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Thank you for using WINanalyze

If you want to install WINanalyze on your PC, put the CD into its drive, click Start, Run, Browse to the CD drive and there on Setup. Press OK and the setup for WINanalyze starts. When the setup program is ready you can not start WINanalyze before you have connected the dongle at LPT1, the parallel connector. Is there any device connected, put the dongle between connector and cable.

Before you start working with WINanalyze you should look at the files in the directory „Introduction“ on the CD. There are samples and a tutor. These files are not loaded onto the Hard drive during the setup process.

1 Contents

1	Contents	5
2	About WINalyze	11
2.1	What is WINalyze?	11
2.2	System Requirements	11
3	The WINalyze Workplace	13
3.1	Starting and Ending WINalyze	13
3.1.1	Starting WINalyze	13
3.1.2	Ending WINalyze	13
3.2	Title Bar	14
3.3	Menu Bar	14
3.4	Toolbar	14
3.5	Working Area with Different Windows	16
3.5.1	Image Sequence Window	16
3.5.2	Analysis Window	16
3.6	Dealing with Dialog Boxes	17
3.7	Right Mouse Button	17
3.7.1	Image Sequence Window	17
3.7.2	Analysis Window	18
3.8	Status Bar	18
3.9	Keyboard Shortcuts	19
4	How to...	21
4.1	Step by Step	21
4.2	Open an Image Sequence	22
4.3	Open a Multiple Image Sequence	23
4.4	Preprocess an Image Sequence	24
4.4.1	Gamma Correction	24
4.4.2	Filter	24
4.5	Play Image Sequences	25
4.6	Calibrate a Single Image Sequence	25
4.7	Calibrate a Multiple Image Sequence	26
4.8	Set New Object Sequences	28
4.9	Create Connections	29
4.10	Create Angles	30
4.11	Track Objects	31
4.12	Make an Analysis	32

4.13	Work on an Analysis Window	32
4.13.1	Adjusting Sequences	32
4.13.2	Importing Data of External Devices	33
4.13.3	Exporting Analysis Data	33
4.13.5	Changing the Display Style	33
4.13.6	Font	34
4.14	Work with Reticules	34
4.15	Zoom Into and Out of a Window	35
4.16	Print Windows	35
5	Menu Commands	37
5.1	File Menu	37
5.1.1	Load Image Sequence Command	37
5.1.2	Load Multiple Image Sequences Command	40
5.1.3	Close Command	44
5.1.4	Print Page Setup Command	44
5.1.5	Print Command	46
5.1.6	Printer Setup Command	47
5.1.7	Exit Command	48
5.2	Player Menu	48
5.2.1	Play Command	48
5.2.2	Stop Command	48
5.2.3	Next Frame Command	49
5.2.4	Previous Frame Command	49
5.2.5	First Frame Command	49
5.2.6	Last Frame Command	50
5.3	Image Sequences Menu	50
5.3.1	Filter Command	50
5.3.2	Gamma Correction Command	52
5.3.3	Document Files Command	54
5.3.4	Calibration Command	55
5.3.5	Layout Submenu	61
5.3.6	Object Display/Only Current Objects Command	61
5.3.7	Object Display/Objects of All Frames Command	61
5.3.8	Object Display/Connections Command	62
5.3.9	Object Display/Angles and Connections Command	62
5.3.10	Show Dialogs Command	62
5.3.11	Info Command	66
5.4	Objects Menu	67
5.4.1	New Object Sequence Command	67

5.4.2	Delete Object Sequence Command	67
5.4.3	Undelete Command	68
5.4.4	Set Object Command	68
5.4.5	Delete Object Command	69
5.4.6	Edit Object Sequence Command	69
5.4.7	Smart Object Position Command	70
5.4.8	Object Editor Command	71
5.4.9	Objects/Save Command	72
5.4.10	Objects/Save as New Command	72
5.4.11	Objects/Load Command	73
5.4.12	Import Command	73
5.4.13	Export Command	74
5.4.14	Presetting Command	76
5.5	Tracking Menu	79
5.5.1	To Sequence End Command	79
5.5.2	One Frame Forward Command	79
5.5.3	One Frame Backward Command	79
5.5.4	To Sequence Begin Command	80
5.6	Analyze Menu	80
5.6.1	New/Sequences Submenu	80
5.6.2	New/Connections Submenu	81
5.6.3	Adjust Sequences Submenu	84
5.6.4	Import External Data Command	85
5.6.5	Delete Imported Data Command	85
5.6.6	Export Analysis Data Command	85
5.6.7	Coordinates Command	88
5.6.8	Display Command	89
5.6.9	Enable/Disable Reticules Command	90
5.6.10	Insert Reticules (Old Position) Command	91
5.6.11	Enable/Disable Showing Frame Numbers Command	91
5.6.12	Select Fonts Command	91
5.6.13	Position Data Left/Right Command	91
5.7	Window Menu	92
5.7.1	Smart Tile Command	92
5.7.2	Cascade Command	92
5.7.3	Tile Command	92
5.7.4	Arrange Icons Command	92
5.7.5	Close All Command	92
5.7.6	Zoom In Command	93

8.4.2	Camera Calibration Techniques	118
8.4.3	Input File Specifications (CMO, CAM)	120
9	Body Model Module	127
9.1	Introduction	127
9.2	How to Work with Body Models	129
9.3	Commands Referring to the Body Models	131
9.3.1	Image Sequences/Object Display/Centers of Mass Command ...	131
9.3.2	Objects/Body Model/Select Body Model Command	131
9.3.3	Select a Body Model Dialog Box	132
9.3.4	Edit Body Model Dialog Box	134
9.3.5	Properties of this Object Dialog Box	134
9.3.6	Properties of this Segment Dialog Box	137
9.3.7	Properties for Body Model Dialog Box	140
9.4.1	Objects/Body Model/Edit/Position Command	142
9.4	Model Positioning Dialog Box	143
9.5	Objects/Body Model/Insert in List Command	144
9.5.1	Insert Model in Database Dialog Box	145
9.6	Objects/Body Model/Delete Command	146
9.7	Analyze/New/Centers of Mass Submenu	146
9.8	Analyze/New/Forces and Moments Submenu	148
10	Calculating Analyses	149
10.1	Origin of Original Coordinates	149
10.2	Calculation of Analyses by the Analyze/New Command	149
11	Index	151

2 About WINalyze

2.1 What is WINalyze?

WINalyze - Software for automatic motion analysis

The software package **WINalyze** was developed for the tracking and analysis of motion.

WINalyze makes it possible to interpret motion exactly. By the help of **WINalyze** you can automatically track objects and analyze their position.

With high-developed methods of pattern recognition and artificial intelligence the position of objects (e.g. the ankle-joint of a foot) is detected automatically. This happens with a speed and precision that can not be reached by the manual detection of motion.

2.2 System Requirements

The program **WINalyze** needs the following system requirements:

Hardware:

WINalyze needs the following computer configuration:

- CPU min. Pentium I
- Graphics adapter with at least 256 colours and a resolution of 800*600 pixel

Software:

WINalyze needs the following software:

- Windows 98®, 2000®, XP®, or
Windows NT 3.51® and later

3 The WINalyze Workplace

3.1 Starting and Ending WINalyze

3.1.1 Starting WINalyze

When you want to start **WINalyze** you go to the Taskbar and click the Start button. From the Programs submenu you then choose **WINalyze**.

You can also start **WINalyze** by double-clicking the **WINalyze** shortcut on the desktop with the left mouse button.

Another way is to mark the **WINalyze** symbol on the desktop with the arrow keys and then press ENTER.

3.1.2 Ending WINalyze

When you end WINalyze, all documents in the program are closed. If there are image or object sequences, which are not yet saved, you will be able to save them after a query.



There are several methods to close WINalyze:

- You can click the Close button on the right edge of the title bar to exit the program.
- You can open the system menu using the context menu on the title bar and select the Close command.
- You can open the program's **File** menu and choose the **Exit** command.

3.2 Title Bar

On the left edge of the title bar you see the name of the program: **WINalyze**.

With a right mouse click on the title bar you get the system menu, by which you can change the size of the program window or end the program.

On the right edge of the title bar there is the Minimize, Maximize and Exit button,  with which you can minimize or maximize the program window respectively exit the program. When the program window is already maximized the Maximize button changes to the Restore button,  with which you can in each case restore the window to its previous size.

3.3 Menu Bar

In the menu bar you can see the menus that are available for the program **WINalyze**.

You can select a menu by clicking on it with the left mouse button. Then you must click again to choose the wanted command.

It's also possible to choose menus and commands by the keyboard. By the ALT key the cursor jumps to the menu bar, where you can move it with the arrow keys. When you have selected a menu, you open it by the ENTER key. When a command is selected, you again choose it by pressing ENTER.





















You can also use the underlined shortcuts together with the ALT key to get to the menu and inside a menu, you just press the underlined letter to select the wanted command.

3.4 Toolbar

On the toolbar you find a row of buttons with symbols on it, which you can click with the left mouse button. These buttons will give you a fast access to the most commonly used commands.

When you stay on the symbols with the mouse pointer for a while, a small window with a description of the button appears.

You can use the buttons instead of the corresponding menu commands.

Buttons	Menu Command
	File/Load Image Sequence
	Player/Play
	Player/Stop
	Player/First Frame
	Player/Previous Frame
	Player/Next Frame
	Player/Last Frame
	Tracking/To Sequence Begin
	Tracking/One Frame Backward
	Tracking/One Frame Forward
	Tracking/To Sequence End
	Analyze/New/Sequences/x to t
	Analyze/New/Sequences/y to t
	Analyze/New/Sequences/z to t
	Analyze/Enable/Disable Reticules
	Analyze/Enable/Disable Showing Frame Numbers
	Window/Set Fit
	Window/Zoom In
	Window/Zoom Out
	Help/Contents

3.5 Working Area with Different Windows

Beneath the button bar there is the working area of the program **WINalyze**, where the different windows and dialog boxes are placed.

Here is a short description of the different kinds of windows; the handling of the dialog boxes is dealt with in the next paragraph.

The title bar of the windows has the functionality of a typical Windows® title bar.

3.5.1 Image Sequence Window

The image sequence window is the window the image sequence is displayed in, when you load an image sequence. When you load multiple camera views for one sequence, they are all shown in the image sequence window.

In the title bar the name of the image sequence is shown.

When the window is active, you can use the commands of the **Player** menu to move in the image sequence.

In the **Image Sequences** menu you find the **Show Dialogs** command, by which you can open a dialog box next to the image sequence window. In this dialog box you can switch between information about the objects, the template and the connections and angles.

Setting new object sequences, selecting objects, etc. all happens in the image sequence window.

With the right mouse button there is a context menu available to you.

A little hint: When your mouse pointer is caught in the image sequence window, e.g. when you select to set a new object sequence and have then decided not to do, you will get out by the ESC key.

3.5.2 Analysis Window

An analysis window you get, when you choose one of the commands in the **Analyze/New/Sequences** or **Connections** sub menus.

In the title bar you see the number of the analysis in the current session together with the name of the image sequence the analysis belongs to.

With the commands from the **Analyze** menu you can work with the window. You can e.g. change the origin of the diagram or measure distances by inserted reticules.

In the analysis window a context menu is also available to you by the right mouse button.

3.6 Dealing with Dialog Boxes

The dialog boxes in the program **WINanalyze** correspond to the style of dialog boxes that is used under Windows®. They contain e.g. text boxes, option buttons and check boxes, which are known from other Windows® applications.

Most of the dialog boxes contain an **OK**, a **Cancel** and a **Help** button.

With **OK** you close the dialog box, and the specification and changes you made are taken over by the program.

By the **Cancel** button you just close the dialog box and the changes you made are canceled.

By the **Help** button you get the context sensitive help for the current dialog box.

3.7 Right Mouse Button

WINanalyze also uses the right mouse button to let you access context menus.

There are two context menus, which you can access by the right

mouse button, one for the image sequence window and one for the analysis window.

3.7.1 Image Sequence Window

When the mouse cursor is in the image sequence window and you click the right mouse button, you get a context menu with the commands that are often used with image sequences.

You can access the following commands:

New Object Sequence, Set Object, Delete Object, Edit Object Sequence, Smart Object Position, Object Editor, Load, Save, Filter, Gamma Correction, Object Display, Show Dialogs

3.7.2 Analysis Window

When the mouse cursor is in the analysis window and not directly at a curve, you can also click the right mouse button and by this way get a context menu with the following commands:

Interpolate Sequences, Smoothing Sequences, Approximate Sequences, Import External Data, Export Analysis Data, Coordinates, Display, Style by Right Mouse Button, Enable Reticules, Enable Showing Frame Numbers, Select Fonts, Position Data Left/Right

When you click directly on a selected curve with the right mouse button, you get a small box, where you can select a new display style for the curve.

3.8 Status Bar

In the left part of the status bar you get short information about the currently marked menu command. When you select a command with the mouse (the mouse pointer is over the command and it is marked), you can see the information in the status bar.

In the middle part of the status bar you can see the frame number of the current image sequence.

As soon as the mouse pointer moves into the current frame, you can see the position of the pointer in the frame (in pixel coordinates) on the right side of the status bar.

3.9 Keyboard Shortcuts

Instead of the associated menu commands you can also use the following keyboard shortcuts:

Shortcut	Menu Command
CTRL+P	Player/Play
CTRL+S	Player/Stop
CTRL+N	Player/Next Frame
CTRL+V	Player/Previous Frame
SHIFT+INS	Objects/New Object Sequence
SHIFT+DEL	Objects/Delete Object Sequence
ALT+BKSPC	Objects/Undelete
INS	Objects/Set Object
DEL	Objects/Delete Object
F4	Tracking/To Sequence End
F5	Tracking/One Frame Forward
SHIFT+F1	Help/Context Help

4 How to...

4.1 Step by Step

As an introduction to this “How to...” chapter a step by step procedure of a simple analysis with **WINalyze** is given. To get deeper information for the single steps please refer to the corresponding paragraphs of this “How to...” chapter.

1. Open **WINalyze** by choosing it from programs in your Windows Start menu or double-clicking the **WINalyze** shortcut on the desktop.
2. With **File/Load Image Sequence** you now open an image sequence.
3. When the image sequence you use is of poor quality, you can improve it by the preprocessing options **Image Sequences/Filter** or/and **Gamma Correction**.
4. An image sequence consisting of only one camera view *can be* calibrated, an image sequence consisting of more than one camera view *must be* calibrated. The calibration is made in the calibration window, which is accessed via the **Image Sequences/Calibration** command.
5. Now the so-called objects are set to the areas in the image sequence that shall be tracked. New objects are generated by the **New Object Sequence** command.
6. After you have set all objects, you can start tracking the objects through the frames of the sequence by the commands from the **Tracking** menu.
7. Finally the wanted analysis data are selected from the **Analyze/New** submenu to open the analysis windows with the trajectories.

4.2 Open an Image Sequence

1. When you want to open an image sequence, you must select the **File/Load Image Sequence** command. Except the case that you open a multiple image sequence with more than one camera view for the first time; then you must choose the **File/Load Multiple Image Sequence** command.
2. The **Open Image Sequence** dialog box opens and from the file selector you choose the image sequence you want to open.
You choose a BLD or AVI file, when you open a single image sequence for the first time. When you have already worked with the image sequence (no matter whether single or multiple image sequence) in **WINanalyze**, you select the RSC file (file type: Document).
To open an AVI file you select **Video for Windows Files (*.avi)** in the drop-down list box **Files of type** in the **Open Image Sequence** dialog box. Then you select the AVI file you want to open. After you left the dialog box clicking the **Open** button, you will get the **AVI Properties** dialog box, where you can adjust several items. This dialog box is explained in paragraph 5.1.1 Load Image Sequence Command.
3. When the image sequence you want to open, can't be displayed with the possibilities of the graphics adapter, immediately after leaving the **Open Image Sequence** dialog box a colour reduction is made on the image sequence.

4.3 Open a Multiple Image Sequence

1. When you want to open an image sequence that consists of more than one camera view for the first time, you must select the **File/Load Multiple Image Sequence** command.
2. In the **Open Image Sequence** dialog box, you choose the first camera view of the image sequence from the file selector (BLD or AVI) and click **OK**. (About loading AVI files see 4.2)
3. Then the **Files of the Document** dialog box opens, where the image sequence document (the RSC file) is shown in the **Document** part.
4. In the **Image Sequence** group of the dialog box, you can see the name of the camera view (the BLD or AVI file) you just opened and beneath the group with the calibration file and the other files needed for calibration (when they already exist).
5. Next to the name of the BLD or AVI file there is the **Further Image Sequence** button. When you click this button, you get the **Open Image Sequence** file selector again, where you choose the next camera view belonging to the image sequence. Then you press **OK**.
6. The **Files of the Document** dialog box opens again. When you have opened all camera views belonging to the image sequence, you close the dialog box with **OK** and the image sequences are displayed in the image sequence window.
7. When the image sequence, you want to open, can't be displayed with the possibilities of the graphics adapter, immediately after leaving the **Files of the Document** dialog box a colour reduction is made on the image sequence.

4.4 Preprocess an Image Sequence

WINalyze gives you two possibilities for front-end manipulation of image sequences.

4.4.1 Gamma Correction

1. When the image sequence window is active, you can choose the **Image Sequences/Gamma Correction** command.
2. The **Gamma Correction** dialog box opens, where you can lighten up or darken the image by the scroll bars. The gamma correction happens online, so that you can see it on the image sequence in the background.
3. When you have chosen the suitable gamma value, you close the dialog box with **OK**.

4.4.2 Filter

1. When the image sequence window is active, you select the **Image Sequences/Filter** command.
2. In the **Filtering the Sequence** dialog box, you can select one of the filters to apply it to the image sequence. You can choose between linear filters, edge filters, morphological filters and texture filters.
3. The application of the filters happens online, so that you immediately see the result on the image sequence.
4. When you have found the appropriate filter, you close the dialog box with **OK**.

4.5 Play Image Sequences

On the left part of the button bar you find the buttons to move in the image sequence. These buttons are very similar to those on a video recorder, so that they are surely easy to use.

When you push the **Play** button, the frames of the image sequence are played as quick as possible. When the end of the image sequence is reached, the playing starts again at the beginning until you stop it with the **Stop** button.

The other buttons are there to move one frame backward or forward, or to go to the last or the first frame of the image sequence.

You can also use the commands of the **Player** menu instead of the buttons on the toolbar.

4.6 Calibrate a Single Image Sequence

An image sequence consisting of only one camera view does not have to be calibrated. However, if you want to refer to real world coordinate values in the results, you will have to calibrate the sequence.

There are two possibilities for the calibration: A. by Linear Sizing and B. by using camera calibration files.

A. Linear Sizing

1. To calibrate a single image sequence you have to choose the **Frame Sequences/Calibration** command.
2. The calibration window that fills the whole screen is opened.
3. When you have a single image sequence, you first set the two calibration points to their position by clicking them with the left mouse button and dragging them with the mouse button pressed down to the position, where you release the mouse button again.
4. Under **Sizing** you then enter the distance of the two points in mm.
5. Then you select the correct values for the relation from

x to y, i.e. the aspect ratio of the imaging system. In general it is for an image sequence from a video recorder 4:3, from a digital high-speed camera 1:1 and for HDTV 16:9.

6. When you made all specifications, you leave the calibration window and go back to **WINalyze** by the **Close** button in the toolbar

B. Calibration with Camera Calibration Files

For calibrating a single image sequence by the help of camera calibration files, proceed as described under 4.7 Calibrate a Multiple Image Sequence.

After you have loaded the calibration files, all calibration methods will be available to you. Coplanar as well as noncoplanar models can be used for calibrating single image sequences.

4.7 Calibrate a Multiple Image Sequence

A sequence consisting of more than one camera view must always be calibrated.

Notice: If you want to do a recalibration with the example files delivered with Winanalyze you should first rename or delete the files with the extension CDC belonging to that example file you use. The examples are already calibrated and some of the steps in the description below are therefore different.

1. To calibrate a multiple image sequence you have to choose the **Image Sequences/Calibration** command.
2. The calibration window that fills the whole screen is opened.
3. As a requirement the calibration files must be loaded first. That is the CDC file, which contains the calibration frame (BLD or AVI file), the camera parameters (CAM file) and the calibration model (CMO file).
You get to the corresponding dialog box by clicking the **Calibration Files** button.
4. Then you choose the **Calibration Model Editing Mode**.

-
- The calibration model must be put to the correct position. You can move it by clicking it with the left mouse button and drag it to the correct position.
5. Now you select the **Calibration Points Editing Mode** to set the calibration points.

When the mouse pointer gets near to a calibration point, the pointer changes to a little cross. Now you can set the point by a click with the left mouse button. You can position a point by holding the left mouse button pressed down and move the point to the wanted position. When you release the button again, the calibration point is set.

There is help available for setting the calibration points: After you have set some calibration points (in general those, which have a distinct position), you start the calibration. As a result you get some green points, which are already in the correct position and the rest of the not yet set points will be marked red. You can now deselect the red points by double-clicking them (or choose the **All Points Off** command from the context menu) and then apply the **Position Points** command from the context menu, which will position these points. The positions are calculated from the calibration data computed so far. By the **All Points On** command from the context menu you activate the formerly red points again.
 6. When calibration model and points are in the correct position, you can start the calibration.

When the image sequence consists of more than one camera view, as a standard the **Optimized** calibration method is taken.
 7. You must press the **Calibration** button and the image is calibrated.
 8. Beneath **Calibration Divergence** you can then see the result of the calibration.

Medium displays the medium error in mm resulting from comparing the projected values (calculated by the calibration) with the values from the calibration model file (CMO). **Variance** shows the scattering of the medium error.
-

In general a green light behind the values means that they are good enough to go on working with the calibration result, with a red light you should calibrate again. In the last case the calibration points may not be set correctly yet, i.e. they are still marked red. You can improve your calibration results by setting these points anew like described under step 5.

