CineCAT 1.2

VISCODA GmbH
Schneiderberg 32
30167 Hannover, Germany

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User Guide

CineCAT 1.2 by
VISCODA GmbH
Schneiderberg 32, 30167 Hannover, Germany
URL: http://www.viscoda.com
Email: info@viscoda.com

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Your Opinion:

We are interested in your comments and suggestions about the User Guide and about the software. Please tell us, what of the User Guide and of the software you like or dislike. We would be pleased to receive suggestions from you in order to improve the User Guide and software.

Contents

1 Introduction

1.1 Welcome to CineCAT

The CineCAT Cinema 4D plugin offers a full automatic and robust solution for camera tracking. CineCAT estimates camera parameters and reconstructs 3D points of the scene from image sequences. The estimated camera parameters and 3D points are inserted into the Cinema 4D scene. The CineCAT plugin is running on Windows and Mac OS X systems.

1.2 How CineCAT Works

The process of camera parameter estimation, which is also known as match moving, can be divided into two steps: feature tracking and camera tracking. The automatic feature tracking consists of detection and subsequent matching of 2D feature points in consecutive images. In the camera tracking step these so called 2D feature tracks are used to estimate the camera parameters focal length, camera position and camera orientation for each image of the sequence. Thereby also the positions of 3D points of the scene are estimated. A final refinement step increases the accuracy of the camera parameters and the 3D points. The obtained camera parameters and 3D points enable the perspectively correct compositing of virtual 3D objects into the real image sequence by a 3D animation package, so that the virtual 3D objects appear as part of the real scene.

1.3 Features

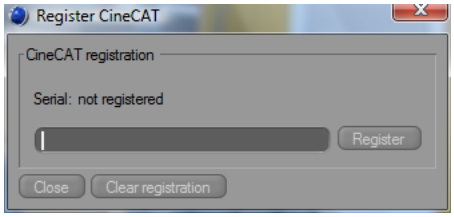
- Supported systems: Windows (32 and 64 bit versions), Mac OS X (Intel or PPC)
- Seamless integration into MAXON Cinema 4D
- Fully automatic match moving
- Very fast multi-threaded tracking engine, which employs up to 4 processors
- Image sequences in the format: JPEG, PNG, GIF, CIN, DPX, PNM, TGA, TIFF, BMP
- Arbitrary image resolution including SDTV and HDTV up to 2048x1156
- Flexible Auto Feature Detector options
- Solves free and nodal pan camera motion
- Solves constant and variable focal length shots
- Lens distortion correction tool
- Polygon mask tool
- Extensive scene modelling tools
- Fast and easy access to scene orientation
- Locator tool for adding manual points where needed
- Controllable number of exported 3D points and scene objects
- Export of image sequences with compensated lens distortion - exported image sequences can be automatically imported as scene backdrops

1.4 Requirements

Maxon Cinema 4D Release 10.5 or greater on Windows or Mac OS X systems.

1.5 Installation and Registration

The installation of CineCAT consists of extracting the CineCAT archive into the Cinema 4D plugin folder. A software license belongs to an individual license key with an associated serial number. The license is activated by the purchased license key.



If no registration info is found CineCAT starts in demo mode. In this mode the plugin will limit the number of frames for the exported camera to 10. There is no frame count limitation when using CineCAT in a demo version of Cinema 4D. All tracked frames will be exported to the Cinema 4D scene.

The registration of the plugin with a valid license and the associated license key disables also the limitation of exported camera frames. CineCAT can be registered at any time by opening the **Registration Dialog** found in **Help** →**Register**. This dialog provides fields for inserting the license key. After clicking the **Register** button the key is checked for validity. If the entered key is valid Cinema 4D has to be restarted for the changes to take effect. A registered version of CineCAT will display its serial number in the **Registration Dialog**.

The button **Clear Registration** can be used to clear all registration information from the current system. CineCAT will then revert to demo mode functionality upon restart.

1.6 Support

CineCAT support can be found at http://www.viscoda.com. The forum is visited regularly by the developers of CineCAT, so problems can be solved quickly. Furthermore, a constantly updated FAQ (Frequently Asked Questions) and Tips and Techniques list is provided on the website.

