AI-Track-tive: open source software for automated recognition and counting of surface semi-tracks using computer vision (artificial intelligence)

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Introduction

A new method for automatic counting of etched fission tracks in minerals is developed and recently published in Geochronology (see Nachtergaele and De Grave, 2021). Artificial intelligence techniques such as deep neural networks and computer vision were trained to detect fission surface semi-tracks on images. The deep neural networks can be used in an open source computer program for semi-automated fission track dating called "AI-Track-tive". Our custom-trained deep neural networks use YOLOv3 object detection algorithm, which is currently one of the most powerful and fastest object recognition algorithms. Two Deep Neural Networks were trained for both apatite and mica using our training dataset with images from our current microscope system (Nikon TRACKFlow).

Code availability

AI-Track-tive is written in Python 3.8. The software is open-source and available on GitHub.

There is a downloadable offline app and an online app hosted on a website **(https://ai-track-tive.ugent.be).**

The offline application is available for Windows users. All code can be downloaded from GitHub repository.

QR code for paper

QR code for GitHub

Funding and contact info

Simon Nachtergaele is supported by a PhD grant from Fonds Wetenschappelijk Onderzoek Vlaanderen (2018-2022)

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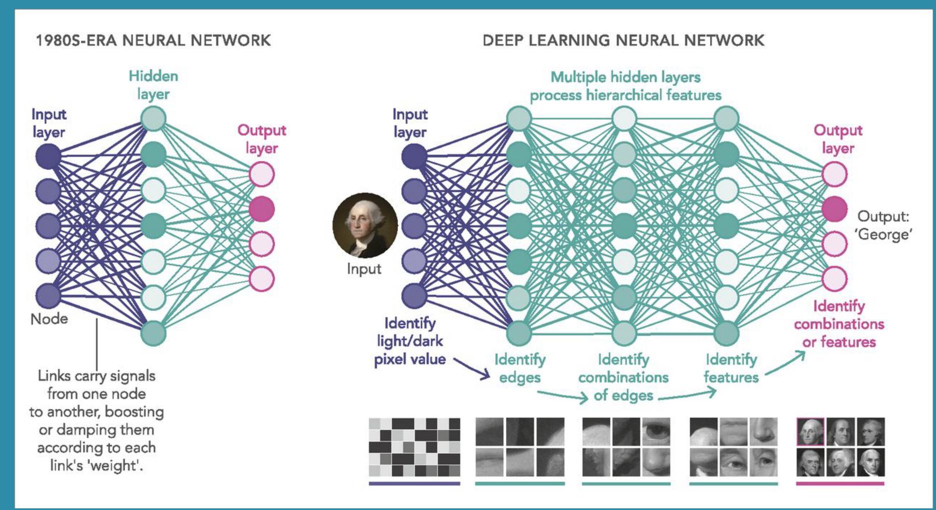
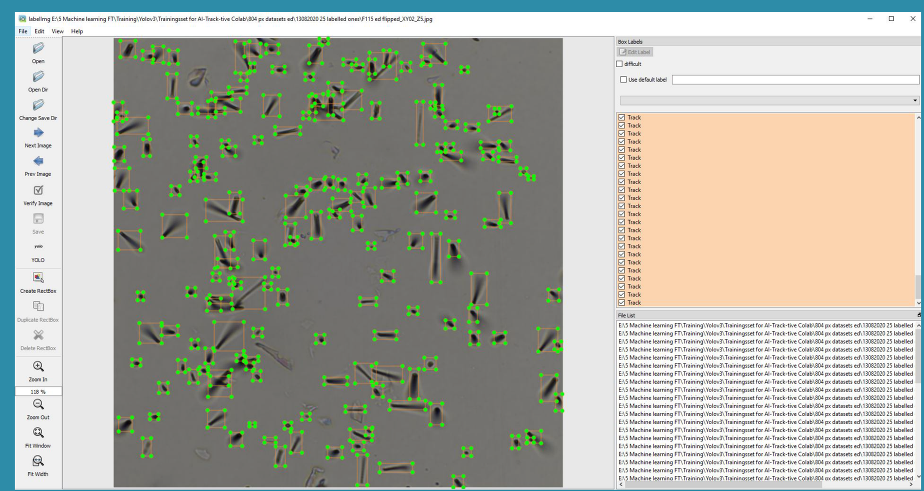
Methods

AI-Track-tive uses previously developed "deep neural networks" that use convolutional layers. These deep neural networks are capable of detecting objects in images. Through transfer learning, it is possible to train the deep neural network to detect an object of choice.

