**Feedback Ingeborg Tastl / HP (blue), responses of Philipp Urban (In Red)**

* On slide 27 of the first slide set it says “We work with Barbieri on a reflectance/transmittance spectrophotometer for automatically measuring RGBA”  
  I know that currently available Barbieri products can measure reflectance / transmissions of samples. I am assuming that for the new devices   
  it would be a measurement for the ”perceived translucency”, versus a percentage of light that is transmitted through a material that is measured currently.  
  Is this understanding correct ?

4 measurements must be performed to obtain both CIELAB and Alpha:

1. Reflectance measurement (white backing, big aperture for illumination) <- for measuring the color
2. Reflectance measurement (black backing, big aperture for illumination) <- for measuring the lateral light transport
3. Reflectance measurement (black backing, small aperture for illumination) <- for measuring the lateral light transport
4. Transmittance <- vertical light transport

The difference between the measurements according to 2 and 3 gives us the lateral light transport.

The idea is to automatize the full measurement procedure as much as possible (changeable apertures to measure later light transport + changeable backing, i.e. black, white, empty for transmittance measurements). The goal is to fully automatically measure the Alpha value in addition to color. Markus Barbieri told me that he will invest in this if the procedure is standardized, i.e. this is a hen and egg problem. So far we have not talked to other spectrophotometer manufacturers.

We received from Markus already a prototype spectrophotometer with a very big aperture for illumination (19mm) allowing us to measure color of highly translucent materials (using an aperture of detection of 2mm) – I assume this will be the starting point of the automatization.

* The psychophysical experiments for establishing a perceptual uniform perceived translucency space were performed on a monitor using physical based renderings.  
  Do we have indications that psychophysical experiments with real materials would result in a similar rescaling of the space ?

The reference materials used in the definition are accurately defined by intrinsic optical properties (absorption and scattering coefficient constant for all wavelengths, refractive index, isotropic phase function) but they are pure virtual, i.e. they do not exist in nature.

A good degree of uniformity was established for these materials using psychophysical experiments based on physically accurate renderings of these virtual materials under front/side lit conditions.

To come up with a one-dimensional definition of translucency (measurable, device independent), all real world materials are mapped to these virtual reference materials based on their similarity of light transport properties (vertical and lateral light transport) --- see Eq. (2) in the paper.

Note that real materials may deviate substantially from the reference materials (wavelength-dependent absorption and scattering, non-isotropic phase function, etc.). Picking the reference material best matching with the real material w.r.t. light transport properties (Eq. (2) in the paper) may still be noticeably different to the real material. Therefore, even if the viewing conditions used in the display experiment are exactly reproduced, it is likely that the uniformity will be worse for real materials. If we change viewing conditions (e.g. using back lit) uniformity will become also worse.

* I assume the anchor pairs used for the psychophysical tests consisted of pairs that varied  
  - only in the scattering coefficient  
  - only in the absorption coefficient  
  - varied in both the scattering and absorption coefficient   
  Is this correct ?

The materials in the anchor pair used in the experiments just varied in scattering. We have recently conducted a new experiment with a more opaque anchor pair at NTNU and will publish the results soon.

* On slide 36 of the original slide set there is one example for **one reference material** linking the “perceived translucency” to a scattering and absorption coefficients.  
  How many reference materials do we envision that we will need ? Would each 3D printer company characterize their own transluscent materials?  
  Which steps do we envision do they need to take ? Or is there some calibration step so that they can get perceived translucency values for their materials using either  
  a new measurement device and or a simulation (public available) and then once the perceived translucency values are known then a single transformation process is used to obtain the scattering and absorption coefficients ?

A printing company does not need to care about reference materials. The spectrophotometer manufacturers need to calibrate their devices to the reference materials and provide a lookup-table that can be used to obtain the Alpha value ( or absorption and scattering values of the reference materials) from the measurements.

**Feedback Matt Shepherd / HP (blue), responses of Philipp Urban (In Red)**

* sRGB to CIELAB: need to clearly align on illuminant (D50?) and observer (2deg)

Yes, we have proposed to align the viewing conditions to the conditions of the ICC standard, i.e. CIE D50 and CIE 1931 (2 deg) observer. See the paper, page 5, section 3.1 and 3.2.  
Here a link to the paper: [https://cloud-ext.igd.fraunhofer.de/s/pAMH67XjstaNcrF#pdfviewer](https://urldefense.proofpoint.com/v2/url?u=https-3A__cloud-2Dext.igd.fraunhofer.de_s_pAMH67XjstaNcrF-23pdfviewer&d=DwMGaQ&c=76Q6Tcqc-t2x0ciWn7KFdCiqt6IQ7a_IF9uzNzd_2pA&r=mu5MNtNhOuifXLWzpoi49Wv6X-RwwmvrOYHi_g4wvL4&m=6BihcT1ZVT2ip9DUq2IzcUqRxqPDu3SwsFGL7b0i1SI&s=lGngh4gIWHM8x07AJXdrhGxURoov6G8ih2Fax1DvFSU&e=)

* Examples.  The example on slide 3 is only grayscale.  It might help to talk though examples of how the transform (σa, σs) <-> (T,L) works for for a non-grayscale value, say blue:
  + Min scattering (e.g. optically transparent blue glass)
  + Max scattering (e.g. opaque blue ceramic tile)

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The transformation (σa, σs) -> (T,L) is computed as follows (note that the reference materials have absorption coefficients that are constant w.r.t. wavelength, i.e. they are grayscale materials):

* T, according to equation (1) in the paper. Slide 4 of the slides in Alexander’s presentation includes the values for the parameters obtained by psychophysical experiments.
* L via simulations (Monte Carlo photon path tracing) for the viewing conditions (45/0 measurement geometry, 4mm thick sample, CIED50, 2deg observer, white backing).

Note that this needs to be done for the reference materials once and can be stored in a 2D lookup table.

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For given RGBA values, the transformation (T,L) -> (σa, σs) is computed according to Eq. (3) in the paper.

For measuring real materials (as the optically transparent blue glass or opaque blue ceramic tile), Eq. (2) in the paper shall be used. It basically picks the closest reference material based on similarities in vertical and lateral light transport.

For the examples you mentioned

* + Max scattering (e.g. opaque blue ceramic tile)

This will give you big σa since the sample is blue (probably low L\* value) and big σs due to low vertical and lateral light transport because of high scattering.

* + Min scattering (e.g. optically transparent blue glass)

This will give you σa according to the measured lightness and small (probably negligible) σs because of the zero lateral light transport.

Note that for very dark tinted blue glass the proposed definition has limitations (see example and explanation in the Paper, Page 11, last paragraph and Figure 12).

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We provide Matlab script for the transformation incl. the lookup table: [https://cloud-ext.igd.fraunhofer.de/s/9BrZaj5Uh5d0cOU/download](https://urldefense.proofpoint.com/v2/url?u=https-3A__cloud-2Dext.igd.fraunhofer.de_s_9BrZaj5Uh5d0cOU_download&d=DwMGaQ&c=76Q6Tcqc-t2x0ciWn7KFdCiqt6IQ7a_IF9uzNzd_2pA&r=mu5MNtNhOuifXLWzpoi49Wv6X-RwwmvrOYHi_g4wvL4&m=6BihcT1ZVT2ip9DUq2IzcUqRxqPDu3SwsFGL7b0i1SI&s=HExk5u0BjYm3B9viNFIcwEhraNQU2-rRPUDBGab5YKI&e=)