

little cms Engine*

lprof - A profile construction set library

How to use the the sample profilers

Ver 1.09

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Welcome to this small guided tour on littlecms sample profilers. The goal of this document is to show how these programs can be used to generate ICC profiles for your monitor, scanner, digital camera, film projector or input device. It has also some advice on color management in general, as well as some guidelines on how to handle several littlecms utilities.

Since the best way to see how it works seems to be by example, we will step by step make a whole calibration procedure for monitor and scanner.

In all this tour, we will make extensive use of the measurement and proof utility: `qtMeasurementTool`. You will also need a IT8 target, available from several vendors. If you plan to do scanner profiling, make sure to get one of these.

`qtMeasurementTool` is a “virtual colorimeter” that used in conjunction with a proper scanner profile can be used as a cheap replacement of expensive hardware. It can also be used to proof an image across two profiles. The most simple way to check if all is going fine is by visual inspection. You can load an image in the measurement tool, and apply a transform between your input profile (AKA, scanner or camera) and your monitor profile. Since right now we have no profiles to check, we should first create a profile for our monitor.

This is done by `qtMonitorProfiler`. This program can work in two different modes. The “advanced” mode, that gives accurate profiles by using hardware devices like X-Rite DP92 or EyeOne, and the “simple” mode, that allow to build reasonably accurate profiles without any additional hardware.

1 Building a monitor profile: a coarse approximation

So, let’s build our first monitor profile to check how all this stuff works. We don’t need right now a big accuracy. We want to calibrate coarsely, just to visually check if is all going ok.

After installing the package, type

```
./qtmonitorprofiler
```

This will start the monitor profiler application. As said, we need only a coarse profile, so, we select the radio button labeled:

I want to build a coarse profile, giving approximate values

This is selected by default. We need not any measurement right now, only a few visual adjusts. Press the button labeled:

Enter monitor values

You will see the monitor values page. In order to obtain maximum performance, we need to adjust first the physical monitor controls.

*<http://www.littlecms.com>

Set contrast to near maximum, (yes, near maximum. This is the gain of monitor and we need as many as monitor can deliver) and then adjust brightness until you can see all grays of a grayscale. Leave the monitor alone, and return to monitor profiler program.

Now we will adjust gamma correction. This is by far the most important setting. On our first approach, we will try with only one gray channel (make sure *Link channels* is checked).

Move the slide until the central frame seems to *fade* on background. Don't spend too much time adjust it, gamma varies with many factors. A coarse adjust will be enough right now.

You should obtain a typical value of 2.1–2.4, in some cases it could be even lower.

Now we go on the white point stuff. Some monitors refers white point as “temperature”. Most users does have white point set to D93 in order to get more bright, unfortunately this restricts the gamut and adds a big quantity of blue, so my advice would be to select something lower.

If you can switch temperature of your monitor, D65 (near 6500K) could be a good choice for multiuse. For proofing devices, D50 is almost a must, but it adds too yellow for a unadapted used. D50 requires a dim or dark room to give the best results. If you don't know which temperature your monitor has, select D65 or D93. On our fist approach both these will give reasonable results.

If your monitor has any other white point, you can select *User defined*, the last option. You can then select your particular white point as a temperature in Kelvin degree.

Don't use CIE illuminants. They are intended for workspace construction, and will be discussed latter.

Next adjust is primaries set. For the primaries, select the default ITU/R BT.709 if you are profiling a CRT monitor. There are primaries for Samsung TFT and LCD, but these devices are not fully supported by the profiler. The reason to not support them is the angular dependence, which makes them unusable for color management tasks.

Other primaries are for building workspaces. If you don't know the primaries, don't worry. Use the default ITU/R BT.709. There are 6 or 7 CRT tube manufacturers in the world, and all them does use this set.

Now you can fill the info about your monitor. Although this is not strictly required, it could prevent a lot of pain when you have more than a couple of profiles. For filling the info field, select the *profile identification* tab, and be creative on your comments!

Now we are ready to generate our profile. We must specify the output filename, so, select the *Main* tab, and press the ... button on right side of the *output profile file* edit.

