User_Manual

Getting Started

Welcome to the FastTrack user manual. This manual will present the tracking software and how to use it. Please contact by email at **benjamin.gallois@fasttrack.sh** or chat on irc if you need more information or to signal a bug. Subscribe to the mailinglist to get the last updates from the fastTrack dev team.

FastTrack is a cross-platform application designed to track multiple objects in video recording. Stable versions of the software are available for Linux, Mac, and Windows. The source code can be downloaded at https://github.com/FastTrackOrg/FastTrack.

Two main features are implemented in the software:

- An automatic tracking algorithm that can detect and track objects, conserving the objects' identities across the video recording.
- An ergonomic tool allowing the user to check, correct and annotate the tracking.

The FastTrack user interface is implemented with Qt, the image analysis with

the OpenCV library. This allows a performant and responsive software amenable to process large video recording.

FastTrack was first a PhD thesis side project started by Benjamin Gallois on his spare time that has then taken dedicated time in his PhD project. The core of the software is still maintained on his spare time therefore new features implementation, bug fixes and help can take some time.

Not sure if you want to use FastTrack? Check these five most common questions:

What video quality is required? FastTrack is designed to work with any video quality and frame rate.

What type of objects and numbers can FastTrack handled?

How it performs? Tracking performances depend on systems (number and type of objects). But with the built-in ergonomic tool, it is possible to achieve 100% tracking accuracy with a minimum of efforts.

It is free? FastTrack is a free software under the GPL3 license.

Do I need programming skills? No.

Installation

Download

Stable versions of FastTrack are released for Linux, Mac (as dmg) and Windows (installer). The nightly version are available on the GitHub repository

Installation

1. For Windows:
    - Download the FastTrack installer.
    - Execute the installer and follow the provided instructions.
2. For Linux (all distributions) as AppImage:
    - Download the AppImage file.
    - Allow FastTrack.AppImage to be executed:
        - Right click on the AppImage file.
        - Click on Properties.
        - Click on Permissions.
        - Tick “Allow executing file as program”.
    - Check the AppImage Launcher to integrate AppImage to the system.
3. For Mac:

- Minimal version required: 10.15.
- Download the FastTrack dmg file.
- Double click on the dmg file.
- Drag the application from the dmg window into the Applications folder.

Update

FastTrack will display a message at the start-up when new a release is available.

1. For Windows: Search the *FastTrackUpdater* in the *Windows Start Menu* or execute directly the *MaintenanceTool.exe* in the installation folder and follow the provided instructions.
2. For Linux: The FastTrack AppImage currently not support the automatic update. Replace the current AppImage with the latest AppImage released.
3. For Mac The FastTrack App currently not support the automatic update. Replace the current App with the latest App released.

A step by step example

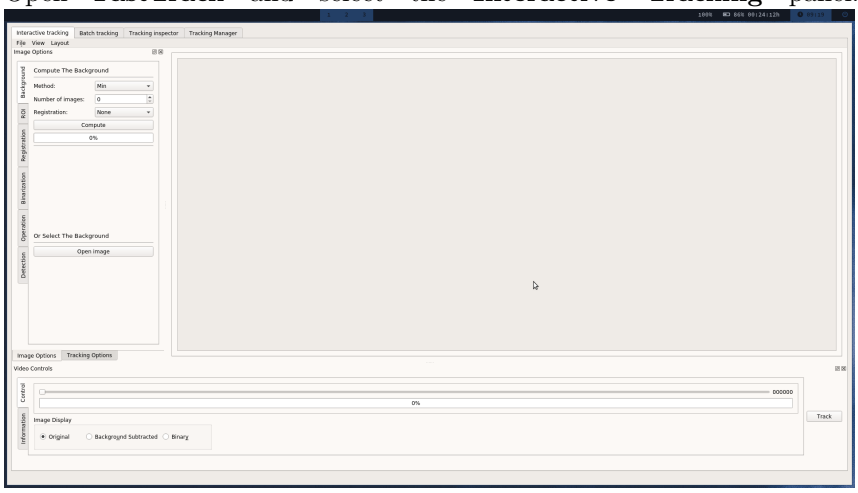
This section details step by step the process to test FastTrack using data from the Two-Dimensional Tracking Dataset. Illustrations originate from v4.x.y and can differ from the current stable version.

