

ADUVC - AN AREADETECTOR DRIVER FOR USB VIDEO CLASS (UVC)

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Abstract

Most devices supported by the Experimental Physics and Industrial Control System (EPICS) areaDetector project fall under one of two categories: detectors and cameras. Many of the cameras in this group can be classified as industrial cameras, and allow for fine control of exposure time, gain, framerate, and many other image acquisition parameters. This flexibility can come at a cost however, with most such industrial cameras' prices starting near one thousand dollars, with the price rising for cameras with more features and better hardware. While these prices are justified for situations that require a large amount of control over the camera, for monitoring tasks, and some basic data acquisition, the use of consumer devices may be sufficient while being far less cost-prohibitive. The solution we developed was to write an areaDetector driver for USB Video Class (UVC) devices, which allows for a variety of cameras and webcams to be used through EPICS and areaDetector, with most costing under \$100.

Introduction

- The EPICS areaDetector project enables universal camera and detector control for EPICS installations through the use of camera-specific driver implementations that all share an underlying base, called ADCore.
- In some cases, expensive industrial cameras may be unnecessary. In such situations, a cheaper more flexible alternative to these expensive industrial cameras would perhaps be more suitable.
- We added USB Video Class (UVC) device support to EPICS areaDetector in order to fill this requirement of very inexpensive cameras.

The USB Video Class (UVC) Standard

The UVC standard is utilized almost universally among USB cameras and video devices, most notably in consumer webcams. Most operating systems that allow for viewing camera images via a dedicated application (i.e. the Windows 10 "Camera" application) are internally using a custom UVC driver for camera control.

- Each UVC device must have a series of predefined formats within firmware that can be read according to the standard, supplying all required image information to the driver prior to streaming initialization, including the data type of the output, and the color mode of the resulting image. (Figure 2)
- Each UVC device must support standard commands sent over the USB interface for starting and stopping streaming
- Each UVC device must send frames back to the driver in a standardized format

UVC gives us a high level communication protocol that can be reused between most devices, much like how ADCore contains functionality common to all areaDetector cameras.

Format	Data Type	Color Mode
MJPEG	UInt8	RGB
RGB	UInt8	RGB
Grayscale	UInt8/UInt16	Mono
YUYV	UInt8	RGB/Mono
Uncompressed	UInt8/UInt16	RGB/Mono

Figure 2: Formats supported by most UVC cameras. Most cameras support least two such formats.

