STEMCorrector

software for correcting distortions in STEM images

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STEM acquisition is not a snapshot; it takes a finite time to record a full scanned frame. Therefore, any dynamical variations occurring during the acquisition are accumulated in the resulting STEM image, distorting the true structure.

One possible way to reconstruct the ground truth is to take two STEM images with mutually perpendicular fast scan directions. The reconstruction assumes that each scan row is rigid, but the row origins may vary in both the x- and y-directions.

This pair of STEM images should be taken consecutively by manually switching the scan direction with a minimal pause between the two acquisitions. Alternatively, the acquisition can be automated by scripting. Such scripts are available as open source, for instance at Acquire STEM Rotated Series.

1 What is STEMCorrector?

STEMCorrector is a stand-alone tool for correcting various types of STEM distortions in a hierarchical manner, starting from simple cross-correlation and progressing to compensation of non-linear oscillations.

The **target group**: physicists and materials scientists using STEM in research and process control. STEMCorrector facilitates:

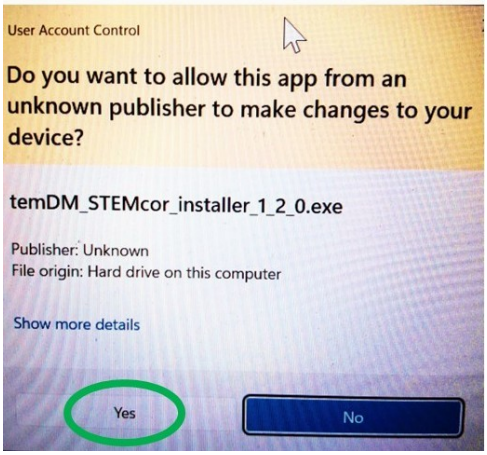
- import/export of STEM data from most common formats,

- alignment of subsequently acquired images,
- correction of shear and contraction/expansion distortions via affine transformation under the assumption of constant drift,
- correction of irregular oscillations occurring during acquisition of each image,
- correction of STEM spectrum-images using shifts learned from simultaneously acquired DF/BF images (under development).

2 Install STEMCorrector

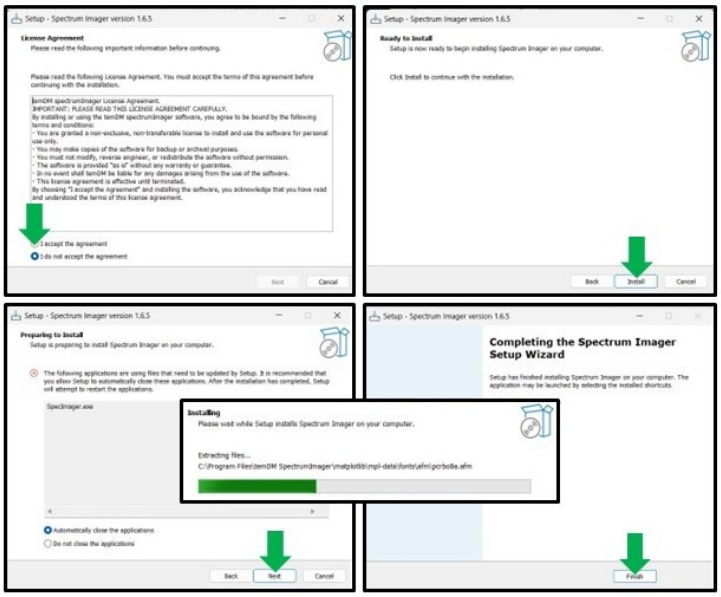
Windows: Auto-installer (most convenient)

Download and run temDM_STEMcor_installer_1_X_X.exe with administrator rights. You may see a rather alarming warning:



This appears because Microsoft does not recognize small companies like TEMDM. That would be hopefully changed in future. Since you visited the TEMDM site, you most likely know our products and trust them. Simply press "Yes".

You must then read and confirm the license agreement and press the confirmation button a few times.



After the procedure is finished, the package is installed in "C:\Program Files" (unless you changed the default directory) under the name "temDM STEMCorrector". The License.txt file is also stored in this folder. If installation went smoothly, you should also find STEMCorrector on your desktop.

Updating works exactly the same way. The installer will automatically replace the old components with the new ones.

