An Approach to Improve Cell-Phone Cameras' Dynamic Range Using A Non-linear Lens Correction

Sergio Goma, Milivoje Aleksic – AMD

6811-1/EI 2008

AMD

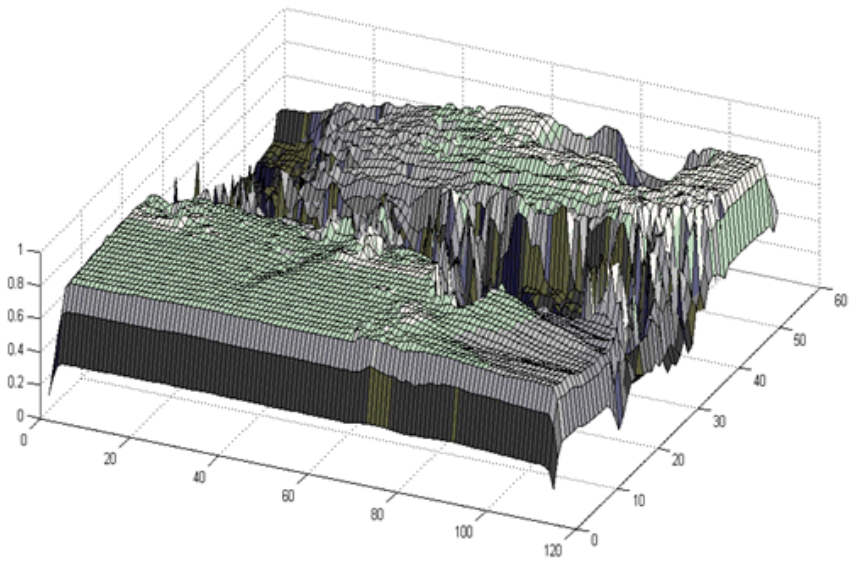
Outline

- Problem definition
- Proposed algorithm
- Implementation details
- Results
- Conclusions and remarks

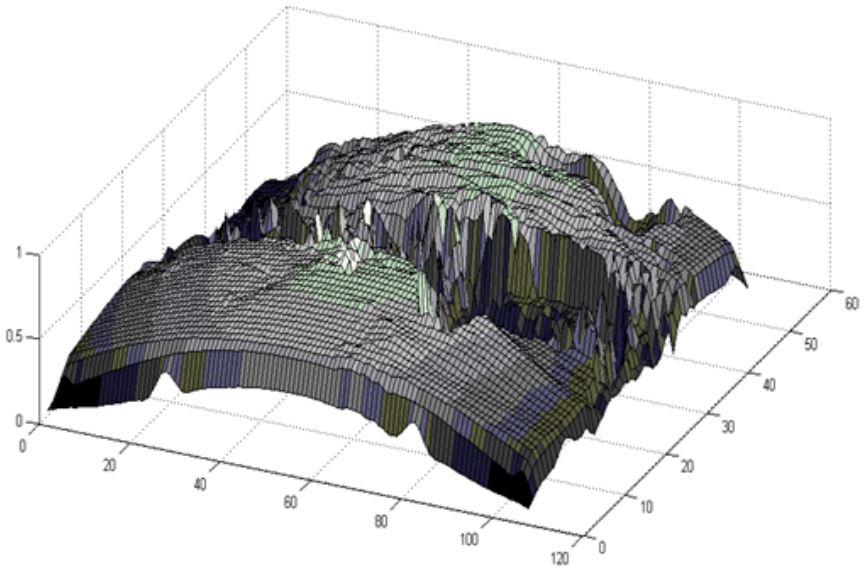
System level and casual photographer underlying assumptions

- Imaging system goal: to have the image sensor exposed as long as possible to light.
- a user will capture a scene having the light source off to the side rather than in centre;
- usually the centre has a med to low light response compared to the corners, as in most cases the centre is a reflective object with some details;

