Multiple Position Tracker
mPosTracker

User Guide

Version 1.00

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Abstract

This manual presents the properties of the proposed software and a few example analysis with screenshots for multiple particles images.

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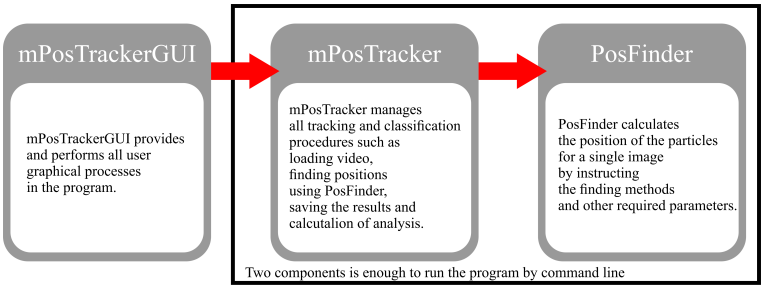
1 Introduction (Main Functions)

mPosTracker consists of the three basic components which are explained as below graphical schema. The first component is mPosTrackerGUI that menages all graphical user interface processes. The second is mPosTracker that performs all procedures of tracking and classification including loading video, saving the results and calculating the physical amounts. The third component is PosFinder that finds the position of particles for a single image. PosFinder also obtains active areas, amount of regions above the threshold value, and average intensity of the active area. Thus, these information are used in the classification process.

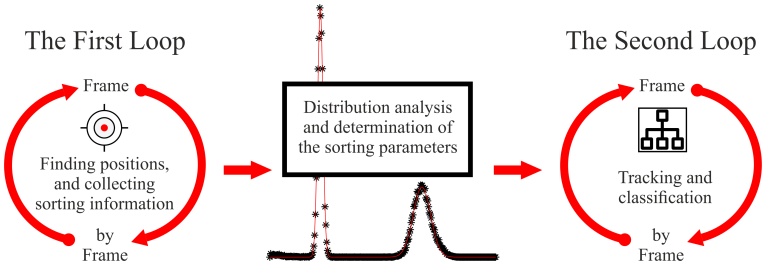
- mPosTrackerGUI: It menages all graphical user interface processes
- mPosTracker: It performs all procedures of tracking and classification
- PosFinder: It finds the position of the particles for a single image



All components are designed as a class to definite object including variables and methods. The components are typed in MATLAB which provides a strong platform to perform both numerical calculation and user graphical interface. Thanks to user graphical interface users can easily menage their tracking projects including loading video, tracking, classification, extracting trajectories, some basic physical analysis. Users can save their results as a tracking project and can load later to make additional analysis.

The other important property of the software is that the program can be executed by command line using only the second and the third components. This property provides to users designing a solution for their own exclusive problems users meet.

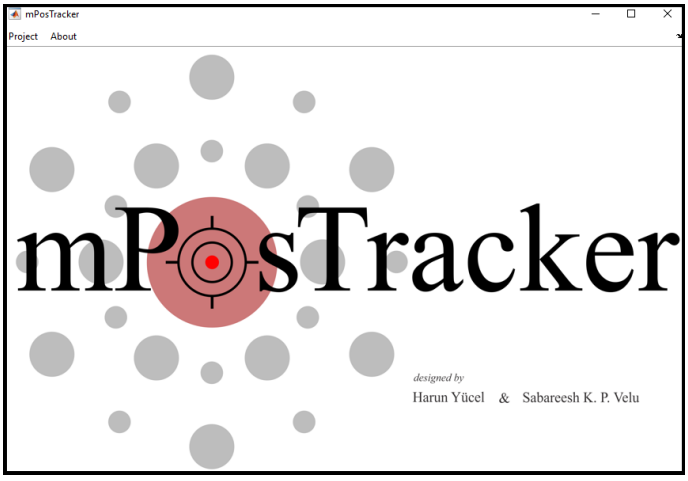
As understood from below figure, the program obtains the trajectories of the particles throughout two main loop. First, the program finds all particle positions over video images meanwhile collects information about particle species. Then in second loop, the program links the positions as a time series frame by frame and classify them according to active area size or average intensity of the active area.



The first loop can be slow in case the number of the particles is huge because to calculate the positions of all particles takes time. In contrast, the second loop runs faster than the first loop and can be executed many times to get optimum tracking and classification result after the particle positions are obtained once.