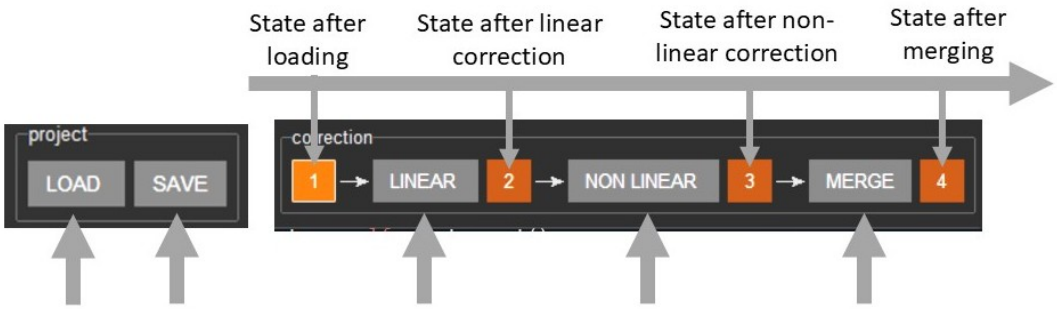
Windows: Manual installation

- Download and unzip the file “temDM SpectrumImager_1._X._X.zip”. Copy the “temDM STEMCorrector” folder to “C:\Program Files” on your PC (administrator rights required). You may place it elsewhere, but then administrator confirmation might be required each time you launch the program.
- Find the file “StemCor.exe” in the “temDM STEMCorrector" folder and create a shortcut in a convenient place, for example on the desktop.
- Run the program by double-clicking the file or the shortcut icon.

For both automatic and manual Windows installations, after the first launch the program creates a “temDM STEMCorrector” folder in "C:\ProgramData" where personal settings, the current file path, and the log file are stored.

3 Quick Start

STEMCorrector is designed with a minimalistic concept — keeping the interface as simple as possible while still providing the full functionality. If you think the workflow could be made even easier or more convenient, please share your feedback.

