cvtool

A computer vision tool
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1 Overview

1.1 Concept

Cvtool is a filter that manipulates one or more images (called frames): it reads frames from standard input and writes the manipulated frames to standard output. It can read and write streams of NetPBM (pbm, pgm, ppm, pnm, pam) and PFS frames.

Cvtool integrates all its functionality into a single binary, and makes it available through commands such as `rotate`, `filter`, and others.

The following command scales a NetPBM frame by a factor of 3:

```
$ cvtool scale --factor 3.0 < input.ppm > output.ppm
```

This is how one would select a rectangle from an PFS frame stream:

```
$ cvtool cut --left 10 --top 10 --width 100 --height 100 \
  < input.pfs > output.pfs
```

`cvtool help` prints a list of available commands, and `cvtool help cmd` prints help for the command `cmd`.

1.2 Supported file types

Due to the use of OpenGL textures to store frame data, some limitations apply:

- The maximum frame size is limited by the OpenGL maximum texture size.
- The maximum number of channels in a frame is 4.

1.2.1 NetPBM formats: 'pnm'

All NetPBM image formats (pbm, pgm, ppm, pnm, pam) are supported, except for their old "plain" variants. Multiple images in one file are supported. They may differ in size and type.

If the input images use more than 8 bit per channel, they are treated as floating point images.

1.2.2 PFS format: 'pfs'

Cvtool supports the PFS format used by pfstools.

Currently, cvtool ignore channel tags. This will be fixed in a future version.

1.3 Output

Cvtool normally prints messages to `stderr`. It prepends messages with its name, the level of information, and the name of the command.

The level of information is `DBG` for debugging messages, `INF` for informational messages, `WRN` for warnings, `ERR` for error messages, and `REQ` for requested information. Normally, cvtool prints only messages of level `INF` or higher, but this can be changed with '`--quiet`' and '`--verbose`'; see below.

Some commands, for example `info`, print special information messages that the user explicitly requests. Such special messages have the level `REQ`, and can usually be redirected using the '`--output`' option. In this case, no additional information will be prepended to the messages.

The special filename `-` means standard output (`stdout`). Redirecting messages to `stdout` is only allowed when no frames are written to `stdout`.

1.4 Global options

`-q|--quiet`
: Reduces the amount of output: only messages with level `WRN` and higher will be printed.

`-v|--verbose`
: Increases the amount of output: all messages will be printed, even those with level `DBG`. This will include progress information in many cases, but much of the output is really only useful for debugging purposes.

1.5 Common parameters

1.5.1 Arrays and Matrices

Some commands need arrays of integer or floating point values as parameters. Matrices are treated as two-dimensional arrays. Higher dimensions are also possible.

All of these array types are treated the same: the first part of the argument determines the number of dimensions of the array and its size in each dimension. The second part lists all values, separated by commas.

If the command requests an array or matrix of fixed dimension and size (or of dimension 1 and arbitrary size), then the first part can be omitted: only the value list is necessary in this case.

Examples:

- An array with three integer values

  ```
  3:1,1,1
  ```

- An array with five floating point values

  ```
  5:1.2,1.3,0.7,0.5,0.0
  1.2,1.3,0.7,0.5,0.0
  ```

- A 3x3 matrix array with integer values

  ```
  3x3:1,2,3,4,5,6,7,8,9
  ```

- A three-dimensional array with floating point values

  ```
  2x2x2:1.11,1.12,1.21,1.22,2.11,2.12,2.21,2.22
  ```

1.5.2 Colors

Colors can be given in one of three forms:

1. SVG color names
   The SVG 1.1 specification of the W3C defines 147 color names. Cvtool accepts each of these names, case insensitively. The full list can be found here: http://www.w3.org/TR/SVG11/types.html.
2. Hex triplets
   The RGB components of a color can be specified directly as a hex triplet: `0xrrggbb`. For example, `0x00ff00` is green, `0xffffff` is white, and `0x000000` is black.
3. Decimal values
   The RGB components of a color can be specified as decimal values, prepended with r, g, or b. For example, `g255` is green (the red and blue components default to zero), `r255g255b255` is white, and `r0g0b0` is black.

1.6 Environment

`TMPDIR` Directory to create temporary files in.

`COLUMNS` Cvtool tries to format its messages so that they do not use more than the given number of columns. If this variable is unset, a default of 80 will be used.

1.7 Exit codes

Cvtool returns `0` on success and `1` on error.

2 Commands

2.1 Informational Commands

2.1.1 help

`help [`*command*`]`

Print general or command specific help.

2.1.2 version

`version`

Print version information.

2.1.3 info

`info [-s|--statistics] [-S|--single] [-o|--output=`*file*`]`

Print information about frames in the input stream.