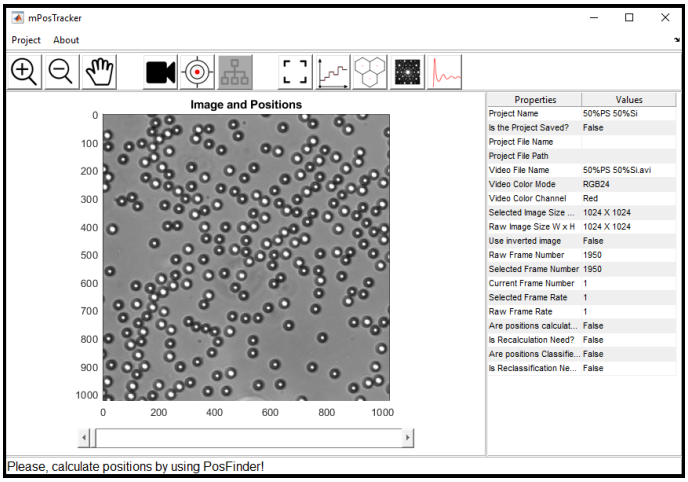
2 Quick Start (an example step by step)

- Running the software
  To run the software, please follow the below instructions.
  - Open the file "RUN.m" in Matlab's editor
  - Run the file using Matlab editor run button
  - Change the current folder to the folder of the file "RUN.m". This is important for running the software properly.



- **Creating a new project**
  A project consist of video file path, analysis parameters and all trajectory results. A new project can be created with a video file or a already created project can be loaded. The video file should be in AVI format. The project

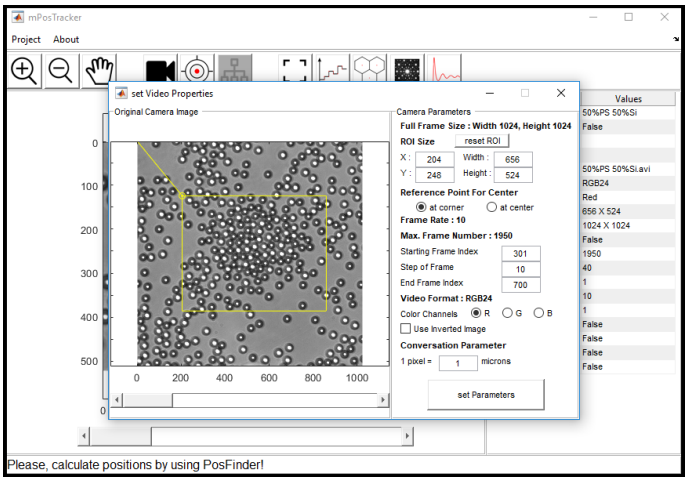
files have “*.mPos” extension name. If loading a existing project, the video file should be in previously recorded folder path. Otherwise loaded project file will not run properly. The software does not change anything on the video file.



After creating a new project with video to be analyzed, the software appears as above figure. At this state, the configuration parameters as video parameters, analysis method properties can be adjust. All properties can be observed on the properties table.

The scroll-bar provides to change the current image of the video shown on the the window. Users can also observe the current image index from the properties table.

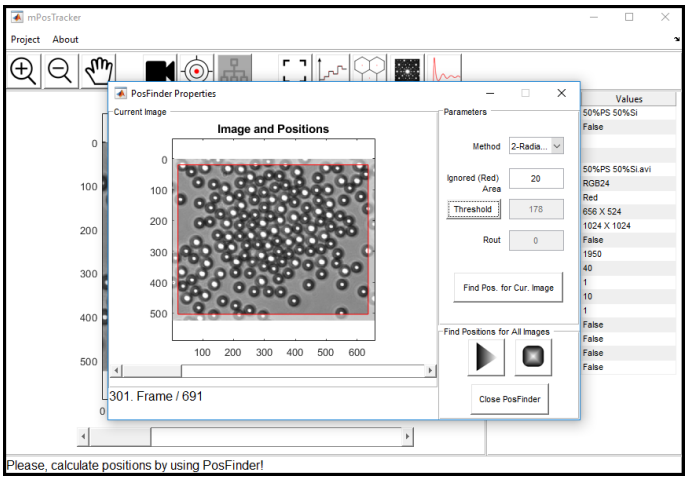
- **Setting video parameters**
  When clicking video parameters button, the below widow will open.