If necessary you can also set back the calibration values to the original by the **Original** button in the **Calibration Values** group.

Whether a calibration result gets a red or green light, depends on the internal reference values, which are very exacting. The internal reference value for the medium error is calculated by computing back the error to pixels and the error must then be smaller than 0.5 pixels. So in some cases a result with a red light may nevertheless be good enough for your purposes.

9. When there are more camera views in the image sequence, you can now go to the next image with the two little arrows in the upper left corner of the window. There you repeat the steps 3 to 9.
10. When you made the calibration, you leave the calibration window and go back to **WINalyze** by the **Close** button on the toolbar.

Notice: Origin of Data in the Calibration Window
When you are calibrating a 2D sequence with Linear Sizing, the origin of the values is set by what is adjusted by the **Window/Origin/Units** command. When calibrating with the calibration data files (2D and 3D sequences), the origin of the values is implicitly defined in the CMO file (calibration model file). For deeper information about the CMO file see the Appendix.

4.8 Set New Object Sequences

1. First you move the image sequence to the frame you want to set the object for the new object sequence in. In most cases this will be the first frame.
2. Now you choose the **Objects/New Object Sequence** command. The mouse pointer changes to a little cross and jumps to the image sequence window.
3. By a click with the left mouse button you can now set the object to the position you want.

When you decide not to position the object, you can get out of the mode by pressing the ESC key.

Notice: To set a new object sequence in an image sequence consisting of more than one camera view you proceed as follows. You set the object in the first camera view with the **New Object Sequence** command, in the further camera views of the image sequence the corresponding object is set with the **Set Object** command. For setting objects in a multiple image sequence you can use the switch **Smart Object Position** command (see 5.4.7).

4.9 Create Connections

When there are objects in the frame and the image sequence window is active, you can create connections.

1. You select the **Image Sequences/Object Display/Connections** or **Angles and Connections** command.
2. Then you must press down the SHIFT key and click on the first object. The mouse pointer is a little cross and has the connection line. You then pull the mouse pointer to the second object and set it there with a mouse click. A connection is created.

or

1. You first select the **Image Sequences/Show Dialogs** command.

-
2. In the displayed dialog box you then select the connections and angles button to get to the corresponding dialog box. When the **Connections and Angles** dialog box is next to the window, you can start creating the connections.
 3. You must press down the SHIFT key and click on the first object. The mouse pointer then is a little cross and has the connection line. You then pull the mouse pointer to the second object and set it there with a mouse click. A connection is created.
 4. In the dialog box you can choose the colour of the connection line. During the creation of the connection you can see the colour of the first and the second object in the little rectangles of the **Connection** group. Above it the distance of the two objects (2D and 3D) is displayed.
 5. When you want to delete a connection, you first click on the connection, control by the object colours in the dialog box, whether you selected the right connection, and then press the **Delete** button in the dialog box.

4.10 Create Angles

There must be objects and connections defined in the frame in the image sequence window. The image sequence window must be active.

Angles are defined in between two connections.

1. You choose the **Image Sequences/Show Dialogs** command and select the **Connections/Angles** dialog box.
2. Then you select the first connection by clicking on it with the left mouse button; the colours of the two objects belonging to the connection are shown in the upper two rectangles in the dialog box.
3. Now you click the second connection and the object colours are shown in the lower two rectangles in the dialog box.

-
4. Next to **2D** and **3D** you see the two- and three-dimensional size of the angle and in the text box at the bottom of the dialog box the angle is described by the objects that belong to it.
 5. There is a **Switch** button, by which you can switch now between the possible angles. If the angle is defined by three objects, with one object being the angle point, you can switch between two possible angles. If four objects specify the angle, respectively two objects defining a distance, then there are eight possibilities to set the angle.
 6. By the **Create** button you create the angle, so that further on you can work with it. When an angle is created, the **Create** button changes to **Delete**, which you can delete an angle with.

You set back the dialog box (so that nothing is selected) by clicking somewhere (not on a connection) in the image sequence window. An angle, which is already created, you select by clicking the two defining connections.

4.11 Track Objects

1. When the objects, respectively the first objects of the object sequences, are set, you can start tracking the objects. The image sequence window with the objects must be active.
2. If you want to, you can select a different tracking algorithm by **Objects/Edit Object Sequences** command. As a standard the **SSD-Algorithm** is selected.
3. The tracking commands you must select from the **Tracking** menu or use the buttons from the button bar, which is more comfortable.
4. Now, for example, you choose **Tracking/To Sequence End**.
5. **WINalyze** starts tracking the objects from one frame to the other until the sequence end is reached. On the

-
- button bar a **Cancel** button appears, which you can press, when you want to interrupt the tracking.
6. There are also commands/buttons to track **One Frame Forward**, **One Frame Backward** or **To Sequence Begin**, that you can use for tracking.

4.12 Make an Analysis

There are a lot of different possibilities to analyze the motion data. You can take a look at the **Analyze/New/Sequences** and the **Analyze/New/Connections** submenu to see, what kind of analysis window you can create.

The image sequence (which contains already tracked object sequences), which you want to make an analysis of, must be active. Then you choose the wanted command from one of the submenus, and the analysis window is created.

4.13 Work on an Analysis Window

You can work in analysis windows in different items. Just as in the image window you can also use the right mouse button in the analysis window.

4.13.1 Adjusting Sequences

With the **Analyze/Adjust Sequences** command you can adjust sequences with the methods of interpolation, smoothing and approximation. By adjusting with approximation you have to enter an order for the polynom approximation.

The adjusting always happens directly on the object sequences and then the diagram is calculated anew; therefore it is highly recommended to save your original data prior to making adjustments!

4.13.2 Importing Data of External Devices

You have the possibility to import data from external devices like e.g. EMG into the analysis windows in **WINalyze**. This may be useful for reason of comparison.

For the import you need files in the DAQ format (see Appendix).

4.13.3 Exporting Analysis Data

All analysis data calculated in WINalyze can be exported.

When an image sequence and its object sequences are loaded, you can choose the **Analyze/Export Analysis Data** command.

In the **Export Analysis Data** dialog box from the object sequences list you select the object sequence, of which data shall be exported.

From the data list you choose the analysis data you want to export.

You can modify the text format by clicking the **Text Format** button.

When you have made all settings, you export the data to a U?? (where “??” stands for the object number) file by clicking the **Export** button.

4.13.4 Coordinates

By the **Analyze/Coordinates** command you can select a different coordinate for the ordinate (vertical axis).

4.13.5 Changing the Display Style

You can change the display style like the decimal places or the style of the curves by the **Analyze/Display** command.

This way you can format the data in the analysis window such as you want it to appear.

4.13.6 Font

You can even select a different font for the lettering in the analysis window. Therefore you must select the **Analyze/Select Fonts** command.

4.14 Work with Reticules

1. When the analysis window is active, you can choose the **Analyze/Enable Reticules** command, and two reticules are positioned in the right upper corner of your analysis window.
On the right side a little box appears, in which further on the position of the reticules will be shown.
2. Now you can take one of the reticules with the left mouse button and drag it (with the mouse button pressed down) to the wanted position.
In the box on the right side you can now see the position of the reticule.
3. You then take the second reticule and also drag it to the foreseen position.
Now you can see the position of the second reticule and the difference between the two reticules in the box.
4. By the **Analyze/Position Data Left** or **Right** you can switch the box with the position data in each case to the other side of the analysis window.
5. When the reticules are enabled, the **Enable Reticules** command changes to **Disable Reticules**. With that command you can then disable the reticules again.
6. With the **Analyze/Insert Reticules (Old Position)** command you can insert the reticules, where they were in their last position without having to position them anew.

4.15 Zoom Into and Out of a Window

1. To zoom in and out you first have to select the respective window and turn off the **Set Fit** command (button or command from the Windows menu).
2. Then you either press the **Zoom In** or **Zoom Out** button or choose the commands from the **Window** menu and zoom out of or into the concerned window.
3. When you want to fit the image or diagram into the window again, you have to turn on again the above-mentioned **Set Fit** command.

4.16 Print Windows

1. To print windows you choose the **File/Print Page Setup** command.
2. The **Print Page Setup** window opens and from the current windows you can select the window you want to print.
3. By the values in the dialog box you can e.g. set margins, select whether to keep the aspect ratio and so on.
4. From the **Print Page Setup** window you can also reach the **Print** or **Page Setup** dialog box.

When you have made all settings, you go to the **Print** dialog box and print the window.

5 Menu Commands

5.1 File Menu

5.1.1 Load Image Sequence Command



With the **File/Load Image Sequence** command you can open an existing image sequence.

Therefore the **Open Image Sequence** dialog box appears.

Opening an AVI file, which affords additional settings, is described further below in this paragraph.

When the image sequence you want to open can't be displayed by the possibilities of the graphics adapter, immediately after leaving the **Open Image Sequence** dialog box the **Colour Reduction** dialog box is called.

Open Image Sequence Dialog Box

Look In

In the drop-down list box next to **Look In** you select the drive that contains the file.

In the box beneath **Look In** double-click the folder that contains the file. Go on double-clicking on the subfolders until you get to the folder that contains the image sequence. In the list of files click the file, which you want to open, and then click **Open**.

File Name

Here the selected file name is displayed.

Files of Type

Here you determine the file format of the files that are displayed in the box above. The **Files of Type** drop-down list box offers you the file formats BLD, RSC, PAR and AVI, which in detail are explained in the Appendix.

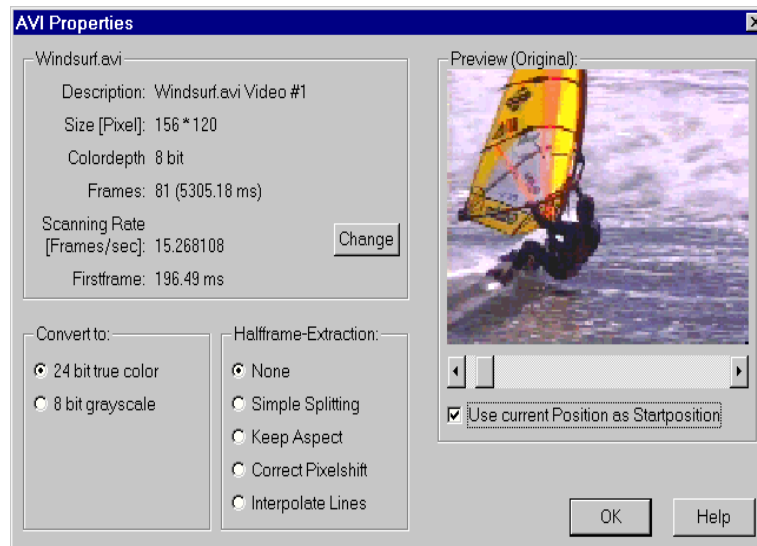
Buttons

In the right upper part of the dialog box there are four buttons: for going up one level, creating a new folder and for listing the files or showing them with all details.

Opening an AVI File

After you selected an AVI file in the **Open Image Sequence** dialog box and left the dialog box with the **Open** button, the **AVI Properties** dialog box appears.

AVI Properties Dialog Box



File Name

Heading the upper left group you see the file name. In this group you find some values concerning the AVI file you want to open: **Description**, **Size** (in Pixel), **Colourdepth**, Number of **Frames**, **Scanning Rate** (Frames/sec), and the **Firstframe**. Next to **Scanning Rate** there is a **Change** button to enter a new frequency if necessary. Changing the frequency does not resample the AVI.

Convert to

Here you can select, whether to convert the AVI file to 24 bit true colour or 8 bit grayscale.

Halfframe-Extraction

Video Files are typically stored with 25 (PAL) or 30 (NTSC) full frames. To make use of the full 50/60 Hz frequency, **WINalyze** can extract the half frames. With **Odd/Even** you can select which field is take first.

The option **None** means that there is no half frame extraction made on the AVI sequence.

Simple Splitting splits up the full frame in its even and uneven lines and builds the half frames out of them.

With **Keep Aspect** additional to the **Simple Splitting** selection the vertical lines are reduced, so that the aspect ratio of the image sequence is kept.

Correct Pixelshift corrects the pixelshift that emerges from splitting up the full frame into half frames by means of interpolation. This option also keeps the aspect ratio of the original frame sequence.

Interpolate Lines splits up the frame into half frames and interpolates lines in the half frames to keep the original size of the image sequence in pixels.

Because of the interpolation the options **Correct Pixelshift** and **Interpolate Lines** result in a slight blurring of the image sequence.

Preview

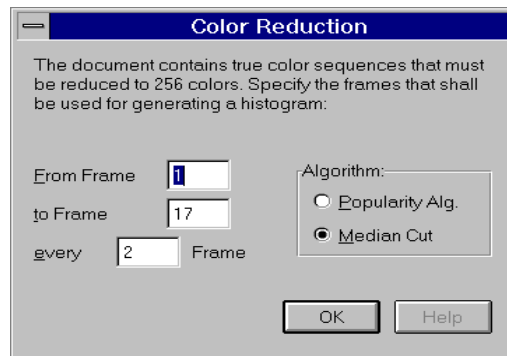
In the right part of the dialog box you see a preview window with the original AVI file.

Beneath the preview there is a scroll bar, by which you can scroll through the AVI sequence.

The **Use Current Position as Start Position** check box (by default not selected) enables you to define a certain frame, which you select with the scroll bar, as the first frame of the AVI sequence.

Colour Reduction Dialog Box

(just for graphic adapter with lower performance)



From Frame/to Frame/every

Here you must enter from which to which frame the colour reduction shall be made and whether every frame, every second frame or... shall be dealt with.

Algorithm

Here you can select between the **Popularity Algorithm** and the **Median Cut**. **Median Cut** is recommended.

OK

When you press **OK**, the histogram for the selected frames is made with the algorithm of your choice.

5.1.2 Load Multiple Image Sequences Command

You must select the **Load Multiple Image Sequences** command, when you open an image sequence with more than one camera view (recorded by two or more cameras) for the first time.

When you choose the **File/Load Multiple Image Sequences**

command, the **Open Image Sequence** dialog box is opened. Here you select the first image sequence you want to load and press the **OK** button. (For the procedure of loading AVI files see 5.1.1.)

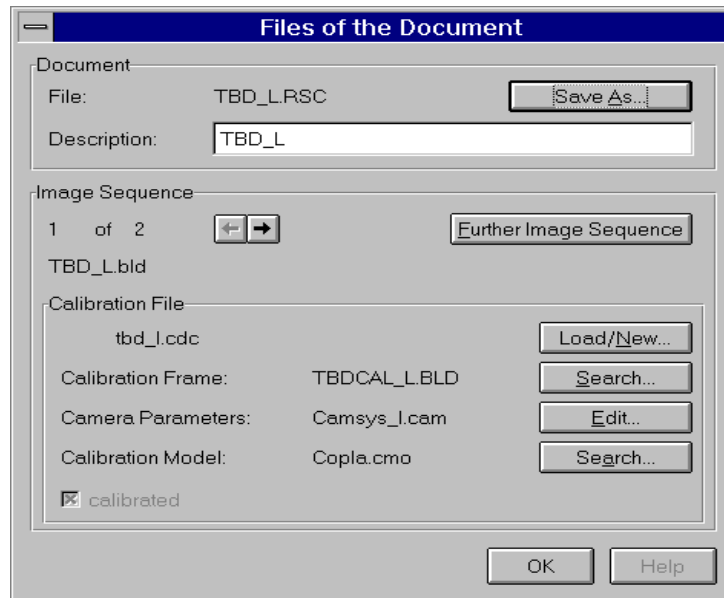
After that you get the **Files of the Document** dialog box, where you can load further camera views of the image sequences as well as the files needed for calibration.

When the image sequence you want to open can't be displayed by the possibilities of the graphics adapter, immediately after leaving the **Files of the Document** dialog box the **Colour Reduction** dialog box is called.

When the camera views you want to load together have differing entries for the frames per second rate in the DSC file, then after clicking **OK** in the **Files of the Document** dialog box the **Ambiguous Parameters** dialog box and the **Frames per Second** dialog box appear (both described at the end of this paragraph).

Files of the Document Dialog Box

see also Page 54



Document

In the group **Document** you get the name of the document file, which is a RSC file.

Below the describing name of the document file is shown.

You will also find a **Save As** push button, which you get to the **Save As** dialog box with, where you can save the document file under a new name or in a new directory.

Image Sequence

From e.g. 1 of 2 you can see the number of camera views of the image sequences that belong to the document (here 2), and you can also see, whether the first, second or another view of the image sequence is selected at the moment (with 1 of 2 it is the first image sequence that is selected).

With the arrows beside the text you can skip from one camera view to the other, forward and backward.

Next to that you find the **Further Image Sequence** button. When you press it, you get to the **Open Image Sequence** dialog box again, where you can load the next camera view of the image sequence (for the procedure of loading AVI files see 5.1.1.). This way you can load the files of all cameras you need for a motion analysis. (Up to 10 camera views are supported.)

Calibration File

First you get the name of the global calibration file, which is a CDC file. Next to it there is the **Load/New** button, which you get to a dialog box with, that allows to load a calibration file or to generate a new calibration file.

Then there is the **Calibration Frame** file. When a calibration frame is already loaded, the name of the file is displayed. You can load a calibration file by the **Search** button next to the calibration file description. The file has a BLD or AVI extension.

Beneath there is shown the file containing the camera parameters, which is a CAM file. With the **Edit** button you get the **Camera Parameters** dialog box, where you can load or create an Parameter file, save it and edit the single camera parameters. For deeper knowledge about the camera parameters see the Appendix.

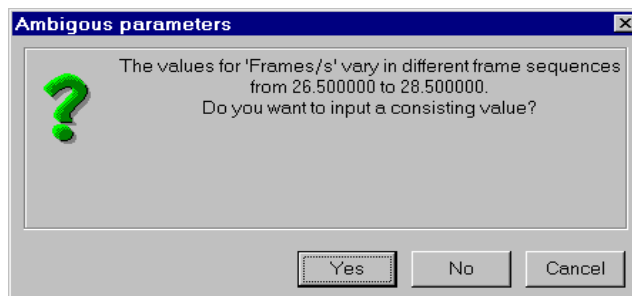
The last is the **Calibration Model** file, which is a CMO file. You can

also load one by the **Search** button.

At the bottom you can see a **calibrated** check box, which is activated, when the selected image sequence is already calibrated.

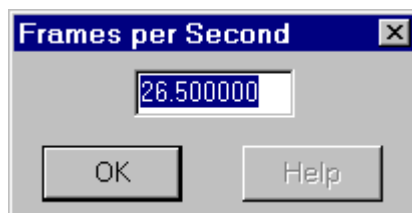
Colour Reduction dialog box see **Load Image Sequence** command.

Ambiguous Parameters Dialog Box



This dialog box tells you how the frames per second rate differs in the single camera views and asks whether you want to enter a consisting value for all camera views. When clicking **Yes**, you can do so in the **Frames per Second** dialog box. When clicking **NO**, the loading process is canceled.

Frames per Second Dialog Box



In the **Frames per Second** dialog box you can enter a consisting

frames per second value for all camera views. By default the value of the image sequence first loaded is given.

5.1.3 Close Command

With the **File/Close** command an image sequence is completely closed, i.e. also all analysis windows that are connected with the image sequence are closed.

This command is only available, when an image sequence window is active.

When the image sequence contains object sequences that are not yet saved, these can be saved after a query.

5.1.4 Print Page Setup Command

The **File/Print Page Setup** command offers you the opportunity of a print preview for the window that is currently opened in the program. In addition you can fix all settings for the printing and look at your later print as it looks on paper. You can select and install a printer and finally of course print the pages.

If you select the **Print Page Setup** command, a window that fills the whole screen is opened. Available to you are a toolbar, a dialog box on the left side and the print preview on the right side of the screen. To go back to **WINanalyze** select the push button **Close** on the toolbar. You can also use the respective buttons on the right edge of the title bar to close, maximize, minimize and restore the **Print Page Setup** window.

The Toolbar

The first two buttons are useful for turning the pages in the **Print Preview**. The Print Preview consists of as many windows as there are image sequence windows and analysis windows. The sorting of the pages is as follows: 1. camera view of the current document, 2. camera view of this document,..., 1. analysis of this document, 2.

analysis of this document, ..., 1. camera view of the document opened before, etc.



In the fields right from the arrow buttons (by which you can page through the windows) the page numbers are shown.



The push button **Print** opens the **Print** dialog box.



The button **Printer** opens the **Page Setup** dialog box.



When pushing the button **Close** you quit the **Print Page Setup** window and return to **WINalyze**.

The Dialog Box

Margins

Left: 10.00
Right: 10.00
Top: 10.00
Bottom: 10.00

Print Area

Left: 0.00
Top: 0.00
Width: 177.00
Height: 268.00

Print Range:
197 x 288

Values in

Inch
 Millimeter

Keep Aspect Ratio
 Whole Page

Margins

Here you set the desired margins for the print page.

Print Area

It is possible to define a print area. The print area is defined by height and width and the distance to the right and left margin.

The values in the group box **Print Area** are only considered, when the option **Whole Page** is not selected.

Keep Aspect Ratio

When this option is selected, it means that the relation between height and width of the image sequence window is kept according to the values in the DSC file.

When this option is not selected, the frame is fit in the print area respectively the whole page according to the position values.

Whole Page

When this option is selected, the values in the group box **Print Area** are not considered. The whole page less the set margins makes up the print area.

Print Range

Print Range shows the size of the area that can be printed by the printer.

The Print Range is not equal to the paper size, because the printer can't print the whole page.

Units

The setting you select here, **Inch** or **Millimeter**, refers to the boxes **Margins**, **Print Area** and **Print Range**.