2 Quick Start

2.1 Interface Overview

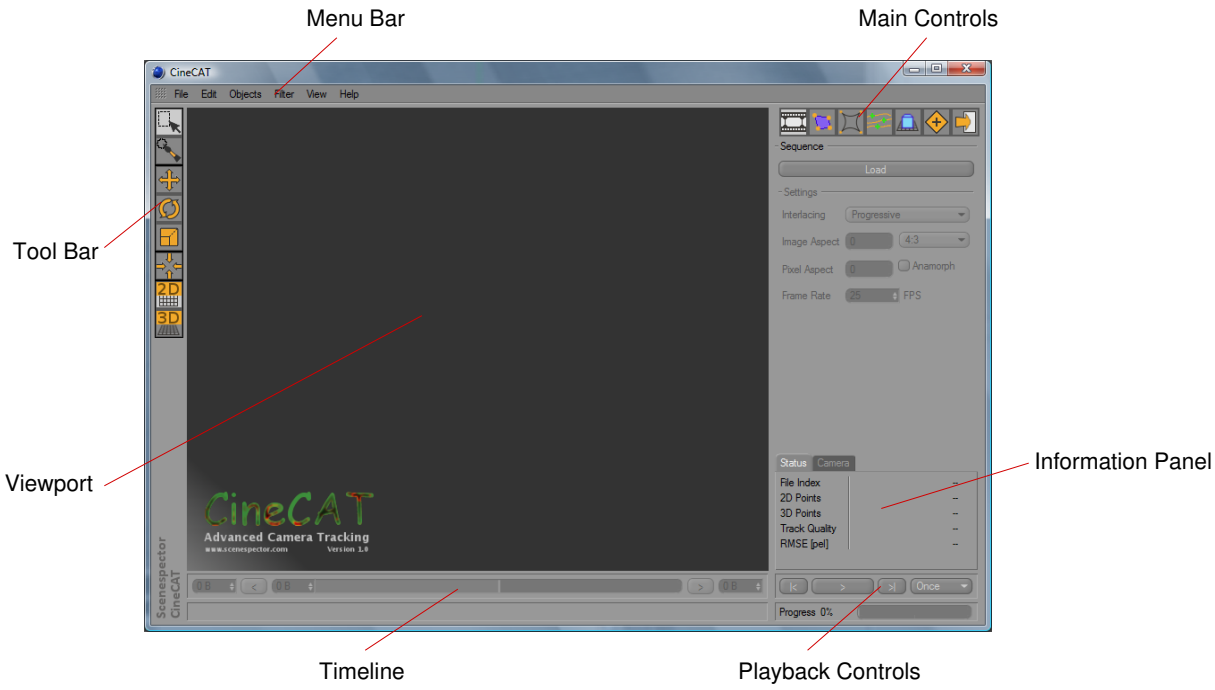


Figure 1: The CineCAT plugin start up window.

2.2 Basic Steps

Three steps are necessary to track a sequence.

1. Select the Sequence Tab and load a sequence Load
2. Select the Tracking Tab and start tracking Start
3. Select the Export Tab and insert the tracking result into the Cinema 4D scene Insert Tracked Scene

2.3 Workflow Overview

Main Controls	Overview	See section
Sequence	• Load image sequence • Select interlacing • Set image and pixel aspect ratio	3.5.1
Polygon Mask	• Create polygon mask	3.5.2
Lens Distortion	• Draw reference lines over an image • Compensate for radial lens distortion • Save image sequence with compensated lens distortion	3.5.3
Tracking	• Select camera motion: **Free Move** or **Pure Rotation** • Start tracking with the **Track** button	3.5.4
Scene	• Select one or more 3D points and add a 3D test object to the scene • Verify the accuracy of the camera parameters visually with the inserted 3D test objects or examine the 3D scene within the 3D view	3.5.5
Locator	• Build 3D locator points by creating and moving 2D anchor points in the images	3.5.6
Export	• Insert camera, 3D points, scene objects, locators and backdrop image into the Cinema 4D scene	3.5.7

3 User Interface

The following sections describe the different parts of the user interface as shown in Fig. 1.

3.1 Tool Bar

The Tool Bar provides easy access to frequently used tools or switches.

The **Rectangle Selection** button enables the standard rectangle selection tool.

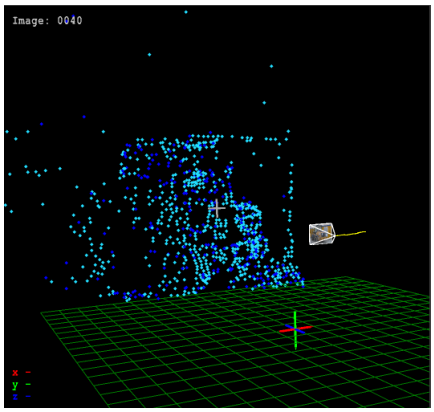
With the **Paint Selection** tool objects can be selected using a paint brush.

The **Translate Object**, **Rotate Object** and **Scale Object** buttons attach transformation handles to a selected 3D test object to translate, rotate or scale the selected 3D test object respectively.

The **Lock View** button can be activated to lock the current view to selected 3D points or to a selected 3D test object in order to judge camera tracking quality in the 2D Image View. The camera image will be shifted in such a way that the last selected 3D point or the last selected 3D test object is always in the center of the viewport.

3.2 Viewport

The Viewport has two viewing modes - **2D Image View** and **3D Scene View**. In **2D Image View** mode the Viewport acts like a movie player and displays the images of the sequence. In mode **3D Scene View** mode the Viewport acts as a 3D viewer, which allows navigating through the 3D scene. The views can be toggled between **2D Image View** and **3D Scene View** with the 2D/3D buttons of the Tool Bar (keyboard shortcut = `v`).



Mouse and Keyboard Controls

Actions inside the Viewport are applied with left, middle and right mouse buttons, the mouse wheel and keyboard inputs. By using the middle mouse button the view point of the observer can be rotated around the fixed point of the scene. If the additional `Ctrl` key is pressed, the view point of the observer rotates only around an axis that goes through the view point of the observer and through the fixed point of the scene.

