Toonification

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NONPHOTOREALISTIC RENDERING

- Involves abstraction and stylization of the target scene, which helps simplify the visual cues and convey certain aspects of the scene more effectively
- With the rising popularity of simple and fun photo effects on the rise, toonification aims to connect the users (having the means to acquire images) with the computational power to perform a sophisticated process (known as cel shading in the computer graphics world) on these images

PROBLEM STATEMENT

The task of image abstraction involves the following major subproblems:

- **Line Extraction:** Capture and display significant height discontinuities. Two algorithms (Marr-Hildreth algorithm and Canny Edge Detection) have been used for comparative study.
- **Region Smoothing:** Remove all insignificant height discontinuities. The use of mean shift algorithm has been made, after which colour quantization has been used (reducing the number of shades).

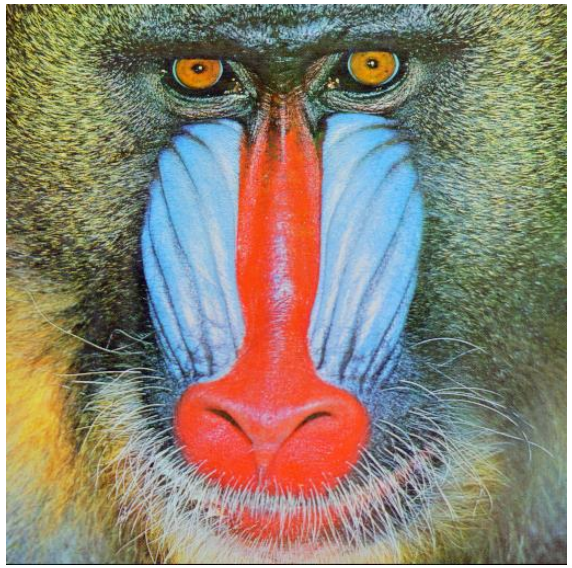
LINE EXTRACTION

- Line extraction (or edge detection) can be performed by numerous methods. The two methods which we will be using in this project will be the Marr-Hildreth Algorithm (which uses DoG as the underlying principle) and the Canny Edge Detection
- Each of the methods are implemented separately and then the performances are evaluated separately
- Since the pictures that we are working with are coloured images, we use the YCbCr space, and apply the edge-detection algorithm to the Y-component of the image.
- For each algorithm, we have shown two results with two different threshold values (the left threshold value is lower than the right one (so the left images generally will have higher number of edges than the right one)).

