

Circumnutation Tracker

Version 1.1

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<http://circumnutation.umcs.lublin.pl>

Lublin 2014

Installation:

1. Download *Circumnutation Tracker* from <http://circumnutation.umcs.lublin.pl>
2. Run: Circumnutation Tracker.exe

Samples

First opening of Sample 1 or Sample 2

1. Run: Circumnutation Tracker.exe
2. File: Open project: “distilled water.db” as Sample 1 or “nutrient solution.db” as Sample 2 from downloaded Circumnutation Tracker Samples catalogue
3. “File does not exist or type of this file is invalid” press OK
4. “Opening of this video file failed, Do you want to change video file” press YES
5. Open Video 1.avi file from downloaded Circumnutation Tracker Samples catalogue

The workflow with *Circumnutation Tracker*:

The crucial steps of working with *CT* include:

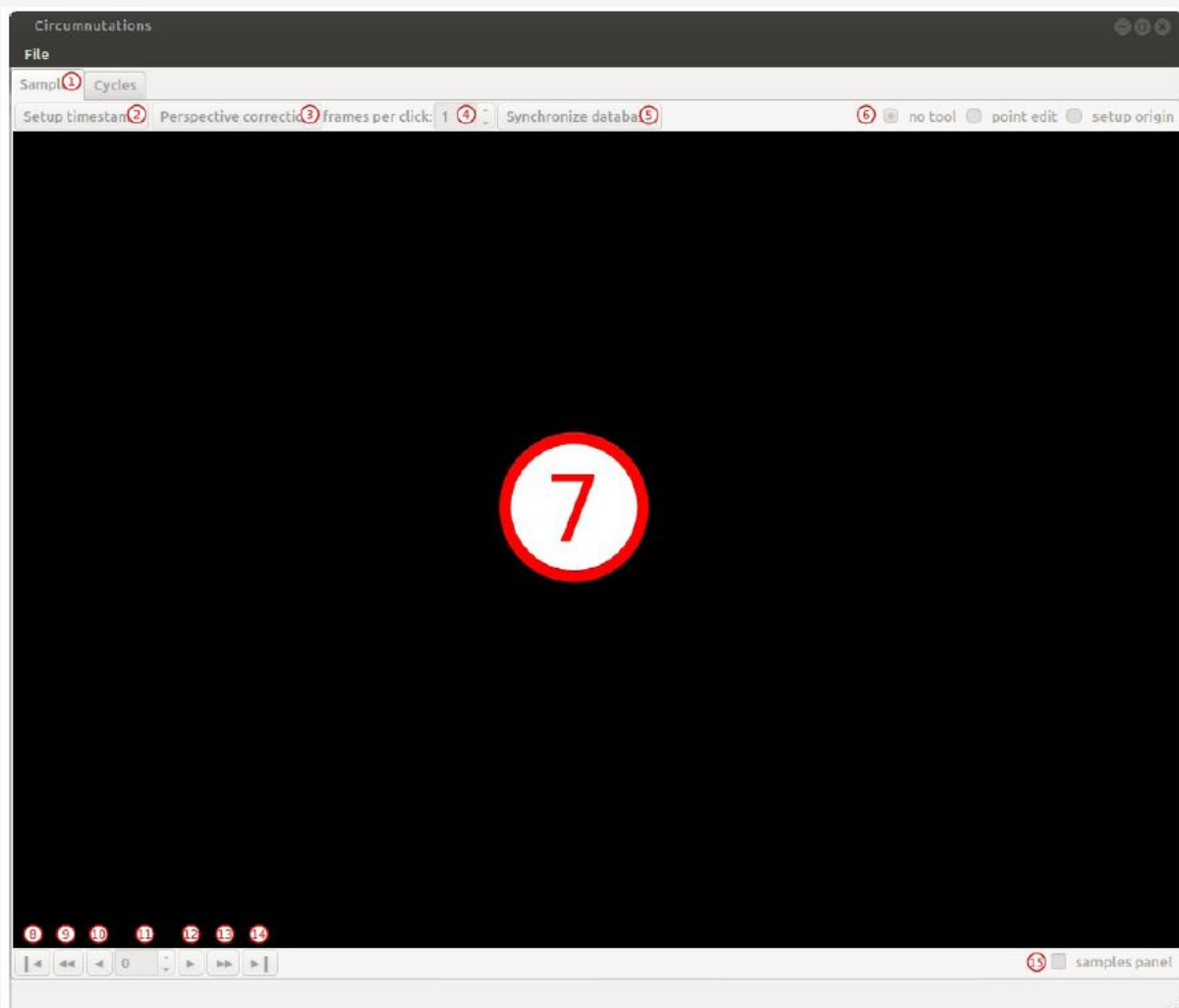
- time-lapse video loading
- calibration of time and space
- manual harvesting of coordinates x and y
- automatic determination of circumnutation parameters
- data and graph exporting

Circumnutation Tracker (CT)

Quick-start guide for new users

The main window of CT

- 1 - Current tab
- 2 - Setting timestamps
- 3 - Perspective correction
- 4 - Number of frames scrolling when clicked
- 5 - Synchronizing database - allows instant saving of the changes to the project
- 6 - Current tool
- 7 - Window of the video
- 8 - Beginning of the video
- 9 - Scroll 10 frames back
- 10 - Scroll 1 frame forward
- 11 - Number of frame
- 12 - Next frame
- 13 - Fast forward 10 frames
- 14 - End of video
- 15 - Samples panel

