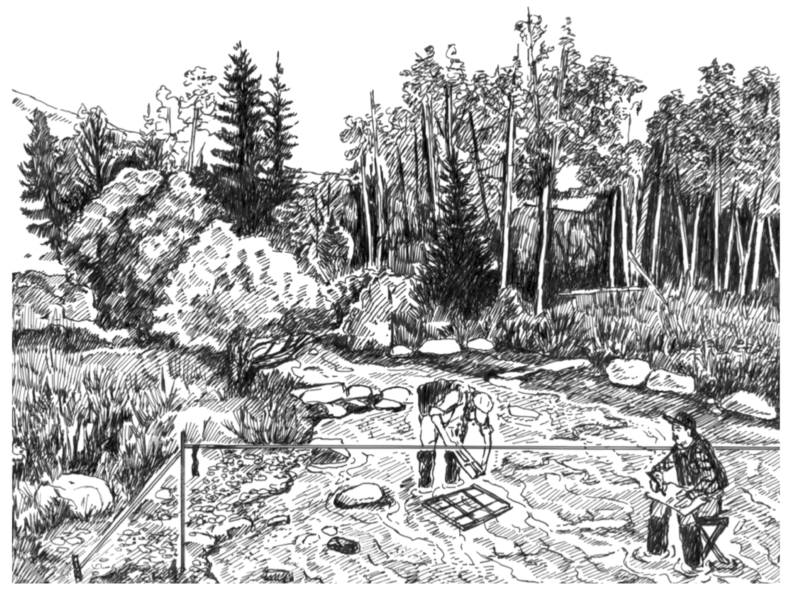
David Mair[1], Ariel Henrique Do Prado[1], Philippos Garefalakis[1], Guillaume Witz[2], Fritz Schlunegger[1]

[1]Institute of Geological Sciences, University of Bern, Switzerland [2]Data Science Lab, University of Bern, Switzerland

UNIVERSITY OF BERN

Background and Motivation

The size and shape of sediment grains is critical for understanding the interactions between hydraulics and sediment transport. **However,** data on grain size is laborious to obtain. Therefore, "Photosieving" was developed, **but still shortcomings persist**.



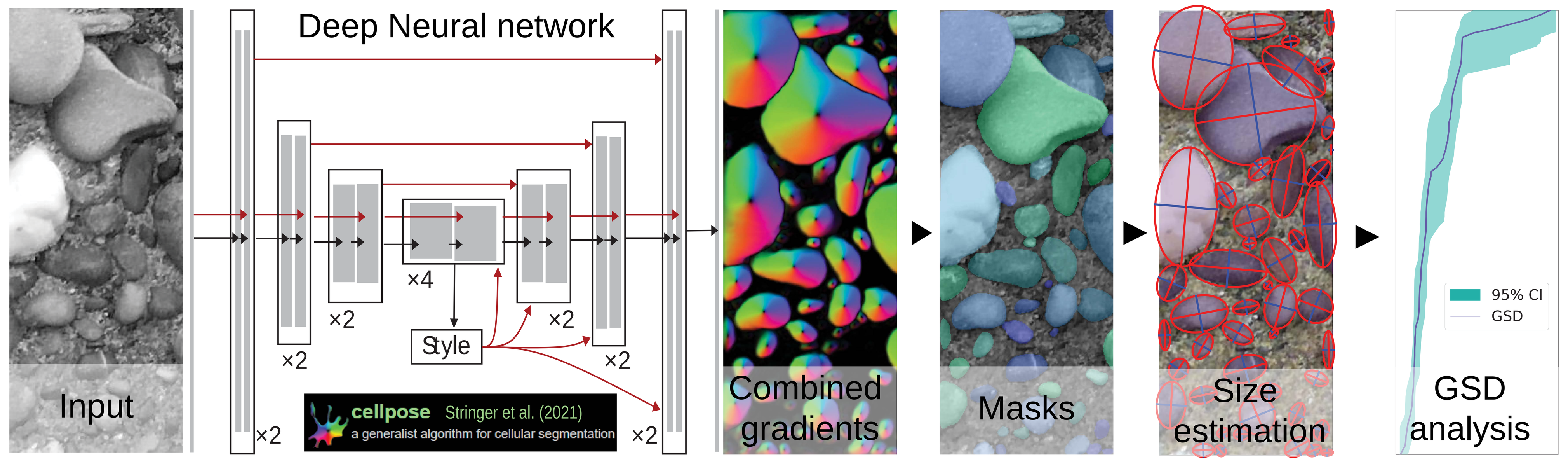
Data on grain size is laborious to obtain, e.g., by manual counting in the field. (Bunte & Abt, 2001)