Select **profiles** directory. This is where other tools will look for monitor profile. There are a couple of profiles there, leave them alone. For the name, we could use **CoarseMonitor.icm**. So, type in the name and then proceed to generate the profile by pressing the *GO!* button. If all is ok, the status console will show *Profile DONE!*

Let's now check how well is working our profile by eye. For that, we need another tool. So, close the monitor profile and start the measurement tool by typing

```
./qtMeasurementTool
```

This utility has many usage. One would be to “proof” a color transform. Let's first configure the measurement tool. Select the *Options* tab. Adjust the default settings as following:

On *Pick template* → *Empty Picker*

On *Input profile* → *Tutorial Workspace*

On *Monitor profile* should appear your profile. If you filled the info fields, here will be your description. If you didn't enter description it will be *(unknown)* - *Little cms construction set*, which is the default string. Now you know why to fill information fields!

We are going to check your profile with a highly tweaked sample image This is a counterexample on what a good workspace should be. NEVER use this profile for practical purposes!

Ok, let's see how an image looks in this tweaked colorspace. Select the *Image* tab, and press *Load Image* button.

Select **pics** directory. There is a **party_4s.png** file. Load it. You will see the raw, non color managed picture. Since the encoding space of this image is quite different of any monitor, the images looks “flat”

and “washed out” Now press the *Proof* button. The image is shown using color management. Color changes should be noticeable, despite gamma of image is near gamma of monitor.

2 Building scanner profile

We have now our monitor calibrated, and will try to generate a scanner profile. For this, we will also need the measurement tool.

Scanner profiles are built by using a thing known as “IT8 target”. IT8 targets are just a photo with a set of color patches. There are known colorimetric measurements for each of these patches. There is also a standard way to specify these measurements, the IT8/CGATS format.

IT8/CGATS is a way to encode data that is both, human and machine readable. You can open any of these IT8 reference sheets with your text editor to see it. You can even modify the contents. Since it is a standard, most color management systems does accept it. For these reasons, seems a good way to store measurement data.

A IT8 file does contain measurements for a set of color patches. The measurement of each patch can be the device colorant values (the RGB or CMYK in 0–255 range) the tristimulus values (XYZ or Lab) and some statistic data.

An IT8 sheet looks like:

```

-----
IT8.7/2
ORIGINATOR "Wolf Faust"
DESCRIPTOR "L* a* b* Batch average data (light D50, viewing angle 2)"
MANUFACTURER "Wolf Faust - http://www.coloraid.de"
CREATED "January 07, 2002"
PROD_DATE "2001:12"
SERIAL "DIN A4 R012020"
MATERIAL "Kodak Professional Digital 3 - Non-Glossy"
NUMBER_OF_FIELDS 9
BEGIN_DATA_FORMAT
SAMPLE_ID  XYZ_X  XYZ_Y  XYZ_Z          LAB_L  LAB_A  LAB_B          LAB_C  LAB_H
END_DATA_FORMAT
NUMBER_OF_SETS 288
BEGIN_DATA
A1           3.25   2.71   1.94          18.86  11.18  2.87          11.55  14.41
A2           4.07   2.73   1.60          18.91  23.59  6.54          24.49  15.48
A3           5.79   3.42   1.75          21.67  33.38  9.60          34.73  16.05
A4           4.28   2.66   1.46          18.62  27.73  7.59          28.75  15.32
A5           11.97  10.30  7.42          38.38  15.04  4.16          15.61  15.47
.... etc ...
-----

```

The target manufacturer does provide a IT8 file containing these measurements for the target. So, the target is giving to us a set of KNOWN colors. We must then, tell to the profiler which RGB values our scanner returns for each of these patches.

Measurement tool can generate sheets with the RGB values of each patch grabbing them from an image. In order to generate a profile, we need the RGB and Lab values for each patch.

let’s outline the scanner profiling procedure:

- First (and very important!) adjust controls of scanner to obtain a proper exchange space.
- Scan by means of you scanning software an image of your target.
- By using measurement tool, grab the RGB values of each patch. Store them in a IT8 file
- The scanner profile then will compare the RGB obtained by the scanner, with the known colorimetric measurement of target, as stored in vendor’s reference sheet.
- The scanner profiler will create a model for the translation RGB → Lab or RGB → XYZ and will store it in a profile.

The math behind this model is not trivial. There is a big quantity of factors taken into account. Don't worry for the apparent missing of data. Yes, there are colors not present in target, however the scanner profiler is capable to "guess" or extrapolate them, and should produce a profile handling all gradients between these colors in a smooth and pleasant way.

Lets' discuss each step in detail:

Step 1: Adjust controls of scanner.

You will need 24 bits per pixel at least. Gray profiles are NOT supported in this revision.

