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Additional material: Automatic Aesthetics-based Lighting Design with Global Illumination

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1. Introduction

In this document, we present additional materials. This document is composed of two main sections. The first section will present implementation details used in the original paper. The second section will present additional results.

2. Implementation details

The method described in the article as been implemented in Python using the LBFGS-B [ZBLN97] optimization method, using scipy [sci13], numpy and openCV for image processing [num13, ope13]. The rendering step has been performed with the Mitsuba rendering platform [Jak10].

Bounds: In the optimization process, some free parameters have to be bounded. The emitted luminance is considered to be strictly positive, but it does not have any upper boundary. Moreover, the bounding values for the scale of the V channel of the HSV background's albedo are $[0.1, 10]$. The scale of the area light source is strictly positive. However, we have to make sure that the light source does not collide with:

- the main object's surface viewed from the camera,
- the camera frustrum,
- and optionally, with all objects of the scene as it is not physically realistic.

The upper bound for the light source's scale is computed using ray-casting. We sample points on the light source surface. We cast a ray through each of those points from the mass center of the source. The minimal distance needed for a ray to intersect the scene is a maximum scaling factor for this light source. Similarly, we cast rays from the camera through the image plane. The scaling factor should not excess the minimal distance between the light source's center and the rays to prevent the source from intersecting the camera frustrum. The scaling factor's upper bound is the minimum of those two factors (Fig. 1).

Initial values: In order to compute the initial value of the emitted luminance of each light source, we compute the emitted flux value that brings the minimal contribution. For the emitted luminance of each light source, we compute the emitted flux that brings a minimal contribution.

For the scaling of the light source, we set-up the light source size as half the radius of the object's bounding sphere. If this scale is bigger than the upper bounds, it will take the upper bounds value times 0.8.

Differential steps and scaling: Differential steps are computed as 10% of the initial value. Free parameter values are scaled automatically before the optimization process, so that they have all comparable order of magnitude.

Computation To compute the different statistics on pixel luminance, we render a High Dynamic Range image, we clip the float luminance value from 0 to 1, we perform Gamma correction with an exponent $1/2.2$, to prevent any imprecision on gradient evaluations because of image quantization.

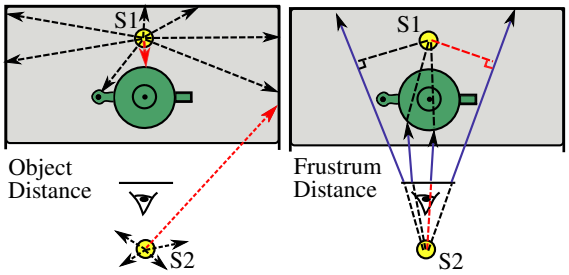
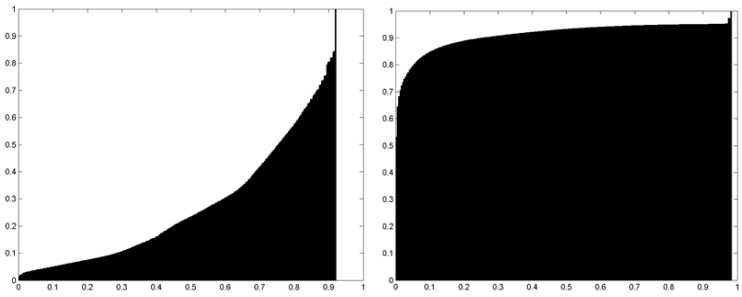


Figure 1: The two strategies to compute the light source's size upper bound: distance to all objects (optional) and distance to the camera's frustrum.

2.1. Signature histogram

The histogram used for the target value is extracted by averaging an set of image [Sic13]. The cumulated histogram is shown in the figure 2. Numeric data of the signatures are given in the Appendix section.



