ivTrace User manual

ivTrace User manual

Elke Braun & Jens Peter Lindemann
Center of Excellence Cognitive Interaction Technology
Bielefeld University
May 2, 2011

Contents

1 The ivTrace package **1**

2 Getting ivTrace **1**

2.1 Installation . . . 1

3 Introduction to ivTrace **1**

3.1 Starting the program . . . 1

3.2 Description of Usage and Results . . . 1

4 Handling Image Sequences **2**

4.1 Input image data formats currently supported by 'ivTrace' . . . 2

4.2 Open a sequence . . . 2

4.2.1 Frame contents: Full-frame or interlaced? . . . 2

4.2.2 Open TIFF-sequence . . . 2

4.2.3 Open other image data . . . 3

4.3 Save Images . . . 3

4.4 Inspecting the Image Sequence . . . 3

5 Working Interactively with the Image Data **3**

5.1 Working Space . . . 3

5.2 Inspection and Restriction of the Working Space . . . 3

5.3 Navigation within the Image Sequence . . . 4

5.4 Displaying Modes of Region Objects and Zoom . . . 4

6 Background Compensation **4**

6.1 Threshold Map Generated from Background Image . . . 4

7 Processing of Individual Images **4**

8 Using template matching for detecting interesting areas **5**

8.1 Creating templates . . . 5

8.2 Template display window . . . 6

9 Scripting and Automatic Sequence Processing **6**

10 Generating and Correcting Region Objects **7**

10.1 Detection of Region Objects . . . 7

10.2 Postprocessing Corrections . . . 7

11 Trace of Region Data **8**

11.1 Trace sorting . . . 8

12 Working in 3d 9

13 Output Data Formats 9

13.1 2D Results 9

13.2 3D Results 10

14 ivTBatch: Non-interactive Commandline Tool Extending 'ivTrace' 10

15 ivTCompressionTools: Custom Made Image Compression 10

1 The ivTrace package

For the detailed analysis of the flight behaviour of insects, the flight trajectories and perhaps deviating viewing direction have to be reconstructed from experimental data. To resolve rapid flight manoeuvres, high frame rates are required, leading to large amounts of raw image data. Manual evaluation of these data is virtually impossible for the large numbers of experiments needed for statistical analysis.

The image processing component of the program IvTrace locates prominent regions, for example representing animals, in each frame in front of an arbitrary, but invariant, background and calculates 2D-position and -orientation individually for each image. If more than one prominent region is identified, there are tools available for automatically separating the traces by identifying the region in the current image that is most likely the successor of a given region in the previous frame. The user interface of the tool is designed to make manual inspection and correction of the automatically generated proposals easy. In order to manually create or visualize 3d trajectories (translation and rotation) the linux version of 'ivTrace' provides tools for handling 3d data.

Additional to the interactive tool the command line tool IvtBatch does the calculations for several image sequences without the need of user interactions. Calculations base on description files that can be conveniently created by 'ivTrace'

For compression of video data we developed a customized compression format that can be directly imported with 'ivTrace'. Use the IvtCompressionTools ivTArchive and ivtDecode to compress/decompress the image data.

2 Getting ivTrace

ivTrace is a component of the free insect vision tools software project available for download at http://opensource.cit-ec.de/projects/ivtool

2.1 Installation

Linux users currently have to build the package from source (for a desciption of the build process see the README from the source directory).

For Windows a precompiled version is available. To install this, unzip the archive to a new subfolder in your program-files folder. Afterwards your can start ivTrace.exe by double-click. Currently there is no automatic installer available, links in the Start-menu or on the Desktop have to be created by hand. See the README in the installation directory for details.

3 Introduction to ivTrace

3.1 Starting the program

Starting the program 'ivTrace' without any command line options opens the main window of the program. Then you may load the image data of one sequence, s. ImageSequence for more details of supported image formats. Giving the image data on the command line directly opens it with start. The number of views to be processed simultaneously is per default 1, may be set to nbViews by the commandline: -n <nbViews> or is determined by the number of image data sequences given.