There is a big amount of controversy about how to set the scanner controls. Some people does advice to use linear gamma (gamma=1.0), which is a wrong advice unless you are working with 16 bits per sample (48 bits per pixel)

If you are going to scan in 8 bits per sample (24 or 32 bits) your best choice is a gamma between 2.2 and 3.0

Gamma 2.2 has the additional benefit of being close to sRGB, and this means the uncorrected image will "look nice" on average monitors. It is also near to perceptual gamma.

Gamma 2.4 has the additional benefit of being closest to perceptual space, and this is a very good reason to use this value.

Less that 2.2 (and of course the infamous 1.0) can generate huge loss of detail in shadows, only to give a slight bettering of highlights. Don't use this unless your are using 16 bits per sample, and even in such case, don't do it unless you know what are you doing!

More that 2.4 (up to 3.0) drops too much highlight to be safe, despite you will still see the image quite correct.

More on controls: Turn off all color management, color enhancing and tweaking on scanner driver. Set brightness contrast and hue (if available) to default values. It is supposed this will be your working scanning mode, so set all to reasonable defaults.

IMPORTANT: The profile will only be valid with those settings!

Step 2: Scan the IT8 target.

Store it in PNG, TIFF, BMP on depending of supported formats of your platform. DON'T use JPEG! Its lousy nature makes it unsuitable for this purpose. You could use JPEG on final images, but not in profiling process.

Step 3: Extract the RGB values for each patch.

Without help, this could be a huge task. There are plenty of patches and taking each sample by hand would be tedious. With the help of measurement tool, this is a easy task.

Start the measurement tool by typing

```
./qtMeasurementTool
```

Press *Load Image* button. Select the image of target you scanned in step 2. I will use the `scandmo.png` image sited on `pics` directory as sample. This is a Kodak film target, scanned with a scanner that adds a huge violet cast. Don't worry, the profile will turn this one to a nice looking image.

Since this is a Kodak target that has some additional patches (those on I,J,K,L - 20,21,22) we can choose a picker template according the nature of target. Press *Options* tab, and in the combo labeled *Pick template* select:

IT8.7 19+3 (Kodak) column picker

Press *Image* tab.

You will see a lot of green rectangles. Using the mouse you must place the pick template over the patches. Use left button to move whole template and right button to resize it. Since this image is not perfectly horizontal, you may want to "unshear" the layout: You can do it by pressing *Ctrl* key while dragging with left mouse button.

The “hot area” is marked with green rectangle. Assure all green rectangles are inside patches. Failure to do so could result in wrong profile! You can also adjust the relative size of “hot areas” by setting the % in *safe frame* on *Options* tab. Normally there is no need to touch anything.

Once you were happy with the location of patch grabber zones, press the *Pick* button, placed on left side of window.

The measurement tool will build a IT8 sheet containing RGB values of each of your patches. Now you can save this sheet by pressing the *Save IT8 sheet* button. For our tutorial I will name this measurement `scandmo.it8` and will place it on `pics` directory. (There is already one `scandmo.it8`, that you can overwrite)

Our work with measurement tool is now done. We have right now the reference sheet of target, which is given by Kodak, and the RGB values obtained by our scanner. Now we can compare these files to create a profile.

Step 4: Close the measurement tool, and launch the scanner profiler by typing:

```
./qtScannerProfiler
```

From here is quite easy. First we must select the target reference. In this tutorial, we have used a film target of reference 1996-08, so, press the *Select target & vendor type* button and select *targets*, *Kodak* folder, then *Emissive* folder (since it is film). Press *Ok*. The left combo will be filled with all target references. Then select 1996-08 (is on last part of list)

Once selected, you need to specify your measurement. Press the ... button placed on right side of *Measurement* edit. Select `picts` folder and `scandmo.it8` file.

Now we have to specify the profile filename. Press the ... button placed on right of *output profile file*, select the *profiles* folder. The name could be `scandmo.icm`.

You can now, as we did in the monitor profile, fill some info to help us to locate the profile latter. Press the *profile identification* tab, and fill in the fields.

You are ready to generate the profile. Press *GO!* button to launch the profiler process. After a few seconds, you will have a small profile for your scanner. In the demo, the obtained dE is about 1.24, which is reasonably. Now, we can better a lot the error level, but this will take more time to generate the profile. Press the *Parameters and tweaking* tab, and select on *Resolution* group *33 points*. Then check the checkbox labeled *local convergence analysis*. Press the *GO!* button. Now the generation will take a while, but the obtained profile has bettered a lot... maximum dE is about 0.7 and the peak value is as small as 3!!!

Step 5: Let's check how this profile does affect the original image.