In this window, one can perform the following properties

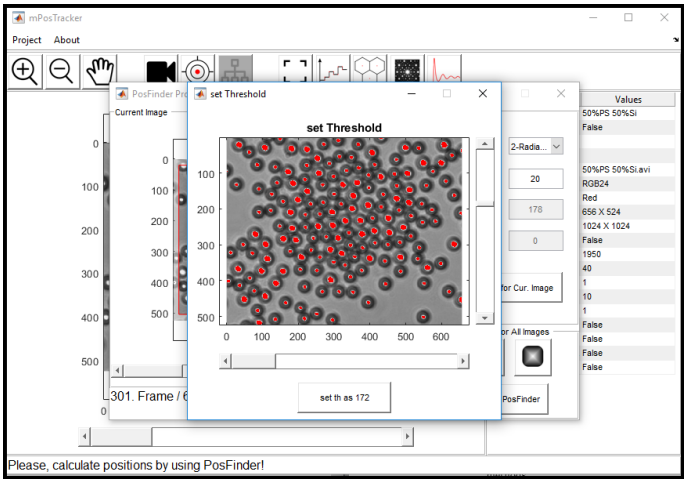
- A fraction of the full video area can be used by setting ROI size. ROI size can be chosen by drawing a square with mouse on the video image.
- A part of the full video frames can be used by setting the starting frame and the end frame indexes. Also, step number between sequential frames to be analyzed can be adjust by setting the step of frame property.
- The software can only use gray scale image. Thus, a color channel should be selected (R, G or B) for color videos.
- If require, inverted gray color can be used in the image analysis.

- **Setting PosFinder Parameters**
  After configuration of the video properties, the positions of the particles can be found by clicking PosFinder Properties button. In the opening window, both the position finding parameters and the calculations of the positions for all frames can be performed.



Before calculation, the following parameters can be adjust.

- Position finding method can be chosen by selecting one of three options centroid, radial symmetry or partial radial symmetry.
- The ignored area can be changed from its default value to another value. The ignored area provide to avoid finding incorrect position where the particles are close to image borders.
- The threshold is the base parameter of the calculation of the position for all finding methods.

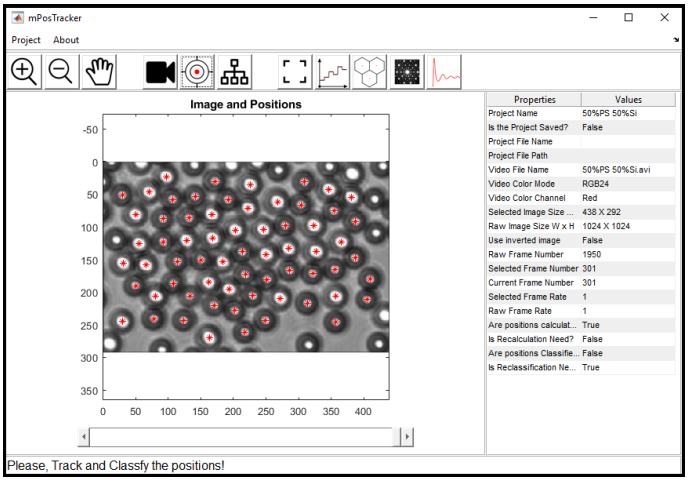


Its value is important to determine particle's central bright region. And the threshold parameter is essential to separate particles each other. The threshold value could be changed by using vertical scroll-bar. At this point, users can check how the threshold value yields the results by changing the current image with the horizontal scroll-bar along the video frames.

– During use of partial radial symmetry method, the effective radius parameter (R_{out}) should be given.

After setting the finding parameters, one can test the performance of the parameters by clicking Find Pos. button. This button runs the algorithm for current image with given parameters and the result positions appears as green points.

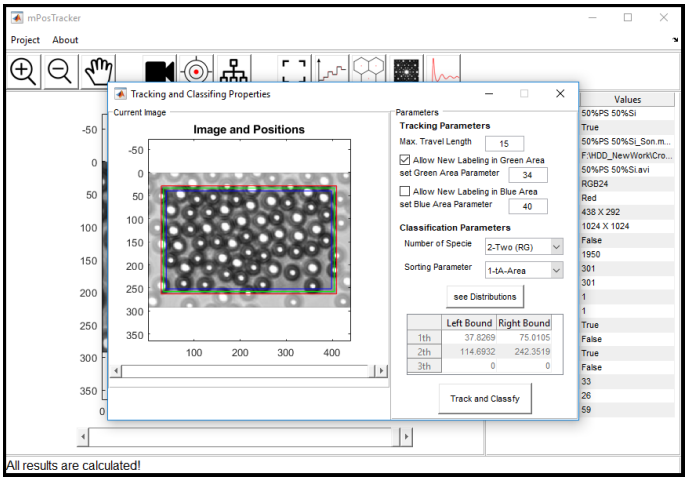
Start button performs the algorithm with given parameters for all frames. This process can take long time according to particle number and image size. To reach the results, this step should be performed for any project. The software first finds all positions for all frames. Then links the positions between frames and classify particle species.



- **Setting Tracking Parameters**
  If all positions for all frames are calculated in PosFinder window, the track and classify button will be active. By clicking track and classify button, the tracking and classifying properties window can be opened. At this point, all tracking properties as areas, travel length and all classification parameters as particles species, base separation parameter (sorting parameter) can be adjust.

