ACES Working Group Proposal

Proposal submitter
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Proposal submission date
06/10/2020

Description of the problem or question(s) the Working Group will be investigating
List of question(s) to be answered by the Working Group.

Background
ACES 1.0 was released in December 2014 and we have now had 5+ years of experience and feedback from that rendering, which has remained static even through the reported problems mentioned below. Meanwhile, adoption of ACES has expanded, and camera and display technology has continued to evolve. The time has come to revise the core of the ACES system to address the known problems, encourage wider adoption, and better situate ACES as *the* production standard for the future.

ACES 1.1 introduced the concept of a combined RRT+ODT Output Transform with parameters for more easily supporting outputs beyond the basic set designed for display standards. The architecture of the ACES 1.1 HDR transforms has been positively received although it was never fully fleshed out. There are many algorithmic components that require design decisions and additional development, and each of the problems identified with the current transform must be addressed in the process of any revision to the algorithm.

Though the current suspicion is that a more careful expansion and fleshing out of the remaining components of the v1.1 Output Transform architecture will allow us to address the known problems, the potential for other rendering algorithms is not excluded from this project and should be explored.

In the development of what ultimately became ACES 1.0, many algorithms were explored, including several that attempted to preserve hue or to separate luminance rendering from color rendering. Though some of these approaches showed some promise and gave favorable results for some tricky images, it was ultimately decided that the result was not what "most people" preferred. While in theory hue and saturation preservation seem like they would be preferred (and in some cases, such as in images of neon lights, they are), there were undesirable side effects in other crucial image areas. Amplification of noise and grain were particular problems of these approaches.

Problems with the current rendering model
- The current rendering is non-invertible
    - "Red modifier" and "glow" modules add complexity to the algorithm and prohibit invertibility
- Appearance
    - Look is too strong - contrast and saturation are frequently reported as too high as a starting point for color grading and look development

    - Rendering primaries can cause artifacting when receiving ACES values outside of AP1
    - Subjective modifications (e.g. “glow”) should be restricted to a Look Transform
    - Rendering should aim to provide “color science in a box” as that is a large audience – however, the rendering should not be so finished so as to preclude expert users from modifying it
- Lack of “official” support for outputs other than those supplied with the reference implementation - users must be enabled to create OT variants to serve their specific needs
- ACES 1.0 was developed in the infancy of HDR and lacks robust support for extended dynamic range
- Currently, custom Output Transforms using the architecture of the v1.1 HDR transforms have no mechanism to communicate the parameters that were used – other than to make a custom CTL. How do Output Transform parameters get communicated? Is this a role for AMF?
- Inconsistencies currently exist between supplied ODTs, including:
    - Desaturation matrix (e.g. Rec. 709)
    - Tone scale stretch vs tone scale (e.g. 100-nit displays stretch the 48-nit tone scale, but other transforms provide a tone scale targeting the non-48-nit luminance)
    - Locations of clipping operators
    - Roll-off to prevent coloring of highlights (e.g. roll-off white) when white point differs from the ACES white point
    - Methods to achieve a CV=0 in PQ encoding
    - Not all transforms support multiple surround viewing environments
    - 18% gray falls at different luminances for different dynamic ranges

Process of work

1. Establish requirements – structured group discussion of the myriad topics that this group faces
2. Define the work – establish tasks to meet requirements and assign people to work on algorithm components
3. Do the work – both individual investigations and collaboration, use meetings to share findings and determine if direction of work seems correct or if course-correction is necessary
4. Testing objectively – create unit testing and consistently assure that the work is fulfilling the requirements (these tests will be a helpful deliverable at the end of the process)
5. Testing subjectively – consistent sharing of the algorithm to the community – particularly colorists, VFX, and DI – encourage testing and feedback on “the look” and more importantly the usability. Ask “Would you use this as your ‘default LUT’?”

Some considerations for Process of Work - Step 1

- Agreement that all the problems/shortcomings with the current model are identified
- Agreement on the ideal system architecture
    - Is a tone scale applied in RGB sufficient?
    - Should luminance and hue rendering be separated?
    - Should “hue” be preserved?