Start the measurement tool, select *options* tab and make sure picker template is set to *empty picker*, *input profile* should be set to this newly created scanner profile, and *monitor profile* should be the profile we have made for monitor. Press *Image* tab, press *Load Image* button, load the scanned image (`scandmo.png` in our sample) and then press the *proof* button to see the results. The girl's image is dark, this is normal. However, rest of patches are hugely modified, the grayscale should appear smooth and without any cast, as well as all violet tint should disappear.

3 Making workspace profiles

Some applications, for example Adobe Photoshop, does use what is called “Workspaces”. These are RGB color spaces, which are not intended to be representing any device, nor storage but a “working space”. That is, image processing operations are performed in such space, and also can be used as a way to interchange image data between applications.

The monitor profiler, despite its name, can be effectively used to build such profiles.

Just select the gamma, primaries set and white point. Press *GO!* and the workspace profile will be generated.

4 Building accurate monitor profiles by hardware measurement devices

To measure your monitor, you need to fill a IT8 sheet, containing XYZ measurements for several RGB combinations. A sample sheet of this kind can be found in `pics` directory. The file is called `sRGB.IT8` and it measures an ideal sRGB monitor.

You need to change the XYZ values by those read by your measurement device. Don't put any Lab value, just RGB and XYZ.

Please keep the RGB values the `sRGB.IT8` has. Optionally, you can use more patches to assure consistent color reproduction, but make sure to include at least that ones.

Note the big amount of gray patches needed. You can also add as many as you wish, on more gray patches, better linearization curves control. You must specify at least 16 gray patches.

Now we will try this procedure, no matter you have not any hardware device. As we will see below, this method could be used to dissect profiles and do some tweaking.

We are going to generate a sRGB profile, by using the `sRGB.IT8` measurement sheet. For that, we will use monitor profiler, so start it by typing:

```
./qtMonitorProfiler
```

Now, we are going to use it in advanced mode. Select the radio button labeled:

I want to build accurate profile from measurement sheet

Then press the `...` button located at right of edit. Select in `pics` directory the file called `sRGB.IT8`. In the *Output profile file*, select a new profile in `profiles` directory. Call it `textttmy_sRGB.icm`.

I will use this sample to present another utility, the profile checker. Since the profile checker can understand advanced tags, we want to include all information in the profile, so select the *parameters and tweaking* tab, and make sure to select *Verbose, store anything* in the *profile verbosity level* group.

Now, fill the info fields if you want (again, I recommend to do that) and press the *GO* button. A new `my_srgb.icm` profile will be created.

We will check now how accurate is this profile. Start the profile checker program by typing

```
./qtProfileChecker
```

The profile checker is a tool for inspecting some of profile internals. In our case, we want to check the accuracy. For selecting the profile, press the `..` button on the right side of the *profile* edit. Select `pics` directory, and choose `my_srgb.icm` profile. Press *GO!* button.

On *dE report* tab you will see the error statistics. (unless you forgot to set the profile verbosity to *store anything*) Our sample scored 0.18, which is a incredibly low value, not to be even reached in real world cases, but this could give an idea of the precision the profiler can give with only a very few measurements.

The profile checker has also the capability of draw chromaticity diagram, to show primaries, color displacements, to guess the gamma of the profile and many other functionality. Feel free to experiment, the profile checker will never write on your profile, so you can play with it in a safe way.

5 Additional utilities

Finally, there is a additional command-line utility that can be used in conjunction of monitor profiler. It is called `icc2it8` and is placed on `ICCToIT8` directory. This utility is capable of generate IT8 measurements from profiles, so, it can be used as a "profile tweaker". You can generate a IT8 sheet from a given profile, then edit manually XYZ values and then build a new profile using the modified sheet. This right now is limited to matrix-shaper profiles, but even with this small limitation, it can become a valuable tool.

Other useful tools are included in `littlecms` CMM package. You have `TIFFICC` that can be used to apply profile transforms to TIFF files, and `JPEGICC` that does same on JPEG. Also, you have `ICCTRANS`, that can be used to check profiles by numbers. See the `littlecms` documentation for more details.

That's all for now. There are still many options that this small introduction don't cover, like the CIECAM97s appearance model, and a more advanced usage. However, you have now a basic knowledge of how this stuff works. There is a mailing list on littlecms for asking and sharing your tricks on how get the best from littlecms profilers. Feel free to ask.

<http://lists.sourceforge.net/lists/listinfo/lcms-user>

Enjoy!