- Often 'black box' approach when texture-based
- **Under-/over-segmentation** when segmentation-based
- Variability in images limits generalization ability
- Large amounts of data needed (for machine learning)

Visual complexity in images of fluvial channel sediments alone. Images from Chen et al. (2022) and Mair et al. (2022).

Method, Workflow and Data

Idea: **Improve segmentation performance through transfer learning** and **train case-specific models** instead of one large model.

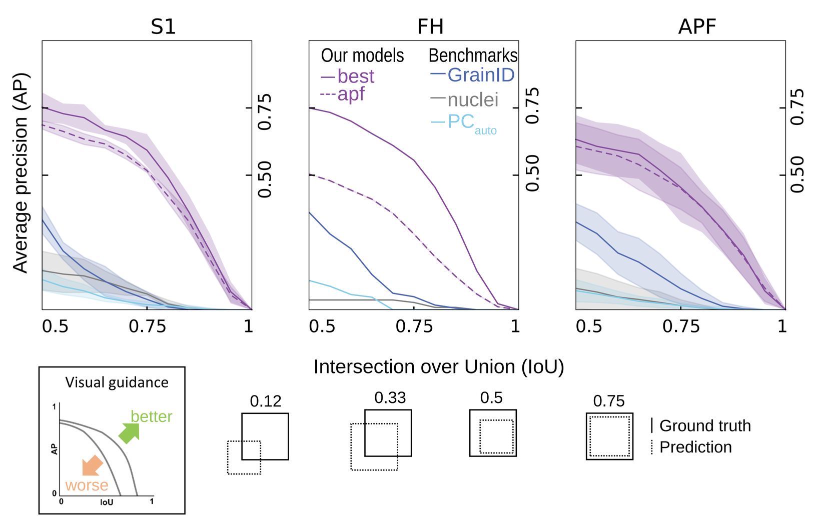


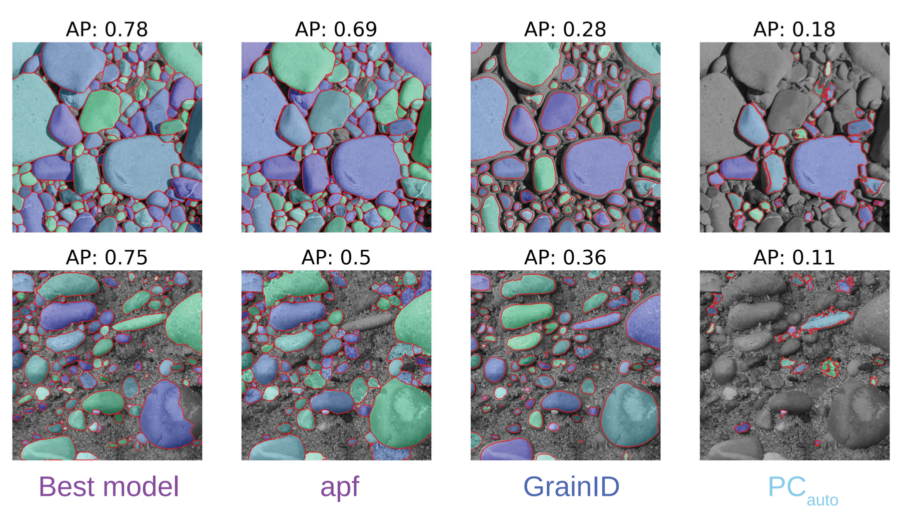
> State-of-the-art segmentation model
> Trained on hundreds of biomedical images
> Fast & flexible, open-source

> Transfer learning:
Re-trained with images of fluvial pebbles, outcrops, periglacial sediments, and images from a gravel pit.