3.2 Description of Usage and Results

- ImageSequence
- UserInterface
- BackgroundCompensation
- ImageProcessing
- TemplateMatching
- ScriptedImageProcessing

- RegionObjects
- RegionTrace
- WorkingIn3d
- ResultsFormat

4 Handling Image Sequences

4.1 Input image data formats currently supported by 'ivTrace'

- Series of uncompressed grayscale TIFF-images and JPEG-images (Can just be loaded interactively, not possible via command line)
- List file (ascii) containing the file names of the TIFF images to be opened
- Sequence file describing a sequence of TIFF images, special ascii file format delivered by 'Optronis' highspeed camera software
- Uncompressed grayscale AVI-files.
- Compressed image data in customized format, for details s. IvtCompressionTools

4.2 Open a sequence

Image data is loaded either while starting the program, if image sequence information is given as command line option or it is done interactively after the graphical user interface has initialized. Open your image sequence by selecting the corresponding entry from the menu 'ImgSeq/'. As default image data is expected to contain full frame data. If this is not the case choose a suitable 'FrameContent/' before loading the image data.

4.2.1 Frame contents: Full-frame or interlaced?

The default for most cameras nowadays is producing full frame images and therefore this is also default for 'ivTrace'. But there may be cameras delivering 'interlaced' frames consisting of two fields: The odd lines in the image form one field, the even lines form the second field. Most cameras acquire these fields at different times, so that a fast moving object will look strangely distorted (comb-like structures instead of vertical lines).

'ivTrace' can take care of this situation, if you select the appropriate entry within the 'ImgSeq/FrameContent/' menu before loading the sequence. After selection of 'ImgSeq/FrameContent/Field', the fields are treated as independent images. This doubles the number of images and the frame rate of the movie. For reconstructing the original ratio between width and height of the image contents each line of each field may be doubled using ImgSeq/FrameContent/Duplicate Fields', which doubles the amount of original image data.

4.2.2 Open TIFF-sequence

- 'ImgSeq/Open SEQ' pops up a browser window where you can define a sequence of TIFF-images to be opened. You can navigate in your filesystem by clicking on directory entries in the left half of the window. (**Windows drive letters are poorly supported in the current version: To change to a different drive you have to enter the drive letter manually. The navigation by click works again, as soon as you enter a valid drive letter and a backslash. This means you have to enter something like 'C:\'.**)

- Mark one or more files in the left part of the window. To mark a sequence, mark the first file by clicking on it's name, then scroll down and mark the name of the last file by clicking with the right mouse button. Now the entire sequence is marked.
- Add the marked files to the list (right part of the window) by clicking on the arrow.

- The 'clear'-Button clears the right part of the window,the 'step'-Counter changes the behaviour of the marking algorithm when you press the right button. If you select '3' as 'step', every third file gets marked. By holding down 'SHIFT', you can also select more than one file.
- For reducing the number of files to be selected from, special file endings may be used as filters (default: *.* means all files).

4.2.3 Open other image data

- Select the appropriate entry from the 'ImgSeq/' menu and select the file to be loaded.

4.3 Save Images

By selecting the 'ImgSeq/Save frame' menu item the current frame is saved as a TIFF file, after selecting the location by a file browser window.

4.4 Inspecting the Image Sequence

is described in UserInterface

5 Working Interactively with the Image Data

5.1 Working Space

The main part of the main windows serves for displaying the currently available information. This is

1. Image sequence, original data or, dependent on the image processing applied, intermediate image data or final region results
2. Background image and threshold image
3. Trace of regions for the current sequence displayed as a whole together with the background.

For controlling these different modes of display four toggled buttons called 'ImgSeq', 'Back', 'ThresMap' and 'Trace' are located just above the image data display.

If the image is too large for the window, sliders are introduced at the right and bottom of the displaying area. Besides clicking the sliders the displayed part of the image can be changed by the arrow buttons of the keyboard.

5.2 Inspection and Restriction of the Working Space

For inspecting parts of the image displayed within the working space more closely a **zoom display** can be opened by holding down the 'ctrl' button of the keyboard and marking an image area by left-clicking at one corner of the area and holding down the mouse button while moving to the opposite corner of the area. The zoom area is displayed within a separate window, the default zooming factor is three. By changing the size of the zoom window using the window manager facilities zoom factors in horizontal and vertical directions are automatically adapted for the zoom area filling the zoom window. The zoom area cannot be moved within the image so far, but has to be redefined as decribed above, if necessary.

