

The CinemaDNG Initiative

Interoperability in Digital Camera Capture

Presented at Siggraph 2010

Los Angeles, July 29, 2010

Today's Agenda

- Presentation - The CinemaDNG Initiative
- Camera demo - ViewPLUS
- Panel discussion - Interoperability on the Capture Side

The CinemaDNG Initiative

An industry-wide initiative

for

An open, raw image format for digital cinematography

Lars Borg , Principal Scientist
Adobe Systems

Outline of Presentation

- Raw image file formats
- Objectives for CinemaDNG
- The road ahead

- Slides posted at <http://www.adobe.com/go/cinemadng>
- Questions welcome in the on-line user forum

Background

- Raw is the image file format of choice for pro photography
- Cinematographers now embracing raw
- What makes raw so great?
- Workflow impacts?

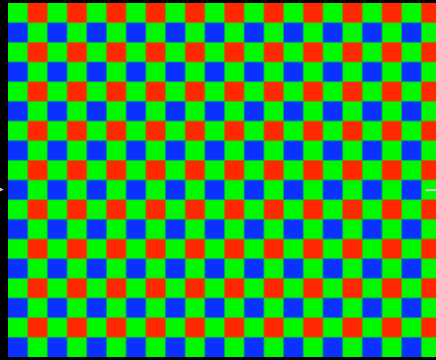
What is a RAW image file?

- Starting with Still Photography ...
- The RAW image captures the digital camera's sensor data with no processing in the camera
 - Raw = unprocessed image sensor data
 - Raw opposite of baked (as in "look or white balance is baked in")
- All image processing is deferred to post
 - Look, white balance, black level, color grade, tone, ...
 - No on-set commitment
 - Better final quality
- 70 % of professional photographers shoot RAW (InfoTrends 2008)

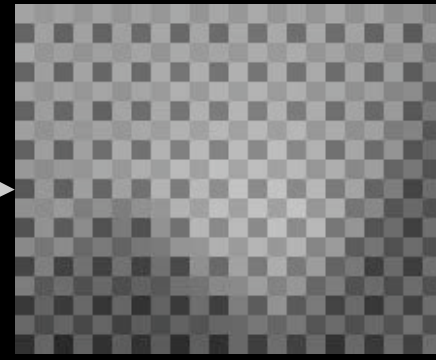
From scene to camera sensor to RAW image file



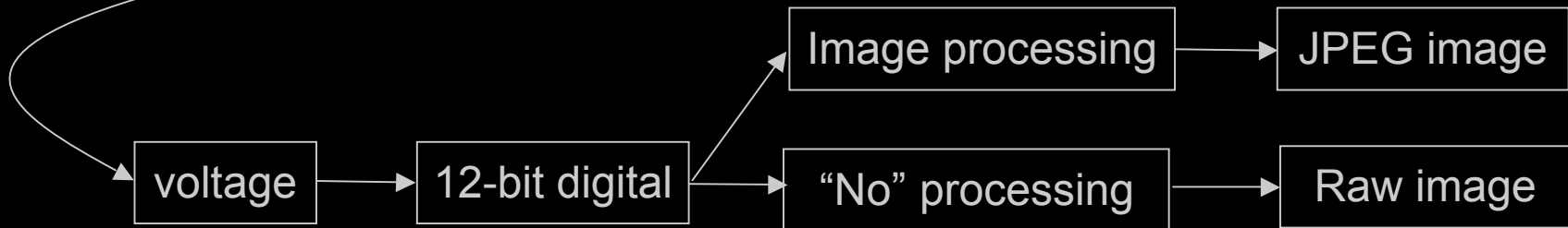
Original scene
light on sensor
(magnified 100x)



Bayer matrix
optical color filter
on the sensor

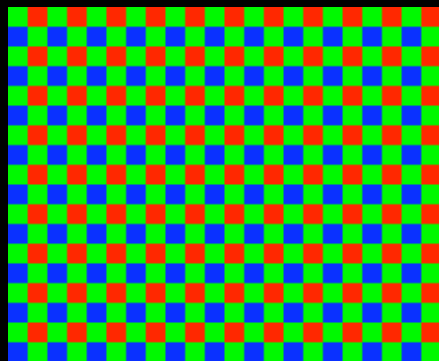
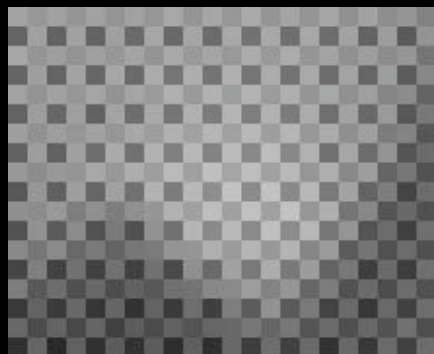


Light on
sensor pixels



From sensor data to final image

Raw digital sensor data
(magnified 100x)



“Digital Inverse”
Bayer matrix

Image
processing
pipeline



When processed in camera:

- Early binding
- JPEG or Video workflow

When processed in post:

- Late binding
- RAW workflow

Final image
Still or Video



Colored items = Destructive!