Downloading

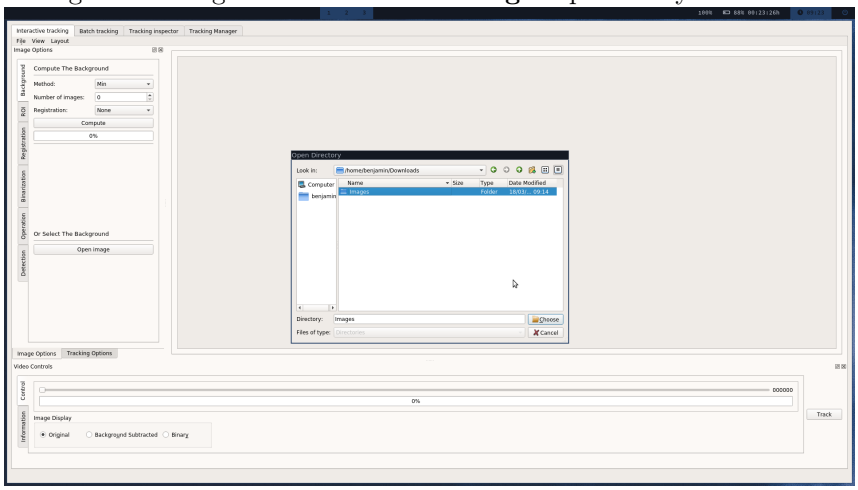
In this example, we will use the challenging movie ZFJ_001. This movie features 14 very active juvenile zebrafish. The principal difficulty of this movie is the frequent and complex occlusions. First, download the zip file and extract it. The image sequence is located inside the **images** folder.

Tracking

1. Open **FastTrack** and select the **Interactive Tracking** panel.



2. Import the movie by clicking on **File** then **Open** and by selecting one image in the folder **images** previously downloaded.



3. Compute the background by clicking on the **Background** tab and selecting these parameters:

- Method: **Max** (project the maximal intensity)
- Number of images: **199** (all the images)
- Registration: **None** (No registration is needed)
- And click the **Compute** button.

4. Click the **Binarization** panel and select these parameters:

- Type: **Light Background** (dark objects on light background)
- Value: **49**

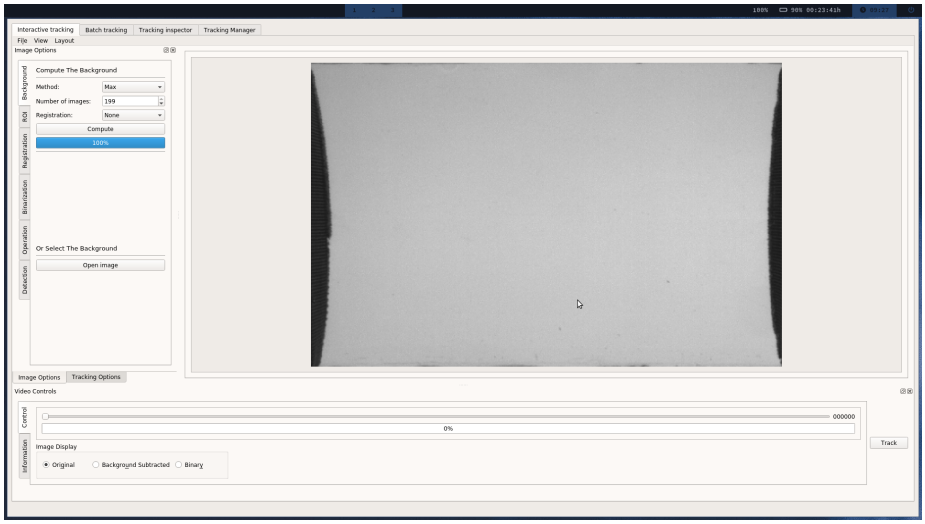


Figure 1: alt text

Figure 2: alt text

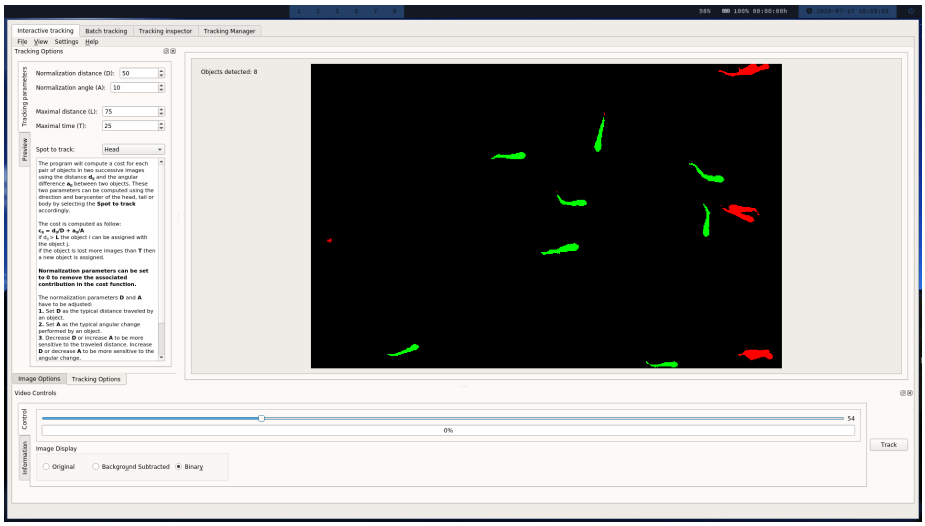
5. Click on the **Detection** panel and select:

- Maximal size: **190** (overlapping objects are rejected in most cases)
- Minimal size: **50** (noise is rejected)

Figure 3: alt text

6. Click the **Tracking Options** tab and select:

- Normalization Distance: **50**
- Normalization Angle: **10**
- Maximal Distance: **75**
- Maximal Time: **25**
- Spot to track: **Head** (best for deformable asymetric objects)



Note: these parameters were found by trials and errors.

7. Click on the **Track** button to start the tracking

Reviewing

When the tracking is completed, FastTrack automatically opens the **Tracking Inspector** which allows the user to review and correct the tracking.

With the previous tracking analysis, only 7 corrections and 6 deletions are necessary to achieve a perfect tracking accuracy.

image	id	delete	swap with
17-20	1-0	x	
17-20	0	x	
22	0		1
23	1		4
27-28	1	x	
63	1		8
97	6		12
50-57	1	x	
109-121	0	x	
114	9		13
116-118	0	x	
122	0		13
124	4		12

Import Data

Image sequence

FastTrack is able to open image sequences if they follow the leading 0 naming convention (name000.xyz, name001.xyz, name002.xyz, etc...). *.bmp,* .dib, *.jpeg,* .jpg, *.jpe,* .jp2, *.png,* .pbm, *.pgm,* .ppm, *.sr,* .ras, *.tiff,* .tif formats are supported. To open an image sequence, select one image of the sequence.

Video

FastTrack is able to open video files, a lot of codecs are supported.

Timeline

To rapidly navigate inside a video, FastTrack provides a tool called the timeline. Hover the mouse cursor above the timeline to move across the video. Right click to place the cursor at a given position, this will saved this position when the cursor exit the timeline. Double left click to place a marker, right click on this marker to delete it. Keyboard shortcurts are available to move the cursor frame by frame:

- D: move to the next frame.
- Q: move to the previous frame (AZERTY layout).
- A: move to the previous frame (QWERTY layout).
- Space: start/stop autoplay.

Interactive Tracking

The Interactive panel provides a means to perform a tracking analysis, and review the tracking in an interactive environment. Several steps have to be performed in the right order (some are mandatory, some are optional) to perform a successful tracking analysis.

Open a file

The first step of a tracking analysis is to open a video file. FastTrack support video files and image sequence. Click on the file or on an image of a sequence to automatically load the movie.

Compute the background

The background can be computed or imported. To compute the background, select a method and a number of images. Images are selected in the image sequence at regular intervals and three methods of computation by z-projection are available:

- Min: each pixel of the background image is the pixel with the minimal value across the selected images from the image sequence. Useful when the objects are light on a dark background.
- Max: each pixel of the background image is the pixel with the maximal value across the selected images from the image sequence. Useful when the objects are dark on light background.
- Average: each pixel of the background image is the average of the pixels across the selected images from the image sequence.

The images can be registered before the z-projection, three methods of registration are available.

Select a region of interest (optional)

To select a region of interest, draw on the display a rectangle with the mouse and click on the Crop button. Cancel the crop by clicking on the reset button.

Compute the binary image

To compute the binary image from the background image and the image sequence, select the threshold value and see the result on the display. The background type is automatically selected after the background computation but can be modified: select Dark Background if the objects are light on a dark background, and Light background if the objects are dark on a light background.

Apply morphological operations (optional)

It is possible to apply a morphological operation on the binary image. Select a morphological operation, kernel size, and geometry. See the result

on the display. For more information about the different operations see https://docs.opencv.org/trunk/d9/d61/tutorial_py_morphological_ops.html.

Tune the detection parameters

Objects are detected by their size. Select the maximum and minimum size of the detected objects. The detected objects will be colored in green in the display and rejected object will be displayed in red.

