Computer Vision and new areaDetector features

by K. Gofron, J. Wlodek, M. Rolland

- CSS opi deployment AD3-4
- areaDetector Binaries
- AD ioc structure
- ImageJ clients
- Codecs and Compression

- Computer Vision
- New AD drivers (Lambda, Spinnaker, Emergent Vision, Barcode plugin, ...)
- USB cameras support

Code:
https://github.com/epicsNSLS2-areaDetector
https://github.com/epicsNSLS2-deploy
https://epics.nsls2.bnl.gov/bundle

January 18, 2019
Organized by K. Gofron (kgofron@bnl.gov) and NSLS2 Controls
Summary

A. The deployment of areaDetector R3-4 for NSLS2 beamline.
   1. Binary package deployment.
   2. New ioc structure components for areaDetector.
   3. Updated features of CSS areaDetector screens.
   4. ImageJ - integrated into CSS.

B. New EPICS areaDetector drivers and plugins for detectors.
   1. Lambda X-ray detector (10ID, 8ID, 12ID).
   2. Spinnaker support for BlackFly S USB3.1 camera (28ID).
   3. EPICS driver for USB Video Class cameras.
   4. EmergentVision (IMX 264, 5Mpel) 10Gb EPICS camera driver, and support for upcoming 25Gb camera.
   5. Barcode ADPluginBar plugin module.

C. The deployment of areaDetector R3-4 for NSLS2 beamline.
   1. The ability to utilize OpenCV functionality from within AD allows for automation and for fast real time image processing by scientists. The solution integrates OpenCV into an AD plugin in such a way that generic input and output variables allow for an exhaustive implementation of the library.
   2. Demonstration on live beamline system will be shown.
areaDetector Binaries

areaDetector ioc

```c
#!/epics/prod/Deb8/master/areaDetector/ADAandor3/iocs/andor3IOC/bin/linux-x86_64/andor3App st.cmd
erlogInit(20000)

< /epics/prod/Deb8/master/envPaths < unique.cmd

dbLoadDatabase("$(ADANDOR3)/iocs/andor3IOC/dbd/andor3App.dbd")
andor3App_registerRecordDeviceDriver(pdbbase)

# andor3Config(const char *portName, int cameraId, int maxBuffers,
#    size_t maxMemory, int priority, int stackSize,
#    int maxFrames)
andor3Config("$(PORT)", $(CAMERA), 0, 0, 0, 0, 100)
dbLoadRecords("$(ADANDOR3)/db/andor3.template", "P=$(PREFIX),R=cam1:,PORT=$(PORT),ADDR=0,TIMEOUT=1")

asynSetTraceIOMask("$(PORT)",0,2)
asynSetTraceMask("$(PORT)",0,255)

# Create a standard arrays plugin, set it to get data from first Andor Neo driver.
NDStdArraysConfigure("Image1", 5, 0, "$(PORT)", 0, 0)```
areaDetector ioc

---

```bash
# Specific to camera
# Date: 2018-08-22
# Author: K. Gofron
#
#
# NELEMENTS = 3*(X x Y) = 1360 x 1024 x 3 = 4177920, which is the number of pixels in RGB image:
#
# CAMERA (X x Y) = NELMT: 3*NELMT: MAX_ARRAY_16b: MAX_ARRAY_24b
# Prosilica GC1290/GT1290: 1280 * 960 = 1228800; 3686400 2457600 Bytes 3686400
# Prosilica Mako G-125B: 1292 * 964 = 1245488; 3736464 2490976 Bytes 3736464
# Prosilica GX1920: 1936 * 1456 = 2818816; 8456448 5637632 Bytes 8456448
# Prosilica GC1380: 1360 * 1024 = 1392640; 4177920 2785280 Bytes 4177920
#
#
# 10.3.23: 00-03-31-4c-9f-3b 50-0503338399 - Manta_G-125B - Unique ID = 5021499
# Andor Neo uses Camera Link with fiber extender

epicsEnvSet("ENGINEER", "K. Gofron X5283")
epicsEnvSet("LOCATION", "ANDOR");
epicsEnvSet("PORT", "ANDOR")

epicsEnvSet("EPICS_CA_AUTO_ADDR_LIST", "NO")
epicsEnvSet("EPICS_CA_ADDR_LIST", "10.18.0.255")
epicsEnvSet("EPICS_CA_MAX_ARRAY_BYTES", "60000000")

