CS448f: Image Processing For Photography and Vision

Sharpening

Sharpening

- Boost detail in an image without introducing noise or artifacts
- Undo blur
  - due to lens aberrations
  - slight misfocus

Recall Denoising

Input

=

Signal + Noise

Recall Denoising

Input

=

Signal + Noise

Sharpening

Input

=

Coarse + Fine

Sharpening

Output

=

Coarse + Fine

Sharpening

- Any Filter which removes fine details can be used to sharpen
  - 1) Coarse = Remove Fine Details from Input
  - 2) Fine = Input - Coarse
  - 3) Output = Input + Fine x 0.5
- Which filters should be use to create the coarse base layer?
- What about noise?

Linear Sharpening Filters

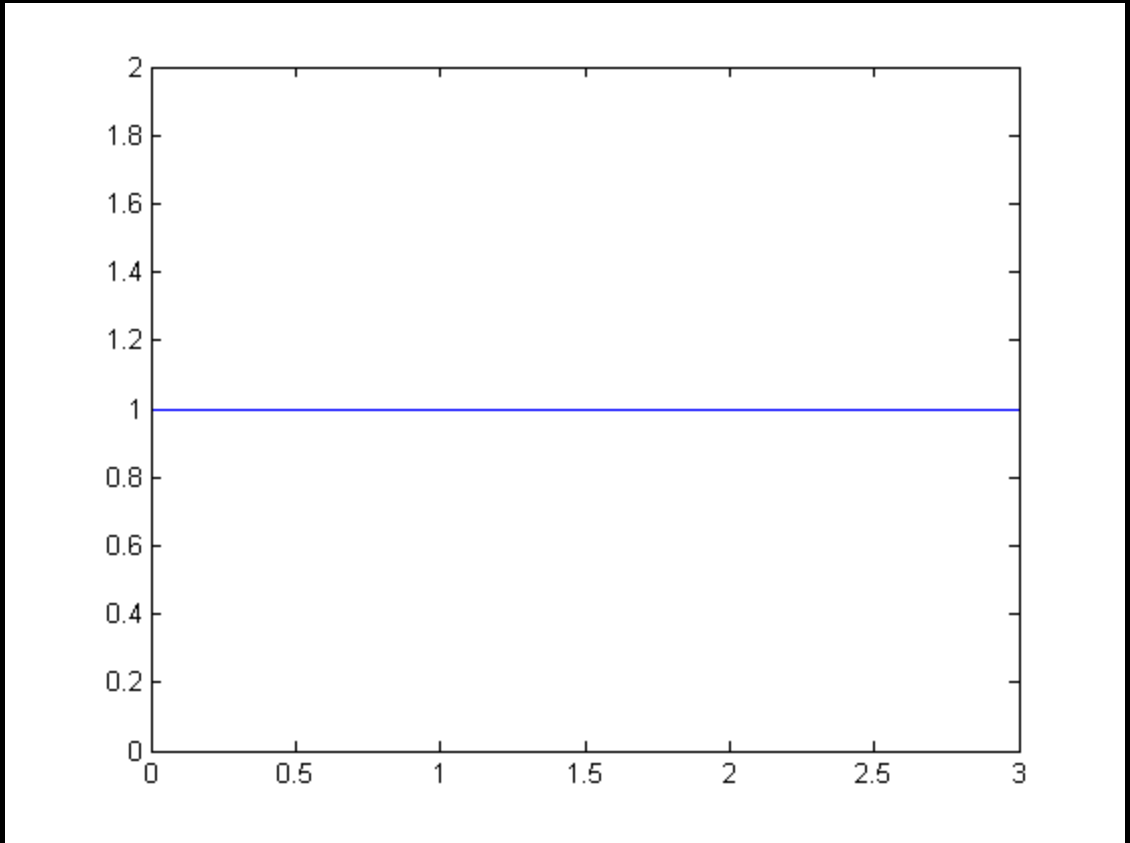
- Let G be a Gaussian Kernel
  - 1) Coarse = G * Input
  - 2) Fine = Input - Coarse
  - 3) Output = Input + Fine x 0.5

Convolution is Linear

- G*(a+b) = G*a + G*b
  - Output = Input + 0.5 Fine
  - Output = Input + 0.5 (Input - G*Input)
  - Output = 1.5 Input - 0.5 G*Input
  - Output = (1.5 I - 0.5 G) * Input
- Or in Fourier Space
  - Output' = (1.5 I' - 0.5 G') x Input'

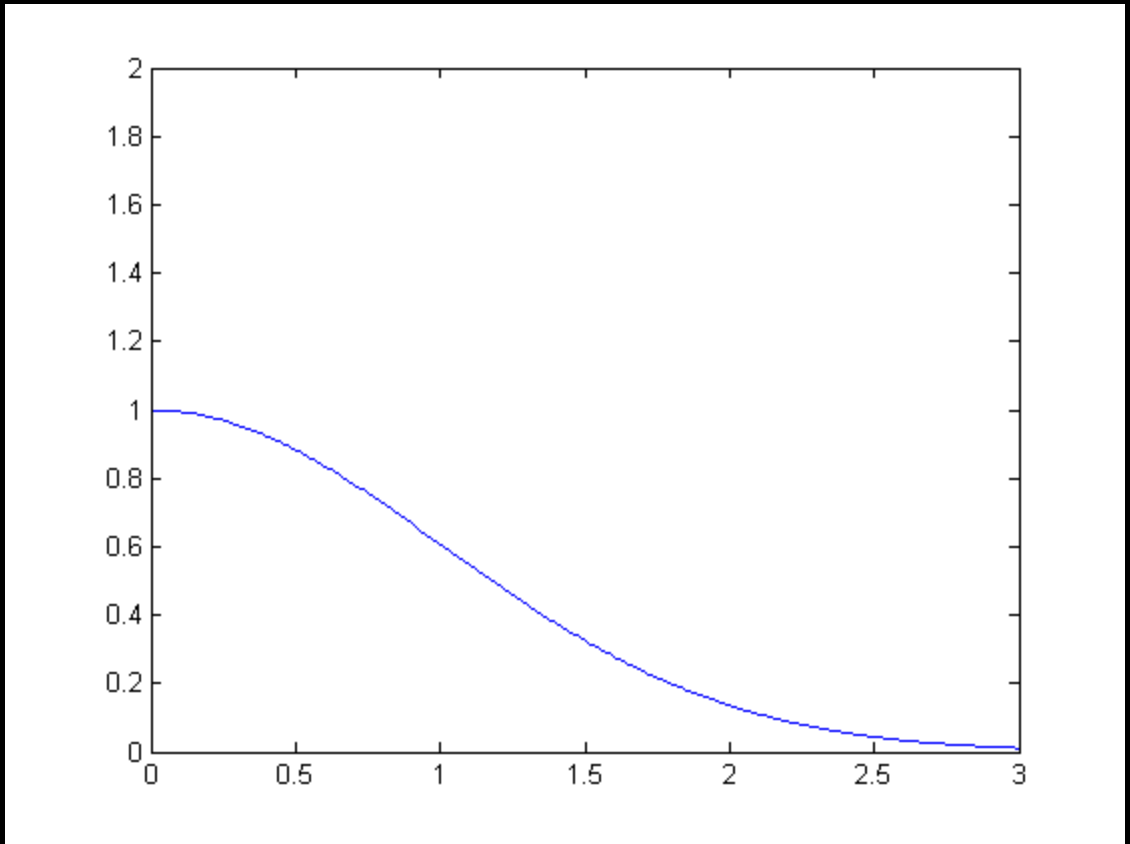
Linear Sharpening Filters

- I is the filter that does nothing when you convolve by it, so I' is the filter that does nothing when you multiply by it => $I' = 1$



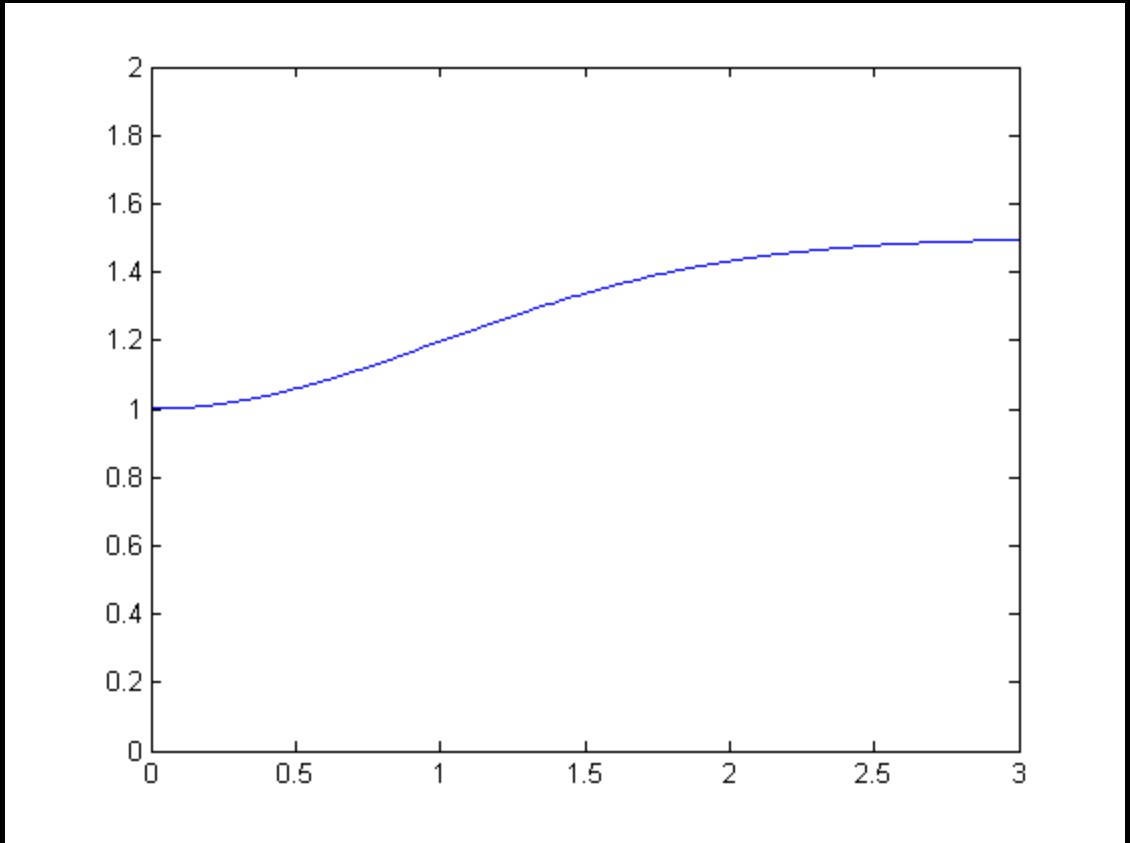
Linear Sharpening Filters

- The Fourier Transform of a Gaussian is a Gaussian
- G’:



The result in Fourier space:

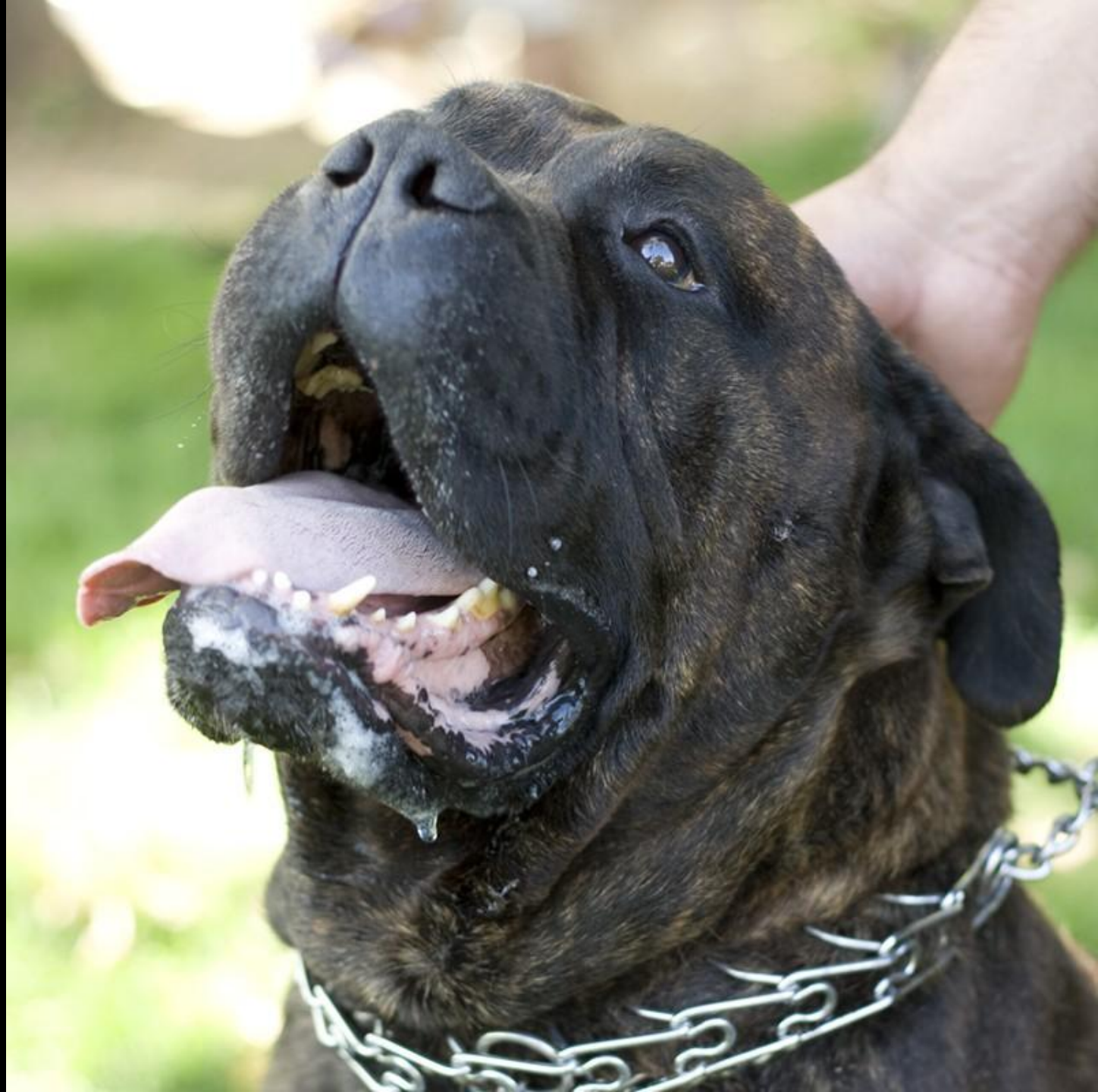
- (1.5 I’ - 0.5 G’) = amplify high frequencies



