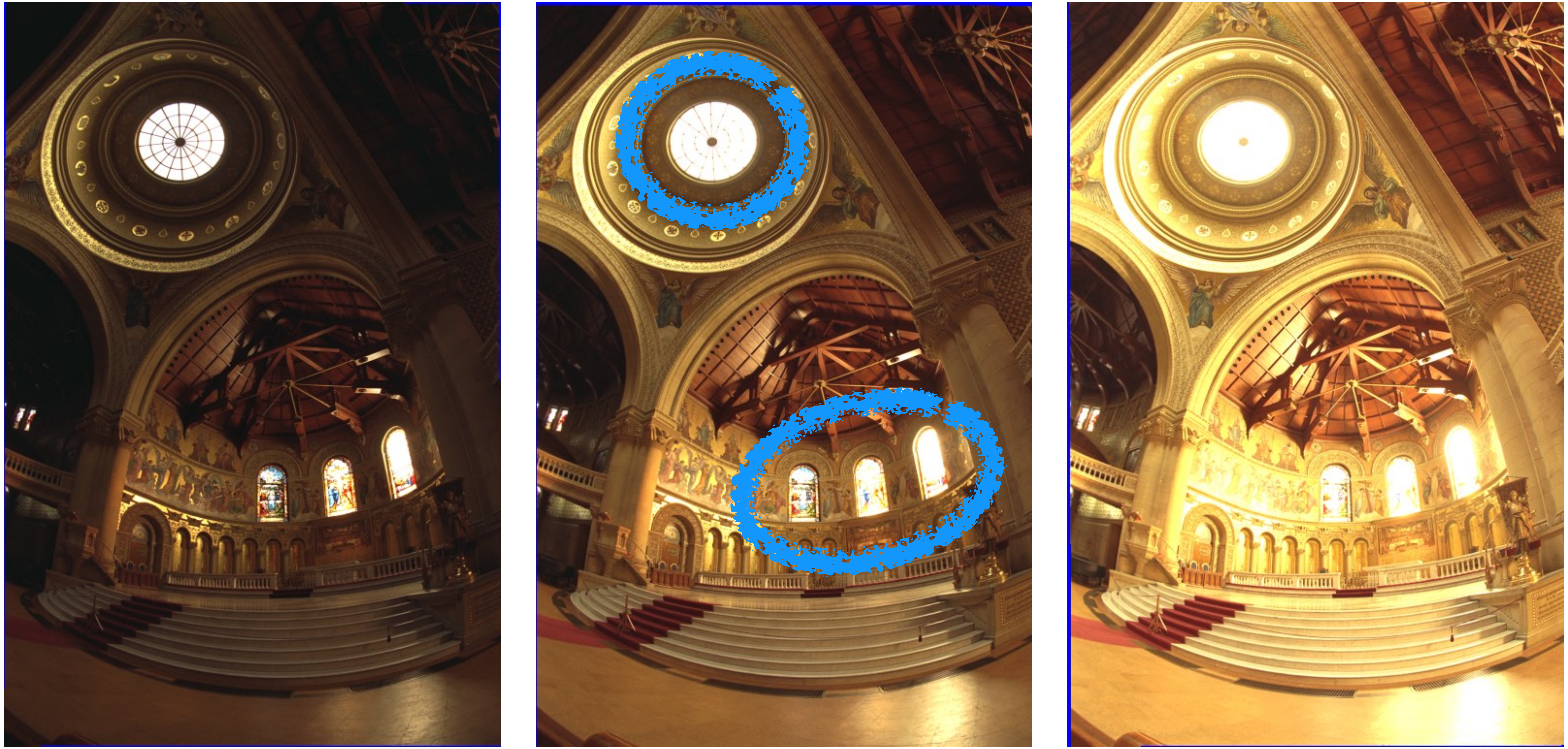


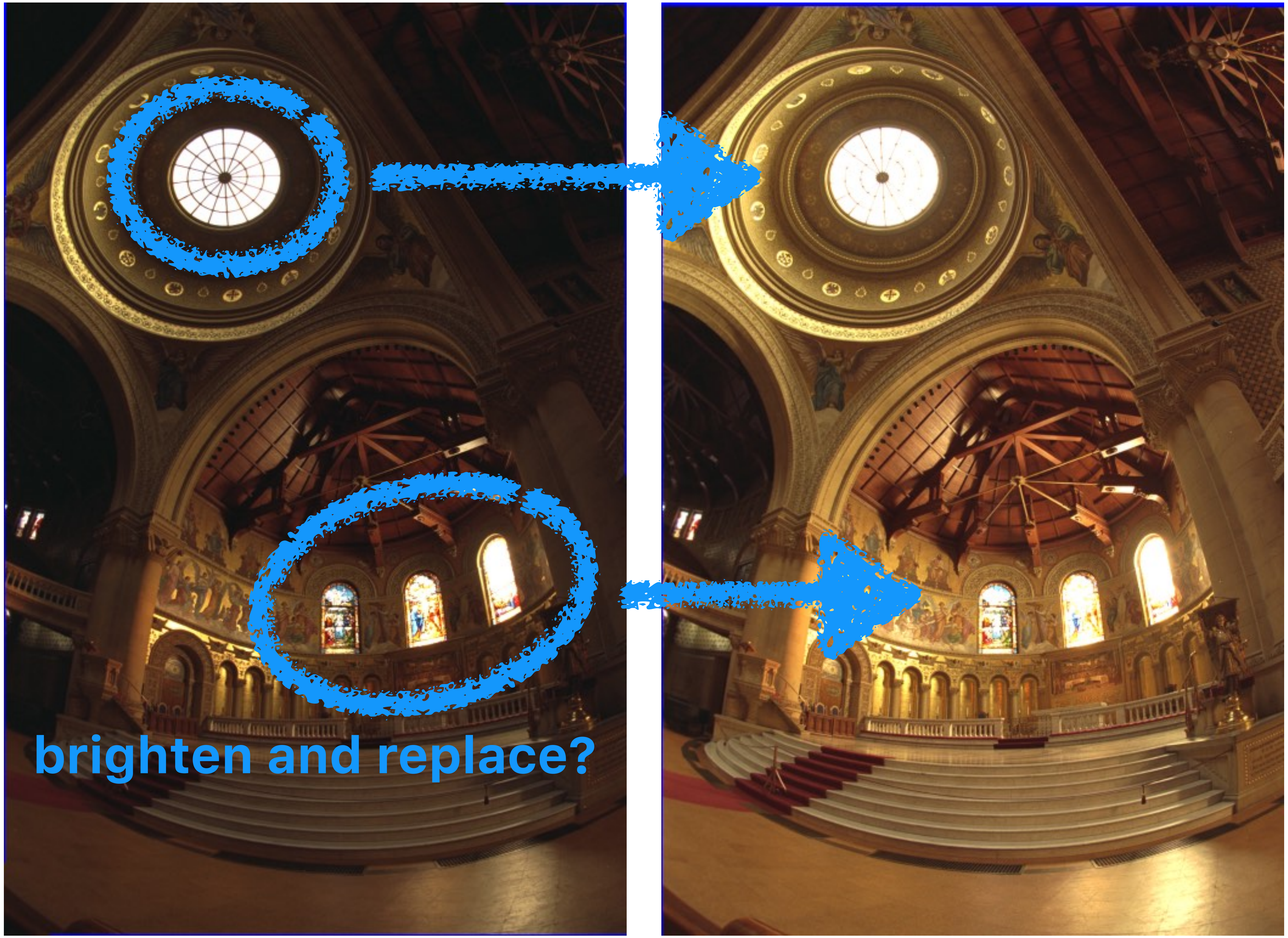
HDR in Microsoft Excel?!