Code & Data

Segmentation Performance



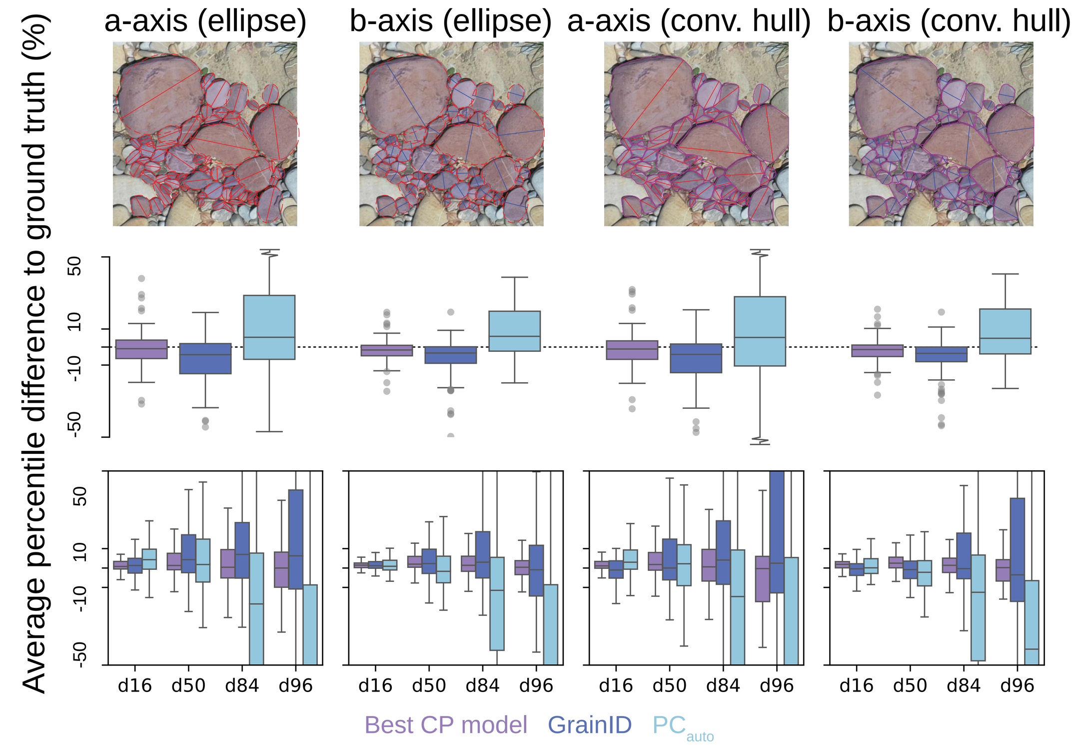


Evaluating average precision (AP) at intersection-over-union (IoU) thresholds of model predictions vs. labels.

> Our segmentation models outperform benchmark methods in the test data.

> The segmentation performance is controlled by data-set composition & training strategy.

Grain Size Results



Overall quality of grain size data collected with different methods in image tiles when compared to ground truth

> Better segmentation translates into precise grain size data, when compared to ground truth.

> This is independent of the grain approximation for our datasets.

> Results are accurate when compared to independent measurements.