If the `Shift` key is pressed the view point of the observer can be moved parallel to the viewing plane of the observer. The view point of the observer can also be moved to or away from the fixed point of the

scene by using the mouse wheel.
For navigation of the scene the following mouse and keyboard shortcuts are used:

Mouse Controls	Description
left-click and drag	Create a selection rectangle (2D and 3D mode)
right-click	Open context menu (2D and 3D mode)
middle-click and drag	Translate the view (2D mode), rotate the view (3D mode)
`Shift`, middle and drag	Translate the view (3D mode)
`Ctrl`, middle and drag	Rotate view with fixed axis (3D mode)
Mouse wheel up/down	Zoom
Keyboard Controls	**Description**
`R`	Create plane
`S`	Create cone
`+`	Zoom in
`-`	Zoom out
arrow keys	Translate view
`Del`	Delete current selection

The position, the size and the orientation of a 3D object can be changed. For this the 3D object has to be selected with a mouse click. Now the selected 3D object can be translated in the plane parallel to the screen by dragging the mouse.

Context Menu

The viewport context menu opens by clicking the right mouse button anywhere in the viewport area.
The menu items **Create Mesh**, **Create Cone** and **Create Plane** create a triangle mesh, a cone or a plane depending on currently selected 3D points or selected 2D feature points.
The creation of a triangle mesh requires at least three selected points. If one point is selected and a cone is created the cone points to the selected 3D point. A created plane is approximated, if more than three points are selected. The size of the plane is determined by the outermost 3D points.
The menu items **Undo** and **Redo** can be used to revert the last changes made to the scene - and to revert these changes respectively.
The menu item **Delete Selection** deletes the currently selected objects: Automatic Feature Points, 2D Anchors, Test objects (cone, plane or triangle mesh).
The viewport can be reset with the menu item **Reset View**.

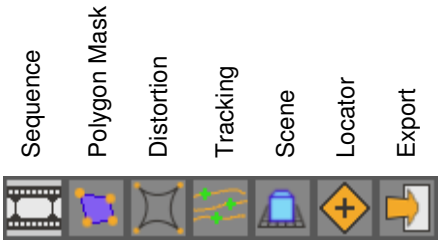
3.3 Playback Controls

The Playback Controls allow to play the image sequence. Apart from the **Start** button, **Jump To Last Frame** and **Jump To First Frame** buttons are provided. The mode selector gives access to the different play modes: **Once**, **Loop** (play from the start upon reaching last frame) and **Bounce** (reverse upon reaching last frame).

3.4 Timeline

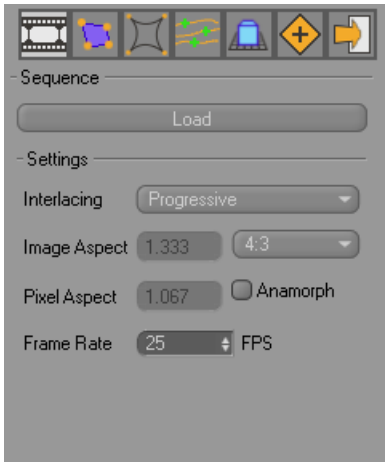
The Timeline allows to navigate through the image sequence with a slider and two editable fields and buttons to control the range of the sequence, that is used for tracking. Clicking a button will set the respective start or end frame depending on the current frame.

3.5 Main Controls



The main controls consist of seven tabs: **Sequence**, **Polygon Mask**, **Lens Distortion**, **Tracking**, **Scene**, **Locator** and **Export**. Initially the **Sequence** tab is activated.

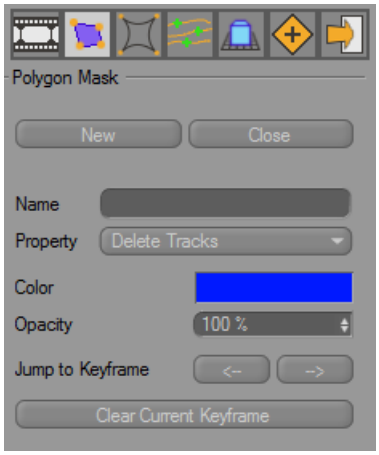
3.5.1 Sequence



Within the Sequence tab an image sequence can be loaded and sequence settings are specified.

Load	Opens a dialog to select the image sequence
Interlacing	**Progressive**, **Top Field First** or **Bottom Field First** are possible.
Image Aspect	The aspect of image width to image height. Available ratios are 4:3, 16:9, 1:1, 1:1.77 or custom.
Pixel Aspect	The Pixel aspect ratio, automatically calculated from image aspect ratio, can be overwritten for anamorphic sequences
Anamorph	Enable independent settings of image and pixel aspects
Frame Rate	Frame rate for playback and scene export

3.5.2 Polygon Mask



For some image sequences the tracking result can be improved by manually masking out distinct areas that contain moving objects.

The menu **Polygon Mask** provides tools to create polygonal masks that inhibit feature tracking within the image area covered by the masks.

It is also possible to edit existing masks. This can be done by dragging the mask or its vertices with the mouse. If more than one vertex has been selected the mouse wheel can be used to scale the selected vertices. A click inside a mask selects all of its vertices.