Kevin Chen • !!Con 2017

Motivation

- N/A

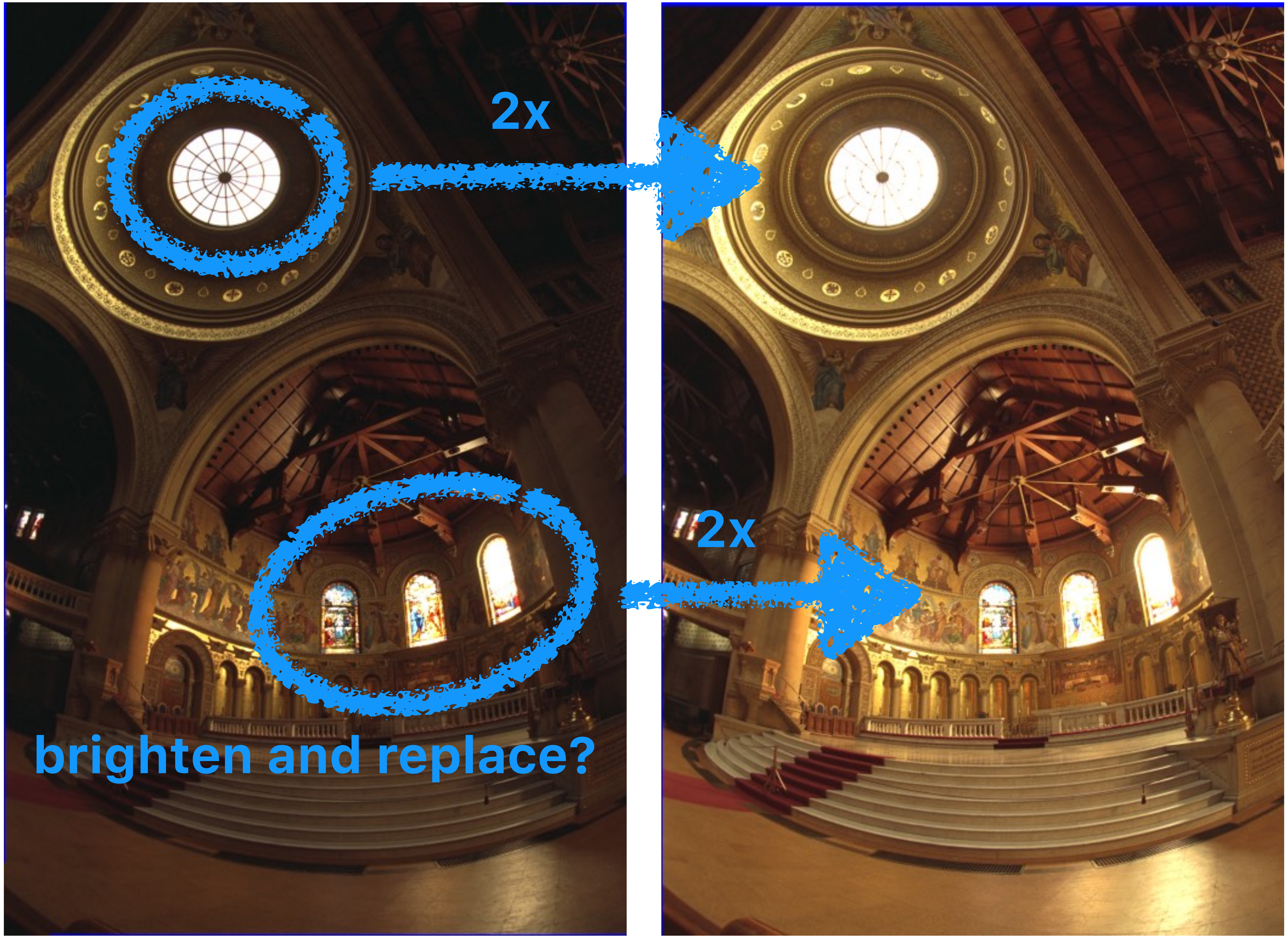
Background

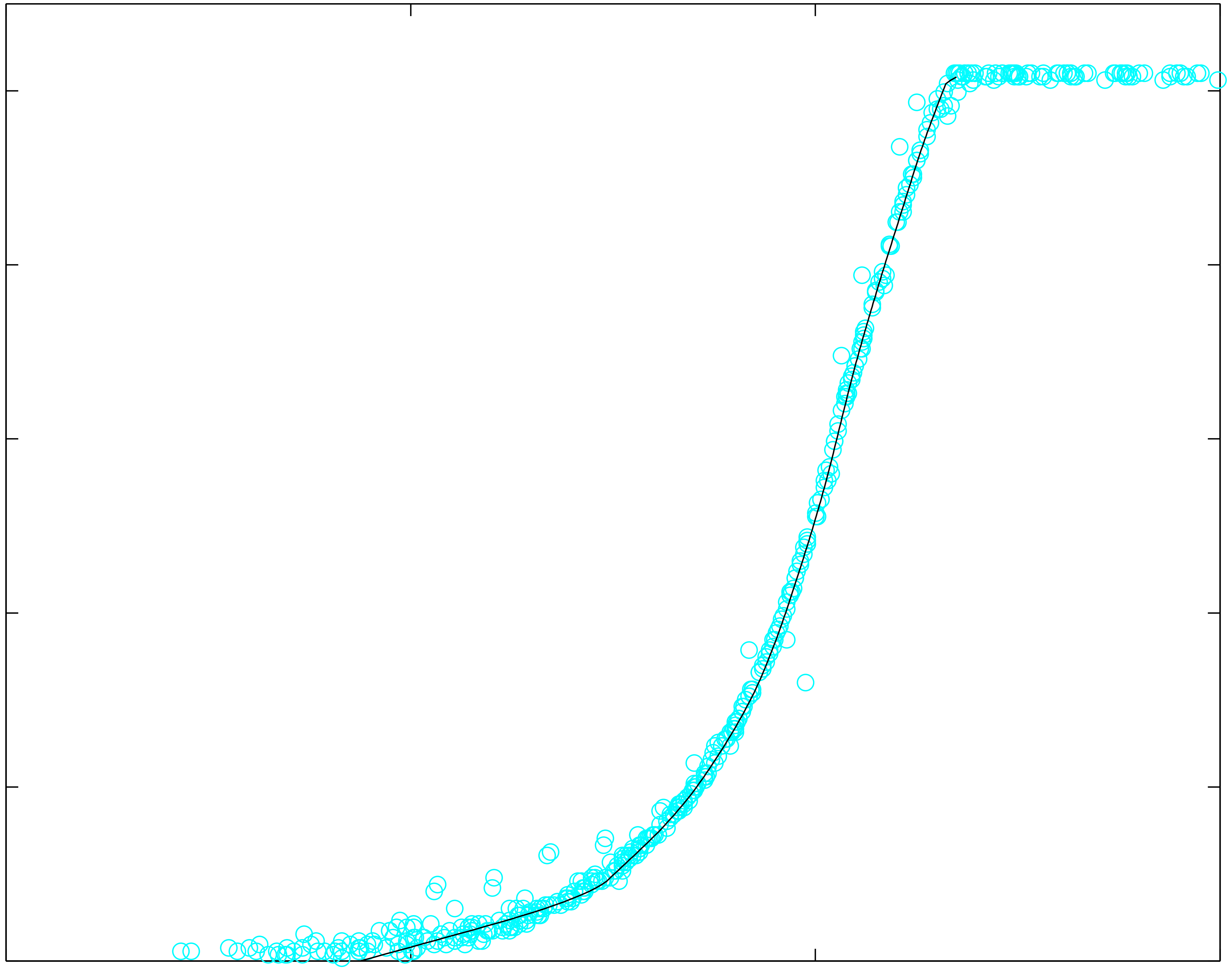

brighten and replace?


Canon
EOS
5D
Mark III

Reciprocity

Open the shutter 2x longer ➡️ 2x more light


2x
2x
brighten and replace?