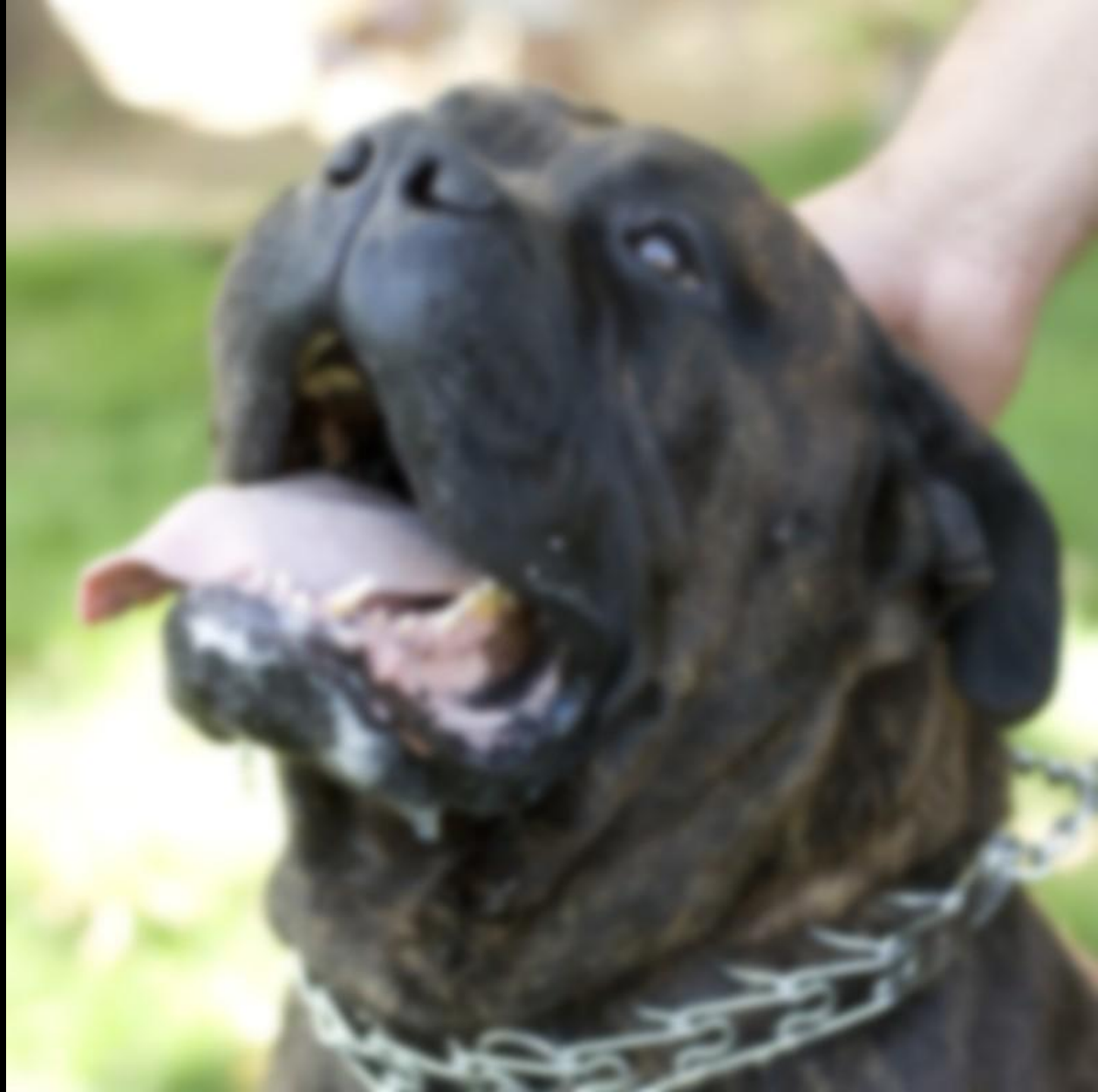
Demo

- ImageStack -load dog.jpg -dup -dup -dup -gaussianblur 4 -pull 1 -subtract -scale 2 -add -adjoin t -resample 10 width height -display