(a) High-key signature (b) Low-key signature

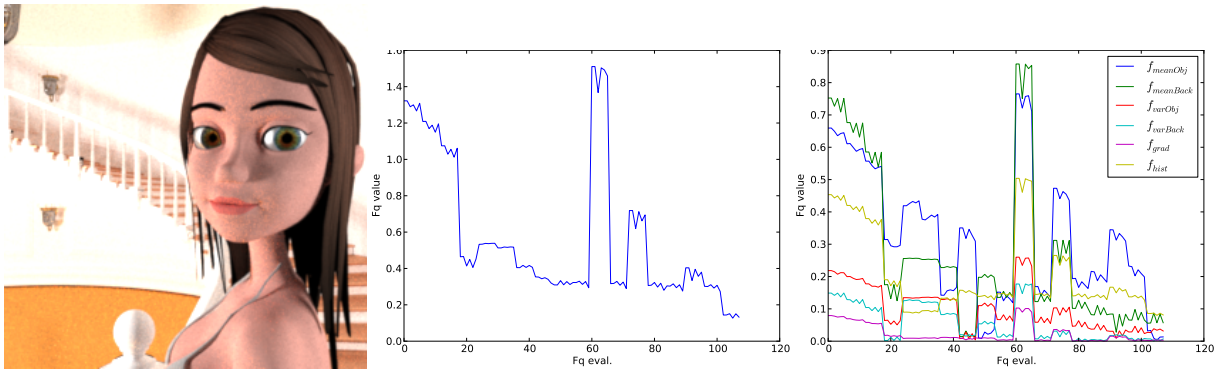
Figure 2: Signature cumulated histograms

3. Results

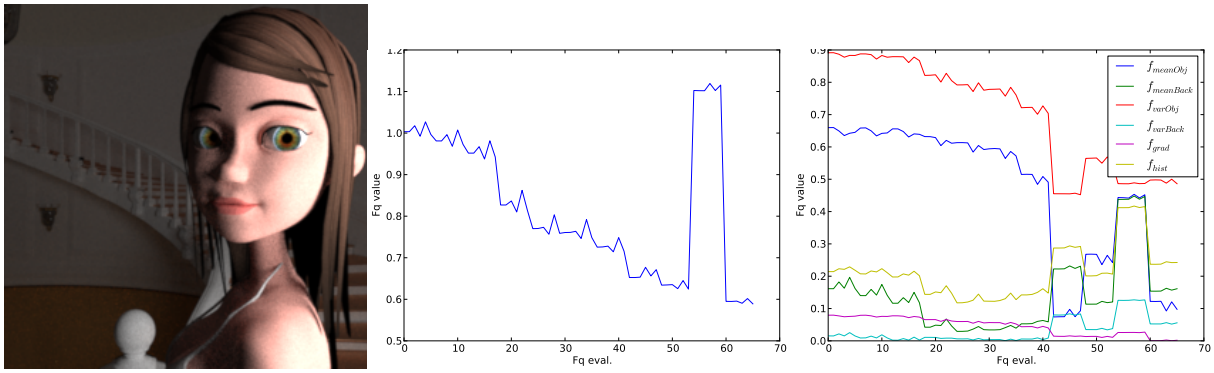
In this section, we present more results with additional scnenes and data compared to the original paper. For each scene, we present the evolution of f_q and the evolution of each term. In each plot, we display all evaluations of the function, including finite differences for gradient evaluation, which explains why the values increase abruptly. In these cases, the algorithm is looking for a new optimization direction, so it computes finite differences in all directions, including those that bring an abrupt evolution of f_q. For the timing, informations are provided in seconds and all the results were computed on an Intel(R) Core(TM) i7-2630QM CPU @ 2.00GHz (ASUS G74SX laptop).

3.1. Teaser scene

On average, a single evaluation of the cost function is made on 45.03 seconds.