Nonlinearity

2x more light 🚫 2x bigger number in JPG

Recovering … hotographs

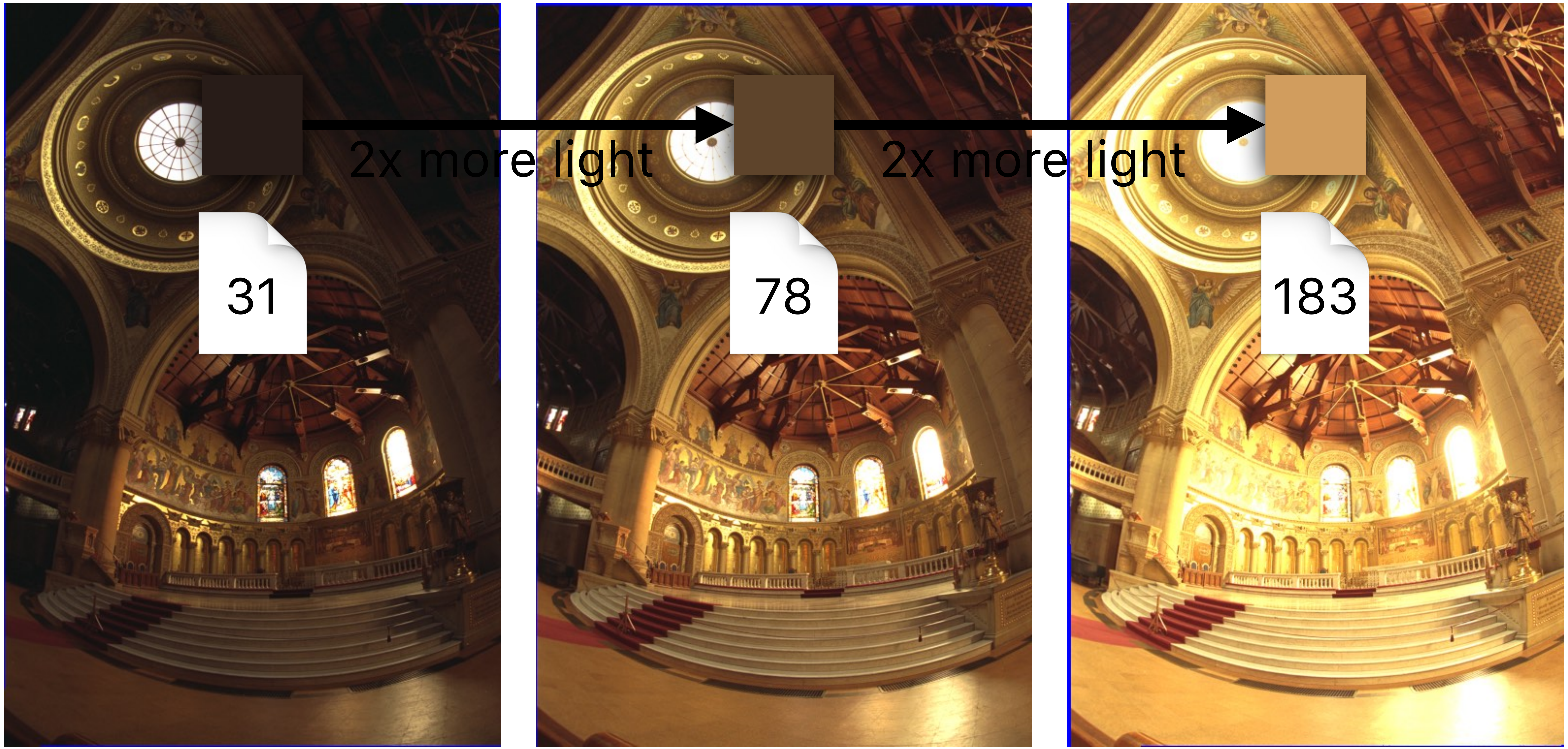
ABSTRACT

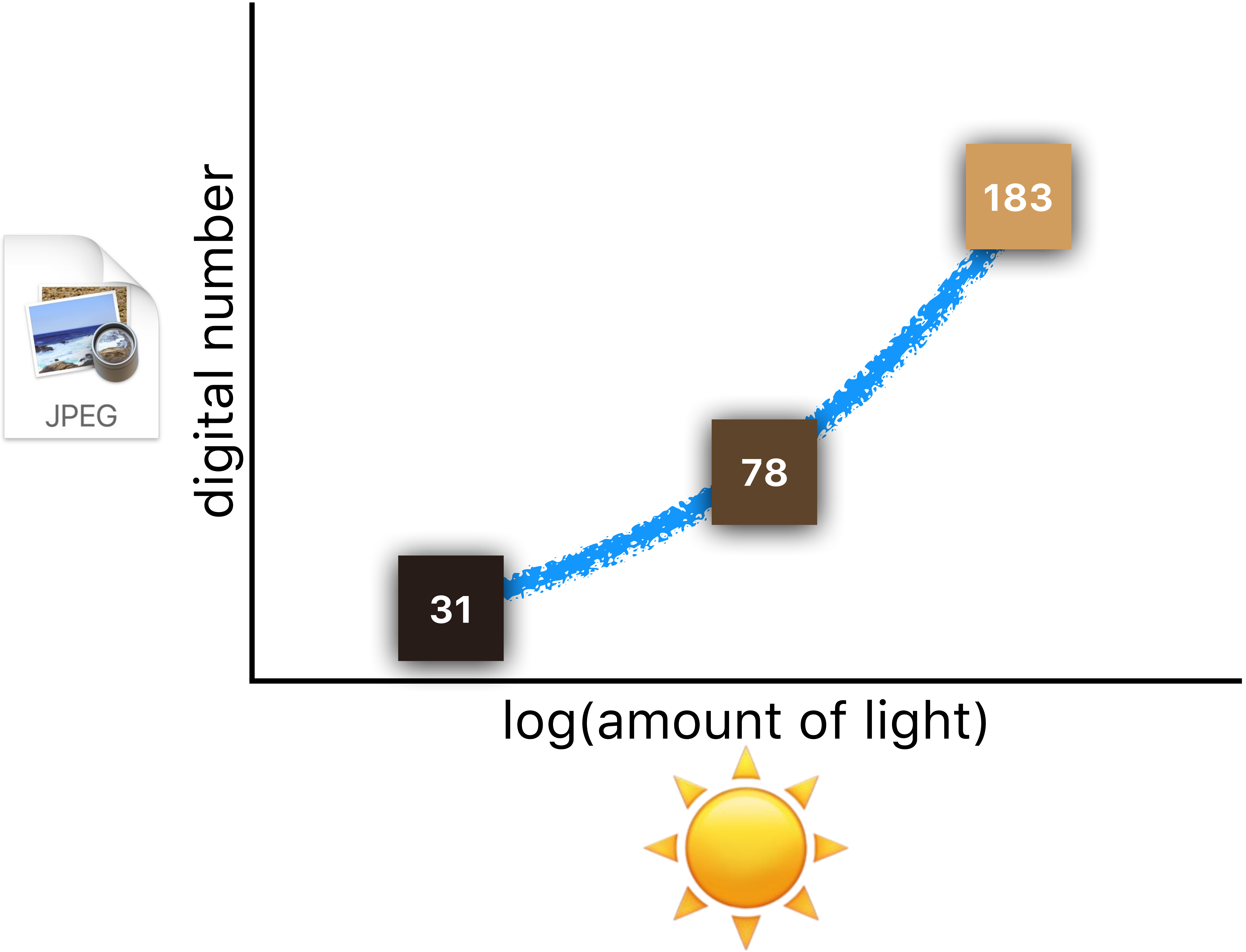
We present a method of r…
maps from photographs t…
ment. In our method, mul…
with different amounts of …
ferently exposed photograp…
imaging process, up to fact…
procity. With the known re…
the multiple photographs in…
map whose pixel values are…
in the scene. We demonstr… both photochemical and digital imaging processes. We discuss how this work is applicable in many areas of computer graphics involving digitized photographs, including image-based modeling, image compositing, and image processing. Lastly, we demonstrate a few applications of having high dynamic range radiance maps, such as synthesizing realistic motion blur and simulating the response of the human visual system.

…n the scene. For example, if
…t is unlikely that it observed
…lly an unknown, nonlinear
…n the scene becomes pixel

…w beforehand because it is
…inear mappings that occur
…tional camera (see Fig. 1),
…a latent image. The film is
…ge into variations in trans-
…can then be digitized using
a film scanner, which projects light through the film onto an electronic light-sensitive array, converting the image to electrical voltages. These voltages are digitized, and then manipulated before finally being written to the storage medium. If prints of the film are scanned rather than the film itself, then the printing process can also introduce nonlinear mappings.

