Linux Driver for Sentech Cameras

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1 Introduction

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Sentech driver for Sentech USB Cameras
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```

2 Video4Linux2API

This driver implements the "VIDEO FOR LINUX TWO API" Specification.

To use the driver in your programs, consult the V4L2 API Specifications `http://v4l2spec.bytesex.org/spec/book1.htm`

3 ProprietaryFunctions

When using a video capture device (like the Sentech camera), users and application developers have the opportunity to select between a set of supported picture formats. Sample formats are: gray, BGR24, RGB24, YUYV, Bayern RGGB, Bayern BGGR.

Most Sentech cameras use Bayern RGGB8 or/and BGGR8 as native (raw) format. Other formats supported by the Linux driver are implemented in software, and therefore slower.

This driver implements some proprietary formats for pictures, as modification of the RGGB8. These formats are specified using the field "priv" of the pix_format structure passed as parameter to the VIDIOC_S_FMT and VIDIOC_G_FMT ioctl commands, for the V4L_PIX_FMT_SBGGR8 pixel format.

The priv flag is supported for drivers 1.x.x:

- priv = 0: standard BGGR Bayern format (with corrections and adjustments)
- priv = 1: native (RGGB) Bayern format without corrections (max speed)
- priv = 2: BGGR obtained by swapping neighboring R←→B fields in RGGB
- priv = 3: BGGR obtained by shifting the original RGGB 1 pixel up and left

Other driver module options are:

- - scale=1: [default], scales the pictures such that the whole capture image fits into the selected frame size. Note that CROP modifications are implemented in software by dropping picture areas. The same holds for picture size in SET FORMAT ioctl requests when scale=0. If partial (half/quarter horizontal lines) picture is set into the camera, then the scaled picture is based on the acquired half/quarter.
- -MARGINS, debug, param_continuous_capture: options are no longer used
- -param_freq_auto: if non-null, tells the frequency in Hz with which autobalance should be run else the value is 3 Hz. Not used in TRIGGER mode.
- -param_freq_auto_exp_avg: if SENTECH_AWB is not supported, then this parameter controls the exponential averaging speed, for moving from a current color balance to a new one. It is a number between 0 and 255.
- -param_buffers: the number of USB buffers to be pre-allocated per camera. Each buffer is of the maximum size for a picture supported by this camera.
- -SUBS_SUBMITTED: the number of USB buffers per camera enqueued at a given time.
- -param_bytesperline: if 1, then align line starts at distance given by the maximum line length
- -param_submit_user_buffers: if 1, then the driver may request data in buffers currently owned by the user process. In that case, the image may be overwritten by the USB while used by the user. Alternatively, if the user is too slow and keeps too many buffers, then the driver may starve of buffers and stop. In this case the driver will eventually restart SUBS_SUBMITTED buffers.
- -dynamic_scale: if 1, then the exposure value of the control will be automatically scaled based on the current format, to allow for fine exposure tuning. Otherwise the exposure is mapped between 0-255.

- -param_preallocate: set to 1 to preallocate USB buffers when the camera is attached, rather than when data is requested
- -param_try_fragments: if 1, then if allocation of large USB buffers fails, it will then try to create buffers out of small chuncks (not fully supported)
- -param_minor: should the device have a requested minor? -1 stands for autodetect
- -first_nb: cameras get names, with numbers, starting with first_nb the format of the name is "Sentech [TB83] USB Camera [minor]:[first_nb]"
- -param_streaming: enable the STREAMING mode with buffers inside the driver.
- -param_streaming: enable the STREAMING mode with buffers inside the client. Currently not supported for lack of interest! If you need support, ask for it!
- -param_overlay: enable the OVERLAY capability. currently not implemented for lack of interest! If you need support, ask for it!
- -param_read: enable the access to images by reading from the device file descriptor. Supported flags for read are: O_SYNC for issuing a software trigger before attempting to read O_NONBLOCK for nonblocking read
- -y16: should enable grey 16 bit /pixel support
- -grey: should enable grey 8 bit / pixel support
- -rggb: should enable rggb Bayern support
- -bggr: should enable bggr Bayern support
- -rgb24: should enable rgb24 support
- -bgr24: should enable bgr24 support
- -yuyv: should enable yuyv support
- -yuv420: should enable yuy420 support (only available if compiled without Sentech_AWB)
- -cfg_saturation: set to 1 to support the Saturation control this will incur in a slight decrease of speed, since the saturation is performed in software.
- -color_correction: set to 1 to support the color Balance controls
- -brightness_correction: set to 1 to support the color Brightness control this will incur in a slight decrease of speed, since the brightness is performed in software. We recommend to use the luminance and gain controls which work in hardware. Alternatively, for Auto Luminance, I recommend setting brightness using the luminance TARGET control.