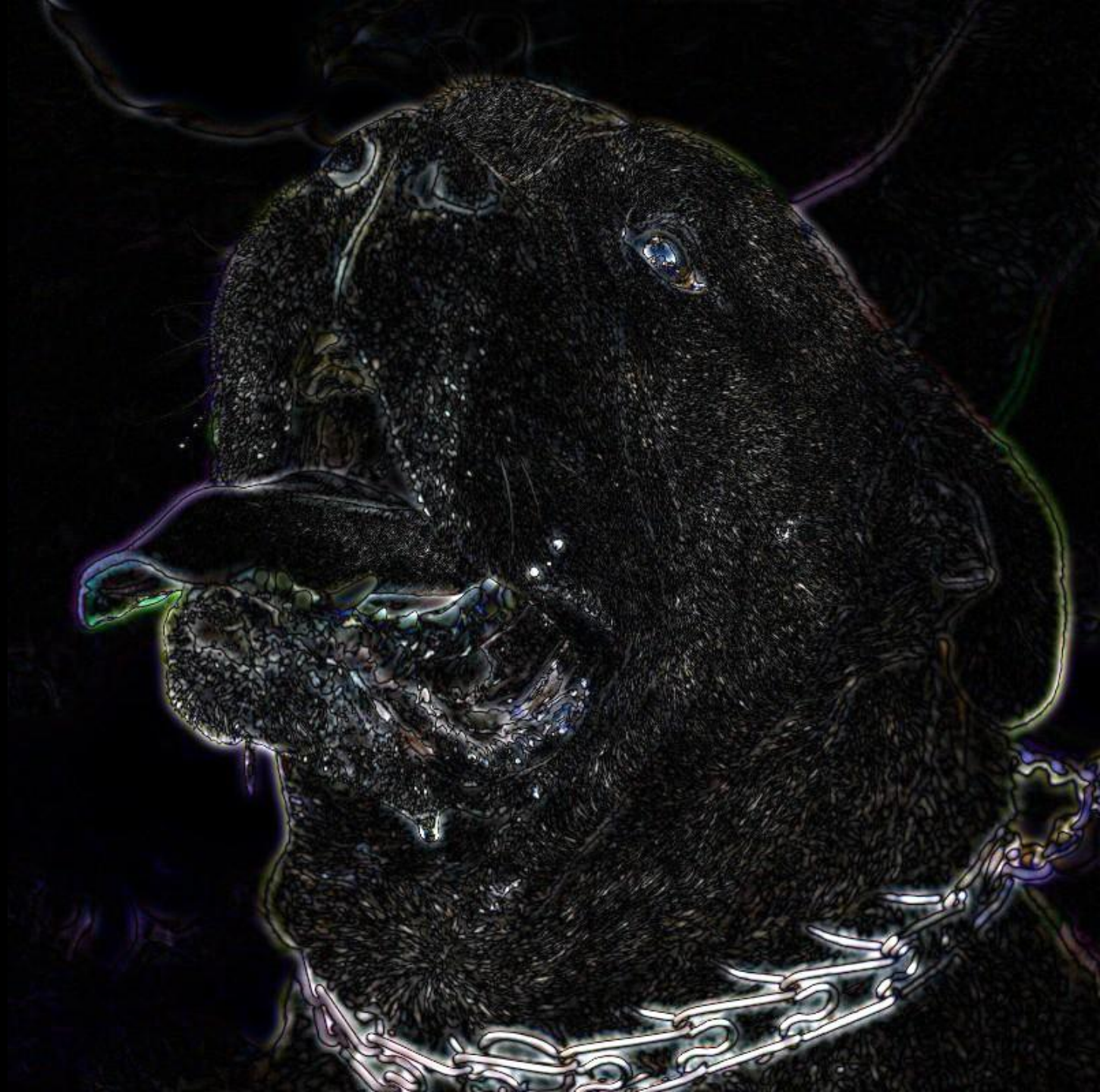
Input



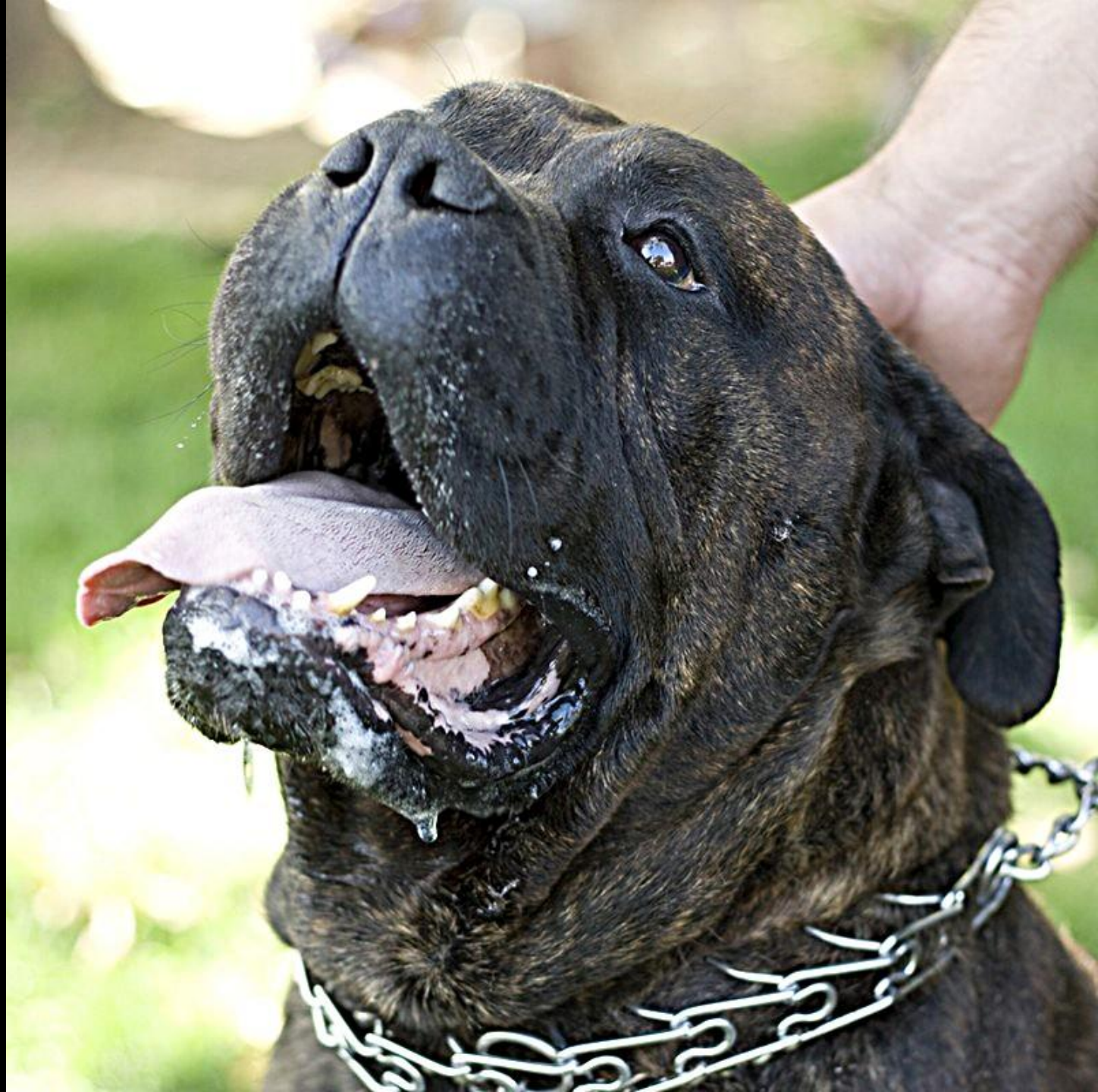
Coarse



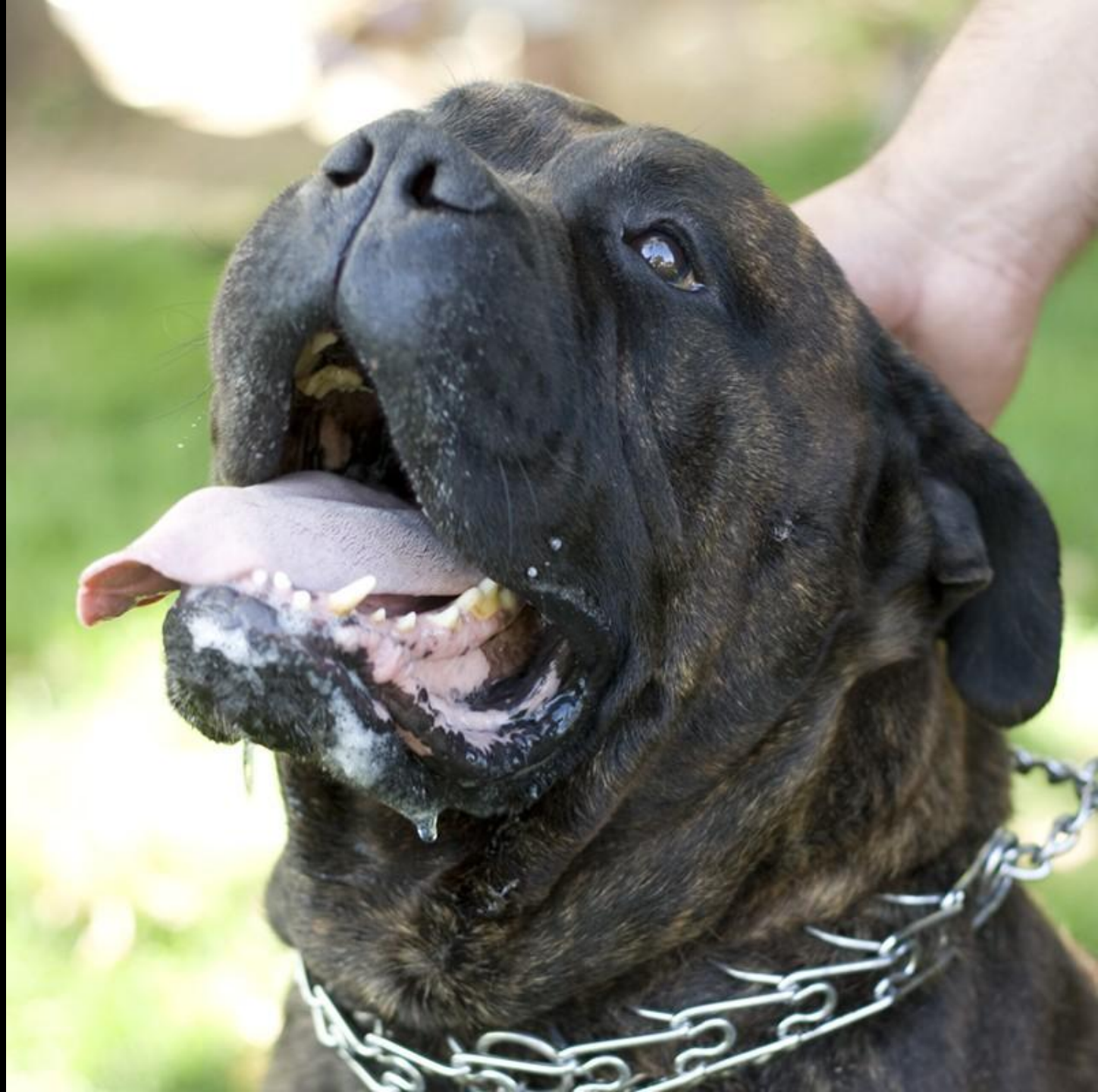
Fine x 3



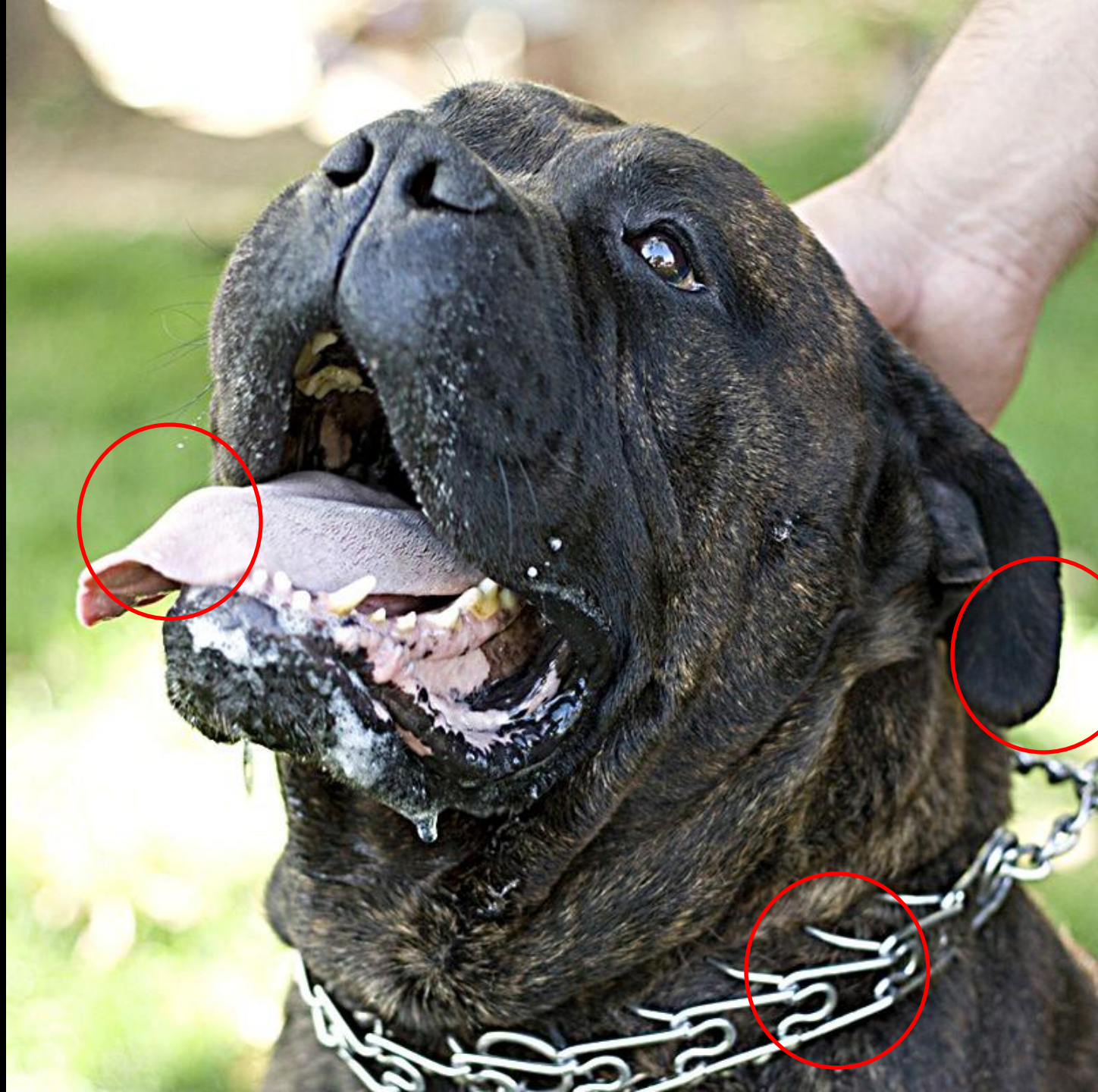
Input +
Fine



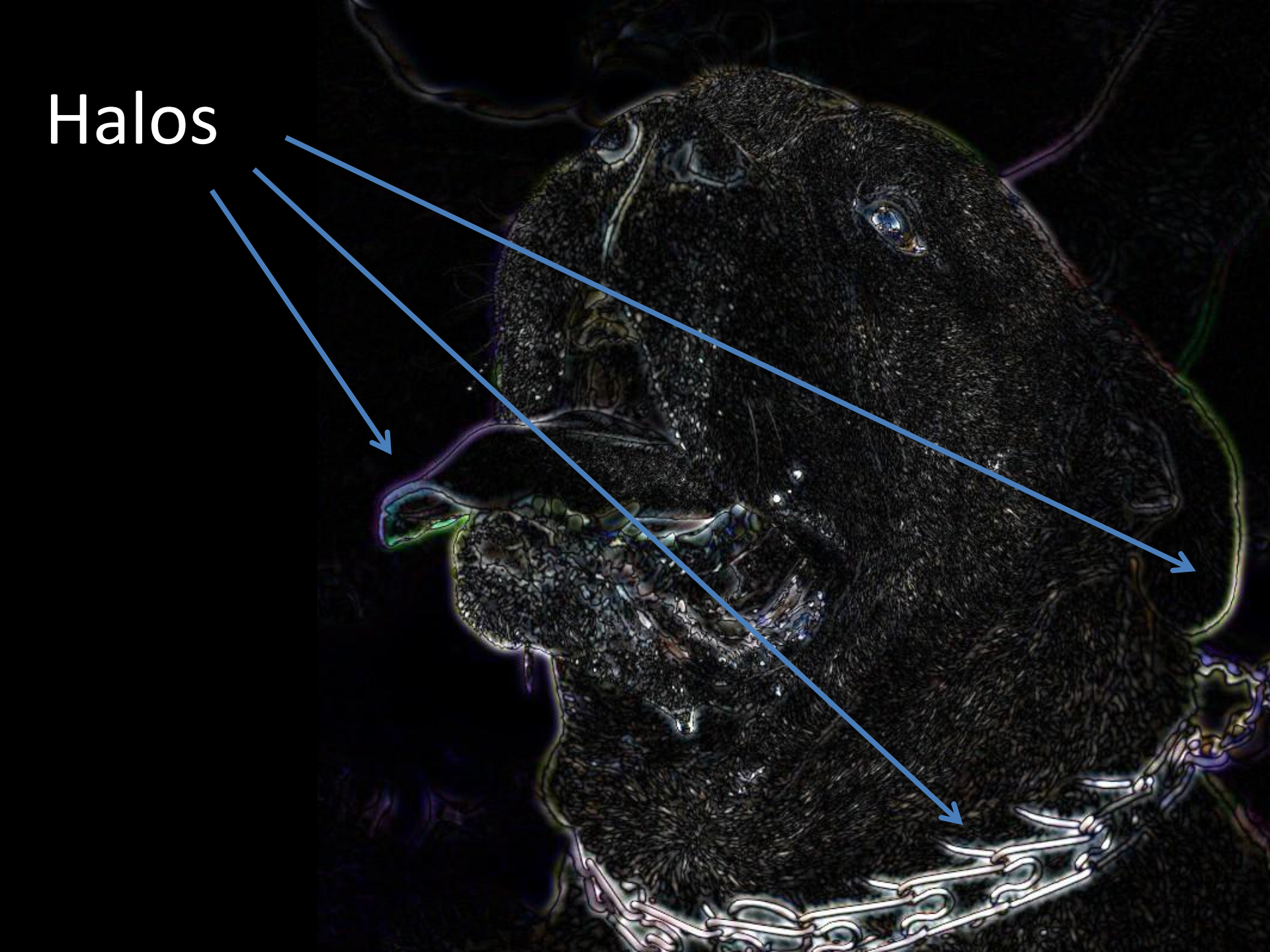
Input



Halos:



Halos



Let’s see what Photoshop Does

- Unsharp Masking...

Let’s see what Photoshop Does

- Unsharp Masking creates halos
- With the threshold set, fine details are not boosted, only strong edges

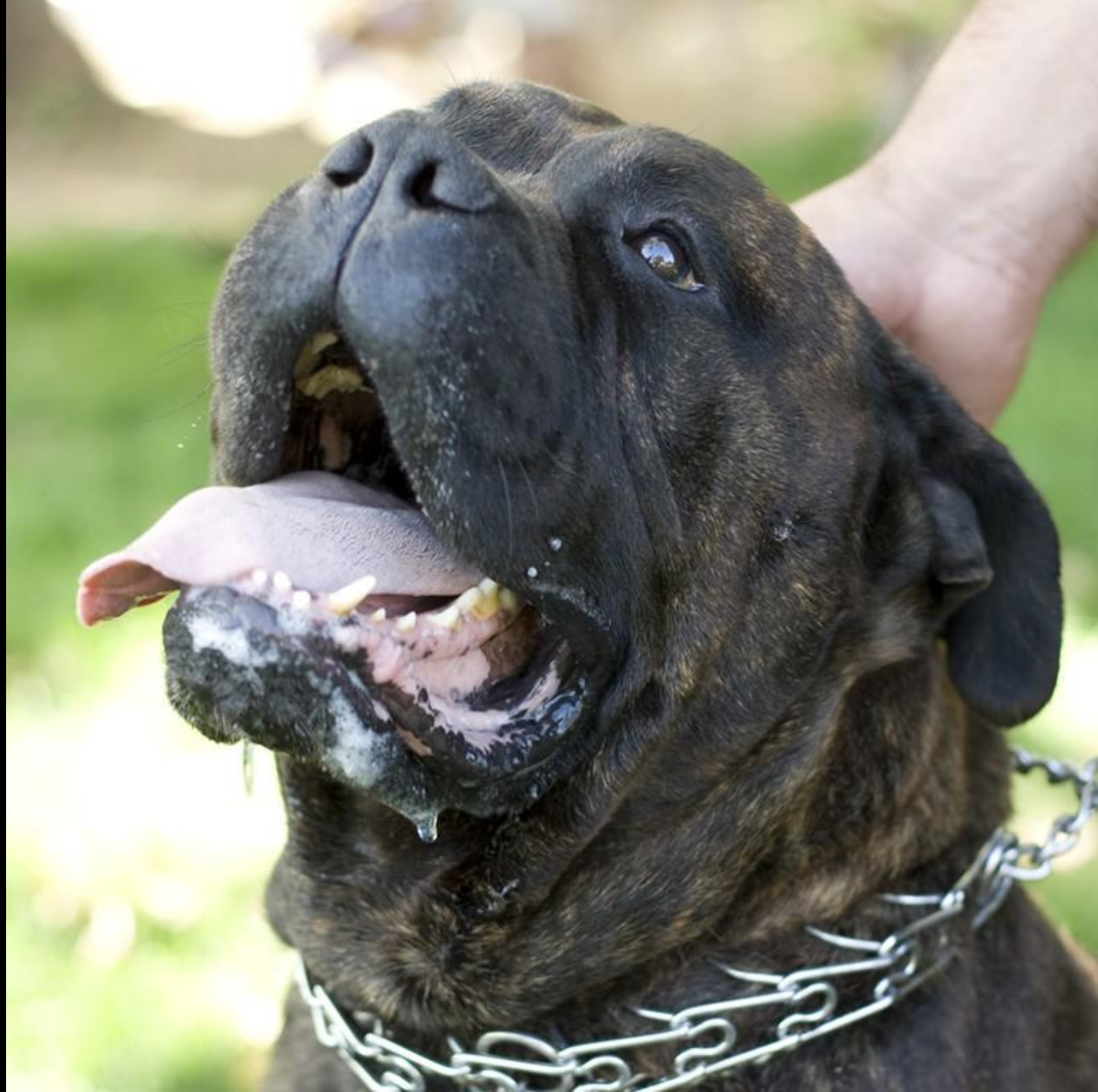
Suggestions?