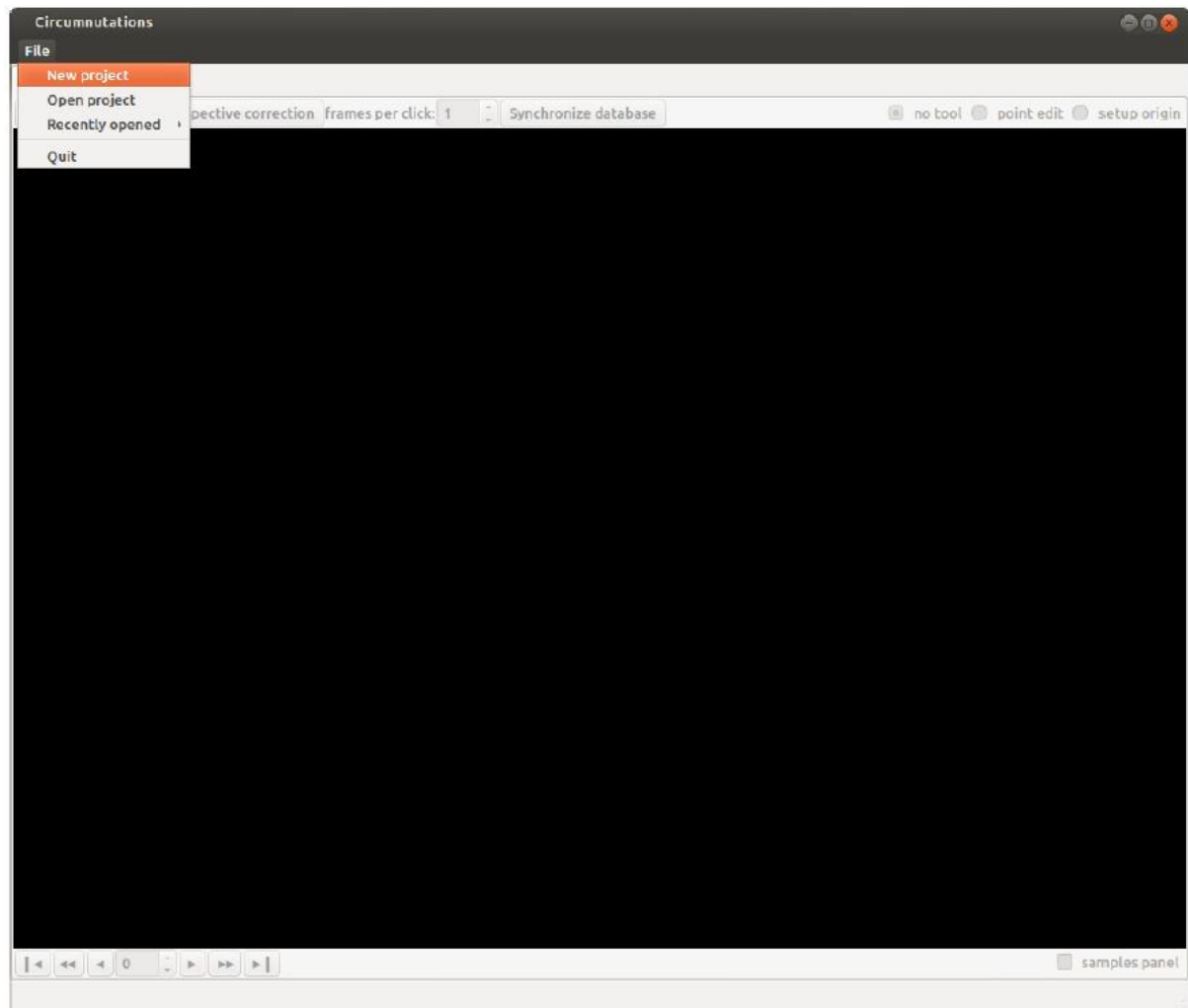


Time-lapse video format for CT

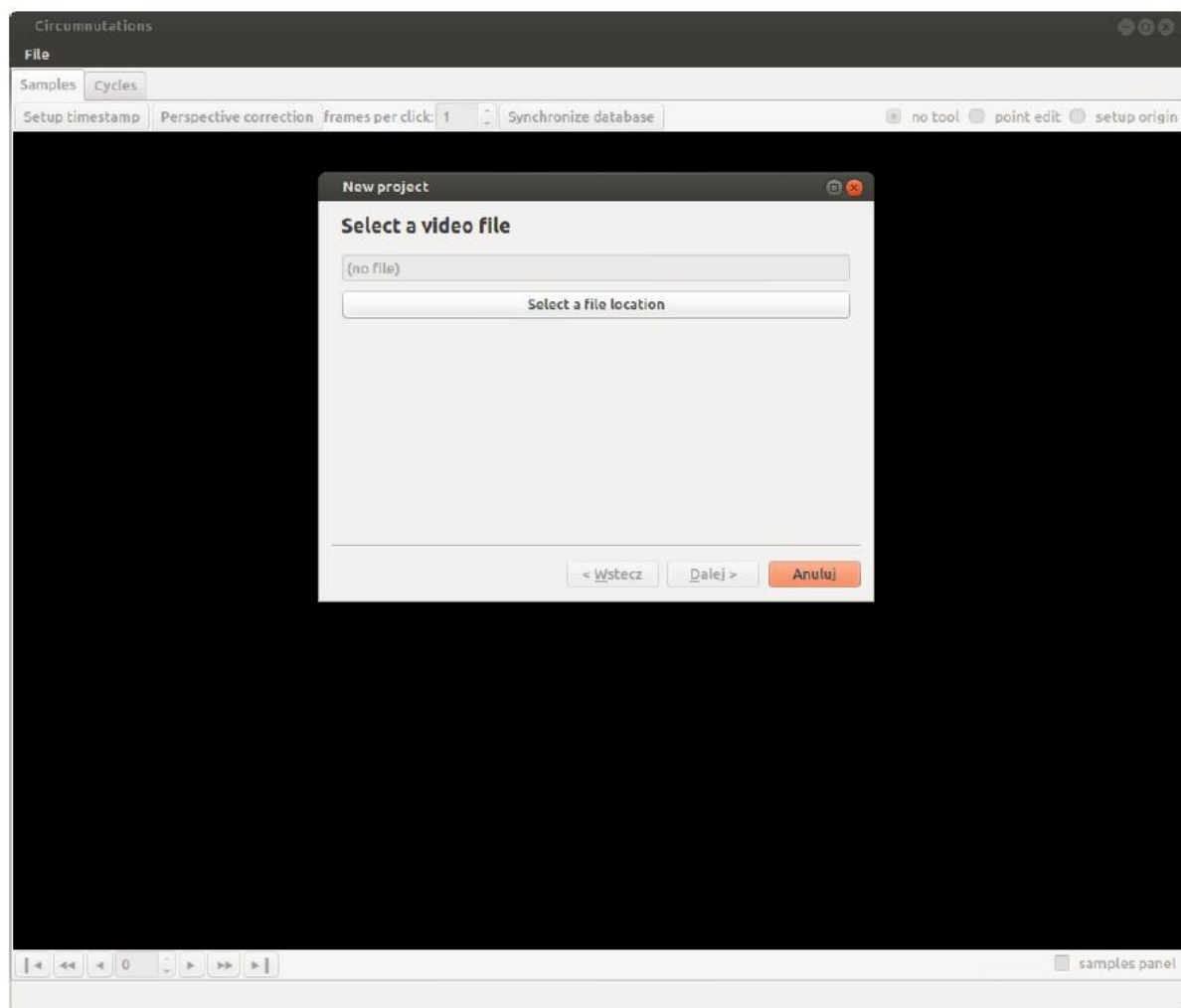
AVI video format with h.264 codec is the best format for CT. Free software - video converter - "Video to video" is recommended to CT users for converting their various video formats to AVI h.264 used by CT. The web site of this converter is <http://www.videotovideo.org> and link for it has been added to our CT web site <http://circumnutation.umcs.lublin.pl>.

Time-lapse video loading (input path)

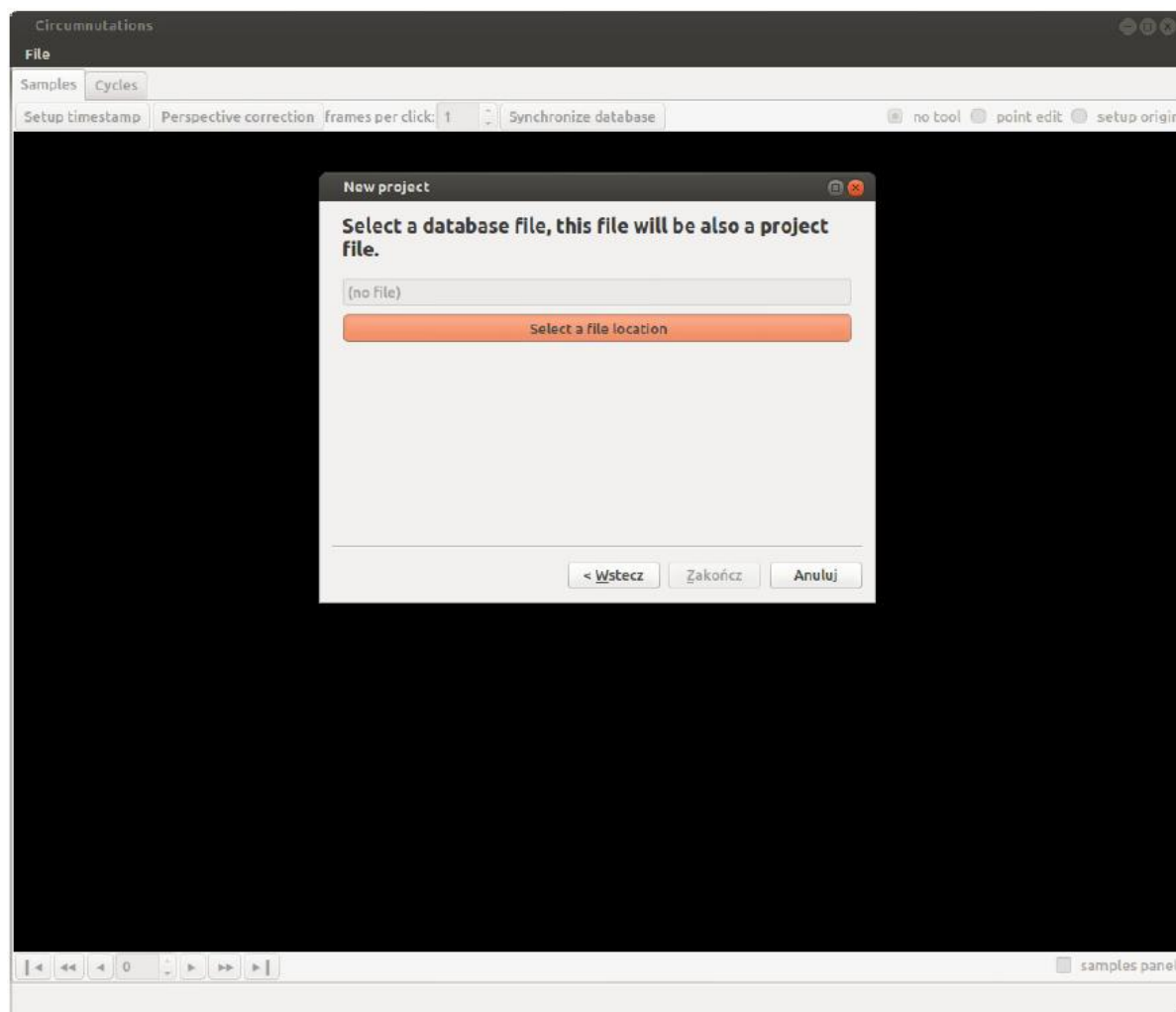
To create a new project from the menu "File" select items "New Project".