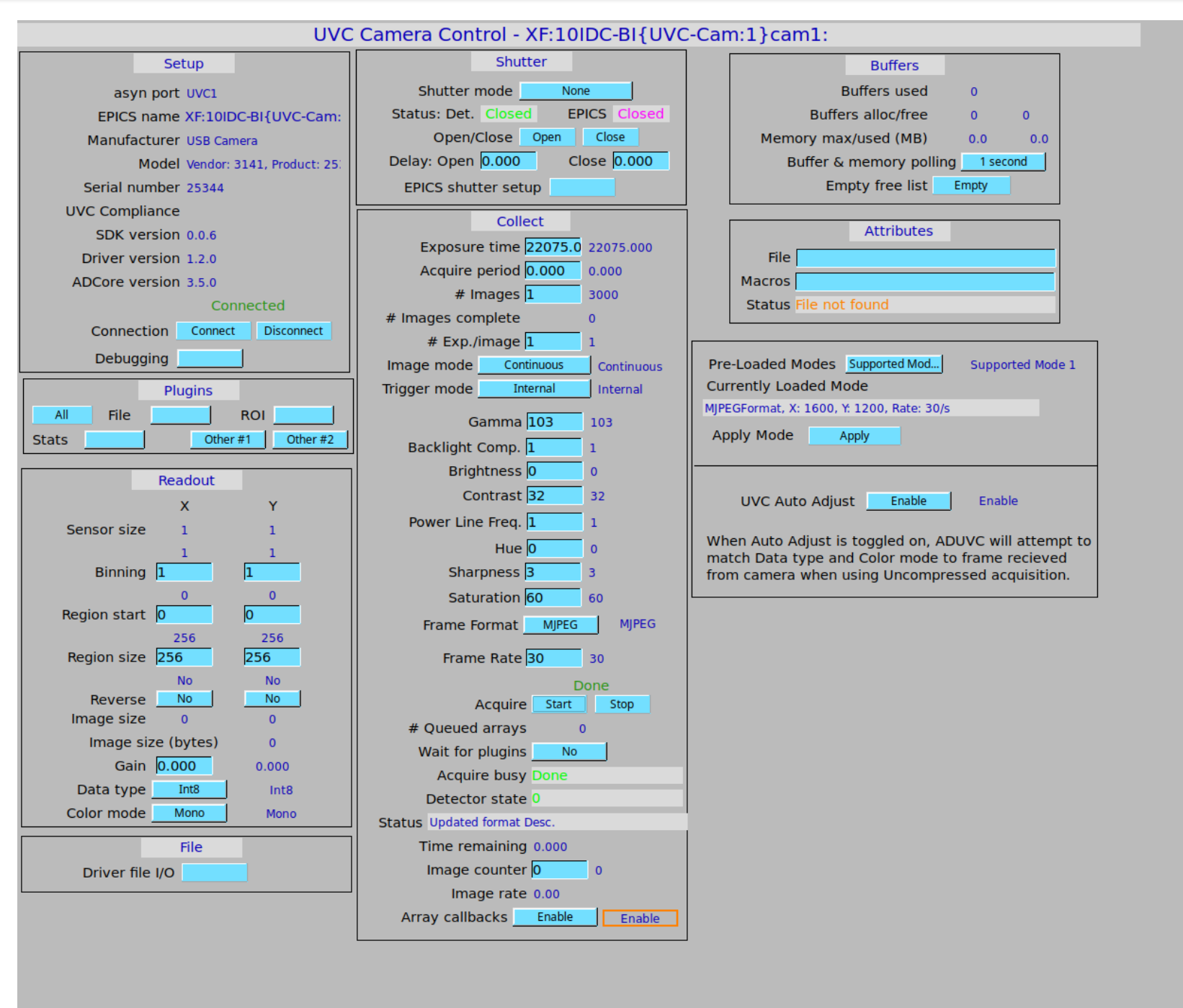


Figure 1: The user interface screen developed for use with the ADUVC driver

ADUVC – An EPICS areaDetector driver for UVC

Uses libusb (for usb communication), libuvc (for handling UVC protocol commands), and libjpeg (for handling JPEG decompression). ADUVC builds an EPICS shell around libuvc, allowing users to call library functions through write requests on EPICS process variables (PVs). The driver is based on other areaDetector drivers, most notably the ADProsilica and ADPointGrey drivers. It uses a callback function defined during the libuvc start streaming call to grab the frames from the UVC device, convert them into the areaDetector ndarray standard, and pass them back up the chain to the EPICS layer. All of the other supported camera parameters in libuvc are represented internally in the driver as PVs, and when writing a new value through a user interface (Figure 1), the appropriate libuvc function is fired sending the new value for the appropriate parameter to the camera.

We tested ADUVC with 8 different cameras at varied price points, and observed very impressive results relative to the costs (Figure 5). Unique form factors were also found when using ADUVC with cameras, with pencil and snake cams (Figure 4) allowing for some use-case flexibility. Presently, there are a total of 9 cameras deployed and in use at NSLS2 beamlines, and this number is likely to grow in the future. Two of the more impressive tested devices were the See 3 Cam from E-Con Systems (Figure 3), which allowed for both 16 bit Mono and 8 bit RGB acquisition at high framerates and resolutions, and the Webcamera IMX322 (Figure 6) which was extraordinarily inexpensive, and came with both a lens and standard mounting hardware (we had to 3D print an enclosure for the See 3 Cam). We used this camera to take some preliminary test images of the beam at the 17BM beamline (Figure 3).