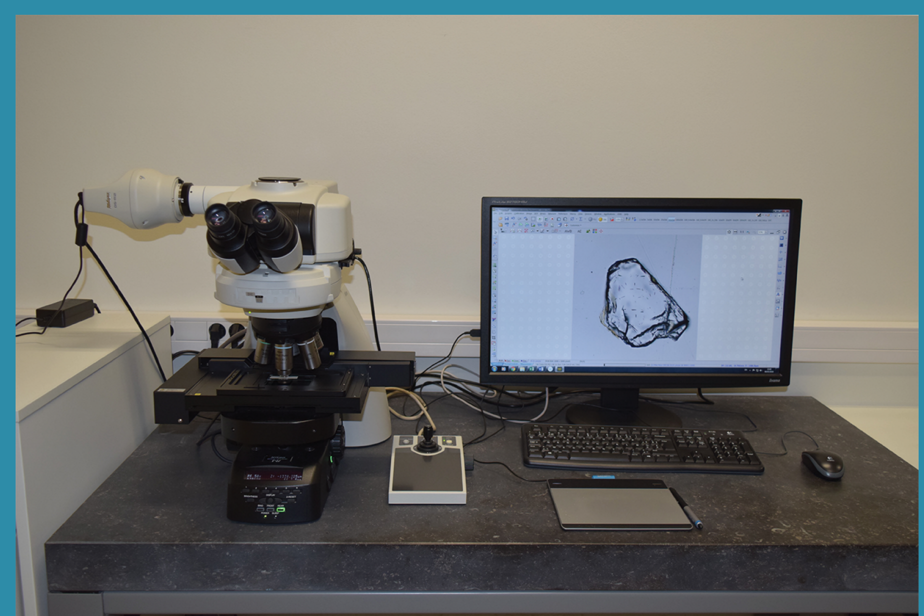


Representation of a deep learning neural network

AI-Track-tive currently uses the popular Yolov3 (Redmon et al. 2018) object detection alghoritm. It is trained on 50 images for apatite and mica containing thousands of manually annotated semi-tracks.



Labelimg program (https://github.com/tzutalin/labelImg) used for construction of the training dataset



Current microscope set-up (Nikon TRACKFlow) (Van Ranst et al. 2020)

How is this Deep Neural Network trained?

1. Build dataset and annotate images with >5000 tracks using LabelImg.
2. Execute Jupyter notebook (see GitHub) on Google Colab and do more than 2000 iterations so that the average loss reaches a minimum.
3. Download the weights and configuration file from Google Drive.

Results and discussion

The deep neural networks can be used in a graphical user interface on- and offline. The deep learning approach can be tested on the online application. More features are available in the offline application, such as:

1. Automatic count and manual reviewing the results
2. Live track recognition using Yolov3 (Nachtergaele and De Grave, 2021)
3. D_{par} measurement

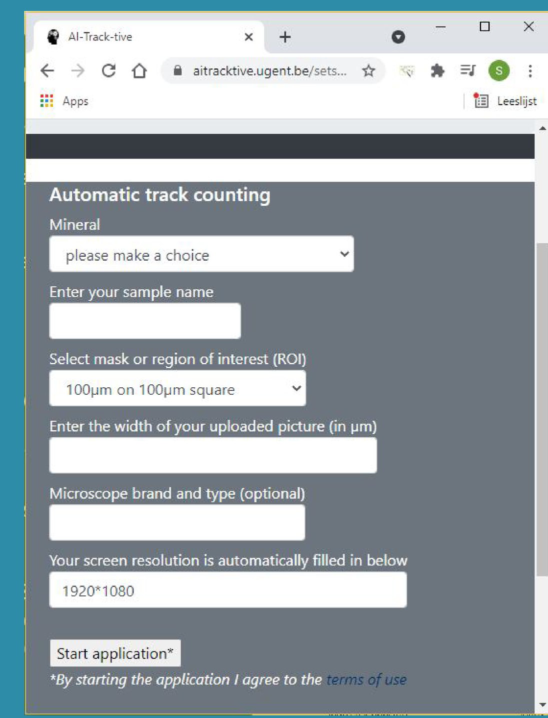
The developed program successfully finds most of the fission tracks in the microscope images, however, the user still needs to supervise the automatic counting.

The presented deep neural networks have high precision for apatite (97%) and mica (98%).

