Review of *AI-Track-tive: open source software for automated recognition and counting of surface semi-tracks using computer vision (Artificial Intelligence)*

Chris Mark, 19-May-2021.

The authors present a novel approach to automated fission track counting using artificial intelligence. A number of highly intelligent design decisions are included, particularly the ability of the offline version to detect tracks on any window open on the user's screen, offering maximum flexibility with regard to input (static images, live microscope camera feeds, remote-accessed computers, etc). I congratulate the authors on tackling a critical problem in FT analysis: minimising operator bias in track detection, and thus greatly reducing inter-lab variability. This approach will also lead to considerable time savings, and by increasing throughput may offer the possibility of greatly improving counting statistics. I strongly support this approach and encourage the authors to persevere.

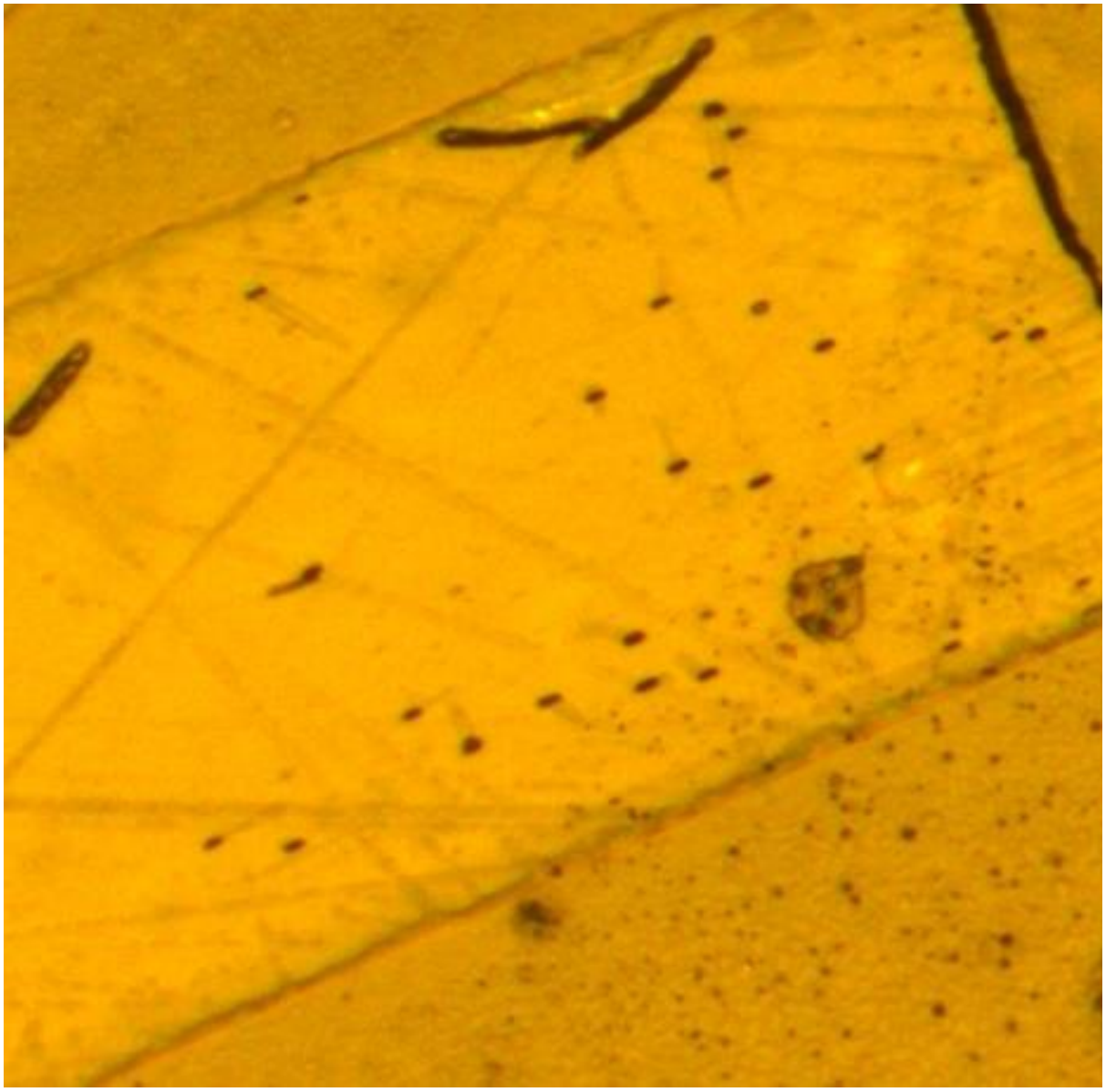
The manuscript itself has already received three reviews by appropriate experts, and I have only minor comments to add (see below). However, neither the online or the offline version of the software is yet ready for release (see detailed bug lists below). I urge the authors to extensively test both versions on a wide range of operating systems and browsers, as well as images acquired from a much wider range of camera-microscope combinations. I also urge the authors to watch the system being tested by at least one, and preferably several, users who have not watched the tuition videos and are working from the on-screen instructions only (these need to be considerably expanded). This will acquaint the authors with the likely mistakes made by casual or unprepared users. I also urge the authors to expand the manual currently included in the supplemental materials – it is far too short. This approach has huge potential, and it would be a pity if community take up was reduced because the program is not yet intuitive.

