DeepColor: On-Screen HDR Drawables for X

Alex Goins, XDC 2017
OVERVIEW

Background
Current Status
The Case for a New Visual Class
Extended Visual Info
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BACKGROUND

HDR Rendering As It Stands Today

Many applications already use HDR for rendering.

Desire for linearity and preservation of relative brightness.

Render into FP16 (aka half-float, 16 bits per component buffer).

“Tone-map” from FP16 to lower precision non-linear, e.g. RGBA8 sRGB drawable.

TrueColor/DirectColor Visual Classes are adequate for presenting RGBA8 sRGB.
New displays support 10 or 12 bit HDR input, e.g. HDR10 (10-bit integer BT.2020 PQ)
Linear HDR formats also needed for composition
Future displays may also support FP16 input
Do not “tone-map” to SDR
DeepColor X Extension

2nd draft on xorg-devel

Adds new X visual class “DeepColor”

Extra mechanisms for querying new metadata

Protocol perspective, implementation to come

1. Introduction

The DeepColor Extension provides a new visual class, DeepColor, designed for handling visuals that are incompatible with the existing core X visual classes: StaticGray, StaticColor, TrueColor, GrayScale, PseudoColor, or DirectColor.

These visual classes provided by the core X11 protocol are insufficient for visuals that require a greater than 32 bit depth, or non-integer formats. As such, they are not suitable for many HDR formats.

In order to support a variety of HDR formats or any other formats that are
THE CASE FOR A NEW VISUAL CLASS
THE CASE FOR A NEW VISUAL CLASS

Pixel Formats

typedef struct {
    Visual *visual;
    VisualID visualid;
    int screen;
    unsigned int depth;
    int class;
    unsigned long red_mask;
    unsigned long green_mask;
    unsigned long blue_mask;
    int colormap_size;
    int bits_per_rgb;
} XVisualInfo;

TrueColor

DirectColor

Maximum 32-bit
Only relevant to integers
typedef struct
{
    Visual *visual;
    VisualID visualid;
    int screen;
    unsigned int depth;
    int class;
    unsigned long red_mask;
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    unsigned long blue_mask;
    int colormap_size;
    int bits_per_rgb;
} XVisualInfo;
# The Case for a New Visual Class

## Color Spaces and Encodings

<table>
<thead>
<tr>
<th>SDR</th>
<th>HDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>sRGB</td>
<td>BT.2020 PQ</td>
</tr>
<tr>
<td></td>
<td>BT.2020 HLG</td>
</tr>
<tr>
<td></td>
<td>BT.2020 Linear</td>
</tr>
<tr>
<td></td>
<td>DCI-P3 Linear</td>
</tr>
<tr>
<td></td>
<td>DCI-P3 Gamma</td>
</tr>
<tr>
<td></td>
<td>ACES AP0</td>
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<tr>
<td></td>
<td>ACES AP1</td>
</tr>
<tr>
<td></td>
<td>scRGB Linear</td>
</tr>
</tbody>
</table>
THE CASE FOR A NEW VISUAL CLASS

Design Goals

Support high precision integer and half-float formats
Enumerate set of color spaces and encodings
Flexible selection
Support composite managers (“external compositors”)  
Support in-server compositing (“internal compositors”)  
Avoid breaking existing applications
EXTENDED VISUAL INFO
struct XVisualInfo is not adequate for describing many HDR pixel formats

Adding additional fields to struct XVisualInfo could complicate compatibility

Follow formula of e.g. EVI and DBE X extensions

Pixel format exposed through extended visual info requested by Visual ID

Changing pixel format requires destroying and recreating drawable with new visual
## EXTENDED VISUAL INFO

### Pixel Formats

<table>
<thead>
<tr>
<th>Half-Float</th>
<th>Integer</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP_R16G16B16A16</td>
<td>UINT_R16G16B16A16</td>
</tr>
<tr>
<td></td>
<td>UINT_A2R10B10G10</td>
</tr>
<tr>
<td></td>
<td>UINT_A2B10G10R10</td>
</tr>
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</table>
WINDOW PROPERTIES
WINDOW PROPERTIES
Exposing Color Space and Encoding

Exposé color space and encoding being rendered by application
Exposé capabilities of compositor
Exposé capabilities of display
Support both external and internal compositors
PropertyNotify feedback
WINDOW PROPERTIES
Enumerated color spaces and encodings

Constant definitions describing set of possible color spaces / encoding pairs

Additional color spaces / encodings require revision of spec

scRGB Linear
BT.2020 Linear, PQ, HLG
DCI-P3 Linear, Gamma
ACES AP0 (Linear), AP1 (Linear)
WINDOW PROPERTIES
Property of Root Window

_DEEPCOLOR_PROPERTIES, WINDOW/32

Global window properties must be associated with root window
Problem: Listening to PropertyNotify events on root window results in spam
Create child of root window named “DEEPCOLOR_PROPERTIES”
Find child via root window property _DEEPCOLOR_PROPERTIES
WINDOW PROPERTIES
Property of “DEEPCOLOR_PROPERTIES”