Destructive image processing

- Examples

- Black current subtraction

- $Out = \text{Max} (0, \text{Image black} - \text{Reference black})$
 - Erroneously high reference black clips shadow details
 - Noise in image black causes positive bias after clip

- White balance to bring neutral objects to $R = G = B$

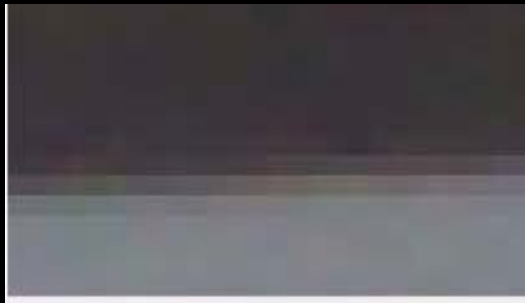
- $Out = \text{Min} (1, \text{RGB} * \text{RGB channel gains})$
 - Overexposed areas are clipped to 1.0, 1.0, 1.0 to look white
 - Later rebalancing brings clipped values below 1.0, 1.0, 1.0



Quality Challenges in Image Processing

- Process-intensive noise reduction & demosaicing
 - Camera processor is weak (to extend battery life)
 - With RAW capture - defer to post to get more compute power
- Compare quality - noise, edge artifacts

Case A



Case B



RAW — Too much of a good thing?

- Proliferation of RAW formats
 - For example, 200+ formats supported in Adobe Photoshop, LightRoom
 - Processing options coded uniquely for each camera model
- Proprietary formats
 - Most formats are undocumented
 - Several formats are encrypted
 - Google “RAW storm in a teacup?”
 - The Digital Millennium Copyright Act may block legal access
- A pro photographer’s nightmare
 - Can your client or publisher read your file format?
- An archivist’s nightmare
 - Some early formats already dead, unsupported, unreadable, DMCA

.arw
.bay
.cap
.cr2
.crw
.dcr
.dcs
.drf
.erf
.fff
.iiq
.k25
.kdc
.mef
.mos
.mrw
.nef
.orf
.pef
.ptx
.pxn
.raf
.raw
.sr2
.srf
.x3f
...

The Digital Negative (DNG) format “to the rescue”

- A unified RAW image format - superset of features in 200+ raw formats
- Published 2004 by Adobe Systems
- Free SDK & tools
- Wide adoption - 20% of raw images archived in DNG (InfoTrends 2008)
- See <http://www.barrypearson.co.uk/articles/dng/products.htm> for DNG products
- ISO standard 12234-2 TIFF/EP - Next rev includes DNG

DNG Format Overview

- File structure is TIFF/EP (like most Raw file formats)
- File contains complete image & decoding description
 - Black level, white level, and linearization parameters
 - Color metadata for sensor colorimetry
 - Processing controls not tied to camera model
- Options include
 - Single-chip (with color filter array) or multi-chip (without CFA) image sensor
 - Arbitrary image dimensions (within 4 Gbyte file size)
 - Sample size = 8-bit to 32-bit integer (typically 10 or 12)
 - Arbitrary-size CFA pattern (Bayer, striped, etc.) with up to seven filter colors
 - Non-standard pixel placements (such as Fujifilm Super CCD EXR)
 - Arbitrary byte order
 - Lossless compression (~ 2:1 ratio)
 - Look controls
 - TIFF/EP, EXIF and XMP metadata
- Encryption is not an option

