Posudek diplomové práce

Matematicko-fyzikální fakulta Univerzity Karlovy

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Název práce Constrained Spectral Uplifting
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Studijní program Informatika **Studijní obor** Počítačová grafika a vývoj počítačových her

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Text posudku:

This diploma thesis shows a new approach to "spectral uplifting", which is a problem of converting RGB colors into their corresponding spectral reflectance. While solving this problem is important as spectral rendering provides higher accuracy and flexibility, the problem is underdetermined as infinitely many spectra resolve to the same RGB response. Hence, prior assumptions are required to get more reasonable results, such as assuming reflectance spectra curves are as smooth as possible.

Unlike the existing solutions, this is the first work that shows how the uplifting can be constrained using a certain catalog of prior spectra, e.g., from industrial color standards such as Pantone or RAL, or from movie asset spectral measurements. The author explains and shows how then all RGB colors should uplift to reasonable interpolations of the spectra from the input catalog. The main benefit is that it allows preserving color changes that may happen when changing the illuminating conditions, e.g., switching to a fluorescent light, even though the original uplifting was pre-computed for another default illuminant.

Overall, I am satisfied with the thesis in general: its overall structure is clear to follow, it is written in good English, the motivation is explained and shown on an example, previous methods are mentioned in the context of the new algorithm, and the method was successfully implemented and used in a renderer. Examples are provided that clearly show that the uplifting behavior is better than of the previous work when dealing with metameric issues under various illuminants. I am very happy how thoroughly the author's decisions to use certain approaches and parameters are investigated and presented, including complementary plots and images. I also praise the author for including results that are not entirely favorable for the method, e.g., the initialization performance.

For these reasons, and furthermore, because the presented problem was not trivial to solve, the author showed she could tackle the issues in a systematic way, and the results are even going to be published in a journal, **I definitely do recommend the thesis for defense.** When I talked to the author, she also seemed to have a very good understanding of her work and she offered more detailed explanations and answers to my questions.

However, while reading the thesis, I generally felt like the description of the method itself is not very easy to follow, and together with several other smaller issues, I think the thesis clarity could be quite improved. I would like to mention a couple of examples. 1) There are certain terms that are only explained later after they were already used, or are not sufficiently defined, e.g., "round-trip error" or "signal warping" in the thesis context, or when Delta E is referred, it is not clear which revision (76, 94, or 2000). 2) Difference figures that use color bars do not have absolute values assigned to the color bars, so it is almost impossible to judge how large the errors actually are. 3) I am missing a brief introduction to MESE and CERES, especially because an introduction to color theory is present, but an introduction to the actual optimization is weak. 4) I found the difference between voxels and voxel corners (vertices) confusing, only quite late in the thesis I understood what role they actually play in the uplifting. 5) I found some confusing typos in the thesis, e.g., a wrong inequality sign (Algorithm 3), wrong column headers (Table 4.2), or wrong pointers to figures (around Fig. 4.11, “rightmost” vs. “leftmost”). 6) Some figures seem to have unnatural aspect ratios or too small font sizes, probably because they were edited from different publications, so one really needs to zoom in to be able to judge them. 7) I would like to see more diagrams in the thesis that would complement the algorithm.

I understand that many of these issues were already solved in the recent journal publication.

I would now like to ask a couple of **questions** that I would like the author to think about and answer during the defense:

1) What would happen if you tried fitting the cube with a fluorescent light as the default illuminant? Would later uplifting under D65 still behave well?

2) Could you propose a way to handle input constraints that contain different spectra that resolve to the same RGB? For example, imagine a movie asset that contains both yellow plastic and gold, and both happen to be the same yellow RGB but different spectra.

3) I realize that the rendering run-time of the proposed method can easily be up to 4 times slower. That is quite a substantial slowdown. Do you think that the whole scene (or its textures) could be pre-uplifted once before rendering instead of doing it in real-time? Could you, e.g., store the moments for each pixel and multiply spectra in the moment basis; or store binned spectra for each pixel?

4) Do you think your method could be used to help with hyperspectral imaging, i.e., resolving spectra from non-spectral photographs? For a brief overview of hyperspectral imaging, consider, e.g., Chapter 1 of Saragadam Raja, V. 2020. Spectrally-Programmable Cameras for Imaging and Inference.

Práci doporučuji k obhajobě.

Práci nenavrhuji na zvláštní ocenění.

Datum 18.06.2021 **Podpis**