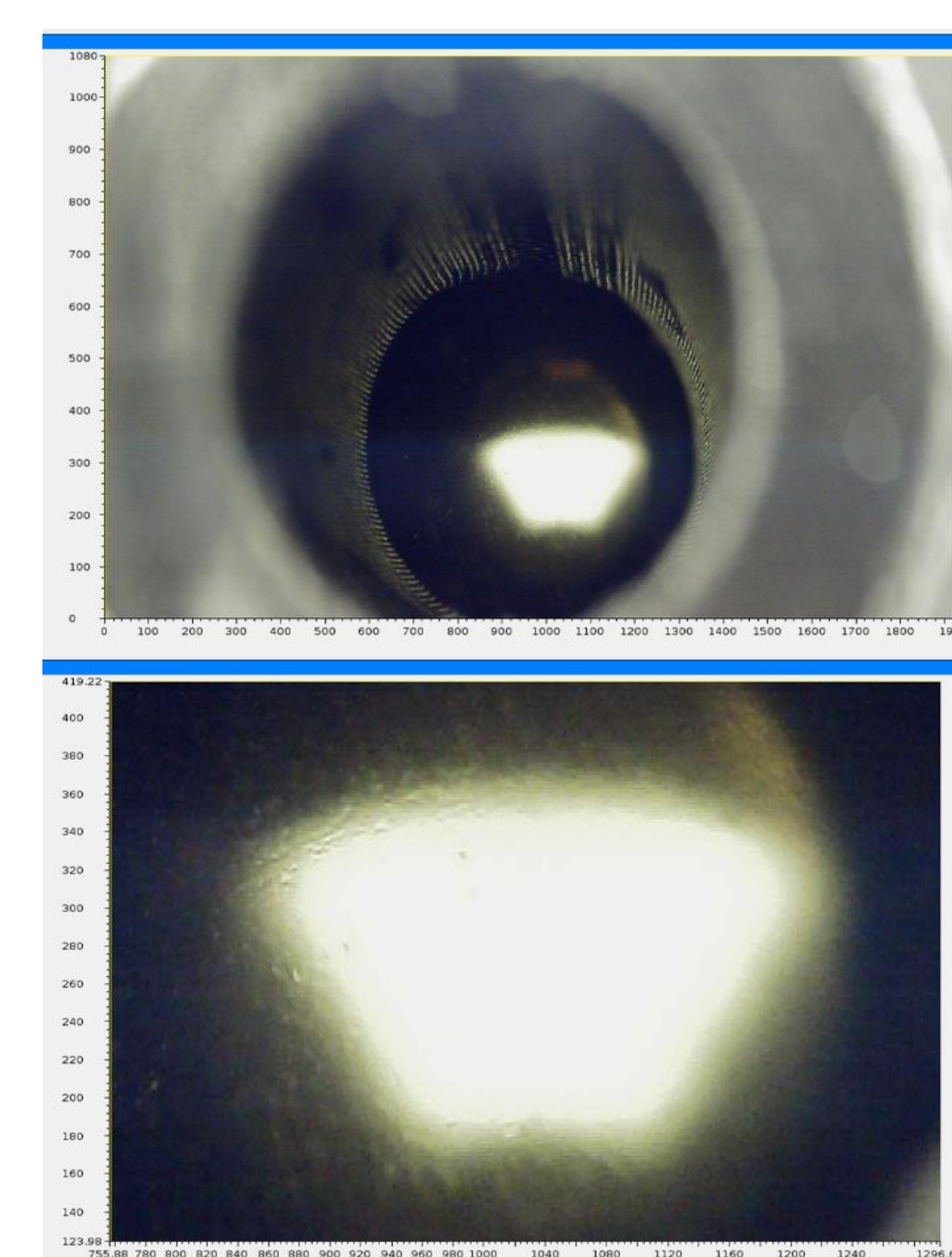


Figure 3: Initial beam images captured with the Webcamera IMX322 (Left), The See 3 Cam industrial camera in monitoring use at the 17BM beamline (Right)



Figure 4: The Opti-Tekscope Pencil Camera, used for monitoring

UVC Device	Max Resolution/Framerate	Cost with lens
E-Con Systems See 3 Cam	2592 x 1944 @ 60 fps	300 \$
Webcamera IMX322	1920 x 1080 @ 30+fps	75 \$
Opti-Tekscope microscope camera	1600 x 1200 @ 30 fps	28 \$
Fantronics Snake Camera	1200 x 900 @ 30 fps	20 \$

Figure 5: Resolution vs Framerate on several of the UVC devices we tested



Figure 6: The Webcamera IMX322, which was used to capture some initial beam images.

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