In the first stage of the process, the film response to variations


2x more light
2x more light
31
78
183



JPEG
digital number
183
78
31
log(amount of light)

📄 = f(☀️)

digital number = f(brightness • shutter open time)

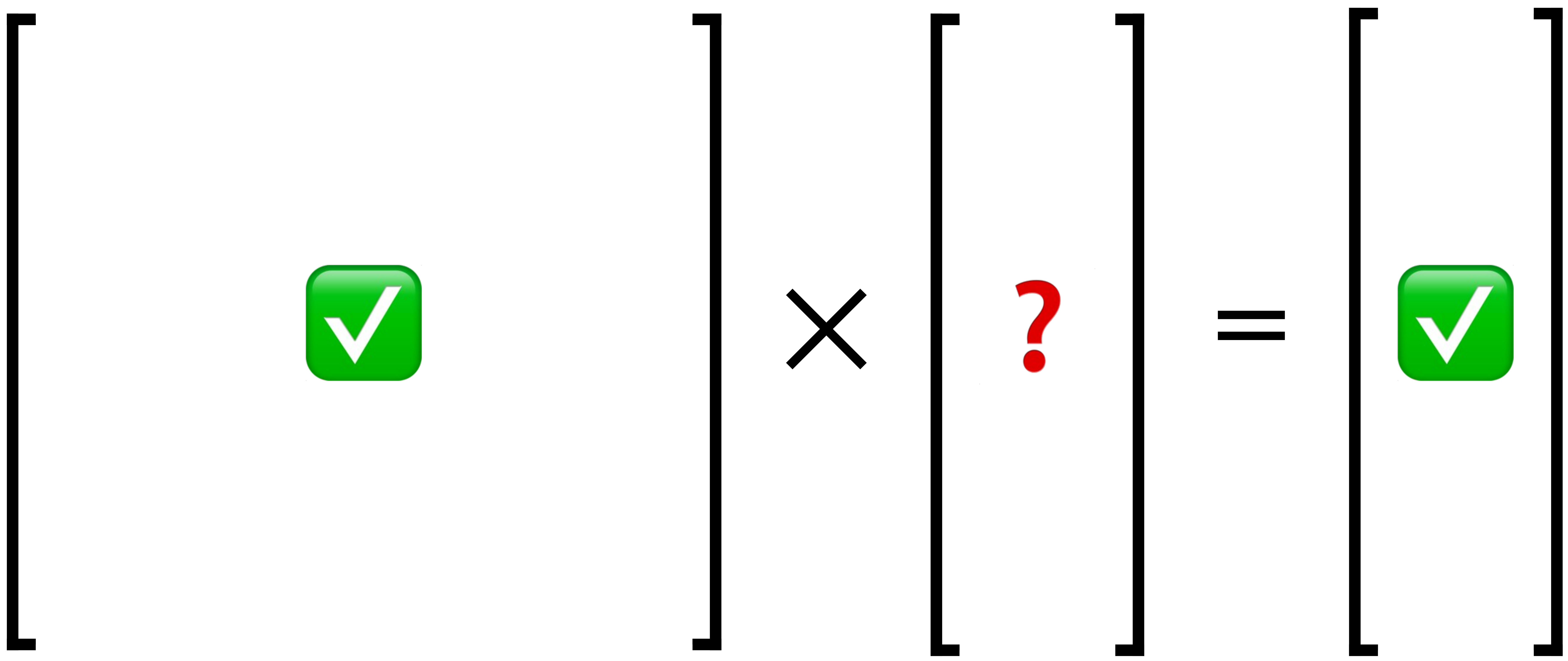
$$Z = f(E \cdot \Delta t)$$

$$f^{-1}(Z) = E \cdot \Delta t$$

flip it!

$$g(Z) = E \cdot \Delta t$$

$$A \times \mathbf{x} = \mathbf{b}$$



Very Big Matrix™

$$A \times \mathbf{x} = \mathbf{b}$$

$$\begin{bmatrix} 0 & 0 & 0 & w_{ij} & 0 & 0 & \cdots & -w_{ij} & \cdots & 0 \\ 0 & \cdots & & & & & & & & \\ \text{sm... ness} & & & & & \text{zeroes} & & & & \end{bmatrix} \times \begin{bmatrix} g(z) \\ \log(E_i) \end{bmatrix} = \begin{bmatrix} w_{ij} \cdot B_j \\ \text{exposure} \\ \text{zeroes} \end{bmatrix}$$

$$A \times \mathbf{x} = \mathbf{b}$$

$$\mathbf{x} = A^{+} \times \mathbf{b}$$

MatheAss

One of the most popular Shareware Math Programs in Germany

Pseudo Inverse Matrix

If the columns of a matrix A are linearly independent, so $A^T \cdot A$ is invertible and we obtain with the following formula the pseudo inverse:

$$\mathbf{A^+ = (A^T \cdot A)^{-1} \cdot A^T}$$

Here A^+ is a left inverse of A, what means: $A^+ \cdot A = E$.