Clicking the middle mouse button over the working space or the zoom window results in displaying the **grayvalue and position** of the clicked pixel. Holding the <ctrl> button down by clicking the middle button, releasing, and clicking again at a second location displays the **distance between the two pixels** within the image.

For restricting the ImageProcessing and thereby the location of resulting RegionObjects within the image a **region of interest** can be defined. The region of interest is defined as a closed polygon which corner points are given by holding down the 'shift' button and left-click at the wanted positions. The polygon is closed (last point connected to first point resulting in a closed area)

by holding the 'shift' button and giving a right-click. By <shift> middle-click the points defined so far are cleared. Once you have defined a region of interest you may save and again load it in order to provide this information to the IvtBatch tool by using the appropriate entries within the 'Roi' menu. Besides the definition of the region of interest by mouse clicks it can also be defined from region object data using its surface or its bounding box using the appropriate entries within the 'Roi' menu. Firstly detected regions may serve as regions of interest for following processing steps that otherwise would take too much computational effort or would deliver too many results.

5.3 Navigation within the Image Sequence

The navigation within the image sequence is done by the control panel at the bottom of the main window. It allows the sequential display of the images using the 'play' button and stopping the playing at an arbitrary position. Besides this, steps to the previous, next, first, or last image is supported. and directly accessing individual image numbers via the number input is possible. The hotkey 'f' is available for displaying the next image, hotkey 'b' for the prvious image, respectively. Using the slider showing the position of the current frame within the sequence by clicking and moving the mouse an arbitrary image within the sequence is selected identified by its sequential number. Directly accessing individual images is possible via the sequential number input.

5.4 Displaying Modes of Region Objects and Zoom

Several modes for displaying the generated region objects within an image are available by selecting the toggle boxes within the menu 'Display'. Region objects are visualized at there center of mass using a circular blob with the corresponding number, a green line for visualizing the main direction or its rectangular direction and the yellow marked surface of the region pixels. The zoom display shows per default a larger view of a defined part of the working space. For detailed ajustment of directions it can be rotated according to the region object direction. All this options can be individually activated or deactivated.

6 Background Compensation

For compensating the background staying invariant for the image sequence, while interesting regions are moving, a background image has to be generated. This image may be loaded and saved as TIFF-file by selecting the 'Back/Open' or 'Back/Save' menu item, respectively.

A background image can be generated from the current image sequence by selecting 'Back/Calculate' from the menu. The pixelwise mean of several images of the sequence is calculated. As a default, ten images selected from the whole sequence are used. These parameters can be changed by selecting the 'Back/Parameters' item.

For showing the resulting image press the 'Back' Button within the button bar just below the main menu.

The background image may be substracted from the current image. Via thresholding the difference image relevant object regions may be extracted, s. ImageProcessing. The simplest form of thesholding is using a fixed number. In dependence on the background content thresholds that are adapted to these background contents may be more useful. The construction of such a threshold map is described in the following.

6.1 Threshold Map Generated from Background Image

The threshold map is calculated from the pixels of the background image. The gray value of each pixel is divided by a given value and afterwards another given value is added for calculating the pixel value of the threshold image. The values can be given via the menu entry 'Back/ParametersThresMap'. The entries 'Back/CalculateThresMap' and 'Back/CancelThresMap' are used for activating and deactivating the map. For showing the resulting map press the 'ThresMap' Button within the button bar just below the main menu. For further details of using the map, s ImageProcessing.

7 Processing of Individual Images

You can individually process the current image by choosing the menu items from the 'ImgProc'-Menu. All processing steps have parameters you can adjust in a window poped up by choosing 'ImgProc/Parameters'.