If '`--single`' is used, the command exits after the first frame has been processed. If '`--statistics`' is used, additional statistics about the frame contents are printed. The output can be redirected to a file or to standard output (-) using the '`--output`' option.

The following information will be printed: STREAM (pfs or pnm), CHANNELS (0-4), FORMAT (luminance or color), TYPE (uint8 or float), WIDTH, HEIGHT.

Statistics are computed for each available channel c: CHc_MIN, CHc_MAX, CHc_MEAN, CHc_MEDIAN, CHc_STDDEVIATION.

Example:

```
$ cvtool info < file.pnm
cvtool: [REQ] info: STREAM=pnm CHANNELS=3 FORMAT=color TYPE=uint8 WIDTH=394 HEIGHT=454
$ eval ‘cvtool info -o - < file.pnm‘
$ echo $WIDTH
394
```

2.2 Stream Manipulation

2.2.1 combine

`combine [-m|--method=(lr|leftright)|(tb|topbottom)] [-j|--justify=(left|top)|center|(right|bottom)] [-c|--color=`*color*`] `*file...*

Combine the given files by placing the frames side by side ('`leftright`') or one below the other ('`topbottom`').

The default is '`leftright`'. If the frames have different sizes, then the smaller ones have to be aligned with the biggest one. The default is to center them. The remaining space will be filled with the given color; the default is black.

Example:

```
$ cvtool combine left.pnm right.pnm > lr.pnm
$ cvtool combine -m tb \
  <(cvtool combine a.pnm b.pnm) \
  <(cvtool combine c.pnm d.pnm) \
  > 2x2.pnm
```

2.2.2 convert

`convert [-t|--type=uint8|float] [-f|--format=lum|color]`

Converts the input frames to another type and format. The default is to keep the input type and format. The output will be PNM for type uint8 and PFS for type float.

Example:

```
$ cvtool convert -t float < in.pnm > out.pfs
```

2.2.3 create

`create [-t|--type=uint8|float] [-f|--format=lum|color] [-n|--n=`*n*`] -w|--width=`*w* `-h|--height=`*h* ` [-c|--color=<color>]`

Create n (default 1) frames with the given format (default color) and the given type (default uint8). The frames will have the given width and height, and they will be filled with the given color (default black). The resulting stream type will be PNM if the type is uint8, and PFS otherwise.

Example:

```
$ cvtool create -t uint8 -f lum -w 720 -h 576 > out.pgm
$ cvtool create -t float -f color -w 10 -h 10 -c green > green.pfs
```

2.2.4 foreach

`foreach [-s|--shell=`*shell*`] [-n|--n=`*n*`]` *cmd*

Execute the given command for every frame.

The command is expected to read *n* frames from standard input (default is *n*=1), and write an arbitrary number (including zero) of frames to standard output. The original frame(s) that were given to the command are replaced by the output of the command. The frames that the command produces are converted to the format of the original frames. The foreach command replaces the following special strings in the command *cmd* before executing the command: `%N` (replaced with frame number), `%W` (replaced with frame width), and `%H` (replaced with frame height). If *n* is greater than 1, these values refer to the first frame that is piped to the command. The command *cmd* is executed by passing it to the system shell. The default is '`/bin/sh -c`' on most systems. This can be overridden with the '`--shell`' option. It expects a string with zero or one spaces: The first part of the string is the shell, the second part (if any) is the first option to the shell. The next option will then be the command to execute.

Example:

```
# Rotate a video. Resize after rotation to keep the original dimensions.
$ cvtool foreach 'cvtool rotate -a %N | cvtool resize -w 352 -h 240' \
  < video.pnm > rotating-video.pnm
```

2.2.5 merge

`merge [-s|--shuffle] [-o|--output=`*file*`]` *file...*

Merges files into one stream, in the given order.

If `--shuffle` is used, the order will be randomized. The file names will be printed to stderr in the order they are merged. If `--output` is used, the file names will be written to the given file instead.

Example:

```
$ ls
frame000.pnm frame001.pnm frame002.pnm
$ cvtool merge frame*.pnm > video.pnm
```

2.2.6 reverse

`reverse`

Reverses the order of the frames in the stream.

This requires a temporary file that is big enough to hold the complete input stream.

Example:

```
$ cvtool reverse < video.pnm > oediv.pnm
```

2.2.7 select

`select [-d|--drop] [-f|--fps=`*`fps`*`] `*`range...`*

Selects frames from a stream.

By default, frames in the given ranges are kept and all others dropped. With `--drop`, frames in the given ranges are dropped and all others kept.