Lens fall-off



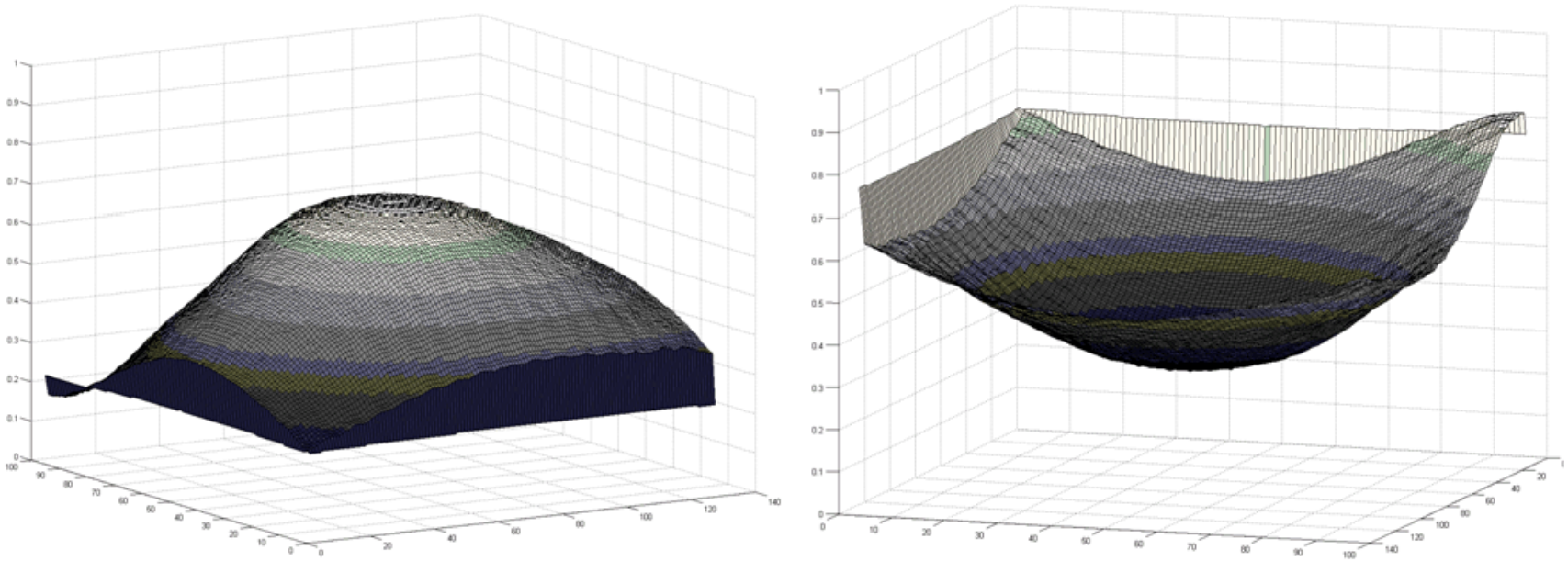
(a) radiance map (simulated)



(b) captured image map (simulated)