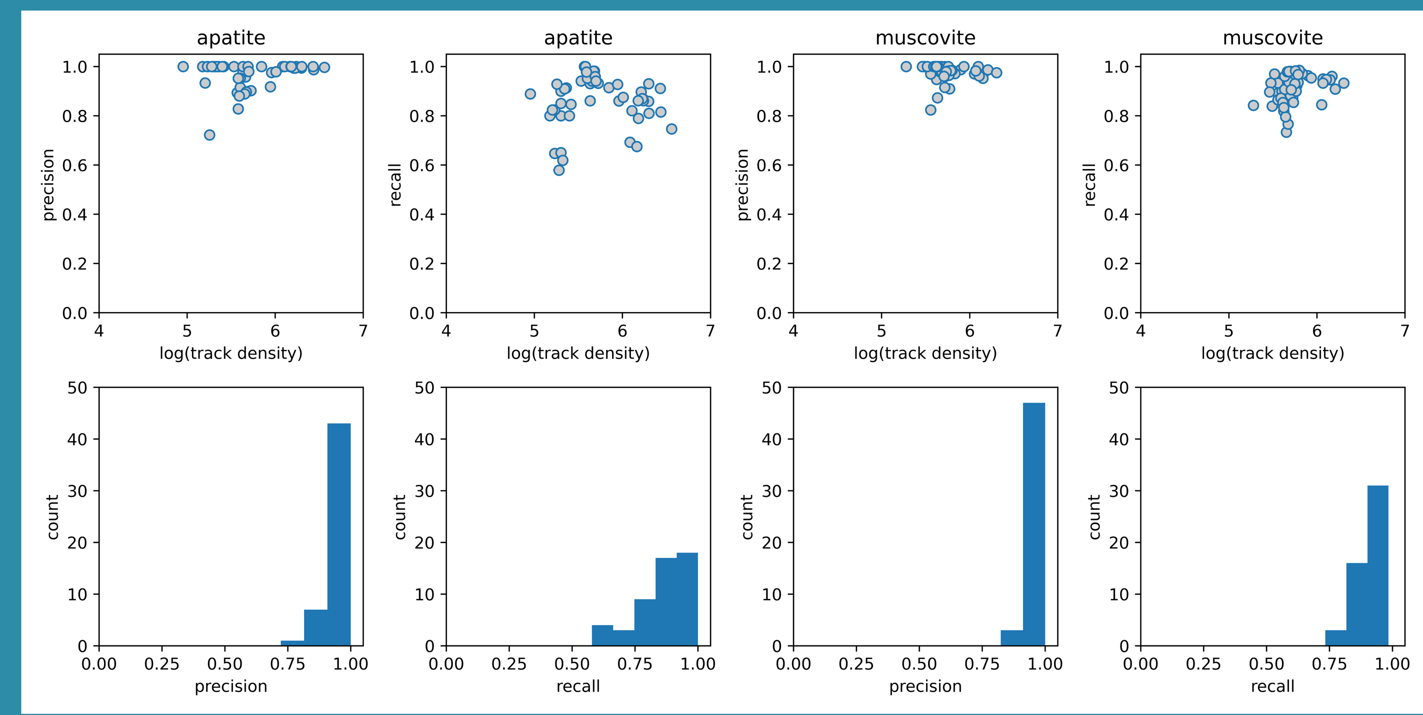
Recall values are lower for apatite(86%) than for mica (91%). These high values have been obtained on images using the same microscope that provided the training images.

Interested in making a detection algorithm trained specifically for your own microscope set-up? If so, send 50 different apatite or mica images to (Simon.Nachtergaele@UGent.be).

Screenshot of the Offline app



Screenshot of the online app



Recall and precision values for the apatite and mica detection using Yolov3

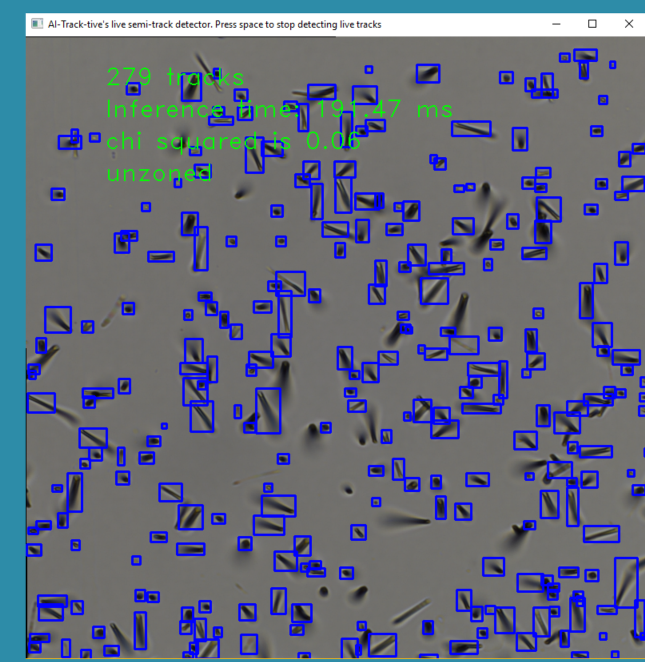
Newest developments

Using the newer ultra-fast tiny-Yolov4 (Bochkovskiy et al. 2020) network architecture, live track detection is **19 times faster** than with AI-Track-tive using Yolov3 (presented in Nachtergaele and De Grave, 2021).

New features:
- real-time confined track finder
- real-time semi-track counter for apatite
- real-time semi-track counter for mica

Expected release date: September 2021

Live confined track detector in apatite



Ultra-fast live semi-track detector

References

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Van Ranst, G., Baert, P., Fernandes, A. C., & De Grave, J. (2020). Nikon–TRACKFlow, a new versatile microscope system for fission track analysis. Geochronology, 2(1), 93-99.
Bochkovskiy, A., Wang, C. Y., & Liao, H. Y. M. (2020). Yolov4: Optimal speed and accuracy of object detection. arXiv preprint arXiv:2004.10934.
Redmon, J., & Farhadi, A. (2018). Yolov3: An incremental improvement. arXiv preprint arXiv:1804.02767.