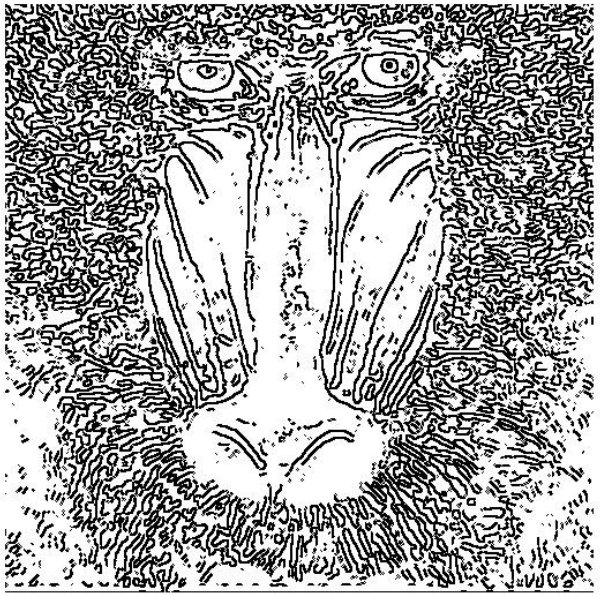
Marr-Hildreth Algorithm

Line Extracted Image

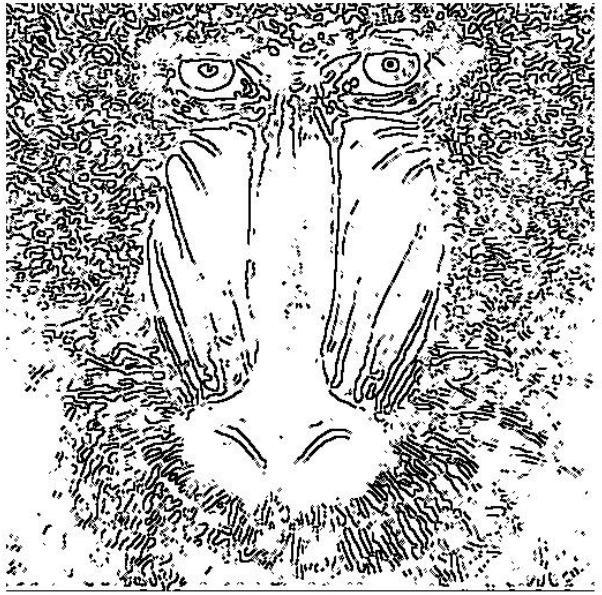
Line Extracted Image



Line Extracted Image



Line Extracted Image



Canny Edge Detection

Line Extracted Image

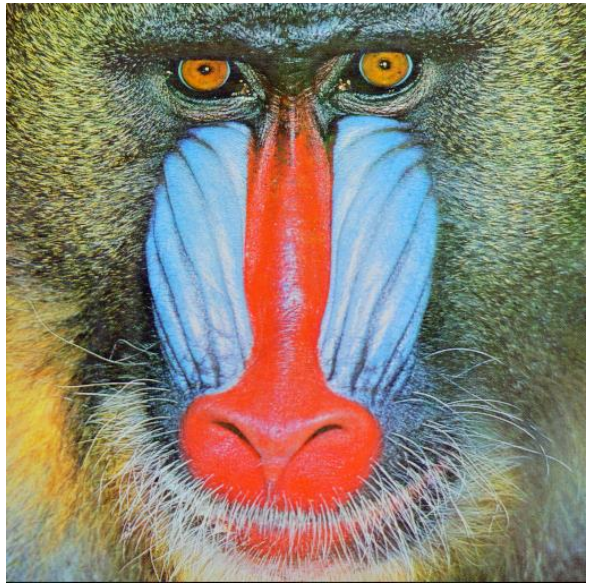
Line Extracted Image

Line Extracted Image

Line Extracted Image

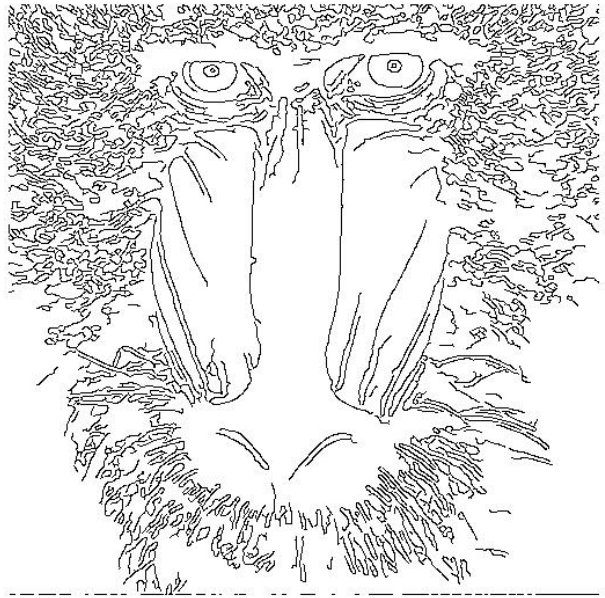
Line Extracted Image

Line Extracted Image



Line Extracted Image

Line Extracted Image



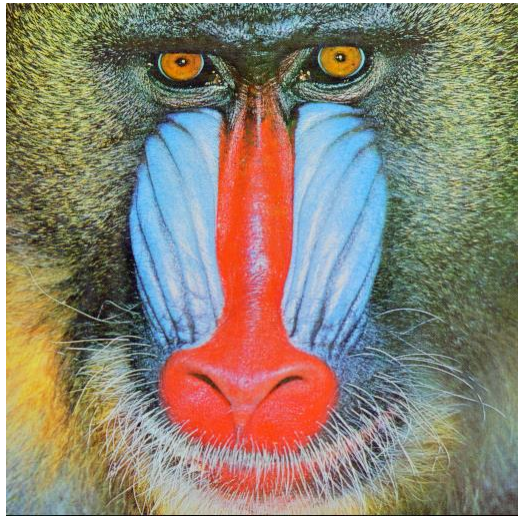
Mean Shift Segmentation and Colour Quantization

- To produce the cartoon effects, a technique known as cel-shading is used, which involves quantization of colour shades.
- For this we use mean-shift segmentation followed by the quantization of color shades (by the use of a floor function).
- The results of this are found to be fairly suitable for the application and these have been summarized on the next slide.