New Create a new mask - vertices can be created by clicking into the image.

Close Close the polygon by connecting the first and the last polygon vertex

Name Name of the polygon mask

Property **Delete Tracks** disables tracking of 2D feature points inside the polygon mask. **Detect Features** locally overrides other masks

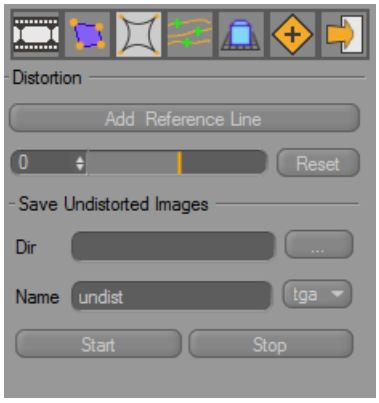
Color Choose color of the polygon face

Opacity Choose opacity of the polygon face - between 0% for full transparency and 100% for full opaqueness

Keys Geometry modification of a polygon mask generates a key frame at the active image for this mask. For images between keyframes the mask geometry is interpolated. The buttons are used to jump to the previous or next key frame or to clear the current key frame of the polygon mask.

Figure 2: Image content covered by polygon masks is excluded from 2D feature tracking.

3.5.3 Lens Distortion



Camera objects in Cinema 4D do not have any optical distortion - they are ”optically perfect”. Real-world lenses often generate some measure of distortion though (an effect that is visible when straight lines appear curved). Image sequences photographed with optical distortion must be undistorted to match the ”perfect” Cinema 4D cameras.

The Distortion tab allows to compensate for the radial lens distortion of the ”real-world” camera. By overlaying the image with reference lines the lens distortion can be determined. A new reference line can be added to the image by clicking the button **New Reference Line**. Start or end points of reference lines can be dragged and moved with the left mouse button pressed. The radial lens distortion can be varied with the slider or by pressing `Ctrl` and moving the mouse in the View Window with left mouse button clicked. An image is undistorted when projected straight lines of the real 3D scene matches the reference lines as shown in Fig. 3.

Add Reference Line Add a reference line overlay

Distortion Control amount of image distortion

Dir Directory to save the undistorted image sequence

Name Name of the saved undistorted image files. The name is extended with a five digit number and the file extension of the selected file format, e.g. ”undist00123.tga”.

Start Start saving of the undistorted image sequence

Stop Stop or cancel saving of the undistorted image sequence

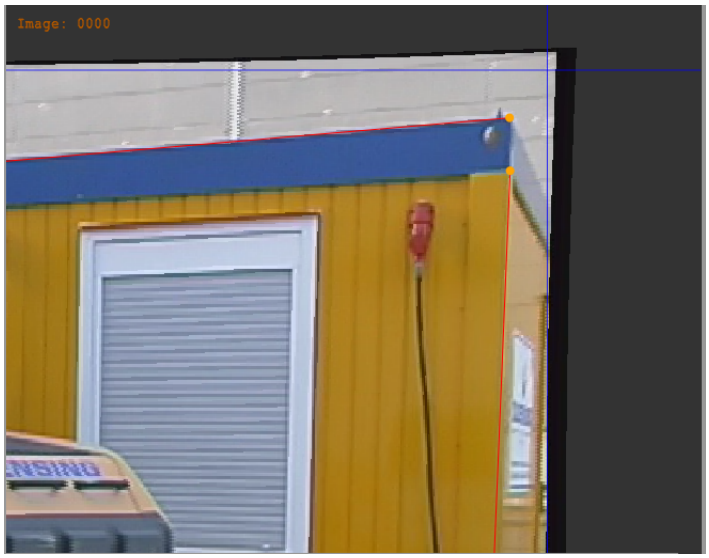


Figure 3: Reference lines to determine lens distortion.

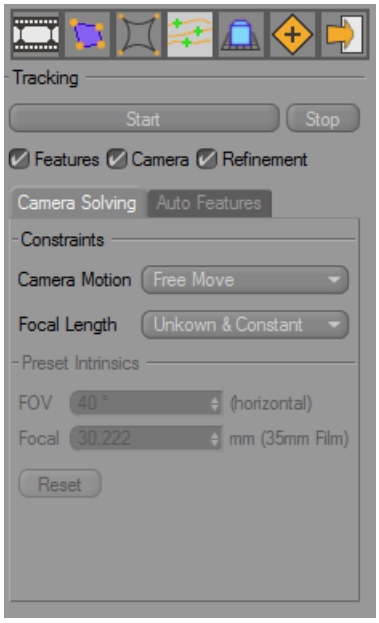
3.5.4 Tracking

The tracking process consists of feature tracking, camera tracking and a final refinement. Each of these steps can also be executed separately. The steps are controlled by the checkboxes located below the **Start** and **Stop** buttons.

The feature tracking step detects and tracks 2D features in the images. The camera tracking step estimates (solves for) the camera parameters like focal length, position and orientation for each image as well as the 3D point cloud of the tracked scene. Finally the refinement step improves the accuracy of the camera parameters and the positions of the 3D points.