- -filter_short_frames: set to 1 to discard frames that were not captured completely. 0 returns frames where bytes were lost (maybe due to the processing speed of the machine), potentially resulting in distortions and color shifts.

- -trigger_on_fail: When in trigger mode, what to do when the requested image is lost due to some USB conflict? If you set this parameter to 1, then a software trigger is issued automatically whenever such an image is lost.

The trigger mode does not support auto-AWB or auto-Luminance! Currently, these could be calibrated with the camera in normal mode, before passing to trigger mode.

The software trigger was tested with the application "kdetv", which can use the controls of the driver to set the trigger mode and the software trigger source (from the advanced controls panel).

Alternatively, users can set the triger modes using the commands:

```
v4l2-ctl -c "trigger_source:_ign_soft_hard=1"
v4l2-ctl -c "trigger:_normal_trigger_t2_t3=1"
```

And then issue software triggers with:

```
v4l2-ctl -c "software_trigger=1"
```

From programs, use the control IDs

- V4L2_CID_STC_TRIGGER_SOURCE (1 for software and 2 for hardware trigger)

- V4L2_CID_STC_TRIGGER_MODE (1 for trigger and 0 for normal)

respectively
V4L2_CID_STC_TRIGGER (button, for raising software trigger)
where:

```
#define V4L2_CID_STC_TRIGGER_MODE V4L2_CID_PRIVATE_BASE+7
#define V4L2_CID_STC_TRIGGER_SOURCE V4L2_CID_PRIVATE_BASE+8
#define V4L2_CID_STC_TRIGGER V4L2_CID_PRIVATE_BASE+11
```

The seing all available values that can be used with MENU controls, run:

```
v4l2-ctl -L
```