  For tracking properties, the most important parameter is the maximum travel length which is in pixel unit. The parameter determines maximum displacement of a particle between sequential two frames. If a particle's displacement between sequential frames is smaller than the travel length parameter, the particles take the same label. It means that the particle take places different position at different time. This is the base technique used by the software in order to extract the particle's trajectory in time.

  The other important parameter for tracking is the parameter of the trackable areas. The software can track the particles which is not in the camera view at the beginning. One particle can come into the camera view after starting to record. The software gives new label for such particles and can track it till it goes to out of the camera view.

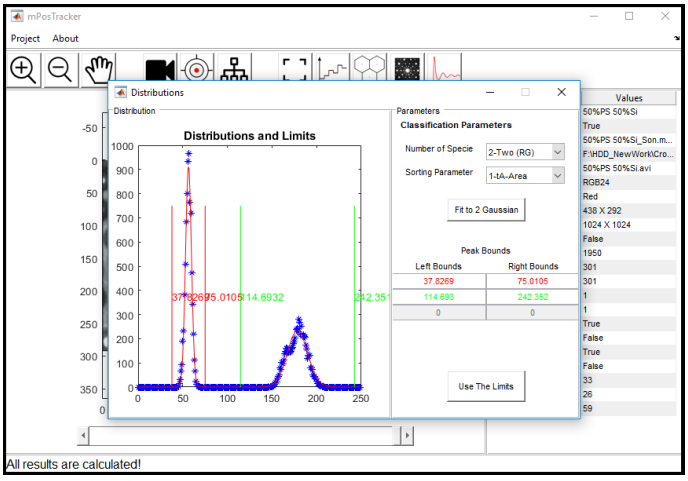


For this aim, the software uses the two areas within the ignored (red) area borders. One of them is the green area which permits to take new labels if the particles is in the green area. The second area is the blue area which doesn't permit to take new labels if the particles is in the blue area. This structure provides that if a particles comes into the camera view by passing the region between green and blue lines, the particles will take new label and the software will track it. Otherwise the particle will not be tracked.

This configuration is default in the software. Users can change the properties of the green and the blue area by clicking the check boxes.

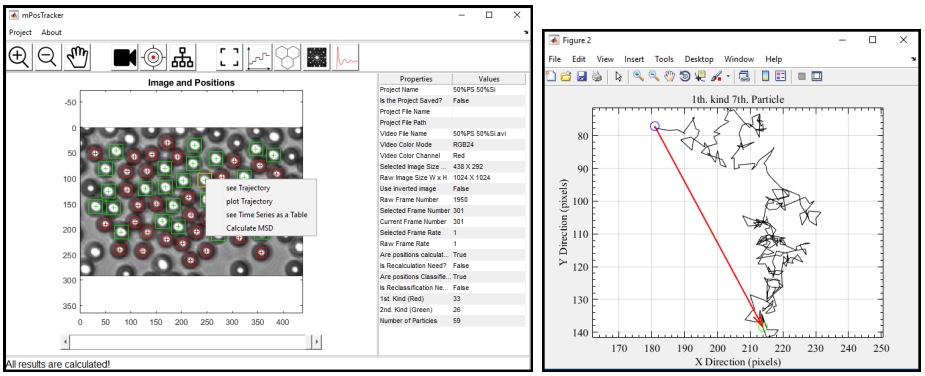
- **The Classification of Particles Species**
  The most important parameter for the classification of the particles is the area size (t_A) of the particles obtained during the position calculation. The area size is the size of the region which has higher intensity values than the threshold value for a particle intensity distribution. Different particle material or particle size creates different type intensity distribution on camera image. The software uses this property to separate the particles. If the area sizes of all particles in the all frames can show a separable distribution, the software can use this distribution to classify particles. After Users determine the number of particles species, can see the particles area size distribution by clicking "see distribution" button. After clicking the button, users should determine the peak bounder parameters by hand or by fitting Gaussian curve.

  Once the bounder parameters for each peak in the particle area size distribution are determined, the software can track and classify quickly the particles by clicking "Track and Classify" button.

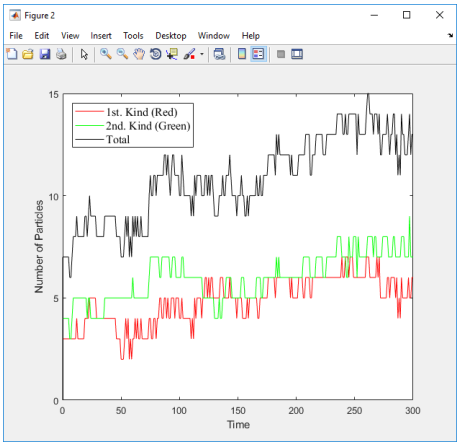


At the end of the process, the software will present all results in the main window where users can perform additional analysis.