The Print Preview

The print preview is directly proportional to the printed page.

The black frame shows the whole print range.

The light gray frame sets the specified **Margins**.

5.1.5 Print Command

The **File/Print** command opens the **Print** dialog box. Here you can make several settings and start the printing.

Print Dialog Box

Printer

Shows the **Name** of the current printer, the **Status**, **Type** and **Where** the printer is located.

There is a **Properties** button, by which you get to the **Document Properties** dialog box.

The **Print to a File** check box redirects the print issue to a new file in the drive you selected, instead of forwarding it to the printer directly. This is useful, when you want to print a file from a computer, where no **WINalyze** is installed, or that you can forward the print issue to a printer that is not available on your system.

Print Range

Under **Print Range** you can select whether you want **All** pages to be printed, certain **Pages** that you can enter, or only the **Selection**.

Copies

Here you can specify the number of copies and with the **Collate** check box determine whether the copies shall be collated.

OK

With the push button **OK** you start the printing. A dialog box appears that shows you the print progress and gives you the possibility to cancel the printing.

5.1.6 Printer Setup Command

The **File/Printer Setup** command opens the **Page Setup** dialog box.

Page Setup Dialog Box

Paper

Here you can select the paper **Size** and the **Source** for the paper.

Orientation

Here you select the **Orientation: Portrait** or **Landscape** Margins

Here you set the margins for the print.

Printer

With this button you get to the **Printer Setup** dialog box. This dialog box shows a list of all installed printers, sets the standard printer and specifies several print options for the printer you selected.

5.1.7 Exit Command

The **File/Exit** command ends **WINalyze**. Before the program is ended, all opened image sequences are closed as described with the **File/Close** command.

5.2 Player Menu

5.2.1 Play Command



CTRL+P

The **Player/Play** menu command starts the “player” in **WINalyze**. The frames of an image sequence that are succeeding each other are displayed one after the other as quickly as possible. When the last frame of a sequence is reached, it is started again with the first frame.

This command is only available, when an image sequence window is active, the image sequence consists of more than one frame and the sequence is not yet played.

The number of the current frame of the image sequence is shown in the status bar next to **Frame:**. The enumeration begins with 1.

5.2.2 Stop Command



CTRL+S

The **Player/Stop** command ends the playing of the image sequence. The number of the current frame of the image sequence is shown in the status bar next to **Frame:.** The enumeration begins with 1.

5.2.3 Next Frame Command



CTRL+N

The **Player/Next Frame** command goes to the next frame in the image sequence of the active window.

The same result you get, when you click on the right arrow on the small scroll bar on the toolbar.

The number of the current frame of the image sequence that is given by the active window is shown in the status bar next to **Frame:.** The enumeration begins with 1.

5.2.4 Previous Frame Command



CTRL+V

The **Player/Previous Frame** command goes to the previous frame in the image sequence of the active window.

The same result you get, when you click on the left arrow on the small scroll bar on the toolbar.

The number of the current frame of the image sequence that is given by the active window is shown in the status bar next to **Frame:**. The enumeration begins with 1.

5.2.5 First Frame Command



The **Player/First Frame** menu command goes to the first frame of the image sequence in the current window.

5.2.6 Last Frame Command



The **Player/Last Frame** command goes to the last frame of the image sequence in the current window.

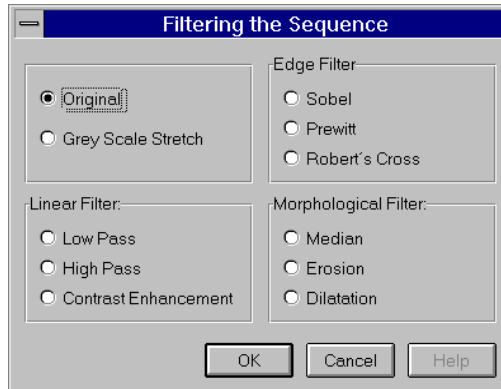
5.3 Image Sequences Menu

5.3.1 Filter Command

With the **Image Sequences/Filter** menu command you can define one or more preprocessing filters that are applied online to the image sequence in the active window.

After you selected the **Filter** command, the **Filtering the Sequence** dialog box is opened.

Filtering the Sequence Dialog Box



Original

By clicking this option you can set the image sequence back to the original without any preprocessing filters applied to it.

Gray Scale Stretch

The gray scales of each individual frame are stretched to the maximum range.

Low Pass

The Low Pass filter is smoothing the transition of the gray scale.

High Pass

The High Pass filter extracts edges and corners.

Contrast Enhancement

Contrast Enhancement adds the high pass component to the original image, thus enhancing the contrast of the image.

Sobel, Prewitt and Robert's Cross

Sobel, Prewitt and Robert's Cross are gradient filters that are useful

for edge detection.

Median

The Median filter deletes some single flaw of the image without, however, smoothing the contrast like for example a Low Pass filter.

Erosion

The Erosion filter effects a thinning of areas.

Dilatation

The Dilatation filter effects a widening of areas.

MOP-8

MOP-8 is a filter that filters textured areas in the image. The value 8 refers to the step width, which is 8 pixels with this filter.

MOP-16

MOP-16 is also a filter, which filters textured areas in the image. 16 here stands for a step width of 16 pixels. The higher the step width, the less image details are filtered.

MOP-24

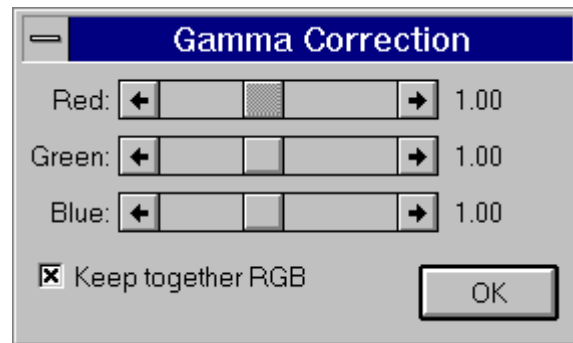
MOP-24 is an addition of the filters MOP-8 and MOP-16.

5.3.2 Gamma Correction Command

The **Image Sequences/Gamma Correction** command causes a gamma correction on the colour palette of the image sequence. After the selection of the **Gamma Correction** command a dialog box is opened, where you can set a factor for the gamma correction.

Note: Gamma Corretion does not modify the sequence but just the display

Gamma Correction Dialog Box



The range for gamma (factor of the gamma correction) varies between 0.25 and 2.0. The original colour palette you get with gamma being 1.0. Values smaller than 1.0 lighten the picture, values higher than 1.0 darken the picture.

Use linear gain

When you select the check box **Use linear gain**, a brightness correction is applied to the image sequence that brightens up all values by the same factor. This way already bright values might fall out of the range. All correction values higher than 1.00 make the image sequence brighter. By default, for a gamma correction, the check box is not selected.

Keep together RGB

With the option **Keep together RGB** you can specify, that the values for red, green and blue are changed together (option selected), or whether they are changed independent from each other (option not selected). For grayscale image sequences RGB should be kept together to affect the grayscale intensity only.

Reset/Save as Default

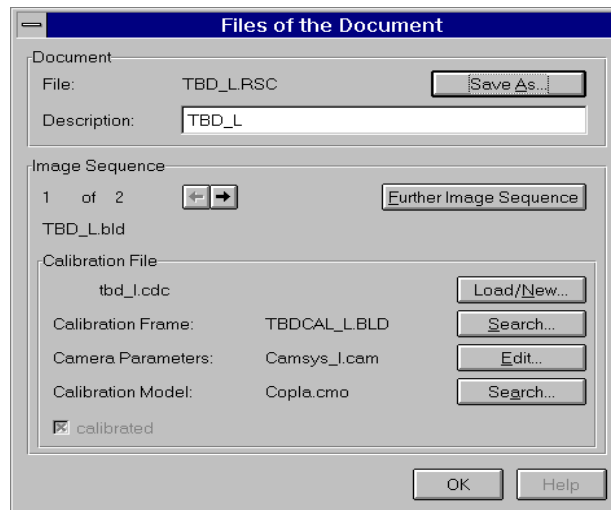
The default value for the gamma correction in **WINalyze** is 1.00. With the **Save as Default** button you can set the currently adjusted

gamma value as a new default value for the program. The **Reset** button serves to reset the gamma value to the original value of 1.00.

5.3.3 Document Files Command

When you choose the **Image Sequences/Document Files** command you will get the dialog box **Files of the Document**, which describes the files that belong to the document.

Files of the Document Dialog Box



Document

In the group **Document** you get the name of the document file, which is a RSC file.

Below the describing name of the document file is shown.

You will also find an **Save As** push button, which you get to the **Save As** dialog box with, where you can save the document file under a new name or in a new directory.

Image Sequence

From e.g. 1 of 2 you can see the number of camera views (when the image sequence consists of more than one camera view) that belong to the document respectively the image sequence (here 2), and you can also see, whether the first, second or another camera view is selected at the moment (with 1 of 2 it is the first camera view that is selected).

With the little arrows beside the text you can skip from one camera view of the image sequence to the other, forward and backward.

Calibration File

First you get the name of the global calibration file, which is a CDC file. Next to it there is the **Load/New** button, with which you get to a dialog box that allows to load a calibration file or to generate a new calibration file.

Then there is the **Calibration Frame file**. When a calibration frame is already loaded, the name of the file is displayed. You can load a calibration frame by the **Search** button next to the calibration frame description. The file can have a BLD or an AVI extension. (For the procedure of loading AVI files see 5.1.1.)

Beneath there is shown the file containing the camera parameters, what is a CAM file. With the **Edit** button you get the **Camera Parameters** dialog box, where you can load or create a parameter file, save it and edit the single camera parameters. For deeper knowledge about the camera parameters see the Appendix.

The last is the **Calibration Model** file, which is a CMO file. You can load one by the **Search** button, as well.

At the bottom you can see a **calibrated** check box, which is activated, when the selected image sequence has already been calibrated.

5.3.4 Calibration Command

When you select the **Calibration** command, the **Calibration** window that fills the whole screen opens. In this window you can undertake a calibration of the pixel coordinates in fixed local values.

Therefore also read 4.6 How to... Calibrate a Single Image Sequence and 4.7 How to... Calibrate a Multiple Image Sequence.

Calibration Window

The calibration window is divided up in three parts. On the top you see the toolbar, on the left side you see a dialog box and on the right side you can see the calibration frame together with the calibration model.

Toolbar



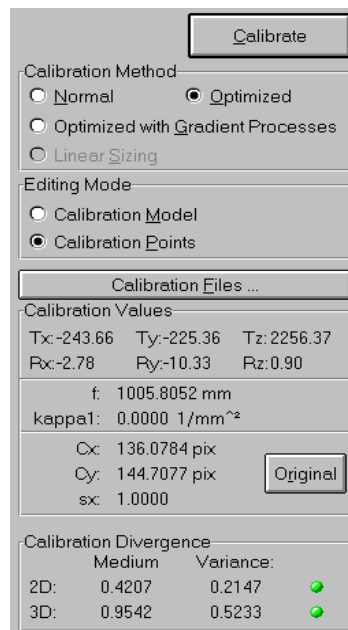
On the toolbar there are two little arrows on the left, with this you can switch between the camera views, when the image sequence consists of more than one camera view. The name of the camera view is shown next to it.

Then there follow the buttons for the **Set Fit** command, the **Zoom In** command, the **Zoom Out** command, the **Filter** command and the **Gamma Correction** command.

At the end of the toolbar there are two buttons, **Save** and a **Save and Exit**, with which you can save the calibration data respectively save the data and exit the **Calibration** window with.

Description of the Calibration Dialog Box

First the dialog box is described as it appears under a 3D calibration:



Calibrate

At the top of the calibration dialog box you find the **Calibrate** button, by which you start the calibration after you have set various settings for the calibration.

Calibration Method

In the **Calibration Method** group box there are four options to define the method of the calibration:

Normal

This method uses the transformation, rotation, focus and kappa parameters.

Optimized	This method adds some other parameters to the parameters used in the normal calibration, that optimizes the calibration.
Optimized with Gradient Processes	Improves the optimized calibration by gradient processes (but takes a long time)
Linear Sizing	Linear Sizing is only possible with a 2D calibration of a single image sequence. See 2D calibration.

Editing Mode

Here you can choose whether you want to edit the **Calibration Model** (drag and drop the whole model) or the **Calibration Points** (drag and drop the calibration points).

Context Menu

In the **Calibration** window you can open a context menu by clicking with the right mouse button. This context menu contains the commands **Filter**, **Gamma Correction**, **All Points On**, **All Points Off** and **Position Points**.

The **Filter** and **Gamma Correction** command correspond to the same commands in the **Image Sequences** menu.

With the **All Points On** and the **All Points Off** command the calibration points are activated/deactivated respectively.

The **Position Points** command is used as described, following to set your calibration points automatically:

After you have set some calibration points (in general those having a distinct position), you start the calibration. As a result you get some green points, which are already in the correct position, and the rest of the not yet set points will be marked red. You can now deselect the red points by double-clicking them (or choose the **All Points Off** command from the context menu) and then apply the **Position Points** command from the context menu, which will position these points. The positions are calculated from the calibration data computed so far. By the **All Points On** command from the context menu you activate the formerly red points again.

Calibration Files

By the **Calibration Files** button you reach the **Files of the Document** dialog box, where you can load and create calibration files, search for files, etc.

Calibration Values

In this box you can see the values needed for the calibration like transformation, rotation, kappa, etc.

There is also an **Original** button, with which you can set back some of the values to the original ones before the calibration was done.

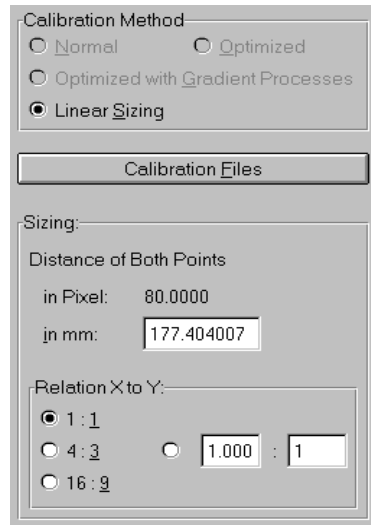
Calibration Divergence

Here the **Medium Divergence** and **Variance** for the 3D calibration are shown.

Medium puts out the medium error in mm resulting from comparing the projected values (calculated by the calibration) with the values from the calibration model file (CMO). **Variance** shows the scattering of the medium error.

In general a green light behind the values means that they are good enough to go on working with the calibration result, with a red light you should calibrate again. In the last case the calibration points may not yet be set correctly, i.e. they are still marked red.

The dialog under a 2D calibration with Linear Sizing:



When you make a 2D calibration, the boxes **Editing Mode** and **Calibration Values** are missing. Instead there is a new box called **Sizing**.

In the 2D calibration you can drag and drop the calibration points without any special settings.

Sizing

The distance of the two points is displayed in pixel and you have to enter it in millimeter. The value for the relation between pixel and millimeter is always saved as it was adjusted at the last linear calibration.

Beneath you can select the relation from x to y, i.e. the aspect ratio of the imaging system. In general it is for an image sequence from a video recorder 4:3, from a digital camera 1:1 and for HDTV 16:9.

5.3.5 Layout Submenu

The **Image Sequences/Layout** submenu is available, when you are working with an image sequence that consists of more than one camera view.

Zoom Command

When one of the camera views in the image sequence is selected, and you select the **Layout/Zoom** command, then this camera view fills the whole image sequence window and is displayed on a larger scale. The command is then marked by a tick in the menu.

The same zoom result you get, when you want to zoom out again, you select the command again.

When you double-click on the camera view you want to zoom in. By double-clicking again you also zoom out again.

“Arrange” Symbols

When there is more than one camera view in your image sequence, you can choose the symbols from the **Layout Submenu** to arrange your camera views in the image sequence window.

5.3.6 Object Display/Only Current Objects Command

With the **Only Current Objects** command you choose a setting, where only the objects of the current frame are displayed in the active image sequence window.

5.3.7 Object Display/Objects of All Frames Command

With the command **Objects of all Frames** you can choose a setting, where the objects of all frames of the current image sequence are displayed in the active image sequence window.

You can use this command simultaneously with the **Object Display/Connections** and **Angles and Connections** command.

5.3.8 Object Display/Connections Command

With the **Connections** command you can choose a setting, where the objects and object connections of the current frame in the active image sequence window are displayed.

You can use this setting simultaneously with the **Object Display/Objects of All Frames** and **Angles and Connections** settings.

5.3.9 Object Display/Angles and Connections Command



With the **Angles and Connections** command you can choose a setting, where the objects, object connections and angles of the current frame in the active image sequence window are displayed.


You can use this setting simultaneously with the **Object Display/Objects of All Frames** and **Connections** settings.


5.3.10 Show Dialogs Command

With the **Show Dialogs** command you can display a dialog next to the image sequence.

First the **Objects** dialog box is shown, where you can make settings for the objects. By using the buttons on top of the dialogs you can change to a **Template** and **Connections/Angles** dialog box, where you can also make changes to the concerned values.

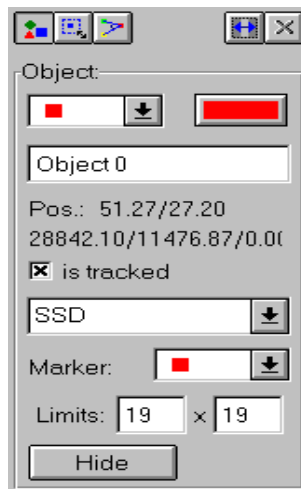
By using the  button you can shift the dialog box to the other side of the image sequence window and by using the  button you close the dialog box again.

Objects Dialog Box 

Templates Dialog Box 

Connections/Angles Dialog Box 

Objects Dialog Box



Object

On the top there is a dropdown-listbox where the colour of the selected object is shown. You can also select a different object from the dropdown-list.

On the right side you find a **Colour** button, by which you can change the colour of the object.

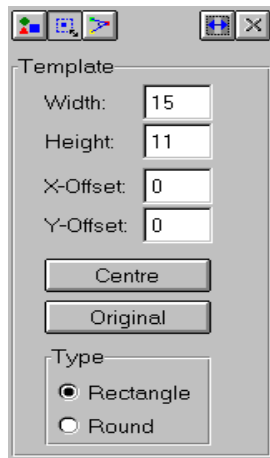
Beneath that you find the name of the object and the position of the object in 2D and 3D coordinates.

Then there follows a check box, where you can select, whether the object will be **tracked** (selected) or not (cleared).

In the lower half you can select the tracking algorithm, a **Marker** for the object sequence and enter the **Limits**. **Limits** means, when an object is tracked from one frame to the next and you set the values for the limits both at 10, then WINalyze searches for the object within a horizontal and vertical range of ten pixels, compared to the position of the object in the previous frame.

At the bottom there is a **Hide** button, by which you can hide the currently selected object.

Templates Dialog Box



Template

Here you can enter the **Width**, the **Height**, the **X-Offset** and the **Y-Offset** of the selected template.

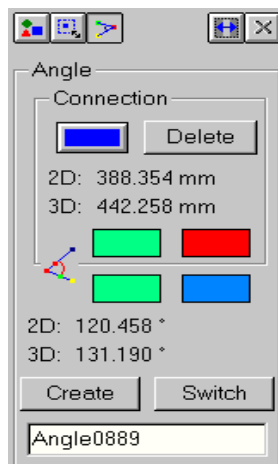
Then there follows a **Center** and an **Original** button, the first to center the template with the object marker in its middle and the other to set the template back to the original after you changed it.

Alternatively you can change the size of the template by using the mouse.

Type

Under **Type** you can choose between a **Rectangle** and a **Circle** template.

Connections/Angles Dialog Box



In the **Connections/Angles** dialog box you find an inner and outer group box. The inner group box is concerned with the connections, the outer the angles.

Connection

In the rectangles at the bottom of the **Connection** group you can see the object colours of the objects, of which the connection is currently selected. (You select a connection by clicking on it in the image sequence window with the left mouse button.)

With the **Colour** button you can select a colour for the selected connection and with the **Delete** button delete the selected connection. Next to **2D** and **3D** you see in each case the length of the connection. See the topic 4.9 How to... Create Connections.

Angle

When a connection is selected and you click on a second connection, the angle between these connections is computed.

In the upper two rectangles you can then see the objects of the first connection and in the lower two rectangles (in the **Angle** group box) you see the two object colours of the objects of the second connection.

At the bottom of the dialog box you can e.g. see "**Angle 0889**"; that means, that the angle lies between the connection Object 0 and Object

8 and the connection Object 8 and Object 9. The second and the third object (here 8) are the same. The angle lies at this object. An angle can of course also be defined by four different objects. Then the angle point is the fix of the two defined distances in their production. Next to **2D** and **3D** you can see again in each case the size of the angle.

Beneath there is the button **Create/Delete**, which you can create respectively delete the current angle with. (You must always create an angle to make it persistent.)

By the **Switch** button you can switch between the different possibilities to define an angle with a certain constellation of points.

When three points, with one of the points being the angle point, define an angle, then you can switch between two possible angles. (Normally you click the first connection and then the second connection and the angle is defined counter-clockwise from the first to the second connection. When you now invert the angle, it is defined counter-clockwise from the second to the first connection and has therefore a size of 360° minus the original angle.)

The other case is that you are working with an angle, which is prescribed by four points. I.e. the angle is built of two distances, each defined by two points, which do not touch. The angle point then is the fix of the two distances in their production. With this kind of definition, you can switch between eight possible angles, depending on the direction of distances.

See the paragraph 4.10 How to... Create Angles.

5.3.11 Info Command

After choosing the **Image Sequences/Info Command** you get the **Current Document** dialog box, where you get information on the current document. This information includes items as the date of generation, the size, trigger ect.