Software testing:

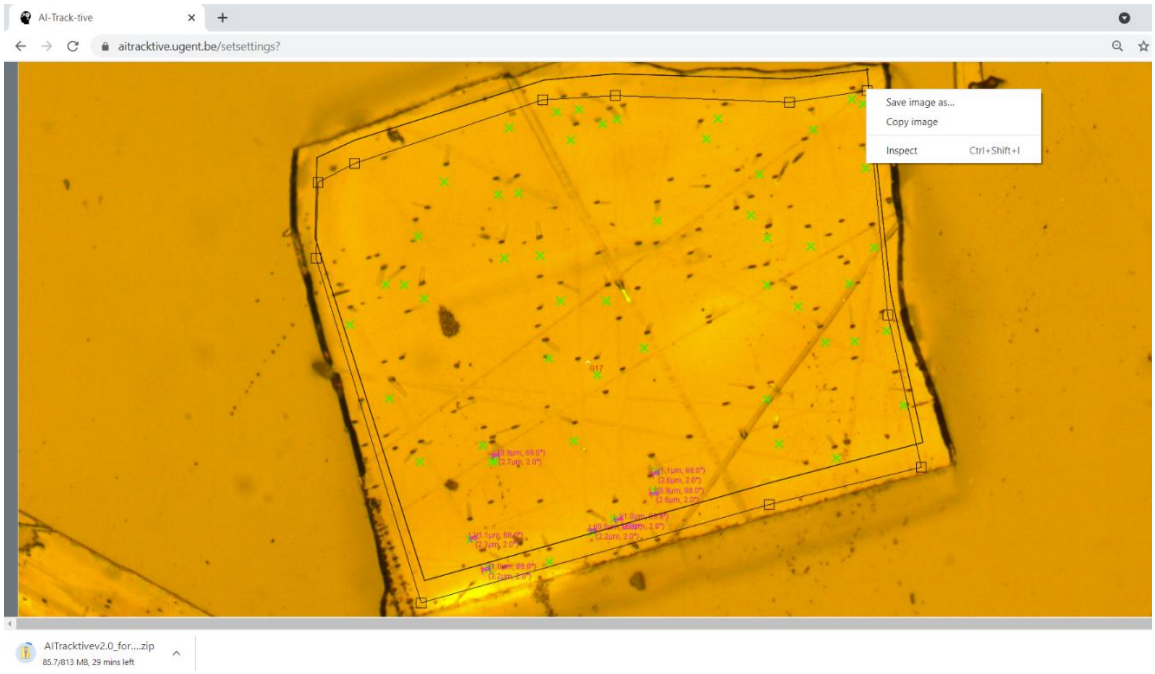
When testing the **online version**, a number of issues were encountered. Unless otherwise stated, all tests were performed using the browsers MS Edge, Opera, and Chrome on a PC running Win10 Pro 64-bit, x64 processor.

- Image widths for the example dataset are not given on the website (that I could see). I assume these are the 117.5 micron width images described in the manuscript text. I recommend stating the widths for the example images on the web app, rather than assuming the user has read the manuscript in detail. Using the example dataset, the online version works ok. I strongly recommend stating explicitly on the manual review screen that the results must be downloaded to be viewed – the casual user will expect to see results displayed on the screen after "clicking here when ready" (pressing the button prepares the csv and annotated image file for download – but as the user does not see anything change, it feels as if pressing the button doesn't do anything at all).