(a) High-key (Total time: 4593 seconds) (b) f_q (c) objective function's terms

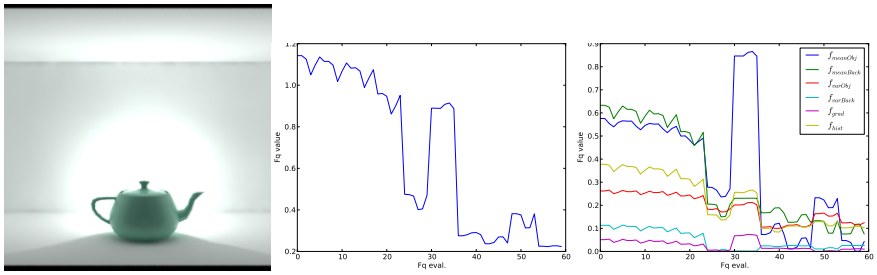


(a) Low-key Total time: 2881 seconds) (b) f_q (c) objective function's terms

3.2. Teapot scene

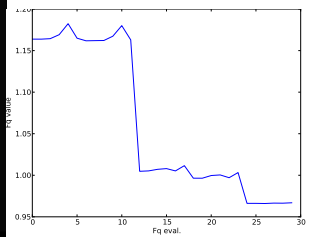
On average, a single evaluation of the cost function takes 7.48 seconds.

Without background optimization

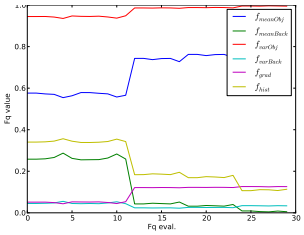


(a) High-key (Total time: 441 seconds) (b) f_q (c) objective function's terms

(a) Low-key (Total time: 209 seconds)



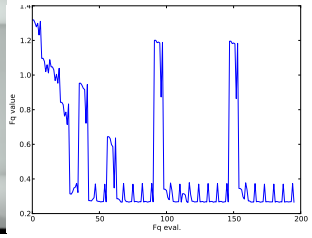
(b) f_q



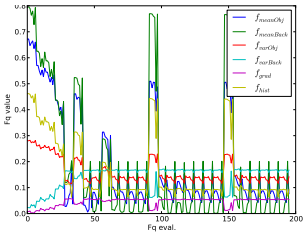
(c) objective function's terms

With background optimization

(a) High-key (Total time: 1436 seconds)

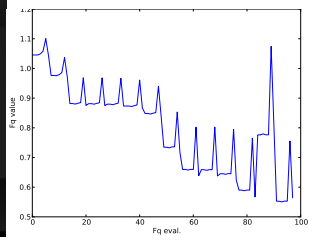


(b) f_q

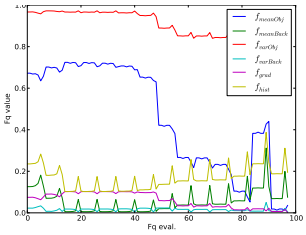


(c) objective function's terms

(a) Low-key (Total time: 710 seconds)