Microsoft Excel Time™

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
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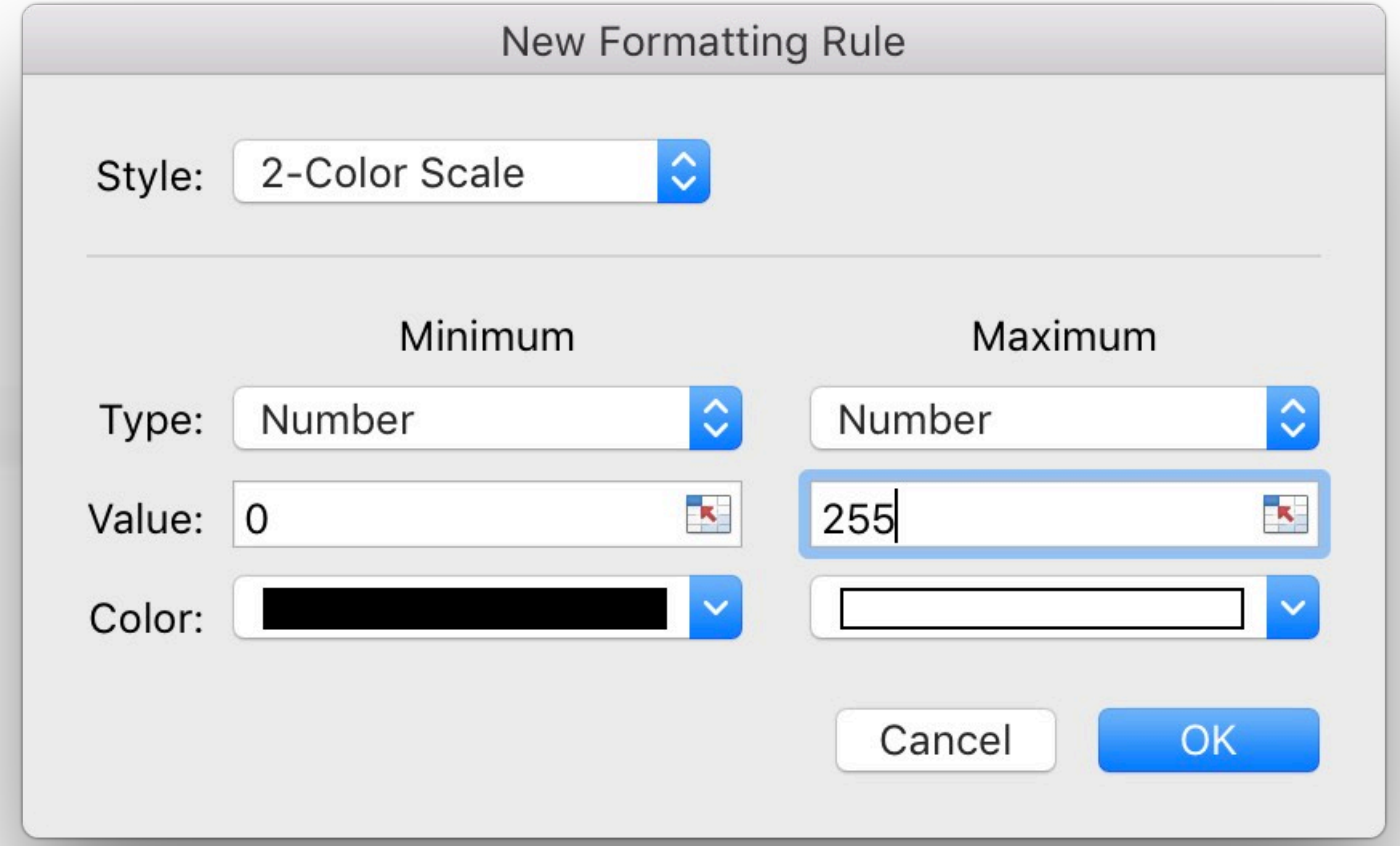
New Formatting Rule
Style:
2-Color Scale
Minimum
Maximum
Type:
Number
Number
Value:
0
255
Color:
Cancel
OK

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R1C1
17
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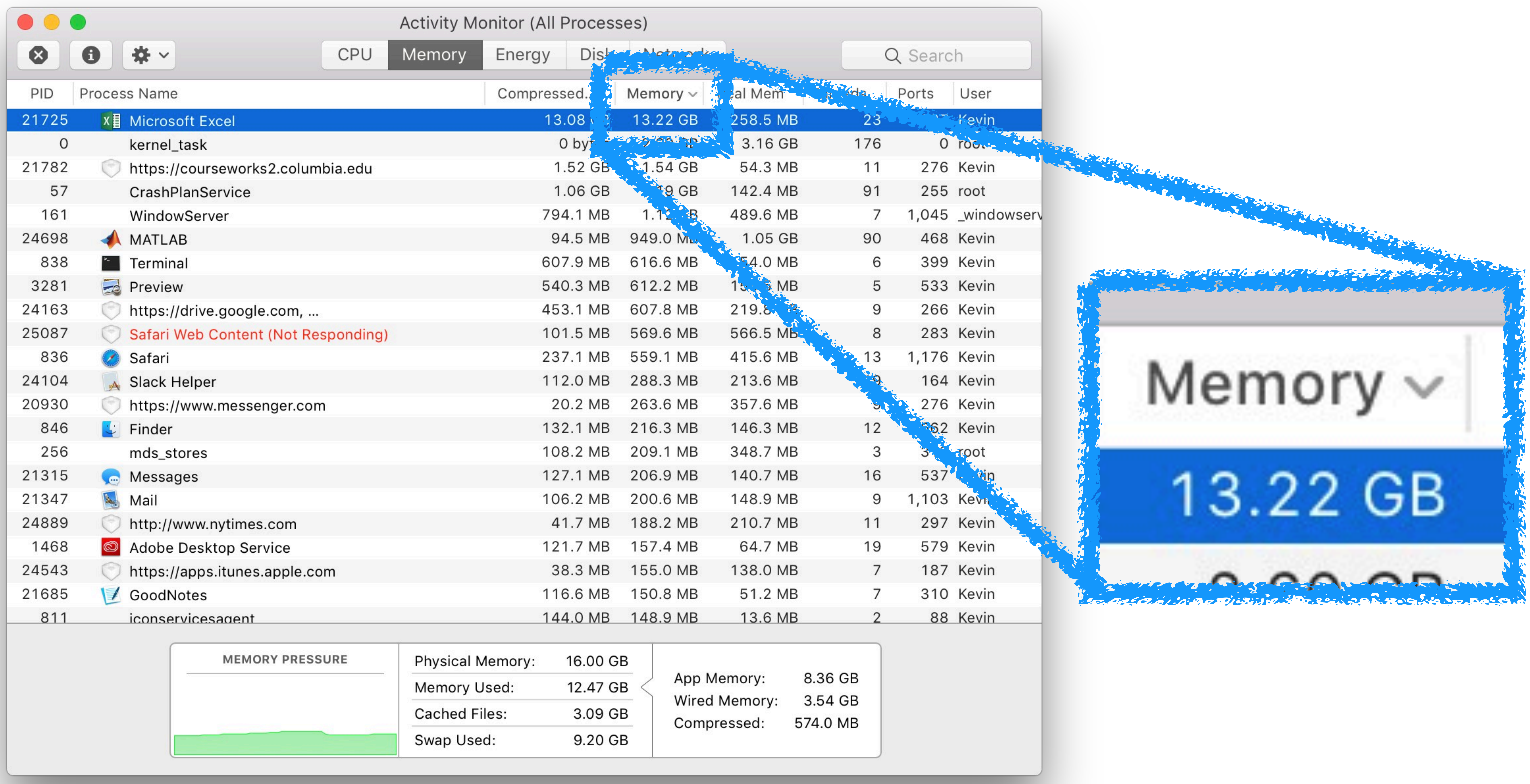
57
R1C1
17