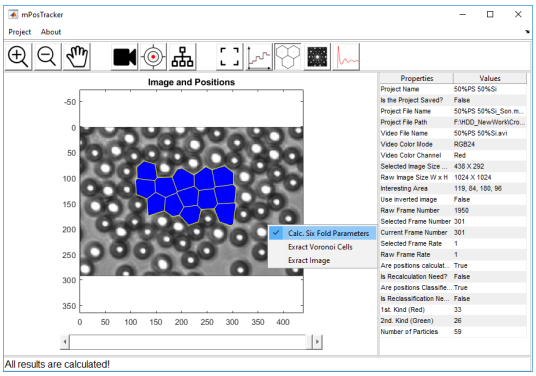
- **Data Analysis**
  The software includes two popup menu which appears by right clicking. One of them runs when users right click on the particles square and presents some basic calculation options can perform by using the found positions. When users right click on the image where no particle, the second popup menu appears. For example, right click to see all particles trajectories on the main window.



The important analysis is to draw the number of the particles within the interesting area. The area can be determined by clicking “Interesting Area” button.

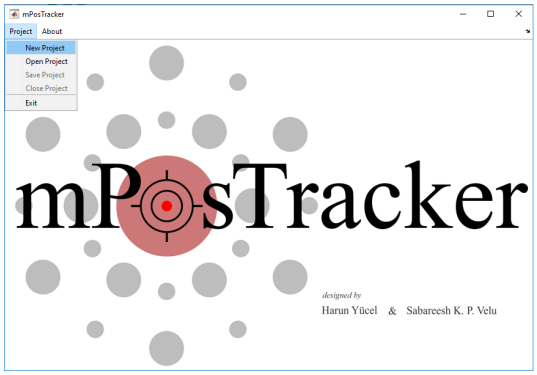


Addition to the number of the particles, the software can draw voronoi diagrams within the interesting area by clicking "Voronoi Cells" button. Moreover, the software can calculate six fold bound parameters for each voronoi cells.

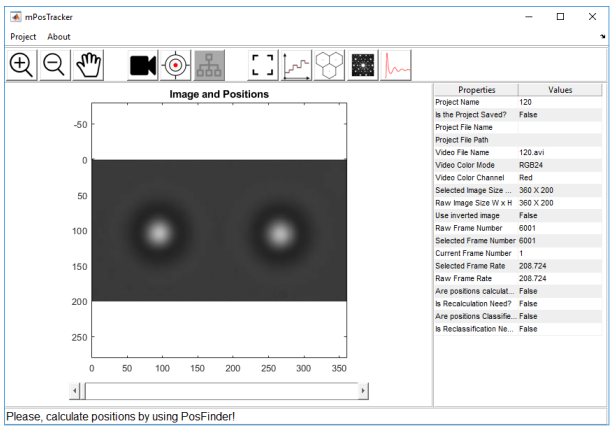


3 An example for two particles

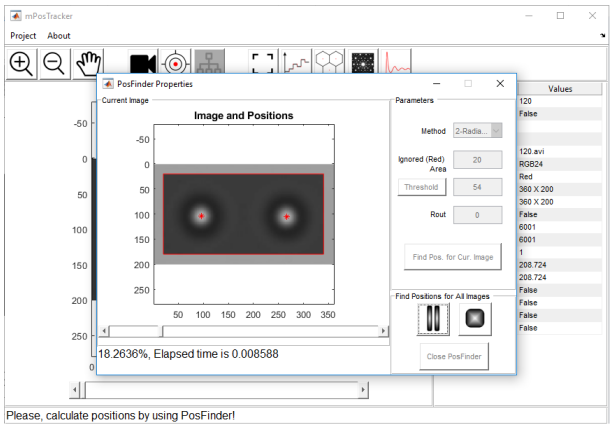
Create a new project by choosing related video file.



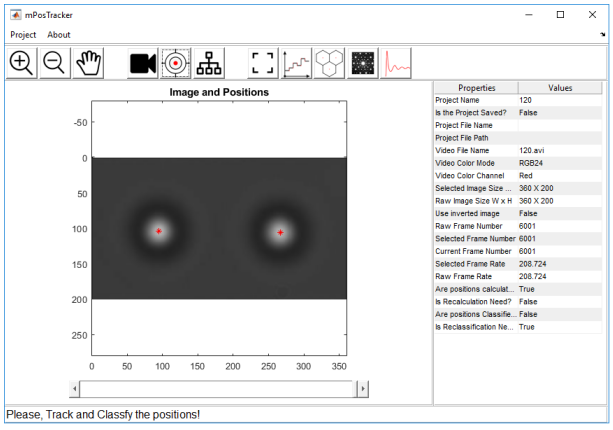
For this file, it is not necessary any configuration on video properties.