AMD

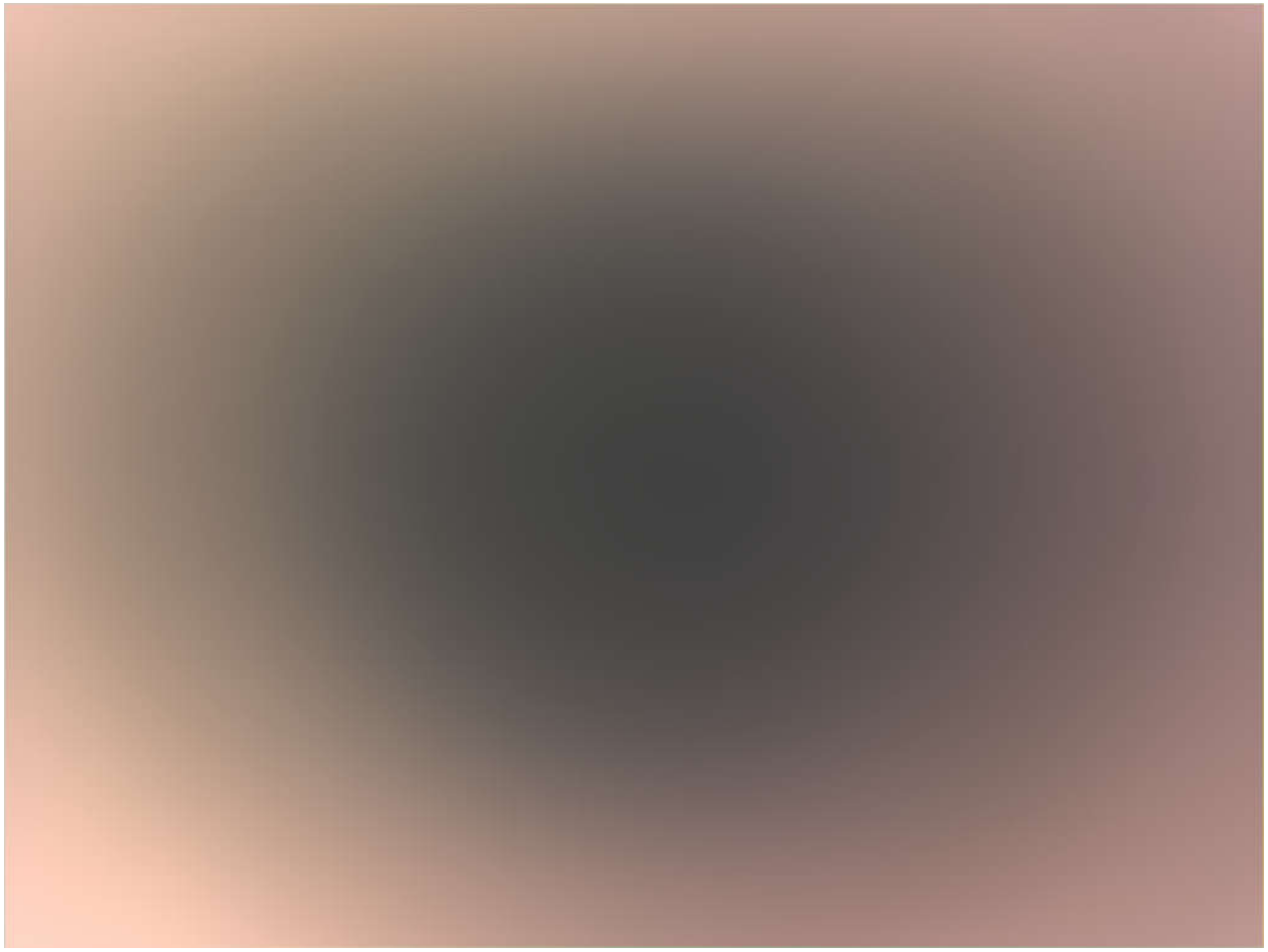
Lens fall-off: real case



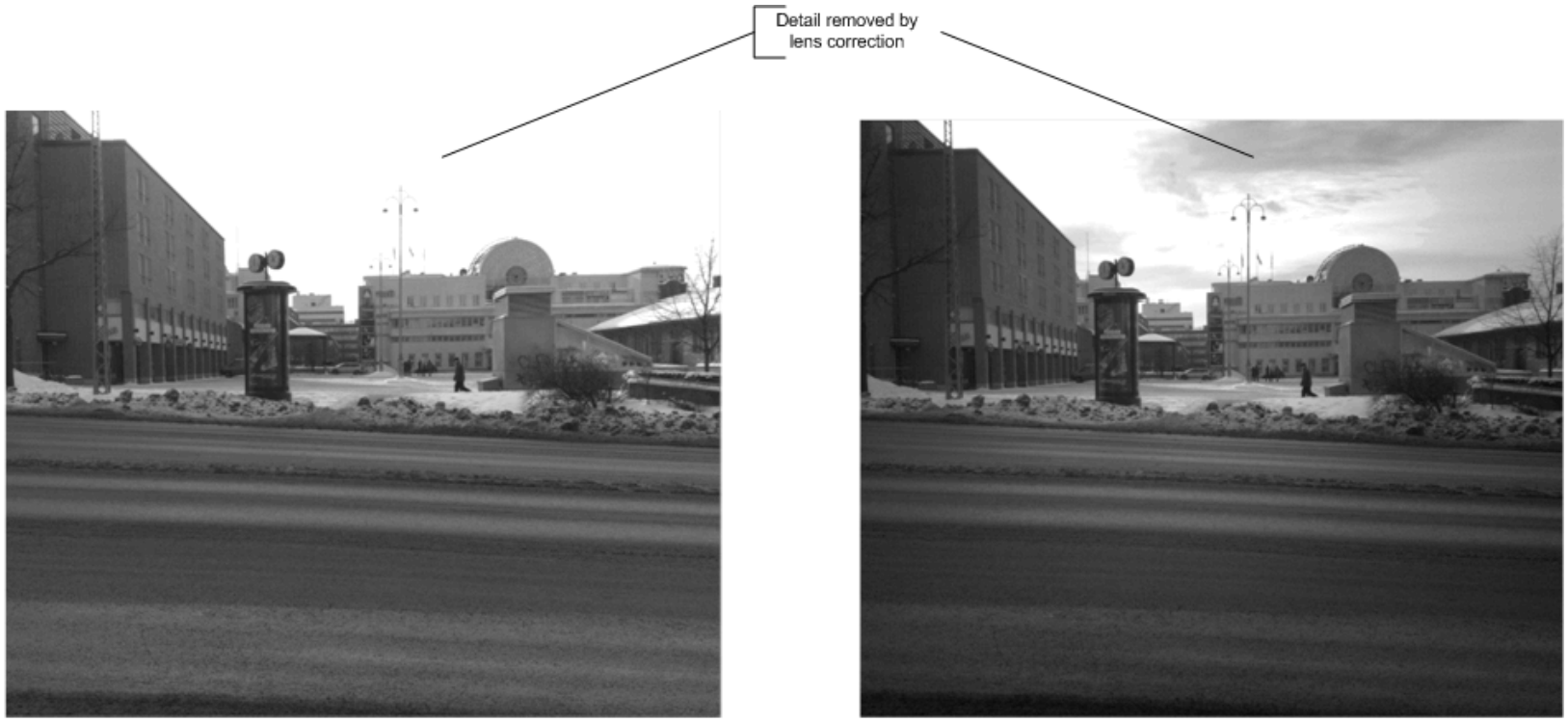
(a) lens fall-off profile