- Agreement on the objective requirements for a new model
    - e.g. parameterized ≠ customizable (creative looks should remain outside these parameters)
- Agreement on the use cases
    - CGI
    - Output-referred imagery
    - Camera vendor or non-LMT based looks
- Agreement on how the subjective aspects will be decided
    - What is “neutral”? How will the “look” be decided? Psychovisual testing methods? Preference voting? Other?
    - Where should 18% gray and diffuse white be rendered?
    - What level of invertibility is required?
    - How will the algorithm be evaluated?
        - To what extent are “reference” images used?
        - Is some sort of psychovisual experimental setup used?
    - How will the algorithm be tested?
        - Immediately to make sure it meets the objective requirements
        - Long-term - unit testing framework?

Preliminary/starter list requirements for the new work

- Simple. Simple. Simple.
    - Simple keeps the algorithm easy to implement without LUTs.
    - Simple keeps the algorithm easier to understand. The rationale for any components should be clearly defined.
    - Simple reduces opportunities for the maths to introduce artifacts.
- Tone Scale
    - Slightly lower default contrast
    - Configurable for arbitrary dynamic ranges - including emulation of a smaller dynamic range in a larger dynamic range
- Use cases
    - Look Development
        - Lower contrast and more “neutral” starting point encourages users to build their own looks
    - Invertibility
        - Logos, graphics, other output-referred content (e.g. archival, video, etc.)
        - Enables conversion of legacy look LUTs (“reversing out”) when necessary
    - Adaptable viewing environments
    - Adaptable display capabilities
    - Emulation
        - Support one type of display rendering on another display’s capabilities (e.g. simulate P3-D60 48-nit gamma 2.6 in a Rec. 2020 1000-nit PQ encoding)
        - Support for the concept of “rendering intent” - i.e. match exactly (to the extent possible) or be “optimized” for the display (e.g. start with Rec. 709 master - match exactly on P3, etc. (gamut limiting, etc.)

Proposed Working Group deliverable(s)

- New reference code, replacing existing CTL transforms on 'aces-dev' repository
    - Unit tests?
- A suite of Output Transforms based on a parameterized framework
    - A new, simpler algorithm
    - Presets for common display standards (e.g. Rec. 709, sRGB, etc.)
    - But, support for all use cases
- Documentation of the design choices made
- Documentation of the options available in the Output Transforms

List of Proponents

The two of us. And also pretty much anyone who has ever used ACES – we can produce an exhaustive list if needed.

Anticipated core Working Group contributors

We anticipate a lot of enthusiasm for contributions to this group.
Major contributors will likely include (but not be limited to) Chris Clark, Joseph Goldstone, Doug Walker, Thomas Mansencal, Nick Shaw, Scott Dyer, those others listed on the RAE paper, and more.

Inclusion of everyone, especially for evaluation in a "beta" phase:

- Colorist community
- VFX community
- others

Anticipated Working Group lifecycle

Phase 1 (Process of Work Steps 1,2): 6 months
Phase 2 (Process of Work Steps 3,4,5): 6-12 months – possibly starting with overlap of Phase 1

Once group meets and can complete Process of Work Step 1, we will be better situated to project anticipated development time needed to explore algorithms that address all problems and use cases.

References

[ACES Retrospective and Enhancements (RAE)]

[RAE Response]

Excerpt from studio feedback (included here for convenience):
“

- *Make RRT simpler and 100% invertible* - this will have two effects:
    - Will produce cleaner results when converting display-referred graphics (sRGB) back into ACES. Currently this comes up on 100% of projects, and there is always a slight compromise of original intent using v1.0.
    - Allows new RRT tone scale to have slightly lower contrast. This is the #1 complaint from creatives and colorists.
- *Improve ODT flexibility* - parameterize the ODT with min, max, surround luminance, and color space (P3-D65 is needed ASAP)
    - Post-production has been shifting to smaller pop-up facilities as technology becomes more affordable. Allow any calibrated monitor to feed these parameters, and generate ODT on the fly.

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ACES Leadership Use

☒ Approved
☐ Not approved
☐ Proposal modifications required

Review date
07/16/2020

Assigned Working Group Name
Output Transform Architecture VWG

Assigned Working Group Lead
Alex Fry (Animal Logic), Kevin Wheatley (Framestore)

Supervising Technical Advisory Committee
☒ Architecture ☐ Implementation

Anticipated Academy resources required
Will need staff help to organize meetings and provide technical guidance, may need Stella resources for testing or review of images

Notes