A range must be of the following form: *l*-*h* (from *l* to *h*), -*h* (from beginning to *h*), *l*- (from *l* to end), *l* (only *l*), or - (everything). Each start and end point can be a frame number (counting from 0) or a time in the format [hours:]minutes:seconds[.fraction]. In short: if it contains a colon, it's a time. Time ranges can only be used if the '`--fps`' option is used to specify the number of frames per second.
IMPORTANT: If you use frame number ranges, the high frame number is inclusive: the frame with this number will be dropped/kept. If you use time ranges, the high time is exclusive and marks the first frame that will not be dropped/kept.

Example:

```
# Drop the frames 0 to 124 from the stream (with a framerate of 25 fps,
# these are the first five seconds).
$ cvtool select --drop 0-124 < in.pnm > out.pnm

# Drop the first 5 seconds of the stream (with a framerate of 25 fps,
# these are the frames 0 to 124. The frame at 0:05, with the frame
# number 125, will be the first that is kept!)
$ cvtool select --fps 25 --drop 0:00-0:05 < in.pnm > out.pnm

# Keep the second 5-minutes-block and drop all the rest. Both
# commands are equivalent.
$ cvtool select --fps 25 5:00-10:00 < in.pnm > out.pnm
$ cvtool select --fps 25 --drop -5:00 10:00- < in.pnm > out.pnm
```

2.2.8 split

`split [-n|--n=`*`n`*`] [-t|--template=`*`template`*`] [-b|--backwards] [-s|--start=`*`i`*`]`

Split the input stream into multiple files.

Each new files contains *n* frames (default is *n*=1). The filename will be generated from the template: the template must contain exactly one appearance of the character `%`. This character must be followed by one of the digits `1` through `9`. The digit must be followed by the uppercase character `N`. This special string `%xN` will be replaced by the number of the first frame of the stream contained in this file. The number will be left-padded with zeros until its width is at least `x` characters. The default template is '`frame-%6N`'.
A start number i for the first frame can be given, and the frames can be counted backwards. If the frames are counted backwards, a start number is required, because negative frame numbers are not accepted.

Example:

```
$ cvtool split -t frame%3N.pnm < ../video.pnm
$ ls
frame000.pnm frame001.pnm frame002.pnm
$ cvtool split -s 99 -b -t img%2N.pnm < ../video.pnm
$ ls
img99.pnm img98.pnm img97.pnm
```

2.3 Resizing Frames

2.3.1 resize

`resize -w|--width=`*w* `-h|--height=`*h* `[-x|--x-offset=`*x*`] [-y|--y-offset=`*y*`] [-c|--color=`*color*`]`

Resize the frames to the given new width and height.

Place the original frame contents at the position (*x*,*y*) relative to the new frame (these offsets may be negative). If no or an incomplete position is given, compute the missing part(s) so that the old contents are centered on the new frame. Fill holes that might result with the given color (default is black).

Example:

```
# Add a green border of 10 pixels to a 352x240 frame
$ cvtool resize -w 372 -h 260 -c green < img.pnm > img2.pnm
```

2.3.2 cut

`cut -l|--left=`*l* `-t|--top=`*t* `-w|--width=`*w* `-h|--height=`*h*

Only let the given rectangle through; cut the rest of each frame.

Example:

```
$ cvtool cut -l 0 -t 0 -w 10 -h 10 < in.pnm > out.pnm
```

2.4 Transforming Frames

Most geometric transformation commands support the option '`--interpolation`' to choose one of the following interpolation types:

- `none`: No interpolation / Nearest Neighbor.
- `bilinear`: Bilinear interpolation.
- `biquadratic`: Biquadratic interpolation.
- `bicubic`: Default bicubic interpolation (Mitchell-Netravali).
- `bicubic-b-spline`: Bicubic B-Spline interpolation.
- `bicubic-cr-spline`: Bicubic Catmull-Rom Spline interpolation.

The default interpolation type is `bilinear`.

2.4.1 affine

`affine -m|--matrix=`*2x2-matrix* `[-c|--color=`*color*`] [-i|--interpolation=`*i*`]`

Apply the affine tranformation defined by the given matrix (4 floating point values separated by commas) to the frames. The frame dimensions will be adapted so that the resulting frame will fit. Possible holes will be filled with the given color; the default is black.

Example:

```
$ cvtool affine -m 2.0,0.1,0.75,1.0 < in.pnm > out.pnm
```

2.4.2 flip

`flip`

Flip frames (left/right).

Example:

```
$ cvtool flip < in.pnm > out.pnm
```

2.4.3 flop

`flop`

Flop frames (top/bottom).

Example:

```
$ cvtool flop < in.pnm > out.pnm
```

2.4.4 rotate

`rotate -a|--angle=`*`angle`* `[-c|--color=`*`color`*`] [-i|--interpolation=`*`i`*`]`

Rotate frames with the given angle (in degrees), counterclockwise.

The dimensions of the rotated frame will be big enough to hold all informations from the source. "Holes" will be filled with the given color; the default is black.