5.4 Objects Menu

5.4.1 New Object Sequence Command

SHIFT+INS

With the **Objects/New Object Sequence** command you can generate a new object sequence in the current image sequence. At first you must put the image sequence to the correct frame by the commands from the **Player** menu or by the corresponding buttons on the toolbar. In most cases it will be the first frame of the sequence.

After you have chosen the command, the cursor changes to a little cross. By a click with the left mouse button you can then set the object to the wanted position.

When you are working on an image sequence consisting of more than one camera view, you proceed as follows: Set the object in the first camera view with the **New Object Sequence** command and in the further camera views of the image sequence the corresponding object is set with the **Set Object** command. For setting objects in a multiple image sequence you can use the switch **Smart Object Position** command (see 5.4.7).

5.4.2 Delete Object Sequence Command

SHIFT+DEL

The **Delete Object Sequence** command serves for deleting a whole object sequence from the current image sequence. You can recover the removal by the **Undelete** command in the same menu.

To delete the object sequence you must click on the concerned object sequence, so that the object sequence is selected. After this use the **Objects/Delete Object Sequence** command to delete the object sequence.

5.4.3 Undelete Command

ALT+BKSPC

With the **Objects/Undelete** command you can recover an object sequence that you have deleted.

When you deleted only one object sequence, you can choose the command and the object is recovered.

When you have already deleted more than one object sequences, you will get the **Recover Object Sequence** dialog box. In this dialog box you choose the object sequence you want to recover and then click the **OK** button. The object sequence is recovered.

5.4.4 Set Object Command

INS

With the **Set Object** command you can set a selected object in the current frame of the current image sequence to a new position.

When you want to set an object anew, you first have to select the concerned object. After you have done this, you choose the **Objects/Set Object** command. The object then disappears and the pointer changes to a little cross. By clicking with the left mouse button you can now set the object to a new position.

Alternatively you can directly click on the object you want to move, hold down the mouse button and drag the object to the new position. With the **Set Object** command you can also set the objects in image sequences with more than one camera view. I.e. you set the object in the first camera view with the **New Object Sequence** command and in the further camera views of the image sequence the corresponding object is set with the **Set Object** command. For setting objects in a multiple image sequence you can use the switch **Smart Object Position** command (see 5.4.7).

When you want to set objects manually or correct an object, which was set by the help of the **Smart Object Position** command, you must turn off the **Smart Object Position** switch.

5.4.5 Delete Object Command

DEL

With the **Objects/Delete Object** command you can delete an object in the current frame.

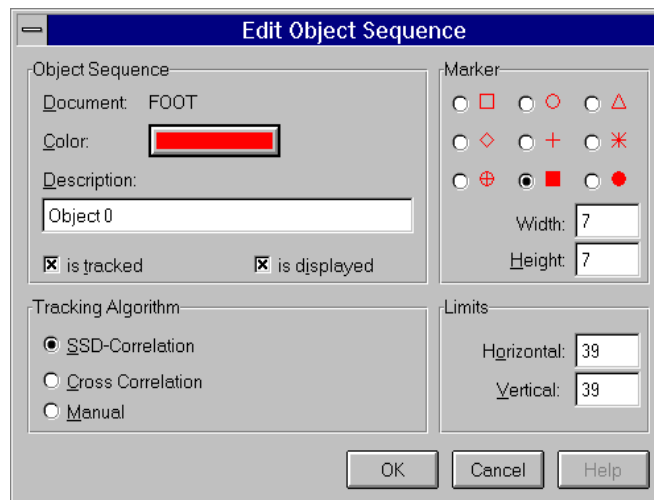
First you select the object you want to delete and then you use the **Delete Object** command. The object is deleted.

Please notice that the **Smart Object Position** command only positions objects, which are not yet set. If you want to apply it to already positioned objects, you have to delete these objects before.

5.4.6 Edit Object Sequence Command

The **Edit Object Sequence** command opens the **Edit Object Sequence** dialog box, where you can adjust several items concerning the selected object sequence.

Edit Object Sequence Dialog Box



Object Sequence

In this group box you get information about the colour and the description of the object sequence, and the name of the document the object sequence belongs to is shown.

In this group there are two check boxes, where you can mark, whether the object shall be displayed or tracked or both.

Marker

In this group box you find nine option buttons, where you can select one kind of marker you want to use for your object sequence.

Beneath the markers there are two small text boxes, where you can enter the **Width** and the **Height** of the marker you have selected.

Tracking Algorithm

In this box you can choose one of the four tracking methods that **WINalyze** offers to you. These are the **SSD-Correlation**, the **Cross Correlation**, the **Texture Tracking** and the **Manual** tracking.

Limits

Here you can enter the **Horizontal** and **Vertical Limits**, in which the object is searched for during the tracking.

That means, when an object is tracked from one frame to the next and you set the values for the limits both at 10, then **WINalyze** searches for the object within a horizontal and vertical range of ten pixels compared to the position of the object in the previous frame.

5.4.7 Smart Object Position Command

The **Objects/Smart Object Position** command is available, when an image sequence consists of at least two different camera views of one motion.

This command serves to position automatically an object that is already set in one of the camera views in all other camera views.

The **Smart Object Position** command is a switch. It is marked by a tick, when it is activated.

To use this command the image sequence must have been calibrated, because the **Smart Object Position** command is working on the

calibration data.

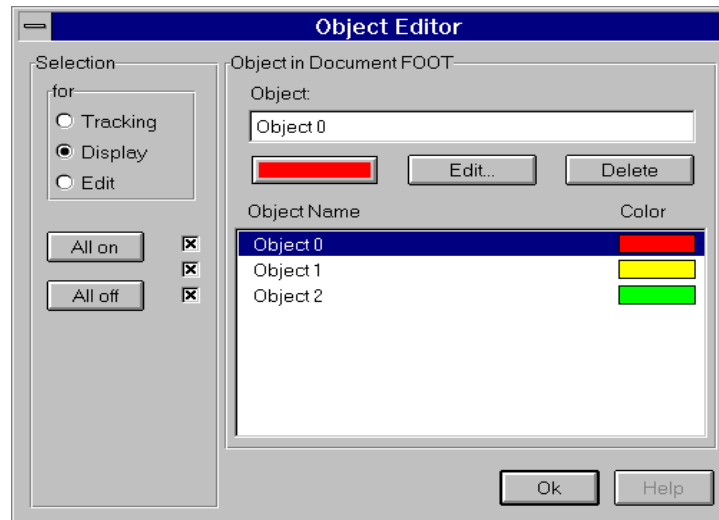
With the **Objects/New Object Sequence** command you position a new object in one camera view. With the **Set Object** command you then position the same object in the second camera view (the **Smart Object Position** command must be switched on). You will notice that the object can only be moved on a certain curve, where it must be positioned. In the rest of the views the object is positioned automatically, when you choose the **Set Object** command.

When you want to set objects manually or correct an object, which was set by the help of the **Smart Object Position** command, you must turn off the **Smart Object Position** switch.

5.4.8 Object Editor Command

When you choose the **Object Editor** command, you get the **Object Editor** dialog box, where you can make settings for all object sequences in the current session.

Object Editor Dialog Box



Selection

In the group box **Selection** you must decide what your selection is for. Whether it is for the **Tracking**, the **Display** or whether you want to **edit** the object sequences.

With **All on** or **All off**, all of the object sequences respectively none of the object sequences are selected. Otherwise selecting is done by clicking on the check boxes next to the concerned object sequences. When in the **for** box **Edit** is selected, then at the bottom an **Edit** push button appears, by which you get to the **Edit Object Sequence** dialog box. In the **Edit Object Sequence** dialog box you can change the properties of the selected object sequence.

Object in Document

In the text box under **Object** the name and the colour of the selected object sequence is shown and can be edited by using this button.

You select an object sequence by clicking on it with the left mouse button in the list under **Object Name**.

By pushing the button **Delete**, you delete the selected object sequence.

5.4.9 Objects/Save Command

By the **Objects/Save** command all object sequences and objects in the current image sequence are saved. With these command the old object sequences are overwritten. If not yet saved a file with the name of the sequence and the extension OS is created

5.4.10 Objects/Save as New Command

The **Objects/Save as New** command serves to save object sequences of an image sequence in different versions.

When you choose this command, **WINalyze** saves the current object sequences in a new file. The filename is the same as the frame sequence but attended an underline and a version number. The version numbers are automatically assigned to the files. They start with 0. The file extension is OS.

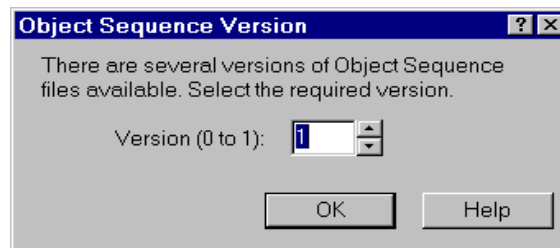
When you load object sequences and more than one version of object sequences exists for the current image sequence, you are asked, which version you want to load.

5.4.11 Objects/Load Command

With the **Objects/Load** command all objects and object sequences belonging to the current image sequence in the active window are loaded and the objects that were displayed in the last session with the current image sequence are displayed. To do that, WINalyze searches for files with the name of the frame sequence and the extension OS. It is searched only in the directory from where the frame sequence was loaded.

When more versions of object sequences for the current image sequence exist, a dialog box is opened, in which you can select the version you want to open.

Object Sequence Version Dialog Box



By default the version that was saved last is selected. From **Versions (a to b)** you can see how many object sequences versions exist for the current image sequence.

5.4.12 Import Command

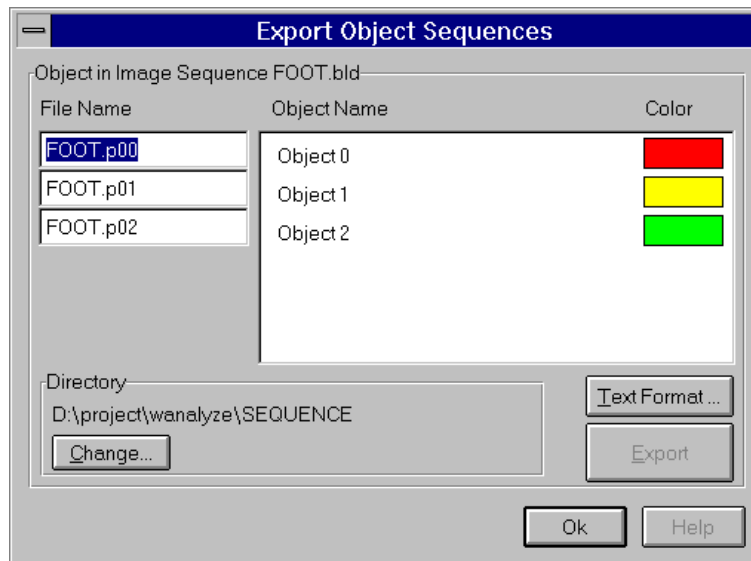
By choosing the **Import** command you can import object sequences to the current image sequence. After you have selected the command, the **Import Object Sequences** dialog box is opened.

In this dialog box you can choose an object sequence file (with a P?? file extension) to import it into the current image sequence.

5.4.13 Export Command

By the **Objects/Export** command you can export object sequences into files, which then can be imported in other image sequences, into data plot programs, spreadsheets or into the program **Analyze**. After you have selected the command, the **Export Object Sequences** dialog box is opened.

Export Object Sequences Dialog Box



Object Name /Colour

Beneath **Object Name** and **Colour** you see all object sequences of the current image sequence that you can export. Here you select the object sequences you want to export by clicking on them. You can

select more object sequences by pushing down CTRL, while you are clicking; when you want to select object sequences that succeed each other, then click the first sequence, and after that hold down SHIFT and click the last sequence (when you hold the left mouse button pressed down and pull it over the sequences, you will receive the same process).

File Name

Here you find a list of the corresponding **File Names**, which **WINalyze** suggests for the export.

You can change the file names, if you wish.

Directories

Here the directory is shown that holds object sequences files. You can change the directory by clicking the **Change** button to get to a dialog box, where you can make the changes.

Text Format

By the **Text Format** button you get to the **Text Format Settings** dialog box, where you can make settings for the text format.

The dialog box is described at the end of this paragraph.

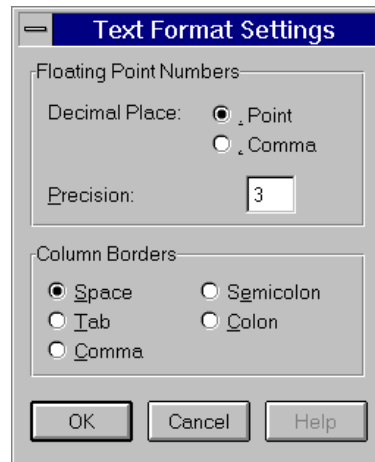
Export

When you click this button, the object sequences are exported to the files and directory that are specified.

OK

With **OK** you close the dialog box.

Text Format Settings Dialog Box



It may be necessary to adjust the text format settings in dependence of the application you want to import the data with. You must refer to your applications manual how e.g. decimal places are interpreted by your application.

Floating Point Numbers

Here you can specify whether the **Decimal Place** is marked by a **Comma** or a **Point**. You can also set the **Precision** of the number after the decimal place.

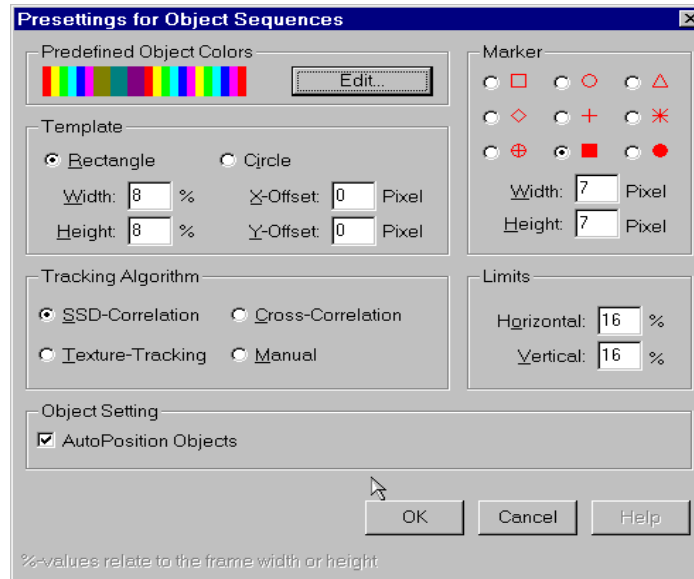
Column Borders

Here you specify how the **Column Borders** (delimiting each single coordinate value) shall be marked.

5.4.14 Presetting Command

With the **Presetting** menu command you get to the dialog box **Presetting for Object Sequences**, where you can specify some object settings that apply to all new object sequences from there on.

Presettings for Object Sequences Dialog Box



Predefined Object Colours

Here you can see the **Predefined Colours** in succession for the object sequences to be set. You can change these colours by pushing the **Edit** button to get to the **Predefined Object Colours** dialog box which is explained at the end of this paragraph.

Template

Here you can make the presettings for the **Template** of a new object sequence.

You can specify whether the template is a **Rectangle** or a **Circle** (the standard is **Rectangle**).

You can enter the **Height** and **Width** (in % which relates to the frame width and height), and the **X-** and **Y-Offset** in **Pixel**.

Tracking Algorithm

Here you can select between the four **Tracking Algorithms** that **WINalyze** offers: **SSD-Correlation**, **Cross-Correlation**, **Texture Tracking** and **Manual**. (The standard setting is the **SSD-Correlation**.)

Marker

There are nine styles of markers to choose from and you can set the **Width** and the **Height** of the marker in **Pixel**.

Limits

Here you can enter the **Horizontal** and **Vertical Limits** for the search of the objects in frames following each other. The value is in %, which relates to the frames width and height.

Predefined Object Colours Dialog Box



File

In this first group box you are given the name of the current colour file. With the **Load** and **Save As** button you can load a new file or save the current colour file into a drive and directory which you have select.

Colour Palette

On the left side you find a list of the current colour palette. You can switch through the palette by using the scroll bar or the two up and down buttons, left from the palette.

On the right side there are four buttons, with which you can change a colour, insert or append a new colour and delete a colour with.

5.5 Tracking Menu

5.5.1 To Sequence End Command



When you choose the **Tracking/To Sequence End** command or the corresponding button, the objects are tracked to the last frame. You will find a **Cancel** button on the toolbar, with which you can cancel the tracking during the process.

5.5.2 One Frame Forward Command



With the **Tracking/One Frame Forward** command or the corresponding button the objects are tracked one frame forward.

5.5.3 One Frame Backward Command



With the **Tracking/One Frame Backward** command or the corresponding button the objects are tracked one frame backward.

5.5.4 To Sequence Begin Command



When you choose the **Tracking/To Sequence Begin** command or the corresponding button, the objects are tracked backwards up to the first frame.

You will find a **Cancel** button on the toolbar, which you can cancel the tracking during the process with.

5.6 Analyze Menu

5.6.1 New/Sequences Submenu

With the commands in the **Analyze/New/Sequences** submenu you can generate analysis windows, in which the object sequences of the current image sequence are displayed in diagrammatic form with relation to time.

When there is no image sequence window currently active, the analysis data are taken from the last active image sequence.



You can select the following coordinates for an analysis:

x to t Position of the objects in horizontal direction related



to time

x' to t The velocity in horizontal direction

x'' to t	The acceleration in horizontal direction
y to t	Position of the objects in vertical direction related to
	time
y' to t	The velocity in vertical direction
y'' to t	The acceleration in vertical direction
z to t	Position of the objects in the depth direction related to
	time
z' to t	The velocity in depth direction
z'' to t	The acceleration in depth direction
$ r '$ to t	The resulting velocity
$ r $ to t	The absolute resulting velocity
$ r ''$ to t	The resulting acceleration
$ r ''$ to t	The absolute resulting acceleration

5.6.2 New/Connections Submenu

With the commands in the **Analyze/New/Connections** submenu you can generate analysis windows, in which the connections and angles of object sequences of the current image sequence are displayed in relation to time in diagrammatic form. It is also possible to display a stick figure this way. This special feature is explained in detail at the end of this paragraph.

When there is no image sequence window currently active, the analysis data are taken from the last active image sequence.

Stick Figure Stick figure made of the connections of the object sequences

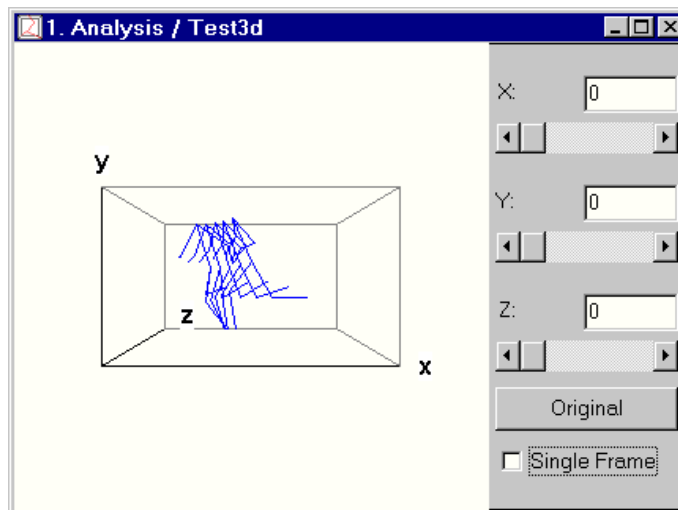
Distances to t Shows the changes of the length of the connections related to t

1. Derivation Distances to t	The velocity of the changes of the connections
2. Derivation Distances to t	The acceleration of the changes of the connections
Angle to t	The changes of the size of the angles related to t
1. Derivation Angle to t	The velocity of the changes of the angles
2. Derivation Angle to t	The acceleration of the changes of the angles
(XY) Angle Projection to t	Sagittal plane projection of angles to time
1. Derivation (XY) Angle to t	Sagittal plane projection of angle velocity to time
2. Derivation (XY) Angle to t	Sagittal plane projection of angle acceleration to time
(XZ) Angle Projection to t	Transversal plane projection of angles to time
1. Derivation (XZ) Angle to t	Transversal plane projection of angle velocity to time
2. Derivation (XZ) Angle to t	Transversal plane projection of angle acceleration to time
(YZ) Angle Projection to t	Frontal plane projection of angles to time
1. Derivation (YZ) Angle to t	Frontal plane projection of angle velocity to time
2. Derivation (YZ) Angle to t	Frontal plane projection of angle acceleration to time

New/Connections/Stick Figure Command

When you select the **New/Connections/Stick Figure** command, the analysis is displayed in a window that looks as follows.

Stick Figure Window



In the left part of the window you see the stick figure situated in a two- or three-dimensional space with the x-, y- and z-axis (z-axis when three-dimensional) displayed.

Clicking on the left mouse button on one of the axes, you can rotate the axis and thus get a different view of the movement.

When you click elsewhere (not on an axis) on the stick figure representation with the left mouse button and move the mouse pointer up and down, you can zoom in and out.

You can use the **Play** button on the toolbar and see the movement of the stick figure in the analysis window simultaneously with the motion in the image sequence.

In the right part of the stick figure window you can see three scroll bars, one for each axis. With these scroll bars you can also define the rotation of the axes the angle of rotation is displayed in the text

box next to the name of the axis. There you can also enter the value directly.

With the **Original** button the stick figure can always be set back to its original form.

The **Single Frame** check box determines, whether you see only the connections of the current frame or of all frames, while playing the sequence. (It is selected by default.)

5.6.3 Adjust Sequences Submenu

With the commands in the **Analyze/Adjust Sequences** submenu you can correct small divergences in the object sequences. The corrections are done in the image sequence window.