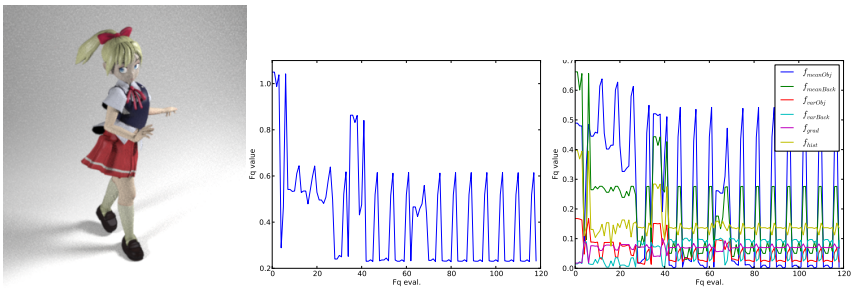
(b) f_q



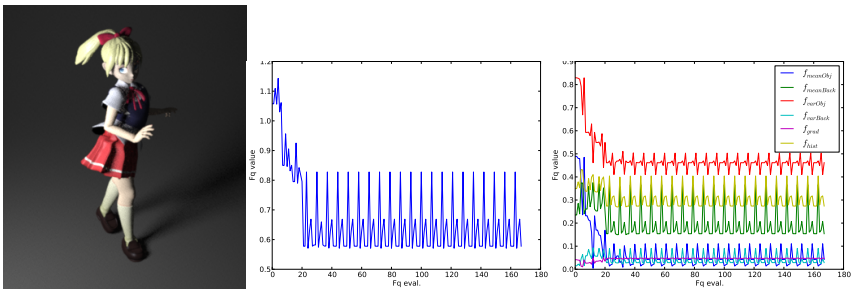
(c) objective function's terms

3.3. Girl scene

On average, a single evaluation of the cost function takes 4.82 seconds.



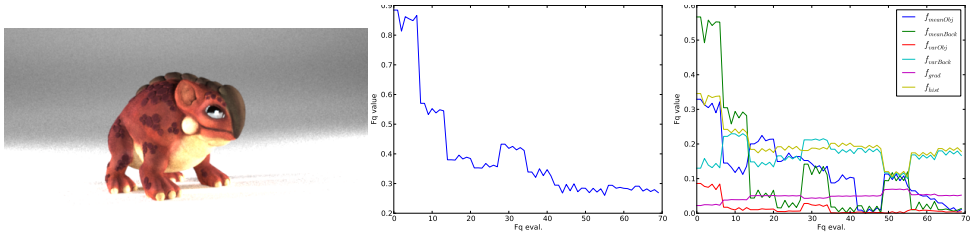
(a) High-key (Total time: 569 seconds) (b) f_q (c) objective function's terms



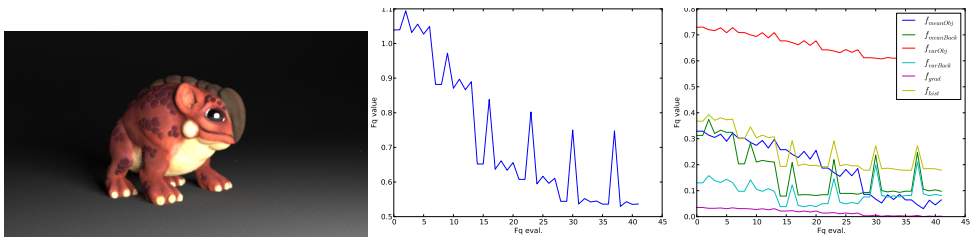
(a) Low-key (Total time: 810 seconds) (b) f_q (c) objective function's terms

3.4. Creature scene

On average, a single evaluation of the cost function takes 11.12 seconds.