- What removes fine detail without blurring edges?

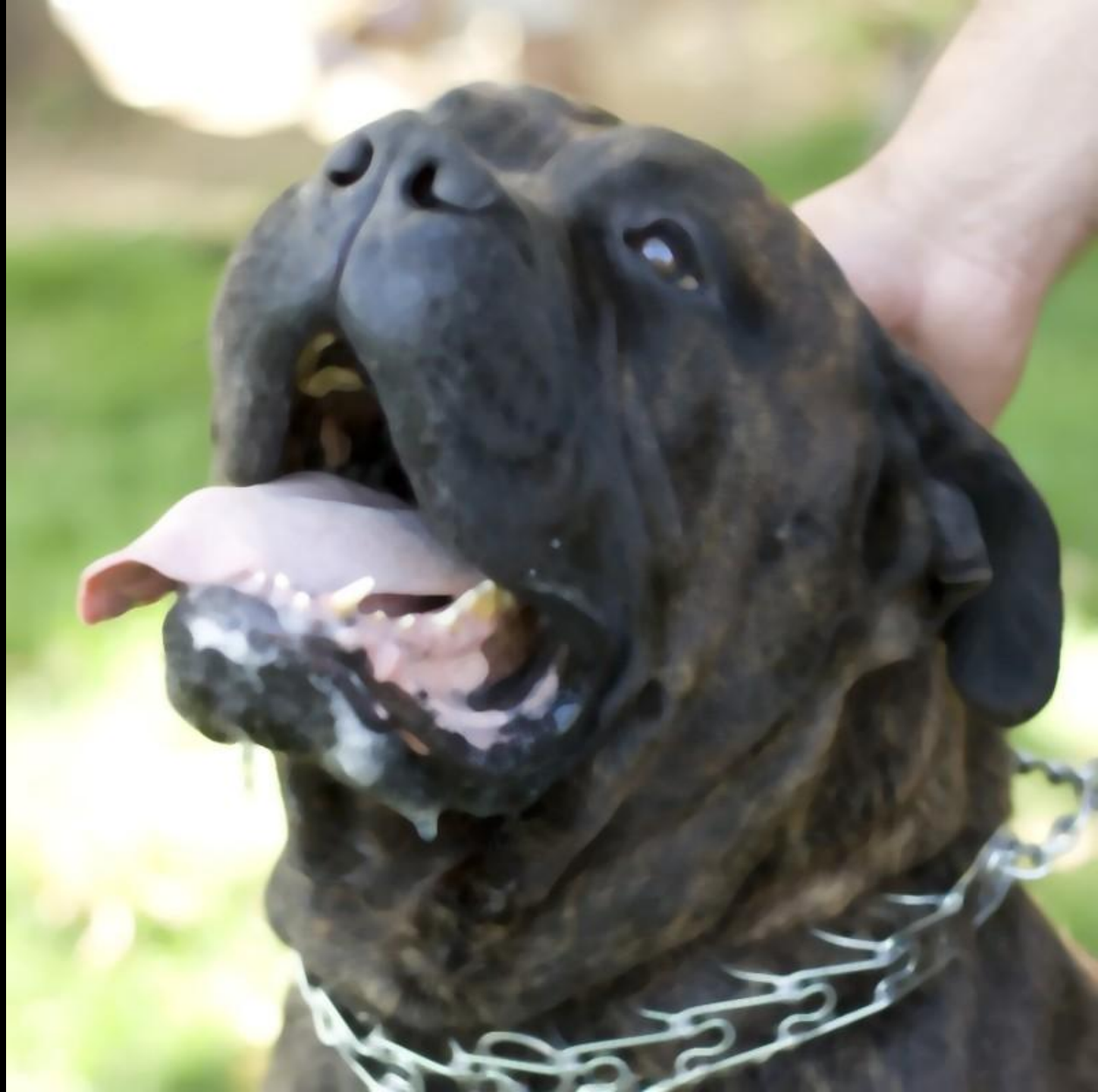
Median Sharpen

- The “Fine” image is the same as the “Method Noise” images in the previous lecture.
- It should only contain fine detail, not strong edges
- Let’s make the base layer with a median filter!

