International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Survey of Camera APIs

Karthick Kumaran Ayyalluseshagiri Viswanathan[1], Karthik Poduval[2]

[1]Member, IEEE

[2]Member, IEEE

Abstract: ***Cameras have become very common in most consumer electronics and industrial products like mobile phones, augmented/virtual reality headsets, tablets, robotics, drones, automobiles, door cameras. To capture frames from the camera sensors these products use different camera APIs based on the industry segment, requirements and the underlying operating system of the product. In this paper we will cover some of the most popular camera APIs used across the industry.***

Keywords: Cameras, HAL3, Genicam, UVC, libcamera

1. Introduction

Many of the consumer electronics products that are selling in the market now have cameras for some use cases. Cameras have become an important peripheral in the various consumer electronics and industrial products. Mobile phones now have more than two cameras in general, one front camera and two or more rear cameras for main, Ultra-wide, telephoto captures. Augmented/virtual reality, robotics, automotive products include multiple cameras for environment tracking for SLAM, object detection, object recognition for computer vision applications and typical color image capture for human vision consumption. Each market or product segment uses cameras differently and hence use a different camera API based on historical use or industry wide agreement or semiconductor company offering or operating system requirements. For example, all Android mobile phones use HAL3 APIs, European Machine Vision Association uses GenICam APIs, webcams use libuvc, chromium-based notebooks and tablets use libcamera APIs and some legacy camera applications use V4L2 APIs. We will see some high-level details of each API in the upcoming sections in this paper.

1) GenICam

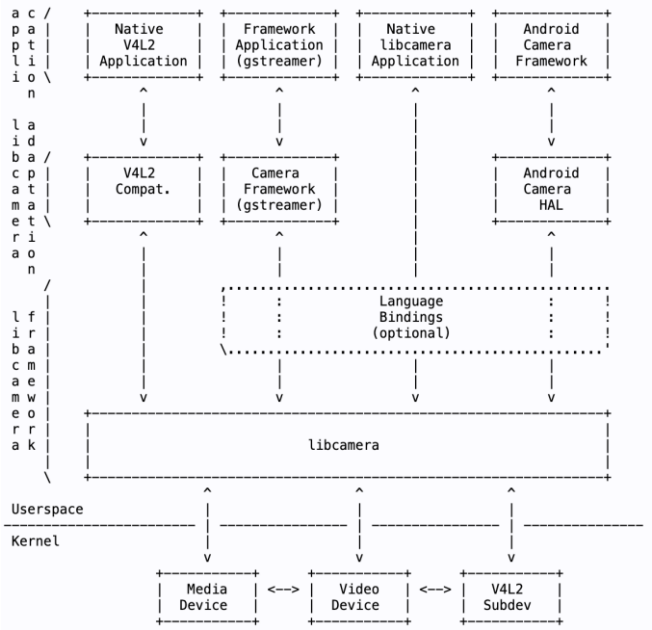
GenICam stands for Generic Interface for Cameras. GenICam is the generic software interface standard used by the European Machine Vision association. Cameras currently used in machine vision are configurable by reading and writing some parameters in the camera sensor registers. GenICam provides an end-to-end configurable software interface for various standard interfaces including GigE vision, Camera Link, USB3 Vision covering all camera types and formats. The core of GenICamis the XML descriptor file which contains the description of the camera properties. A translator or parser parses the XML file and generates an API called GenAPI or the elements of the Graphical User Interface. This allows the user to access the gain, exposure time and other functions available on the camera. The most popular Basler cameras use the GenICam APIs.

2) Android HAL3

All Android mobiles phones come with one camera sensor in the front and one or more camera sensors in the rear side of the phone. Android phones use HAL3 camera APIs to take snapshot, video recording, slow motion, timelapse and video streaming use cases. HAL3 provides the benefit of changing the camera parameters at a per-frame level. Each frame has a request and result. Camera application has to submit a request, process_capture_request, for each frame capture with the buffer and other settings attached to the request. This buffer will be used by the underlying camera driver for dumping the captured image contents from the camera. There are two callbacks provided by HAL3 namely notify and process_capture_result. Upon each frame capture, the camera application gets notification from both notify and process_capture_result. Notify callback is used to notify the timestamp of the successfully captured frame and error in case of any failures whereas process_capture_result contains the buffers filled by the underlying camera driver which then be used by the application for display or video streaming or storage. Camera applications can also change the camera settings like exposure, gain, crop parameters every frame in the process_capture_request call.

3) Libcamera

Libcamera is the open source API developed for the chromium project and also envisioned to be the default camera API for many linux distros. libcamera's vision is to sit on top of Linux V4L2 Media Controller devices and provide a high level API similar in spirit to Android HAL3. The reason libcamera came into existence is because directly implementing complex ISP pipelines on top of V4L2 Media Controller was getting very difficult. Libcamera provides a set of common re-usable objects that make it easier to interact with V4L2 Media Controller devices while doing ISP pipeline specific implementations inside of a custom pipeline handler. This is quite different from HAL3 which only defines an API while libcamera provides a suite of helper objects to make development of pipeline handlers easier. Libcamera also provides a mechanism to ship proprietary algorithms such as 3A algorithms and provides a customizable framework for doing this to ISP implementers. Libcamera also contains a HAL3 emulation on top of native libcamera API as well as V4L2 Compat to deal with applications written to use simple USB webcams. Fundamentally the libcamera API consists of creating requests that contain one or more streams. Such requests can get set with controls and request return back the metadata. Such request controls can be set on a per frame basis and requests will return with metadata. This allows us to implement HAL3 requests on top of libcamera API. Libcamera also includes a multi stream capable libcamerasrc gst plugin.



4) Libuvc

UVC stands for USB Video Class. libuvc is a cross platform library used for USB video devices like webcams. This library is built on top of the Linux USB library libusb. libuvc supports enumeration, control and streaming for USB Video class devices such as webcams. libuvc provides UVC devic discovery and management API. It supports video streaming with asynchronous and synchronous callback modes. It also supports read/write access to the UVC device settings. The library also can convert between various image formats like RGB, YUV.

5) V4L2

V4L2 stands for Video for Linux 2. V4L2 is the oldest and legacy camera API implemented in the Linux operating system for capturing images from the camera sensor and displaying images to the display. The concept of traditional V4L2 applies to just a single camera like the USB cameras or simpler cameras that support single streams. The API is very powerful and provides support to set/get formats, frame rates, parameters, allocate/deallocate/import buffers, queue/ dequeue buffers etc and it's up to the application to make use of all these API's in whatever way possible thus making it very flexible. The media controller enhancement of V4L2 supports complex ISP pipelines and it is recommended to use this in conjunction with libcamera.

2. Conclusion

This paper provided the high-level overview of the most popular camera APIs used in the industry. This paper doesn't recommend any particular camera API to use as it is completely dependent on various factors like the market segment, underlying operating system, semiconductor vendor offerings etc., For more details of the particular API please refer to the corresponding API specification.

References

[1] https://source.android.com/docs/core/camera/camera3
[2] HAL3 Documentation https://android.googlesource.com/platform/hardware/libhardware/+/refs/heads/main/include_all/hardware/camera3.h
[3] https://libcamera.org/docs.html
[4] https://github.com/libuvc/libuvc