(b) lens correction gain-map

2D linear gain map: real case



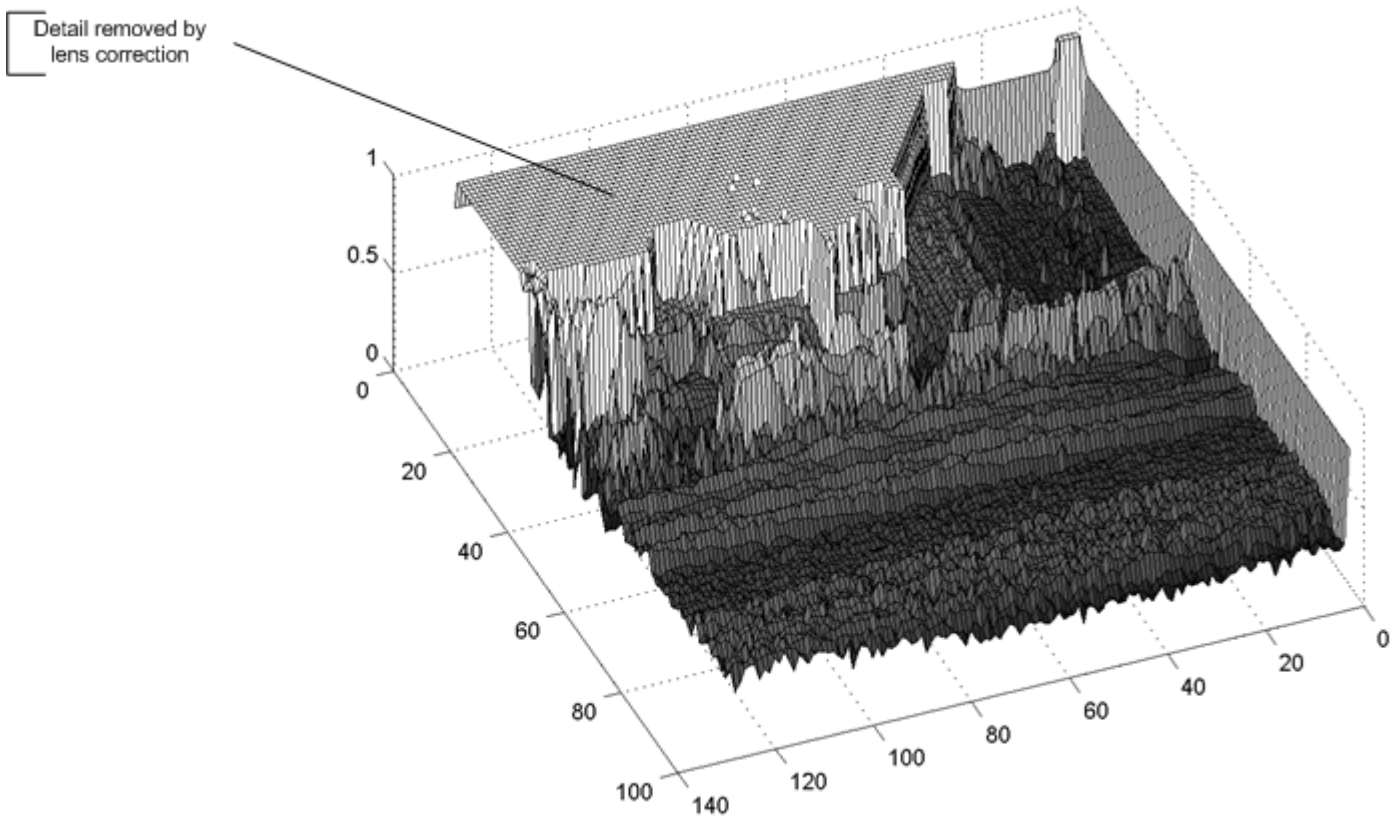
Lens fall-off correction for high-dynamic scenes