When you work on derivations of object sequences, the corrections are made on the underlying sequences. After that the derivations are newly calculated.

Therefore it is highly recommended to save your original data prior to making adjustments!

You can select the different correction methods from the submenu:

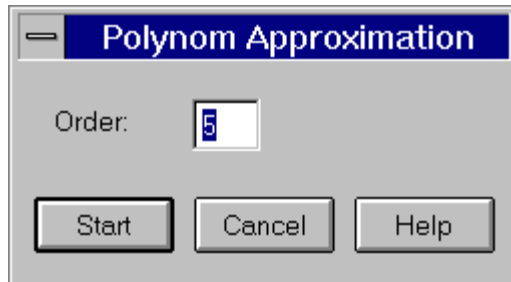
Interpolation By using **Interpolation** you can fill the gaps in the sequences. WINalyze tries to find out the curve of the lacking part by use of a neural net.

Smoothing Smaller derivations in the sequence course are removed by a low pass filter.

Approximation With **Approximation** the sequence course is approximated by a polynom.

When you choose **Approximation**, the **Polynom Approximation** dialog box opens, where you must enter the order of the polynom. By default the approximation is made with an order of five.

Polynom Approximation Dialog Box



5.6.4 Import External Data Command

With the **Analyze/Import External Data** command you can import data from external devices like e.g. EMG.

When you select the command you will get a file selector dialog box, where you can select a file to import, which must have a DAQ file (see 8 Appendix) extension.

5.6.5 Delete Imported Data Command

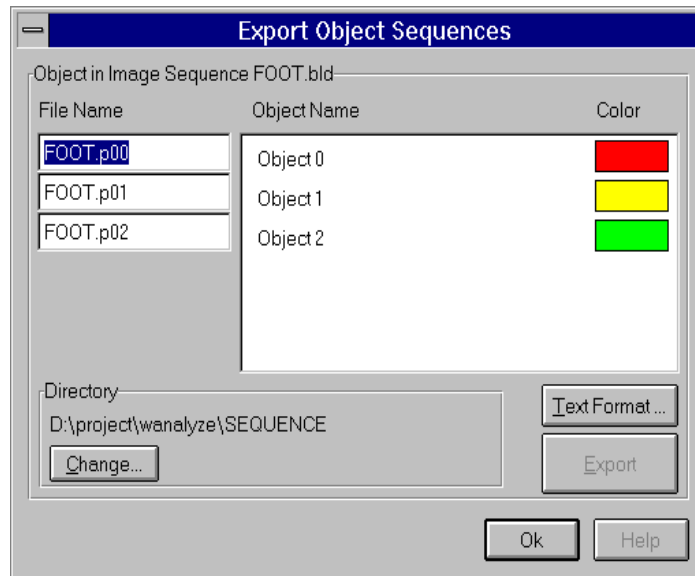
With the **Analyze/Delete Imported Data** command you can delete analysis data that was imported to an analysis window.

5.6.6 Export Analysis Data Command

The **Export Analysis Data** command allows you to export different analysis data.

After you have selected the command the **Export Analysis Data** dialog box appears.

Export Analysis Data Dialog Box



File Name

Here you can see the file name for the data to be exported; as a standard file name the name of the image sequence is taken. The file name has to end with a U?? extension, where ?? stands for numbers to specify the data belonging to one image sequence.

Object Name/Colour

Here you can see the **Object Name** and the corresponding **Colour**. You can select the object, from which data shall be exported. You select the object by clicking on it. You can select more objects by pushing down CTRL while you are clicking; when you want to select object sequences that succeed each other, then click the first sequence and hold down SHIFT and click the last sequence (When you hold the left mouse button pressed down and pull it over the sequences, you will receive the same effect).

Directory/Change

Here you can see the directory, under which the files are saved. By clicking the **Change** button you get to a dialog box, where you can change the directory.

Data to be Exported

By activating the check boxes, you specify which data, like e.g. x, y' or angles, of the object sequences analysis are exported. You can select all data by pushing the **All Data** button.

Text Format

By the **Text Format** button you get to the **Text Format Settings** dialog box, where you can make settings for the text format. The dialog box is described at the end of this paragraph.

Export

When you click this button, the object sequences analysis data are exported to the files and directory that are specified.

OK

With **OK** you close the dialog box.

Text Format Settings Dialog Box



It may be necessary to adjust the text format settings in dependent on the application you want to import the data with. You must refer to your applications manual how e.g. decimal places are interpreted by your application.

Floating Point Numbers

Here you can specify whether the **Decimal Place** is marked by a **Comma** or a **Point**. You can also set the **Precision** of the number after the decimal place.

Column Borders

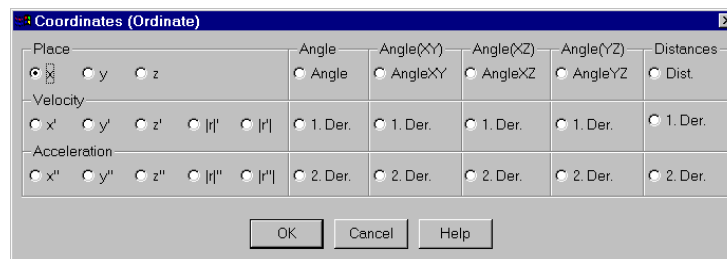
Here you specify, how the **Column Borders** (delimiting each single coordinate value) shall be marked.

5.6.7 Coordinates Command

By the **Coordinates** command you get the **Coordinate (Ordinate)** dialog box, where you can specify the coordinate for the ordinate (y-axis) of the current analysis window.

This command is not available, when there is no analysis window active.

Coordinates (Ordinate) Dialog Box



You must select the option button of the coordinate you want to appear on the ordinate (y-axis) in this dialog box.

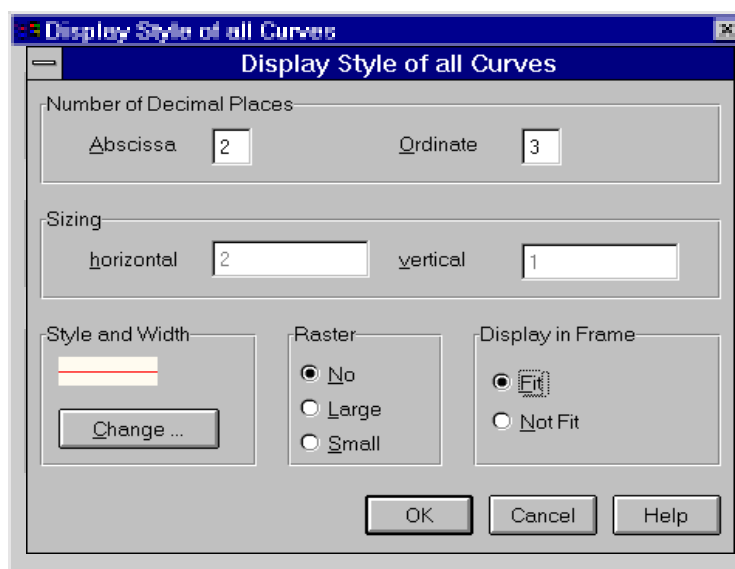
5.6.8 Display Command

The **Analyze/Display Command** serves for changing the display style, for example, decimal places, sizing of the current analysis window.

After you have selected the command, the **Display Style of All Curves** dialog box appears.

Another way to change only the style and width of the curves is to click directly on a selected curve with the right mouse button. Then you get a small box, where you can select a new display style for the curve.

Display Style of All Curves Dialog Box



Number of Decimal Places

Here you can enter the number of **Decimal Places**, which you want for the abscissa respectively the ordinate.

Sizing

Here you enter the **Sizing** of the axis in horizontal and vertical direction.

Style and Width

In this group box you can change the **Style and Width** of the curves. You can see the current style of the curves, and with the **Change** button you get a small dialog box, where you can select another style or width by clicking on it.

Grid

Here you can select between a **Large, Small** or **No Grid** for the current analysis window. By default there is no grid.

Display in Frame

Here you specify, whether the display does **Fit** or **Not Fit** into the frame.

5.6.9 Enable/Disable Reticules Command



WINanalyze gives you the opportunity to insert reticules in an analysis window to measure distances.

When you have chosen the command, two reticules (one round and one rectangular) appear in the top right of the analysis window. On the right side of the window there appears a little box, this shows the position of the two reticules and the difference between the values.

You can now drag both reticules to the wanted position (the drag and drop method). In the box on the right side you then see the position and the distance of the two reticules, in each case the values for the ordinate and the abscissa.

When there are reticules inserted in the analysis window the **Enable Reticules** command changes to **Disable Reticules**, by using this you can turn off the reticules again.

5.6.10 Insert Reticules (Old Position) Command

When you choose the **Insert Reticules (Old Position)** command, the reticules are inserted in the position you dragged them to before, i.e. they are recovered in their old position.

When you want to set new reticules, you must select the **Enable Reticules** Command.

5.6.11 Enable/Disable Showing Frame Numbers Command



After you have selected the **Enable Showing Frame Numbers** command, a small box appears next to the analysis window, this will always shows the current frame number.

When the reticules are turned on, the frame number appears at the bottom of the reticules box.

Additionally there appears a time bar in the analysis window, which moves with the frames.

When the display of the frame numbers is turned on, the menu command changes to **Disable Showing Frame Numbers**, by which you can turn off the display again.

5.6.12 Select Fonts Command

By the **Select Fonts** command you get to the **Font** dialog box, where you can specify the **Font**, the **Font Style** and the **Size** of the lettering in the analysis window.

5.6.13 Position Data Left/Right Command

By choosing the **Position Data Left** or the **Position Data Right** command you can set the reticule and frame number box to the left otherwise to the right side of the analysis window.

5.7 Window Menu

5.7.1 Smart Tile Command

The **Smart Tile** command arranges the open windows on the screen in a clear and understandable way using the current window locations as a suggestion for the tiling arrangement.

Before you use this command you should drag the windows to an approximate location, about where they shall be positioned. The windows also may not overlap when using this command.

5.7.2 Cascade Command

The **Cascade** command cascades the open windows on your screen.

5.7.3 Tile Command

The **Tile** command tiles the open windows horizontally.

5.7.4 Arrange Icons Command

The **Arrange Icons** command arranges the icons at the bottom of your application window.

5.7.5 Close All Command

The **Close All** command closes all open windows.

When there are unsaved object sequences in the current image sequence, you are asked whether you would like to save them.

5.7.6 Zoom In Command



The **Zoom In** command is only available when the **Set Fit** command is turned off.

By selecting the **Zoom In** command or pushing the corresponding button you can zoom into the image sequence or the analysis window.

For zooming out again, you have to use the **Zoom Out** command.

5.7.7 Zoom Out Command



The **Zoom Out** command is only available, when the **Set Fit** command is turned off.

By selecting the **Zoom Out** command or pushing the corresponding button you can zoom out of the image sequence or the analysis window.

For zooming in you have to use the **Zoom In** command.

5.7.8 Set Fit Command



With the **Window/Set Fit** command the contents of the image sequence or analysis window is fit into the size of the window.

You can see that the command is turned on by a tick next to the command; when you want to turn it off again, simply select the command again.

When you want to zoom into or out of a window, you have to turn off the **Set Fit** command.

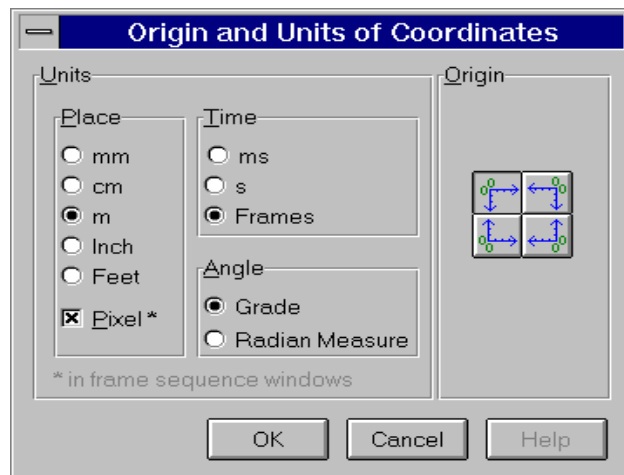
This command is activated by default.

5.7.9 Origin/Units Command

With the **Origin/Units** command you can select the units for the analysis and image sequence windows and also set the position for the origin of the graphs.

After you have selected the command, the **Origin and Units of Coordinates** dialog box is opened.

Origin and Units of Coordinates Dialog Box



Units

In the box **Units** you find the group boxes for **Place**, **Time** and **Angle**, where you can specify the units for this items by, in each case, selecting one of the option buttons.

Origin

In the **Origin** box you can select one of the four positions for the origin by clicking on them.

5.8 Help Menu

5.8.1 Contents Command



The **Contents** command leads you to the contents tab of the **WINalyze Help**.

5.8.2 Context Help Command

SHIFT+F1

When you select the **Context Help** command, the cursor changes to a little arrow with a question mark. You can click on a menu command or a button and on this way you get the appropriate help topic.

5.8.3 How to Use Help Command

By selecting the **How to Use Help** command you get the contents tab of the topics concerned with the use of a help file. This corresponds to pushing the F1 key in the help file.

5.8.4 About Command

The **About** command gives you information about **WINalyze**, that tells you about the version number, the copyright, etc.

6 Hints and Tricks

6.1 Tracking Objects and Analyzing the Motion Simultaneously

WINalyze gives you the possibility to have an analysis window kept open during the tracking, so that you can see the resulting motion analysis at the same time as the tracking.

You proceed as follows:

1. You load an image sequence with the **File/Load Image Sequence** or **Load Multiple Image Sequence** command and do all the necessary preprocessing and calibration on the image sequence.
2. With the **Objects/New Object Sequence** command you now set your objects in the first frame of the image sequence.
3. Then you create an analysis window with e.g. the **Analyze/New/Sequences/x to t** command.
4. Now you start tracking the objects with the **Tracking/To Sequence End** command. You can watch on one side the tracking of the objects in the image sequence window and on the other side simultaneously the development of the motion analysis x to t .

6.2 Playing an Image Sequence and Following the Associated Analysis

In the program **WINalyze** you can play an image sequence with already tracked object sequences. At the same time an associated

analysis window can be kept open, where you can simultaneously watch the course of the diagrams as it plays each frames.

You proceed as follows:

1. You load an image sequence with the **File/Load Image Sequence** or **Load Multiple Image Sequence** command and do the necessary preprocessing and calibration.
2. Now you set the objects in the first frame of the image sequence with the **Objects/New Object Sequence** command.
3. Then you track the objects with the **Tracking/To Sequence End** command to the end of the sequence.
4. You create an analysis window for example with the **Analyze/New/Sequences/x to t** command and select the **Analyze/Enable Showing Frame Numbers** command.
5. When you want to follow the analysis from frame to frame, you must select **Frames** as the unit for **Time** in the **Origin and Units of the Coordinates** dialog box (**Window/Origin and Units** command).
6. Now you start the Player with the **Player /Play** command (otherwise the **Play** button). You see the time bar move parallel to the ordinate synchronously with the frames in the image window.
7. When you additionally click one of the curves, you can then see next to **Ord.:** in succession of time the values for this curve (object sequence) shown in the box beside the analysis window.

6.3 Object Leaving the Frame Borders

When an object is leaving the frame borders, you should set this object so that it is no longer tracked. You can do this in the **Objects** dialog box, which you can reach by the **Image Sequence/Show Dialogs** command.

6.4 Setting Reference Points

6.4.1 Single Reference points

When you want to set reference points on a static object in an image sequence, then it is best to set the tracking algorithm for these objects to **Manual** tracking and press TrackingTo Sequence End. This way the objects do not move during tracking.(see also 5.5.1)

When you need these point in several sequences made from the same camera position, export the object sequences and import them into the other sequences

6.4.2 Reference Grid

When you need a fixed grid in any form in your camera view set objects with the attribute “tracked manual” and connect them. Save this with Objects/Save. A file with the name of your sequence file with the extension OS is created. Copy this file and rename it to the name of that sequence you want to analyse with a grid. Now open the sequence and load the grid by using Object/Load.

6.5 Problems in Object Tracking

When there problems appear during object tracking, you should check the following items, mentioned below, which can lead to an improvement in tracking objects.

6.5.1 Changing Templates

When there are problems in tracking an object, you can try to change the size and/or position of the template.

When marking an object you should consider that the template should select an area in the frame, which is characteristic.

WINalyze tries to match the templates, when detecting the object positions. Therefore you will get the best results, when the template represents a detail in the frame, which is distinct from other image details within the search limits of the respective object. (Also see 6.5.2 Changing Limits)

6.5.2 Changing Limits

When the tracking of an object does not work, you can try to change the values for the horizontal and/or vertical limit. The values entered for the horizontal and vertical limits mean that **WINalyze**, e.g. with a horizontal limit of 11, searches for the respective object in the following frame within a range of 5 pixels to the left and 5 pixels to the right, compared to the object position in the previous frame. Therefore a limit, which is too high, increases the risk of errors in detection and needs more processing time. When the limit is too small, the object position in the following frame might be out of the range, where **WINalyze** searches for it.

The size of the limits must be adjusted with respect to the kind of image sequence you are working on and the motion characteristics of your objects.

For example: If you do not want that an object is searched in vertical direction, you can set the vertical limit to 0.

When you are working with several markers in the image sequence, you should consider, that in either direction the limits must be smaller than the distance to the next marker, so that the template can not jump to the next marker during the tracking.

6.5.3 Using Filters

When you are working with markers and the markers are not tracked to your satisfaction, you can try to use the Edge Filters (Sobel or Robert's Cross filter) or the Texture filters on the image sequence. After that you should track the objects with the Cross-Correlation, which will in this case deliver better results than the SSD-Correlation.

6.5.4 Tracking Algorithm

When you have problems in object tracking, you can try to use a different tracking algorithm.

The SSD-Correlation is the right choice, when the light respectively the gray scale brightness or the colour difference shall be taken in consideration.

The Cross-Correlation is normalized, this means that it can be used, when the sequence is recorded with changing illumination.

When you have worked with markers on the moving object during recording the image sequence, the Texture Tracking is recommended.

6.5.5 Single Tracking

When the tracking does not deliver reasonable results, you can try to get better results using single tracking. This means that you use the **Tracking/One Frame Forward** command to do the tracking just from one frame to the next.

This will give you better results more than before, because when the tracking is stopped after each frame, the template can be set back each time.

In all cases it is better to do single tracking rather than manual tracking, because you can not get the subpixel precision by using manual tracking.

6.5.6 Using Markers

When you track objects in an image sequence, in spite of applying the listed methods, are not successful in tracking the objects, we recommend to use markers on the moving objects and record it again. Using markers can optimize object tracking. (Also see 6.5.7 Colour Tracking)

6.5.7 Colour Tracking

When tracking objects **WINalyze** considers colour information. This means that, if you have a coloured image sequence and do not depend on a high processing speed, you should not convert it to gray scale. But keep in mind that colour tracking will need about three times more time as normal tracking, which only considers gray scale values.

When using markers, for recording a sequence, this means, that coloured markers will yield better results (we recommend red or green). When markers are placed very near to each other, you can try to alternate marker colours (e.g. red, green, red,...).

6.5.8 Manual Tracking

Manual tracking means clicking each object with the mouse, pushing one frame forward on the left part of the buttonbar (see 4.5) and clicking each object again. Therefore here is no need for templates. Go to Objects/Presetting (see 5.4.19 and edit 11% for Width and Height of Template).

7 Glossary

Approximation

With Approximation the course of an object sequence is approximated by a polynomial of an adjustable order.

Colour Reduction

Colour Reduction is made, when an image sequence can not be displayed by the means of a graphics adapter. In the program WINanalyze Colour Reduction is done by the Median Cut or the Popularity Algorithm.

Cross-Correlation

Cross-Correlation is a normalized tracking algorithm; i.e. brightness, light and shadow or light reflection have no significant influence on the tracking.

Gamma Correction

Gamma Correction is an adjustment of the medium colour and gray values in the image sequence.

Image Sequence

Image Sequence means a digital video, which shall be analyzed. It consists of a certain number of image frames.

In the context of the program WINanalyze an image sequence can consist of more than one camera view. Then all the camera views of the same project, which are each an image sequence themselves, are also called an image sequence.

Interpolation

Interpolation fills gaps in the object sequence by trying to calculate intermediate values between two points.

Median Cut

The Median Cut uses the histogram to compute 256 colours out of the distribution of the RGB values and takes these colours for the image sequence.

Colour Reduction by the Median Cut most often delivers better results than by the Popularity Algorithm.

Object

Object is a certain point in the frame of an image sequence. In the program WINanalyze it is marked by a marker and a template which can be tracked through the image sequence.

Object Sequence

Object sequence is an object, which is tracked through the frames of an image sequence. It is the number of objects that result from the tracking of one object through the frames of an image sequence. It is displayed as a trajectory (curve).

Popularity Algorithm

The Popularity Algorithm selects the 256 most often used colours from the histogram for the image sequence. For colours, which are not amongst these 256 colours, the next similar of the 256 colours is taken.

Smoothing

Smoothing deletes small deviations in the course of an object sequence by a low pass filter.

SSD-Correlation

SSD-Correlation is a non-normalized tracking algorithm; i.e. light respectively gray scale brightness and colour difference are taken in consideration while tracking.

Template

The template cuts out a surrounding area of the object. This template area is then searched for in the next frame during the tracking.

Texture Tracking

The Texture Tracking automatically preprocesses the image sequence with a Texture filter before tracking. Otherwise it works like the Cross Correlation. The Texture Tracking is recommended, when you have used markers on the moving object in the sequence you recorded.