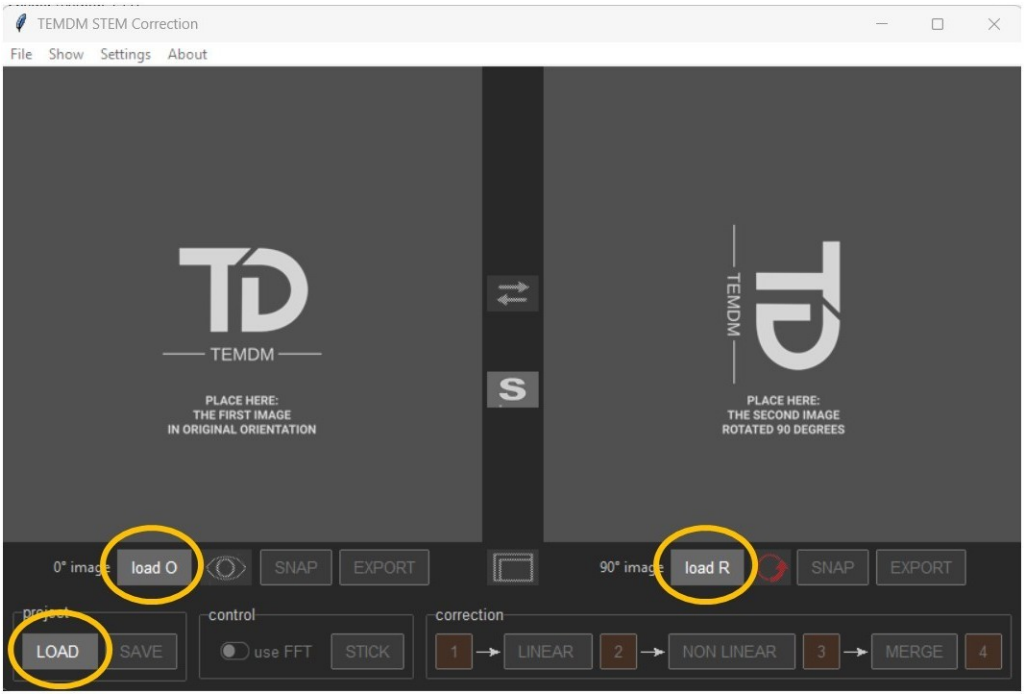


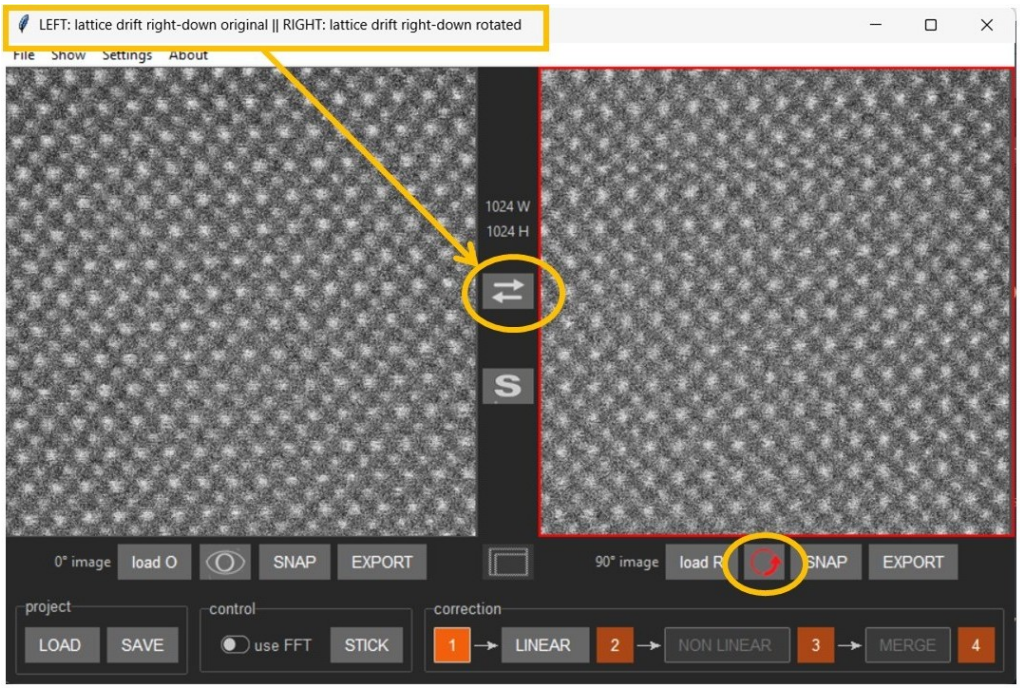
3.1 Basic Flow

The basic workflow proceeds by pressing the buttons in the lower band of the tool. The user simply clicks the processing buttons from left to right and visually checks the results. You can always return to previous processing steps to inspect the correction state. Finally, the project and intermediate images can be stored.

3.2 Load Data

As mentioned above, two essentially identical images acquired in the original orientation and in the 90-degree clockwise-rotated orientation are required. The former should be placed in the left window and the latter in the right window of the tool. The easiest way is to click the **open O** or **open R** buttons and choose the corresponding files, for example in Gatan dm3/dm4 format.