After the camera tracking has been completed the estimated 3D points are displayed in the colors blue and cyan. Thereby the color of a 3D point marks its visibility. A cyan 3D point is a 3D point, which has a corresponding 2D feature point in the actual displayed image and which may be visible in the actual displayed image. A blue 3D point does not have a corresponding 2D feature point in the actual displayed image or is hidden in the actual displayed image and thus not visible.

The tracking settings are divided into the two tabs **Camera Solving** and **Auto Features**.

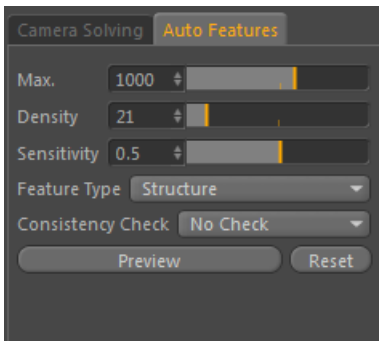


With the **Camera Solving** tab the camera motion and the focal length can be constrained. The camera motion can be constrained with two kinds of camera motion models. The model **Pure Rotation** takes only camera rotation and camera zoom into account. This motion model is suitable for sequences taken with a camera on a tripod. The model **Free Move** takes translation as well as zoom and rotation of the camera into account. This motion model is suitable for sequences taken with hand-held cameras and should be used as default. In this case it is important that the camera performs a sufficiently large translational motion.

Tip: Repeated refinement steps may increase the tracking quality and decrease the Root Mean Square Error (RMSE) of projected 3D points respectively.

Tip: If tracking has failed, the following procedure may yield to sufficient tracking results: Select a shorter part of the sequence as start and end frame and apply camera tracking. Use the value of estimated focal length or field of view for a fixed focal length constraint. Apply camera tracking and refinement for the whole sequence again.

Start	Start tracking. The tracking process is divided into the three steps feature tracking, camera tracking and refinement. The three steps can be enabled or disabled with check boxes.
Stop	Stop or cancel tracking
Camera Motion	Selection of camera motion constraint: **Free Move** for e.g. a handheld camera or **Pure Rotation** for a camera on a tripod
Focal Length	Selection of focal length constraint: **Unknown Constant**, **Unknown Variable**, **Initialized Constant**, **Initialized Variable** or **Fixed, given**
Preset Intrinsics	The horizontal field of view (FOV) or a focal length, which is related to a $22mm$ filmback width of a 35mm film, is used to initialize or fix the focal length estimation.



The **Auto Features** tab allows to change the automatic feature detection settings. The maximum number of detected features in each image, the density of feature points as well as the sensitivity of detection can be be controlled. In addition, the feature type is selectable as **Structure** or **Corner**. An example of these two types is shown in Fig. 4.

By selecting a **Consistency Check**, the image content in the range of a feature point in the current image will be compared to the corresponding image content in the image the feature point was initially detected. These tests can lead to an improvement of the tracking result by reducing erroneous assignments of feature points to a trajectory. Three different tests are available:

- Translation: Compares region contents allowing translation and scaling.
- Similarity: Compares region contents allowing translation, rotation and scaling (similarity transformation)
- Affine: Compares region contents allowing translation, rotation, scaling and shear (affine transformation)

A click on the **Preview** shows the features, that are detected with current settings.

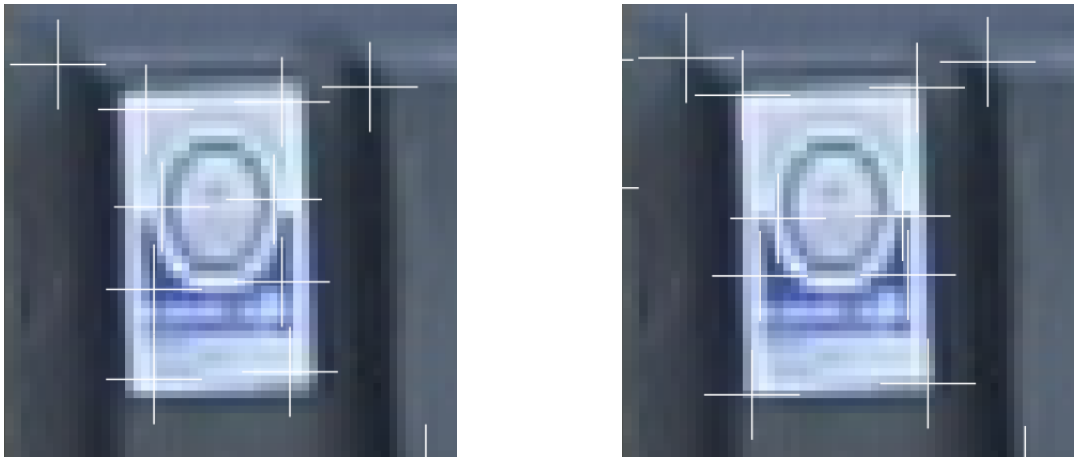


Figure 4: Examples of the two feature types structure (left) and corner (right).

Max	Maximum number of detected features per image
Density	Distance between the feature points
Sensitivity	A high sensitivity forces the detection of features in image regions with low image structure.
Feature Type	The default feature type is **Structure**. **Corner** results in features located at corners in the image.
Preview	Detect and show features in the actual image with current settings. (check filter settings for feature point visibility)
Reset	Revert auto feature settings to their default values.
Min. Track Len.	Select a minimal feature track length. If **Apply** is pressed all feature tracks with a length below the minimal length are removed.