The possible image processing steps are executed one after the other generally taking the ouput of the previous step as input. For restarting the whole 'Reload' the original image. Possible image processing steps are:

- Correct - is used to normalise the contrast within the current image
- Median - convolves the image using a median filter for smoothing without affecting the edges
- Match Template - matches one or more templates to the image data
- Difference - calculate the differences between the background and the current image
- Find Threshold - does not change anything in the image, but uses the current (difference) image to calibrate the binarising threshold
- Binarise - apply the threshold (or threshold map, if -1 is given as threshold parameter) for separating interesting pixel areas from the background
- Opening - eliminates small white regions and smoothes the region shape
- Closing - closes gaps within the region area
- Find regions - identifies sets of connected white pixels (within a binarized image) to form a region and adds a colored mark and a number
- Region Size/Region Shape - eliminates regions of implausible size and shape.
- Region Extremes - defines per region two additional ones by identifying the point where the main axis of the region cuts the surface

All processing steps have parameters you can adjust in a window poped up by choosing 'ImgProc/Parameters'.

Templates are defined, opend and stored by selectings adequate items of the 'Templates' menu.

Within the window visualizing the currently available templates this data may be stored and/or deleted. Additionally, some aspects of matching can be selected within the 'Matching' menu-item. Matching results are stored in the form of RegionObjects and collected within the RegionTrace.

Sequences of these commands (except template matching so far) can be executed automatically by defining scripts as described in ScriptedImageProcessing.

8 Using template matching for detecting interesting areas

Templates are (small) patches of graylevel images that cover some interesting image area. Generally, template matching shifts the patch step by step over the whole image and calculates a similarity value either based grayvalue differences or correlations and detects the position within the image, where the similarity is highest.

8.1 Creating templates

Templates may be created by defining a region of interest, as described in UserInterface for restricting the area for image processing. Using the menu entry 'Templates/Define from roi' the current marked area is added to the list of templates. The template information may be enriched by creating a region object, either automatically or by hand, s. RegionObjects, and take over the direction information from this object to the template by 'Templates/Set direction'. Template lists that have been saved to mass storage, s. below, may be opened and substitute ('Templates/Open LIST') or complement (Templates/Add LIST') the current list.

8.2 Template display window

The current template list can by displayed within an independent window using the menu entry 'Templates/Show'. This window itself offers a menu for handling the templates stuff. By directly clicking into the window individual templates may be marked.

The list of templates may be extended by adding rotated versions of the currently marked template ('Edit/Define by Rotation'). Those rotated templates are used for matching equivalent to the original ones. Template matching itself is not rotationally invariant. The marked template or the whole list may be saved to mass storage or deleted by using the corresponding entries within the 'Edit' menu.

Some parameters concerning the matching are handled from the 'Matching' menu. Either the marked or all the templates are matched ('Matching/Template Selection') using either differences or correlations for detecting similarities ('Matching/Matching Mode'). Either just the result, which is the most similar position, is marked by a region object, or the similarity/difference values themselves are displayed within the working field. The parameter settings chosen here are used for the matching process that is started by 'ImgProc/Match template' within the camera view window.

Within the template list display besides the raw graylevel value and numerical parameters, the center of mass and direction of the template may be displayed ('Display').

9 Scripting and Automatic Sequence Processing

For automatic image processing a script of commands can be defined instead of calling the processing steps manually one after the other. By selecting 'Script/Open' and 'Script/Save' scripts can be loaded and saved to the mass storage.

For editing a loaded script use the 'Script/Edit' item. Each line corresponds to one command, the number of parameters depend on the current command. For comments use the characters '//' followed by a 'space'.

Current image processing parameters, adjusted interactively within the parameters window are not instantaniously introduced into a script. Use the item 'Script/From parameters' for doing this explicitely.

Valid script commands are currently:

- correctVals <part>
- median <num>
- diff
- directedDiff <-1:(null-work)|0:abs(work-null)|1:(work-null)>
- binarize <thres> : thres==0 or thres==auto: take threshold detected by findThreshold (see ImageProcessing)
  - thres<0 : take binarizeThresMap
- opening <num>
- closing <num>
- regions
- regrange <min> <max>
- epsrange <min> <max>
- tempMatch (not yet doing anything, so far)
- regExtremes <bool> (true: extremes additional, false: extremes substitute original region)
- roiFromReg <bool> (true:take reg bounding box, false: true reg surface)
- reload
- editRegion <cmdCode> <val> <option>

  - <cmdCode>:
  - 1: add <val> to direction of region <regInd> (-1 for all)
  - 2: flip direction into the intervall [<val>-90; <val>+90], if necessary. Treat region <option> (-1 for all)
  - 3: cut region at <val> from extreme, <option> true adds new reg, false substitutes original reg
  - 4: shift region about <val> in direction, <option> true adds new reg, false substitutes original reg
- "// " for comments
- blank lines are also allowed

The currently defined script is applied to the current image by selecting 'ImgProc/Execute script'.