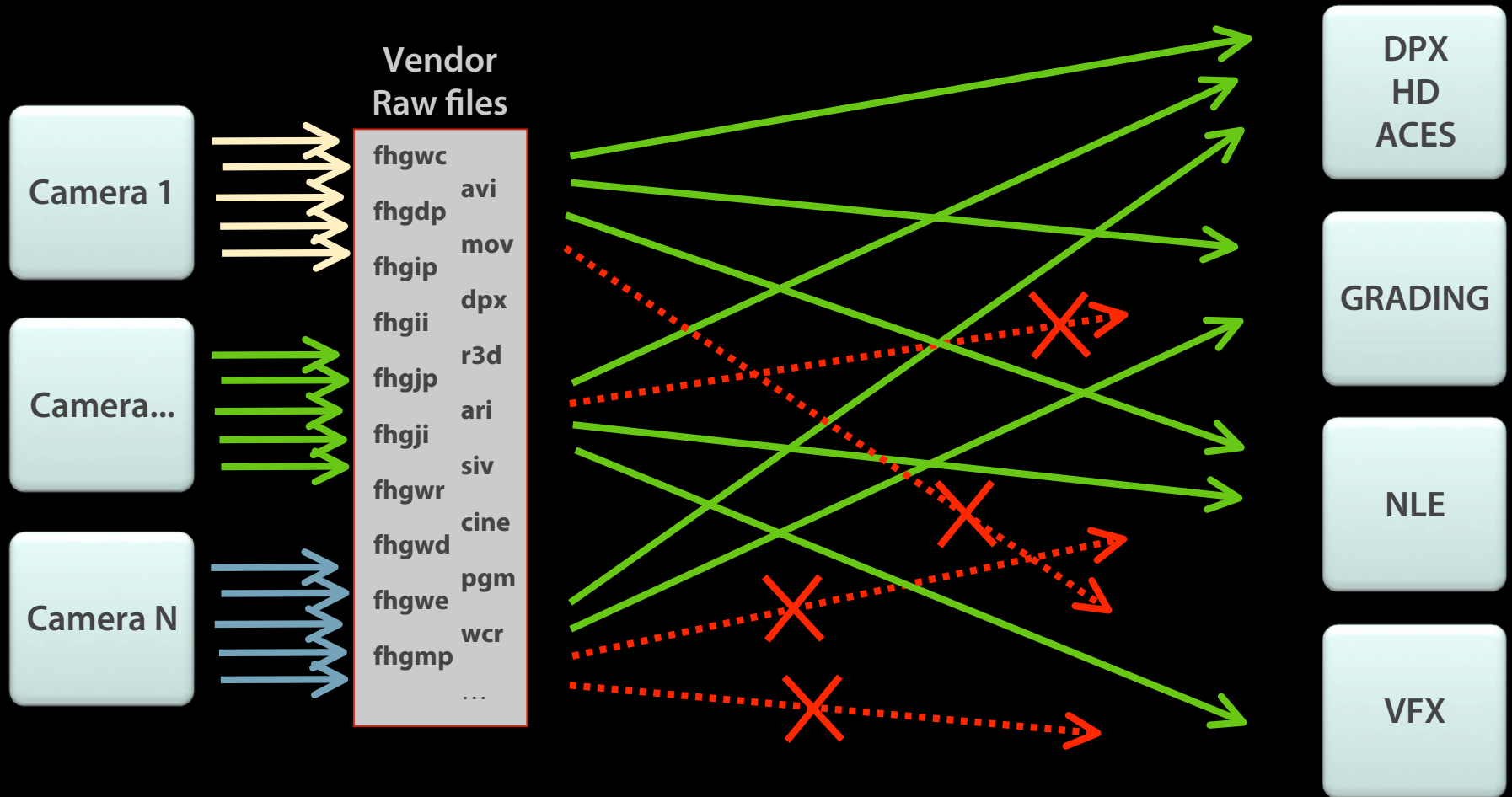
RAW Increasingly Embraced in Cinematography

- RAW suitable for cinematography
 - Set look on set, non-destructive
 - For example, see Lightroom
 - No commitment on set
 - Deliver look + raw image data to post
 - Better final quality
 - Raw images excellent source for green-screen work
- Drawbacks with multiple, proprietary RAW formats
 - Already at 30 proprietary formats for digital cinema
 - Applications must be updated for each new format
 - Some camera vendors already gone
 - Uncertain or limited interoperability
 - Expect an onslaught of DSLR raw video formats - 200?
 - Long-term archiving at risk

.avi
.mov
.dpx
.dng
.r3d
.ari
.siv
.cine
.pgm
.wcr
.fhgwc
.fhgdp
.fhgip
.fhgii
.fhgjp
.fhgji
.fhgwr
.fhgwd
.fhgwe
.fhgmp