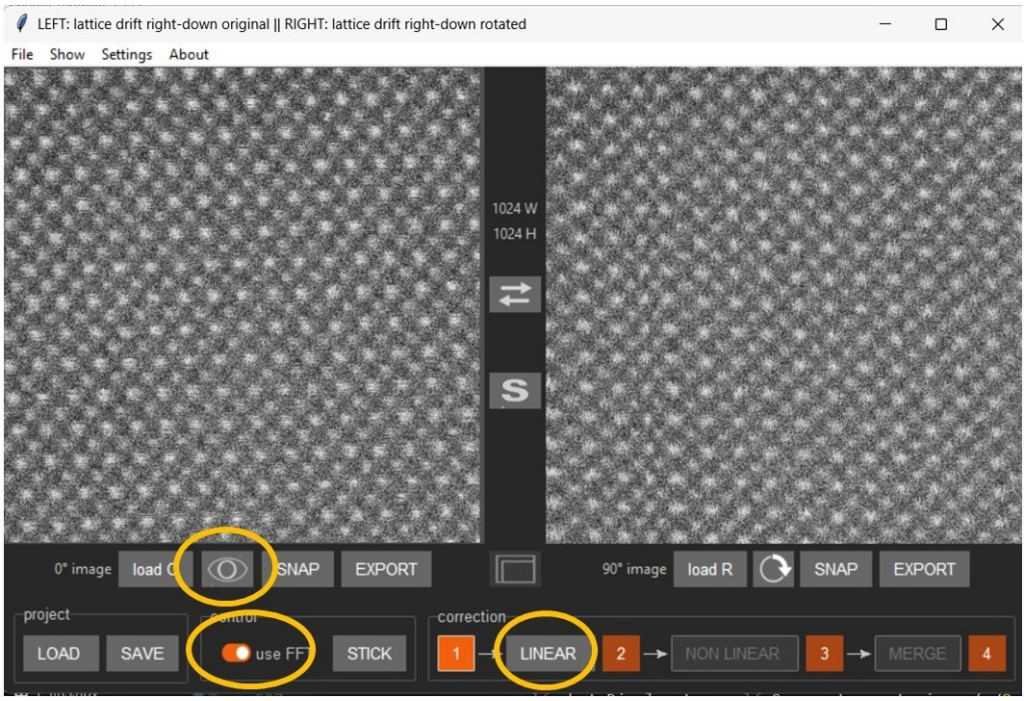




You can also load two files at once by clicking the **Open** button in the project field and selecting both files while holding the *CTRL* key.

The image in the original orientation must be on the left and the rotated one on the right. You can verify this by reading the captions in the upper bar of the tool. If the images are swapped, exchange them using the ⇄ icon between the windows.

You might wonder why the right image has a red border. This simply reminds you that it is rotated relative to the left one. It is recommended to click the ↻ icon for better comparison (the red border disappears).



3.3 Linear Correction

Even after rotating the right image clockwise, the images still appear sheared relative to each other. This is due to linear drift during acquisition, which distorts the lattice. You can visualize this clearly by clicking the small icon under the left image — this briefly switches between the two images.

It is now time to apply linear correction. The program determines the shift between the two images and calculates the continuous drift, provided that *the pause between the two acquisitions was minimal*.

Before starting, determine whether your images are atomically resolved. *This is very important*, as the shift is evaluated differently for different resolutions. FFT analysis is used for atomic-resolution images, while cross-correlation is used for lower-resolution images. The FFT method does not work for low-resolution images, while cross-correlation for high-resolution images is reasonable only if a clearly recognizable pattern exists on top of the atomic lattice.

After choosing the appropriate method, press **LINEAR**.

