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Deep Learning-Based semantic segmentation for geomorphic processes signals in tree-ring records

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Trees encapsulate environmental changes in their growth through the records in the tree rings, but extracting this signal proves challenging and time consuming. These challenges persist in the study of geomorphic processes, requiring meticulous and prolonged efforts by a specialised technician to identify and date growth disturbances (GD). The presence of false annual rings adds another layer of complexity to the task.

Today, many classical computer vision-based techniques have been developed for the automatic detection of annual rings. However, to the best of our knowledge, these techniques have not been applied to the detection of GD associated with geomorphic events, which are more challenging because they do not present as clear visual patterns as annual rings. Deep learning-based architectures have shown great capacity for automatic localisation of objects in images with complex shapes.

We have applied these systems to the segmentation of evidence of geomorphological processes (i) wounds (ii) callus tissue (iii) latewood (iv) traumatic resin ducts and (v) growth rings. The deep learning (DL) architectures used were Faster R-CNN with ResNet-101-FPN backbone, YOLOv8 and a U-Net architecture. For the application of the system, it is necessary divide the image into smaller patches, and post-processing techniques for the correct unification of the predictions of each image. Training and evaluation of the networks was performed in Google Colaboratory. The algorithm was tested on 150 cores taken ad hoc from a debris flow cone in the Pyrenees (Pineta Valley), where historical debris flows have occurred. The cores were subjected to a sanding process and the images were obtained using a Canon Eos8 camera. 120 were used to train and validate and 30 to test the architectures, comparing the results obtained by a classical approach and by DL. The evaluations were performed at the pixel level using the accuracy, precision and recall metrics. After post-processing the predictions, the pixels were converted into instances and the predictions were compared with the ground truth, and the metrics Intersection over Union (IoU), precision and recall per category were calculated.

Our preliminary results suggest that, with a sufficiently large dataset, deep learning-based models can capture sufficient information to identify the complex patterns to be classified. This implies that it is possible to achieve a model capable of automatically identifying geomorphological event

signals, thereby speeding up the process of obtaining evidence. This opens the possibility of having proposals of event signals without subjective bias, obtaining in different studies, evidence datasets made with a homogeneous and systematised criterion.