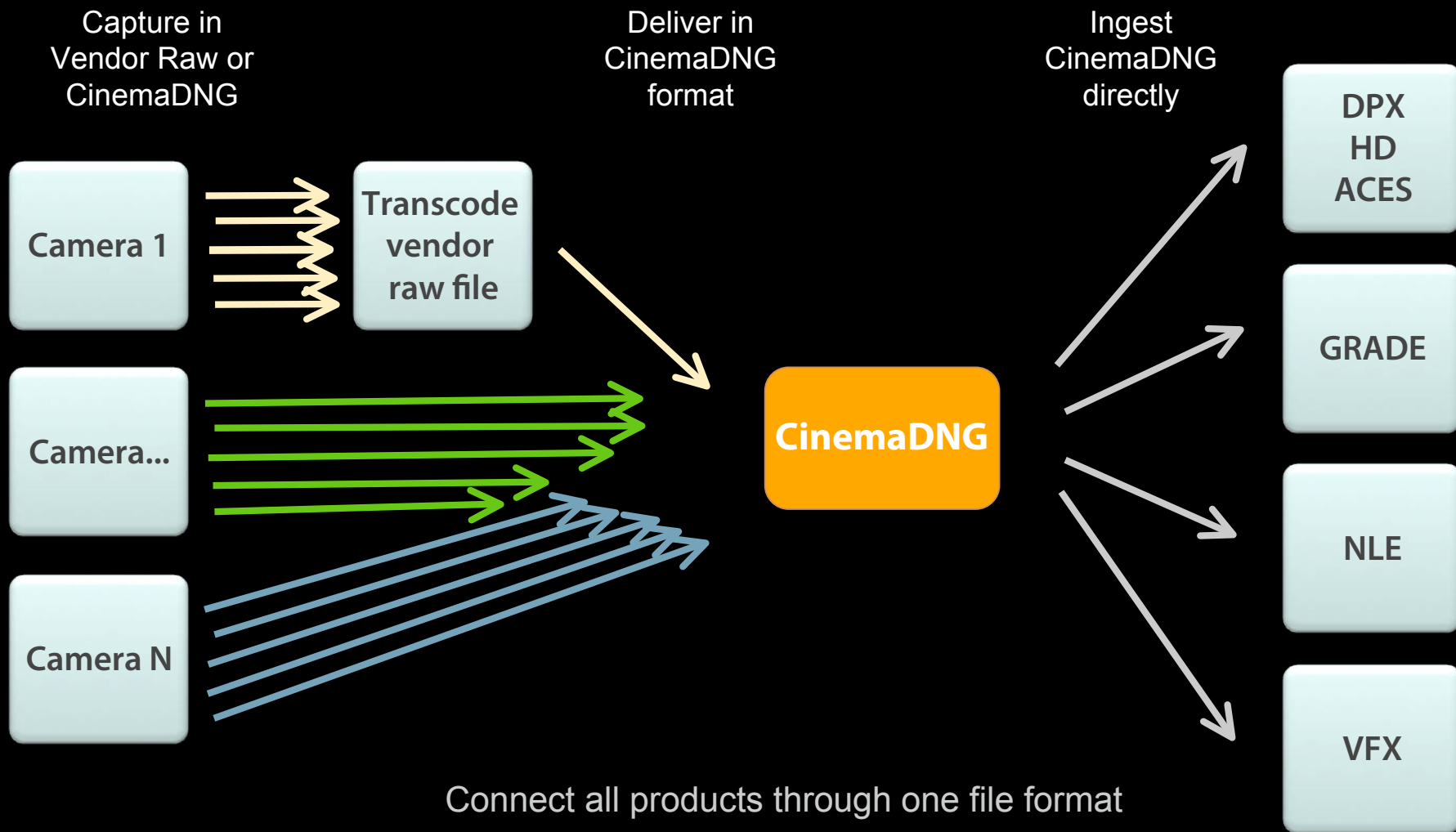
Cinematography Workflows with Multiple RAW Formats

Are you fully connected?