- Using my own transmitted light images (Fish Canyon Tuff apatite), collected in the FT lab at Trinity College Dublin using a Zeiss AxioImager Z1m microscope equipped with an Autoscan automated stage system running Trackworks, no or very few tracks are detected, possibly because of the different colour balancing and contrast in this image. A fixed 70x70 ROI was chosen. A typical example of the images used is shown below (width 127 microns);



- The vertices of the interactive ROI generated using the browsers MS Edge, Opera, and Chrome are offset from the click locations. The image below uses an image with overlay from Trackworks to illustrate the problem in Chrome: the vertices defined by boxes are the click locations, and the offset vertices of the second polygon are the AI-track-tive vertices. In Opera and MS Edge the offset seemed worse. There is also the issue that left-clicking an image in Chrome (and other browsers) often brings up a menu, which obscures the grain.



- Pressing the “Start application” button with an interactive ROI defined gives the error message “Input error: An error occurred: no coordinates for the polygon were chosen”.

After encountering the problems listed above, I abandoned testing the online app and downloaded the offline version. I did not test the functionality of the episcopic/diascopic illumination or Z-stack features in the online version.

The **offline version** launched successfully on the same system used for the online tests, and the various fields in the data entry screen could be populated. I strongly recommend that the authors should load the weight and configuration files by asking the user to input a single folder location for AI-track-tive, rather than loading folder addresses from the lead author’s PC as a default and forcing the user to play hunt-the-file in the AI-track-tive folder based on the file extensions.

Running the program in automated track finding mode for apatite opened a new window, which successfully found the grain image (from my own collection) open on my screen. It is not intuitive that the user needs to open their grain image separately – I suggest including more explicit instructions (the design decision of using live detection in a separate window is really excellent because the program can be used with a live microscope camera feed without the inconvenience of exporting static images – you just need to include more explicit instructions). It is also critical that the grain image is not overlapped by any other windows, or some very strange effects occur.

However, the custom detector window did not then detect anything. Running the program again using one of the demonstration images supplied led to successful detection of tracks, but nothing else happened – no track density output? Running the program in manual detection mode caused it to repeatedly close unexpectedly when “continue” was pressed, after one of the demonstration images was loaded; loading one of my own images in manual counting mode repeatedly gave the error of a mismatch in image width (the pixel width I had entered was correct).

No further tests of the offline version were carried out, and I do not claim that the testing above has been comprehensive, but in my opinion enough bugs have been revealed to discourage the average user from proceeding.

I also very strongly encourage the authors to implement interactive ROI selection in the offline version, if possible. For the EDM approach, the ROI is often the whole grain surface, for LA-ICP analysis the ROI is normally the diameter of the laser spot (to avoid having to assume U/Ca homogeneity, which is frequently not the case). So the user will typically want to define their own ROI, and typing in pixel(?) coordinates as currently offered is not very appealing. If you insist on keeping the coordinate approach, then you need to tell the user where the origin is (top LH-corner?).

Manuscript Comments:

L.19 The thermal dependence of fission track annealing (and thus the potential for thermal history reconstruction) was recognized already by Fleischer & Price (1964, Glass dating by fission fragment tracks, J. Geophys. Res. 69,331-339) and by Fleischer et al (1965, Effects of temperature, pressure, and ionization on the formation and stability of fission tracks in minerals and glasses, J. Geophys. Res. 70, 1497-1502.). Recognition of thermal dependance explicitly in apatite was discussed in detail by Naeser & Paul (1969, J. Geophys. Res. 74, 705-710). So, long before Wagner 1981. At least one of these refs should be cited.

L.208 Either U, or uranium.

L.244 I encourage you to report recall and precision statistics for densities as low as 10^3-10^4, as low-density grains are more common than the literature might suggest. Most FT studies are applied to bedrock, and so suitable (high-U) lithologies such as granitoids are preferentially targeted. However, detrital studies also encounter apatite from unsuitable, low-U lithologies (e.g., metapelites, metacarbonates, metabasites…) for which dating must be attempted nonetheless. See, for example, Ansberque et al (2021, Chemical Geology, doi.org/10.1016/j.chemgeo.2020.119977), and Huyghe et al (2020, EPSL, doi.org/10.1016/j.epsl.2020.116078).

L. 285 You might add that AI-track-tive is also robust because it presumably does not experience changes in visual perception (and understanding) over time, unlike a human operator. This can be corrected for by regularly re-calculating one's zeta, but not many researchers I know actually do this.