Input

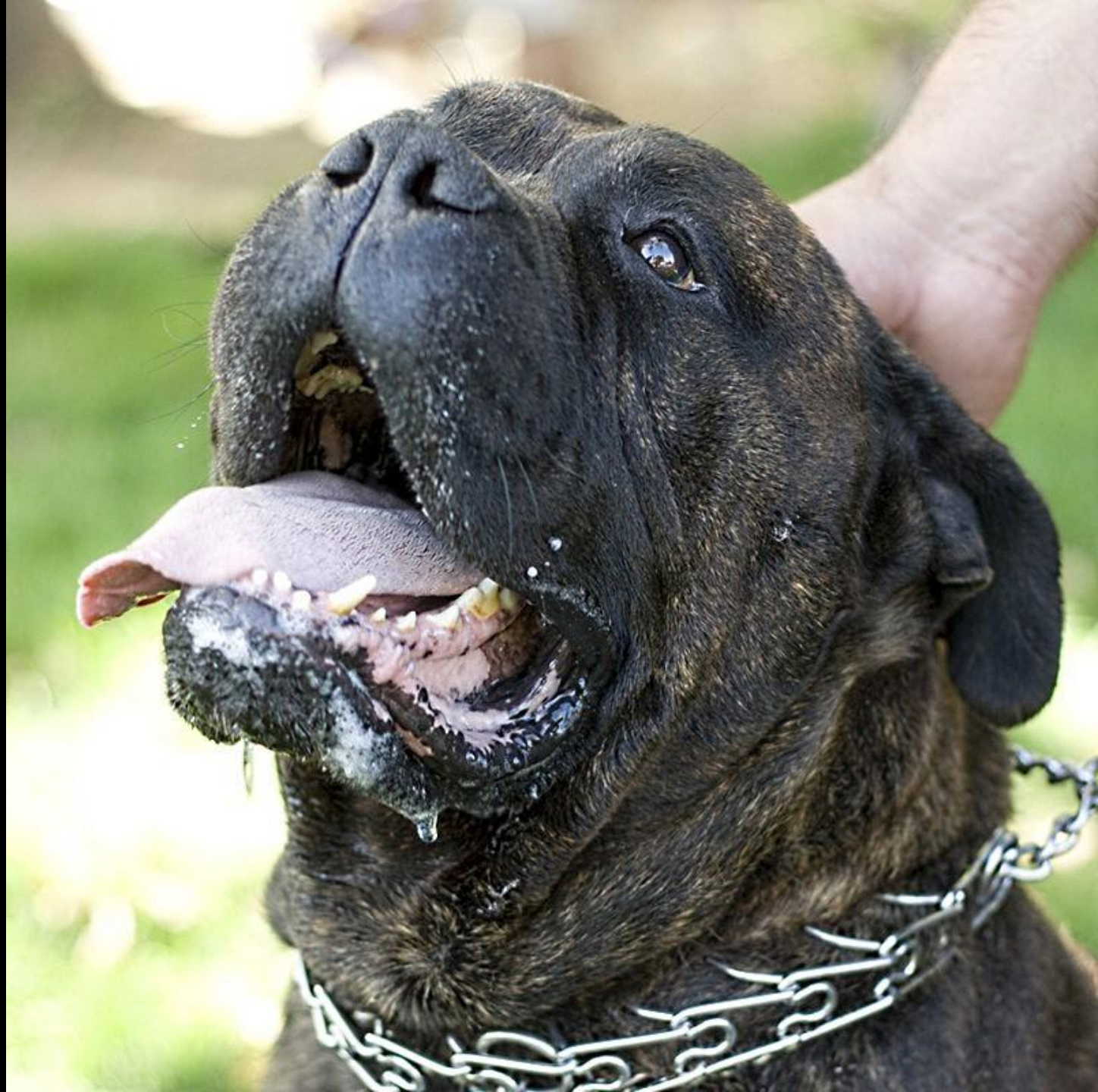


Median
Coarse

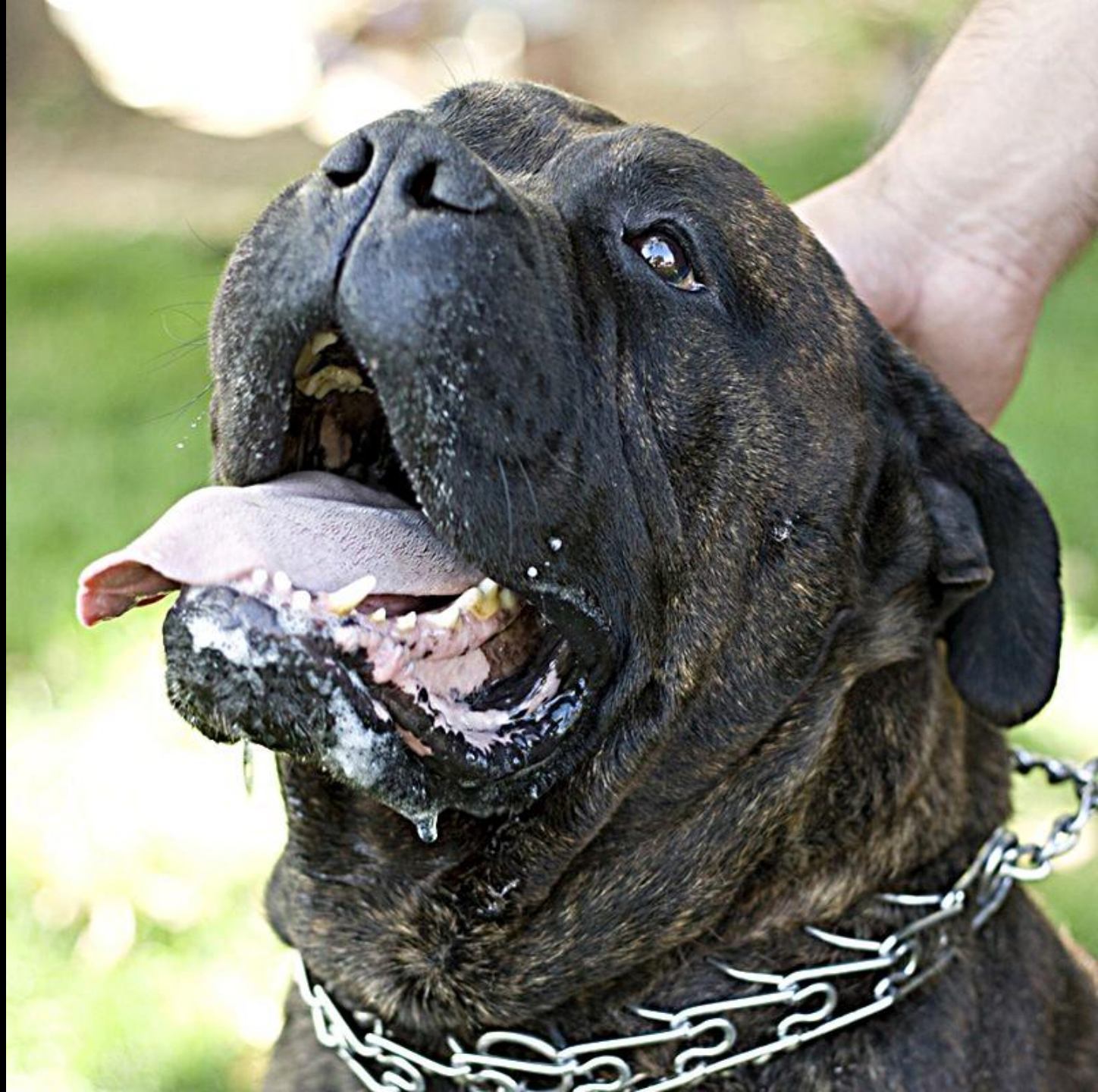


Median
Fine x 3

Median Result



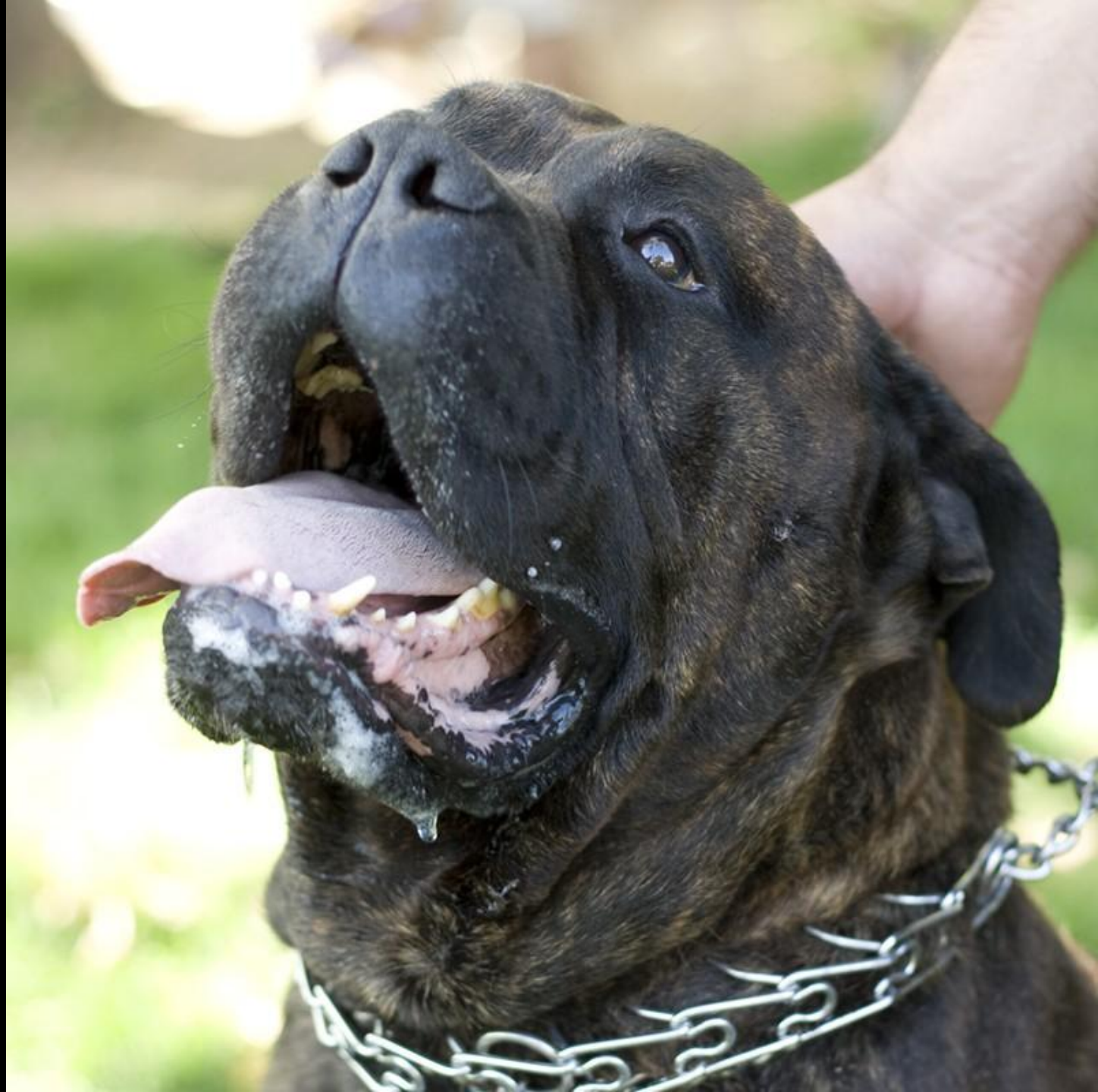
Linear Result



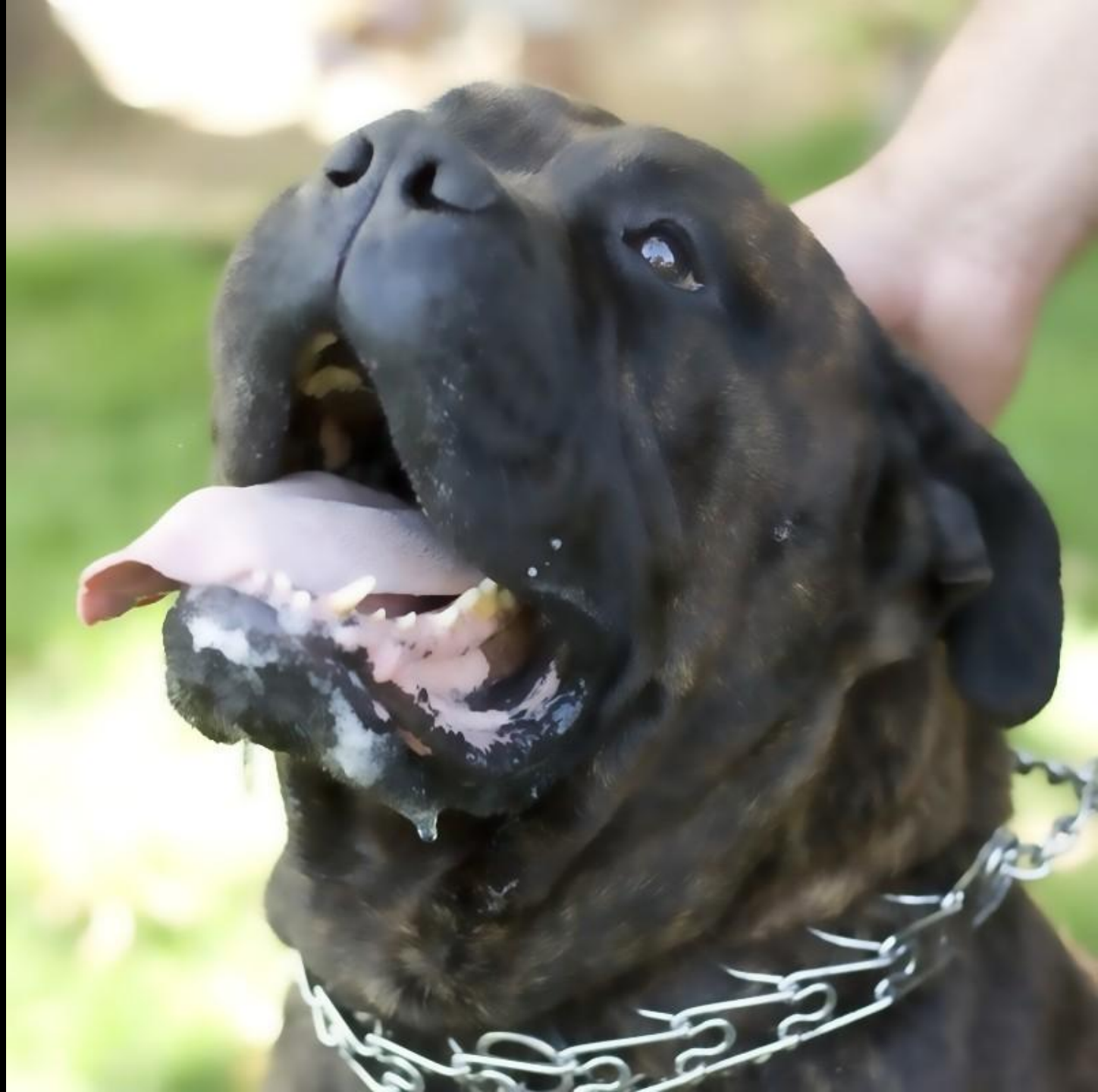
Bilateral Sharpen

- Let’s make the base layer with a bilateral filter!