# epicsEnvSet("CAM-IP", "10.18.1.41")
# epicsEnvSet("UID-NUM", "5021499")
epicsEnvSet("PREFIX", "XF:18IDB-BI\{DetNeo\}")
epicsEnvSet("CTPREFIX", "XF:18IDB-BI\{DetNeo\})
epicsEnvSet("HOSTNAME", "xf18idb-loc1")
epicsEnvSet("IOCNAME", "camb1")
epicsEnvSet("QSIZE", "21")
epicsEnvSet("NCHANS", "2048")
epicsEnvSet("HIST_SIZE", "4096")
epicsEnvSet("XSIZE", "2560")
epicsEnvSet("YSIZE", "2160")
epicsEnvSet("NELMT", "5529600")
epicsEnvSet("NDTYPE", "Int16") #Int8 (8bit B/W, Color) | Int16 (16bit B/W)
epicsEnvSet("NDFTVL", "SHORT") #UCHAR (8bit B/W, Color) | SHORT (16bit B/W)
epicsEnvSet("CBUFFS", "500")

# The ANDOR camera number in the system
epicsEnvSet("CAMERA", "0")
```

Brookhaven National Laboratory

Brookhaven Science Associates
EPICS AD deployment and drivers

https://github.com/epicsNSLS2-deploy

opi_organizer
Scripts for creating a directory of CS-Studio OPIs
- Python  Updated 17 days ago

ioc_deploy
Scripts for deploying an areaDetector IOC
https://rollandmichael7.github.io/ioc-manual/
- Shell  ★ 1  ★ 1  Updated on Dec 7, 2018

ImageJmacro
A ImageJ macros for populating the PV in EPICS CA/PVA plugins
- Shell  Updated on Nov 8, 2018

https://github.com/epicsNSLS2-areaDetector

ADCompVision
Forked from jwlodek/ADCompVision
A computer vision extension plugin for EPICS Area detector.
- C++  1  Updated 3 days ago

ADPluginBar
Forked from jwlodek/ADPluginBar
A barcode and QR code reader for EPICS area detector
- C++  2  Updated 13 days ago

ADUVC
Forked from jwlodek/ADUVC
An EPICS area detector driver for USB Video Class (UVC) devices
- C  1  Updated 22 days ago
EPICS AD deployment and drivers
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</tbody>
</table>
EPICS AD deployment

https://github.com/epicsNSLS2-deploy

A. The deployment of areaDetector R3-4 for NSLS2 beamline.
   1. Binary package deployment.
   2. New ioc structure components for areaDetector.
   3. Updated features of CSS areaDetector screens.
   4. ImageJ - integrated into CSS.
CSS opi versions
AreaDetector: Deployments

- Centralized repository of pre-compiled AreaDetector installations
- Removes need to download and compile AreaDetector for every new computer, new release, new OS
- Support for Debian 7, 8, 9
- Deployment for ‘master’ version and legacy versions

- Can be downloaded from:
  - https://gitlab.nsls2.bnl.gov/kgofron/ADbinaries
  - NFS mount: /controls/prod/Deb9

- Each deployment:
  - Stored as .tar file
  - Contains README with version information
  - Contains ADAndor3, ADCore, ADLambda, ADMerlin, ADPilatus, ADPluginBar, ADProsilica, ADSimDetector, ADSupport, ADViewers
  - Also contains EPICS base, ‘core’ EPICS modules
  - asyn, autosave, busy, calc, iocStats, seq, sscan
  - Not full copies; only required parts
ImageJ - PVA

Java-based image processing program integrated with EPICS

Access from color_camera_pva opi

Two options: Channel Access and PVA

Click Start in ImageJ screen to display image
ImageJ: Dynamic Profiler

Use rectangle or line tool to select part of image

Click Plugins → Dynamic Profiler

ImageJ constructs profile of selected area in real time
OneWire screens for 18id
Machine Vision in areaDetecor

1. The ability to utilize OpenCV functionality from within AD allows for automation and for fast real time image processing by scientists. The solution integrates OpenCV into an AD plugin in such a way that generic input and output variables allow for an exhaustive implementation of the library.

2. Demonstration on live beamline system will be shown.
Introduction to CV