Example:

```
$ cvtool rotate -a -45 < in.pnm > out.pnm
```

2.4.5 scale

`scale [-w|--width=`*`w`*`] [-h|--height=`*`h`*`] [-i|--interpolation=`*`i`*`]`
`scale -x|--factor-x=`*`factor-x`* `-y|--factor-y=`*`factor-y`* `[-i|--interpolation=`*`i`*
`scale -f|--factor=`*`factor`* `[-i|--interpolation=`*`i`*`]`

Scale frames to new size.

First form: Give new width and/or height. If one value is missing, it is computed from the other so that the aspect ratio remains the same.

Second form: Give scale factors for width and height.

Third form: Give one scale factor for both width and height.

Example:

```
# The following three commands do the same for a 400x200 frame:
$ cvtool scale -w 100 -h 50    < in.pnm > out.pnm
$ cvtool scale -x 0.25 -y 0.25 < in.pnm > out.pnm
$ cvtool scale -f 0.25         < in.pnm > out.pnm
```

2.4.6 shear

`shear [-x|--shear-x=`*`angle-x`*`] [-y|--shear-y=`*`angle-y`*`] [-c|--color=`*`color`*`]`
`[-i|--interpolation=`*`i`*`]`

Shear frames in horizontal and/or vertical direction.

The frames are sheared with the given angle(s) from (-90,90). Negative angles shear clockwise. "Holes" will be filled with the given color; the default is black.

Example:

```
$ cvtool shear -x 20 -y 10 < in.pnm > out.pnm
```

2.5 Mixing Frames

2.5.1 blend

`blend -s|--source=`*file* `[-a|--alpha=`*file*`] [-S|--single] [-x|--x=`*x*`] [-y|--y=`*y*`]`

Blends the source into the frame stream, using an alpha map.

With no alpha map, the source is simply copied into the frames. *x* and *y* specify the position that the source should be copied to. The default is (0,0). Positions outside of the frames are possible: parts of the source that do not fit into the frames will be ignored. When '`--single`' is used, only the first frame of the source will be used; this frame will be copied into all frames of the stream.

Example:

```
$ cvtool blend --single -s logo.pnm -a logo-alpha.pgm -x 700 -y 0 \
  < video.pnm > video-with-logo.pnm
```

2.5.2 layer

`layer -m|--mode=min|max|median|or|and|xor|diff|add|xadd|sub|xsub|mul|div file...`

Layers the frames from the given files on top of each other, using the given mode.

Layering will be done for each channel separately. The input frames may differ in size. In this case, they will be implicitly scaled to a common size. Graylevel frames have

The modes are as follows:

- `min`: Use minimum value.
- `max`: Use maximum value.
- `median`: Use median value.
- `or`: Bitwise or.
- `and`: Bitwise and.
- `xor`: Bitwise xor.
- `diff`: Use difference between maximum and minimum value.
- `add`: Use sum of values.
- `xadd`: Use sum of values. The ranges are transformed so that the results fit in [0,1]. Example for two layers: X = (A/2) + (B/2).
- `sub`: Subtract values from the first value.
- `xsub`: Subtract values from the first value. The ranges are transformed so that the results fit in [0,1]. Example for two layers: X = (A/2) - (B/2) + 1/2.
- `mul`: Multiply values.
- `div`: Divide values.

Example:

```
$ cvtool layer --mode=or red.pnm green.pnm blue.pnm \
  > allchannels.pnm
```

2.5.3 mix

`mix -w|--firstweight=`*fw*`... [-W|--lastweight=`*lw*`...] [-s|--steps=`*s*`] [-b|--bias=`*b*`] file...`

Mixes the given sources into a single stream using the given weights.

The default is to produce a single step, i.e. one output frame for each set of input frames. If more steps are requested, the weights are interpolated between the set of first weights and the

set of last weights. By default, this interpolation is done linearly, which corresponds to a bias setting of 0.5. Smaller bias values will give more attention to the first weights, larger values more to the last weigths. The bias must be from (0,1).

The input frames may differ in size. In this case, they will be implicitly scaled to a common size.

Example:

```
$ cvtool mix --weight=1,1 black.pgm white.pgm > gray.pgm
$ cvtool mix -w 1,0 -W 0,1 -s 10 black.pgm white.pgm \
  > from-black-to-white.pgm
```

2.6 Color Manipulation

2.6.1 channelextract

`channelextract -c|--channel=0|1|2|3|r|g|b|lum`

Extract the given channel from the input. If '`channel`' is 0, 1, 2, or 3, then the data is copied unmodified. If the '`channel`' is r, g, b, or lum, then the input is first converted to the red, gree, blue, or luminance form.