Editing Feature Tracks

In some case a manual editing of the feature track can improve the tracking result. Two designated tools allow the editing of the feature tracks. First, a minimum feature track length can be specified to keep only long-duration feature tracks. Second, selected feature tracks can be removed.

After editing the feature tracks, the camera has to be tracked again. To track the camera again, disable feature tracking, enable camera tracking and refinement, then press **Start** to track the camera again. In a few cases repeating the refinement step can improve the accuracy of the camera track and the 3D point cloud.

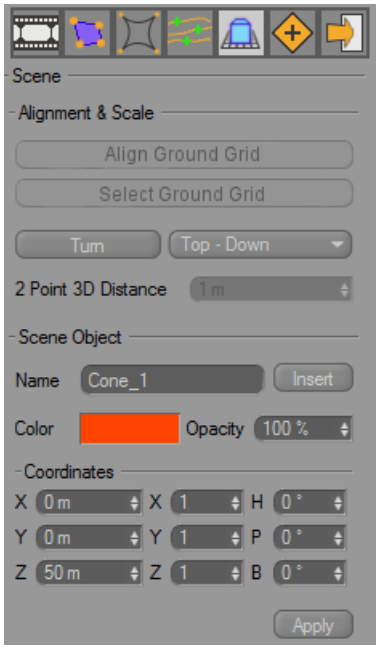
Minimum Feature Track Length

After feature tracking the minimum feature track length can be controlled by selecting a minimum track length in the edit field of the **Auto Features** tab. A click on the associated **Apply** button will remove all feature tracks that are shorter than the given limit.

Removing Feature Tracks

If feature tracks interfere with the camera tracking, because for example some features are on moving objects or on reflections in the scene, these outlier feature tracks can be removed and the camera can be tracked again. To remove feature tracks, enable the display of 2D features, select 2D features with the mouse and press the delete key or click on Delete Selection within the right click context menu.

3.5.5 Scene



The Scene tab can be used to examine and scale the tracked scene, to align the ground grid or to model scene geometry based on tracked 3D points.

Examining Tracking

The accuracy of the camera track can be checked with 3D objects that are added to the 3D scene. 3D objects like cones are especially well-suited to compare the tracked camera with the real-world scene. If one 3D point is selected, a 3D cone is created at the position of the selected 3D point by clicking the item **Create Cone** within the main menu or within the context menu of the viewport.

Ground Grid Alignment

The ground grid, which lies in the XZ plane of the world coordinate system (WCS), can be aligned with 3D manipulators, with coordinate edit fields or by fitting the ground grid to a number of selected 3D points.

For the alignment with 3D manipulators the ground grid has to be selected with the corresponding button. Then the grid can be translated, rotated or scaled by attaching 3D manipulators with the Tool Bar.

The ground grid can be aligned by selecting a number of 3D points or by selecting an existing 3D scene object. The ground grid will be placed in a best-fit manner to the selected 3D points or to the local coordinate systems of the selected 3D scene object. The alignment is executed by pressing the **Align Ground Grid** button or via the right mouse context menu within the viewport. The button **Align Ground Grid** is only active if at least three 3D points or one scene object are selected.

Tip: 3D points, that lie on the ground of the scene may be easier to select if the viewport is in 2D Image View and only **Current 3D Points** are displayed.

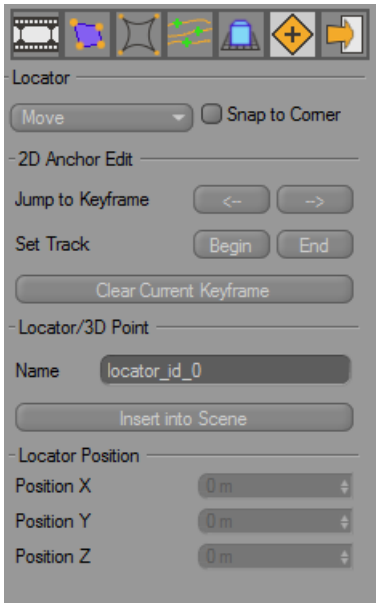
Model 3D Scene Geometry

The tracked scene is represented as a 3D point cloud. These 3D points can now be used to model the geometry of the tracked scene with 3D objects like planes and triangle meshes. After selecting a number of 3D points or 2D features a plane or a triangle mesh will be created with a click on the item **Create Plane** or **Create Mesh** of the main or context menu. These scene objects can be inserted to the Cinema 4D scene, where they are helpful to realize any kind of interactions between the virtual and real scene, e.g. shadow casting or occlusions. A new 3D test object can be created by clicking **Add Object**. With the selection **Rectangle** or pressing the key `p` a triangle is created, if three 3D points are selected. If a rectangle is added with more than three selected 3D points, the rectangle is fitted into the selected 3D points.