Each application must read 30 (200) file formats

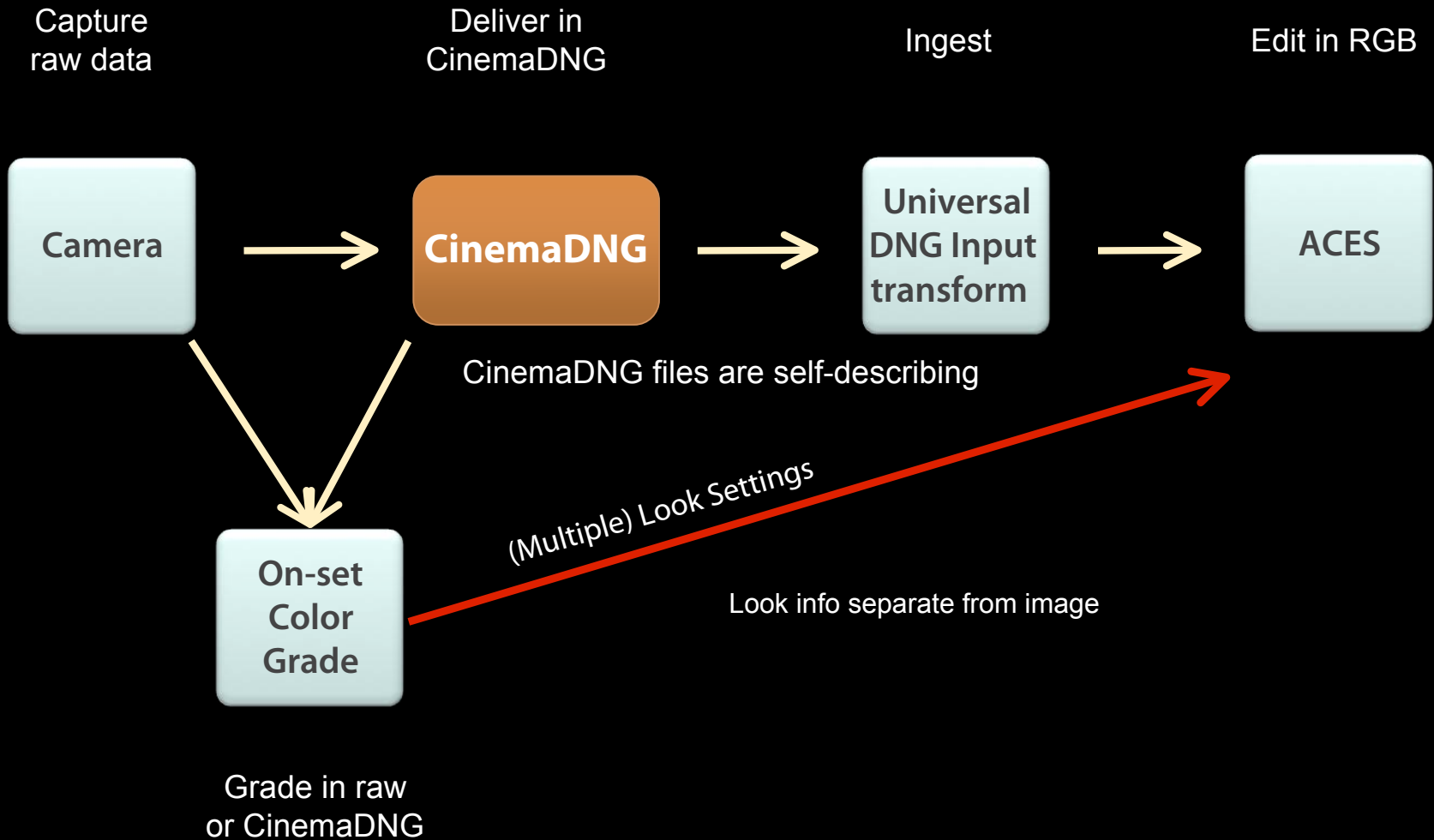
Adding CinemaDNG to Cinematography Workflows



CinemaDNG format summary

- Image essence in DNG format
 - Complete image description
- Each clip is stored as
 - A folder with a DNG file sequence or
 - A single MXF file (OP1a or OP-Atom)
- When wrapped as MXF, a clip can include
 - Single, Stereo (3D), or more image tracks
 - 0 - 16 audio tracks
- Details at <http://www.adobe.com/go/cinemadng>

Example Workflow - Camera to Academy IIF



CinemaDNG Objectives

- Facilitate source-material exchange between raw-format devices, storage systems, and applications
- Leveraging existing (or extended) standards
 - Image essence = (ISO) TIFF/EP Profile 2 - built on Adobe DNG
 - Wrapping = (SMPTE) MXF Material Exchange Format
 - Metadata = XMP, TIFF, EXIF metadata sets
- Creating an open, documented image format for RAW data from digital motion picture cameras into post-production
- Building an open platform for raw image processing tools
- Low threshold to entry
 - No IP encumbrances, no license fees, free SDKs
- Not a goal: mastering, distribution stages

CinemaDNG Status

- 50+ companies participating
- CinemaDNG 1.0 format spec released Sep 2009
- SMPTE Standard in FCD ballot
 - ST 2055 Mapping TIFF/EP Essence into MXF GC
- ISO Standard in the works
 - Revising ISO 12234-2 TIFF/EP image data format
- IRIDAS SpeedGrade shipped CinemaDNG April 2009
- Several cameras now available
- In next major releases from Adobe & other vendors
- SDKs, sample plug-ins, sample files available