Tune the tracking parameters

Several parameters can be modified to ensure a good tracking analysis, see this page for more details:

Hard parameters

Hard parameters have to be set manually by the user:

- Maximal distance: if an object traveled more than this distance between two consecutive images, it will be considered as a new object.
- Maximal time: number of images an object is allowed to disappear. If an object reappears after this time, it will be considered as a new object. If the number of objects is constant throughout the movie, set the Maximal Time equal to the number of frames in the movie.
- Spot to track: part of the object features used to do the tracking. Select the part that reflects the better the direction of the object. Legacy parameter, head correspond to the smaller mid-part of the object, tail ellipse the wider mid-part of the object and body is the full object.

Soft parameters

The soft parameters can be leveled automatically by clicking on the Level button. This will automatically compute the soft parameters as each contribution weight one quarter in the total cost. It has to be manually tuning by the user to find the optimal soft parameters with the knowledge of the system. For example, for a system where the direction of the objects is not relevant, the user will select the Normalization angle equal to 0.

- Normalization distance (legacy Maximal length/ Typical length): typical distance traveled between two consecutive images.
- Normalization angle (legacy Maximal angle/Typical angle): typical reorientation possible between two consecutive images.
- Normalization area: typical difference in area.
- Normalization perimeter: typical difference in perimeter.

Registration

The image registration is the process to correct small displacements and rotation of the camera that can occur during the movie. Fast Track provides several methods for registering the movie:

- By phase correlation
- ECC image alignment
- Features based

Image registration is very computationally intensive and can drastically decrease the speed of the program.

Preview the tracking

The tracking can be previewed on a sub-sequence of image. It can be useful to tune parameters if the tracking is slow.

Display options

Several display options are available and unlocked at each step of the analysis.

- Original: original image sequence
- Background subtracted: image sequence minus the background image.
- Binary: binary image sequence with detection overlays.
- Tracking: tracking data overlay.

Layout options

Several layouts ant themes are available in the layout menu in the top bar. You can also build your layout by dragging the option docks in the window.

See a video demonstration

Batch Tracking

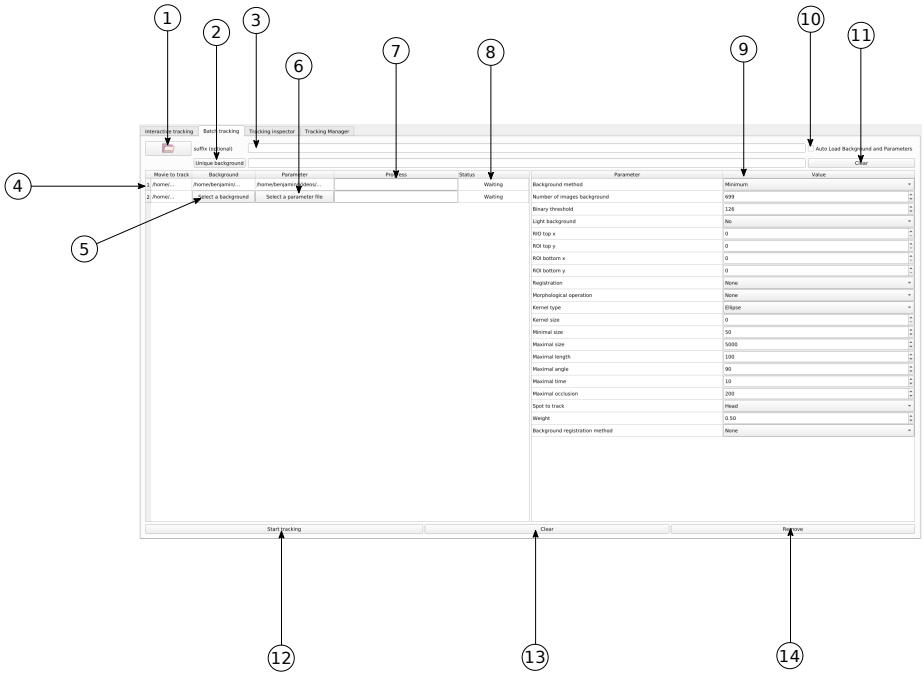


Figure 4: alt text

- 1: Open folder
- 2: Unique background
- 3: Suffix selection
- 4: Processing stack

- 5: Background selection
- 6: Parameter selection
- 7: Progress bar
- 8: Status
- 9: Parameters table
- 10: Autoload
- 11: Clear background
- 12: Start tracking
- 13: Clear stack
- 14: Remove from stack

The Batch Tracking panel is an advanced tool to track automatically a large amount of movies. Several behaviors can be combined to load image sequences in batch with specific background images or parameter files.