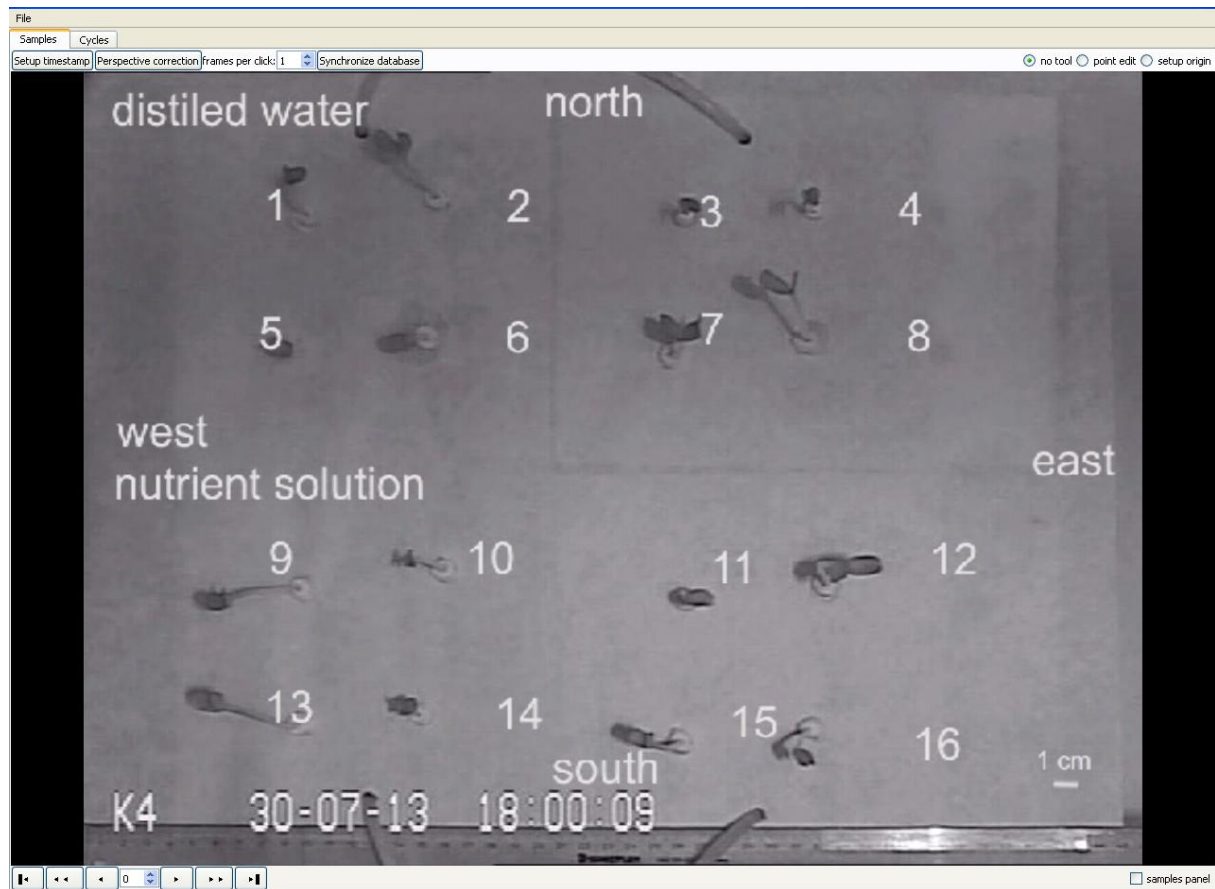
You will get a dialogue window for creating a new project. On the first page you should select the "Select a file location" to select the video file. *CT* works on black/white or colour time-lapse video images (AVI Audio Video Interleave), with any resolution. The supporting video codec's include Indeo Video 5 and H.264



On the next page, select a file, which will be a project file.



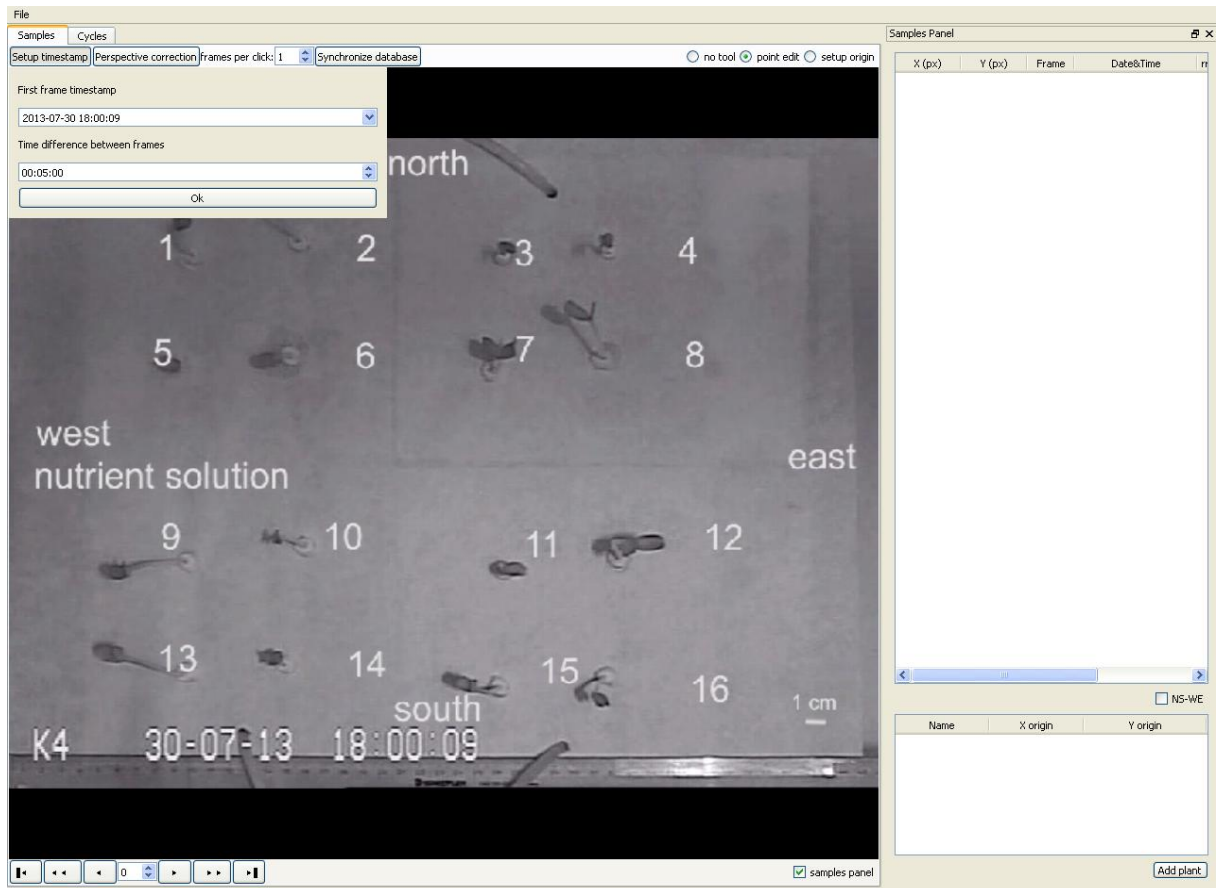
The window of the video after creating a new project



Calibration of time and space

Setup timestamp

Before x and y harvesting, the proper time should be set by using "Setup timestamp". To do this, rewind the movie to frame 0. After clicking the "Setup timestamp", a window will appear in which we give the current timestamp (read it from the video timestamp). In the "Time difference between frames", enter the differences in treatment time between the successive frames of the film in minutes.

