## The Problem:

When lit, Glossy- surfaces with a high roughness- value will become darker. This is an effect that we sometimes prefer to avoid. I measured average brightness- values of an evenly lit white (ffffff) Ashikhmin- Shirley- Surface at the roughness- values:
$\{0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0\}$
And created a plot from it. (The measurements might be inaccurate by $\sim 1 \%$ or less)
Now the goal will be to approximate the plot of the measured data adequately by a simple function $f:[0,1] \rightarrow[0,100]$, that will give an (for the Ashikhmin-Shirley- shader) expected brightness- value $f(x)$, for a given roughness- value $x$ and creating a node setup, based on that function, that counters the darkening of the surface.

*Wanted describes the fact that we would like to have a constant energy level of $100 \%$.

## Observations:

When first looking at the plot of the measurements, you might think that an approach like:
$f(x)=f(0) * e^{k x}$ (an exponential growth function) would offer an adequate approximation. This however is not true, since only values of $x<0.4$ are well approximated by an exponential function, but for larger values the plot runs almost linearly.

## First Approach:

Maybe the measurements can be well approximated by a function in the form of:
$f(x)=a^{*} x^{2}+b^{*} x+c$
A sensible approximation gives:
$f(x)=-34.3 x^{2}-28.5 x+101.9$


As we can see this Quadratic approximation is significantly better than the linear one.


But we surely can do better than that.

Let' s try to do a cubic approximation:
$f(x)=a^{*} x^{3}+b^{*} x^{2}+c^{*} x+d$
$f^{\prime}(x)=3 a * x^{2}+2 b^{*} x+c$
$f(0)=100=a^{*}(0)^{3}+b^{*}(0)^{2}+c(0)+d$
$\Rightarrow d=100$
$a^{*}(1)^{3}+b^{*}(1)^{2}+c(1)+100=41 \mid-100$
$a+b+c=-59$
I want 100 to be a local maximum value of $f(x)$, so:
$3 a *(0)^{2}+2 b^{*}(0)+c=0$
$\Rightarrow c=0$
$a+b=-59$
I also want $f(0.5)$ to be 78
$a^{*}(0.125)+b^{*}(0.25)+100=78$
$\Rightarrow$
Eq1: $a+b=-59$
Eq2: $0.125 a+0.25 b=-22$
$\Rightarrow$
$a=58 ; b=-117$
$\Rightarrow f(x)=58 x^{3}-117 x^{2}+100$ (Or similar values)
This is technically not the most accurate cubic approximation that you can get, but it works really well and has nice coefficients ;P


The cubic function seems to approximate the measurments really well. As can be seen better in the error- plot:


So let' s use the cubic approximation to try to create a Brightness- correction-node- setup:
$f(x)=58 x^{3}-117 x^{2}+100$
The maximum error of this approximation is $\sim 1.9 \%$. The average error is only $\sim 0.5 \%$. (Keep in mind that these values describe the difference between the measurements and the approximation the actual error in the energy level of the surface material later should be even smaller)

Lets convert this function to a weighting- function for Blender now:

$$
\begin{aligned}
& f_{w}(x)=\left(-58 x^{3}+117 x^{2}\right) / 100 \\
& =-0.58 x^{3}+1.17 x^{2}
\end{aligned}
$$

Yay!
Now i create the brightness- correction node- setup and put my newly built gloffuse- shader into the same environment $i$ used to measure the brightnessvalues of the Ashikhmin- Shirley- surface, expecting to measure brightnessvalues of around $100 \%$ at any given roughness- value (yes i am simple like that).
...which of course doesn't happen. Instead i get some light grey values at the higher end of roughness- values.

At this point is seriously question my approach.
A few Measurements later i know that the loss of brightness in percent doesn't depend (at least not strongly) on any part of the color- value (HSV) of the Ashikhmin- Shirley- surface, which is great news:) This seems to be true for the whole roughness- range which means that the correction- function is still usable, which feels like inredible luck to me now. (Remember that i got my initial measurements from a completely white surface.)

Now figuring out what's wrong is pretty easy. Soon enough i notice that the mix- and add shader work very differently from what i thought. Mixing a white and a black diffuse- surface at a mix value of 0.500 gives me a light grey. No matter which diffuse i plug into the first input. Great...
And adding two mid- grey diffuse surfaces gives a light grey result aswell (I expected white)... Awesome.
I have absolutely no clue how to deal with this issue, since i have absolutely no idea how these both shaders work. Using the correction- function to affect the input color of an Ashikhmin- Shirley- surface leads to ugly results, so i can't get around a node- setup that uses mix- and add shaders.

On the other hand, the results of the tests looked good enough for me not to notice the slight distortion and the falloff is still precise, so i decide to keep the setup. In further tests it holds up (now) unexpectedly well or (as i initially expected it would do).
The Surface still darkens with increasing roughness- values, but the effect is greatly reduced.
Later i also notice that every material shows up darker than expected in the render, except for glossy materials at a roughness- value of ".
*Another thing to mention is, that the energy- loss depends on the viewers angle to some extend (but not that strongly), so a correction setup that takes the viewing angle into account would be more precise, but this is a minor 'problem". And i honestly would care about it much more if i would have managed to completely eliminate the darkening effect in the first place ;)

But whatever. You be the judge! Also if you can enlighten me on this issue please message me! @ChrisCordova on Blenderartist.