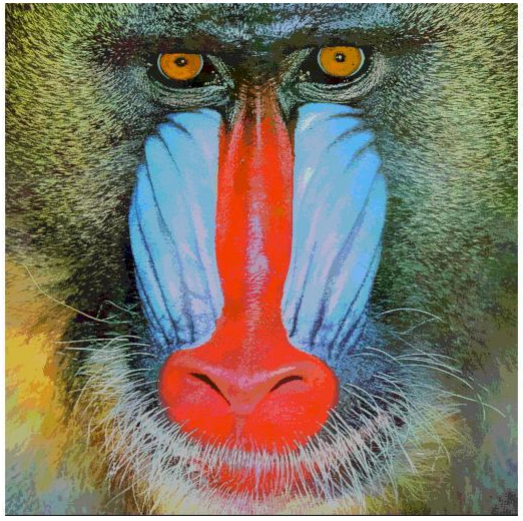
Region Smoothing

Region Smoothing

Region Smoothing



Region Smoothing



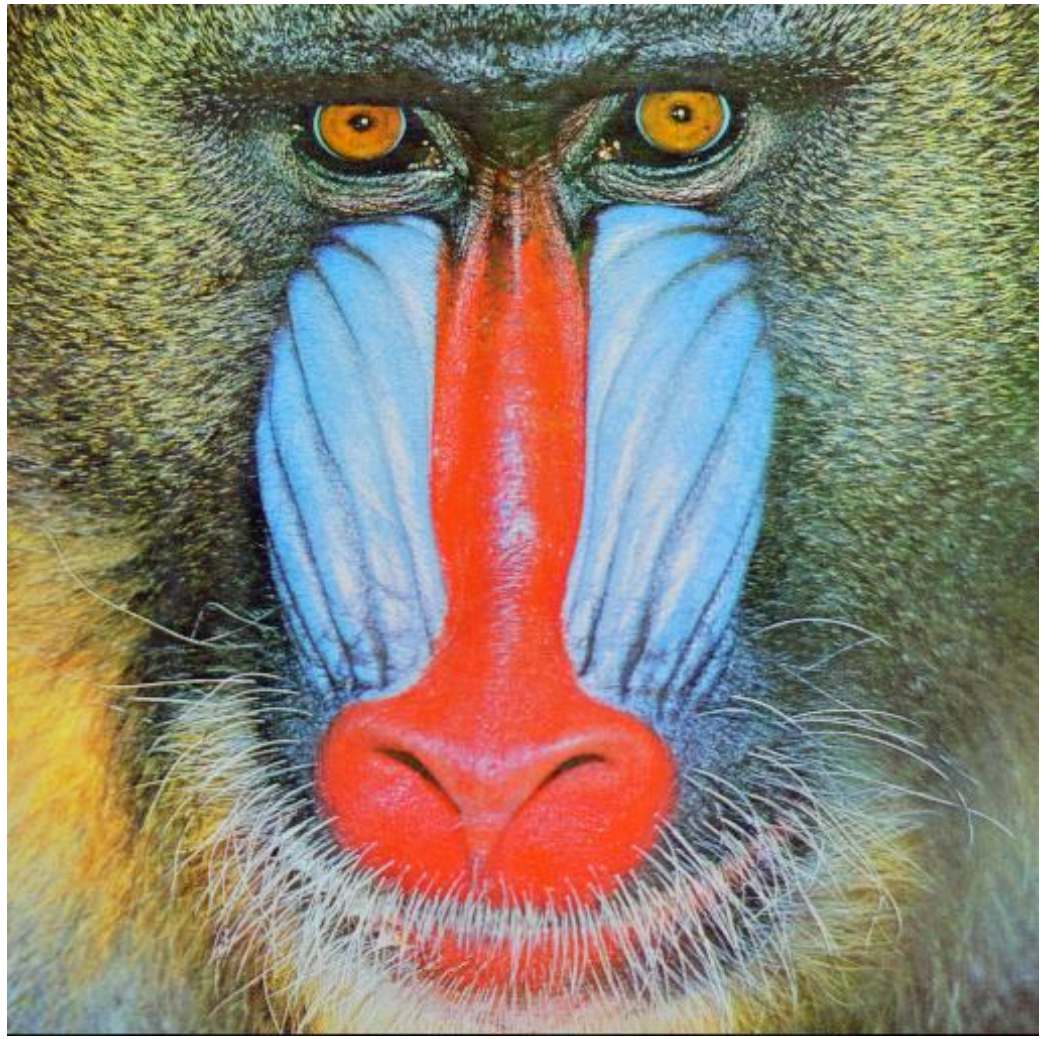
FINAL STEP

- For the completion of the toonification process, we take the line extracted images and superpose them over the region smoothed images to simulate the cartoon effect.
- This has been demonstrated on the next slide (the first set of images are using the Marr-Hildreth algorithm for edge detection and the latter set of images are using the Canny Edge Detection).