3.4 Frame Size

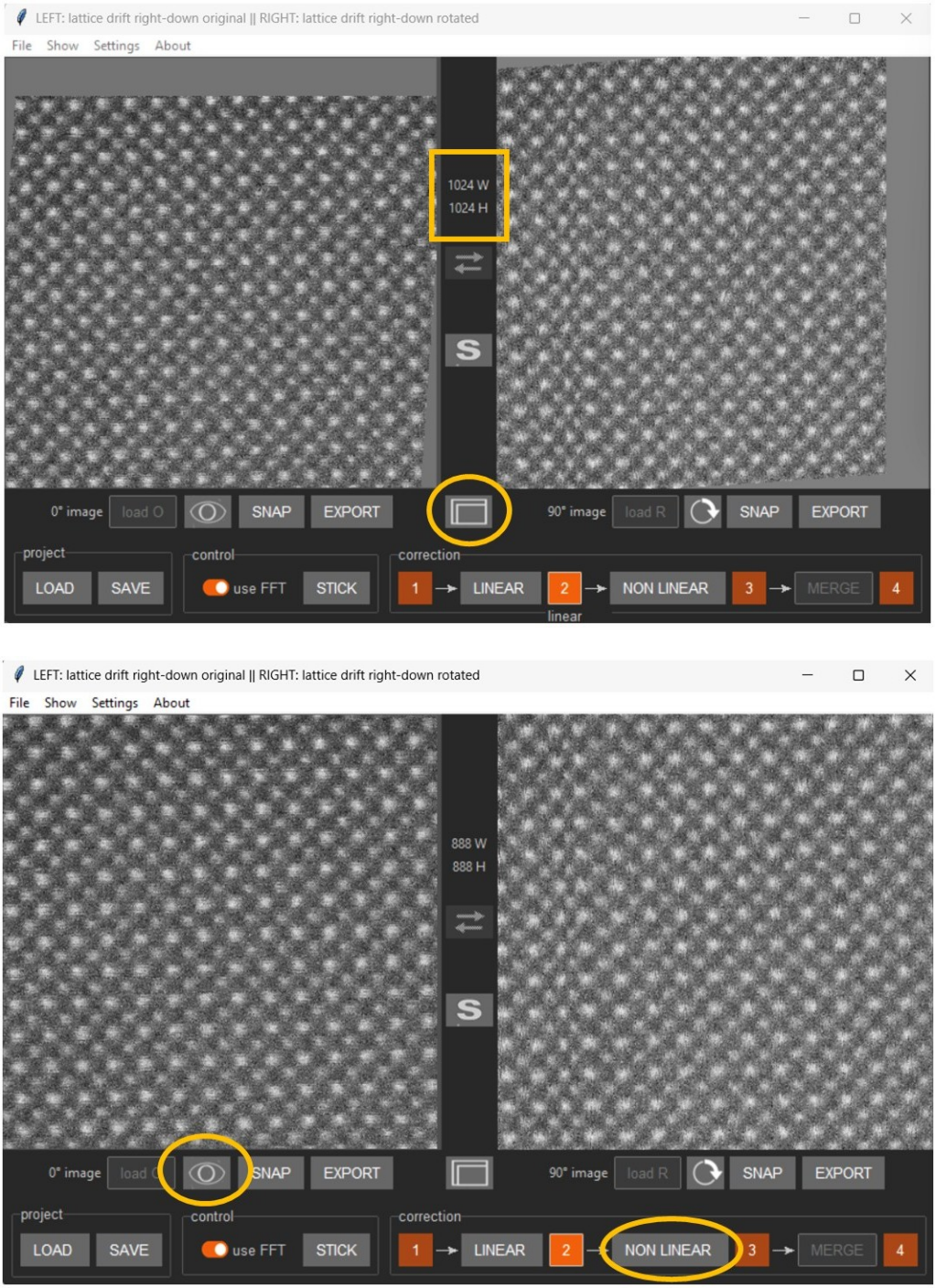
The affine transformation changes the image size. Between the left and right windows, there is a "frames" icon that allows you to view the results in different frames.

Initially, the display retains the original image size, cutting off some edges. The first click shows the complete (largest) view of both images. The second click shows the minimal area, i.e. a rectangle with no out-of-image pixels. Further clicks cycle through these views.

The current image width and height (in pixels) are displayed in the bar between the windows.

3.5 Non-Linear Correction

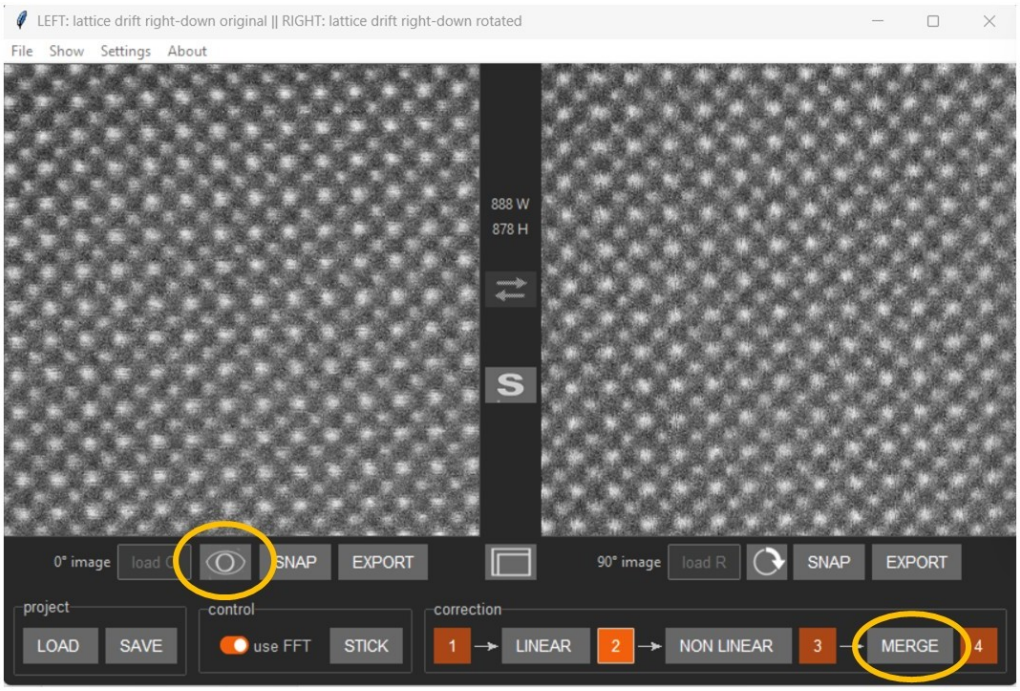
Although linear correction significantly improves the agreement between the left and right images (check with the click), it may still be insufficient. You may observe local jumps and shears, as well as a general misalignment.