Example:

```
$ cvtool channelextract -c r < color.ppm > red.pgm
```

2.6.2 channelcombine

`channelcombine file0 [file1 [file2 [file3]]]`

Extract the first channel from the given files and combine them into multichannel output data.

Example:

```
$ cvtool channelcombine red.pgm green.pgm blue.pgm > rgb.ppm
```

2.6.3 color

`color [-h|--hue=`*h*`] [-s|--saturation=`*s*`] [-l|--lightness=`*l*`] [-c|--contrast=`*c*`]`

Color adjustment.

Hue, saturation, lightness, and constrast are manipulated in the HSL (Hue, Saturation, Lightness) color space. *h* is an additive constant to the hue angle, in degrees. *s*, *l*, *c* measure the relative change in saturation, lightness, contrast: -1 means the result will be zero, 0 means the result will be the same as the original, and +1 means that the result will be two times as high as the original. Values greater than +1 are possible. For example, s = -1 will convert the input frames to graylevels. See the Wikipedia entry for HSL color space for more information.

Example:

```
$ cvtool color -h 120 < red.pnm > green.pnm
$ cvtool color -h 120 < green.pnm > blue.pnm
$ cvtool color -h 120 < blue.pnm > red.pnm
$ cvtool color -s -1 < colored.pnm > gray.pnm
$ cvtool color -l +1 < dark.pnm > light.pnm
```

2.6.4 gamma

`gamma`

Gamma correction.

Example:

```
$ cvtool gamma -g 2.2 < dark.pnm > bright.pnm
```

2.6.5 invert

`invert`

Invert input frames.

Example:

```
$ cvtool invert < in.pnm > out.pnm
```

2.7 Drawing

2.7.1 draw

`draw [-w|--width=`*`width`*`] [-d|--dash=`*`dash-specification`*`] [-l|--line-cap=butt|round|square] [-L|--line-join=miter|round|bevel] [-s|--border-style=none|color|pattern|multipattern|linear-gradient|radial-gradient] [-c|--border-color=`*`color`*`] [-p|--border-pattern=`*`file`*`] [-g|--border-gradient=`*`gradient-specification`*`] [-S|--fill-style=none|color|pattern|multipattern|linear-gradient|radial-gradient] [-C|--fill-color=`*`color`*`] [-P|--fill-pattern=`*`file`*`] [-G|--fill-gradient=`*`gradient-specification`*`] [-f|--font-family=`*`font`*`] [-t|--font-slant=normal|italic|oblique] [-W|--font-weight=normal|bold] [-F|--font-size=`*`size`*`|`*`size-x,size-y`*`] [-j|--justify-x=left|right|center] [-J|--justify-y=bottom|top|center] [-a|--antialias] [-u|--unit] `*`command...`*

Draw simple geometric forms, lines and curves, and/or text.

The style for the object lines and the filling can be specified separately; it is either '`none`' (line/filling is not drawn), '`color`' (solid color), '`pattern`' (a pattern read from a file), '`multipattern`' (a different pattern for each input frame, all read from a file), '`linear-gradient`' (a linear gradient), or '`radial-gradient`' (a radial gradient). The default is the solid color black for lines and no filling.

A linear gradient specification `x0,y0,color0,x1,y1,color1` defines a gradient along the line from start point `x0,y0` (with color `color0` to end point `x1,y1` (with color `color1`). Any number of additional color stops can be added by appending an offset value and its associated color to the gradient specification. The offsets must be between 0.0 and 1.0 and describe the position on the gradient line, where 0.0 is the start point and 1.0 is the end point.

A radial gradient specification `x0,y0,r0,color0,x1,y1,r1,color1` defines a gradient from the start cirlce `x0,y0,r0` with color `color0` to the end circle `x1,y1,r1` with color `color1`. Additional stops can be added in the same way as for linear gradients.

The style of lines can be further adjusted with the '`--width`', '`--dash`', '`--line-cap`', and '`--line-join`' options. The '`--width`' option selects the line width; it is 2.0 by default. The '`--dash`' takes a list of values that specify alternating lengths for `"line on"` and `"line off"` segments of a line. If only one value is given, these lengths are equal. The '`--line-cap`' option selects the style of line and curve ends. The '`--line-join`' options selects the style of the meeting point of two line or curve segments.

Antialiasing can be turned on (default) and off with '`--antialias`'.

If '`--unit`' is given, then all coordinates and sizes on the command line refer to a frame of size 1x1. All values are then scaled so that they match the real frame dimensions. For example, the point (0.5,0.5) will always be in the middle of a frame, regardless of the frame dimensions.