Basic usage

The user can open several image sequences by clicking on the **Open folder** (1) button and select one or several folders. FastTrack can load automatically a background and/or a parameters file if a **Tracking_Result** folder is provided with the image sequence, check the **Autoload** (10) tick to activate this behavior. After opening, image sequences are added to the **Processing stack** (4). If a background image and/or a set of parameters are automatically loaded, the path will be displayed in the second and third columns. If not, the user can select them with the (5) and (6) buttons after importation. **By default**, if no background image and parameter file are selected, FastTrack will use the parameters provided in the Parameters table (9) **before** the image sequence importation. The user can delete an image sequence by selecting the corresponding line in the **Processing stack** (4) and click on the **Remove** (14) button. The user can clear all the **Processing stack** (14) by clicking the **Clear** (13) button. To process the stack, click the **Start Tracking** (12) button.

More advanced options

Add a suffix

The user can append a suffix to the imported folders *folder_path/ + suffix/* For example, it can be usefull with a folder tree like this one:

- /myExperiment/Run1/images
- /myExperiment/Run2/images
- /myExperiment/Run3/images

The user can easily select in one time the folders

- /myExperiment/Run1
- /myExperiment/Run2
- /myExperiment/Run3

And then add the suffix *images/* to select the desired folders without having to do it manually three times.

Unique background image

The user can select a unique background image. Open an image with the **Unique background** (2) button and **all the sequences in the stack** and sequences that will be imported will be using this background image. You can use the **Clear** (12) to reset the default behavior.

One parameter file

To apply the same parameters file to all the imported sequences:

Manual selection:

- Untick the **Autoload** (10).
- Select a set of parameters in the **Parameters table** (9).
- The sequences that will be imported will use this set of parameters.

With a file:

- Tick the **Autoload** (10)
- Load the sequence with the right parameters file.
- Untick the **Autoload** (10).
- The sequences that will be imported will use this set of parameters.

With a file:

- Untick the **Autoload** (10).
- Load a sequence.
- Select the parameter file with the (6) button.
- The sequences that will be imported will use this set of parameters.

Behavior reminder

- 10. unticked, (2) not selected: FastTrack will use the parameters provided in the Parameters table (9) **before** the image sequence is added to the stack. Can be overwritten after importation with the (5) and (6) buttons.
- 10. ticked, (2) not selected: FastTrack will use the background and the parameters file in the Tracking_Result folder, if these files are missing, FastTrack will use the parameters provided in the Parameters table (9) **before** the image sequence is added to the stack.
- 10. ticked, (2) selected: the background selected in (2) will overwrite the automatically detected background.
- 3. selected: the image sequence path will be appended with the suffix and default behavior will be applied with this path.

- 2. selected: select a unique background will overwrite all the existing background in the stack.

Tracking Inspector

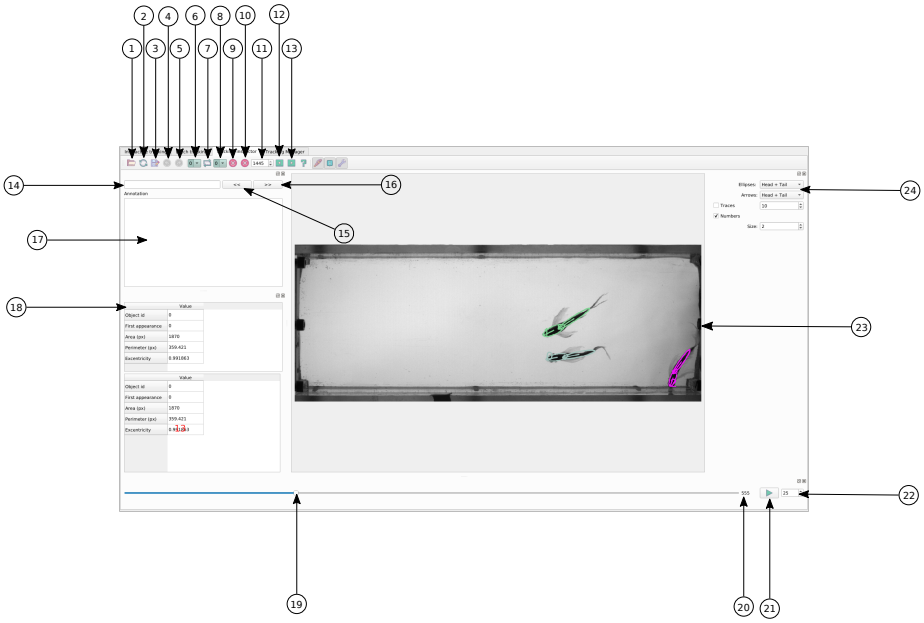


Figure 5: alt text

- 1: Open Folder
- 2: Reload
- 3: Export video
- 4: Undo
- 5: Redo
- 6: First object selection box
- 7: Swap
- 8: Second object selection box
- 9: Delete one
- 10: Delete
- 11: Delete selection box
- 12: Previous occlusion
- 13: Next occlusion
- 14: Annotation search
- 15: Annotation previous match
- 16: Annotation next match
- 17: Annotation entry
- 18: Objects information table