Full study

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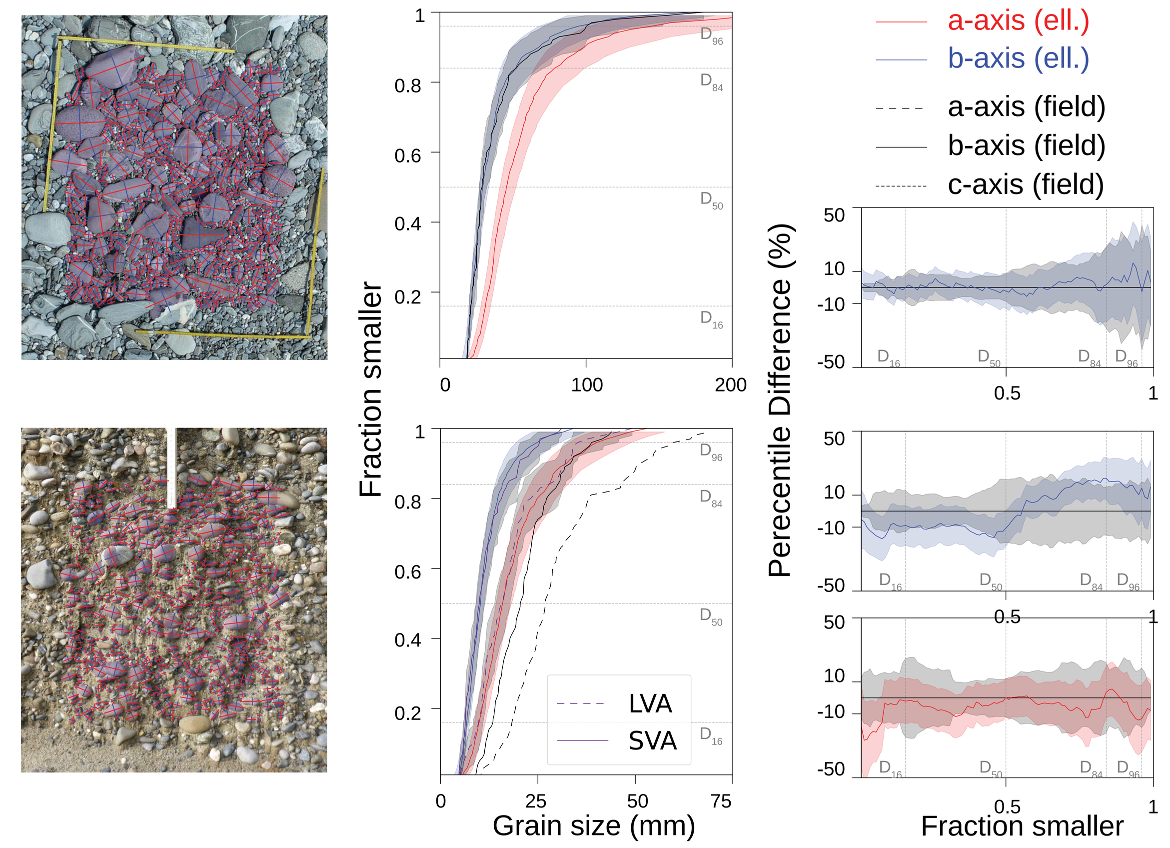
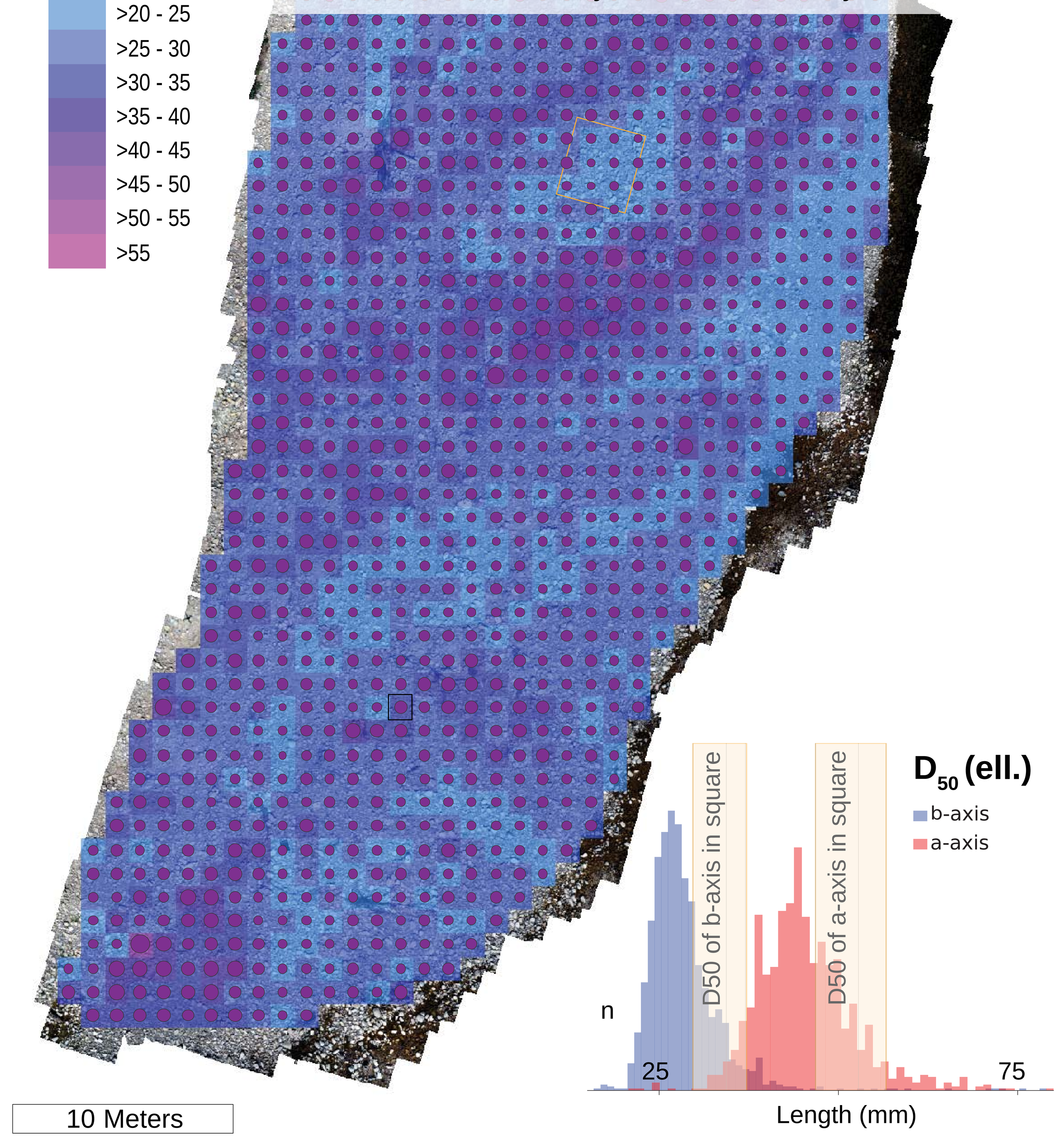