Activity Monitor (All Processes)
CPU
Memory
Energy
Search
PID
Process Name
Compressed...
Memory
Ports
User
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0 kernel_task 3.16 GB 176 0
21782 https://courseworks2.columbia.edu 1.52 GB 54.3 MB 11 276 Kevin
57 CrashPlanService 1.06 GB 142.4 MB 91 255 root
161 WindowServer 794.1 MB 489.6 MB 7 1,045
24698 MATLAB 94.5 MB 1.05 GB 90 468 Kevin
838 Terminal 607.9 MB 616.6 MB 6 399 Kevin
3281 Preview 540.3 MB 612.2 MB 5 533 Kevin
24163 https://drive.google.com, ... 453.1 MB 607.8 MB 9 266 Kevin
25087 Safari Web Content (Not Responding) 101.5 MB 569.6 MB 8 283 Kevin
836 Safari 237.1 MB 559.1 MB 415.6 MB 13 1,176 Kevin
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21347 Mail 106.2 MB 200.6 MB 148.9 MB 9 1,103
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24543 https://apps.itunes.apple.com 38.3 MB 155.0 MB 138.0 MB 7 187 Kevin
21685 GoodNotes 116.6 MB 150.8 MB 51.2 MB 7 310 Kevin
811 iconservicesagent 144.0 MB 148.9 MB 13.6 MB 2 88 Kevin
MEMORY PRESSURE
Physical Memory: 16.00 GB
Memory Used: 12.47 GB
Cached Files: 3.09 GB
Swap Used: 9.20 GB
App Memory: 8.36 GB
Wired Memory: 3.54 GB
Compressed: 574.0 MB
Memory
13.22 GB

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R3C4

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2	2.0794415	8							
3	0.6931472	2							
4	-0.693147	0.5							
5	-2.0794415	0.125							
6	-3.4657359	0.03125							
7	-4.8520303	0.0078125							
8	-6.2383246	0.0019531							
9									
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16									

z1 z2 z3 z4 z5 z6 z7 z8 exp w pixels wij Zij A b x

Select destination and press ENTER or choose Paste

205%

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R2C16

This helper sheet calculates the pixel coordinates that we will use in recovering g(Z). There are a total of 49 values that form a 7x7 grid.

num tile row	7
image dimen	500

i	row	col
0	36	36
1	36	107
2	36	179
3	36	250
4	36	321
5	36	393
6	36	464
7	107	36
8	107	107
9	107	179
10	107	250
11	107	321
12	107	393
13	107	464
14	179	36
15	179	107
16	179	179
17	179	250
18	179	321
19	179	393
20	179	464
21	250	36
22	250	107
23	250	179
24	250	250
25	250	321
26	250	393
27	250	464
28	321	36
29	321	107
30	321	179
31	321	250
32	321	321
33	321	393

This helper sheet calculates the pixel coordinates that we will use in recovering g(Z). There are a total of 49 values that form a 7x7 grid.

z1 z2 z3 z4 z5 z6 z7 z8 exp w pixels wij Zij A b x

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ExcelHDR

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R2C16

	1	2	3	4	5	6
1	i	row	col		This helper sheet calculates the pixel coordinates that we will use in recovering g(Z). There are a total of 49 values that form a 7x7 grid.	
2	0	36	36		num tile row	7
3	1	36	107		image dimen	500
4	2	36	179			
5	3	36	250			
6	4	36	321			
7	5	36	393			
8	6	36	464			
9	7	107	36			
10	8	107	107			
11	9	107	179			
12	10	107	250			
13	11	107	321			
14	12	107	393			
15	13	107	464			
16	14	179	36			
17	15	179	107			
18	16	179	179			
19	17	179	250			
20	18	179	321			
21	19	179	393			
22	20	179	464			
23	21	250	36			
24	22	250	107			
25	23	250	179			
26	24	250	250			
27	25	250	321			
28	26	250	393			
29	27	250	464			
30	28	321	36			

z1 | z2 | z3 | z4 | z5 | z6 | z7 | z8 | exp | w | pixels | wij | Zij | A | b | x

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R2C16

This helper sheet calculates the pixel coordinates that we will use i

i	row	col
0	36	36
1	36	107
2	36	179
3	36	250
4	36	321
5	36	393
6	36	464
7	107	36
8	107	107
9	107	179
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25	250	321
26	250	393
27	250	464
28	321	36
29	321	107
30	321	179
31	321	250
32	321	321
33	321	393

num tile row	7
image dimen	500

Pixels (i values)

This helper sheet

coordinates that we will use in recovering g(Z). There are a total of 49 values that form a 7x7 grid.