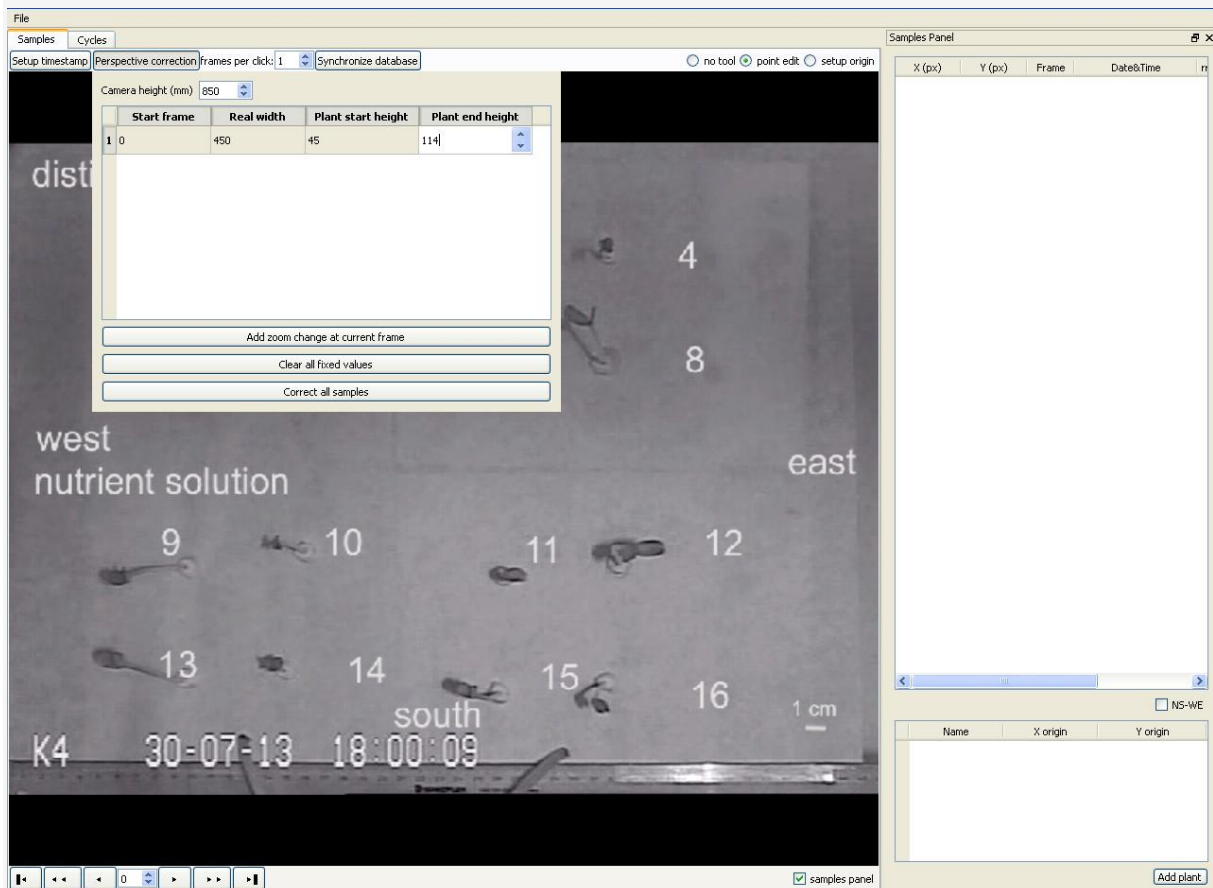


Perspective correction

After clicking the "Perspective correction", a window will appear and perspective correction will be set by clicking the "Add zoom change at current time". The following values should be completed:

- Camera height - height of the camera above the ground (millimetres)
- Real width - width of the frame in the magnification at the ground level (millimetres)
- Plant start / end height - height of the plants at the beginning / end of the experiment (millimetres)

After entering the data, click the button "Correct all samples". All plants will be corrected. If for some reason you want to remove an adjusted value, click the "Clear all fixed values".



We propose to set a top-view camera corresponding to the geographical plane and thus the coordinates X, Y simultaneously correspond to the geographical east-west (EW) and north-south (NS), respectively.

The software interface displays a top-view camera feed of a plant growth experiment. The feed shows 16 numbered seedlings arranged in a grid. Labels include 'distilled water', 'north', 'west', 'nutrient solution', 'east', 'south', 'K4', '30-07-13', '20:35:08', and a '1 cm' scale bar. A 'Samples Panel' on the right lists 20 samples with their X (W-E), Y (N-S), Frame, and Date&Time. A table at the bottom shows 'Name', 'X origin', and 'Y origin' for 'seedling 14' and 'Plant 2'. The 'NS-WE' checkbox is checked.

X (W-E) [px]	Y (N-S) [px]	Frame	Date&Time
5,0087	-0,834778	0	2013-07-30 18:00:09
5,0087	0	1	2013-07-30 18:05:09
5,0087	2,50435	2	2013-07-30 18:10:09
5,0087	3,33913	3	2013-07-30 18:15:09
5,0087	5,84348	4	2013-07-30 18:20:09
6,67825	8,34783	5	2013-07-30 18:25:09
7,51303	9,18261	6	2013-07-30 18:30:09
8,34781	10,8522	7	2013-07-30 18:35:09
8,34781	12,5217	8	2013-07-30 18:40:09
8,34781	12,5217	9	2013-07-30 18:45:09
10,0174	12,5217	10	2013-07-30 18:50:09
10,8522	10,8522	11	2013-07-30 18:55:09
11,687	9,18261	12	2013-07-30 19:00:09
13,3565	9,18261	13	2013-07-30 19:05:09
14,1913	9,18261	14	2013-07-30 19:10:09
17,5304	7,51305	15	2013-07-30 19:15:09
17,5304	6,67826	16	2013-07-30 19:20:09
17,5304	5,84348	17	2013-07-30 19:25:09
20,0348	4,17391	18	2013-07-30 19:30:09
20,8696	4,17391	19	2013-07-30 19:35:09
20,8696	4,17391	20	2013-07-30 19:40:09

Name	X origin	Y origin
1 seedling 14	403,2	90,9913
2 Plant 2	0	0

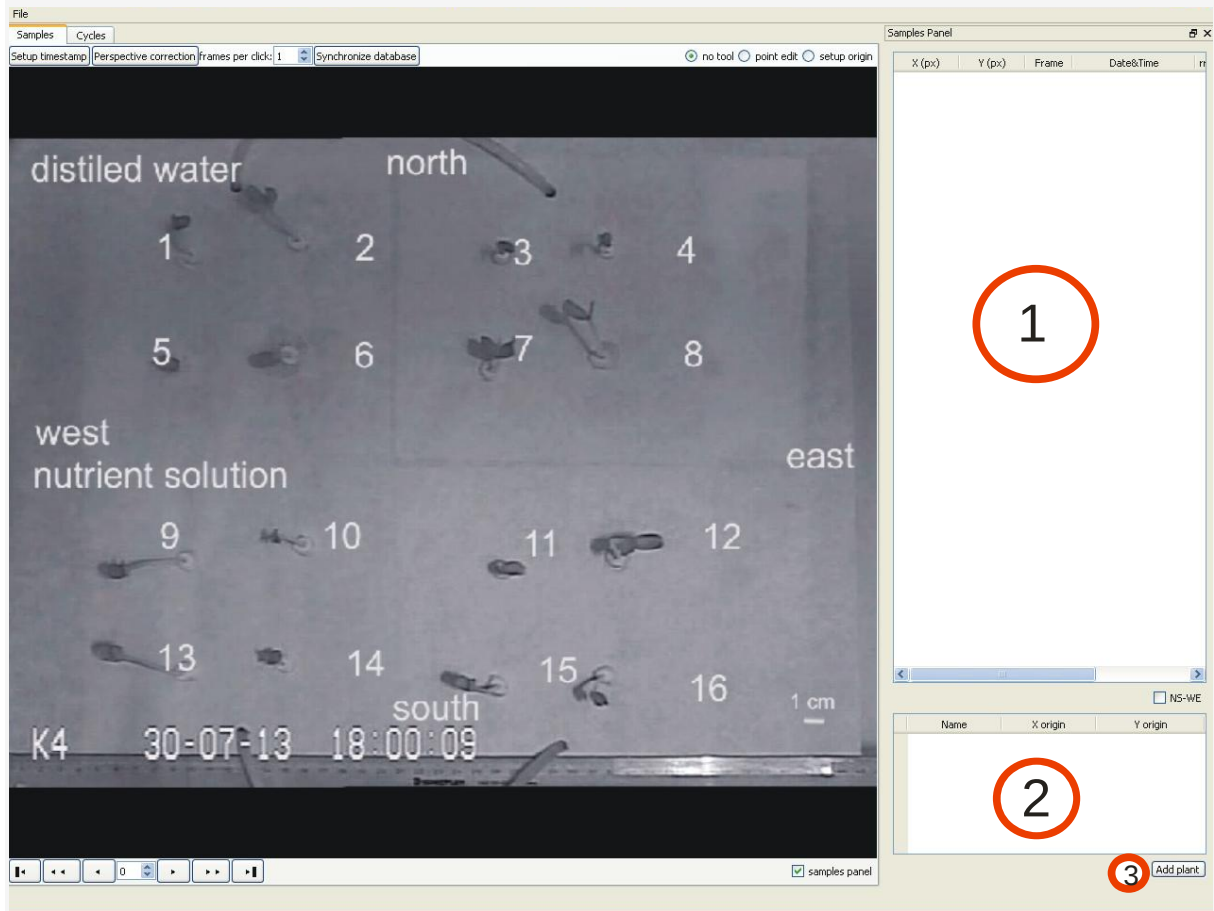
Manual harvesting of coordinates X and Y