_DEEPCOLOR_COMPOSITOR_COLORSPACES, colorspace, score, CARDINAL[][2]/32

Set of color spaces and encodings supported by compositor
Initialized by internal compositor, overridden by external compositor
Selection prioritized by score
Target surface should correspond to highest score to minimize conversion overhead
WINDOW PROPERTIES
Property of “DEEPCOLOR_PROPERTIES”

DATEDEPCOLOR_DISPLAY_COLORSPACES, colorspace, score, CARDINAL[][2]/32

Set of color spaces and encodings supported by server for display
Initialized by server (X driver)
Used to bootstrap external compositors
Primary mode should correspond to highest score to minimize conversion overhead
Set of color spaces and encodings cannot change, but score can change
WINDOW PROPERTIES

Property of HDR Window

_DEEPCOLOR_COLORSPACE, CARDINAL/32

Color space and encoding being used for rendering into window
Selected based on scoring of compositor color spaces
Application must listen for PropertyNotify events to determine if capabilities change
Application may change to any supported option at any time
CONTROL FLOW
CONTROL FLOW
Server Initialization

Server

Root Window

"DEEPCOLOR_PROPERTIES"

(_DEEPCOLOR_BT2020_PQ, 100),
(_DEEPCOLOR_BT2020_LINEAR, 85)

(_DEEPCOLOR_BT2020_LINEAR, 100),
(_DEEPCOLOR_BT2020_PQ, 85),
(_DEEPCOLOR_SCRGB_LINEAR, 75)

CreateWindow

Window Property Write

Window Property Read
CONTROL FLOW

HDR Window Creation

FP_R16G16B16A16

_misc_protocol

Window Property Write

Window Property Read

_misc_protocol

Server

Application

DPCGetVisualInfo

CreateWindow

DeepColor Window

_DEEPCOLOR_COLORSPACE

_DEEPCOLOR_BT2020_LINEAR

Window Property Write

Window Property Read

_DEEPCOLOR_DOUBLEWORDCOLORSPACE

_ROOT_WINDOW

_DEEPCOLOR_PROPERTIES

"DEEPCOLOR_PROPERTIES"

_DEEPCOLOR_DISPLAY_COLORSPACES

_DEEPCOLOR_COMPOSITOR_COLORSPACES

Application

FP_R16G16B16A16

_SERVER

_DEEPCOLOR_COLORSPACE

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_ROOT_WINDOW

_DEEPCOLOR_PROPERTIES

"DEEPCOLOR_PROPER
CONTROL FLOW
HDR-Aware External Compositor Override

Root Window
- _DEEPCOLOR_PROPERTIES

Compositor
- RedirectSubwindows
- _DEEPCOLOR_PROPERTIES
- _DEEPCOLOR_DISPLAY_COLORSPACES
- _DEEPCOLOR_COMPOSITOR_COLORSPACES

DeepColor Window
- _DEEPCOLOR_COLORSPACE

Server
- PropertyNotify

Application
- PropertyNotify

Misc. Protocol
- Window Property Write
- Window Property Read
CONTROL FLOW

HDR-Unaware External Compositor Override

1. Root Window
   - _DEEPCOLOR_PROPERTIES

2. Compositor
   - "DEEPCOLOR_PROPERTIES"
   - _DEEPCOLOR_DISPLAY_COLORSPACES
   - _DEEPCOLOR_COMPOSITOR_COLORSPACES

3. DeepColor Window
   - _DEEPCOLOR_COLORSPACE

4. Server
   - RedirectSubwindows
   - Window Property Write
   - Misc. Protocol

5. Application
   - Window Property Read
   - Misc. Protocol
   - PropertyNotify
CONTROL FLOW
Transition Back to Internal Compositor

1. UnredirectSubwindows (or connection dies)

Root Window
  _DEEPCOLOR_PROPERTIES

Compositor

2. PropertyNotify

DeepColor Window
  _DEEPCOLOR_COLORSPACE

“DEEPCOLOR_PROPERTIES”
  _DEEPCOLOR_DISPLAY_COLORSPACES
  _DEEPCOLOR_COMPOSITOR_COLORSPACES

Server

3. PropertyNotify

Application


Misc. Protocol

Window Property Write

Window Property Read
ISSUES
ISSUES
HDR Unaware Clients

DeepColor visuals could cause naïve clients to crash

Suggestion for TrueColor-masquerading DeepColor visuals

Downsample automatic redirection, XGetImage(), core X11 / RENDER rendering

Problem: Duplicate TrueColor visuals could cause unnecessary conversions

Opt-in mechanism via core protocol minor version bump?
ISSUES
DCI-P3 White Point and Gamma

DCI-P3 doesn’t have a defined white point or gamma
Relatively small set of possible white points could be enumerated
Gamma could be anything, varies by display
Additional gamma field in window property tuples?
White point and gamma need to be more clearly documented for other options
Applications can change \_DEEPCOLOR\_COLORSPACE at any time

When does this correspond to a change in rendering?

“Frames” are poorly defined in X without the Present extension

Hand off atomic updating of \_DEEPCOLOR\_COLORSPACE to Present extension?
ISSUES
EGL and Vulkan Extensions

EGL_EXT_gl_colorspace_*
VK_EXT_swapchain_colorspace
GLX

Definitions of color spaces and encodings need to align
ACKNOWLEDGEMENTS

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QUESTIONS?
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