By choosing the main window menu item 'HandleAllViews/Execute script' you can execute the script on your entire image sequence(s) starting from the current position within the sequence.

10 Generating and Correcting Region Objects

10.1 Detection of Region Objects

Prominent regions are detected from a binarized image as connected sets of white pixels. They may result from binarized difference images or from template matching and masking the template area. Regions are described by their center of mass, their main direction, their size, given as the number of participating pixels and finally a parameter describing their shape. (For the details of a region object description see also ResultsFormat.)

Data concerned with the region objects can be visualized in different ways, as described in UserInterface, and exported as ascii trace data, as described in RegionTrace.

10.2 Postprocessing Corrections

When the automatic processing fails, you can edit the region data after enabling the editing mode within the 'EditRegs' menu. To add an object, left-click on the image, where the object should be placed.

To manipulate an existing individual region object, mark it by a left-click and it becomes red. Then you can

- shift the region by left-click and drag to new position
- 'EditRegs/Shift': shift the region for a given fixed offset into the direction of its main axis (may be also done within the script, s. ScriptedImageProcessing)
- 'EditRegs/Cut': cut the region area (if there is one from automatic detection) at a fixed given offset from the surface point that marks the intersection between surface and main directed axis. Cut is done by taking the given offset from this surface point along the main axis in reversed direction and there introduce a orthogonal artificial surface element (may be also done within the script, s. ScriptedImageProcessing)
- change the direction of the object (green line attached to the blob represents the main axis of the region) by
  - right-click: the direction marker now turns to your click position, dragging possible
  - <ctrl> right-click: change the direction by 180 degrees, independent of the click position
- delete the object by hitting the key 'd' on your keyboard or selecting the 'EditRegs/Delete' item.

For deleting the region data calculated for one image choose the 'EditRegs/ClearSET' item (Hotkey: <Shift> d). The 'EditRegs/-ClearINDEX' item is followed by an input window for a region index and then deletes for all images of the sequence the region object that carries this index. Finally, choosing the 'EditRegs/ClearALL' item deletes all the region objects available for the whole image sequence.

Instead of clicking region objects individually, you may take over the set of regions from the previous into the current image ('EditRegs/TakeOverSet or hotkey: t). This may be useful, if there are just minor changes within the set of regions.

11 Trace of Region Data

The amount of detected region objects for each image of the sequence constitutes the resulting trace. In case of more than one region object per image several enumerated sets of data per image are available. For the detailed description of the output data format look at section ResultsFormat

For saving this data as ASCII file or, correspondingly, loading it, use the 'Trace/Open' and 'Trace/Save' menu items, respectively. For saving trace data the dialog offers two additional options that are:

- saving the trace including the line that does not contain region data or ommitting those lines
- saving the whole trace or selecting a part by defining the minimal and maximal image index.

The option settings do not influence each other. Whether the one or the other setting is useful depends on the trace contents and the following processing steps.

The trace data can be shown within a separate window by selecting 'Trace/ShowData' or visualized within the workspace of the main window by selecting the 'Trace' toggle button just above the workspace. Per default one region object per image, carrying the number 0 is displayed together with the background image. For changing this index, give the desired one with menu item 'Trace/ShowRegSelect' (-1 for all regions).

11.1 Trace sorting

After detecting the region objects within the individual images of the sequence some inspections, corrections and sorting is provided in order to end up with a trace that contains unique individual region indices for the different objects without gaps and errors due to image processing problems. The region data for an individual image can be manually corrected, as described in RegionObjects, and the indices may be sorted to achieve correspondence by selecting the 'Trace/Sort' menu item. You get a window with a table of buttons. To have the first and the thrid object flipped in the result table, just click on the third button in the first row: The first button in the third row is now also activated, the third button in the third row is switched off. The table is interpreted as: First row gives the final position of the object now numbered as 1, second row descides the final number of object now numbered 2 and so on.