The following elements appear after opening the samples panel

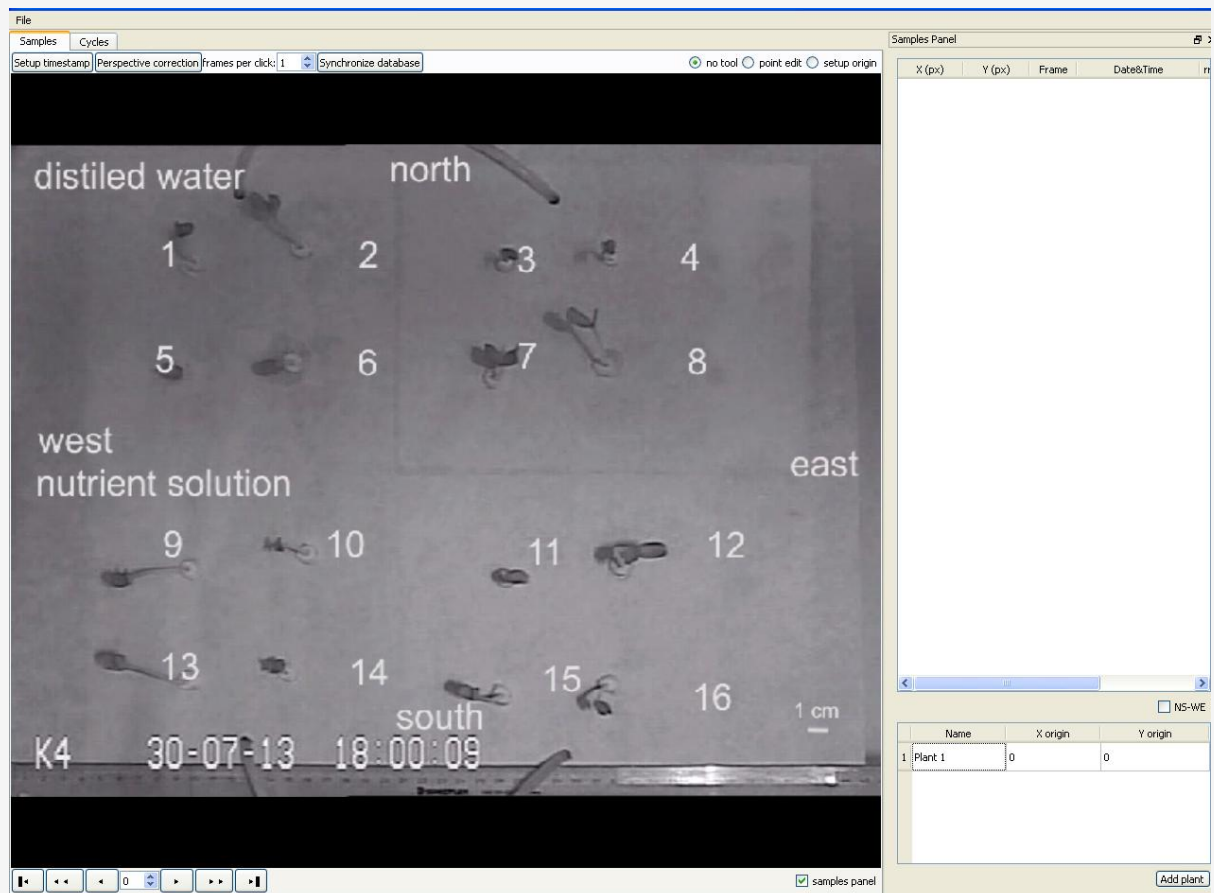
1 – Samples panel

2 – Plants panel

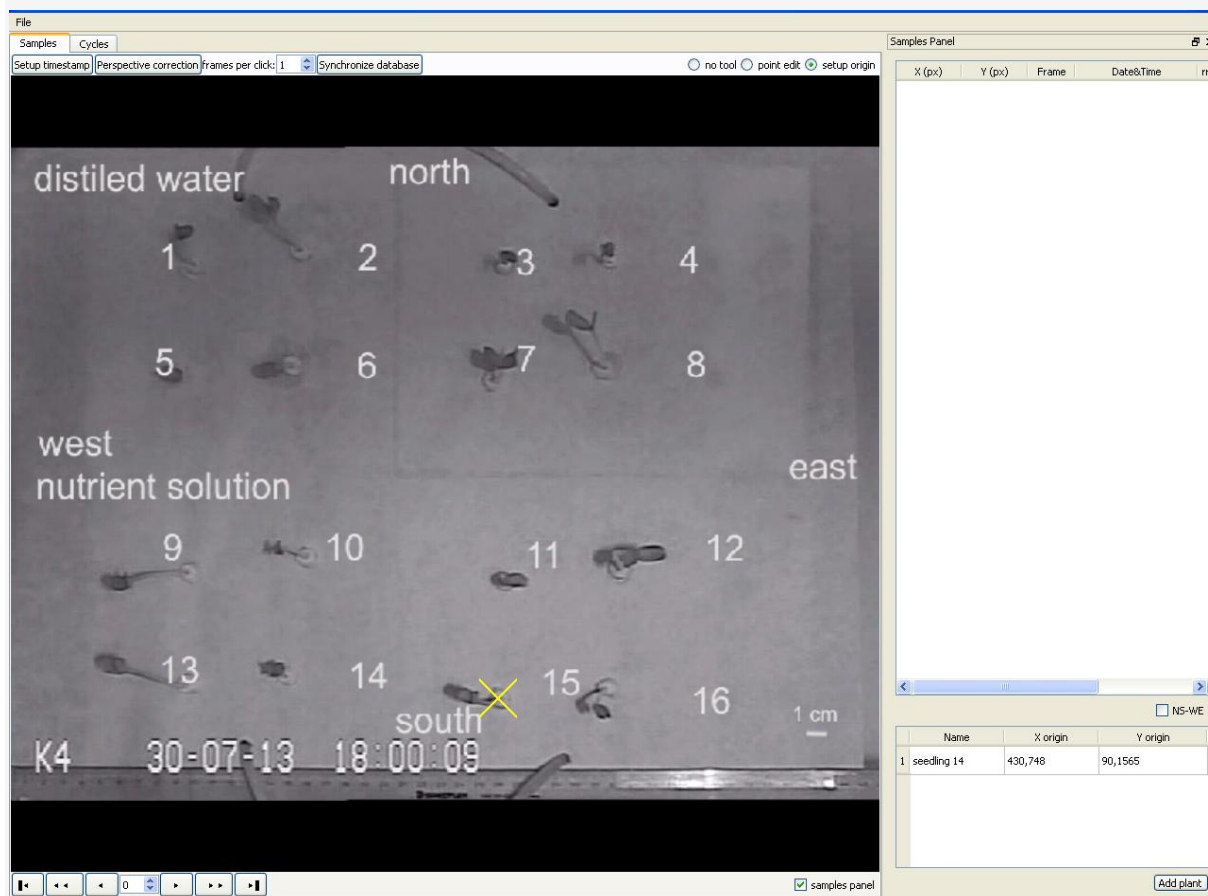
3 - Adding new plants



Click to add a new plant. You can change the name of the plant by clicking twice on the field with the current name and by typing a new name and confirming by pressing enter. Subsequent plants can be added by clicking the "Add a plant."



To set the frame of reference of circumnutation, the centre of the coordinate system can be set using "setup origin" tools (yellow X).



When you change the current tool to "point edit", you can begin manual harvesting of the subsequent coordinates x and y of the apex of the plant organ. Each time you click, the movie will be automatically shifted by the value specified with the label 'frames-per-click ". After x and y coordination harvesting, "correct all samples" in "perspective correction" should be done. After perspective correction, the corrected values appear in the samples panel as a corrected x and corrected y in millimetres.