Adobe Systems

Avid

Cine-tal

Fraunhofer IIS

Gamma & Density

Ikonoskop

Image Engineering

Indiecam

IRIDAS

MXF4mac

RadiantGrid Technologies

Silicon Imaging

Synthetic Aperture

The Foundry

ViewPLUS

Vision Research

Weisscam

Ahead for CinemaDNG Initiative

- Product announcements IBC 2010, NAB 2011
- Publish standards and next spec
- Further work
 - Look management workflow
 - Real-time playback on laptop
 - Better demosaicing of moving objects - consistent frame-to-frame
 - On-set camera (re-)calibration
 - Metadata set
 - High-quality “lossy” compression for raw
 - Further standardizations
 - Increased adoption
- Contributions welcome
 - No IP encumbrances, no license fees, free SDKs
 - See <http://www.adobe.com/go/cinemadng>

Summary - The Benefits of The CinemaDNG File Format

- A unified raw image format for motion picture capture
 - Can replace proprietary RAW formats
- Retaining the user benefits found in proprietary raw formats
 - No on-set commitment, unaltered sensor data
- Adding interoperability, metadata, standards, long-term viability

What's not to like about this?

ViewPLUS Lumiere 4K digital camera

Toru Nakamura, ViewPLUS



Lumiere PCIe data camera

4K x 60P x 12bit RAW

Cinema quality images for programmer

Toru Nakamura
Program Manager
ViewPLUS Inc.

Key Features

- 4096 x 2048pixels 60fps 12bit
- Non compressed RAW recording
- PCIe x4 external cabling technology
- F-mount SLR Lens
- PC-based recording system
- Turnkey solution





Development of
advanced digital imaging systems
for computer vision and scientific
research

Founded in November 1997

Number of employees: 11

Location: Tokyo, Japan

URL: www.ViewPLUS.co.jp





ViewPLUS



original design
camera and system



POINT GREY

Point Grey Research Inc.
Exclusive Distributer
Technical Representative
in Japan



4Kx60Px12bitRAW PC Camera

ViewPLUS



ViewPLUS

4Kx2K 60fps 12bit RAW camera

Lumiere

Model : Lumiere-01

Key Features

- 4096 x 2048pixels 60fps 12bit
- Non compressed RAW recording
- PCIe x4 external cabling technology
- F-mount SLR Lens
- PC-based recording system
- Turnkey solution



3D Model : Lumiere3D

Lumiere is developed by ViewPLUS Inc. in collaboration with NHK Engineering Service, Inc.

Lumiere 4K Camera head

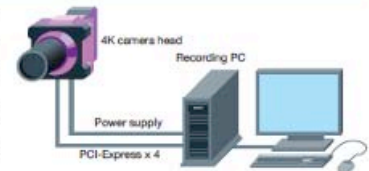


Specifications

Model : Lumiere-01

Camera Head specifications

Sensor resolution	4096x2160 pixels
Frame rate	60fps, 59.94fps
Image sensor	Custom 1.25inch CMOS sensor
Pixel size	4.2 μm
Shutter type	Rolling shutter
Recording format	Uncompressed RAW12bit
Interface	PCIe x4 external cabling
Power supply	12V
power consumption	24W
Lens mount	Nikon F-mount (with G-type lens support)
Dimensions	114mm (width) x 114mm (height) x 164mm (length)
Weight	1250g
External sync	format 480i, 480p, 1080i, 1080p input : CVBS, S-VIDEO (Bi-level, tri-level sync)



Recording time

12min 30sec (at 4Kx2K 60fps 12bit RAW)

Lumiere system includes:

- Lumiere head
- Recording PC
- PCIe x4 external cable (length 3m)
- Power cable (length 3m)
- PC interface card
- RAID disk arrays

ViewPLUS

ViewPLUS Inc.

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E-mail: spcontact@viewplus.co.jp
www.viewplus.co.jp

Information in this document is subject to change without notice.

Lumiere is developed by ViewPLUS Inc. in collaboration with NHK Engineering Service, Inc.

4K camera designed for PC

ViewPLUS



	Lumiere (head)	RED One	JVC KY-F4000 (production model)
	PC camera (input device for PC)	cinema camera	TV camera
output	data	file	TV signal
	live data on main memory	recorded image	live image
media	PCI Express Cable	Proprietary HDD/Flash	HD-SDI x 4 (Dual-link x 2)
form	12bit RAW (uncompressed)	12bit RAW (compressed)	4:2:2/10bit (SDI spec)
Ext sync	frame sync	not specified	gen lock