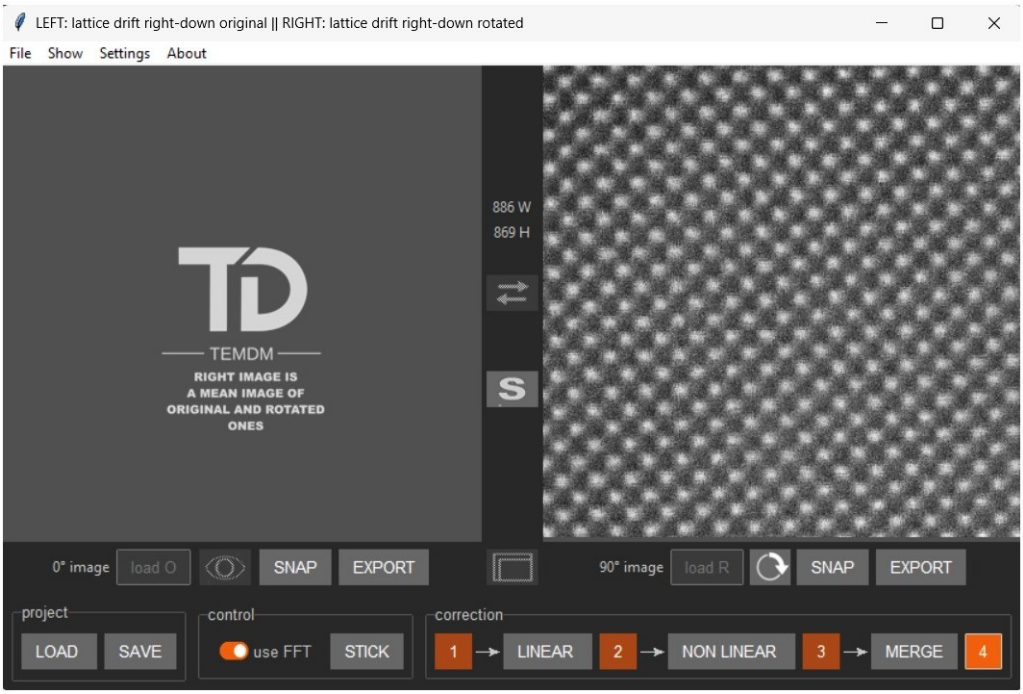


Press the **NON LINEAR** button and, hopefully, achieve a better match between the two images.

Note that no explicit reference is used for this correction. The method relies solely on the different distortion orientations in the two images, so the result should approach the ground truth.