8 Appendix

8.1 WINalyze File Format Specifications

8.1.1 Image Sequences Files

RSC Format

The RSC file is a document file in ASCII format, it gives a description of the image sequence. It contains the image sequence name, the number of camera views (sequences) the image sequence consists of, the names of the sequence files and the calibration file name (CDC).

Example for the file test_l.RSC:

```
#WINalyze generated Resourcefile test_l.RSC
#last modified: Tue Aug 08 12:40:30 2000
```

```
DESCRIPTION: Test_l
SEQUENCES: 2
Sequence_1: test_l.bld
CALIB_DATA: test_l.cdc
SEQUENCE_2: test_r.bld
```

BLD Format

The BLD format is a file format to store image sequences. Each BLD file needs a corresponding descriptor file in the DSC format. In a BLD file all single frames of an image sequence are stored successively uncompressed in the block format. The data is in binary raw data format (e.g. for greyscale pictures 1 Byte per Pixel).

The BLD format corresponds to the file format RAW, which is known from several other applications.

BLD files are not intended to be manipulated.

DSC Format

The descriptor file (DSC) belongs to the corresponding BLD file and is a line-orientated ASCII file. In it values like e.g. resolution, frames or date are stored. The DSC file is created by the applications Mikrokam, WINscan or Avi2Bld, but can also be created with any text editor.

A DSC file contains keywords followed by the corresponding values; one can also insert comments marked by using the “#” sign. In the following an example for a DSC file given (for the BLD file foot.bld):

```
# WINanalyze generated file Foot.DSC
# last modified: Wed Jan 22 17:58:14 1997
# this file contains information about the
# corresponding BLD-file Foot.bld
SEQUENCENAME:Barefoot
DATE:26.08.92
RESOLUTION:256x256
FRAMES:24
COLORSPACE:GREY
FRAMES/S:530.5
UNITS:0.1875
ASPECT:1
```

As a minimum the keywords and values for RESOLUTION, FRAMES and FRAMES/S must be specified.

By supplying a corresponding DSC file, any RAW data file (renamed as BLD) can be used for WINanalyze.

AVI Format

AVI (Audio Video Interleaved) is a file format specified by the Microsoft Corporation. It serves as an interface for arbitrary coder-decoders. WINanalyze supports all common AVI compression

methods. (Nevertheless you must keep in mind, that there are special compression methods, which need special decompression codes. These may even be embedded in the hardware for example frame grabbers with on-board compression. For using those AVI files the equivalent hardware is needed.)

8.1.2 Camera Calibration Files

CDC Format

Files in the CDC format contain the calibration data of an image sequence. CDC files are files in the ASCII format.

They specify the calibration frame (BLD or AVI), the camera hardware parameter file (CAM) and the calibration model (CMO). Above that they contain the calibration constants, data and the 2D coordinates of the calibration points how they are positioned in the calibration window.

This file should not be manipulated by the user. It is created with the Image Sequences/Calibration cimmand

Example for heder of file test1.cdc:

```
# WINanalyze generated file test1.cdc
# last modified: Wed Aug 09 19:48:01 2000
#
# this file contains calibration-files, -
# constants and -data
#
```

```
CALIB_IMAGE: Calib_1.BLD
CAMERA: Camsys_1.cam
MODEL: Calib.cmo
Calibrated: 1
FullOptimized: 1
GradientSearch: 0
Cx: 131.036
Cy: 141.565
```

sx: 1.00154
f: 8.216
kappa1: 0.00168033
Tx: -1686.52
Ty: -1028.94
Tz: 7416.77
Rx: 0.0196184
Ry: 0.2893
Rz: 0.0110526
POINT_1: 69.3125 191.438
POINT_2: 121.574 193.608
POINT_3: 177.177 195.639
POINT_4: 236 198
POINT_5: 45.1667 197.833
POINT_6: 102.5 200.833
POINT_7: 164 203.667
POINT_8: 229.842 206.341
POINT_9: 15.125 206.125
POINT_10: 78.1253 209.766
POINT_11: 147.5 213.667
POINT_12: 222.167 217
POINT_13: 69.3333 136.333
POINT_14: 121.75 136.75
POINT_15: 177.588 137.43
POINT_16: 236.75 137.75
POINT_17: 45.25 136.75
POINT_18: 102.625 137.25
POINT_19: 164.5 137.75
POINT_20: 230.75 138.5
POINT_21: 14.6485 137.418
POINT_22: 78.5 138
POINT_23: 147.875 138.75
POINT_24: 223 139.25
POINT_25: 69.5434 81.9532
POINT_26: 122.125 80.6875
POINT_27: 178.167 79.1667
POINT_28: 237.342 78.0891
POINT_29: 45.4375 76.1875
POINT_30: 102.888 74.4883
POINT_31: 165 72.5

POINT_32: 231.237 71.0635
POINT_33: 14.8333 69
POINT_34: 78.8229 66.3545
POINT_35: 148 64.3333
POINT_36: 224 61.75
PROJPOINT_1: 14.788 68.4792
PROJPOINT_2: 224.192 61.6297
PROJPOINT_3: 222.448 216.521
PROJPOINT_4: 14.788 205.818
PROJPOINT_5: 68.7782 81.2522
PROJPOINT_6: 237.348 76.9712
PROJPOINT_7: 236.999 196.689
PROJPOINT_8: 68.7782 191.551

CMO Format

See 8.4.3 Calibration Model Data File

CAM Format

See 8.3.3 Camera Hardware Parameter File

ABM Format

See Bodymodel. Format for new bodymodels

BMD Format

See Bodamodel. Format for a collection of bodymodels

8.1.3 Object Sequences Files

OS Format

The OS format is a binary format that contains the object sequences data of the corresponding image sequence.

The file should not be manipulated by the user. It is created when you push Save under Object pull down menu.

OS_1 Format

It is the same Format as the OS format an is created when you push Save As under the Object pull down menu. The number incremented with each Save As.

P?? Format

The P?? format is used for the files to import and export object sequences data. The “??” stands for the object number.

The P?? files are in ASCII format and contain the coordinates for the position of the objects in each frame given in pixel values.

Example for the file foot.P00:

```
0 42.299 93.209
1 63.400 102.251
2 78.809 109.899
3 89.237 118.202
4 94.593 124.690
5 96.662 132.676
6 96.792 141.532
```

N?? Format

The N?? files are also files for the import and export of object sequences. It is created together with the P?? file.

They contain the name and the colour (RGB) of the object sequence in ASCII format.

Example for foot.N00:

```
Object 0
255 0 0
```

8.1.4 Analysis Data Files

U?? Format

The U?? files contain exported analysis data for single object sequences in ASCII format.

The units of the exported analysis values depend on what you adjusted with the Origins/Units command.

Example for the file foot.U00:

```
#t[frames] x[mm] y[mm]
1.000 8.847 40.845
2.000 17.340 38.601
3.000 21.231 36.650
4.000 23.819 34.578
5.000 25.597 32.808
6.000 26.536 30.829
7.000 27.103 27.988
```

CON Format

If object sequence is containing connections and analysis data are exported additional a file with the name of sequence is created with the extension CON. It is an ASCII file and contains information about the connections.

Example: file foot.con

```
foot.u01 foot.u00
foot.u02 foot.u00
foot.u02 foot.u01
```

8.2 DAQ and DQS Format

Data from external devices like e.g. EMG force plates or audio data can be imported into an analysis window. To enable this feature the data must be brought to the DAQ/DQS format according to the following specifications.

DAQ Format

The recorded data, e.g. an audio sample, are saved in an own file. The filename of the data file consists of the base name and the extension DAQ.

The data can be stored in the ASCII or binary (RAW) format. In both cases they are always 16-bit values. Depending whether the data is bi- or unipolar, the data values are saved signed or unsigned. The additional information about in each case the storage format and the polarity of the values can be taken from the DQS file.

Example: Part of the file EMG.DAQ

```
15
18
18
18
15
21
21
12
28
17
23 and so on
```

DQS Format

To take hold of the technical specification with the storage for every data file an associated descriptor file is created.

It has the same base name as the data file, but the extension DQS. The entries of this file consist of a line-orientated description in the ASCII format. Every line begins with a keyword (Token), followed by a comma and then in each case the entry.

<Token>:<characters>

The following entries are used in the DQS File:

Token	Data Type	Format	Description	Example
DAQ_AMP	int	1, 2, 5, 10	Amplification	5
DAQ_BITS	int	12, 13, , 16	Bits per sample	12
DAQ_COUPLING	string	AC, DC	Coupling	AC
DAQ_DATE	string	dd.mm.jjjj	Date of storage	
01.01.1995				
DAQ_FRAMERATE	float/double		Frames/sec	1000.00
DAQ_FORMAT	string	ASCII, RAW	Storage type of file	ASCII
DAQ_LENGTH	int	>0	Number of samples	10240
DAQ_MAXVOLT	float/double	+5, +2,5	Maximum voltage	5
DAQ_MINVOLT	float/double	0, -2,5	Minimum voltage	0
DAQ_NAME	string		Description	Audio
DAQ_SAMPLERATE		float	Sample rate	10000.00
DAQ_POLARITY	string	uni. Bi	Polarity of the record	UNI
DAQ_SpF	int		Samples/Frame	100
DAQ_TIME	string	hh.mm	Storage time	10.30

Example file EMG.DQS

```
DAQ_AMP:1
DAQ_BITS:16
DAQ_COUPLING:AC
DAQ_DATE:13.01.1997
DAQ_FRAMERATE:500.00
DAQ_FORMAT:ASCII
DAQ_LENGTH:480
DAQ_MAXVOLT:0
DAQ_MINVOLT:5
DAQ_NAME:EMG
DAQ_SAMPLERATE:25.0
DAQ_POLARITY:UNI
DAQ_SpF:20
DAQ_TIME:35.96
```

8.3 Calculating Analyses

In the following a short description is given on how the values and trajectories in the analyses of the program WINanalyze are calculated.

8.3.1 Origin of Original Coordinates

The origin for the x-, y-, and z-coordinate is taken from the calibration model used in calibrating the respective sequence. This applies to all 2D and 3D image sequences that are calibrated with a calibration model (.CMO file). The coordinate system is always right-handed. Here the Windows/Origin/Units command affects only the display of the analysis window, except when the sequence is calibrated by Linear Sizing. Then the origin is defined by what had been adjusted in the Origin/Units command, and the size of the coordinate system depends on the frame size in the image sequence.

8.3.2 Calculation of Analysis by the Analyze/ New Command

Sequences Submenu

The values for x' , y' and z' are calculated directly on the original coordinates. The first derivative is calculated according to Savitzky/Golay with a kernel of 5. Therefore the first derivative for the first and last two frames of the sequence can not be calculated. The second derivatives (x'' , y'' and z'') are also calculated directly on the original coordinates according to Savitzky/Golay. Here a kernel of 7 is taken, so that the second derivative can not be calculated for the first and the last three frames of the sequence. The resulting velocity and acceleration are calculated by first calculating the magnitude of the vector and then computing the first respectively second derivative according to Savitzky/Golay. The absolute resulting velocity and acceleration are calculated by first computing the first respectively second derivative for the x-, y- and z-coordinates according to Savitzky/Golay and then calculating

8.4 Camera Calibration

We have attached a chapter about the camera calibration like it is used in WINanalyze for deeper knowledge about calibration. It also contains some hints for better calibration.

8.4.1 Binocular Stereo-Vision

WINalyze is able to use up to ten cameras, but as an example the basic principles are explained here using two cameras.

Binocular stereo-vision is established by the use of two cameras. There are several different coordinates used in this two-camera-model:

- The 3D world-coordinate-system (X_w, Y_w, Z_w) spans the working volume. Units are in mm.
- The 3D camera-coordinate-system (X_l, Y_l, Z_l (left camera) and X_r, Y_r, Z_r (right camera)) with origins at the optical centers have the same z-axis as the optical axis. Units are in mm.
- The 2D sensor-coordinate-system (X_{ls}, Y_{ls} and X_{rs}, Y_{rs}) span the sensor planes. Units are in mm.
- The 2D framebuffer-coordinate-system (X_{lf}, Y_{lf} and X_{rf}, Y_{rf}) describe the camera's (computer's) framebuffer. Units are in pixel.

Transformation from 3D world coordinates to computer image coordinates is done in four steps, which are as follows for the right camera:

1. **World Coordinates to Camera Coordinates**
 $(x_r \ y_r \ z_r)^T = R (x_w \ y_w \ z_w)^T + T$
Where R is a rotation matrix and T is a translation vector.
2. **Camera Coordinates to Sensor Coordinates**
 $X_{rs} = f_r * x_r / z_r$
 $Y_{rs} = f_r * y_r / z_r$
where f_r is the focal length of the right camera. Note that we are using a pinhole camera model here.
3. **Undistorted Sensor Coordinates**
 $X_{rs}' = X_{rs} - D_x$
 $Y_{rs}' = Y_{rs} - D_y$
where
 $D_x = X_{rs}' * \kappa * (X_{rs}' * X_{rs}' + Y_{rs}' * Y_{rs}')$
 $D_y = Y_{rs}' * \kappa * (X_{rs}' * X_{rs}' + Y_{rs}' * Y_{rs}')$
 κ is the distortion coefficient for radial lens distortion.

Note that we do not consider tangential lens distortion, which often causes numerical instability (see [TSAI, 1986])!

4. **Undistorted Sensor Coordinates to Computer Image Coordinates**

$$X_{rf} = X_{rs}' * s_x / dx + C_x$$

$$Y_{rf} = Y_{rs}' / dy + C_y$$

where

C_x, C_y are the Computer image coordinates for the image plane origin

s_x is an uncertainty factor for image scale

dy is the vertical size of a sensor element in mm

$dx = dx' * N_{cx} / N_{fx}$ with

dx' : horizontal sensor element size in mm

N_{cx} : number of horizontal sensor elements

N_{fx} : number of horizontal pixels in computer frame buffer

8.4.2 Camera Calibration Techniques

From the paragraph Binocular Stereo-Vision it is obvious that calibration must compute the following parameters:

R Rotation matrix; encoded in the three Euler angles; 3 parameters

T Translation vector; 3 parameters

f Focal length; 1 parameter

kappa Radial lens distortion coefficient; 1 parameter

sx Image scale uncertainty factor; 1 parameter

Cx, Cy Image plane origin; 2 parameters

Ncx, Nfx, dx, dy

The values for these parameters are found in the camera hardware manual.

There exist a large number of calibration techniques to solve the unknown parameters above. We implemented the method of Roger Y. Tsai (see [TSAI, 1986]), which can be seen as the state-of-the-art in calibration methods.

The principle of calibration is: put a calibration object into the working-volume, record an image of this object with the camera to

be used, and acquire the two-dimensional image points for every calibration point. By giving the precise 3-D coordinates of the calibration points (so called ground truth information) in comparison to the acquired 2-D image points, automatic routines can compute the unknown parameters for the camera model.

Calibration Models

Models used for calibration can be chosen almost arbitrary. The object should span the working space in at least 2 axis. Every calibration point of the object must be precisely known in its true 3-D world coordinates (in mm). Each point should be clearly seen in the recorded image (which can be established by the use of markers, etc.). As it can easily be concluded from the number of parameters to be computed by calibration, any calibration model should at least have 11 different points.

Coplanar Calibration Models

Coplanar objects are flat; i.e. they do not extend in the z-axis. A flat wall with markers on it is an example. The calibration routine used in this program has the restriction that the z-axis must be 0. With coplanar calibration the uncertainty factor cannot be computed and should be set to 1.

Noncoplanar Calibration Models

Noncoplanar objects extend to all 3 axis. Commonly used are three-dimensional arrays of cubes. Also, coplanar models shifted on a precise z-stage can be used. Noncoplanar calibration can compute every unknown parameter of the camera model and usually gives the best results in successive measurements.

Special Considerations

With our implementation of camera routines, the user has a huge amount of freedom concerning the installation of cameras. The cameras used can be of different types, can have different focal lengths and the position can be set almost anywhere (no common axis required).

Nevertheless there is one restriction on choosing camera positions: None of the cameras may look orthogonal at the working space. An angle of about 25 degrees is recommended.

Remarks on Camera Calibration

Note that for the optimized calibrations care has to be taken, when routines compute center-coordinates far away from the theoretical middle of the sensor. Even though the calibration data is approximated very precisely (low statistic error values), the result may be worse than with normal calibration for successive practical measures. The best way to manage this problem is through using the following procedure:

Use full optimization once to determine Cx and Cy. If they are within reasonable limits surrounding the sensor center, use them with normal calibration.

Only if normal calibration yields poor results (as can be seen by the statistical output), optimized calibration routines should be used for camera calibration.

8.4.3 Input File Specifications (CMO, CAM)

Calibration Model Data File

This text file with the extension CMO contains the ground truth world coordinates of the calibration model in use. Each calibration point must be specified by x, y and z coordinates in mm, one line per point.

Coordinates can be entered in floating point notation. The number of calibration points (i.e. the number of lines in the ASCII-file) are determined automatically and must not be specified.

Please note that for coplanar calibration all z-coordinates must be 0. The software needs to make this assumption, so do not try to enter values other than 0. Different z-coordinates can only be used by noncoplanar calibration.

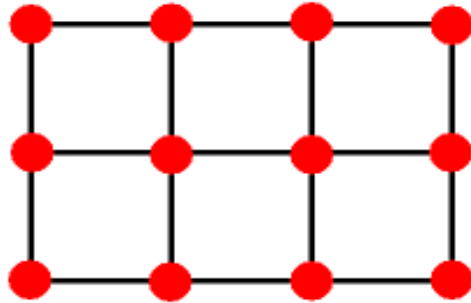
Additionally, not all x-, y- and z-coordinates of a point may be 0. So the origin of the calibration model (0,0,0) may not be part of the ground truth data!

The coordinate system for displaying calibration models is a right handed cartesian one, with positive x to the right, positive y down, positive z back. Any point defined in the CMO file is independent from its position in the file – it is always drawn assuming (0,0,0) being in the upper left front. By using this information calibration models can be defined translating the origin (0,0,0) to any position. So building your own calibration models by creating individual CMO files allows you to define an arbitrary coordinate system with the origin at any position – with the only restriction that increasing values will always be to the right (for x), bottom (for y) and back (for z). So when defining a model with the origin at the lower left corner, you will get decreasing y-values to the top! For more information on how to modify this please refer to the 3d samples on the distribution disks.

Examples for Calibration Model Data Files

Coplanar Calibration Model Data File

Consider a grid-like calibration plane, having 4 columns and 3 rows. We are using the crossing points as calibration points:



For example each point has a distance of 30 mm from its neighbor, both in horizontal and vertical direction. So a CMO file, consisting of the (x,y,z) coordinates in mm for each point, in the first instance would look like this:

```
0 0 0
30 0 0
```

60	0	0
90	0	0
0	30	0
30	30	0
60	30	0
90	30	0
0	60	0
30	60	0
60	60	0
90	60	0

Points are entered from top to bottom, left to right. The coordinate origin here is in the upper left corner. Please take care for the right-hand coordinates in this system: increasing x values to the right, imply increasing y values to the bottom.

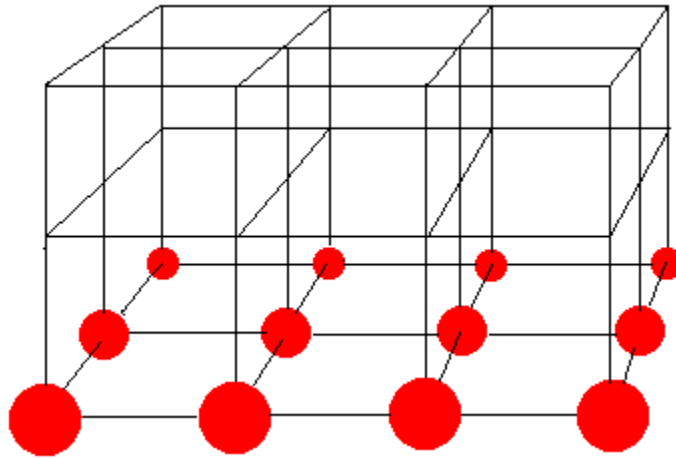
According to the restriction of not using (0,0,0) as a calibration point, the first point (in the upper left corner) has to be discarded. The resulting CMO file therefore has 11 point entries:

30	0	0
60	0	0
90	0	0
0	30	0
30	30	0
60	30	0
90	30	0
0	60	0
30	60	0
60	60	0
90	60	0

Noncoplanar Calibration Model Data File

Consider a cube-like calibration frame, built of 36 balls, having 3 planes of 4x3 grid structures as outlined in the picture below:

Each ball's center is 1 m away from its neighbor in all 3 (x,y,z) directions. For example the diameter of a ball is 56.6 mm, so each center point is 28.3 mm above its lower border. If we want to define the coordinate origin in the lower left frontal corner of the basement, the CMO entries must be like this:



0	-2028.3	2000
1000	-2028.3	2000
2000	-2028.3	2000
3000	-2028.3	2000
0	-2028.3	1000
1000	-2028.3	1000
2000	-2028.3	1000
3000	-2028.3	1000
0	-2028.3	0
1000	-2028.3	0
2000	-2028.3	0
3000	-2028.3	0
0	-1028.3	2000
1000	-1028.3	2000
2000	-1028.3	2000
3000	-1028.3	2000
0	-1028.3	1000
1000	-1028.3	1000
2000	-1028.3	1000
3000	-1028.3	1000
0	-1028.3	0
1000	-1028.3	0

2000	-1028.3	0
3000	-1028.3	0
0	-28.3	2000
1000	-28.3	2000
2000	-28.3	2000
3000	-28.3	2000
0	-28.3	1000
1000	-28.3	1000
2000	-28.3	1000
3000	-28.3	1000
0	-28.3	0
1000	-28.3	0
2000	-28.3	0
3000	-28.3	0

The single lines have been built from left to right, from the plane most far away to the nearest plane and top to bottom. So the first line represents the most distant point in the upper left corner; the next one is its right neighbor, etc. Because of the right-handed coordinate system, z-planes behind the origin must be positive (positive x to the right, positive y down, implies positive z). Note that an offset of 28.3 mm has been added to all y-values, because of the ball's radius (we want to use the center of the balls as calibration points).