Text is drawn relative to the current drawing position (previously set with `move_to`, for example). By default, the current drawing position sets the bottom left point of the first character of the text. This can be changed with the '`--justify-x`' and '`--justify-y`' options. The font family, slant, weight, and size can be chosen. Note that you may not get an error message if '`--font-family`' fails to set the given font, because the underlying library may not

report this error. If you use two values for the font size, then the first applies to the horizontal direction and the second to the vertical direction, so that you can scale the font asymmetrically.

A drawing command consists of a command name and parameter sets that define one or more instances of the command.

Simple geometric forms:

`rectangle` *`topleft-x,topleft-y,width,height`* `[...]`
Draw a rectangle.

`circle` *`center-x,center-y,radius`* `[...]`
Draw a circle.

`ellipse` *`rect-topleft-x,rect-topleft-y,width,height`* `[...]`
Draw an ellipse in the given enclosing rectangle.

`arc` *`center-x,center-y,radius,start-angle,stop-angle`*
Draw a part of a circle, from the given start angle to the given stop angle.

Text:

`text` *`string`*
Print the string at the current drawing position.

Lines and curves:

`move_to` *`x,y`* `[...]`
Move current point.

`line_to` *`x,y`* `[...]`
Draw a line from the old current point to the new current point.

`curve_to` *`x0,y0,x1,y1,x2,y2`* `[...]`
Draw a curve from the old current point to the new current point *x2,y2*, Using the control points *x0,y0* and *x1,y1*.

`rel_move_to` *`dx,dy`* `[...]`
Move the current point using relative coordinates.

`rel_line_to` *`dx,dy`* `[...]`
Draw a line using relative coordinates.

`rel_curve_to` *`dx0,dy0,dx1,dy1,dx2,dy2`* `[...]`
Draw a curve using relative coordinates.

`close`
Close the currnet line/curve figure: draw a line from the current point to the start point of the figure and combine start and end point into one point.

Open lines and curves will automatically be closed when drawing geometric forms or text.

The draw command is only a simple interface to the excellent CAIRO graphics library. Much of the CAIRO documentation is useful for this command, too, especially the FAQ.

Example:

```
# Draw two green circles with a line width of 5.
$ cvtool draw -w 5 -c green circle 50,50,40 50,50,20 \
  < blank.pnm > circle.pnm
# The same, but filled with linear gradient from red to yellow to blue.
$ cvtool draw -w 5 -S linear-gradient \
  -G 10,50,red,90,50,blue,0.5,yellow circle 50,50,40 50,50,20 \
  < blank.pnm > circle.pnm
# Display one video inside another video in the form of a circle.
$ cvtool draw -s none -S multipattern -P video2.pnm circle 50,50,40 \
  < video1.onm > out.pnm
```

```
# Print a string exactly centered in the middle of blank.pnm.
$ cvtool draw -u -f "Serif" -F 0.1,0.1 -j center -J center \
  move_to 0.5,0.5 text "Hello world" \
  < blank.pnm > text.pnm
```

2.8 Filtering Frames

2.8.1 gauss

`filter gauss [-3|--3d] -k|--k=`*k*
`filter gauss [-3|--3d] -s|--sigma=`*s*
`filter gauss [-3|--3d] -x|--k-x=`*kx* `-y|--k-y=`*ky* `[-t|--k-t=`*kt*`]`
`filter gauss [-3|--3d] [-k|--k=`*k*`] [-x|--k-x=`*kx*`] [-y|--k-y=`*ky*`] [-t|--k-t=`*kt*`] [-s|--sigma=`*s*`] [--sigma-x=`*sx*`] [--sigma-y=`*sy*`] [--sigma-t=`*st*`]`

Filter framess with a Gauss filter, in 2D or 3D (with the third dimension being the time). The kernel size can be given for each dimension, or once for all. It will be (2*kx*+1)x(2*ky*+1)[x(2*kt*+1)]. Different values for each direction lead to asymmetric filtering. The gauss filter can be specified by the sigma value(s): the mask size will be computed so that roughly 95% of the mass lies within the resulting mask. It is also possible to specify both sigma and k.

Example:

```
$ cvtool gauss --3d -k 3 < video.pnm > smoothed-video.pnm
```

2.8.2 mean

`filter mean [-3|--3d] -k|--k=`*k*
`filter mean [-3|--3d] -x|--k-x=`*kx* `-y|--k-y=`*ky* `[-t|--k-t=`*kt*`]`

Filter frames with a Mean filter, in 2D or 3D (with the third dimension being the time). The kernel size can be given for each dimension, or once for all. It will be (2*kx*+1)x(2*ky*+1)[x(2*kt*+1)]. Different values for each direction lead to asymmetric filtering.