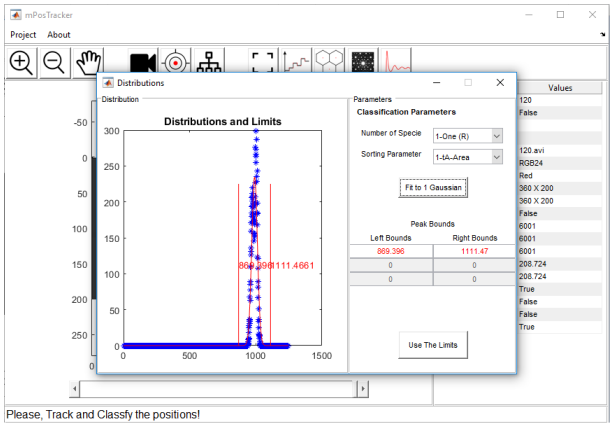
Set PosFinder properties and calculate positions for all frames.



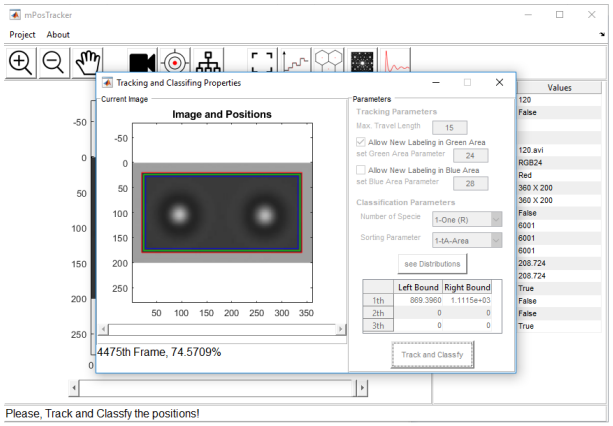
After calculation, close the PosFinder window.



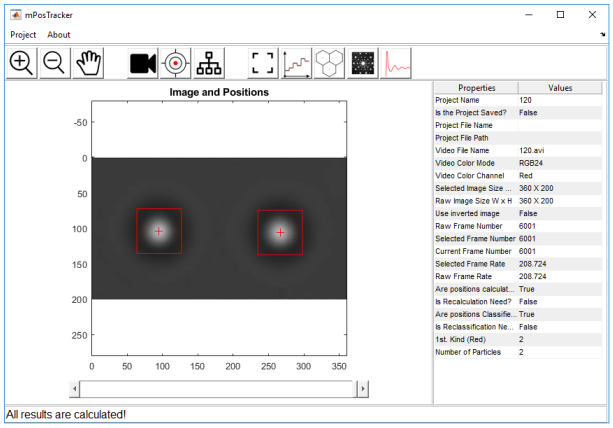
Then, set tracking and classification parameters,



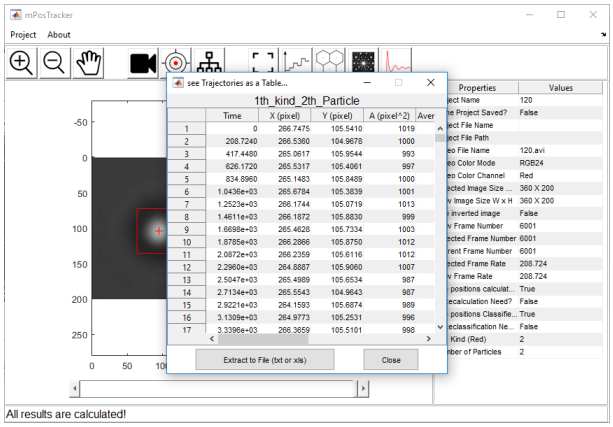
and track and classify. At this point there is no any importance of Green and Blue areas because there is no a new particle coming into the field of view.