- What is Computer Vision?
- Why is it useful?
- What are some CV solutions?

Courtesy of 11BM - Masa
ADCompVision

1. CV has many applications - should be integrated into EPICS/CSS

2. How? - an areaDetector plugin

3. ADCompVision is intended to be a comprehensive implementation of OpenCV for use with areaDetector. Currently, it supports:

- Gaussian Blur
- Thresholding
- Laplacian edge detection
- Canny edge detection
- Centroid identification
- And user definable functions
ADCompVision is structured in such a way that adding additional, custom functionality requires only basic understanding of C++ programming and the OpenCV Library. The entirety of the plugin’s interfacing with EPICS has been contained in a separate location to make adding new functionality as painless as possible.

In addition, because of the breadth of the solution, generic input and output variables are reused between functions, but each is described when a function is selected.
ADCompVision - Threshold

**Vision Function Set #1**  
<table>
<thead>
<tr>
<th>Input #1</th>
<th>80</th>
<th>Threshold Value (Int)</th>
<th>Output #1</th>
<th>361</th>
<th>Not Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input #2</td>
<td>255</td>
<td>Max Pixel Value (Int)</td>
<td>Output #2</td>
<td>388</td>
<td>Not Used</td>
</tr>
</tbody>
</table>

**Vision Function Set #2**  
| Input #3 | 0 | Not Used | Output #3 | 227 | Not Used |

**Vision Function Set #3**  
| Input #4 | 0 | Not Used | Output #4 | 386 | Not Used |

**Input Descriptions**  
- Input #1: Threshold Value (Int)
- Input #2: Max Pixel Value (Int)
- Input #3: Not Used
- Input #4: Not Used
- Input #5: Not Used
- Input #6: Not Used
- Input #7: Not Used
- Input #8: Not Used
- Input #9: Not Used
- Input #10: Not Used

**Output Descriptions**  
- Output #1: 361, Not Used
- Output #2: 388, Not Used
- Output #3: 227, Not Used
- Output #4: 386, Not Used
- Output #5: 420, Not Used
- Output #6: 34, Not Used
- Output #7: 167, Not Used
- Output #8: 555, Not Used
- Output #9: 0, Not Used
- Output #10: 0, Not Used

**Function Description**  
Will create binary image with cutoff at Threshold Value.
ADCompVision – Canny Edge

Function Description: Edge detection using the ‘Canny’ function. First blurs the image, then thresholds, then runs the canny algorithm.
ADCompVision - Centroid

Function Description: Centroid computation. Thresholds, then finds centroid. Thresholds used to remove contours by area.
New areaDetector EPICS Drivers

1. **Lambda** X-ray detector (10ID, 8ID, 12ID).
2. **Spinnaker** support for BlackFly S USB3.1 camera (28ID).
3. EPICS driver for **USB Video Class** cameras.
4. **EmergentVision** (IMX 264, 5Mpel) 10Gb EPICS camera driver, and support for upcoming 25Gb camera.
5. Barcode **ADPluginBar** plugin module.
New AD Drivers

Several new AD Drivers have also been developed:

- **ADSpinnaker** – has been modified and tested to run on Linux (Ubuntu 18.04 and Ubuntu 16); {28ID}.

- **ADLambda** - has been modified and tested to run on Debian 7-9 (Dual Threshold not yet supported); {10ID, 8ID, 12ID}.

- **ADUVC** – Driver that adds support for UVC based USB cameras.

ADPluginBar

Release R2-0 of ADPluginBar adds several key improvements:

- More image formats supported.
- Live barcode detection display.
- All detected barcode corners are accessible.
Conclusions & Questions

• Deployment of binary areaDetector packages.
• New EPICS drivers for detectors.
• Computer Vision integration into the areaDetector.
• Demo on live beamline system.