z1 z2 z3 z4 z5 z6 z7 z8 exp w pixels wij Zij A b x

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27	255	255	255	253	235	203	111	47
28	196	103	51	26	18	17	16	17
29	249	197	101	41	21	16	17	16
30	245	209	128	65	31	18	16	17

z1 | z2 | z3 | z4 | z5 | z6 | z7 | z8 | exp | w | pixels | wij | Zij | A | b | x

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R161C276
=IF(COLUMN() - 256 = b!RC2, -1 * INDEX(wij!R1C1:R49C8, b!RC2, b!RC3), 0)
data-fitting equations
A
zeroes
constraint
z1
z2
z3
z4
z5
z6
z7
z8
exp
w
pixels
wij
Zij
A
b
x
g
E
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INDEX
=MMULT(MMULT(MINVERSE(MMULT(TRANSPOSE(A), A)), TRANSPOSE(A)), b)
$\mathbf{x} = A^{+} \times \mathbf{b}$
X (output array)
A)), b)
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-11.222177
-10.886972
-10.551767
-10.216563
-9.8813576
-9.5461525
-9.2109474
-8.8757422
-8.5405369
-8.2053316
-7.8701263
-7.5349209
-7.1997155
-6.86451
-6.5293046
-6.1947912
-5.8644336
-5.5436868
-5.2369134
-4.9469873
-4.6753615
-4.4221891
-4.1873334
-3.9702255
-3.7701979
-3.5865433
-3.4182791
-3.2643371
-3.123602
-2.9949015
-2.877115
-2.7691917
-2.6701545
MatheAss
One of the most popular Shareware Math Programs in Germany
The first 256 values are the function g(Z). Everything else is the sample pixel values after they are run through g(Z).
z1
z2
z3
z4
z5
z6
z7
z8
exp
w
pixels
wij
Zij
A
b
x
Edit
Average: -0.996583252
Count: 305
Sum: -303.9578919
100%

ExcelHDR

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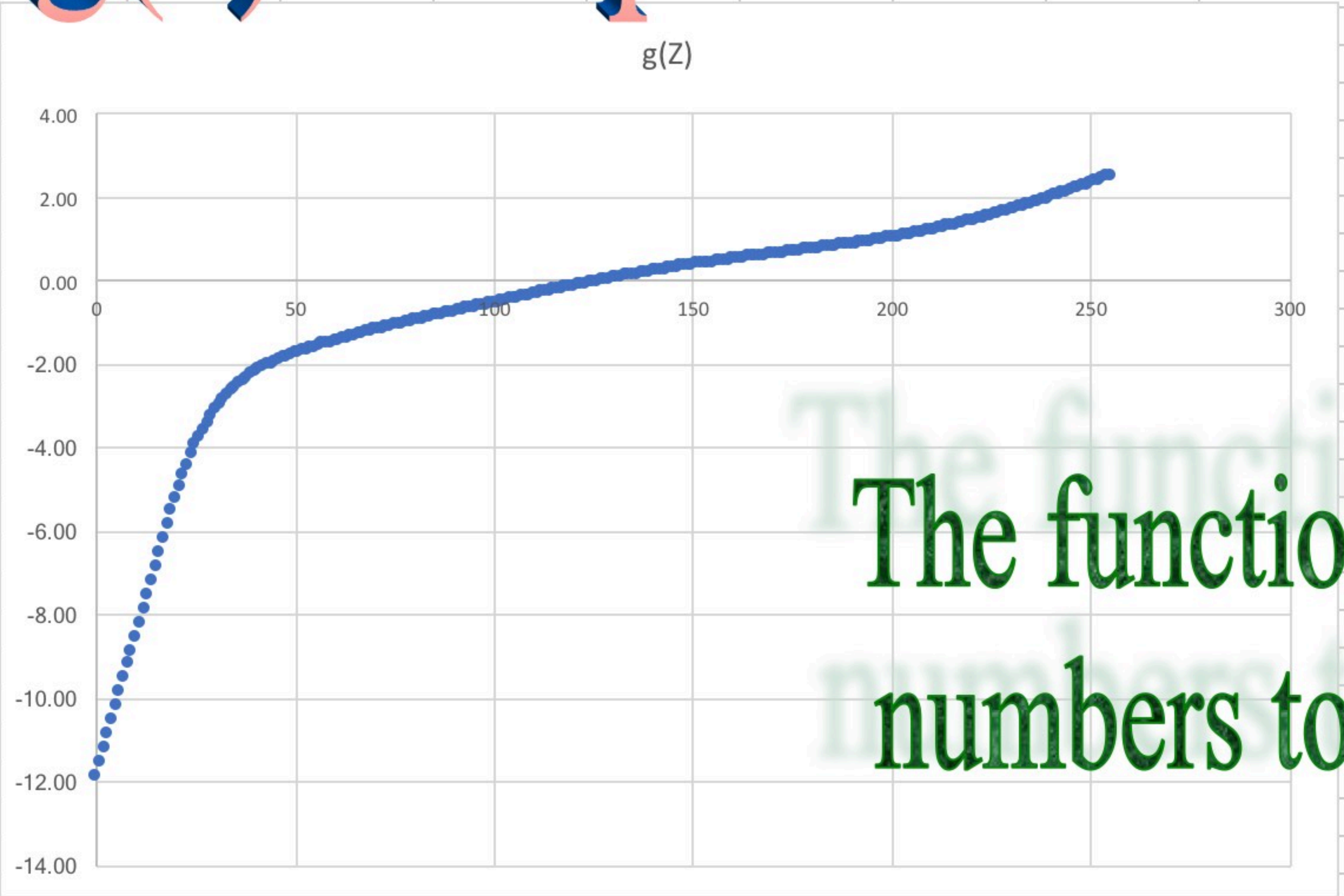
R1C2 fx g(Z)

	1	2	3
1	Z	g(Z)	g''(Z/2)
2	0	-11.89	N/A
3	1	-11.56	0.00
4	2	-11.22	0.00
5	3	-10.89	0.00
6	4	-10.55	0.00
7	5	-10.22	0.00
8	6	-9.88	0.00
9	7	-9.55	0.00
10	8	-9.21	0.00
11	9	-8.88	0.00
12	10	-8.54	0.00
13	11	-8.21	0.00
14	12	-7.87	0.00
15	13	-7.53	0.00
16	14	-7.20	0.00
17	15	-6.86	0.00
18	16	-6.53	0.00
19	17	-6.19	0.00
20	18	-5.86	-0.01
21	19	-5.54	-0.01
22	20	-5.24	-0.02
23	21	-4.95	-0.02
24	22	-4.68	-0.02
25	23	-4.42	-0.02
26	24	-4.19	-0.02
27	25	-3.97	-0.02
28	26	-3.77	-0.02
29	27	-3.59	-0.02
30	28	-3.42	-0.01
31	29	-3.26	-0.01
32	30	-3.12	-0.01
33	31	-2.99	-0.01
34	32	-2.88	-0.01
35	33	-2.77	-0.01