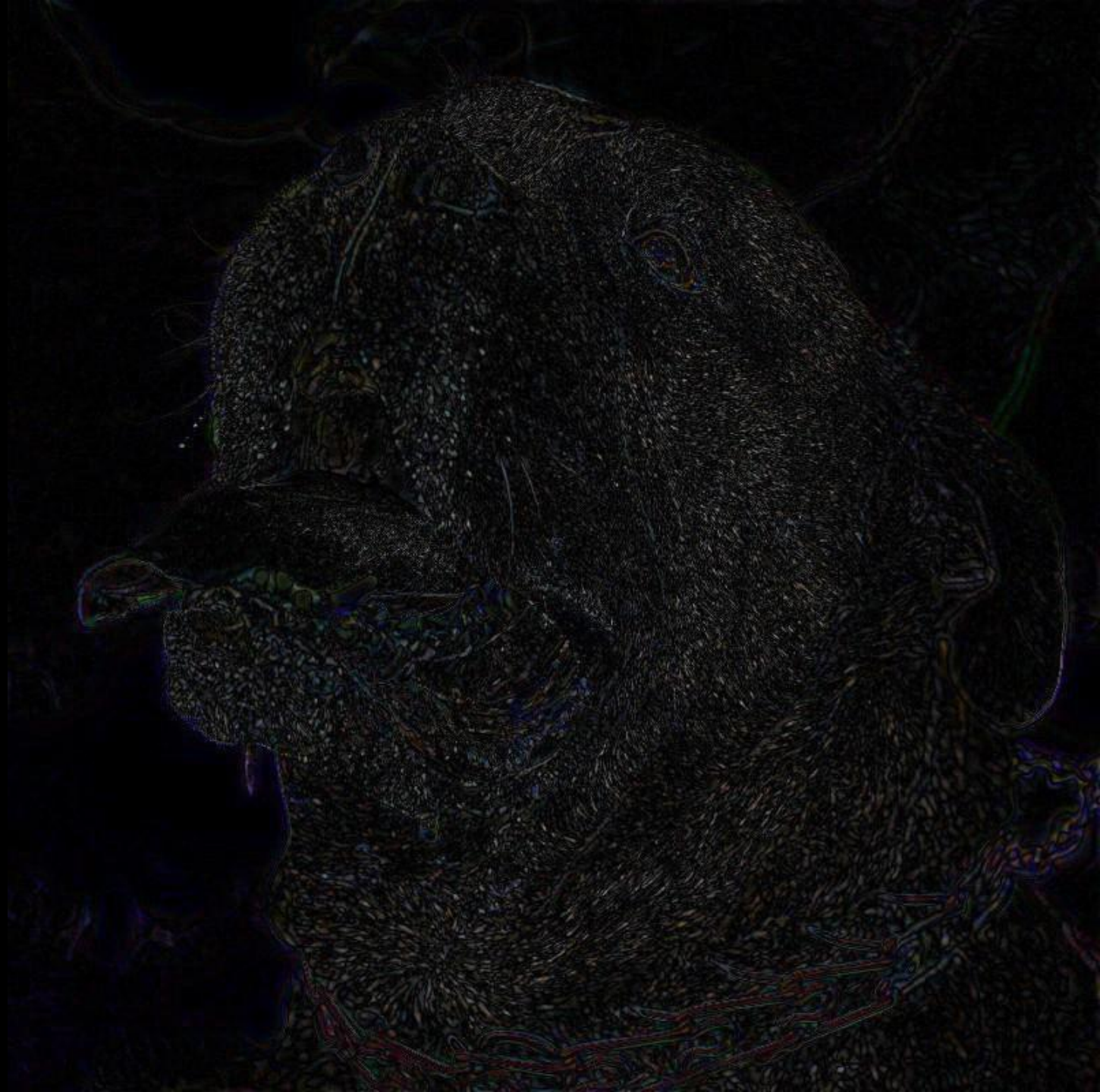
Input



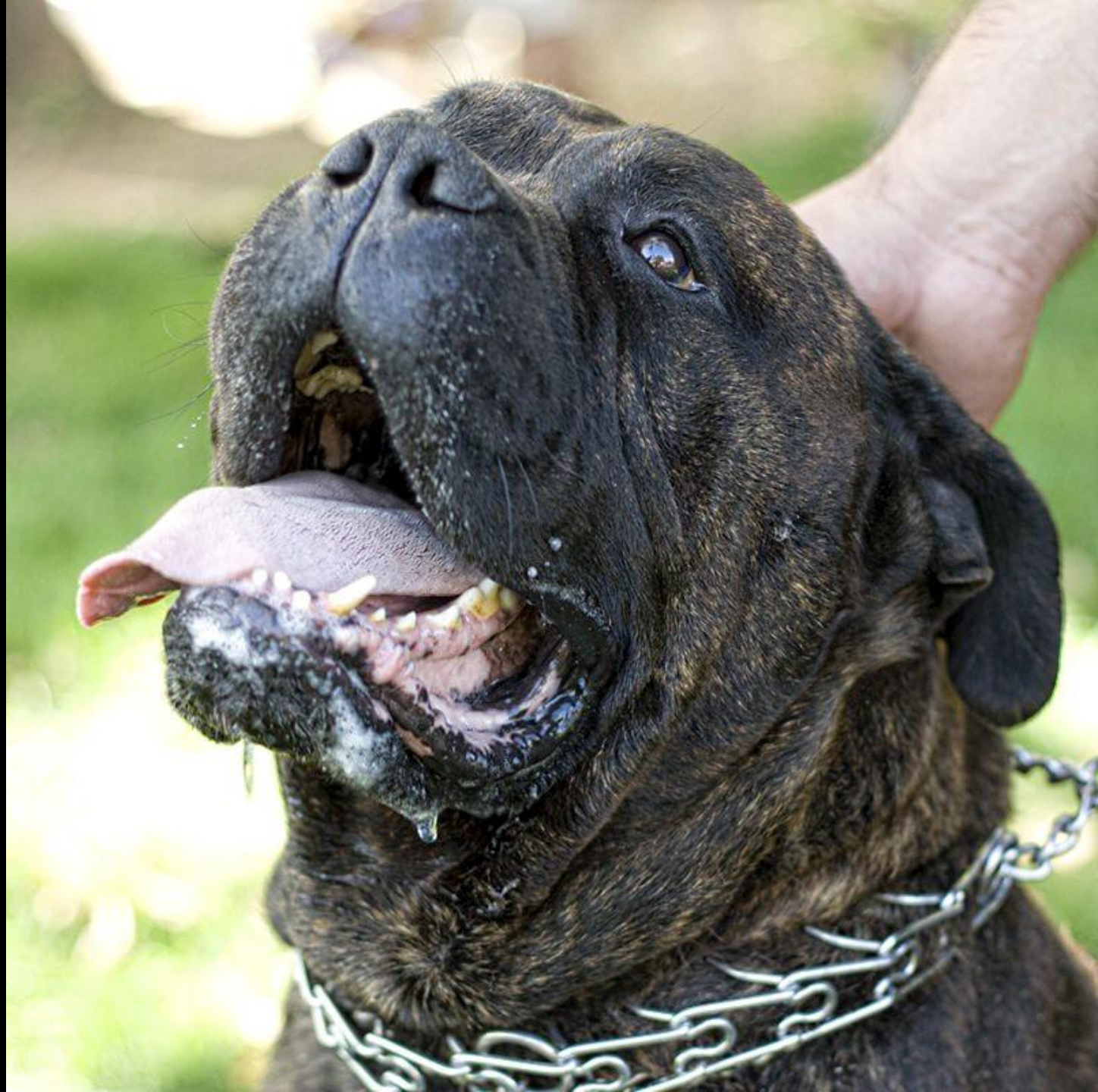
Bilateral Coarse



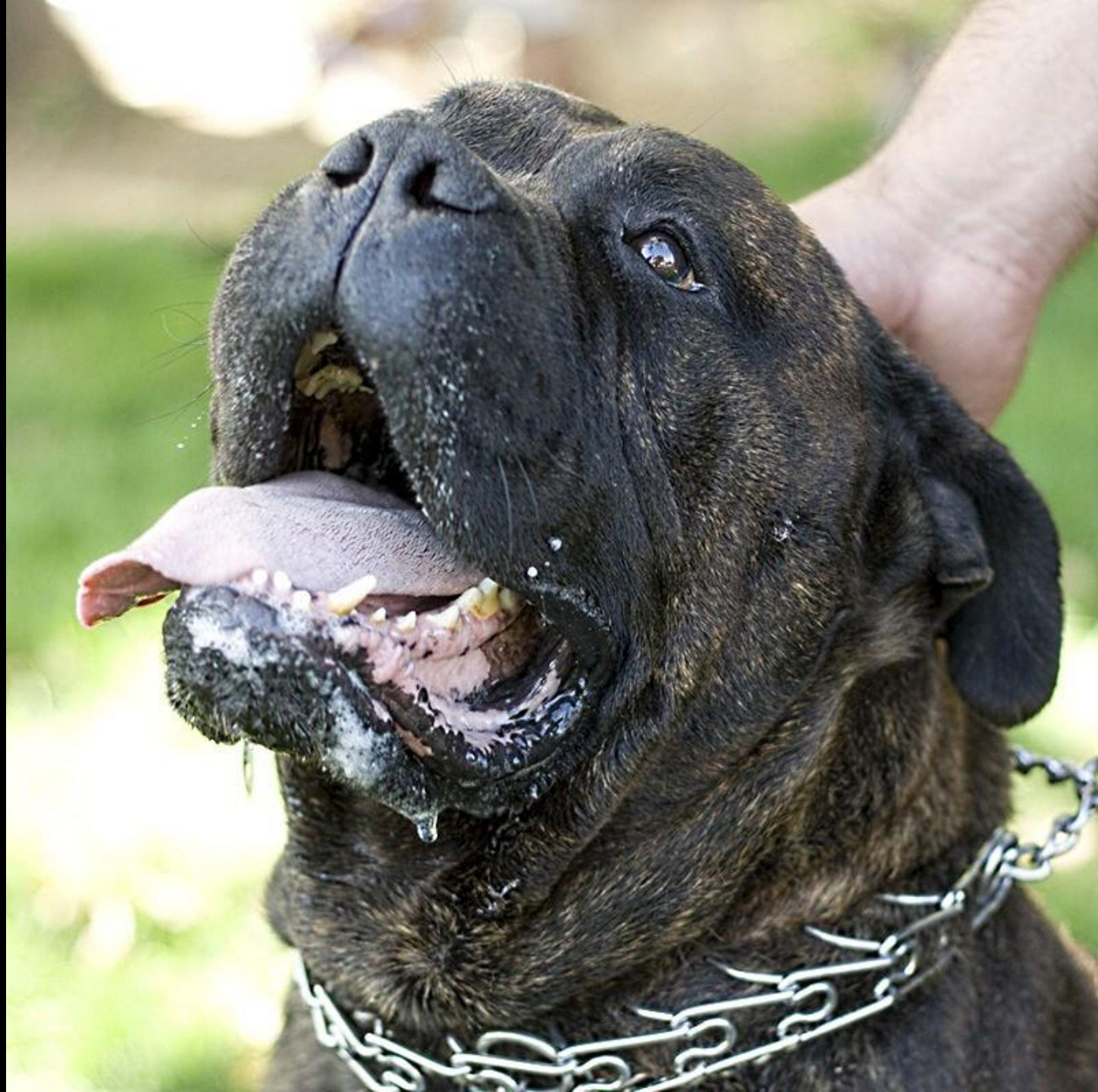
Bilateral
Fine x 3



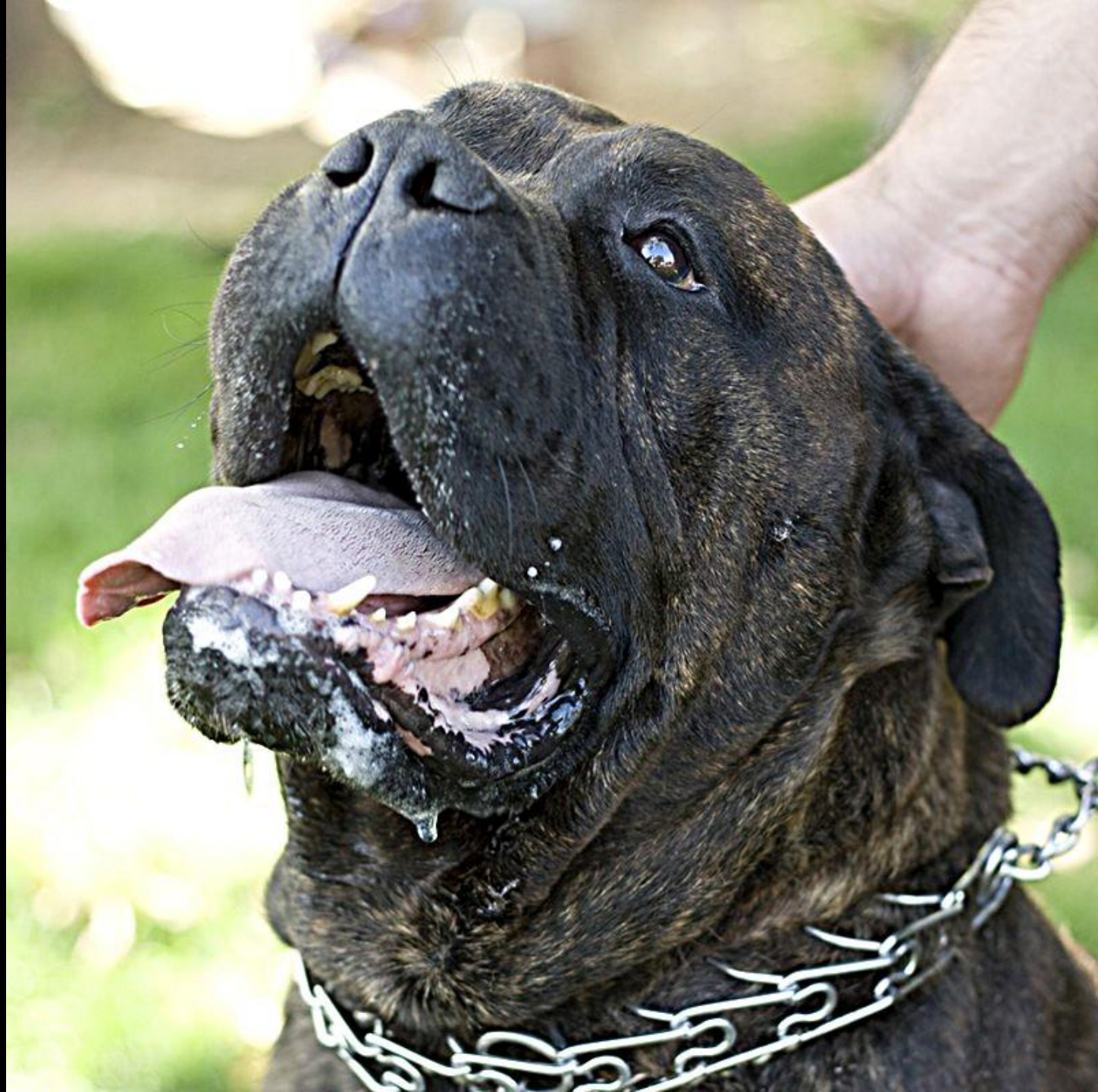
Bilateral Result



Median Result



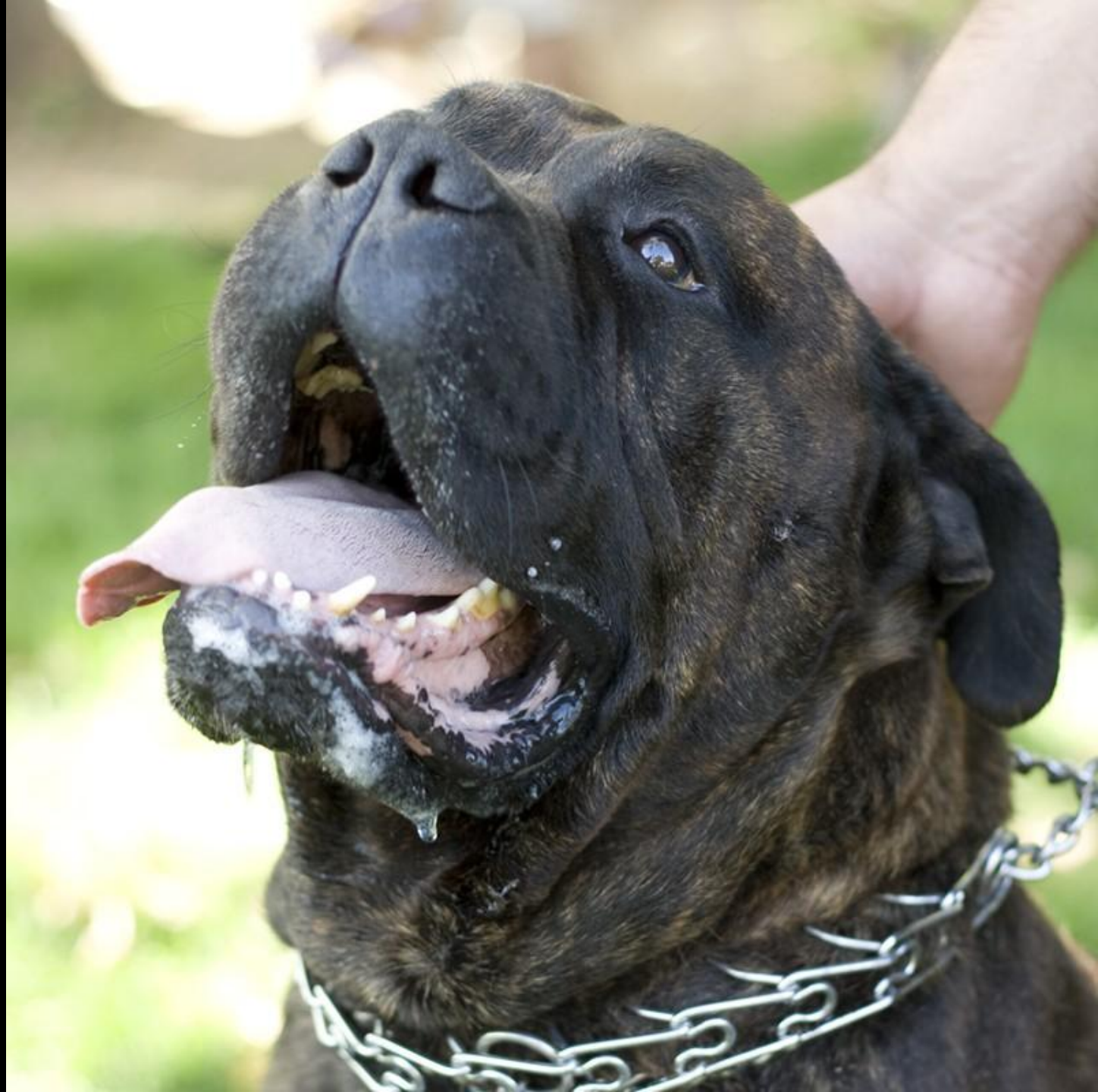
Linear Result