Toonified Image

Toonified Image

Toonified Image

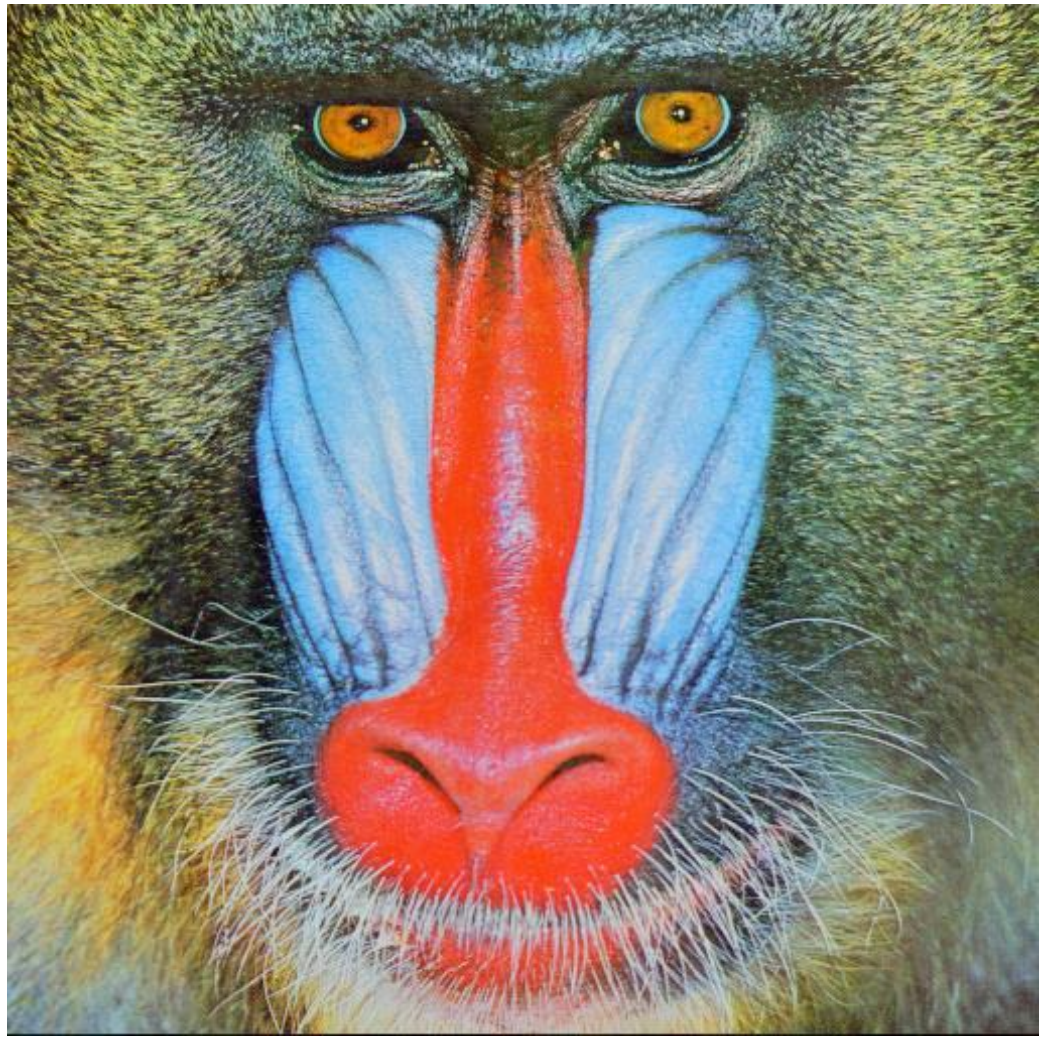


Toonified Image

Toonified Image

Toonified Image

Toonified Image



Toonified Image

ISSUES

- This technique may not always work well with the portrait pictures of people (the edge detector detects fine texture in people’s faces and sometimes does not detect major edges due to the brightness of the background)
- Often the results with portrait images have unnecessarily large amount of edges which are not required (generally caused by the fine textures present in the facial area) as well major edges are missing
- These results have been demonstrated on the next slide

Toonified Image

Toonified Image

Toonified Image

Toonified Image

THE WAY FORWARD

- A technique called the Edge Tangent Flow can be used for better results in the field of toonification
- This results uses the computation of a vector field (which is called the flow), which is basically perpendicular to the gradient at every point in the image (this is basically the direction of the edge in the image)
- The edge tangent flow can be visualised using any of the numerous techniques which are used to visualise vector fields
- The code for computation of the edge tangent flow has been written

EDGE TANGENT FLOW

- The following formula is used for the computation of Edge Tangent Flow Vector

$$\mathbf{t}'(\mathbf{x}) = \frac{1}{k}\iint_{\Omega_\mu} \phi(\mathbf{x},\mathbf{y})\mathbf{t}(\mathbf{y})w_s(\mathbf{x},\mathbf{y})w_m(\mathbf{x},\mathbf{y})w_d(\mathbf{x},\mathbf{y})d\mathbf{y}$$

where

$$w_s(\mathbf{x},\mathbf{y}) = \begin{cases} 1 & \text{if } \|\mathbf{x}-\mathbf{y}\| < \mu, \\ 0 & \text{otherwise.} \end{cases}$$

$$w_m(\mathbf{x},\mathbf{y}) = [\hat{g}(\mathbf{y}) - \hat{g}(\mathbf{x}) + 1]/2$$

$$\phi(\mathbf{x},\mathbf{y}) = \begin{cases} 1 & \text{if } \mathbf{t}(\mathbf{x})\cdot\mathbf{t}(\mathbf{y}) > 0, \\ -1 & \text{otherwise.} \end{cases}$$

$$w_d(\mathbf{x},\mathbf{y}) = |\mathbf{t}(\mathbf{x})\cdot\mathbf{t}(\mathbf{y})|$$

FURTHER ALGORITHM