Here is the list of all controls IDs:

```
// MENU Controlling the frame/second parameter
#define V4L2_CID_STC_FPS V4L2_CID_PRIVATE_BASE+0
// MENU Controlling the height of the image
#define V4L2_CID_STC_HEIGHT V4L2_CID_PRIVATE_BASE+1
```

```
// Controlling the red balance
#define V4L2_CID_STC_RED V4L2_CID_PRIVATE_BASE+2
// Controlling the green balance
#define V4L2_CID_STC_GREEN V4L2_CID_PRIVATE_BASE+3
// Controlling the blue balance
#define V4L2_CID_STC_BLUE V4L2_CID_PRIVATE_BASE+4
// Controlling the gamma correction. A limited set of
// gamma correction values are available. Ask for other
// values if you need.
#define V4L2_CID_STC_GAMMA V4L2_CID_PRIVATE_BASE+5
// Controlling the target luminance at Auto Luminance
#define V4L2_CID_STC_TARGET V4L2_CID_PRIVATE_BASE+6
// MENU Controlling the trigger mode: Normal, Trigger, etc
#define V4L2_CID_STC_TRIGGER_MODE V4L2_CID_PRIVATE_BASE+7
// MENU Controlling the trigger source: ignore, software, hardware
#define V4L2_CID_STC_TRIGGER_SOURCE V4L2_CID_PRIVATE_BASE+8
// Controlling the digital gain (in hardware)
#define V4L2_CID_STC_DIGITAL_GAIN V4L2_CID_PRIVATE_BASE+31
// Button control to issue the software trigger
#define V4L2_CID_STC_TRIGGER V4L2_CID_PRIVATE_BASE+11
// MENU Controls to set the function of IO channels
#define V4L2_CID_STC_IO0_FUNCTION V4L2_CID_PRIVATE_BASE+12
#define V4L2_CID_STC_IO1_FUNCTION V4L2_CID_PRIVATE_BASE+13
#define V4L2_CID_STC_IO2_FUNCTION V4L2_CID_PRIVATE_BASE+14
#define V4L2_CID_STC_IO3_FUNCTION V4L2_CID_PRIVATE_BASE+15
// Control to read/set the LED
#define V4L2_CID_STC_LED V4L2_CID_PRIVATE_BASE+16
// Control for ReadOut select
#define V4L2_CID_STC_RO_SEL V4L2_CID_PRIVATE_BASE+17
// Control for selecting the exposure mode
#define V4L2_CID_STC_EXP_MODE V4L2_CID_PRIVATE_BASE+18
// Controls to set corresponding trigger/exposure delays
#define V4L2_CID_STC_EXP_D1 V4L2_CID_PRIVATE_BASE+19
#define V4L2_CID_STC_EXP_D2 V4L2_CID_PRIVATE_BASE+20
#define V4L2_CID_STC_D_TRG_EXP V4L2_CID_PRIVATE_BASE+21
#define V4L2_CID_STC_D_TRG_ST V4L2_CID_PRIVATE_BASE+22
#define V4L2_CID_STC_D_TRG_END V4L2_CID_PRIVATE_BASE+23
#define V4L2_CID_STC_D_TRG_I_O V4L2_CID_PRIVATE_BASE+24
#define V4L2_CID_STC_W_TRG_OUT V4L2_CID_PRIVATE_BASE+25
#define V4L2_CID_STC_D_RO V4L2_CID_PRIVATE_BASE+26
// Control for refreshing memory
#define V4L2_CID_STC_REFRESH V4L2_CID_PRIVATE_BASE+27
// Button Control for reseting the frame counter
#define V4L2_CID_STC_CNT_RST V4L2_CID_PRIVATE_BASE+28
// Button Control for issuing a ReadOut request
#define V4L2_CID_STC_RO V4L2_CID_PRIVATE_BASE+29
```

```
// Button Control for issuing a SubTrigger request
// for ending the exposure
#define V4L2_CID_STC_SUB_TRG V4L2_CID_PRIVATE_BASE+30
// From 2.2.19, there is a button control with the id (V4L2_CID_PRIVATE_BASE+31)
which will clear the buffers of the camera.
#define V4L2_CID_STC_CLEAR_STATE V4L2_CID_PRIVATE_BASE+31
// Sentech versions of the autowhitebalance \& gain
#define V4L2_CID_STC_AUTO_WHITE_BALANCE V4L2_CID_PRIVATE_BASE+36
#define V4L2_CID_STC_AUTOGAIN V4L2_CID_PRIVATE_BASE+37
// The exposure setting in us
#define V4L2_CID_STC_EXPOSURE_US V4L2_CID_PRIVATE_BASE+38
```

Note that after the button control is set, a picture found on transfer on the USB bus may still arrive. Therefore for safety this button should be set with at least one frame delay after the camera mode is set to trigger.

Also note that one will still require one hardware trigger before the mode is fully set to "hardware trigger".

Setting the frame rate The frame rate (i.e. the clock speed) can be set in 2 ways:

- The control V4L2_CID_STC_FPS, defined above. It allows to set a value between 0 and 2, specifying the WHOLE_SCREEN, HALF_SCREEN, and QUART_SCREEN, respectively. Note that the frame rate is automatically doubled if the scan mode halves the picture height.
- The VIDIOC_S_PARM ioctl can set the frame rate by using the parameter V4L2_CAP_TIMEPERFRAME can specify the frame rate using a ratio. The current value for the ratio is obtained with the ioctl VIDIOC_G_PARM. The available ratios are given by the smallest irreducible fractions needed to describe the full-picture framerate corresponding with the desired clock rate. You can see the list of available ratio under the entry for "frames_per_second_4_25_9_5_19" with:

  ```
  v4l2-ctl -L
  ```

  Note that currently the framerate ratio does not correspond to the real value if the picture scan mode is STC_HALF_SCREEN or STC_QUART_SCREEN.

4 Capabilities

This release of the driver implements:

1. Capture of data using:
   - -read (tested with ekiga)

- -mmap
  - driver_buffers (Memory mapping with user buffers is only implemented in the generation 1.x.x of the drivers. If you need it for newer versions, please formulate your request to Sentech).