The screenshot displays a software interface for plant growth analysis. The main window shows a grayscale image of 16 numbered plant seedlings arranged in a 4x4 grid. The grid is labeled with 'distilled water' (top-left), 'north' (top-center), 'west' (left-center), 'nutrient solution' (bottom-left), 'east' (right-center), and 'south' (bottom-center). A 1 cm scale bar is in the bottom right. The interface includes a menu bar (File, Samples, Cycles), a toolbar with 'Setup timestamp', 'Perspective correction', 'Frames per click: 1', and 'Synchronize database'. On the right, the 'Samples Panel' shows a table of 12 samples with columns for X (px), Y (px), Frame, Date&Time, and n. At the bottom right, there is a table for plant origins with columns for Name, X origin, and Y origin, showing data for 'seedling 14' and 'Plant 2'. A status bar at the bottom shows frame 13 and a 'samples panel' checkbox.

X (px)	Y (px)	Frame	Date&Time	n
-25,0436	0,834801	0	2013-07-30 18:00:00	
-24,2089	0,834801	1	2013-07-30 18:05:00	
-23,3741	0,834801	2	2013-07-30 18:10:00	
-23,3741	0,834801	3	2013-07-30 18:15:00	
-22,5393	0,834801	4	2013-07-30 18:20:00	
-22,5393	0,834801	5	2013-07-30 18:25:00	
-21,7045	0,834801	6	2013-07-30 18:30:00	
-21,7045	0,834801	7	2013-07-30 18:35:00	
-21,7045	0,834801	8	2013-07-30 18:40:00	
-21,7045	1,66959	9	2013-07-30 18:45:00	
-20,8697	1,66959	10	2013-07-30 18:50:00	
-20,8697	1,66959	11	2013-07-30 18:55:00	
-20,8697	1,66959	12	2013-07-30 19:00:00	

Name	X origin	Y origin
1 seedling 14	430,748	90,1565
2 Plant 2	0	0

Automatic determination of circumnutation parameters

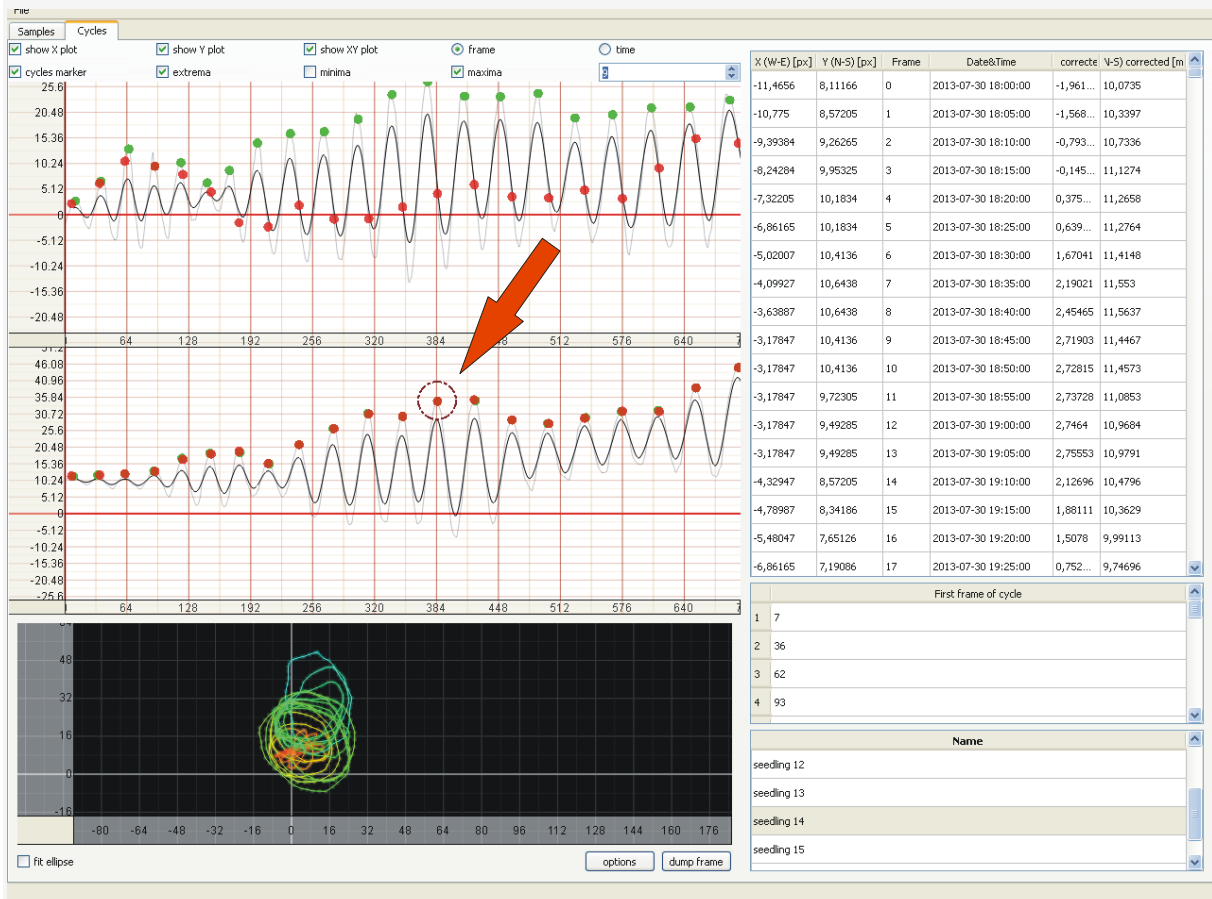
The parameters of cycles are determined by using the tab "cycle".

The tab "cycle" consists of the following elements:

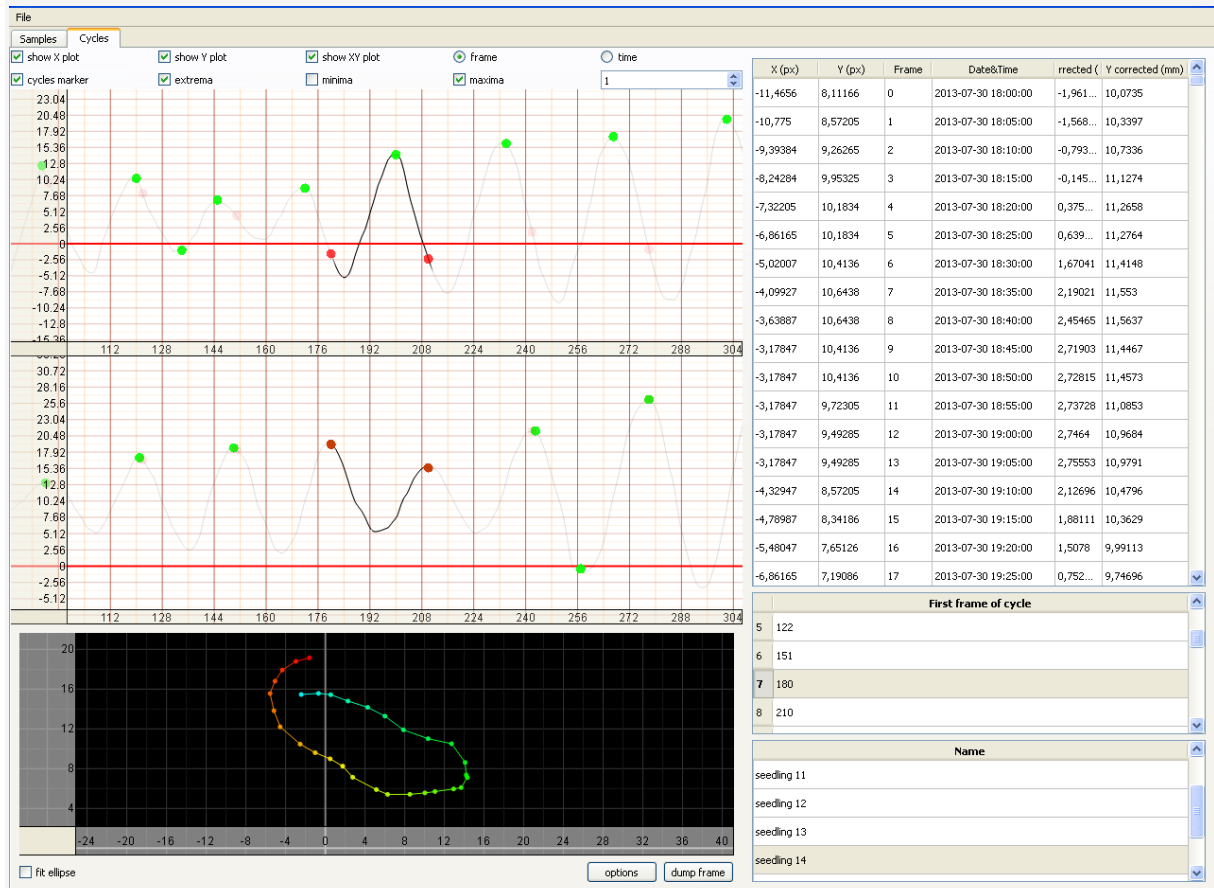
- 1 - Display graph X
- 2 - Display graph Y
- 3 - Display graph XY
- 4 - X axis as the frame number
- 5 - X axis as the value of time
- 6 - Marking the beginnings of cycles on graph X and Y
- 7 - Marking the extremes on chart X and Y
- 8 - Marking the minima
- 9 - Marking the maxima
- 10 - Value of the smoothing factor
- 11 - Table of samples
- 12 - Table of the beginnings of cycles
- 13 - Table of plants
- 14 - Window of graph where coordinate X is presented relative to time
- 15 - Window of graph where coordinate Y is presented relative to time
- 16 - Window of graph with the XY plot - the top view of organ apex trajectory
- 17 - Drawing a fitted ellipse
- 18 - Options of graph XY (axis, labels, background ...)
- 19 - Export of graphs of all or a single cycle in the SVG format