Align Ground Grid	Alignment of the ground grid to current selected 3D points or selected 2D feature points.
Turn	The orientation of the ground grid is changed depending on the selection of the combo box: **Top - Down**, **Left - Right** or **Front - Back**
2 Point 3D Distance	If exactly two 3D points or two 2D feature points are selected, the distance in 3D space between these points is displayed and can be changed.
Name	Name of the scene object. This name is also used for the scene node of the object, which is inserted into the Cinema 4D scene.
Color	Choose color of the scene object
Opacity	Choose opacity of the scene object between 0% for full transparency and 100% for full opacity
Insert	Inserts currently selected 3D object into the Cinema 4D scene.
Coordinates	Position, scaling and orientation of the selected 3D scene object are displayed and can be changed.
Apply	Position, scaling and orientation in the coordinate edit fields are applied to the selected 3D scene object.

Figure 5: 3D scene view to navigate through the tracked scene.

3.5.6 Locator



The Locator tab is used to create user generated 3D point locators by inserting manual 2D points as anchors into the scene where needed. If the automatic tracking has not placed a 3D point where the user needs one, a 3D point locator can be added to the scene.

A 2D anchor can be created by clicking at the appropriate location in the viewport, while the **Create** combo box is active.

Note for Version 1.0.3: The mode can now be toggled with a button.

If the 2D anchor point is added to a specific frame, a keyframe is generated. The mode **Move** adjusts already placed 2D anchors. By switching to a different image and moving an existing anchor, another keyframe is generated. If an anchor has more than one keyframe, the 3D coordinate of the associated 3D point locator is calculated and added to the 3D scene. The projection of the 3D point locator is displayed as a 2D anchor track as shown in Fig. 6 and can be used to control the placement of the 3D locator.

If the box **Snap To Feature** is checked, 2D anchors are created and moved to image positions in the current image, where suitable corner features are determined. The corner snapping feature is available in **Create** and **Move** mode. This can be useful to adjust a 2D anchor position. This feature works at sub-pixel accuracy.

Create/Move	Create or move 2D anchor and the associated 3D locator
Snap to Corner	Moved 2D anchors are snapped to corner features
Keyframes	2D anchor movement generates a key frame at the active image for this anchor track. The arrow buttons are used to jump to the to previous or next keyframe. The button **Clear** removes the keyframe of the selected 2D anchor at current image.
Set Track	Selected 2D anchor track begins or ends in the current image
Name	Name of the 3D locator. This name is also used for scene node of the locator, which is inserted into the Cinema 4D scene.
Insert	Inserts currently selected 3D locator into the Cinema 4D scene.
Locator Color	Color of the inserted locator.
Locator Type	The Insertion as **NULL Object** or as **Single Object** creates a grouped NULL object or a polygon, which has the 3D locators as vertices, respectively.
X,Y,Z	Position of the 3D locator

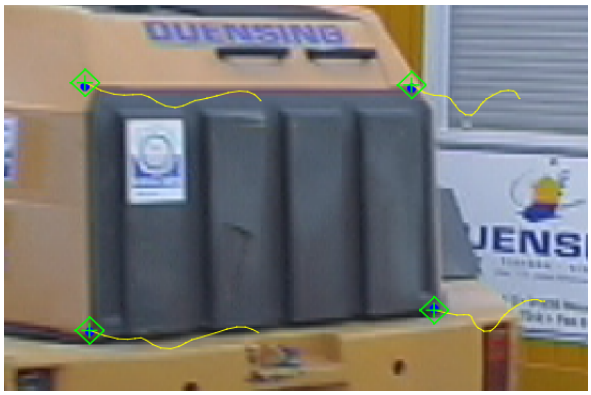
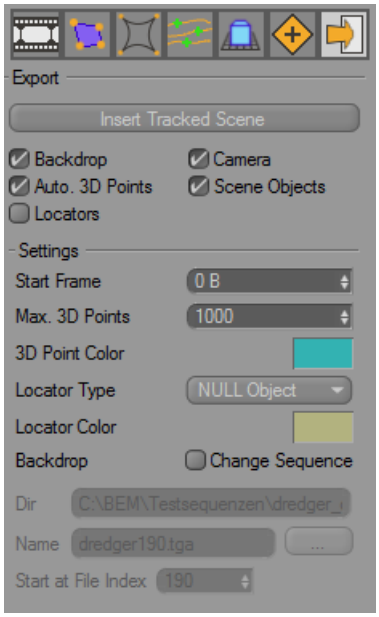


Figure 6: 3D point locators are controlled by user defined 2D anchor points.

3.5.7 Export



The Export tab controls the insertion of the camera, 3D points, 3D object and 3D point locators into the Cinema 4D scene. The insertion of several objects of the tracked scene can be enabled or disabled by checking the associated box.

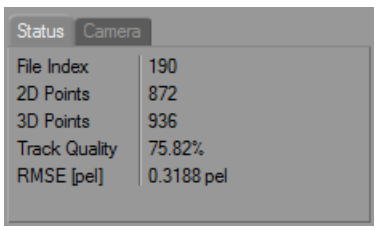
A subsequent insertion of the tracked scene creates a new Cinema 4D scene object each time. The settings of this tab are used to control the number of automatic 3D points to insert, to specify the frame on the timeline, where the tracked scene starts within Cinema 4D timeline and to select the color of inserted objects.