Lumiere vs. other 4K camera

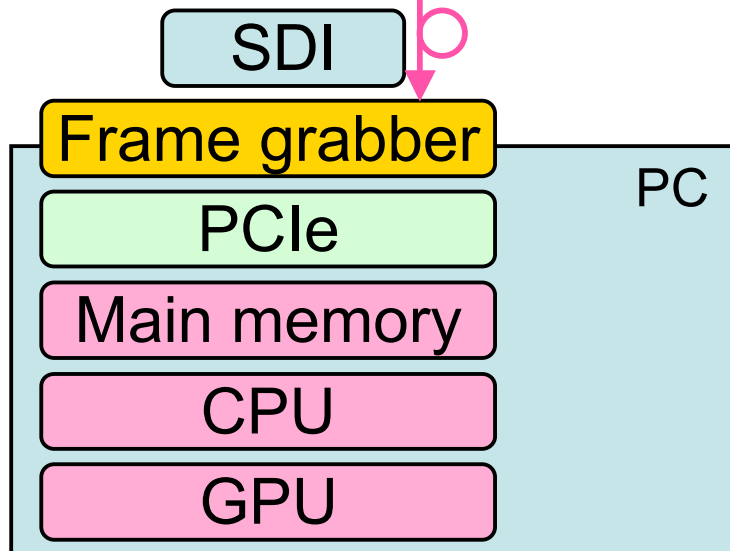
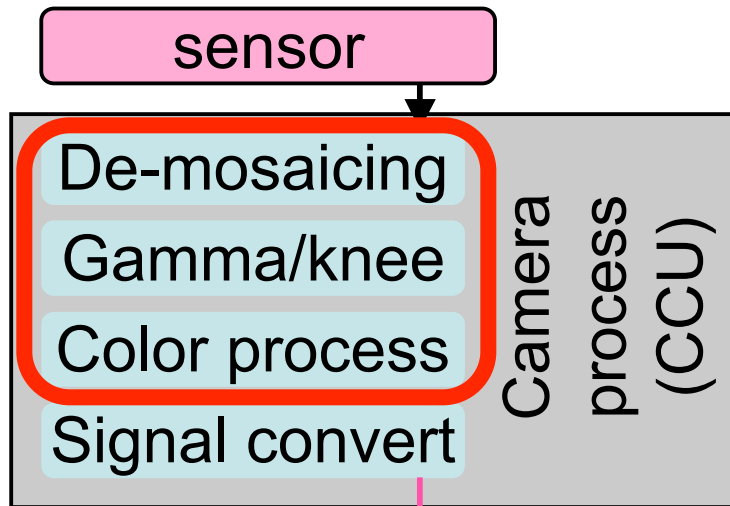
ViewPLUS



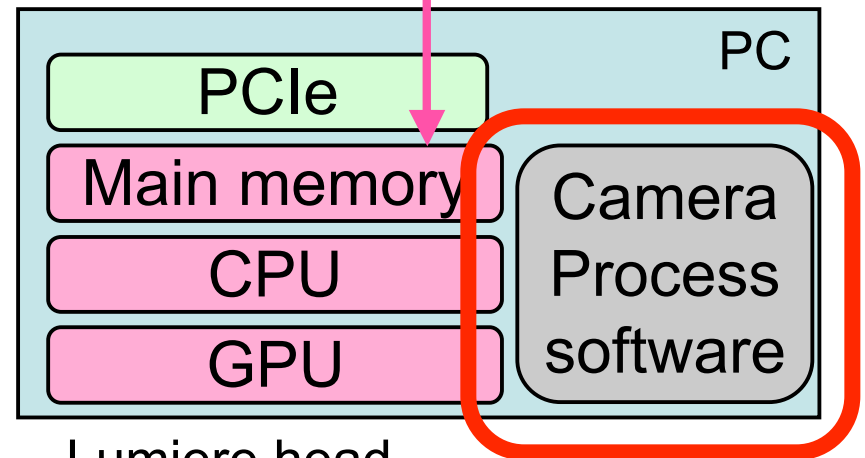
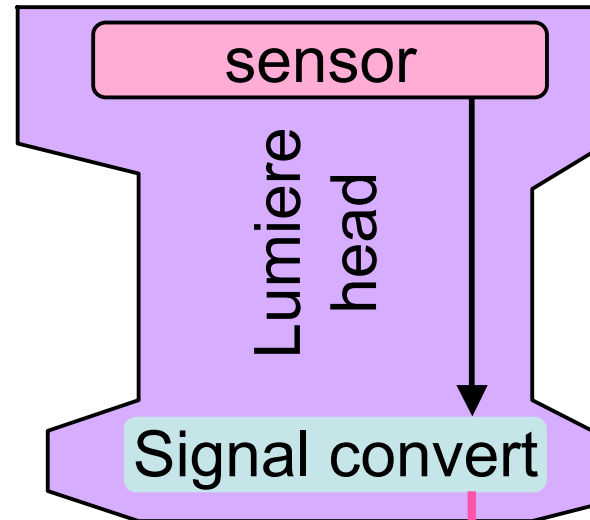
	Lumiere (head)	RED One	JVC KY-F4000 (production model)
Sensor	8.9M pix CMOS	12M pix	8.9M pix CMOS
Physical Size	17.3mm x 9.1mm	24.4mm x 13.7mm	17.3mm x 9.1mm
Active Pixel	4096(h)x2048(v)	4520 (h) x 2540 (v)	3840(h)x2160(v)
Full Pixel Array	4112(h)x2168(v)	4900 (h) x 2580 (v)	4112(h)x2168(v)
Lens mount	Nikon F (G type)	PL	Nikon F
Frame Rates	60, 59.94fps	23.98, 24, 25, 29.97, 30 fps 4K	59.94fps
size WxHxL	114x 114 x 164	132x 161 x 305	98 x 120 x 254
weight	about 1.3Kg	about 4.5Kg	about 3.0Kg