(a) linear lens correction

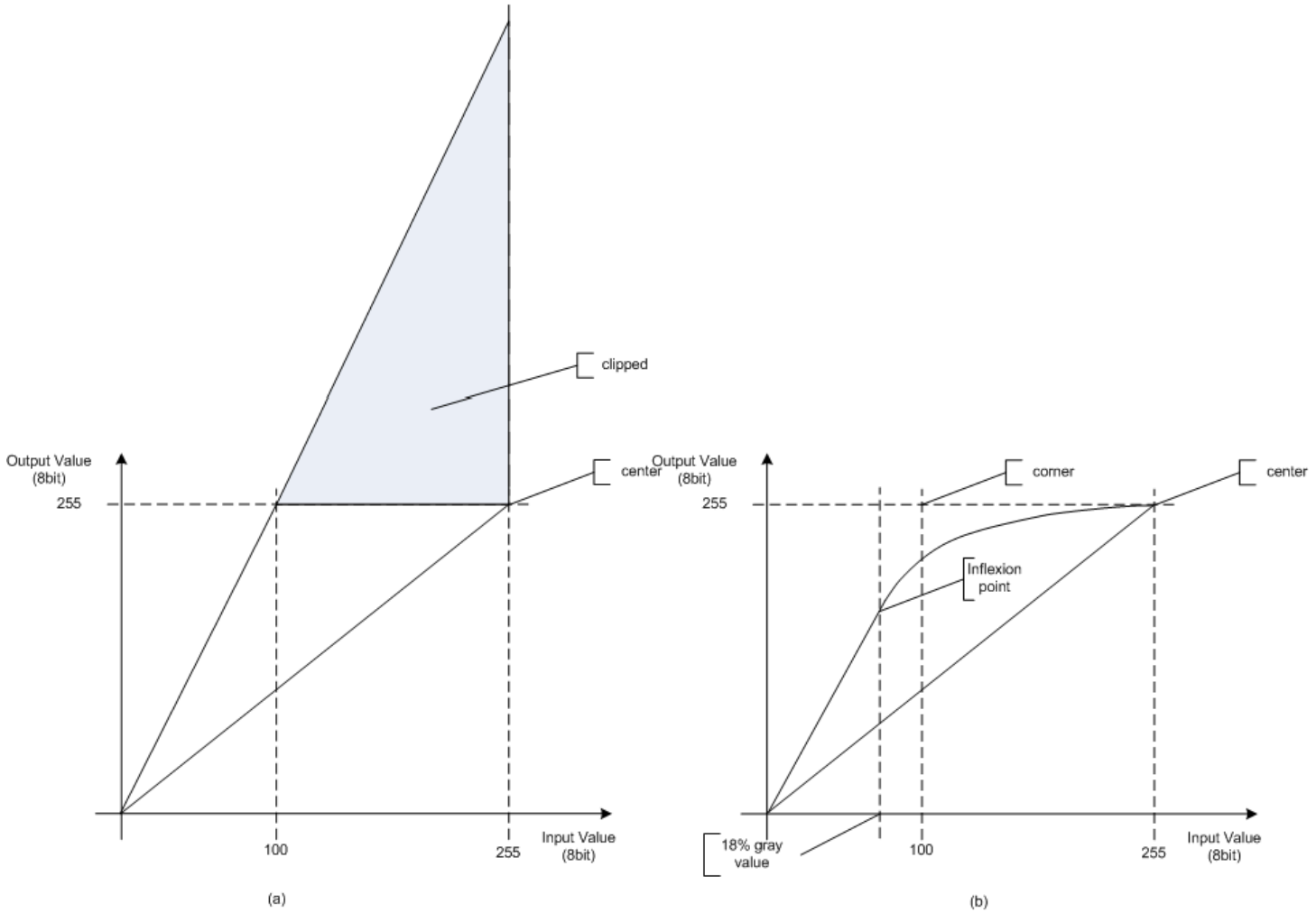
(b) original

Linear lens correction for high dynamic scenes



AMD

Pixel transfer characteristics



Transfer characteristics conditions

- To build a continuous pixel transfer function, the following conditions need to be met:
- $H(x,y,1)=1$ or in other words, the compression function should map 1 to 1;