The automatics described in the following are applied for all images within the displayed sequence(s) and therefor located at the 'HandleAllViews' menu of the main window.

For distinguishing regions that correspond to different objects, use the 'HandleAllViews/AutoSort' item. It exchanges region indices starting from the current image (or in case of trace is displayed for the whole image sequence) by minimizing the differences between the parameters of corresponding regions. The parameters to be taken into account and theirs weights can be configured via the corresponding parameter window. During the process the original image data may be displayed for the user to proof the results visually ('HandleAllViews/AutoSort/Show inter. frames'). Otherwise the process works in the background but stops within the image sequence, if there are problems, mostly the number of regions changes. (Perhaps this aspect should be inspected individually before sorting by 'AutoInspect/InspectRegionNb', s. below).

'HandleAllViews/AutoCorrectDirs' automatically corrects the direction information for the individual traces of regions of one constant index. The detection within the individual images delivers direction information from -90 to 90 degrees that is sufficient to describe the main axis of a region. By setting the correct orientation for a region, for example giving the direction of the head in contrast to the abdomen the direction values need to be from -180 to 180 degrees. The automatics corrects for jumps of 180 degrees in order to produce a smooth traces of region directions. Within such a trace there may occur jumps from -180 to 180 and vice versa, which may disturb following processing. The trace is therefor also corrected for these jumps resulting in smooth traces containing in principle indefinite value ranges.

The resulting trace data can be inspected with respect to different parameters, in order to find detection errors more easily. The simplest test is to detect gaps in trace by inspecting the number of regions (item: 'AutoInspect'). After ensuring the data to be correct there and successfully sorting corresponding regions, the advanced inspection of other region parameters may further help to detect errors. Which parameters should be checked and which differences should be noticed can be configured via the corresponding parameter window.

12 Working in 3d

The 3d extensions of 'ivTrace' are implemented using the Open Inventor/Coin software and is so far just available for Linux. These extension cannot be used in the Windows version, appropriate buttons are deactivated.

Using 'ivTrace' for generating or visualising 3d trajectories is based on the idea of generating a virtual 3d world containing cameras whose open angle, position and orientation to each other is described within the stereo calibration results. A 3d model of the object to be detected, for example the head of a fly, can then be adjusted within the virtual 3d world. The position and orientation of the model corresponds to the real position and orientation of the object, if its projections to the different virtual camera planes correspond to the projections of the real object to the real images. So, the real images are mapped to the virtual camera planes appropriately and the model can be adjusted until the projections to all views fit. Optionally, the user may choose to project the model to a white background and mix the model projection (everything in the projection that is not white) and the camera image in a postprocessing step. By defining the mixing factor individually for each camera view (Menu 'Display', Entry '3dModelMix'), the result may be more convenient for manual adjustments.

Call 'ivTrace' with the command line option -n <nbViews> or directly with nbView image sequences to get nbView windows for simultaneously inspecting nbViews image sequences containing the different views of one scene.

The 3d coordinate system is the camera coordinate system of the first camera (first view, leading camera for calibration). For all further cameras their transformation from this coordinate system is expected to be known and given.

For working with the 3d extension to 'ivTrace' you need:

- an Inventor model of the object
- a description of the individual camera open angle and the transformation that is needed to get from the first to another camera position and orientation (results of calibration procedure)
- a description of the adjusting range for x, y and z

This information is expected to be stored into 3 parameter files that can be loaded using the items '3dWorldParameters' and '3dModel' from the main window menu. Examples for the format of the ascii description files can be found within the package.

The 3d trajectory of the object within the coordinate system of the first camera consists of 3 translation values (x, y, z) and 3 rotation values (a rotation vector whose length encodes the angle in radians the object has to be rotated about around the axis). For details about the ascii 3d trace file format, s. ResultsFormat.