Example:

```
$ cvtool mean -k 2 < in.pnm > out.pnm
```

2.8.3 median

`filter median [-a|--approximated] [-3|--3d] -k|--k=`*k*
`filter median [-a|--approximated] [-3|--3d] -x|--k-x=`*kx* `-y|--k-y=`*ky* `[-t|--k-t=`*kt*`]`

Filter frames with a Median filter, in 2D or 3D (with the third dimension being the time). The kernel size can be given for each dimension, or once for all. It will be (2*kx*+1)x(2*ky*+1)[x(2*kt*+1)]. Different values for each direction lead to asymmetric filtering.

If the *–approxmated* option is given, then the median will be approximated. This helps to allow larger mask sizes.

Example:

```
$ cvtool median -a -k 2 < in.pnm > out.pnm
```

2.8.4 min

`filter min [-3|--3d] -k|--k=`*k*
`filter min [-3|--3d] -x|--k-x=`*kx* `-y|--k-y=`*ky* `[-t|--k-t=`*kt*`]`

Filter frames with a Minimum filter, in 2D or 3D (with the third dimension being the time). The kernel size can be given for each dimension, or once for all. It will be (2*kx*+1)x(2*ky*+1)[x(2*kt*+1)]. Different values for each direction lead to asymmetric filtering.

Example:

```
$ cvtool min -k 2 < in.pnm > out.pnm
```

2.8.5 max

`filter max [-3|--3d] -k|--k=`*k*
`filter max [-3|--3d] -x|--k-x=`*kx* `-y|--k-y=`*ky* `[-t|--k-t=`*kt*`]`

Filter frames with a Maximum filter, in 2D or 3D (with the third dimension being the time). The kernel size can be given for each dimension, or once for all. It will be (2*kx*+1)x(2*ky*+1)[x(2*kt*+1)]. Different values for each direction lead to asymmetric filtering.

Example:

```
$ cvtool max -k 2 < in.pnm > out.pnm
```

2.8.6 convolve

`convolve -K|--kernel=`*K*
`convolve -X|--vector-x=`*X* `-Y|--vector-y=`*Y* `[-T|--vector-t=`*T*`]`

Convolve frames with the given convolution kernel.

Both 2D and 3D kernels are accepted (the third dimension is the time). If the kernel is separable, the vectors that generate it can be given instead, to reduce computation costs. All kernel elements must be integers. The size of the kernel must be an odd number in each dimension.

Example:

```
# Both commands are equivalent to 2D smoothing with the
# mean filter with k=1:
$ cvtool convolve -K 3x3:1,1,1,1,1,1,1,1,1 < in.pnm > out.pnm
$ cvtool convolve -X 3:1,1,1 -Y 3:1,1,1    < in.pnm > out.pnm
```

2.8.7 laplace

`laplace [-c|--c=`*c*`]`

Sharpens the input frames using the Laplace operator.

The sharpness factor *c* must be greater than or equal to zero. Larger values increase the effect. The default is 0.5.

Example:

```
$ cvtool laplace -c 0.7 < smooth.pnm > sharp.pnm
```

2.8.8 unsharpmask

`unsharpmask -u|--unsharp=`*file* `[-c|--c=`*c*`]`

Sharpens the input frames using unsharp masking.

The unsharp version of the input frames must be given using the '`--unsharp`' option. It can be produced using e.g. a 3x3 Gauss filter. The sharpness parameter *c* must be from (0.5, 1.0). The default is 0.7.

Example:

```
$ cvtool unsharpmask -u smoothsmooth.pnm -c 0.7 < smooth.pnm > sharp.pnm
```

2.9 Detecting Image Features

2.9.1 edge

`edge sobel`
`edge canny -s|--sigma=`*sigma* `-l|--low=`*l* `-h|--high=`*h*

Detect edges.

Sobel will generate graylevel frames: the brighter a point, the stronger the edge.

Canny will generate binary frames. The *sigma* parameter is for Gauss smoothing. *l* and *h* are used for Hysterese thresholding; both must be from [0,1].

If the input is PFS, then the output will be PFS too and will contain both a channel containing the edge strengths and a channel containing the edge directions. If the input is PNM, then the output will be graylevel frames containing only the strength information.

Example:

```
$ cvtool edge sobel < in.pgm > gray-edges.pgm
$ cvtool edge canny -s 1.2 -l 4 -h 8 < in.pgm > bw-edges.pgm
```

2.10 Comparing Frames

2.10.1 diff

`diff [-s|--statistics] [-o|--output=`*file*`]` *file-1 file-2*

Shows the differences between the two sources.

The sources must have the same pixel type, width, and height. This command produces frames of the same dimensions and of the same pixel type. Each pixel will be the absolute value of the difference of the corresponding pixels in the two sources. For RGB frames, the values will be computed for each channel separately.