3.6 Merging Images

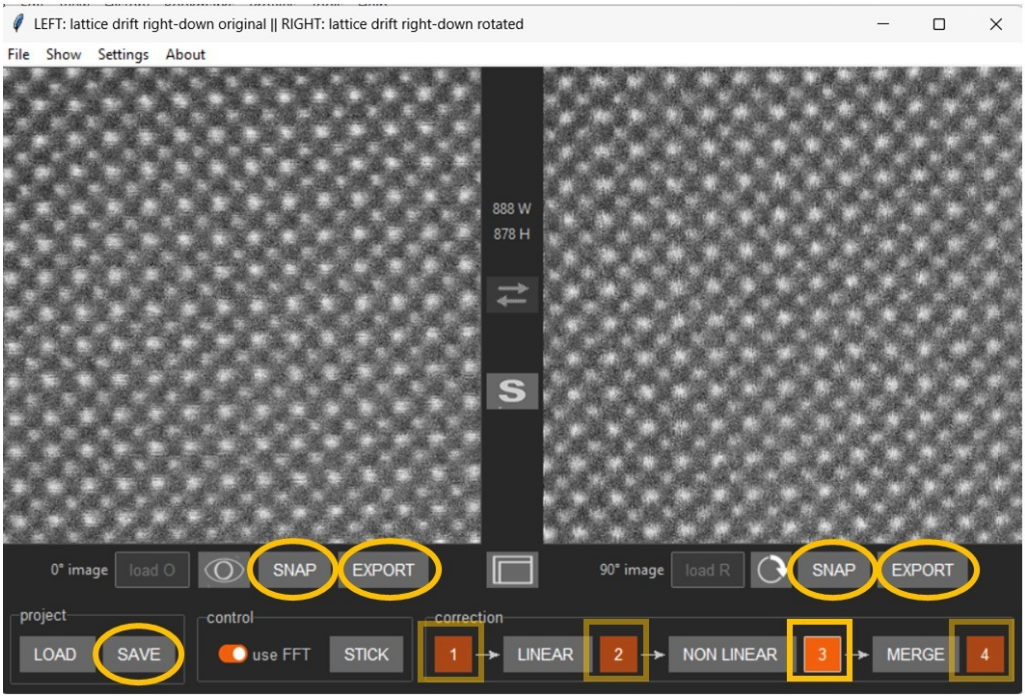




You may want to sum both images to improve statistics or smooth small imperfections not fully corrected.

Simply press the last processing button — **MERGE**.

At this step, the frame size cannot be changed; only the minimal common area (with no out-of-image pixels) is used.

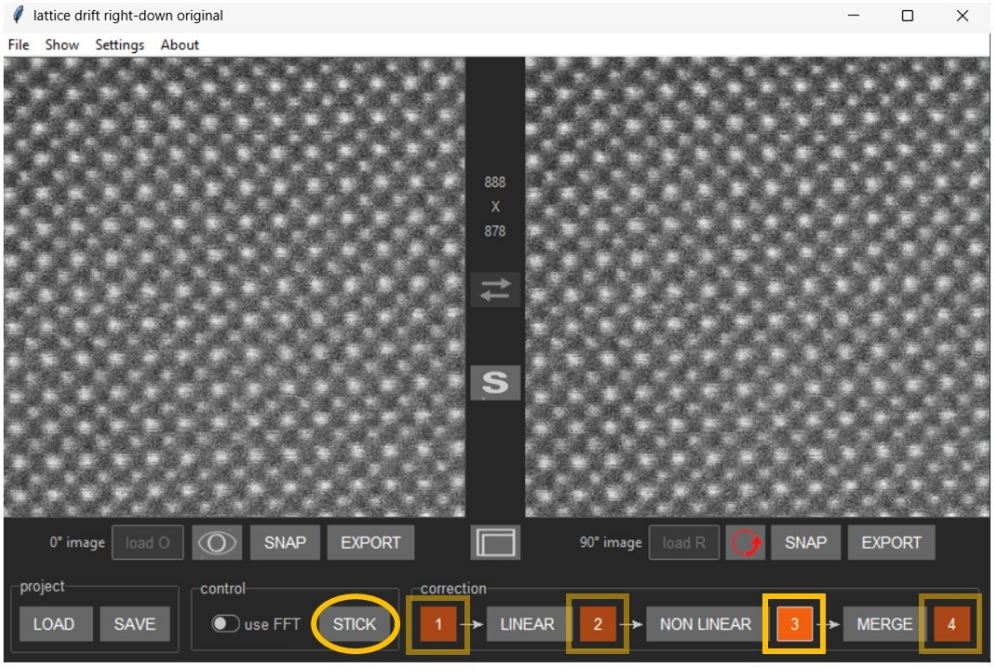


4 Storing Results

The square numbered icons at the bottom bar represent the correction steps. By clicking them, you can view previous states. At each step, you can export the left or right image (**EXPORT**) to Gatan or other formats, or store a snapshot display as jpeg (**SNAP**).

It is also recommended to save the entire project in the native TEMDM format. Press **SAVE** in the project field. You can later reopen the full image set without repeating all processing steps.

