Cartoonification of Images using Flow-Based Techniques

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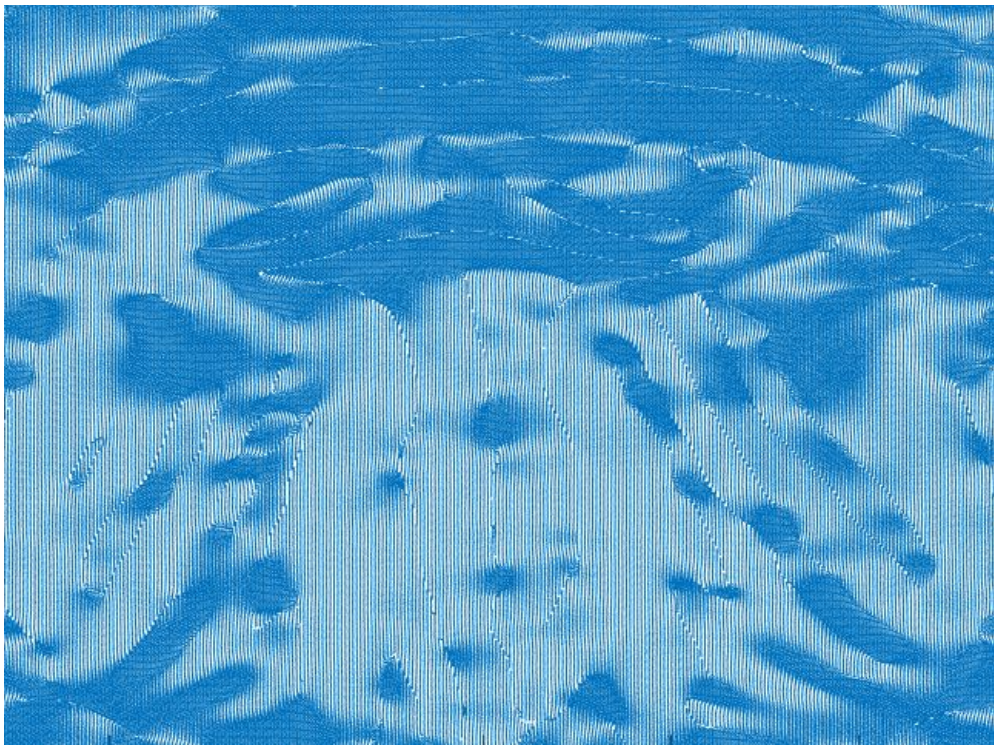
Details of Processing:

1. **Flow Construction:** The second paper [KLC] considers a novel approach to edge extraction based on flow construction. The details are as follows:
    a. Edge Tangent Flows (ETF) - Edge tangents **t** are generated perpendicular to the image gradient.
    b. In the paper, this has been formulated as an ETF construction filter. Iterative application of this filter is done to smoothen the flows. The paper suggests an optimized algorithm for this purpose.

    Below is the ETF calculation for the Baboon image. We can see the eyes and its snout



2. **Line Extraction:**
    a. The ETF computed above gives us the local tangent direction. We then apply a DoG filter along the edges. Once a particular cutoff is reached along the flow we may declare the flow to be an edge.
    b. This can be viewed intuitively as accumulating evidence for the presence of an edge. Flows that do not qualify are not considered and treated as false positives. This is called an FDoG filter (DoG on flows). This filter also may be applied iteratively.

Baboon image

Various values were tested for the threshold τ between 0.2 and 0.7. For low values of τ, we get weak coherence (disconnected lines). For high values, the number of false positives increase. The quality of output is heavily dependent on the smoothness of ETF flows detected in the first stage. The parameter in the DoG filter ρ also affects the erroneous edges. We varied it between 0.97 and 1.0 as was specified in the paper to obtain optimal results.

Kodak Image - House (ρ = 0.987, τ = 0.7)