- 19: Play cursor
- 20: Image number
- 21: Play
- 22: FPS selection box
- 23: Display
- 24: Overlay

The Tracking Inspector is a tool to display the result of a tracking analysis and to manually correct the tracking if necessary. For example, the user can delete an object to remove an artifact or change the object ID to correct a tracking error. To make the user's life easier, an ergonomic interface with build-in keyboard shortcuts are provided. FastTrack alleviates the tedious work of review and correction, and the user can achieve 100% tracking accuracy rapidly and easily.

Load an image sequence

To load a tracking analysis previously tracked in FastTrack, click on the **Open Folder** button (1) and select the **Tracking_Result** folder of the analysis to review. In the case where the image sequence was tracked several times, the last tracking analysis is stored in the **Tracking_Result** folder and the previous tracking analysis in the **Tracking_Result_Date** folders. Click on the **Reload** button (2) to reload the tracking data if necessary. The software can only load a tracking analysis if the folder architecture is preserved, .ie the folder with the image sequence has to have a sub-folder named **Tracking_Result** containing at least the *tracking.txt* file.

Display options

Several tracking overlay options are available on the tracking overlay panel (24):

- Ellipse: display the head, tail and or body ellipses on the tracked objects.
- Arrows: display an arrow on the head, tail and or body of the tracked object indicating the orientation.
- Numbers: display the ids of the tracked objects.
- Traces: display the previous 50 positions of the tracked objects.
- Size: the size of the tracking overlay.
- Frame rate: display and saving frame rate.

Several useful information on the selected object can be found in the information table (18). The user can go to the image where the object has appeared for the first time by clicking directly on the corresponding cell of the table.

Inspect the tracking

The tracking can be inspected by moving the display cursor (19), see the image number (20) and automatically play the movie (21) at a selected frame rate

(22). Automatically detected occlusions (overlapped objects) can be reviewed by clicking on the **Previous** (12) and **Next** (13) occlusion buttons (this function is experimental and can miss some occlusions).

Annotate the tracking

The user can annotate any image of the tracking. Write the annotation in the annotate text entry (17). The user can search across annotations with the find bar (14) and the buttons (15)(16). All the annotations are saved in the *annotation.txt* file in the **Tracking_Result** folder.

Correct the tracking

Swap the data of two objects

The user can correct an error by swapping two object's ID from the current image to the end of the sequence as follow:

- Left-click on the first object, the object ID and color are displayed on the first selection box (6).
- Left-click on the second object, the object ID and color are displayed on the second selection box (8)
- Right-click or click on the **Swap Button** (7) to exchange the ID of the two selected objects from the current image to the last image of the sequence.

Delete the data of an object

To delete one object of several frames:

- Double left click on the object, the object ID and color are displayed on the second selection box (8).
- Select the number of frames on which to delete the object in the box (11). Shortcut C is available to focus on the selection box.
- Click on the **Delete** button (10) to delete the object from the current frame to the current frame plus the selected number.

To delete one object on the current frame:

- Double left-click on the object, the object ID and color are displayed on the second selection box (8).
- Click on the **Delete One** button (9) to delete the object on the current frame.

Keyboard shortcuts summary

A set of keyboard shortcuts are available to speed-up the tracking correction.

- Q/A: go to the previous image.
- D: go to the next image.

- F: delete the selected object on the current image.
- C: enter the number of images where an object has to be deleted.
- G: delete an object from the current image to the current plus the selected number.

Saving

All the changes made in the inspector are automatically saved in the original *tracking.txt* file.

Export a movie

To export a movie of a tracking analysis, select the desired display overlay and click on the **Save** button (3). Select a folder and a name to save the file, only .avi format is supported.

Note: Movie with a large number of objects by frame can be difficult to load and review in the tracking Inspector.

See a video demonstration

FastTrack Command line interface

Installing fasttrack-cli

A command line interface is available for MacOs, Linux and by using WSL for Windows. It can be downloaded on the release page.