- $H(x,y,Luma)=G(x,y,Luma)$ i.e. should be continuous in Luma;
- $H'(x,y,Luma)=G'(x,y,Luma)$ in order for the tangent of to be continuous in Luma;

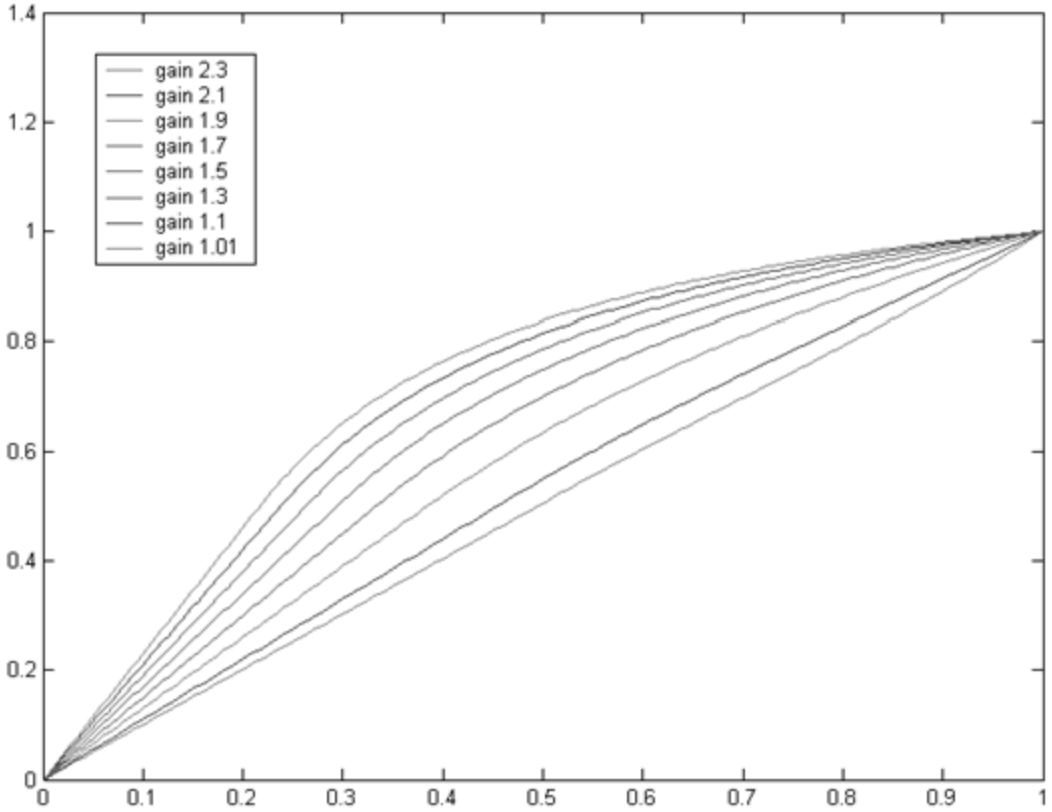
$$F(x,y,v)=\begin{cases} G(x,y)*v & if \quad G(x,y)*v < Luma \\ H(x,y,v) & if \quad G(x,y)*v \geq Luma \end{cases}$$