(a) High-key (Total time: 718 seconds) (b) f_q (c) objective function's terms

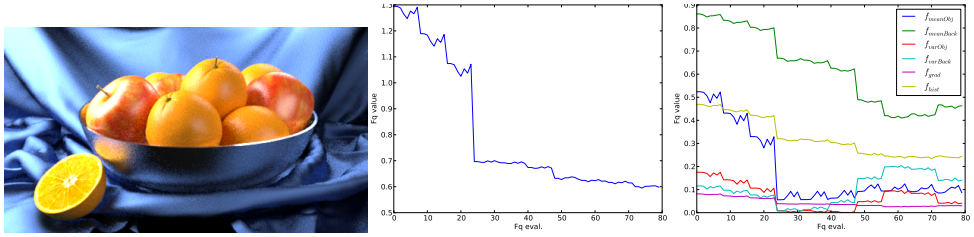


(a) Low-key (Total time: 467 seconds) (b) f_q (c) objective function's terms

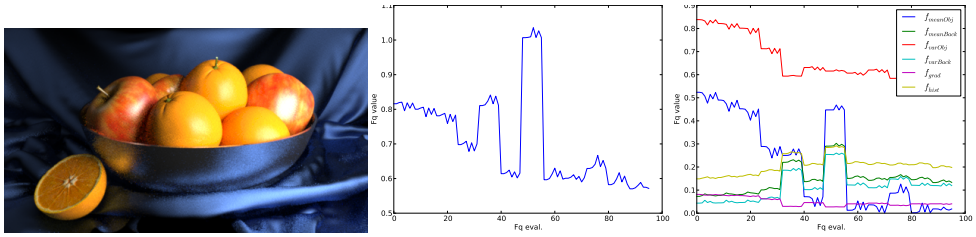
3.5. Fruit basket

On average, a single evaluation of the cost function takes 18.38 seconds.

Without background changes

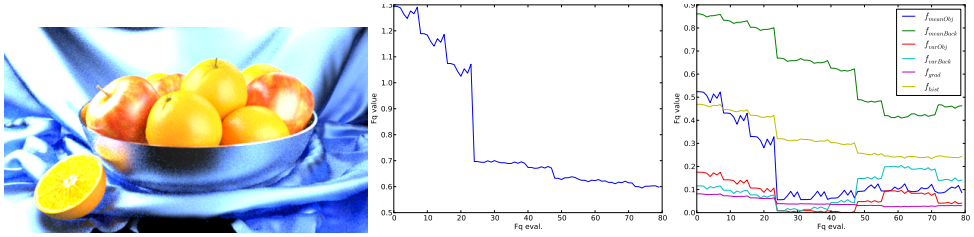


(a) High-key (Total time: 1452 seconds) (b) f_q (c) objective function's terms

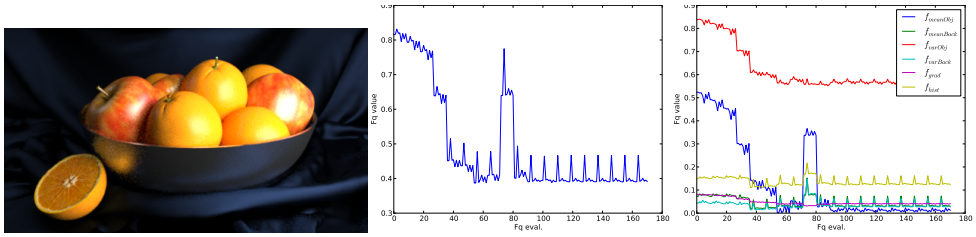


(a) Low-key (Total time: 1746 seconds) (b) f_q (c) objective function's terms

With background changes



(a) High-key (Total time: 1446 seconds) (b) f_q (c) objective function's terms



(a) Low-key (Total time: 3124 seconds) (b) f_q (c) objective function's terms

Acknowledgements

The different scenes can be download at blendswap.com. *Girl* is by Sharon. *Creature* is by Kevin Hays. *Fruit basket* is by Andrew Price. For the teaser scene, the main character is by Oscar Leif and the rest of the scene is by blenderjunky.

Appendix A: Histogram signature

This is the numerical value of the histogram signature (accumulated form). Each bin of the histogram is separated by an ;