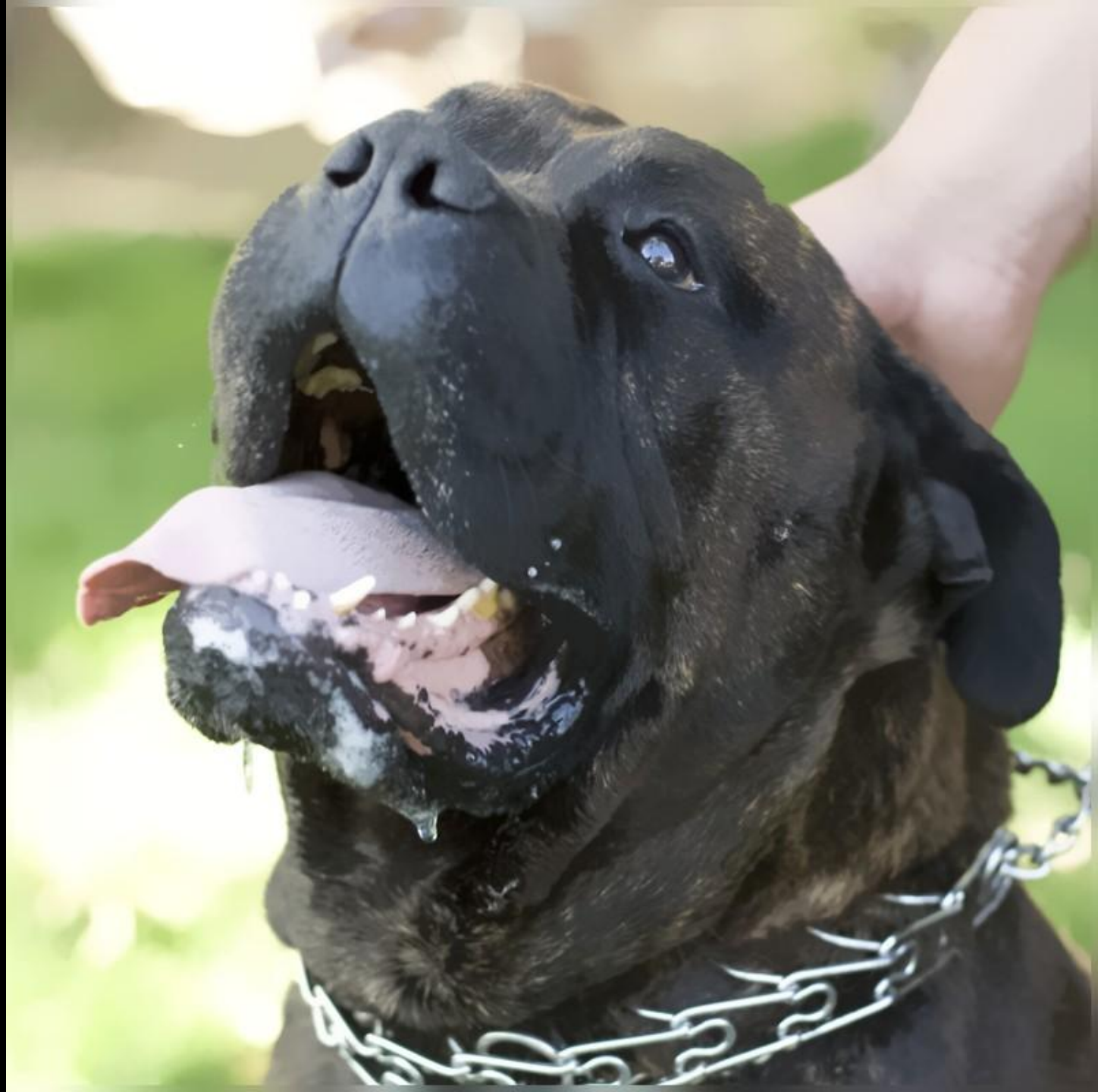
Non-Local Means Sharpen?

- Non-Local Means looks for similar patches and averages my value with theirs
  - Conformity with peer group
- Non-Local Means sharpening figures out what makes me different from other similar things in the image, and exaggerates that
  - Rebellion against peer group