2. Controls:
   (a) - brightness
   (b) - saturation
   (c) - gain (following controls are temporarily disabled)
   (d) - frame rate: 14fps 30fps 60fps (V4L2_CID_PRIVATE_BASE)
   (e) - picture height: 1/4 1/2 1 (V4L2_CID_PRIVATE_BASE+1)
   (f) - red and blue balance
   (g) - autogain and luminance
   (h) - auto white balance
   (i) - one shot white balance

3. Picture formats (non-interlaced):
   (a) - Bayern BGGR, RGGB (see "ProprietaryFunctions" file for details)
   (b) - RGB24, BGR24, YUYV 4:2:2
   (c) - YUV420 is available under some systems, same as Y16.

4. Module parameters
   (a) - to disable yuyv output you need to set parameter "yuyv=0"
   (b) - to disable support for READ interface set "param_read=0"
   (c) - to disable support for streaming (mmap) interface set "param_streaming=0"
   (d) - to enable color compensation controls, set parameter color_correction
   (e) - use param_freq_auto to set speed of auto-white-balance

The exposure target tells the desired luminance of the picture. The "Exposure" of Sentech cameras can be set in 2 ways. The first way is by specifying a value in range 0-255, which is internally scaled to whatever is the maximum range for the "Number of Total Clocks". 0 is the default exposure of the hardware. The default exposure value of the module is 33, but it will be automatically if the "auto luminance" is active (which is the default setting).

Actually, the exposure range is in newer versions automatically extended to enable maximum resolution, and the default is 0.

Values for exposure:

A rough calculation can be made based on the fact that the maximum exposure is 1/15th of a second (when set to 15 frames per second clocking). If 1/15th of a second equals an exposure control value of 255, then it would seem a rough exposure would be:

```
255 = 1/15th
128 = 1/30th
64 = 1/60th
32 = 1/120th
16 = 1/240th
```

Currently the CONTRAST is treated as a the EXPOSURE (but reading the value of the control returns only the value set with the same method). The gain is set with the GAIN control.

The frame rate is set with the control id V4L2_CID_PRIVATE_BASE, and the picture height is set with V4L2_CID_PRIVATE_BASE+1.

Gamma correction Another similar couple of synonyms is V4L2_CID_GAMMA and V4L2_CID_PRIVATE_BASE+5, which are used for specifying the gamma correction. There are 25 possible values for the gamma correction, between 0 and 24, the default being 14. The smallest gamma correction value corresponds to an exponent of 0.01, and the largest to an exponent of 3. The default gamma exponent is 1.

The available values for gamma exponents are: 0.01, 0.025, 0.05, 0.075, 0.1, 0.125, 0.15, 0.175, 0.2, 0.25, 0.3, 0.45, 0.6, 0.8, 1, 1.2, 1.4, 1.6, 1.8, 2, 2.2, 2.4, 2.6, 2.8, 3

The control ID values for these parameters are:

```
auto gain/exposure (ctrl = V4L2_CID_AUTOGAIN)
auto white balance (ctrl = V4L2_CID_AUTO_WHITE_BALANCE)
do white balance (ctrl = V4L2_CID_DO_WHITE_BALANCE)
auto exposure target (ctrl = V4L2_CID_PRIVATE_BASE+6)
```

In the driver version 2.3.12 we have added the possibility to set the defaults for:

1. -brightness,
2. -gamma,
3. -exposure,
4. -gain, and
5. -auto exposure target

both when you compile, and when you insert the module

At insertion you could use parameters: default_gamma, default_gain, default_exposure, default_brightness, default_exposure_target

At compilation time you can uncomment and edit the following lines of the Makefile:

```
#EXTRA_CFLAGS += -DSTC_DEFAULT_GAMMA=14
#EXTRA_CFLAGS += -DSTC_DEFAULT_EXPOSURE=0
#EXTRA_CFLAGS += -DSTC_DEFAULT_EXPOSURE_TARGET=33
#EXTRA_CFLAGS += -DSTC_DEFAULT_GAIN=128
#EXTRA_CFLAGS += -DSTC_DEFAULT_BRIGHTNESS=0
```