$$P_{xy}^{o} = P_{xy}^{i} \cdot g_{xy}$$

$$H(x,y,v)=a(x,y)\cdot \ln(\frac{1}{v}+b(x,y))+c(x,y)$$

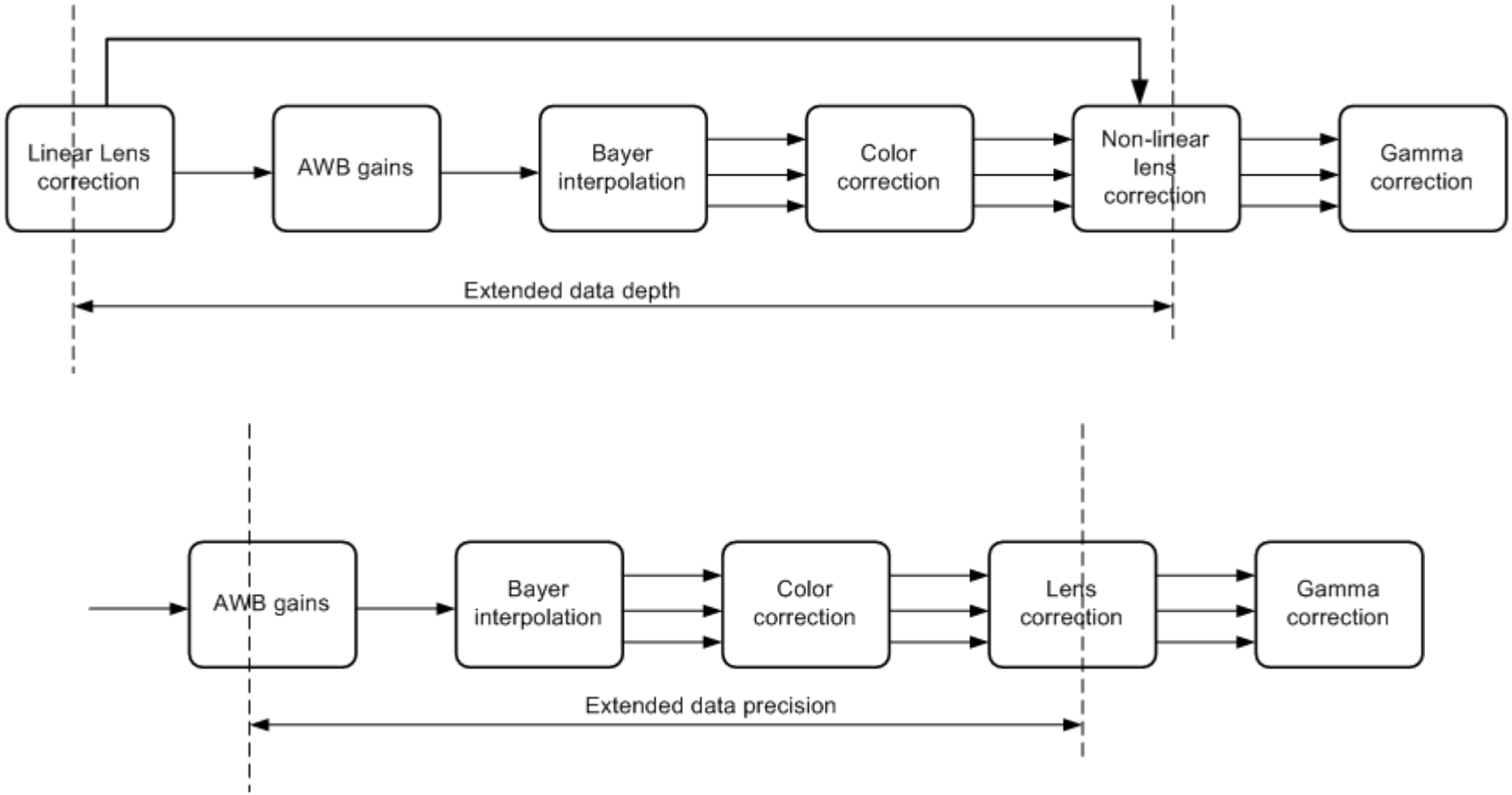
AMD

Transfer curves for gains 1x to 2.2x

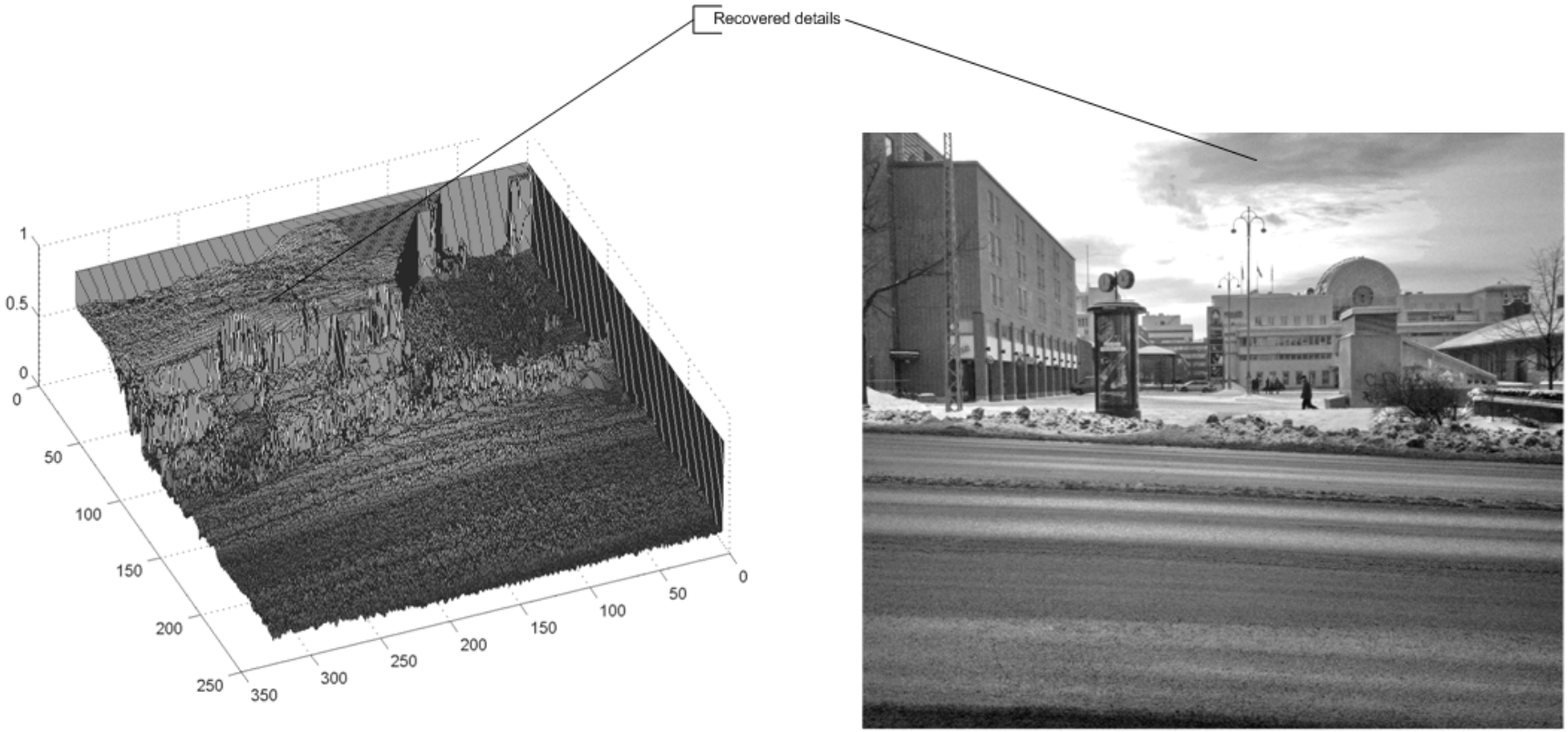


gain	b
2.3	5.375
2.1	3.829
1.9	2.518
1.7	1.435
1.5	0.568
1.3	-0.098
1.1	-0.5695
1.01	-0.7219

Implementations



Results



(a) proposed method image map

(b) proposed method final image

System level and casual photographer underlying assumptions

- Imaging system goal: to have the image sensor exposed as long as possible to light.
- Light distribution:
  - Uniform scene radiance -> logarithmic part dos not come into play, as average luminance is below inflexion point;
  - Higher central radiance -> logarithmic part does not come into play, as centre of image has minimal fall off;
  - High dynamic range radiance with increasing radiance towards the edges -> in this case extra details are recovered;

Conclusions

- Changing pixel transfer characteristics in 2D space, using a two-piece : linear for color accuracy and logarithmic for perceptual detail preservation;

- If scene radiance doesn’t have high dynamic range, linear correction is used,

End remarks

- If lens fall-off is significant, let's use that to our advantage instead of 'fixing' it;
- Distance between analytical image processing and perceptual image processing decreases;