If we wanted to define the model's origin in the upper left frontal corner, translating it so that the basement will have a y-value of 2 meters, the CMO file must look like:

0	1971.7	2000
1000	1971.7	2000
2000	1971.7	2000
3000	1971.7	2000
0	1971.7	1000
1000	1971.7	1000
2000	1971.7	1000
3000	1971.7	1000
0	1971.7	0
1000	1971.7	0
2000	1971.7	0
3000	1971.7	0

0	971.7	2000
1000	971.7	2000
2000	971.7	2000
3000	971.7	2000
0	971.7	1000
1000	971.7	1000
2000	971.7	1000
3000	971.7	1000
0	971.7	0
1000	971.7	0
2000	971.7	0
3000	971.7	0
0	-28.3	2000
1000	-28.3	2000
2000	-28.3	2000
3000	-28.3	2000
0	-28.3	1000
1000	-28.3	1000
2000	-28.3	1000
3000	-28.3	1000
0	-28.3	0
1000	-28.3	0
2000	-28.3	0
3000	-28.3	0

As calibration models are always dynamically built from top to bottom with smaller values at the top, the point in the first line (0,971.7,2000) defines the middle of the lowest ball in the left corner. Adding its radius the base will have a value of 2000 mm as intended.

Camera Hardware Parameter File

This text file with the extension CAM contains the hardware-specific intrinsic parameters for each camera. Its syntax should be self-explanatory. Here the contents of an example CAM file:

Ncx: 256.0 No. Horizontal Sensor elements (sel) in CCD array
 Nfx: 256.0 No. Horizontal Pixels in computer's frame buffer
 dx: 0.016 Horizontal distance b/w sensor elements centers (mm)

dy: 0.016 Vertical distance b/w sensor elements centers (mm)
Cx: 160.0 Image Center X-coordinate (pixels)
Cy: 130.0 Image Center Y-coordinate (pixels)
sx: 1.0 Grabbing uncertainty factor

These parameters are the so-called intrinsic parameters. Most of them are fixed for a certain kind of camera: N_{cx} , N_{fx} , dx and dy are specified in the technical manual for the camera in use. C_x and C_y are the image center, which, in the example above, are expected to be both 128. Doing optimized coplanar calibration gave the results used in the file. The last one, s_x , should be 1.0 by using a square-aspect CCD-camera. Nevertheless, by using noncoplanar calibration this parameter can be calibrated, too.

Note that even by using two cameras of the same type, you will probably need two different parameter files - C_x and C_y may vary a lot.

Reference: Roger Y. Tsai, "An Efficient and Accurate Camera Calibration Technique For 3D Machine Vision", IEEE Computer Society, Conference on Computer Vision and Pattern Recognition, Proceedings, p.364-374, 1986

9 Body Model Module

9.1 Introduction

Body models are mathematical constructions for example of the human body and its segments. They are particularly used in biomechanical research to simplify the analysis of movement. Those body models contain variables like weight and height of a body, centers of mass of the single body segments and the whole body and masses of the segments.

The module body models expands the functionality of **WINalyze**. From a model list (body model database) body models can be selected, which after adjusting them, are copied to an image sequence in **WINalyze**. You can also define your own body models, add them to the database and apply them to your sequence.

On the basis of the body models movement in the image sequences is analyzed. In the analysis trajectories for the center of mass, the momentum/impulse, the force, the moment of momentum and the moment of torsion are calculated.

9.2 How to Work with Body Models

In the following we give a step-by-step procedure as an example how you can use the body model module in the program **WINalyze**.

1. After you have started **WINalyze** you open an image sequence with the **File/Load Image Sequence** or the **File/Load Multiple Image Sequence** command (described in the **WINalyze** manual).
2. You then select the **Objects/Body Model/Select Body Model** command to open the **Select a Body Model** dialog box. Here you can select between creating a new model, editing one of the models from the model list or editing a copy of one of the models of the model list. In this example we edit the copy of a model from the model list.
3. You select a body model from the list and press the **Duplicate** button.
4. The dialog box is opened, where you can now adjust the body model to suit your purposes. There are a lot of possibilities to adjust the properties of the body model, the objects and the segments. The different tabs of the **Properties** dialog box, where you can change the settings, are described in the paragraphs **9.3.5** to **9.3.7** of this manual.
5. When you have adjusted the body model, you close the **Edit Body Model** dialog box by using **OK**. Your changed body model is taken over in the model list.
6. When you leave the **Select a Body Model** dialog box with **OK**, the currently selected model in the list is copied to the current image sequence (into the current frame) in **WINalyze**.
7. In **WINalyze** you can now choose the **Objects/Body Model/Edit/Position** command to position the body model in the frame. In the **Model Positioning** dialog box you can once again edit the properties of the body model and its elements in the context menu (by using the right mouse button).

-
8. After the body model is positioned you close the **Model Positioning** dialog box with **OK** and the positioned objects are taken over into the image sequence in **WINalyze**. Now you track the objects in the sequence with the commands from the **Tracking** menu.
 9. From the **Analyze/New** submenus you can now select the coordinates for the analysis of your sequence. In the **Centers of Mass** submenu you can choose between the position, velocity and acceleration in horizontal and vertical direction also for depth and the resulting velocity and acceleration. In the **Forces and Moments** submenu you can optionally select the impulse, force, the moment of momentum and the moment of torsion of the centers of mass for the three directions and in each case its resulting magnitude.

9.3 Commands Referring to the Body Models

9.3.1 Image Sequences/Object Display/Centers of Mass Command

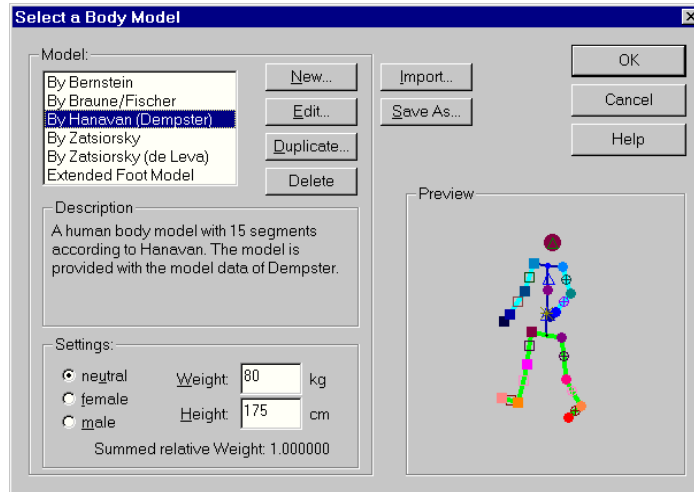
With the **Object Display/Centers of Mass** command you can choose a setting, where additional to the objects and connections/segments the centers of mass are displayed in the image sequence window.

The centers of mass of all segments as well as the center of mass of the whole body are displayed in the shape you have adjusted in the tabs (9.3.6 **Shape** Tab, 9.3.7 **CM-Mark** Tab) of the **Properties** dialog box.

9.3.2 Objects/Body Model/Select Body Model Command

After you selected the **Select Body Model** command, a dialog box opens, where you can select a body model, edit it or create a new model.

9.3.3 Select a Body Model Dialog Box



Model

In the list box all available body models are displayed and you can select a model by clicking it with the left mouse button or using the arrow keys to highlight one of the models.

Buttons

Next to the list box there are four buttons, with which you can edit, duplicate or delete the selected body model with, or even create a new body model with the **New** button.

After clicking the **New** button the **Edit Body Model** dialog box (described below) is opened, where you will be able to create a new body model.

Clicking the **Edit** button you also get to the **Edit Body Model** dialog box, where you can manipulate objects and segments of the selected body model.

With the **Duplicate** button a copy of the selected body model is

opened in the **Edit Body Model** dialog box, where you then can change the copy for your purposes.

The **Delete** button deletes the selected body model after a query. The deletion cannot be undone.

Description

Beneath the model list you find a description of the body model, which you have selected. (You can edit this description in the **Edit Body Model** dialog box)

Settings

Here the settings for the body model, which is selected in the model list, are shown. You can select between a **neutral**, **female** and **male** body model and edit the **Weight** and the **Height** for the model.

Beneath the options and the number boxes you see the **total relative weight**, which sums up the relative weights of all segments of the body model. It may differ in relation to the option you have selected in the **Settings**. The **total relative weight** may have a value lower than 1, because in some body models parts of the body for example hands are not considered.

Preview

On the right side you see a preview of the in each case selected model.

Import

With the **Import** button in the upper part of the dialog box you can open a file selector to select additional body model files. with this you can to add body models to the default body model list.

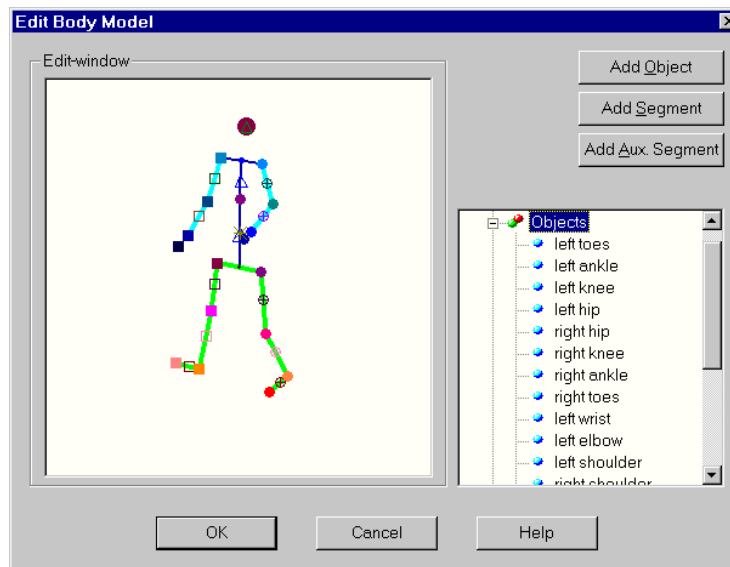
You can Import .bmd files (body model database) and .abm files (body model files from WINanalyze).

OK

When you leave the **Select a Body Model** dialog box with **OK**, the selected body model is tranfered to the current image sequence in WINanalyze. The objects of the body model are set/displayed in the current frame in the active image sequence window, where in the next step you can set them to the correct position with the **Objects/Body Model/Edit/Position** command.

9.3.4 Edit Body Model Dialog Box

In the **Edit Body Model** dialog box you can edit a body model (original model or a copy of it) or create a new body model.



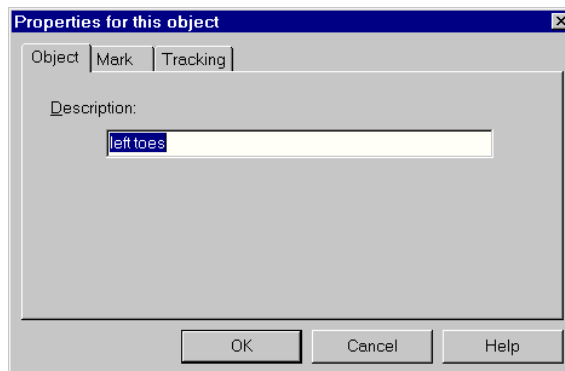
Add Object

With the **Add Object** button you can add an object to your body model. After you have clicked on this button the **Properties of this Object** dialog box is opened.

9.3.5 Properties of this Object Dialog Box

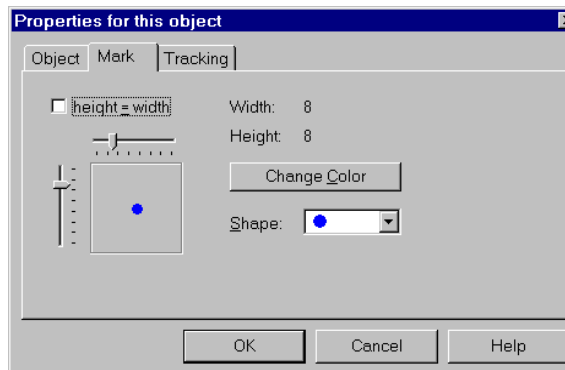
This dialog box contains three tabs:

Object Tab



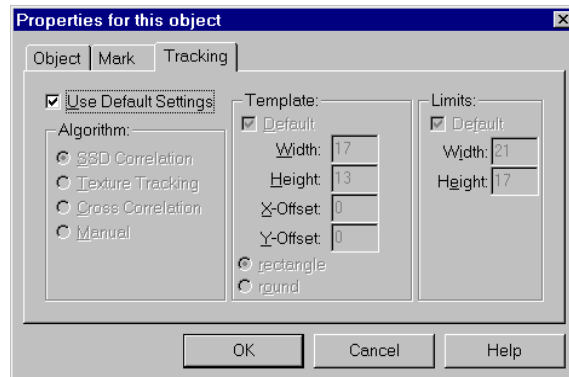
On the **Object** tab you can type a **Description** (name) for the object. Mark Tab

Mark Tab



On the **Mark** tab you can select the size, the colour and the shape of the object.

Tracking Tab



the Tracking tab you can preset the objects properties for the later tracking process in WINanalyze.

By default the general **Use Default Settings** check box is checked, so that all settings are taken over from the **WINanalyze** objects presets. When you uncheck this check box, you can edit the settings for the **Algorithm**, the **Template** and the **Limits**. For the **Template** and **Limits** settings you can check or uncheck the **Use Default Settings** check box to transfer or not these values from **WINanalyze**. (For an explanation of tracking algorithms, templates and limits please consult the **WINanalyze** manual.)

After you have closed the **Properties of this Object** dialog box with **OK** the mouse pointer changes into an object. With this you can set this object to a position in the **Edit Window**.

Add Segment

After you have clicked the **Add Segment** button, the mouse pointer changes into a hand. You now move the pointer to an object, click on it with the left mouse button, draw the segment to the second object and click again.

The segments should always be drawn from the more proximal object (near to the trunk) to the more distal object (further away from the trunk), because the centers of mass always refer to the

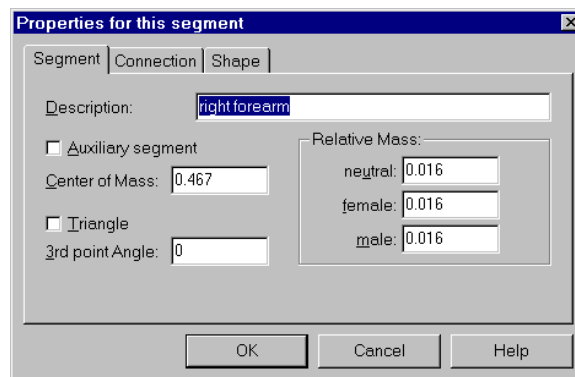
proximal objects.

After you have drawn the segment, the **Properties of this Segment** dialog box is opened, where you can adjust the settings for the segment just drawn.

9.3.6 Properties of this Segment Dialog Box

This dialog box contains three tabs:

Segment Tab



On the **Segment** tab you can type the **Description** (name) for the segment.

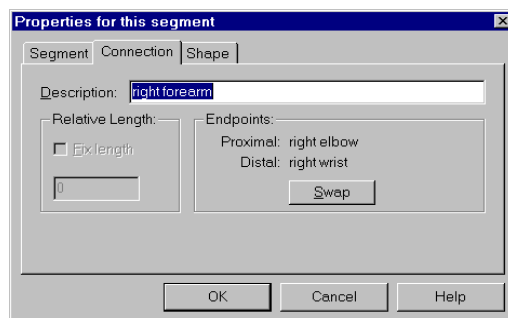
On the left side you find the **Auxiliary Segment** check box, which by default is unchecked. You can check this box, then the segment becomes an auxiliary segment. (Auxiliary segments are not taken into consideration in the final calculation of the center of mass of the body.)

Beneath you can enter a value for the **Center of Mass**. By default the value is 0.5 for a new segment, i.e. the center of mass is in the middle of the segment.

When you check the **Triangle** check box the segment is defined by a third point, which again is defined by its angle, so that the two endpoints of the segment build an isosceles triangle together with the third point. Enter the **3rd Point Angle** (enter the size of the

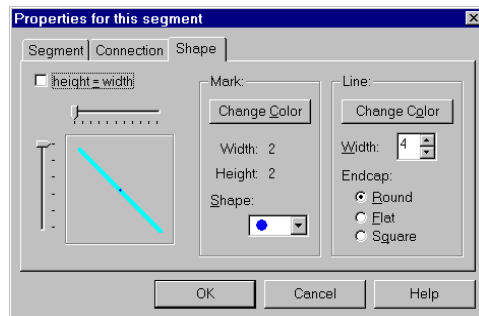
angle in grade) after having checked the **Triangle** check box. (This feature is used in the body model according to Zatsiorsky.) In the **Relative Mass** group on the right side of the tab you can enter the values for the relative mass of the segment. These values are processed separately for the **neutral**, **female** and **male** version of the body model.

Connection Tab



On the **Connection** tab you can again enter/edit the description of the segment. Under **Endpoints** the proximal and distal endpoint of the segment are displayed. You can exchange the points by clicking the **Swap** button. (Proximal here means more close to the trunk, distal means further away from the trunk.)

Shape Tab



On the left side of the tab you see a display of the currently selected shape of the segment and the center of mass of the segment, all marked on the segment. With the sliders you can adjust the size of the mark for the center of mass. When you check the check box next to **height = width**, the width will be automatically adapted to the height of the mark.

In the middle of the tab there is the **Mark** group, where you can change the colour of the center of mass mark and select a shape for the marker. Here also the height and width of the marker is displayed (pixel).

On the right side in the **Line** group you can adjust the **Linewidth**, the **Colour** and the form of the **Endcap** of the segment line.

Add Aux. Segment

With the **Add Aux. Segment** button you add an auxiliary segment to the body model.

This function is similar to the **Add Segment** function. It only differs in the default settings on the **Segment** tab of the **Properties** dialog box. Here by default the **Auxiliary Segment** check box is checked and therefore the **Relative Mass** number boxes are disabled.

Edit Window

In the **Edit Window** the selected body model is displayed and can be edited. In case of creating a new body model you set the objects and draw the segments in the **Edit Window**.

In the **Edit Window** you select objects or segments by clicking them with the left mouse button. You select a group of segments and objects by drawing a rectangle with the pressed down left mouse button. All objects and segments within this rectangle are selected. Holding down the SHIFT key and at the same time clicking an object/segment with the left mouse button you add this element to a selection, by holding down the CTRL key and clicking with the left mouse button you deselect objects/segments.

When you have selected an object, segment or a group of elements, you can see a surrounding rectangle with handles on the corners and also in the middle of each side. By dragging these handles with the left mouse button you can resize the selection. Holding down SHIFT and dragging you resize the selection proportionally. You

can move a selection by clicking into the selection (mouse pointer changes to a cross) and dragging it to a new position. As long as you hold the mouse button pressed down, you can undo the resizing or positioning by pressing the ESC key.

In the **Edit Window** there is a context menu available, which you can access by clicking the right mouse button in the window. In the context menu you can select the **Add Object**, **Add Segment** and the **Add Aux. Segment** command. When there are objects or segments selected and you open the context menu, there is also a **Delete** option. When you have already deleted objects/segments, an **Undelete** command available to you. A dialog box with different tabs already described, is opened by using the **Properties** command, found in the context menu. This is done dependably to the selected objects/segments. When nothing is selected, the **Properties** command of the context menu opens the **Properties for Body Model** dialog box (described below).

Folder Window

The **Folder Window** in the right part of the **Edit Body Model** dialog box contains the name of the body model with folders for objects, segments and auxiliary segments. You can expand and collapse the folders by clicking the +/- sign in front of the folders. (When there is no + sign in front of a folder, this folder contains no elements.)

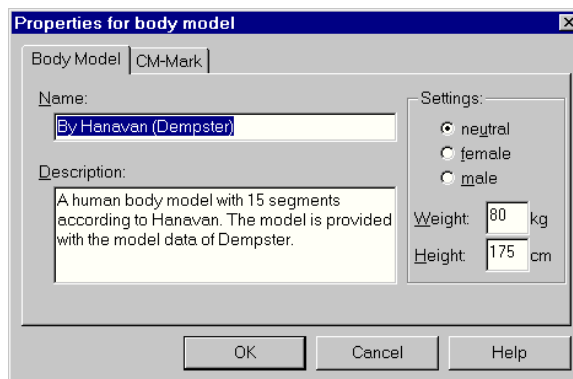
In the **Folder Window** you can also work with context menus:

You can select the body model and then open the context menu with the right mouse button. The context menu contains an **Undelete** command and a **Properties** command. The **Properties** command leads to the **Properties for Body Model** dialog box.

9.3.7 Properties for Body Model Dialog Box

The Properties for Body Model dialog box contains two tabs: the **Body Model** tab and the **CM Mark** tab.

Body Model

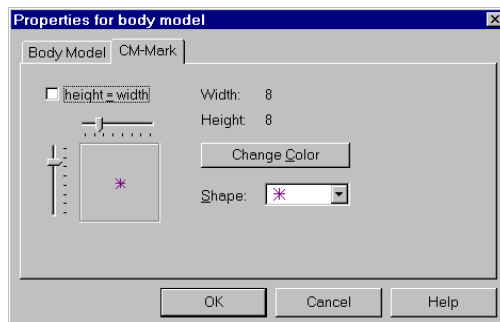


Under **Name** you see the name of the body model. This you can edit it so as to rename the model.