5 Sticking Points



You may notice that the correction example above contains one inaccuracy — the left and right images are shifted relative to each other by half a lattice period. As a result, the superstructure is washed out in the merged image.

Such a shift can occur because the algorithm struggles to distinguish two sublattices, especially if the difference in atoms intensity is not large.

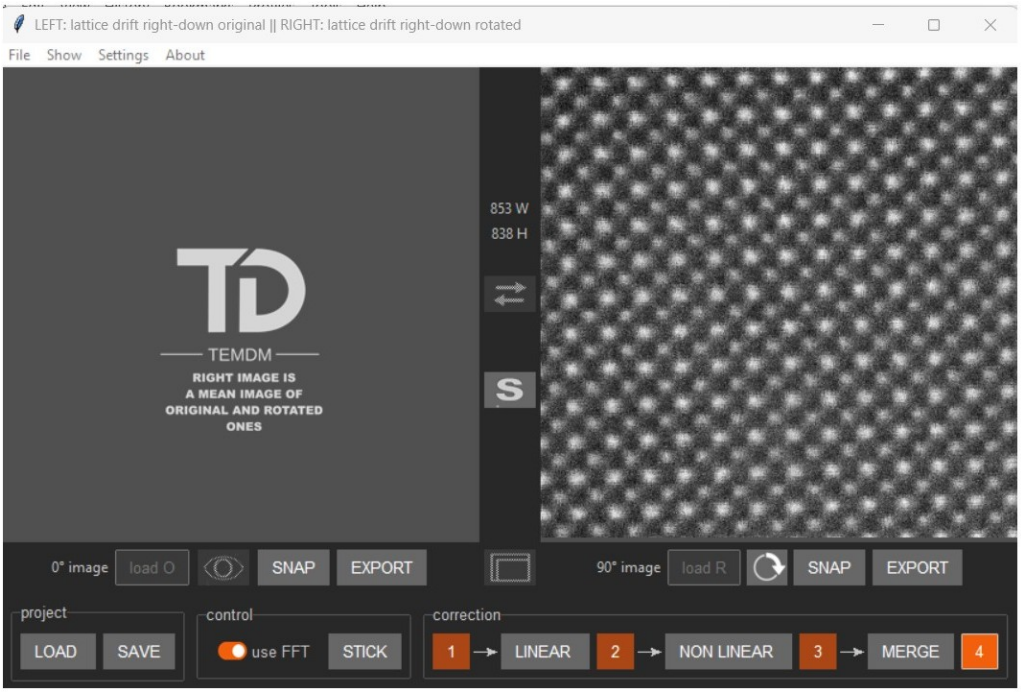
The easiest fix is to guide the tool using *Sticking Points*.

Go to the previous step (square button — State **3**) and press **Stick**.

Two red circles appear in the left and right images. They are supposed to mark the same structural motif, but they do not — brightest and weakest atoms are interchanged. This clearly shows the half-period shift.

To fix it, drag one circle to a recognizable pattern. The second circle moves synchronously, which is not desired. Uncouple the circles using the switch at the lower-left of the tool. Then place the second circle on the same motif and click **Confirm**.

Then press **MERGE** again and observe the improved result. The sublattices are now clearly recognized.



6 FAQ

1. **Is STEMCorrector free?** At the moment, yes. After full debugging and refinement, the code is planned to be released as open source. However, software development is costly and must be supported. Future versions may be available by paid subscription.

2. **Does it require other software like DigitalMicrograph or Python?** No. It is a stand-alone application compiled for Windows (Linux planned) and works independently of other packages such as Python. Moreover, it can import and export formats from most common microscopy suites, e.g. DigitalMicrograph, TIA, PantaRhei, etc.

3. **Is STEMCorrector a successor of the temDM DigitalMicrograph STEMCor plugin?** Yes. It inherits many features of the temDM plugin while introducing new options. It is also faster and more robust, not to mention easier to use. Users of STEMCor plugin are strongly encouraged to migrate to STEMCorrector.

4. **Does it use an internet connection?** No. STEMCorrector does not use internet commands and does not require a connection. The help system may open your default browser, but only to display local HTML files included in the package.

5. **Where are logs and settings stored?** In Windows: C:/ProgramData/temDM STEMCorrector/.