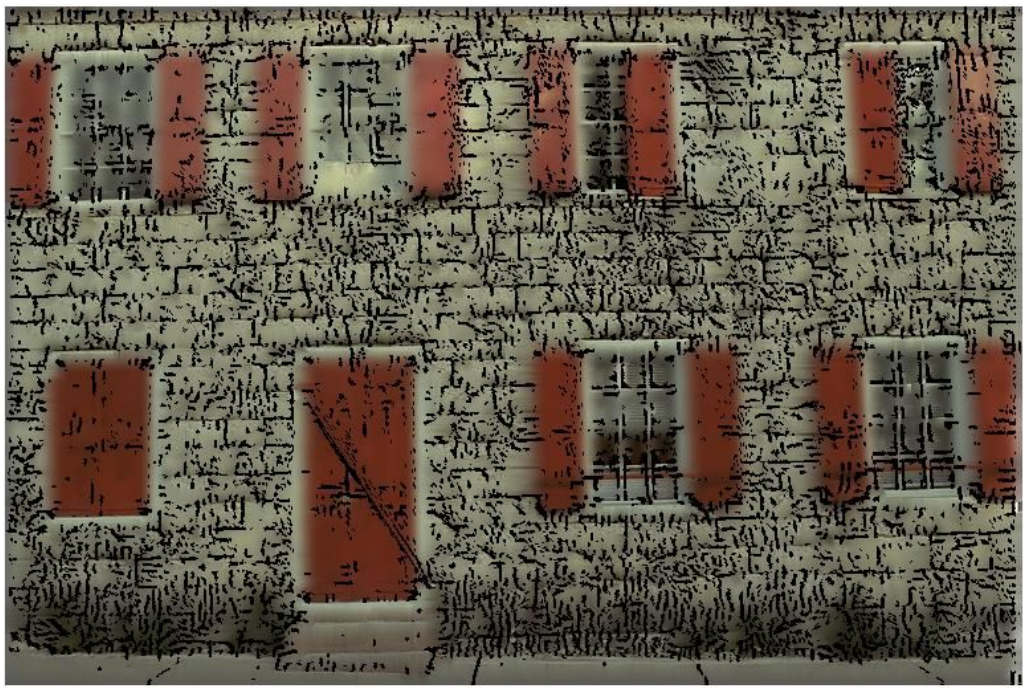
Kodak Image - House (ρ = 0.98, τ = 0.7)

We note that the output is extremely sensitive to the value of ρ. Increasing ρ increases noise but also increases detail.

We realised that the code still suffers from broken extracted lines. (The sharper the image edges, the better is the ETF extracted and hence we get a better line extraction.)

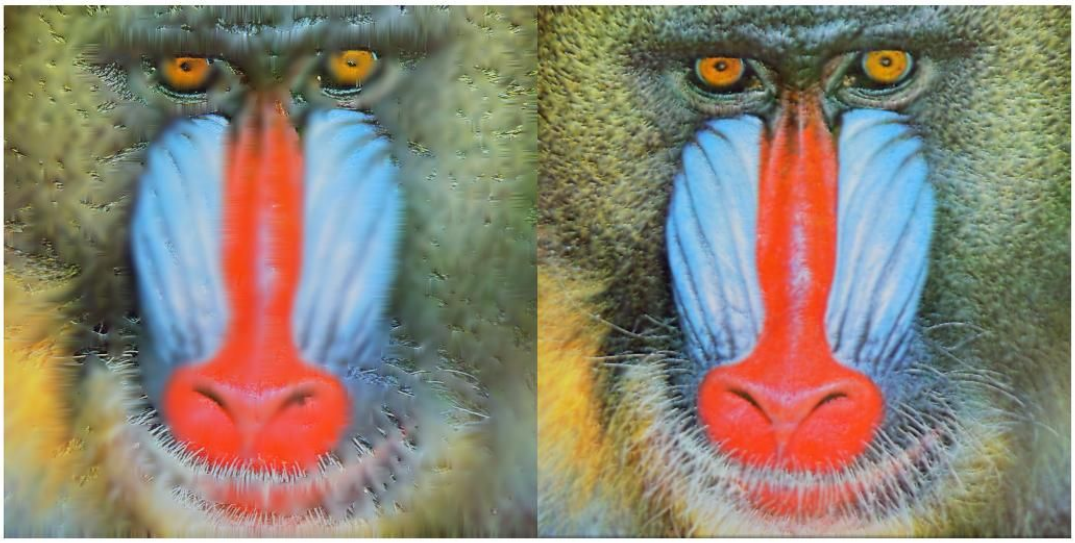
3. **Region Smoothing:**
    a. We use a flow-based bilateral filter using oriented/anisotropic spatial kernel. It consists of two bilateral filters which filter along the edge and gradient.
    b. The gradient filter smoothes out the colour within a region, while the edge filter preserves its shape boundaries. This helps preserve subtle but meaningful features and does not smoothen it indiscriminately.

The values for sigma spacial is 5 along ETF and 2 perpendicular to it.
The values for intensity sigma is 50 along ETF and 10 perpendicular to it.