High-key: 1e-02;1.5334496e-02;1.9675618e-02;2.2711704e-02;2.5395563e-02;2.7329995e-02;2.8937466e-02;3.0315195e-02;3.1573631e-02;3.2632492e-02;3.3728852e-02;3.4835710e-02;3.5770154e-02;3.6776457e-02;3.7679474e-02;3.8676890e-02;3.9523544e-02;4.0553678e-02;4.1386854e-02;4.2210074e-02;4.3203679e-02;4.3994996e-02;4.4753692e-02;4.5781908e-02;4.6625727e-02;4.7458303e-02;4.8267961e-02;4.9328009e-02;5.0207163e-02;5.1011734e-02;5.1899099e-02;5.2749627e-02;5.3663411e-02;5.4858596e-02;5.5837067e-02;5.6674860e-02;5.7552359e-02;5.8555301e-02;5.9461692e-02;6.0452433e-02;6.1311525e-02;6.2147026e-02;6.3009741e-02;6.3987673e-02;6.4857490e-02;6.5711153e-02;6.6529843e-02;6.7358251e-02;6.8291826e-02;6.9142055e-02;7.0612479e-02;7.1445544e-02;7.2272779e-02;7.3121577e-02;7.3965731e-02;7.4803137e-02;7.5630759e-02;7.6542115e-02;7.7493198e-02;7.8426803e-02;7.9367505e-02;8.0336141e-02;8.1306227e-02;8.2274292e-02;8.3028513e-02;8.4076430e-02;8.5104170e-02;8.6128951e-02;8.7178279e-02;8.8041072e-02;8.8864354e-02;9.0022458e-02;9.1192593e-02;9.2360441e-02;9.3316992e-02;9.4552387e-02;9.5886282e-02;9.7270034e-02;9.8655194e-02;9.9734753e-02;1.0096243e-01;1.0254515e-01;1.0417794e-01;1.0557164e-01;1.0746039e-01;1.0916329e-01;1.1107404e-01;1.1264226e-01;1.1470369e-01;1.1700243e-01;1.1849398e-01;1.2065665e-01;1.2247672e-01;1.2460697e-01;1.2641568e-01;1.2824343e-01;1.3040191e-01;1.3186263e-01;1.3393176e-01;1.3602810e-01;1.3783632e-01;1.3929752e-01;1.4121975e-01;1.4307980e-01;1.4528283e-01;1.4663178e-01;1.4874220e-01;1.5137779e-01;1.5397457e-01;1.5508678e-01;1.5784461e-01;1.6092792e-01;1.6211609e-01;1.6563181e-01;1.6950394e-01;1.7316648e-01;1.7474473e-01;1.7861782e-01;1.8218890e-01;1.8382353e-01;1.8731167e-01;1.9116857e-01;1.9273118e-01;1.9609512e-01;1.9970534e-01;2.0109627e-01;2.0461377e-01;2.0789500e-01;2.0944460e-01;2.1249505e-01;2.1501510e-01;2.1683278e-01;2.1944689e-01;2.2172854e-01;2.2372561e-01;2.2611621e-01;2.2869512e-01;2.3057186e-01;2.3317270e-01;2.3503694e-01;2.3756017e-01;2.4014286e-01;2.4198386e-01;2.4498929e-01;2.4667689e-01;2.4968514e-01;2.5257549e-01;2.5434773e-01;2.5749063e-01;2.5997114e-01;2.6219702e-01;2.6490551e-01;2.6709701e-01;2.7011343e-01;2.7294451e-01;2.7525140e-01;2.7800267e-01;2.8010013e-01;2.8290914e-01;2.8508356e-01;2.8801841e-01;2.9078995e-01;2.9280224e-01;2.9553047e-01;2.9752056e-01;3.0056897e-01;3.0249589e-01;3.0563912e-01;3.0826617e-01;3.1110107e-01;3.1380998e-01;3.1658504e-01;3.1974069e-01;3.2227573e-01;3.2603931e-01;3.2864978e-01;3.3242137e-01;3.3638746e-01;3.3946002e-01;3.4411986e-01;3.4700024e-01;3.5211779e-01;3.5543641e-01;3.6107362e-01;3.6442648e-01;3.7087124e-01;3.7443783e-01;3.8099081e-01;3.8579937e-01;3.9147151e-01;3.9664601e-01;4.0266726e-01;4.0828742e-01;4.1312031e-01;4.1938044e-01;4.2359817e-01;4.3006531e-01;4.3456744e-01;4.3987893e-01;4.4558038e-01;4.5082423e-01;4.5662041e-01;4.6181689e-01;4.6786392e-01;4.7323669e-01;4.7952225e-01;4.8455812e-01;4.9114102e-01;4.9596649e-01;5.0165999e-01;5.0721563e-01;5.1323999e-01;5.1840231e-01;5.2459045e-01;5.3020198e-01;5.3651210e-01;5.4173000e-01;5.4803364e-01;5.5239208e-01;5.5988792e-01;5.6421081e-01;5.6946706e-01;5.7695518e-01;5.8216615e-01;5.8977360e-01;5.9541390e-01;6.0339576e-01;6.0953742e-01;6.1758615e-01;6.2266153e-01;6.3191643e-01;6.3652403e-01;6.4138052e-01;6.5179824e-01;6.5626706e-01;6.6682580e-01;6.6986298e-01;6.8043963e-01;6.8547683e-01;6.9376114e-01;7.0120611e-01;7.0411540e-01;7.1843826e-01;7.2104887e-01;7.3547730e-01;7.3846594e-01;7.5252459e-01;7.5500049e-01;7.9489243e-01;8.0417084e-01;8.0564050e-01;8.1978709e-01;8.2134063e-01;8.4125530e-01;8.4479006e-01;1.0000000e+00