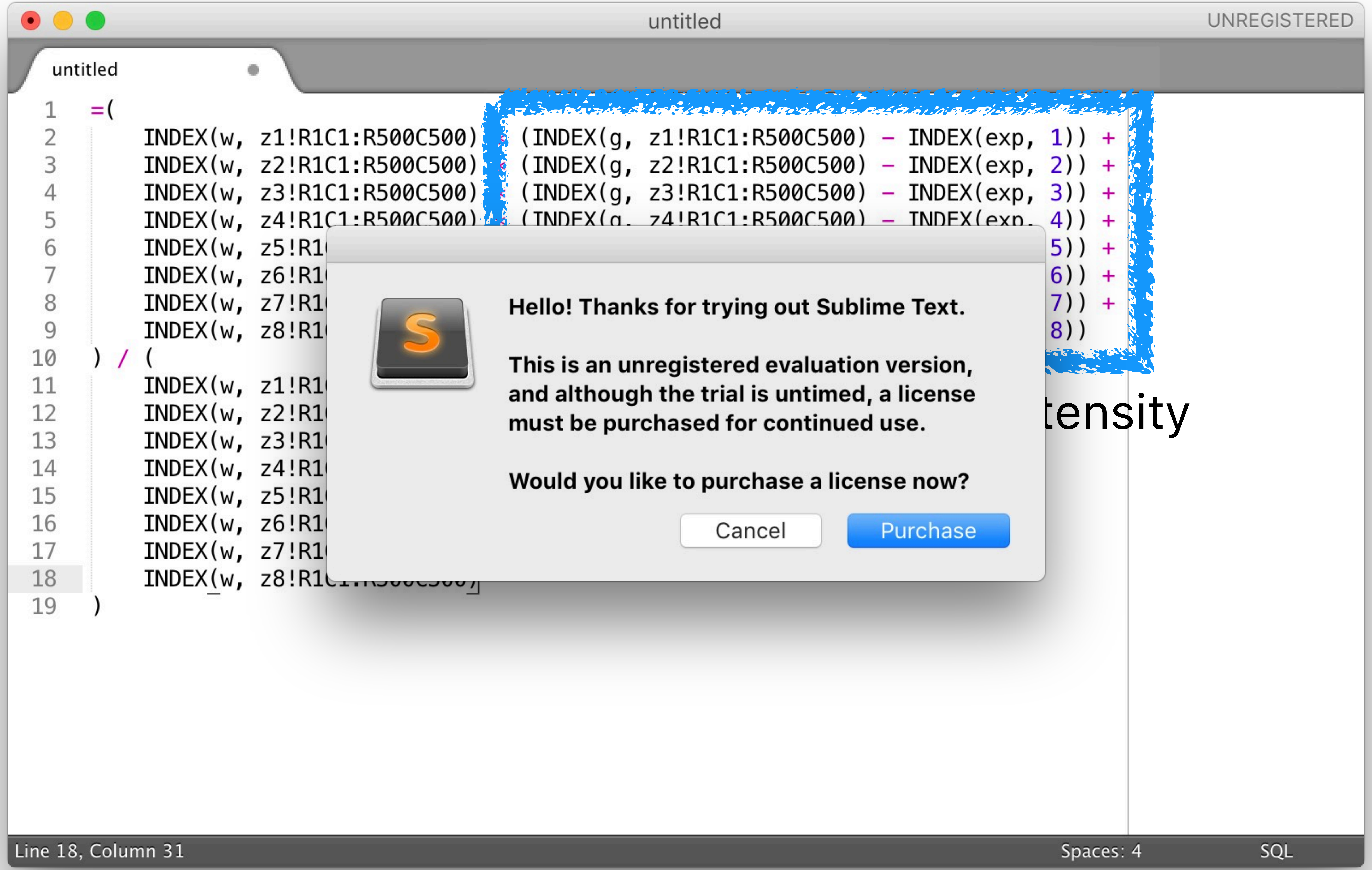
g(z) - response function



The function g(Z) maps digital numbers to brightness values.

z5 z6 z7 z8 exp w pixels wij Zij A b x g E +

Ready Calculate Average: -0.77 Count: 257 Sum: -196.35 100%


untitled
UNREGISTERED
untitled
=(
INDEX(w, z1!R1C1:R500C500) * (INDEX(g, z1!R1C1:R500C500) − INDEX(exp, 1)) +
INDEX(w, z2!R1C1:R500C500) * (INDEX(g, z2!R1C1:R500C500) − INDEX(exp, 2)) +
INDEX(w, z3!R1C1:R500C500) * (INDEX(g, z3!R1C1:R500C500) − INDEX(exp, 3)) +
INDEX(w, z4!R1C1:R500C500) * (INDEX(g, z4!R1C1:R500C500) − INDEX(exp, 4)) +
INDEX(w, z5!R1
5)) +
INDEX(w, z6!R1
6)) +
INDEX(w, z7!R1
7)) +
INDEX(w, z8!R1
8))
) / (
INDEX(w, z1!R1
INDEX(w, z2!R1
INDEX(w, z3!R1
INDEX(w, z4!R1
INDEX(w, z5!R1
INDEX(w, z6!R1
INDEX(w, z7!R1
INDEX(w, z8!R1
)
tensity
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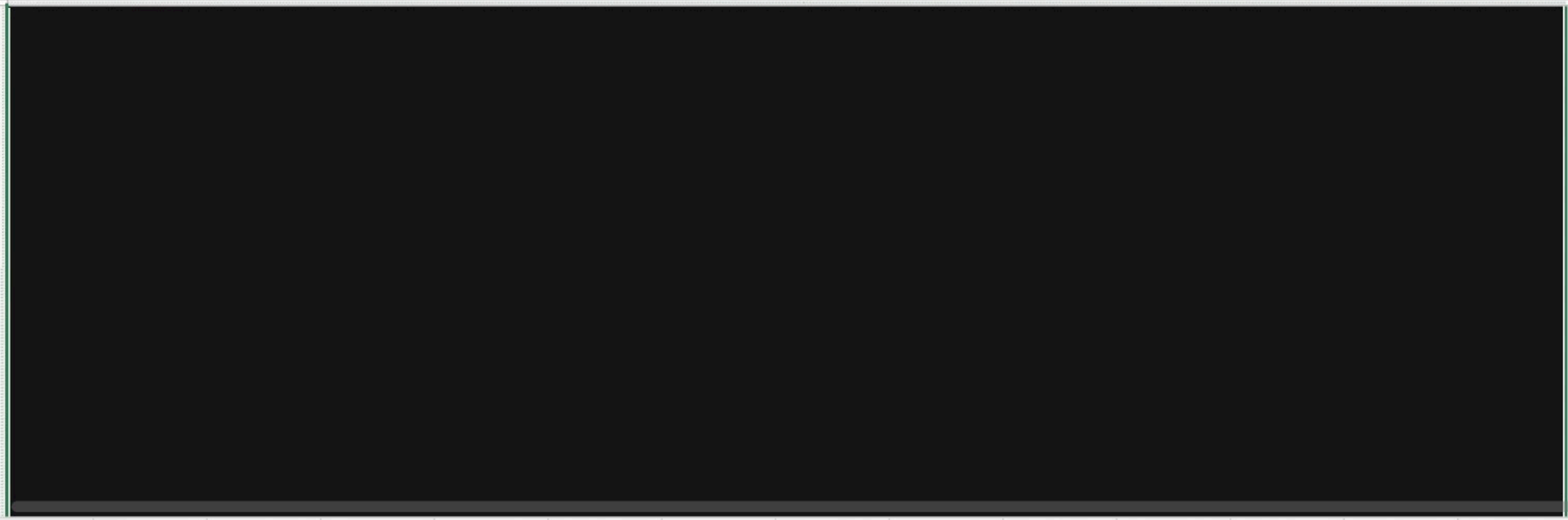

z5 | z6 | z7 | z8 | exp | w | pixels | wij | Zij | A | b | x | g | E | +

Ready

10%


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