The full list of parameters can be found by calling `./fasttrack-cli --help`. Parameters can be declared individually by calling `./fasttrack-cli --path path/to/movie.webm --parameter1 value --parameter2 value` or in batch with a parameters file `./fasttrack-cli --path path/to/movie.webm --cfg path/cfg.toml`. Note that the path option need to be the first option.

fasttrack-cli doesn't support natively Windows. The workaround is to use WSL. * Install WSL https://docs.microsoft.com/en-us/windows/wsl/install-win10. * Install FastTrack in a Linux terminal:

```
wget https://github.com/FastTrackOrg/FastTrack/releases/download/continuous_cli/fasttrack-cl
chmod +x fasttrack-cli-x86_64.AppImage
./fasttrack-cli-x86_64.AppImage --appimage-extract
sudo ln -s ~/squashfs-root/usr/bin/fasttrack-cli /usr/local/bin/
```

- FastTrack-cli can now be called directly by typing fasttrack-cli –help

Calling FastTrack from a Python script

FastTrack can be called inside a Python script to automate the tracking.

```
import os

cmd = "./fasttrack-cli --maxArea 500 --minArea 50 --lightBack 0 --thresh 80 --reg 0 --spot 0
os.system(cmd)
```

```
import os

cmd = "./fasttrack-cli --path ZFJ_001.avi --cfg Tracking_Result_ZFJ_001/cfg.toml"
os.system(cmd)
```

Tracking parameters

In this section, we detail how to select the relevant tracking features to be included in the cost function and how to tune them.

How it works

FastTrack uses the so-called Hungarian method to solve the assignment problem of each object between two frames. This method is based on minimizing the global cost of the association pairs of objects.

Cost function

The cost is calculated from a cost function that can be constructed from several parameters, in the following, i is indexing the image n, and j the image n + 1: * The distance \(d{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}\) * The angle \(a_{ij} = min(\theta_i - \theta_j)\) * The area \(ar_{ij} = abs(area_i - area_j)\) * The perimeter \(p_{ij} = abs(perimeter_i - perimeter_j)\)

The relative weight of these contributions to the cost function are set by 4 normalization parameters: \[c_{ij} = \frac{d{ij}}{D} + \frac{a{ij}}{A}+ \frac{ar{ij}}{AR} + \frac{p{ij}}{P}\] These parameters can be set to 0 to cancel one or several tracking feature from the cost computation. All these features are not always relevant and has to be chosen carrefully for the best tracking accuracy. For example, for tracking circles of radius r, and squares of the same area moving at 10px/image, it is best to set \[(D=10, A=0, AR=0, P=2r(\pi-2\sqrt{\pi}))\]. For tracking fish of the same size, travelling at 35px/image, doing small reorientation of 20°, it is best to set \[(D=35, A=20, AR=0, P=0))\]. For tracking fish of different size, travelling at 35px/image, doing small reorientation of 20°, with size difference of 100px it is best to set \[(D=35, A=20, AR=100, P=0))\].

The best way to set the parameter is to first set the normalization parameters to the mean of the variable, .ie the typical change between two consecutive images: * \(D = mean(d_{ij})\) where i and j are the same object. * \(A = mean(a_{ij})\) where i and j are the same object. * \(AR = mean(ar_{ij})\) where i and j are the same object. * \(P = mean(p_{ij})\) where i and j are

the same object. In this case, each tracking feature has the same contribution to the cost. To tune the cost function by weighting more (resp. less) a tracking feature, decrease (resp. increase) the normalization parameter of this feature or increase (resp. decrease) all the normalization parameters of the others.

Memory and distance

A parameter of memory named maximal time can be set to account for disappearing objects. If the maximal time is set to m, one object can only disappears during m image, if it reappears after, it will be considered as a new object.

To speed-up the tracking, the maximal distance (L) parameter sets an infinite cost for all the pairs of objects to such as \(d_{ij} > L\). In practice, L is corresponding to the maximal distance an object can disappear.

Spot

The spot to track will determine if the distance and the angular difference will be calculated from the head, the tail, or the body of the object. Area and perimeter are always computed from the body. Head is defined as the bigger half of the object, separated alongside the minor axis of the object.

Conclusion

Setting the tracking parameters can be tedious. It can be best achieved by trials and errors (see the Preview option in the Interactive panel). to summarize: 1. Choose the right tracking features. 2. Set the normalization parameters equal to the mean of the tracking feature, ie the typical value. 3. Tune the normalization parameters to increase or decrease the relative weight between each contribution.

Tips and Tricks to set parameters

Setting the parameters

They are several tricks that can be used to increase tracking accuracy and select the optimal set of parameters.

Detection

The detection parameters reject objects that are smaller or bigger than a certain size. To increase the tracking accuracy, we want to reject noise and artifacts, and reject blobs constitute of more of one object. If all the objects are of similar size, these two parameters can be selected easily in four steps:

- Select an image where two objects are in contact forming a single blob.
- Select the **Maximal Size** parameter just at the limit to reject this blob.