Live image in PC

ViewPLUS



Conventional TV camera system



Lumiere head



- **CMOS**
 - Rolling shutter
- **60 fps in full resolution**
 - Little rolling shutter artifacts
- **Tuned for broadcasting quality**
 - Developed by NHK
- **Image size: 17.3mm x 9.11mm**
 - H size is 1/2 of 35mm full
- **Full pixels: 4112 x 2168**





- SDK(Software Developing Kit) available
- Camera API
 - Data acquisition function
 - Camera hardware control function
 - Sample codes





$$\begin{aligned} &4096 \text{ (H pix)} \\ &\quad \times \\ &2048 \text{ (V pix)} \\ &\quad \times \\ &1.5 \text{ byte(12bit)} \\ &\quad \times \\ &60 \text{ fps} \\ &= \\ &720\text{MByte} \end{aligned}$$

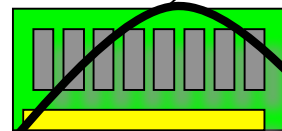


- Camera with RAID HDD system
 - 12 minutes recording
 - Software “Lumiere Rec”
(recording mode, playback/**exporting** mode)
- Not easy recording 720MByte/sec
 - Need very careful choice of PC parts, MB, HDD/SSD, etc.
- Our main customer is researcher
 - **RAW data is needed**
 - Turn-key is preferable in Japan
 - Easy to handle data in file

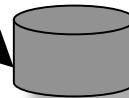




- uncompress recording
- **over 720MByte/sec**
- **continuous data stream**



preview



Proprietary special file

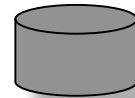
Dedicated file for high speed **continuous** recording. This file can not be accessed by user program.

Recording mode

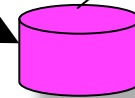
Process mode change

Playback / Data **export** mode

- non real time processing
- file to file converting



Proprietary special file



General file

- **CinemaDNG (Sequential DNG)**
- Sequential BMP
- ViewPLUS RAW

ordinary file for general application.



	+	-
LibTiff	<ul style="list-style-type: none">*low level (tag level) controllable*multi-platform (Linux)	<ul style="list-style-type: none">*need some patches (bugs, vulnerability)*Insufficient document about DNG*need low level control
Adobe DNG SDK	<ul style="list-style-type: none">*proprietary (expectations of adobe support)*pre-installed tags	<ul style="list-style-type: none">*Insufficient document/sample code*large size library



- Adobe DNG Software Development Kit (SDK) based
- 1. There was already DNG converter code in our company
- 2. We do not have validation application except of Adobe's.
 - genuine tools for safety net
- 3. Expectation of support
 - Secure issue update etc.
 - Our customer's expectation



- **Minimum**
 - As a container of RAW data

Demonstration : software camera

ViewPLUS



PCIe x4
RAW data

Software camera
real time 'development' by software

Camera control
Software on CPU

Camera process
Software (SLGL) on GPU

2x
dual-link
DVI



Main memory: 6GByte
CPU: Core i7-9 (2.6GHz)
OS: Win7 64bit
GPU: nVIDIA GTX295

IBM T221 LCD
3840 x 2400
48Hz



Panel Discussion

Achieving Interoperability on the Capture Side

Investigate current interoperability problems in video capture

Discuss its various implications and potential solutions

On the panel

- Dr. Dairoku Sekiguchi, ViewPLUS
- Michael Cioni, LIGHT IRON Digital
- Gary Demos, Image Essence
- Steve Crouch, IRIDAS
- Lars Borg, Adobe Systems



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