Low-key: 1e-02;5.3214032e-01;6.4500308e-01;6.8271716e-01;7.0444548e-01;7.2212854e-01;7.3568966e-01;7.4693987e-01;7.5605675e-01;7.6435964e-01;7.7235038e-01;7.7991461e-01;7.8713589e-01;7.9333443e-01;7.9929690e-01;8.0511069e-01;8.1008792e-01;8.1504673e-01;8.1951071e-01;8.2365087e-01;8.2760108e-01;8.3116823e-01;8.3424739e-01;8.3759592e-01;8.4072014e-01;8.4352251e-01;8.4640932e-01;8.4921924e-01;8.5174411e-01;8.5419620e-01;8.5649679e-01;8.5858470e-01;8.6081309e-01;8.6254483e-01;8.6467812e-01;8.6638337e-01;8.6785529e-01;8.6970138e-01;8.7127576e-01;8.7295347e-01;8.7445343e-01;8.7595808e-01;8.7732083e-01;8.7879749e-01;8.7993160e-01;8.8103645e-01;8.8220378e-01;8.8323021e-01;8.8439687e-01;8.8534405e-01;8.8638603e-01;8.8810288e-01;8.8898348e-01;8.8983503e-01;8.9070771e-01;8.9154848e-01;8.9254262e-01;8.9331055e-01;8.9410167e-01;8.9488339e-01;8.9561096e-01;8.9635660e-01;8.9712490e-01;8.9784941e-01;8.9857016e-01;8.9926131e-01;9.0001179e-01;9.0065471e-01;9.0128993e-01;9.0194406e-01;9.0244792e-01;9.0304962e-01;9.0369256e-01;9.0436178e-01;9.0498780e-01;9.0563933e-01;9.0627211e-01;9.0690108e-01;9.0752891e-01;9.0811818e-01;9.0857345e-01;9.0920360e-01;9.0980526e-01;9.1045475e-01;9.1103070e-01;9.1163910e-01;9.1222389e-01;9.1269580e-01;9.1328517e-01;9.1382952e-01;9.1441511e-01;9.1504511e-01;9.1543023e-01;9.1595105e-01;9.1654646e-01;9.1709968e-01;9.1765985e-01;9.1800306e-01;9.1856376e-01;9.1909924e-01;9.1963920e-01;9.2007326e-01;9.2056955e-01;9.2111301e-01;9.2166082e-01;9.2202277e-01;9.2255119e-01;9.2310174e-01;9.2360914e-01;9.2394719e-01;9.2448755e-01;9.2495787e-01;9.2530154e-01;9.2582446e-01;9.2628537e-01;9.2677180e-01;9.2707488e-01;9.2753327e-01;9.2804388e-

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