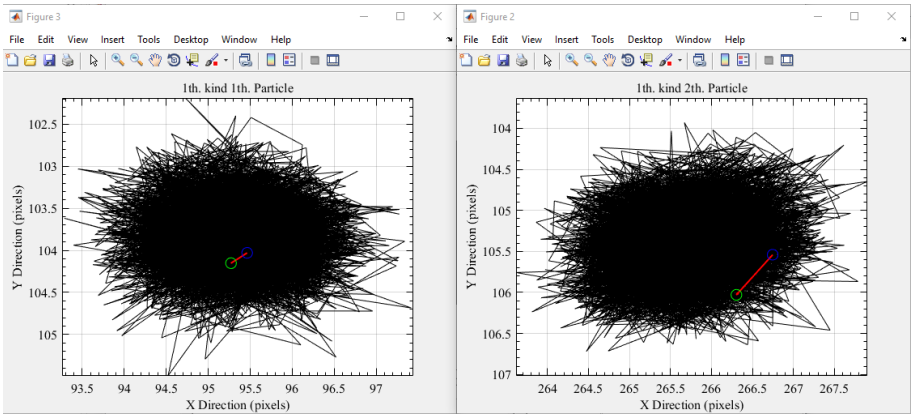
After process, you will get the results as below.



Then you can extract the position results as XLS or TXT file.

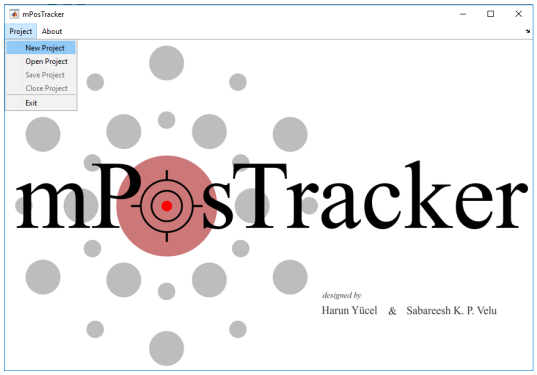


Then you can see the trajectories as separately figure by right clicking on the particle.

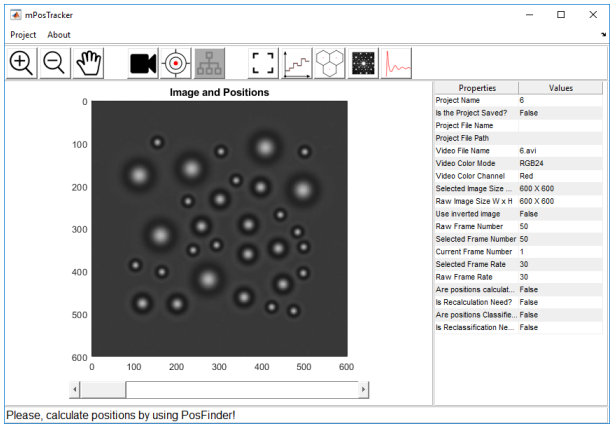


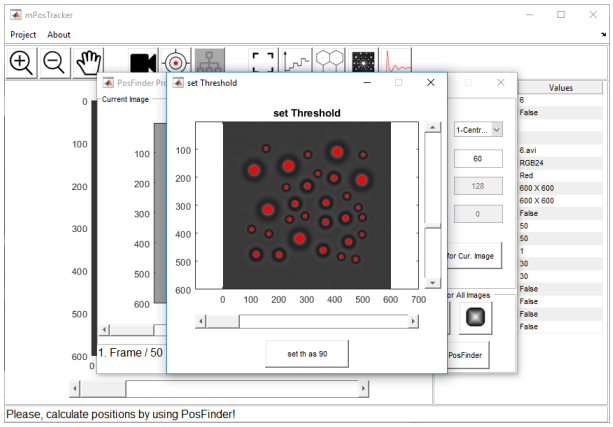
4 An example for three different size particles

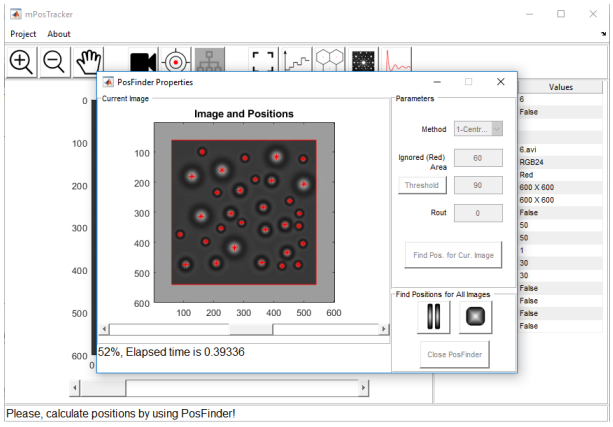
This example includes three different size particles. Please, create a new project by choosing related video file. The steps are the same. First find positions for all frames using PosFinder, then Track and Classify.