Grain size accuracy when comparing to independent data.

Automated size mapping

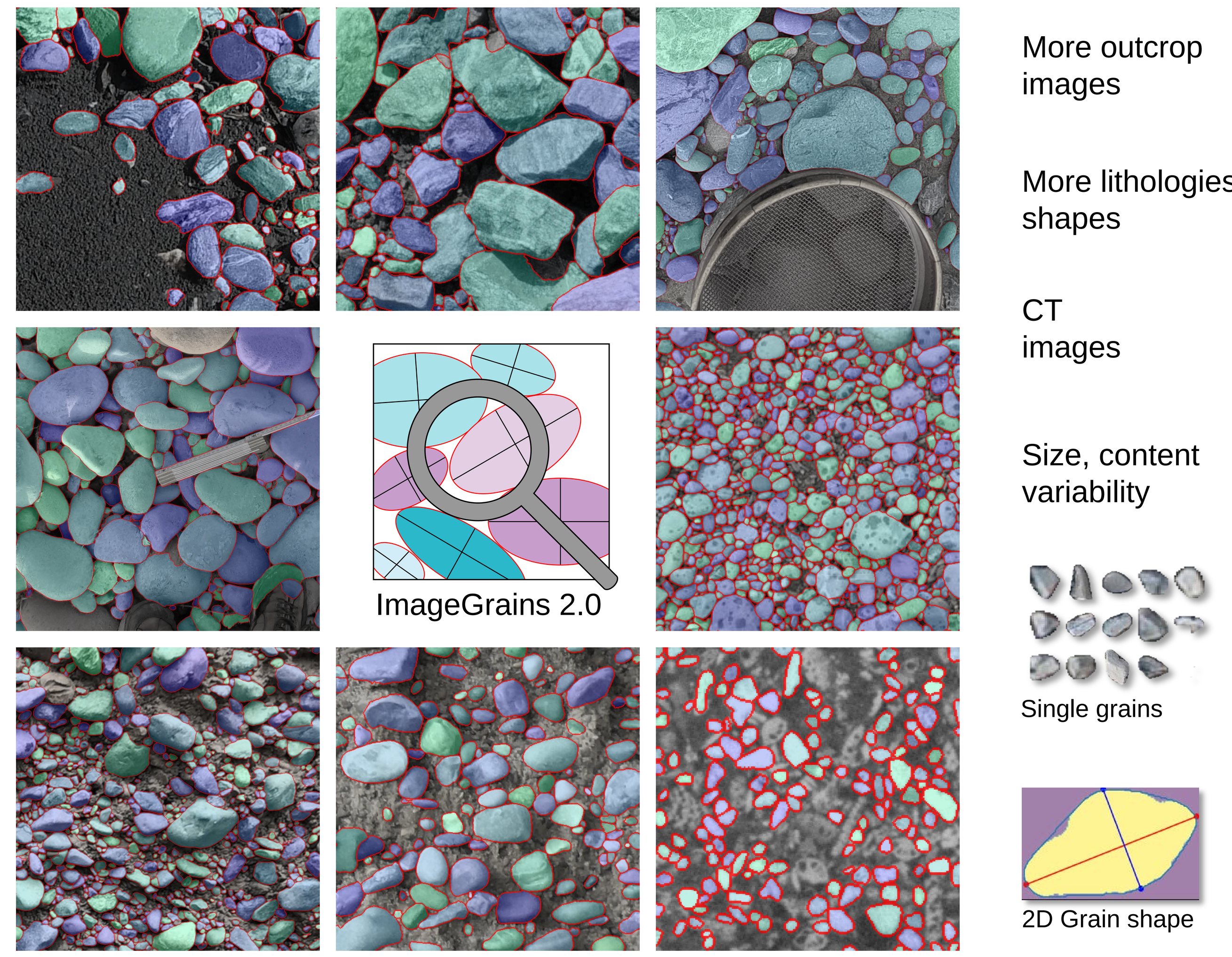
> Over 268'000 individual grains measured.
> Full grain size distribution for each tile.
> Less than 2h for fully automated analysis.



Precentile D50 map for a gravel bar in the Swiss Kander River.

Outlook

A major update is in development, which will allow for more flexible custom model training and will include more specialist models for a wider range of settings.



Segmentation results for a range of settings and image types.

References

Bunte, K. and Abt, S. R. - https://doi.org/10.2737/RMRS-GTR-74, 2001.
Chen, X., Hassan, M. A., and Fu, X.- Earth Surf. Dyn. 10, 349–366, https://doi.org/10.5194/esurf-10-349-2022, 2022.
Mair, D., Henrique, A., Prado, D., Garefalakis, P., Lechmann, A., Whittaker, A., and Schlunegger, F. - Earth Surf. Dyn., 10, 953–973, https://doi.org/10.5194/esurf-10-953-2022, 2022.
Stringer, C., Wang, T., Michaelos, M., and Pachitariu, M. - Nat. Methods, 18, 100–106, https://doi.org/10.1038/s41592-020-01018-x, 2021.