- Select the **Maximal Size** parameter just at the limit to detect the smaller object of the movie.
- Fine tune these parameters to account for size variability across the movie.

Tracking

Tracking parameters are mostly found by trials and errors. But some rules of thumbs can be applied.

Spot to track has to be set to **Body** for quasi-symmetric objects and low-resolution objects. For deformable objects with enough resolution, select **Head** or **Tail** according to the part that predicts best the traveling direction of the object.

Parameters file

For each tracking analysis, FastTrack will save the parameters used in `cfg.toml` that can be reloaded in the software or in fasttrack_cli. Before FastTrack version 5.2.1, the software used to saved the parameters in `parameter.param`, these file can be converted as following (left: old file, right: new file):

```
                                    title = "FastTrack cfg""

                                    [parameters]
Light background = 0                lightBack = 0
Maximal size = 170                  maxArea = 170
Maximal occlusion = 200             maxDist = 200
Maximal time = 100                  maxTime = 100
Background method = 1               methBack = 1
Minimal size = 50                   minArea = 50
Morphological operation = 8         morph = 8
Kernel type = 2                     morphSize = 2
Kernel size = 0                     morphType = 0
Number of images background = 20    nBack = 20
Maximal angle = 90                  normAngle = 90
Binary threshold = 60               normArea = 0
Normalization area = 0              normDist = 100
Maximal length = 100                normPerim = 0
Normalization perimeter = 0         reg = 0
Registration = 0                    regBack = 0
Background registration method = 0  spot = 0
Spot to track = 0                   thresh = 60
ROI bottom x = 0                    xBottom = 0
ROI top x = 0                       xTop = 0
ROI bottom y = 0                    yBottom = 0
ROI top y = 0                       yTop = 0
```

Tracking Result

After a tracking analysis (or an analysis preview), FastTrack saves several files inside the **Tracking_Result** folder located inside the image sequence folder or inside the **Tracking_Result_VideoFileName** for a video file:

- *tracking.txt*: the tracking result
- *annotation.txt*: the annotation
- *background.pgm*: the background image
- *cfg.toml*: the parameters used for the tracking

The tracking result file is simply a text file with 20 columns separated by a ' character. This file can easily be loaded to subsequent analysis see this example.

- **xHead, yHead, tHead**: the position (x, y) and the absolute angle of the object's head.
- **xTail, yTail, tTail**: the position (x, y) and the absolute angle of the object's tail.
- **xBody, yBody, tBody**: the position (x, y) and the absolute angle of the object.
- **headMajorAxisLength, headMinorAxisLength, headExcentricity**: parameters of the head's ellipse (headMinorAxisLength and headExcentricity are semi-axis length).
- **bodyMajorAxisLength, bodyMinorAxisLength, bodyExcentricity**: parameters of the body's ellipse (bodyMinorAxisLength and bodyExcentricity are semi-axis length).
- **tailMajorAxisLength, tailMinorAxisLength, tailExcentricity**: parameters of the tail's ellipse (bodyMinorAxisLength and bodyExcentricity are semi-axis length).
- **imageNumber**: index of the frame.
- **id**: object unique identification number.

	xHead	yHead	tHead	xTail	yTail	tTail	xBody	yBody	tBody	curvature
0	515.733	181.263	3.086240	577.710	191.101	2.801250	545.303	185.957	2.961370	2.856190e-
1	723.060	167.722	3.204620	789.967	163.884	3.232200	755.204	165.879	3.205630	6.985190e-
2	506.872	178.392	2.991110	570.443	188.991	2.945870	537.073	183.428	2.972330	6.621030e-
3	721.137	168.071	3.196860	787.819	164.195	3.233310	753.288	166.202	3.205520	2.174710e-
4	497.370	176.719	3.037370	561.544	188.657	2.922960	527.723	182.365	2.959540	9.497620e-
5	719.335	168.806	3.200110	787.030	165.102	3.232640	751.426	167.050	3.203170	1.624720e-

Positions are in pixels, in the frame of reference of the original image, zero is in the top left corner. Lengths and areas are in pixels. Angles are in radians in the intervale 0 to 2*pi.

0 − > x
¦
¦

v
y

Note: If several tracking analysis are performed on the same image sequence, the previous folder is not erased, it will be renamed as **Tracking_result_DateOfTheNewAnalysis**.

Data analysis

The tracking file can be opened for subsequent analysis:

```
# Python
data = pandas.read_csv("tracking.txt", sep='\t')

# Julia
using CSV
CSV.read("tracking.txt", delim='\t')

# R
read.csv("tracking.txt", header=T sep="\t")
```