Workshop on Material Appearance Modeling (2015)
H. Rushmeier and R. Klein (Editors)

Proposal for an Appearance Exchange Format

Gero Mueller [1] and Francis Lamy[1]

[1]X-Rite, Inc., 4300 44th St. SE, Grand Rapids, MI 49505

Abstract

In this short paper X-Rite proposes a new file format for exchanging digital material appearance. The format is a vital part of X-Rite's appearance initiative consisting of a new generation of appearance capturing devices currently under development. In order to make the usage of measured appearance as simple as possible for users, a broad support by software vendors is essential. Therefore, X-Rite aims to initiate the assembly of a consortium of hard- and software vendors, members of the scientific community and users, which would be responsible for the further development and standardization of the format.

1. Motivation

Driven by the ongoing virtualization of the product design process we see a growing demand for measured material appearance. This trend pushes the need for efficient and standardized exchange, communication and archival of digital appearance data.

Nonetheless, current digital material workflows are far from being standardized. In practice most often proprietary data formats are used. If materials need to be transferred between software packages data usually needs to be stripped down to a least common denominator like an image or a simple Phong model at best. While workarounds can be found for individual cases, this situation is not acceptable for users of appearance measurement devices because a physical material measurement should be independent of specific 3D rendering software platforms.

We are aware of the fact that due to the highly competitive and innovative nature of the field it is not an easy task to reach for standardization in graphics. On the other hand, starting this endeavor from the measurement side seems to be a promising approach. It should be the common goal of both software and hardware vendors to achieve a consistent reproduction of measured appearance across different systems. This, and nothing less, is expected by the users.

2. Requirements

Besides mandatory requirements like efficiency and platform independence we want to bring attention to some special requirements for appearance data.

Scalability The format should be able to store raw measurement data which easily can range up to several gigabytes. Therefore the format must be scalable, which means access times should not depend on the filesize. This requirement rules out text-based formats like XML which lack indexing capabilities.

Generality The structure of appearance data can be quite diverse ranging from a single spectrum up to complex combinations of data from hundreds of sensors or even procedural descriptions. Therefore the format must be extensible and self-describing in order to accommodate all these different kinds of representations. This requirement does not only hold for payload but also for metadata.

Workflow compatibility Supporting a least common denominator of appearance representations in addition to a full blown BTF or even BSSRDF is critical for format adoption. This requires the ability to store different versions of a material in a single file. We propose to define a SVBRDF variant as least common denominator since most up-to-date rendering software supports at least a material model based on diffuse+specular color texture, normal and/or height map and some specification of gloss.

In an industrial environment, data security and protection are also important and will become an integral part of the format.

3. Design Decisions

Based on the above requirements, AxF is designed in layers. Since a binary format is inevitable for efficiency and scalability we first define a binary layer. On top of the binary

DOI: 10.2312/mam.20151196

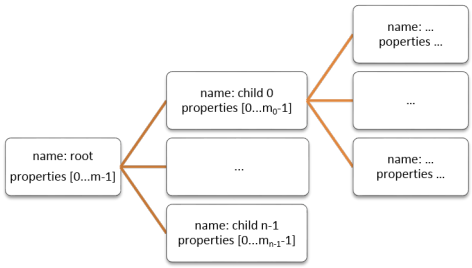

Figure 1: *Property node tree concept*

layer we propose a basic structuring mechanism which allows to define the hierarchical semantic structure of payload and metadata. The final layer consists of the explicit definition of the semantic structures.

We propose to use the HDF5 [hdf15] format as *binary base layer*. HDF5 defines a versatile data model which can represent any kind of complex data objects and metadata. The format is completely portable with no (practical) limits on the number or size of data objects in the file.

The second layer implements a simple but powerful *property node tree* concept on top of HDF5 (cf. Figure 1). This concept is analogue to a basic filesystem concept where nodes correspond to folders (structuring) and properties to files (payload). Properties support various typical datatypes like integral types, strings and unbound multi-dimensional data arrays.

The third layer defines a *baseline* for valid AxF files that partly should be supported by all applications integrating AxF. Essentially it defines a set of node- and property-types and their semantic as described in the following section.

4. Baseline AxF

The basic semantic structure of an AxF file is related to the Color Exchange Format [CxF] which has been defined by X-Rite as a portable format for system and device independent exchange of color data and has been released as a proposed draft international standard. An exhaustive list of all node types and their semantics is beyond the scope of this document but to convey the idea we will briefly sketch the three so-called root-level node collections as shown in Figure 2:

DeviceSpecCollection contains specification and calibration data for measurement devices. It allows the specification of geometric and radiometric device properties.

ColorSpecCollection specifies arbitrary (linear) colorspaces and spectral samplings. Since AxF stores floating point color values non-linear color spaces are currently not part of the current specification.

MaterialCollection is a more general container for metadata, semantics (*RepresentationCollection*) and payload (*ResourceCollection*).

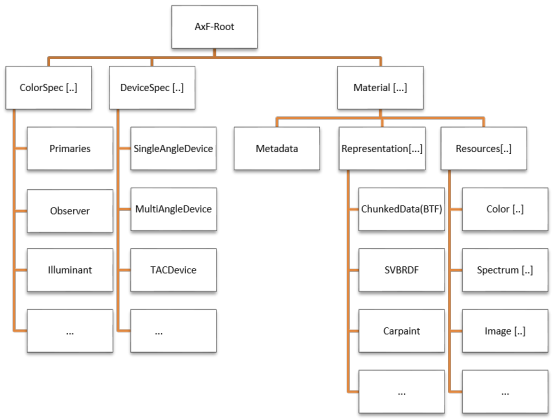

Figure 2: *Excerpt from the definition of* Baseline AxF. *Collections are denoted by* [..].