Under **Description** you see the description of the body model, which can also be edited.

In the **Settings** group you select between a **neutral**, **female** and **male** version of the body model and can in each case edit the **Weight** and the **Height**.

CM-Mark



The **CM-Mark** tab refers to the mark for the center of mass of the whole body.

With the sliders you can adjust the height and the width of the marker,

when you check the **height = width** check box the width and height are resized to the same values.

On the tab you can also change the **Colour** and select a **Shape** for the marker.

When you select a folder in the **Folder Window** and access the context menu with the right mouse button, you will find commands to add the respective element, to undelete and to open the **Properties** dialog box, which then refers to all elements of the selected folder.

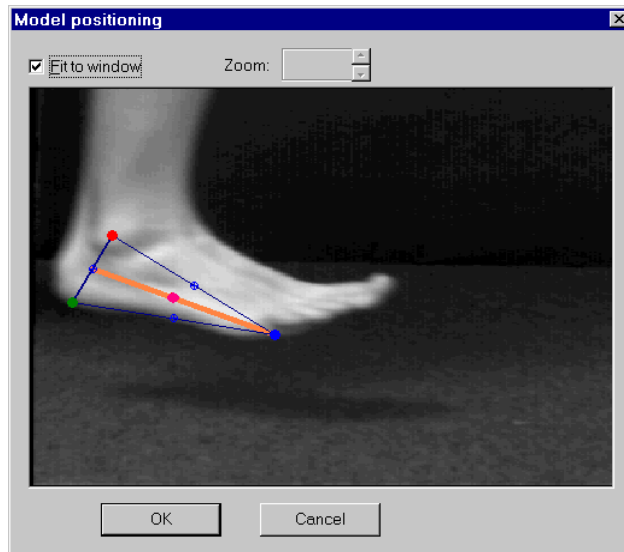
When you select one object and open the context menu, you can select the commands **Move**, **Undelete**, **Delete** or **Properties**. The **Move** command makes the mouse pointer jump to the **Edit Window**, where you can set the object anew.

The context menu for the single segments contains the commands **Undelete**, **Delete**, **Connect to** and **Properties**. With the **Connect to** command you can connect a segment (its center of mass) with any other segment or object. After you have selected the command, the mouse pointer jumps to the **Edit Window**, where you then proceed analogous to using the **Add Segment** function.

9.4.1 Objects/Body Model/Edit/Position Command

After you selected the **Body Model/Edit/Position** command the **Model Positioning** dialog box is opened, where you can position the objects of the body model in the respective frame of the current image sequence.

9.4 Model Positioning Dialog Box



Fit to Window

Checking or unchecking the **Fit to Window** check box you can decide, whether the image shall fit into the window or not. By default the check box is checked.

Zoom

When the **Fit to Window** check box is unchecked, a **Zoom** function is available, by which you can zoom into and out of the image.

Positioning Window

In the **Positioning Window** you can position the objects in the frame of your image sequence. To set them to a new position drag them with the pressed down left mouse button.

You can also select a group of segments and objects by drawing a rectangle with the pressed left mouse button. All objects and

segments within this rectangle are then selected. Holding down SHIFT and dragging you are able to resize the selection proportionally. You can move a selection by clicking onto the selection (the mouse pointer changes to a cross) and dragging it to a new position. As long as you hold the mouse button pressed down, you can undo the resizing or positioning by pressing the ESC key. Here also a context menu is available via the right mouse button. This menu contains the **Properties** command, which in dependence of the currently selected elements opens the **Properties** dialog box with different tabs. The dialog box may contain the tabs **Object**, **Mark**, **Tracking**, **Segment**, **Connection**, **Shape**, **Body Model** and **CM-Mark**. (The tabs are described above.)

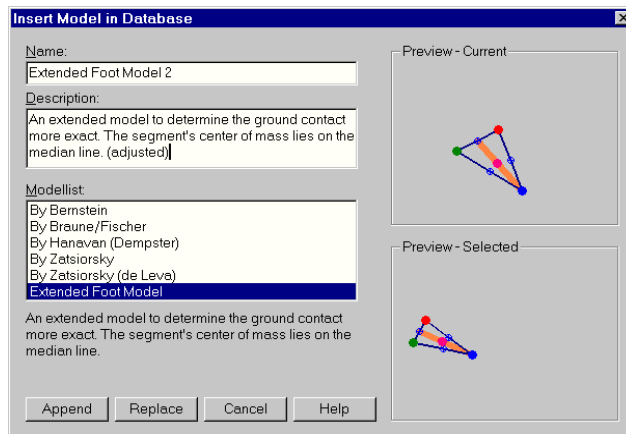
OK

When you leave the **Model Positioning** dialog box with **OK** the positioned objects are taken over into the image sequence window in **WINalyze**.

9.5 Objects/Body Model/Insert in List Command

After you have selected the **Body Model/Insert in List** command, the **Insert Model in Database** dialog box is opened, where you can insert the current body model of **WINalyze** into the default list of all body models.

9.5.1 Insert Model in Database Dialog Box



Name

In the text box under **Name** you are able to see the current name of the body model in **WINalyze**. You can edit the text box to rename the body model.

Description

In the **Description** box you can see the description of the above named body model. The description can also be edited.

Next to the **Name** and **Description** box you are given a **Preview** of the body model referred to.

Modellist

Under **Modellist** there is a list of all available body models. Beneath the modellist the description of the currently selected body model is displayed. Next to the list you see a **Preview** of the model currently selected in the list.

Append

With the **Append** button you append the body model (with the above given name and description) to the list of all available body models. The body model is taken over as it currently is configured in

WINalyze. After that the dialog box is closed.

Replace

With the **Replace** button the body model (with the above given name and description) is also taken over to the list of all available body models, but it replaces the currently selected body model in the **Modellist**. After that the dialog box is closed.

9.6 Objects/Body Model/Delete Command

With the **Body Model/Delete** command you can delete a body model from the current image sequence in **WINalyze**. This command is therefore only available, when there is a body model in the current image sequence.

After you have selected the **Body Model/Delete** command, the body model and all objects belonging to it are deleted from the image sequence after answering a query. Notice that this deletion can not be made undone.

9.7 Analyze/New/Centers of Mass Submenu

In the **Analyze/Centers of Mass** Submenu you can select the coordinates for the calculation of the trajectories for the position, velocity and acceleration of the centers of mass. (Also see the Appendix: Calculating Analysis). The following analysis possibilities are available:

x to t	x position of the centers of mass in relation to time
x' to t	velocity of the centers of mass in horizontal direction
x'' to t	acceleration of the centers of mass in horizontal direction

y to t	y position of the centers of mass in relation to time
y' to t	velocity of the centers of mass in vertical direction
y'' to t	acceleration of the centers of mass in vertical direction
z to t	z position of the centers of mass in relation to time
z' to t	velocity of the centers of mass in depth direction
z'' to t	acceleration of the centers of mass in depth direction
r' to t	resulting velocity of the centers of mass
r'' to t	absolute resulting velocity of the centers of mass
$r ''$ to t	resulting acceleration of the centers of mass
$r ''$ to t	absolute resulting acceleration of the centers of mass

9.8 Analyze/New/Forces and Moments Submenu

In the **Analyze/New/Forces and Moments** submenu you can select the coordinates for the position and the magnitude of impulse, force, moment of momentum and moment of torsion. (Also see the Appendix: Calculating Analysis)

Impulse x to t	x-coordinate of the vector of the impulse to time
Impulse y to t	y-coordinate of the vector of the impulse to time
Impulse z to t	z-coordinate of the vector of the impulse to time
 Impulse to t	magnitude of the impulse to time
Force x to t	x-coordinate of the vector of the force to time
Force y to t	y-coordinate of the vector of the force to time
Force z to t	z-coordinate of the vector of the force to time
 Force to t	magnitude of the force to time
Moment of Momentum x to t	x-coordinate of the vector for the moment of momentum to

10 Calculating Analyses

In the following page a short description is given on how the values and trajectories in the analyses of the program WINanalyze are calculated.

10.1 Origin of Original Coordinates

The origin for the x-, y-, and z-coordinates are taken from the calibration model used in calibrating the sequence. This applies to all 2D and 3D image sequences that are calibrated with an calibration model (.CMO file). The coordinate-system is always right-handed. Here the *Windows/Origin/Units* command only affects the display of the analysis window, Except when the sequence is calibrated by Linear Sizing.

Then the origin is defined by what has been adjusted in the *Origin/Units* command and the size of the coordinate-system depends on the size of the frames of the image sequence.

10.2 Calculation of Analyses by the Analyze/New Command

Centers of Mass Submenu

By the help of the original coordinates and the body model the centers of mass are calculated (segment centers of mass and body center of mass).

The values for x' , y' and z' are calculated on the values for the centers of mass. The first derivative is calculated according to Savitzky/Golay with a kernel of 5. Therefore the first derivative for the first and last two frames of the sequence can not be calculated. The second derivatives (x'' , y'' and z'') are also calculated directly on the values for the centers of mass according to Savitzky/Golay. Here a kernel of value 7 is taken, so that the second derivative can not be calculated for the first and the last three frames of the sequence.

The resulting velocity and acceleration are calculated by first calculating the magnitude of the vector and then computing the first respectively second derivative according to Savitzky/Golay. The absolute resulting velocity and acceleration are calculated by first computing the first respectively second derivative for the x-, y- and z-coordinates according to Savitzky/Golay and then by calculating the magnitude of the vector.

Forces and Moments Submenu

The units are independent from the settings adjusted with the Origin/Units command.

Impulse

The impulse **p** is computed by $\mathbf{p} = m * \mathbf{v}$. The unit for the impulse is Ns (Newton seconds).

The magnitude **|p|** of the impulse is calculated by first building the derivative according to Savitzky/Golay and then computing the magnitude of the impulse vector.

Force

The force **F** is computed by $\mathbf{F} = m * \mathbf{a}$. The Unit is N (Newton). The magnitude is **|F|**.

Moment of Momentum

The moment of momentum **L** is calculated by $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ (**r** = radius vector). The unit is Nms (Newton meter seconds). The magnitude is **|L|**.

Moment of Torsion

The moment of torsion **M** is calculated by $\mathbf{M} = \mathbf{r} \times \mathbf{F}$ (**r** = radius vector). The unit is Nm (Newton meter). The magnitude is **|M|**.

Reference: Savitzky, A. and Golay, J., "Smoothing and Differentiation of Data by Simplified Least Square Procedure", Analytical Chemistry 36 (1964)

11 Index

Symbole

2D calibration 60

3D calibration 57

A

About command 95

acceleration

 changes of angles 82

 changes of angles (frontal plane projection) 82

 changes of angles (sagital plane projection) 82

 changes of angles (transversal plane projection) 82

 changes of connections 82

 depth 81

 horizontal 81

 resulting 81

 vertical 81

Adjust Sequences command 32

Adjust Sequences submenu 84

Ambiguous Parameters dialog box 43

analysis

 adjusting 84

 adjusting data 32

 approximation 84

 coordinates 33

 curve style 90

 data 80, 81

 data exporting 85

 data importing 85

 decimal places 89

 display styles 33, 89

 exporting data 33

 fit in frame 90

 fonts 34, 91

 generating 80, 81

 grid 90

 importing data 33

- interpolation 84
- sizing 90
- smoothing 84
- windows 17, 32
- Analyze/Enable Reticules command 34
- Analyze/New/Centers of Mass Submenu 146
- Analyze/New/Forces and Moments Submenu 148
- angles
 - creating 30, 65
 - deleting 31, 66
 - displaying 62
 - editing 65
 - switching between 31, 66
- approximation 32, 84, 103
- Arrange Icons command 92
- Arrange Symbols 61
- AVI 22, 23, 26, 42, 55, 108

B

- BLD 22, 23, 26, 42, 55, 107
- Body models 127
 - import 133
- Buttons 15
- buttons 14

C

- Calculating Analyses 115
- Calculation of Analyses by the Analyze/New 149
- calibration
 - files 41, 55
 - model 27
 - points 25, 27
 - window 25, 26, 55
- Calibration command 25, 26, 55
- calibration models 119
- CAM 26, 42, 55, 111, 120
- camera calibration 116
- cancelling tracking 80
- Cascade command 92

CDC 26, 42, 55, 109
Center of Mass 137
Centers of Mass 130
Centers of Mass Submenu 149
changes of angles 82
 acceleration 82
 acceleration (frontal plane projection) 82
 acceleration (sagittal plane projection) 82
 acceleration (transversal plane projection) 82
 frontal plane projection 82
 sagittal plane projection 82
 transversal plane projection 82
 velocity 82
 velocity (frontal plane projection) 82
 velocity (sagittal plane projection) 82
 velocity (transversal plane projection) 82
changes of connections 81
 acceleration 82
 velocity 82
Close All command 92
Close command 44
CMO 26, 42, 55, 111, 120, 121
color reduction 40, 103
colors
 connections 65
 object sequences 70, 72, 77
 objects 63, 77
 tracking 102
connections
 colors 30, 65
 creating 29
 deleting 30, 65
 displaying 62
 editing 65
Connections and Angles dialog box 30, 65
Contents command 95
Context Help command 95
context menus 17
Contrast Enhancement 51
Coordinate (Ordinate) dialog box 88

Coordinates command 33, 88
coordinates, ordinate 88
Coplanar Calibration Model 121
coplanar calibration models 119
copyright 95
creating
 angles 30, 65
 connections 29
Cross-Correlation 103
curve style 90

D

DAQ 85, 114
DAQ and DQS Format 113
DAQ file 114
date 66
decimal places 89
Delete Imported Data command 85
Delete Object command 69
Delete Object Sequence command 67
deleting
 angles 31, 66
 connections 30, 65
 object sequences 67, 72
 objects 69
depth
 acceleration 81
 position 81
 velocity 81
dialog boxes 17, 129
 Ambiguous Parameters 43
 Connections and Angles 30, 65
 Coordinates (Ordinate) 88
 Display Style of all Curves 89
 Edit Body Model 129, 134
 Edit Object Sequence 69
 Export Object Sequences 74
 Files of the Document 23, 54, 59
 Filtering the Sequence 24, 51
 Frames per Second 43

Gamma Correction 24, 53
Insert Model in Database 145
Model Positioning 129, 143
Object Editor 71
Object Sequence Version 73
Objects 63
Open Image Sequence 22, 23, 37
Origin and Units of Coordinates 94
Page Setup 47
Polynom Approximation 84
Predefined Object Colors 78
Presettings for Object Sequences 77
Print 46
Print Page Setup 45
Properties for Body Model 140
Properties of this Object 134
Properties of this Segment 137
Recover Object Sequence 68
Select a Body Model 129
Templates 64
Text Format Settings 76, 87
Dilatation filter 52
Display command 33, 89
Display Style of All Curves dialog box 89
displaying
 angles and connections 62
 connections 62
 current objects 61
 objects of all frames 61
Document Files command 54
DQS 114
DSC 108

E

Edit Body Model 133
Edit Object Sequence command 69
Edit Object Sequence dialog box 69
editing
 angles 65
 connections 65

- object sequences 69, 71
- Enable/Disable Reticules command 90
- Enable/Disable Showing Frame Numbers command 91
- Endcap 139
- ending program 13, 48
- Ending WINalyze 13
- Endpoints 138
- Erosion filter 52
- Exit command 13, 48
- exit program 13, 48
- Export Analysis Data command 85
- Export command 74
- Export Object Sequences dialog box 74
- exporting
 - analysis data 85
 - object sequences 74
 - text format 75

F

- female 138, 141
- Files of the Document dialog box 23, 54, 59
- filter 24, 50, 100
- Filter command 24, 50
- Filtering the Sequence dialog box 24, 51
- First Frame command 50
- fonts for analysis 91
- Force 150
- Forces and Moments Submenu 150
- frame numbers 19, 91
 - disabling 91
 - enabling 91
- Frames per Second dialog box 43

G

- gamma correction 24, 52, 103
- Gamma Correction command 24, 52
- Gamma Correction dialog box 24, 53
- generating analysis 80, 81
- glossary 103

graphics adapter 11
Gray Scale Stretch 51
grid 90

H

half frame 39
hardware 11
Hardware: 11
help contents 95
High Pass filter 51
horizontal
 acceleration 81
 velocity 80
How to Use Help command 95

I

image sequences
 calibrating 25, 26
 closing 44
 filter 50
 going to first frame 50
 going to last frame 50
 going to next frame 49
 going to previous frame 49
 loading 22, 23, 37
 manipulating 24
 multiple 23
 opening 22, 23, 37
 playing 25, 48, 98
 preprocessing 24
 single 22, 37
 stopping 49
 windows 16
Image Sequences/Object Display/Centers of Mass Com 131
Import 133
Import Analysis Data command 85
Import command 73
importing
 analysis data 85

object sequences 74
Impulse 150
Info command 66
information
 menu commands 18
Insert Reticules (Old Position) command 34, 91
interpolation 32, 84, 104
introduction 11

K

keyboard 14, 19

L

Last Frame command 50
Layout submenu 61
leaving set object mode 29
limits 63, 70, 78, 100
Load Image Sequence Command 37
Load Image Sequence command 22
Load Multiple Image Sequence command 23
Load Multiple Image Sequences command 40
Low Pass filter 51

M

male 138, 141
markers 70, 78, 101
Median Cut 40, 104
Median filter 52
menus 14
Moment of Momentum 150
Moment of Torsion 150
MOP-16 filter 52
MOP-24 filter 52
MOP-8 filter 52
mouse pointer 19
multiple image sequences 23

N

N?? 112

neutral 138, 141
New Object Sequence command 67, 71
New Object sequence command 29
New/Connections submenu 32, 81
New/Sequences submenu 32, 80
Next Frame command 49
Noncoplanar Calibration Model 122
noncoplanar calibration models 119

O

Object Display/Angles and Connections command 62
Object Display/Connections and Angles command 29
Object Display/Connections command 29, 62
Object Display/Objects of All Frames command 61
Object Display/Only Current Objects command 61
Object Editor command 71
Object Editor dialog box 71
Object Sequence Version dialog box 73
object sequences
 colors 70, 72, 77
 deleting 67, 72
 editing 69, 71
 exporting 74
 importing 74
 loading 73
 new 29, 67
 presettings 76
 recovering 68
 saving 72
 undeleting 68
objects
 colors 63, 77
 deleting 69
 displaying 61
 leaving frame borders 98
 loading 73
 presettings 76
 saving 72
 setting 68
 tracking 31, 97

Objects dialog box 63
Objects/Body Model/Delete Command 146
Objects/Body Model/Edit/Position Command 142
Objects/Body Model/Insert in List Command 144
Objects/Body Model/Select Body Model Command 131
Objects/Load command 73
Objects/Save as New command 72
Objects/Save command 72
Odd/Even 39
One Frame Backward command 80
One Frame Forward command 79
Open Image Sequence dialog box 22, 23, 37
ordinate
 coordinates 88
origin 94
Origin and Units of Coordinates dialog box 94
Origin/Units command 94
OS 111

P

P?? 74, 112
page setup 44
Page Setup dialog box 47
Play command 25, 48
playing image sequences 25, 48, 98
Polynom Approximation dialog box 84
Popularity Algorithm 40, 104
position
 depth 81
 frame number box 91
 reticule box 91
 vertical 81
Position Data Left/Right command 91
Predefined Object Colors dialog box 78
Presetting command 76
Presettings for Object Sequences dialog box 77
Previous Frame command 49
Prewitt filter 51
Print command 46
Print dialog box 46

- Print Page Setup command 35, 44
- Print Page Setup dialog box 45
- print preview 46
- Printer Setup command 47
- printing 35, 44, 46
 - page setup 44
 - preview 46
- problems in object tracking 99
- program
 - ending 13, 48
 - exit 13, 48
 - starting 13

R

- Recover Object Sequence dialog box 68
- recovering object sequences 68
- reference points 99
- Relative Mass 138
- Requirements 11
- requirements 11
- reticules
 - disabling 34, 90
 - enabling 34, 90
 - old position 34, 91
 - position 34, 90
- Robert's Cross filter 51
- RSC 22, 23, 107

S

- Select a Body Model Dialog Box 132
- Select Fonts command 34, 91
- Set Fit command 35, 93
- Set Object command 68, 71
- setting
 - new object sequences 29, 67
 - objects 68
- shortcuts 19
- Show Dialogs command 29, 62
- single image sequences 22, 37

single tracking 101
sizing of analysis 90
Smart Object Position command 29, 67, 68, 70
Smart Tile command 92
smoothing 32, 84, 104
Sobel filter 51
software 11
SSD-Correlation 31, 105
starting program 13
Starting WINalyze 13
stick figure 81, 83
Stop command 25, 49
switching between angles 31, 66
system menu 14

T

templates 64, 77, 99, 105
Templates dialog box 64
text format 75, 87
Text Format Settings dialog box 76, 87
Texture Tracking 105
Tile command 92
To Sequence Begin command 80
To Sequence End command 79
tracking
 algorithm 31, 63, 70, 78, 101
 cancelling 32, 80
 colors 102
 objects 31, 97
 one frame backward 80
 one frame forward 79
 single 101
 to sequence end 79, 80
Triangle 138
trigger 66

U

U?? 86, 113
Undelete command 68

undeleting object sequences 68
units 94

V

velocity

- changes of angles 82
- changes of angles (frontal plane projection) 82
- changes of angles (sagittal plane projection) 82
- changes of angles (transversal plane projection) 82
- changes of connections 82
- depth 81
- horizontal 80
- resulting 81
- vertical 81

version number 95

vertical

- acceleration 81
- position 81
- velocity 81

W

windows 16, 17

- printing 35
- setting fit 35, 93
- zooming in 35, 93
- zooming out 35, 93

Z

Zoom command 61

Zoom In command 35, 93

Zoom Out command 35, 93