- Once the edge tangent flow has been computed, we take ‘m’ number of points in the direction of edge tangent flow on either side of the pixel in consideration.
- On each of these points in consideration, take ‘n’ points in the direction perpendicular to the edge tangent flow vector (direction of the gradient vector at that point) and at each of these points, perform a DoG filtering to values at each of the previously chosen ‘m’ points.
- Apply Gaussian filtering to the values at each of these points to get the value at the pixel at which the iteration is happening.

CONCLUSIONS

- As with any algorithm that seeks to meet an aesthetic goal, measuring the success of toonification poses some problems.
- In general, we see that both the Edge Detection algorithms work fairly well given the right parameter tuning.
- Mean Shift Segmentation and quantizing colors work fairly well to simulate the cel-shading effect (removal of the finer textures in the image)
- These two algorithms in conjunction provide the toonification effect that is the aim of the project
- However, sometimes the toonification effect might not work well especially for human faces when the finer textures in the facial region might be seen as false edges
- In these cases, more complex algorithms like the use of edge tangent flow can be applied

References

- http://www.cs.umsl.edu/~kang/Papers/kang_tvcg09.pdf
- https://stacks.stanford.edu/file/druid:yt916dh6570/Dade_Toonify.pdf

Course project

You should upload (1) all code, (2) datasets (unless they are very large or very well known), (3) sample outputs and (4) your report here in the form of a single zip file. You shoul
do this before you come for the viva (to be held after the endsems are over).

Submission status

Submission status	Submitted for grading
Grading status	Graded
Due date	Tuesday, 26 November 2019, 12:00 AM
Time remaining	Assignment was submitted 2 hours 16 mins early
Last modified	Monday, 25 November 2019, 9:43 PM
File submissions	170040043_17D100009_17D070032_Course_Project.zip
Submission comments	▶ Comments (0)