The *RepresentationCollection* as part of a material definition deserves further explanation: it defines a particular material model like a BRDF or BTF model which references basic (simply structured) payload like colors and textures stored in the *ResourceCollection*. Currently, AxF defines a general and configurable SVBRDF representation, a representation for measured carpaint (based on a multi-lobe Cook-Torrance BRDF model) and a BTF representation (based on Matrix Factorization). These representations are currently used to represent materials captured using X-Rite's TAC technology.

Please note that the general layer concept of AxF does not restrict the range of possible representations in any way. It is mainly a question of support by devices and software and upcoming standardization efforts, which representations will become an obligatory part of AxF in the future.

5. Wrap-up

In this short paper we gave an idea of X-Rite's proposal for an appearance exchange format. In the presented form it is mainly a general framework which handles the low-level details like efficient storage and access of payload and metadata, how colors are specified etc. Although a first set of representations has been defined and first implementations into commercial software like NVidia's MDL [MDL15] or Autodesk VRED are available (cf. Figure 3 for an example), the definition of the top-layer semantic (Baseline AxF) and especially its material representations are by far not complete.

Further definition of the format needs to focus on additional representations which extent the gamut of materials that can be well represented in a portable, i.e. exchangeable way. Obviously, this cannot be achieved by X-Rite or

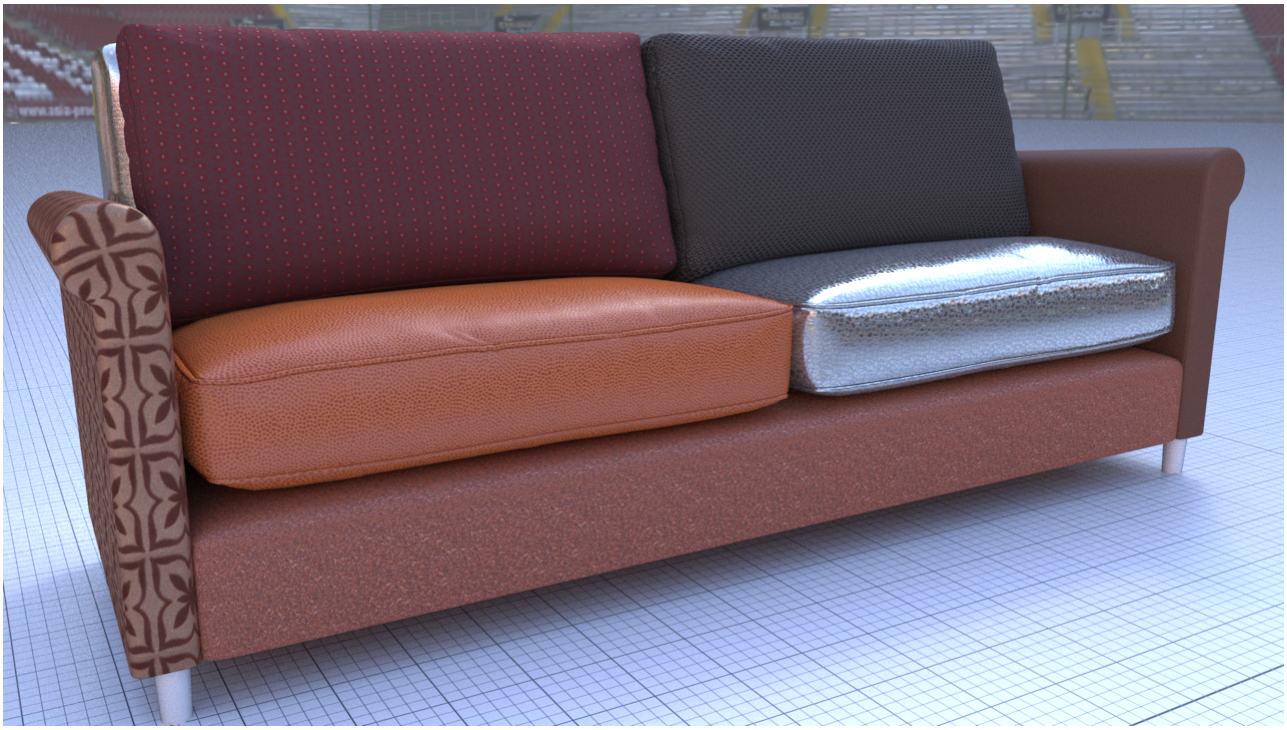

Figure 3: *The* "AxF Sofa" *covered with several measured AxF materials like fabrics, plastics, leather and metals rendered using Autodesk VRED. Some of the materials are taken from the MAM-2014 sample set [mam14].*

any measurement devices vendor alone but has to be done in close collaboration with both the software vendors, who decide which kind of material models they will support and integrate in their software, and the users, who define the types of materials that need to be digitized as accurate as possible in order to increase the quality and credibility of the digital design process.

As a next step, X-Rite plans to make the detailed definition of the AxF node types and structure and also a SDK available to the community short-term. Then the goal would be to build a consortium of hardware and software vendors, members of the research community and users of measured material appearance to define future requirements and demands for additional AxF features and especially material representations. If a broad support for an agreed baseline of representations can be achieved this can be the first step towards a standardization of digital material appearance making efficient exchange and archival of appearance possible for industry and research.

References

[CxF] http://www.colorexchangeformat.com/documents/literature/CxF/CxF_Standard.pdf. 2

[hdf15] Hierarchical Data Format, version 5, 1997-2015. http://www.hdfgroup.org/HDF5/. 2

[mam14] MAM-2014 Sample Set, 2014. https://sites.google.com/site/mam2014samples/. 3

[MDL15] NVidia MDL - Material Definition Language, 2015. http://www.nvidia.com/object/material-definition-language.html. 2