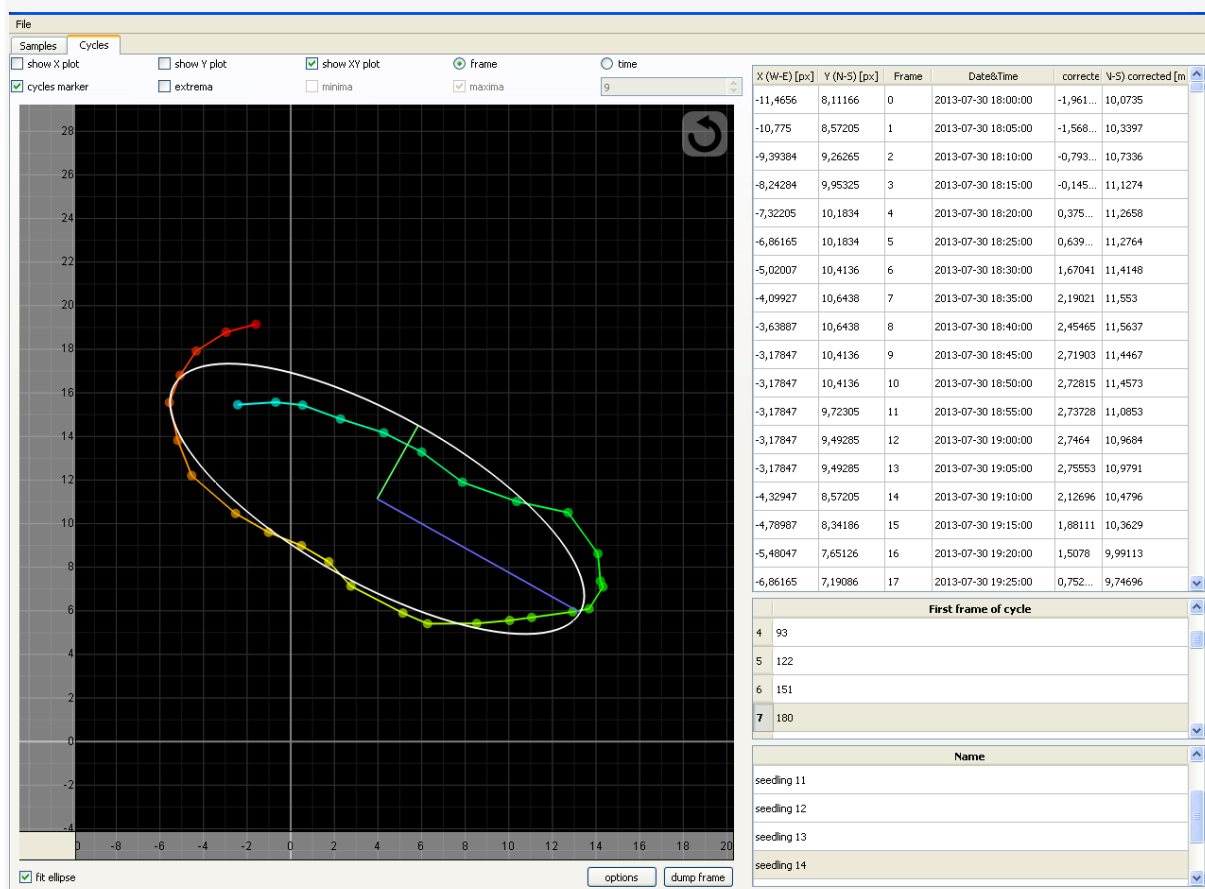
All types of graphs are shown. The original line is shaded; the bold line is for smoothed data. On graph X and graph Y highlighting the extremes, only maxima are visible as green dots. After moving the mouse cursor to the maximum, a circular rim appears (indicated by a red arrow) - when you click the left mouse button to add a new cycle to “the table of the beginnings of cycles”, the number of the first frame of the cycle will occur in the table and a red dot will appear on the graph. If the marked extremes do not coincide with the real extremes, we can turn off the “extremes” and each of the data samples can be chosen as the beginning of the cycle.



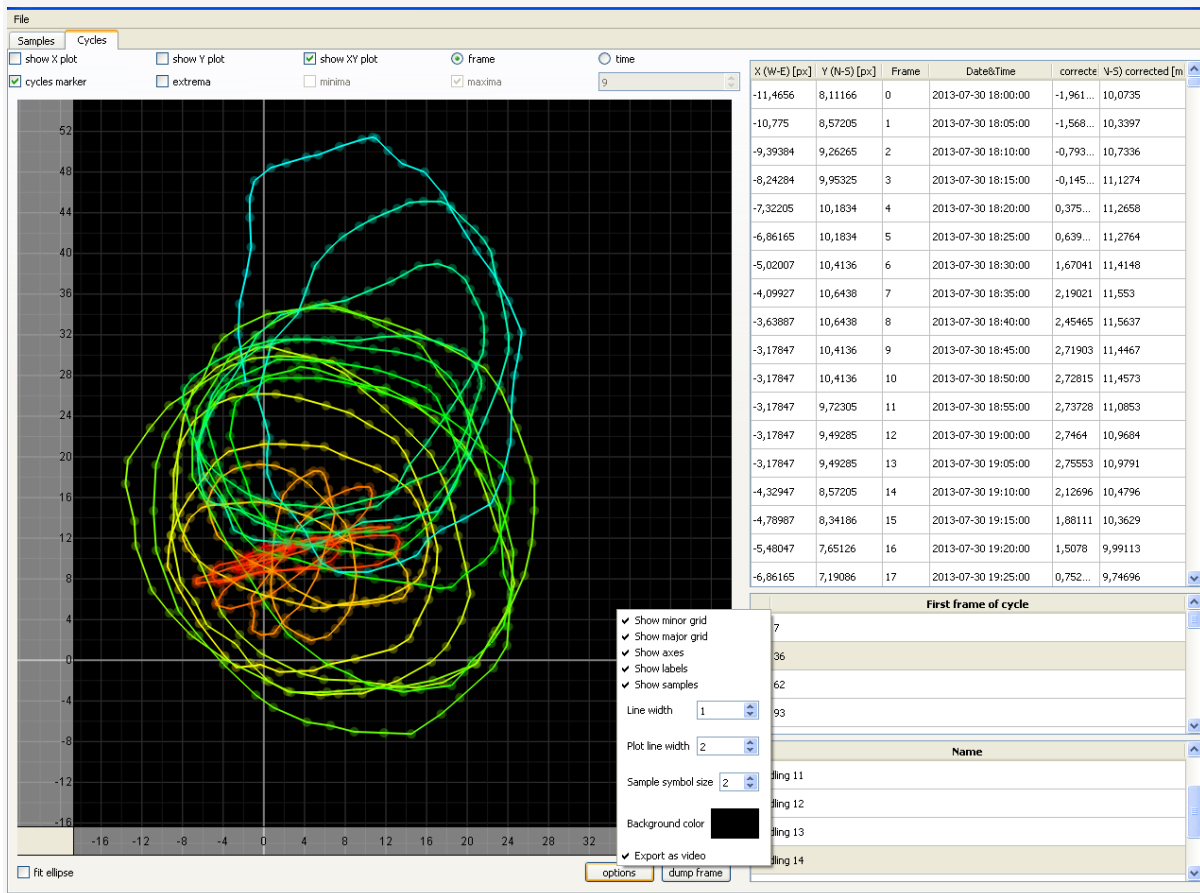
After selection, the cycle will be highlighted on the chart and plotted as x y top view.