If '`--statistics`' is used, the command will also compute the minimum, maximum, mean, and median error, and the standard deviation. For RGB frames, these values will be computed for each channel separately. For YUV frames, only the Y channel is considered. The output will be printed to `stderr`, unless it is redirected with the '`--output`' option. If the output is redirected to `stdout` (-), then only the statistics and no frames will be written to `stdout`.

Example:

```
$ cvtool create -w 10 -h 10 -c r255g0b0 > red.pnm
$ cvtool create -w 10 -h 10 -c r0g255b0 > green.pnm
$ cvtool diff -s -o - red.pnm green.pnm
frame pair 0: minimum error      = 1.0000 1.0000 0.0000
frame pair 0: maximum error      = 1.0000 1.0000 0.0000
frame pair 0: median error       = 1.0000 1.0000 0.0000
frame pair 0: mean error         = 0.9600 0.9600 0.0000
frame pair 0: standard deviation = 0.1969 0.1969 0.0000
```

2.11 High Dynamic Range (HDR) Images

2.11.1 tonemap

`tonemap -m|--method=schlick94 [--brightness=`*b*`]`
`tonemap -m|--method=tumblin99 [-l|--max-absolute-luminance=`*l*`] [--display-adaptation-level=`*d*`] [--max-displayable-contrast=`*c*`]`
`tonemap -m|--method=drago03 [-l|--max-absolute-luminance=`*l*`] [--max-display-luminance=`*d*`] [--bias=`*b*`]`

`tonemap -m|--method=reinhard05 [--intensity=i] [--light-adaptation=l] [--chromatic-adaptation=c]`
`tonemap -m|--method=ashikhmin02 [-l|--max-absolute-luminance=l] [--local-contrast=c]`
`tonemap -m|--method=durand02 [-l|--max-absolute-luminance=l] [--sigma-spatial=ss] [--sigma-color=sc] [--base-contrast=bc]`
`tonemap -m|--method=reinhard02 [--key-value=a] [--white=w] [--sharpness=s] [--epsilon=e]`

Tone map frames.

High dynamic range (HDR) frames are read from standard input, and low dynamic range (LDR) frames are written to standard output. See the original papers for a description of the parameters. For some methods, the results should be gamma corrected.

The default for the maximum absolute luminance is to get it from the file (if specified), or else 150.0.

The default for schlick94 is b=100.0.

The defaults for tumblin99 are d=100.0, c=70.0.

The defaults for drago03 are d=200.0, b=0.85.

The defaults for reinhard05 are i=0.0, l=0.5, c=0.5.

The default for ashikhmin02 is c=0.5.

The defaults for durand02 are ss=0.3, sc=0.4, bc=2.0.

The defaults for reinhard02 are a=0.1, w=1.0, s=10.0, e=0.5.

See also:

For general information:
E. Reinhard, G. Ward, S. Pattanaik, and P. Debevec. High Dynamic Range Imaging: Acquisition, Display and Image-based Lighting. *Morgan Kaufmann*, 2005.

For the `schlick94` method:
Section 7.2.9 of the HDRI book.

For the `tumblin99` method:
Section 7.2.2 of the HDRI book.

For the `drago03` method:
F. Drago, K. Myszkowski, T. Annen and N. Chiba. Adaptive Logarithmic Mapping For Displaying High Contrast Scenes. *Proc. Eurographics 2003*.

For the `durand02` method:
F. Durand and J. Dorsey. Fast Bilateral Filtering for the Display of High-Dynamic-Range Images. *Proc. ACM SIGGRAPH 2002*, pp. 257-266.

2.12 Miscellaneous

2.12.1 visualize

`visualize scalar [-p|--pseudo-color] [-m|--min=m] [-M|--max=M] [-l|--log=base]`
`visualize vector2 -m|--mode=color`
`visualize vector2 -m|--mode=needle [-x|--sample-x=x] [-y|--sample-y=y] [-X|--dist-x=dx] [-Y|--dist-y=dy] [-f|--factor=f]`

`visualize scalar`: Visualizes scalar values by transforming values from $[m,M]$ to [0,1] and writing the result as graylevel frames. M and m are automatically determined from the input if they are not given. By default, the transformation is linear. If '`--log`' is given, then the transformation will use the logarithm with the given base. If '`--pseudo-color`' is given, then pseudo colors are used instead of gray levels.

`visualize vector2`: Reads vector fields and visualizes them. Visualization as colors: Each of the x,y,z components, which range from -1 to 1, are transformed to R,G,B values that range from 0 to 1. Visualization as needle diagrams: Every x-th vector in horizontal direction and every y-th vector in vertical direction will be represented by a needle. The needles will have a distance of dx pixels in horizontal and dy pixels in vertical direction. The needle length is the length of the vector after it was scaled with the factor f. The default values are x=y=dx=dy=10, f=1.0.

Appendix A Command index

Appendix B Copying Information

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Version 3, 29 June 2007

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