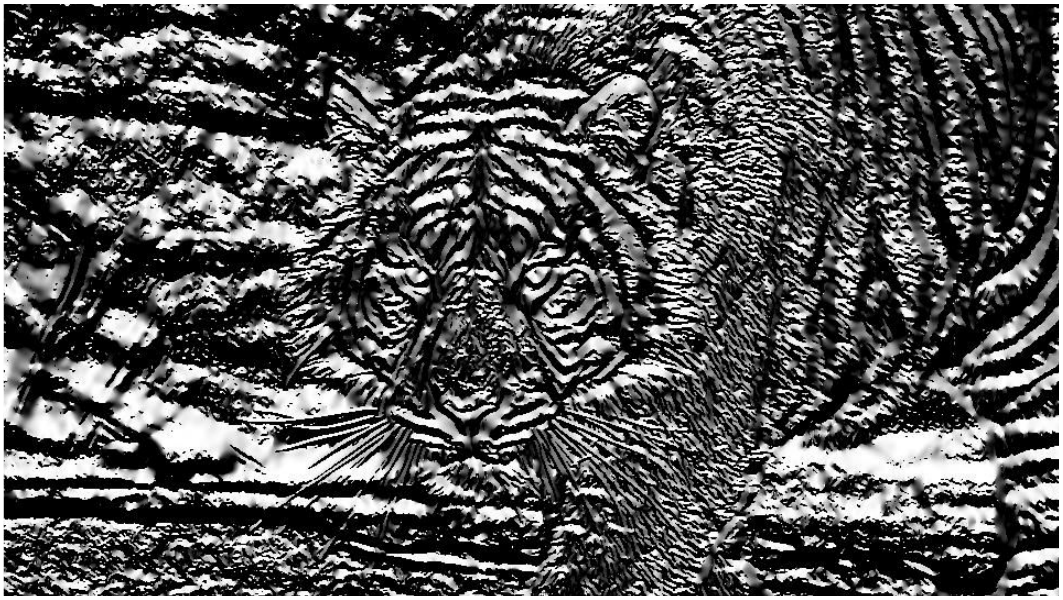


1. The effects of change in line extraction parameter. The same parameters do not work for all the images and a lot of tuning is required.

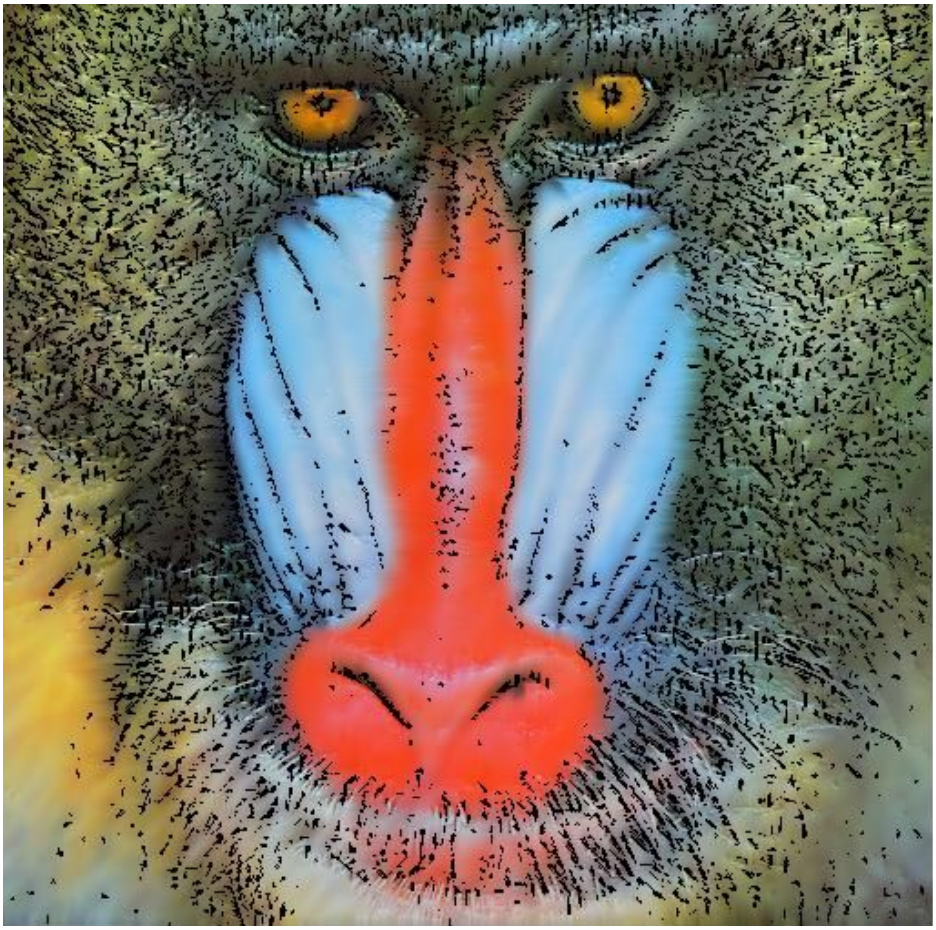
2. To smoothen our results and remove patchiness we had also tried resizing the images and then again compressing it. The results were the same as if the sigmas for the spatial and the intensity parameters were reduced. The right side image is the one with resizing. We can see that not much changes have occurred.



3. In many images, the line extraction was not effective.



Line extraction for tiger



Bibliography :

Papers to take motivation from/be implemented:
[D] https://stacks.stanford.edu/file/druid:yt916dh6570/Dade_Toonify.pdf
[KLC] http://www.cs.umsl.edu/~kang/Papers/kang_tvcg09.pdf