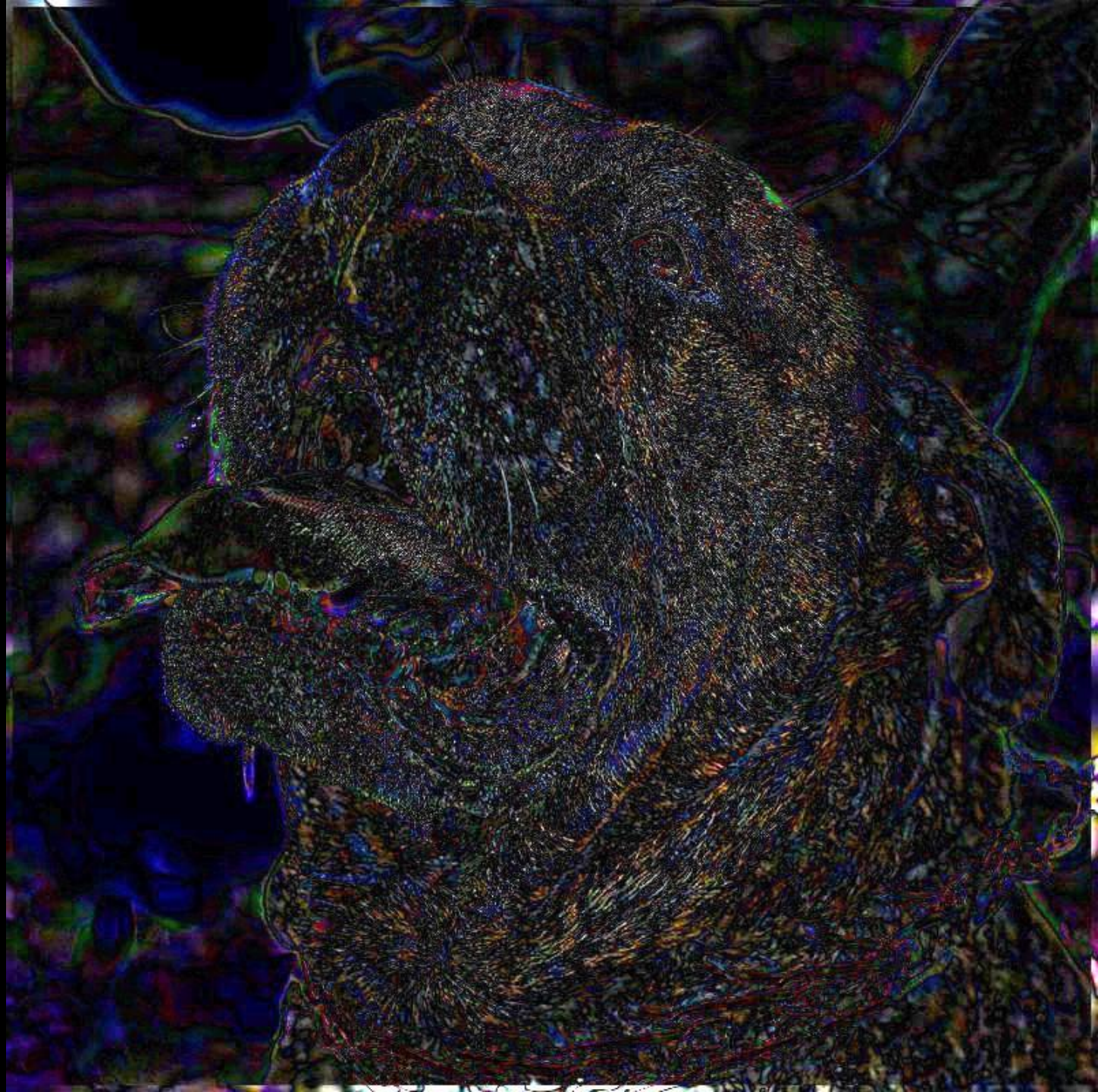
Input



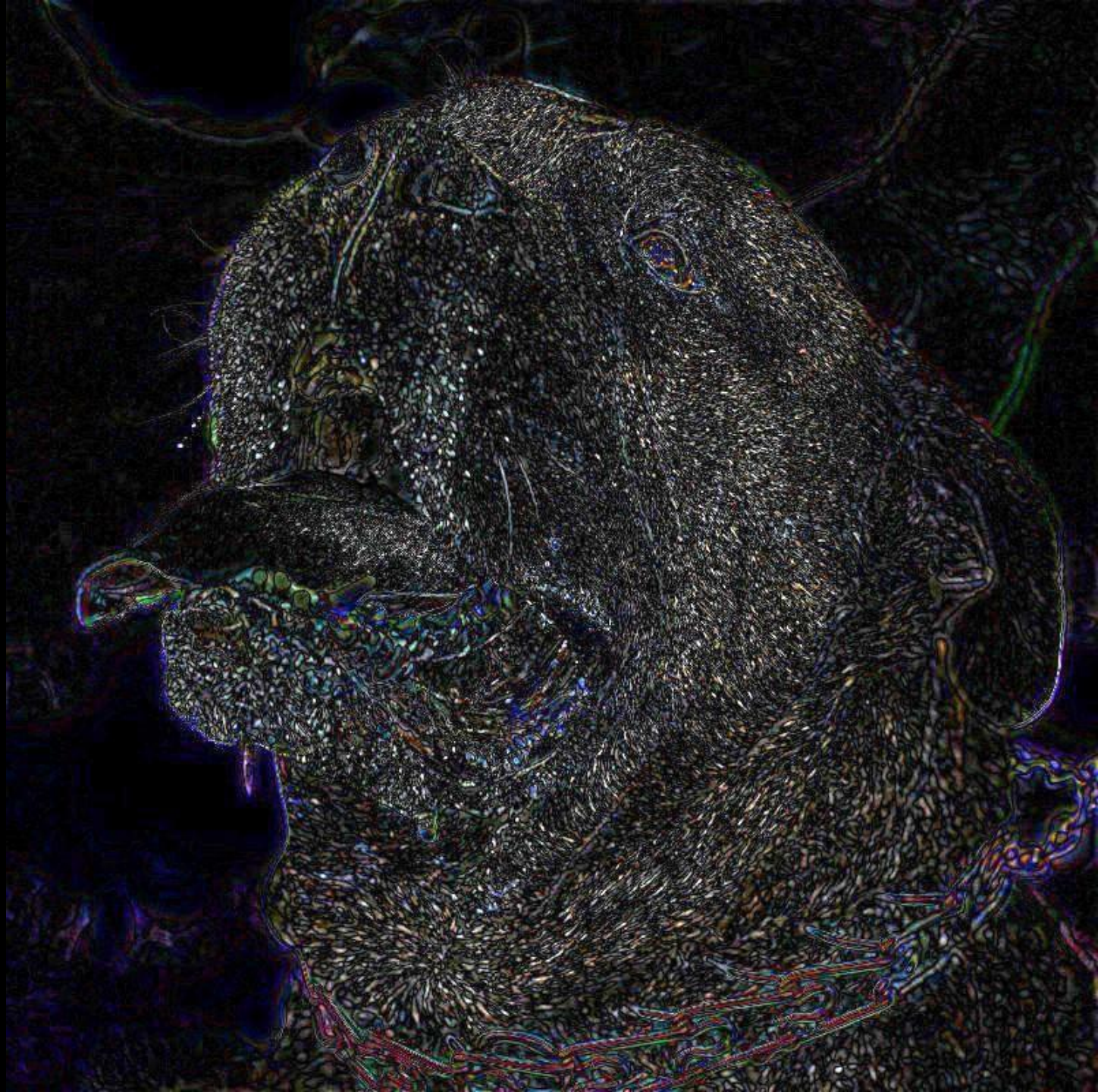
NLMeans Coarse



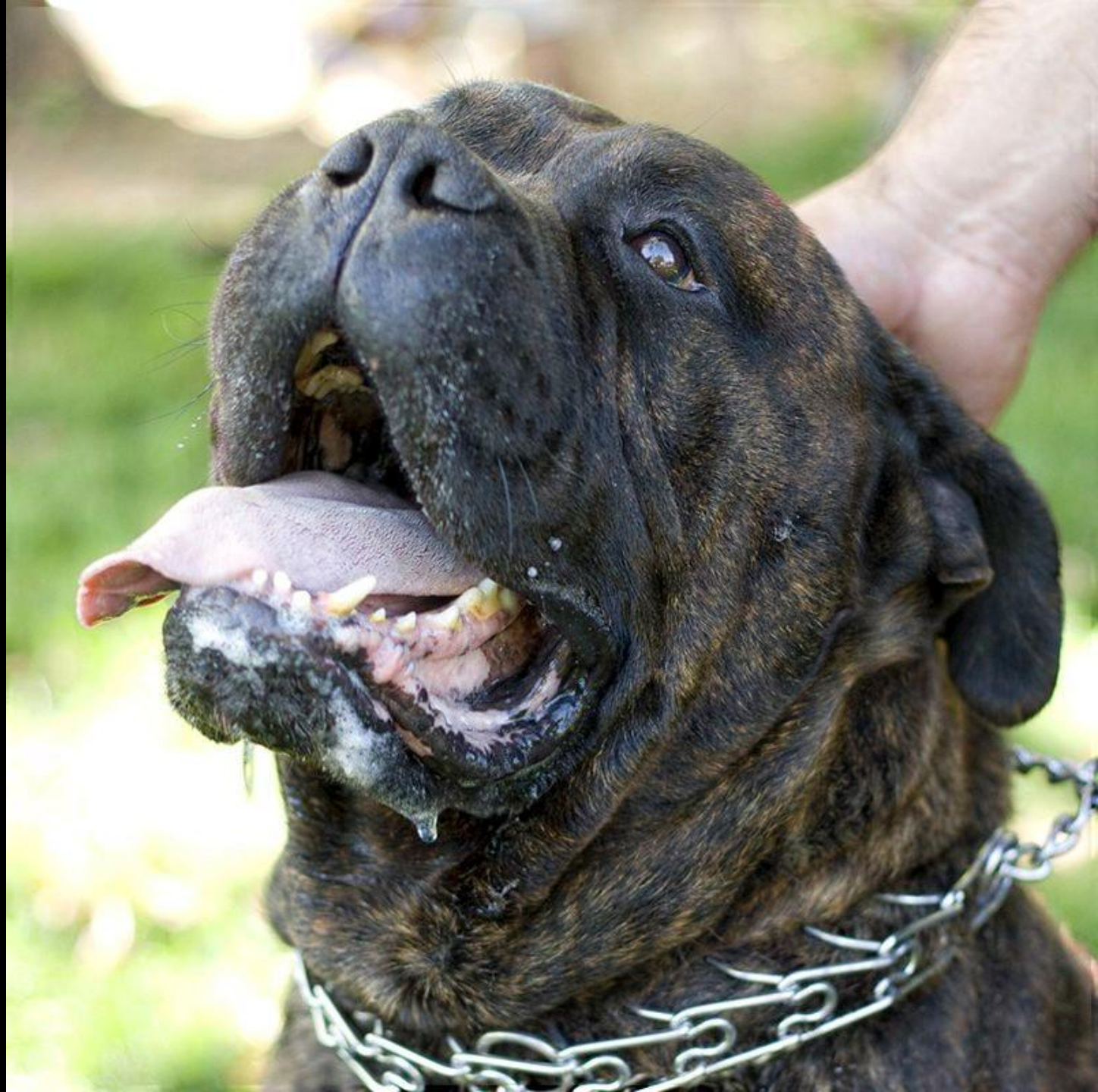
NLMeans
Fine x 8



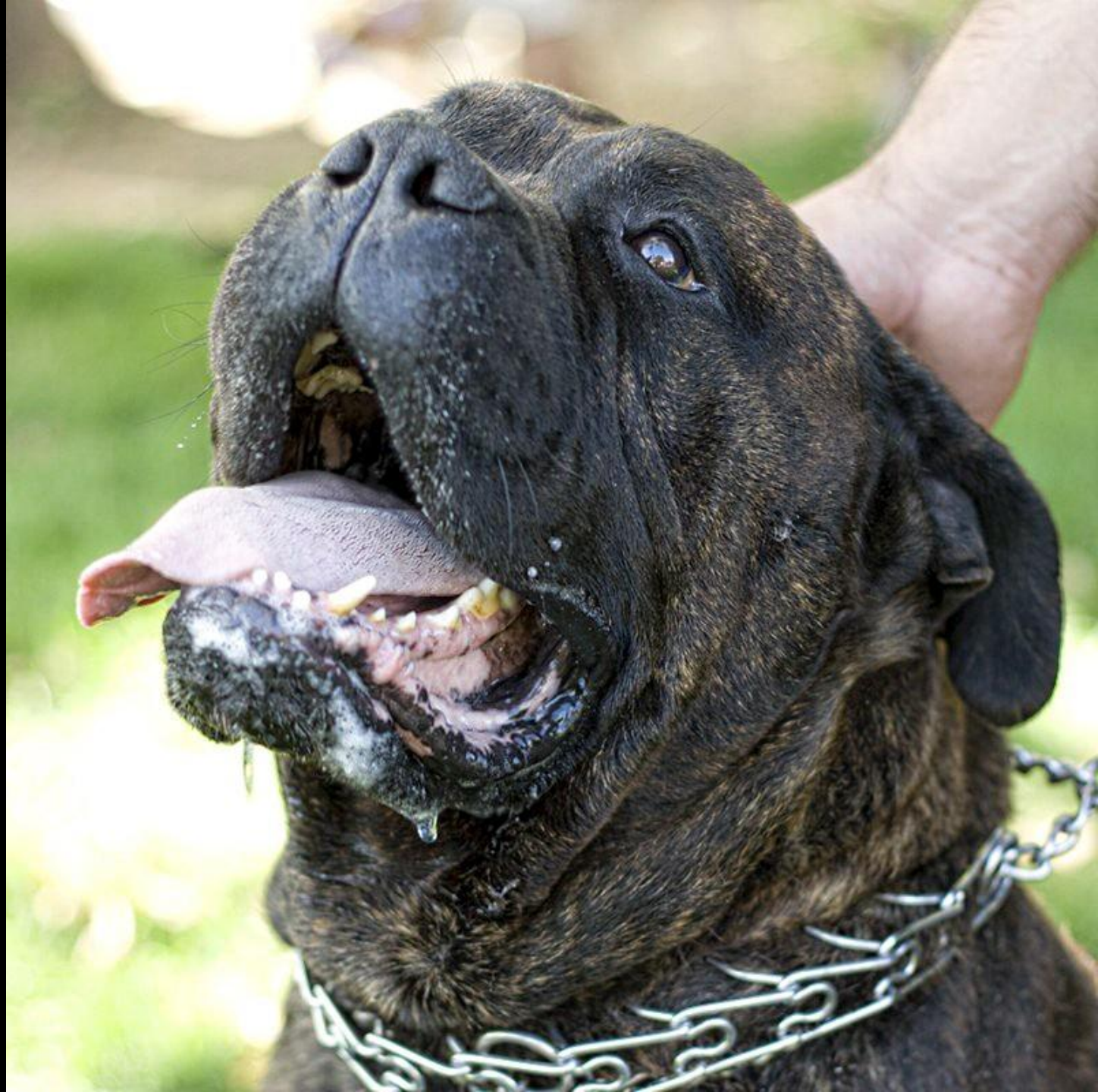
Bilateral
Fine x 8



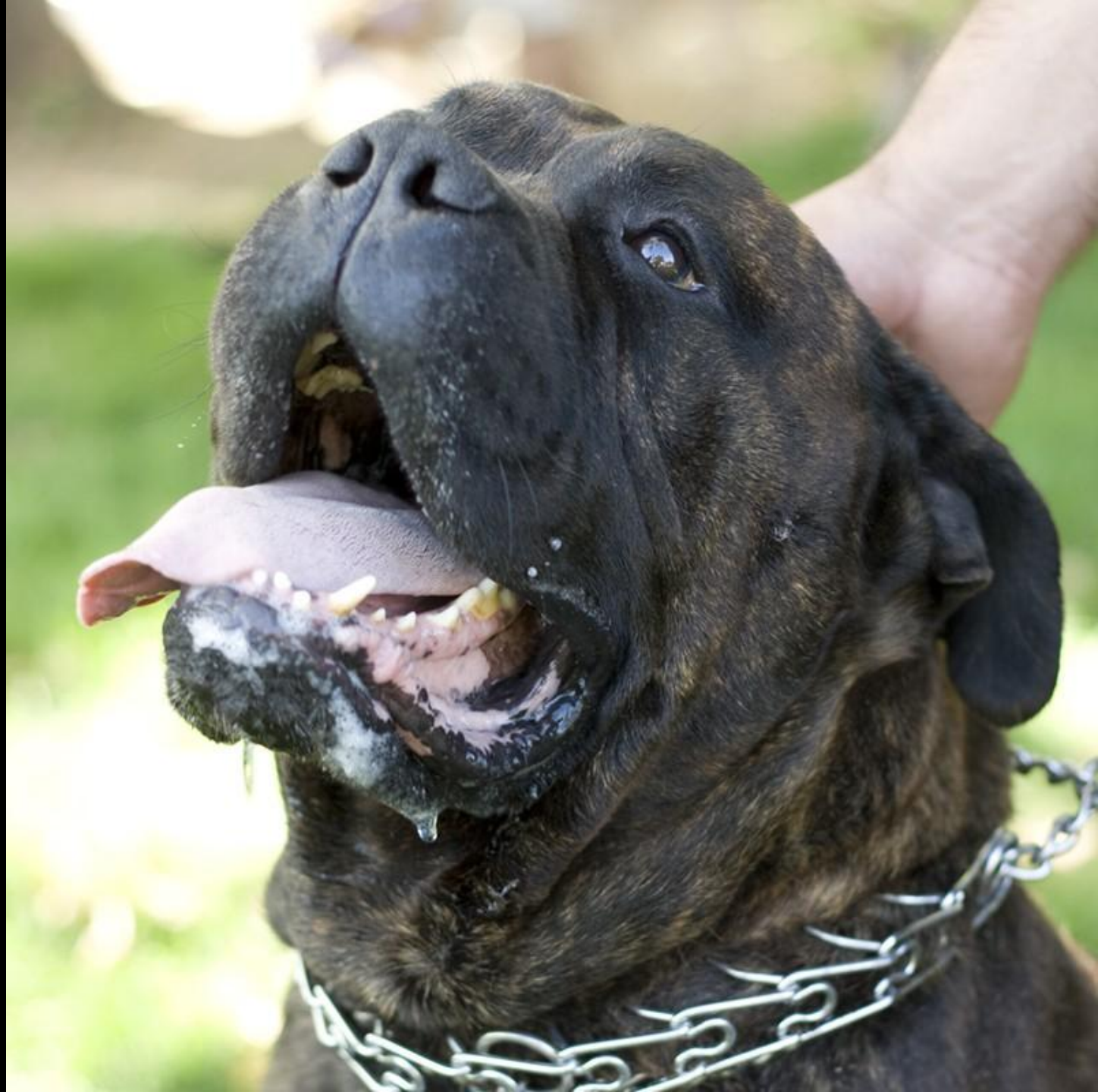
NLMeans Result



Bilateral Result



Input

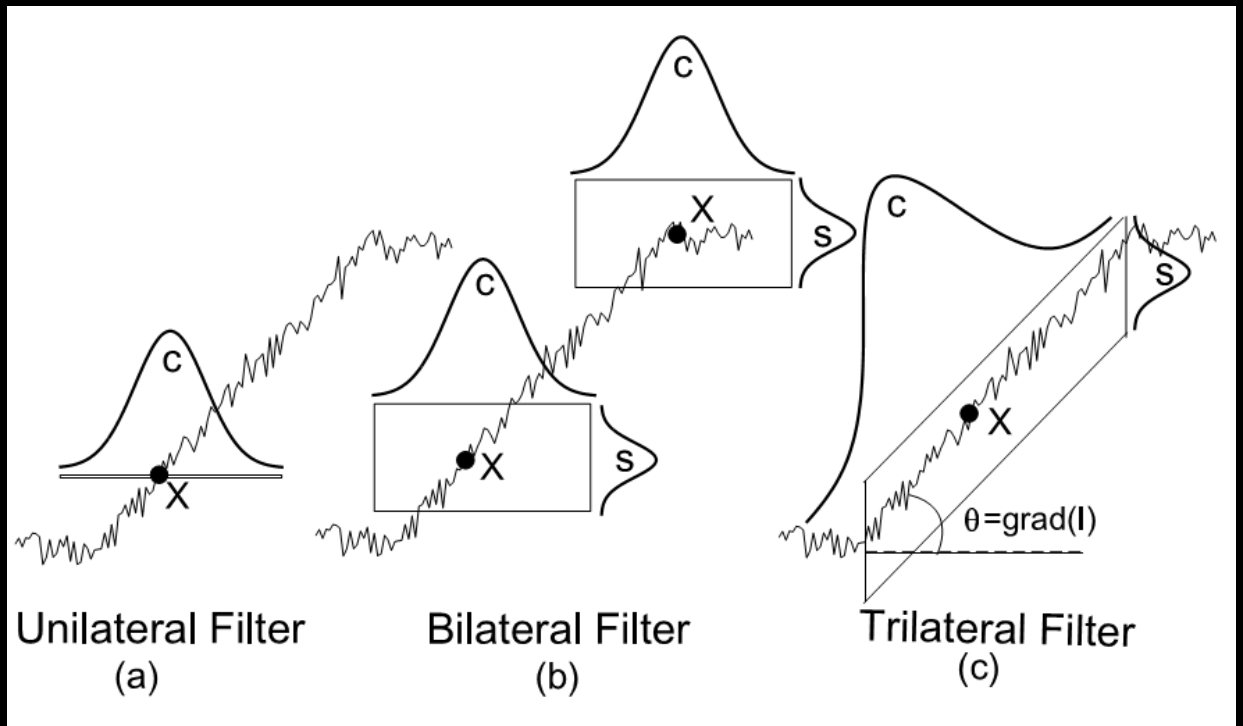


Remember...

- None of this is useful if we can’t make it go fast

Other Techniques

- Everyone wants to best the bilateral filter
- Two notable papers to look at:
  - The Trilateral filter (Tumblin et al, EGSR 2003)



Other Techniques

- Edge Preserving Decompositions for Multi-Scale Tone and Detail Manipulation:
  - Farbman et al, SIGGRAPH 2008