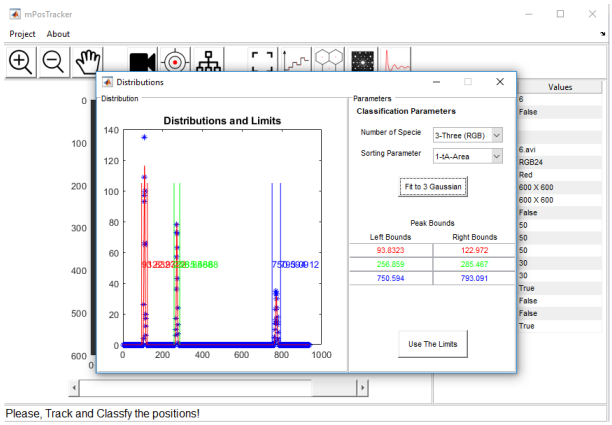
Set threshold parameter and choose detection method as is below



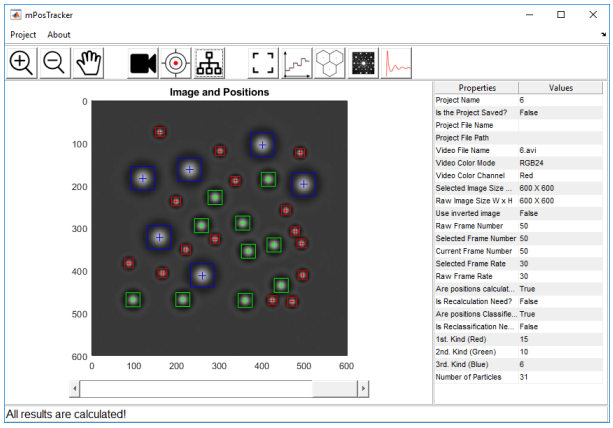




After calculation of the positions, set classification parameter. At this point, set Number of Species as three because the data includes only three different size particle.



After determination of limits values of species, click Track and Classify button to get results

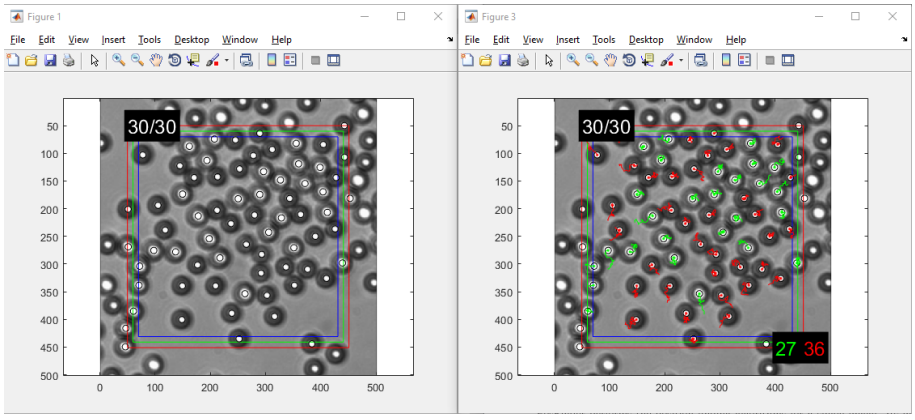


5 Command Line Examples

5.1 mPosTracker

mPosTracker can be used by command line. An example code for command line use and its outputs as follows

```
vid_patName='ExpData/';
vid_Name='1.avi';
Tra = mPosTracker();
Tra.addVideo(vid_patName, vid_Name);
Tra.th = 220;
Tra.StepLength = 15;
Tra.CalcMethod = 1;
Tra.panel_l = 1;
Tra.show_HamData = 1;
Tra.show_Num=1;
Tra.show_borders = 1;
Tra.start();
Tra.tursay = 2;
Tra.turpar = 1;
Tra.distributions();
figure, plot(Tra.centers, Tra.nelements);
Tra.limits = [20, 60; 100, 180];
Tra.Classify();
Tra.show_trajectories = 1;
figure, Tra.Show_Results();
```



5.2 PosFinder (Single Image Analysis)

PosFinder performs the position finding algorithms for a single image. Its input arguments are as follows

```
PosFinder(Image, Threshold, Ignored_Area_Length, Method, Ro);

Image --> Gray scale image and it should be double array
Threshold --> Threshold value in gray scale
Ignored_Area_Length --> Length to be ignored at image borders (Red Area)
Method --> It takes integer number.
           For Centroid method use 1 (CM)
           For radial symmetry method use 2 (RSM)
           For partial radial symmetry method use 3 (pRSM)
Ro --> If method is 3, it is required.
```

An example to find the positions of the multiple particles in a single image can be realized as below matlab code.

```
im = imread('ExpData/test_im.png');
im = double(im);
Pos = PosFinder(im, 110, 40, 2, 0);
Pos.show_panel();
disp(Pos.dCent);
```

Its output is the below figure