Cycle after fitting an ellipse ("fit ellipse" button). In the upper right corner, you see the icon of the direction of circumnutation (clockwise- or counterclockwise). If the circumnutation length is a very small (below 10 mm) and the circumnutation direction is uncertain, the icon turns into a sign '?'. The blue line shows the long axis of ellipse and thus circumnutation angle.



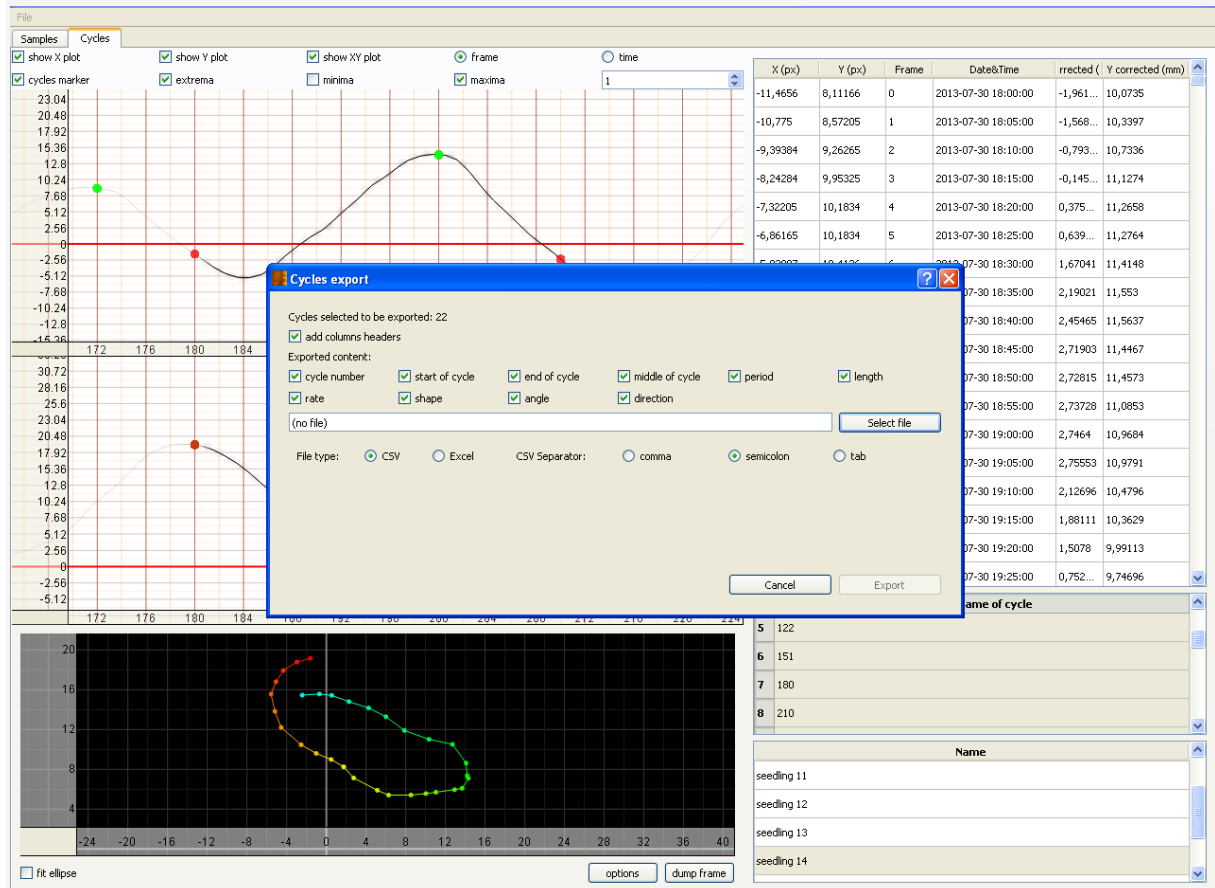
An example of an XY chart with all cycles. By marking a part of coordinates x and y in the “sample panel”, a few cycles can be plotted. The option of plotting can be changed by the “options” tab.



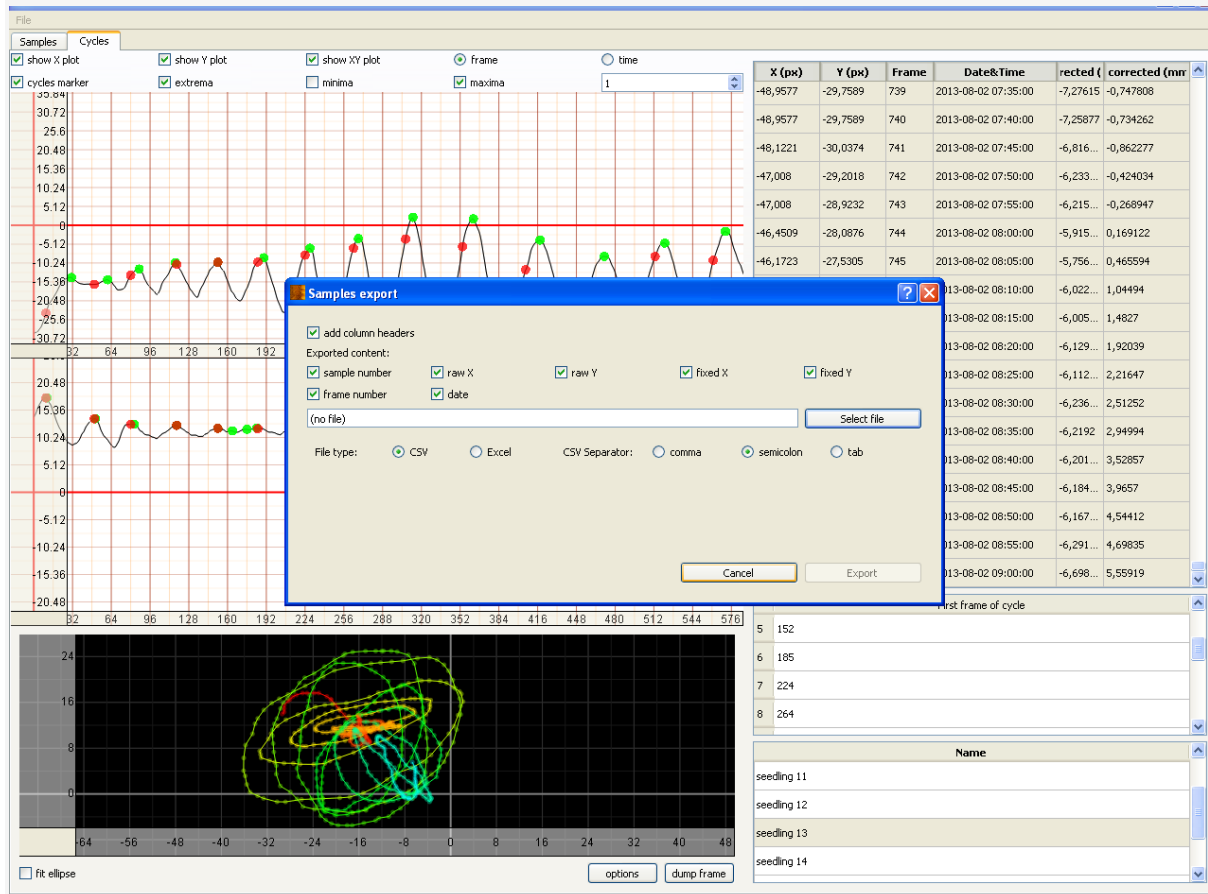
Data and graph exporting (output path)

Data export

The circumnutation parameter values can be exported as a CSV (comma-separated values) or XLS file that can be opened in spreadsheet software (e.g. Microsoft Excel). After selecting the cycles in the “the table of beginnings of cycles” and clicking the right of bottom of the mouse, a "cycles export" window will appear on the context menu.



After selecting a sample of x and y, you can export the data from the samples panel.



Graph export

The circumnutation trajectory can be seen in CT and in colour copy as PrtScn and all cycles after marking can be exported by “dump frame” to a SVG (vector image) type file that can be opened in graphics software (e.g. Corel Draw).