13 Output Data Formats

13.1 2D Results

The resulting trace file contains one line for each image of the sequence. All the region objects detected within one image are always containg into one line. Whether there are lines not containing any data depends on the parameters given for saving. Each line starts with the 4 digit wide image index, followed by the available sets of region data. Each set of region data contains of the center of mass (2 unsigned float coordinates with four (three before October 2006) leading digits and two decimals), the direction in radiants measured against the horizontal direction (1 signed float value with 5 decimals), the size of the region represented as number of contained pixels (1 int value) and an parameter describing the excentricity of the region shape reaching from 0.0 (circle shape) to 1.0 (line shape) (1 unsigned float value with 2 decimals). The following line gives an example:

- ```
  1 .....
  2 367.91 750.01 -1.09350 99 0.35 397.02 740.69 -0.35149 197 0.59
  3 .....
  ```

You probably should also store the script of the image processing for documentation purposes.
  ```

13.2 3D Results

The resulting 3D trace file generated from at least two correspinding 2D views of a scene generally also contains one line for each image of the sequence. For the moment there can be just one object by stored. Whether empty lines are included within the trace depends on the parameters while saving. Each line starts with the 4 digit wide image index, followed by the 6D region data, 3D translation and 3d rotation. Data entries are separated by a blank and formated to take 11 digits at all, 6 digits after and 4 digits before the decimal point. Translation is given as x-, y-, z-coordinate within the main camera coordinate system. Rotation is given as rotation axis, whose length encodes the angle the object is rotated around the axis in radian. As an example

- ```
  1 .....
  2 0.000000 0.000000 500.000000 1.166664 1.273190 -1.273190
  3 .....
  ```

14 ivTBatch: Non-interactive Commandline Tool Extending 'ivTrace'

Command line tool for detecting interesting regions within images that are stored within AVI files or tif sequences. For the detailed description of the analyzing properties, see IvTrace, which is the interactive counterpart to 'ivTBatch'. The description files needed here for determining the processing steps can be conveniently created from the interactive analysis of example sequences.

Dependent on the given analysis intructions a trace file for each given image sequence is created and stored. The trace file is named automatically based on the image file name and description file names. The generated trace file may be inspected and futher modified by the interactive processing tool.

Call ivTBtbatch from the commandline by:

ivTBatch [-b <backImage.tif>] [-r <roi.txt>] [-s <script.scr>] [-d <diffVal>] [-a <addVal>] [-v] [-n] [-l] {<file>}

-b background image (default: calculate it from image sequence)

-r roi polygon for restrincting calculations

-s script file defining processing steps

-d diffVal for defining binarising threshold map from background

-a addVal for defining binarising threshold map from background

-v verbose mode

-n do no image processing, just open files and report what to do

-l following files does not contain an AVI but one list of tiff files each

{<file>} one or more filenames containing one AVI each or, with option -l, one list of tiff files each

15 ivTCompressionTools: Custom Made Image Compression

Image data may easily fill large amounts of storage media. This often includes large amounts of redundant information, if the interesting content of an image is, for example one object in front of a stationary background. To get rid of the large amounts of redundant information without loosing the interesting parts, the customized compression form, the ivtrace archive, ita, was developed. Main idea is to compress image data lossless, using the 'deflate' algorithm and further just store the constant background image in its original size and for each image of the sequence a smaller window around the position of the interesting object, given as trajectory. This form of storing one background image, compressed patches of interesting image data and a trajectory to locate the patches reduces the amount of data enormously. This format can directly be imported into IvTrace, s. ImageSequence. The archive is generated on the command line by the tool ivTArchive and restored to flat video data using the tool ivTDecode.

ivTArchive -t <trajectory.tra> [-b <backImage.tif>] [-o <output.ita>] [-w <window_size>] [-v] [-n] [-l] {<file>}
  ```

-t trajectory used to generate window positions

-b background image (default: calculate it from image sequence)

-o output filename (default: trajectory basename + .ita)

-w window size (default: 128x128 pixels)

-v verbose mode

-n do no image processing, just open files and report what to do

-l following files does not contain an AVI but one list of tiff files each

{<file>} One or more filenames containing one AVI each or, with option -l, one list of tiff files each

ivTDecode [-b] archive.ita

-b extract background image