The option to specify another sequence than the tracked sequence as backdrop allows to insert a sequence with compensated lens distortion (undistorted sequence). This option is activated if the box **Change Sequence** is checked.

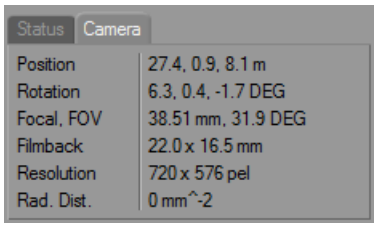
Insert Tracked Scene	**Backdrop**, **Camera**, **Auto. 3D Points**, **Scene Objects** or **Locators** are inserted in to the Cinema 4D scene if the corresponding box is checked.
Start Frame	Start frame of the Cinema 4D scene from where the tracked camera is inserted.
Max. 3D Points	Limits the total number of inserted 3D points to the specified amount.
3D Point Color	Color of the inserted 3D points can be chosen.
Locator Type	3D point locators are inserted as either a Cinema 4D NULL object or polygon object.
Locator Color	Color of the inserted 3D point locator can be chosen.
Backdrop	Backdrop can be changed by checking the box **Change Sequence** and selecting a the directory and name of the sequence. The file index with which the sequence starts can also be chosen.

3.6 Information

The information panel consists of two tabs - **Status** and **Camera**.



The **Status** tab shows the file index of the currently displayed image and the total number of images. After successful tracking also the number of 2D features and 3D points, the field of view of the camera as well as the final estimation error in pixel (pel) is shown. The estimation error is a Root Mean Square Error (RMSE) of re-projected 3D points and is measured as distance in the image. The lower the RMSE, the better the tracking is. An RMSE value below 0.5 pel indicates a good tracking result.



The **Camera** tab shows the camera parameter of current image. The camera parameter are position, orientation, focal length, respective

field of view (FOV), size of the filmback and radial distortion.

The progress bar indicates the applied time as percentage of the total processing time and counts from 0 to 100%. The progress bar is used during tracking or during saving of undistorted images.

3.7 Menu Bar

The menu bar consists of the menus **File**, **Edit**, **Objects**, **Filter**, **View**, and **Help**. The menus are shown in Fig. 7.

Within **File** a sequence can be loaded, the tracking results including the polygon masks can be saved and loaded as a project file. The menu **Edit** includes undo and redo commands as well as items to delete the current selection or to reset the global scene scale.

Within the **Objects** menu a triangle mesh, a plane or a Cone can be created from a selection of 3D points.

The items of the menu **Filter** control the currently displayed objects. The menu **View** allows to switch between the 2D Image and 3D Scene View, to lock the view to a selected object, reset the view or to enable and disable displaying of a zoom window.

The items of the last menu **Help** open a dialog to register the plugin with a valid license key and a dialog to inform about the plugin version.

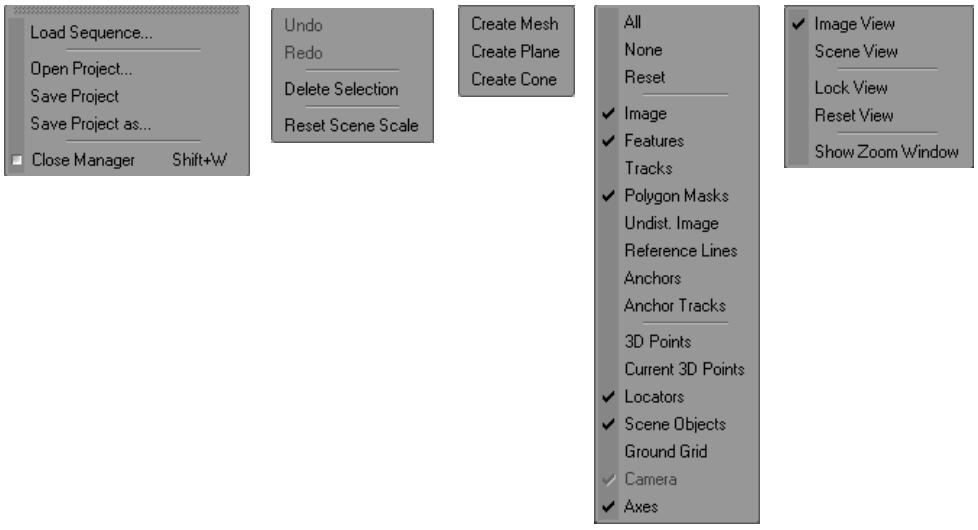


Figure 7: The **File**, **Edit**, **Objects**, **Filter**, **View**, and **Help** menus.

4 References

4.1 Image/Video Formats

Table 1: Supported image file formats.

Format	Description	File Extension
JPEG	Joint Photographic Experts Group	.jpg, .jpeg
GIF	Graphic Interchange Format	.gif
CIN	Digital Cinema Cineon	.cin
DPX	Digital Picture Exchange	.dpx
PNG	Portable Network Graphics	.png
PNM	Portable Anymap	.ppm, .pgm
TGA	Truevision Targa	.tga
TIFF	Tagged Image File Format	.tif, .tiff
BMP	Windows Bitmap	.bmp