Image Enhancement for Diagnostics in Ophthalmology

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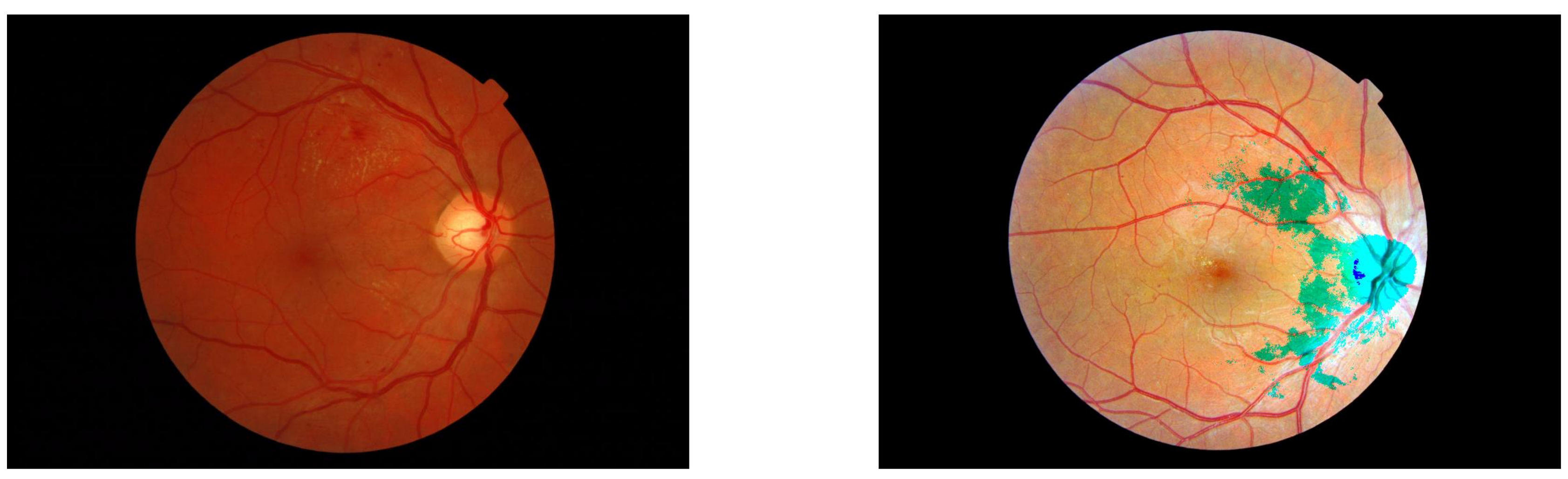
Luminosity and contrast normalization

One of the relevant technique is also methodology discovered by M. Forachio. This method divides retina image to three layers. In the next steps technique uses only green layer (RGB). Here is the first mentioned difference - I used similar calculation for each layer separately and than I merged them into one final image. Correction of luminosity is constructed on the following model, which divided image into background part and foreground part: $I = f(I^*) = f(I^*b + I^*f)$ Where f is transformation function, I*b is background part of the image and I*f is part consisting of foreground pixels. Background does not consist of blood vessels, retinopathy signs and optical disc. Foreground is mostly more contrast area which includes mentioned elements. Model f* describes contrast and luminosity drift. This model can be defined as: $I(x,y) = f(I^*(x,y)) = C(x,y)I^*(x,y) + L(x,y)$ In the model C(x,y) means contrast drift and L(x,y) is luminosity drift. Both of them are independent space vectors and could be implemented as two separate images. Adjustment of the original image can be established on these drift by applying this equation: $\check{I}(x,y) = (I(x,y) - \check{L}(x,y))/\check{C}(x,y)$ In the following step we need to extract background pixels. This is possible because of these three axioms: Both adjustments of luminosity and contrast are constant, more than 50% of image is background and every pixels of background are visible different than pixels of foreground.

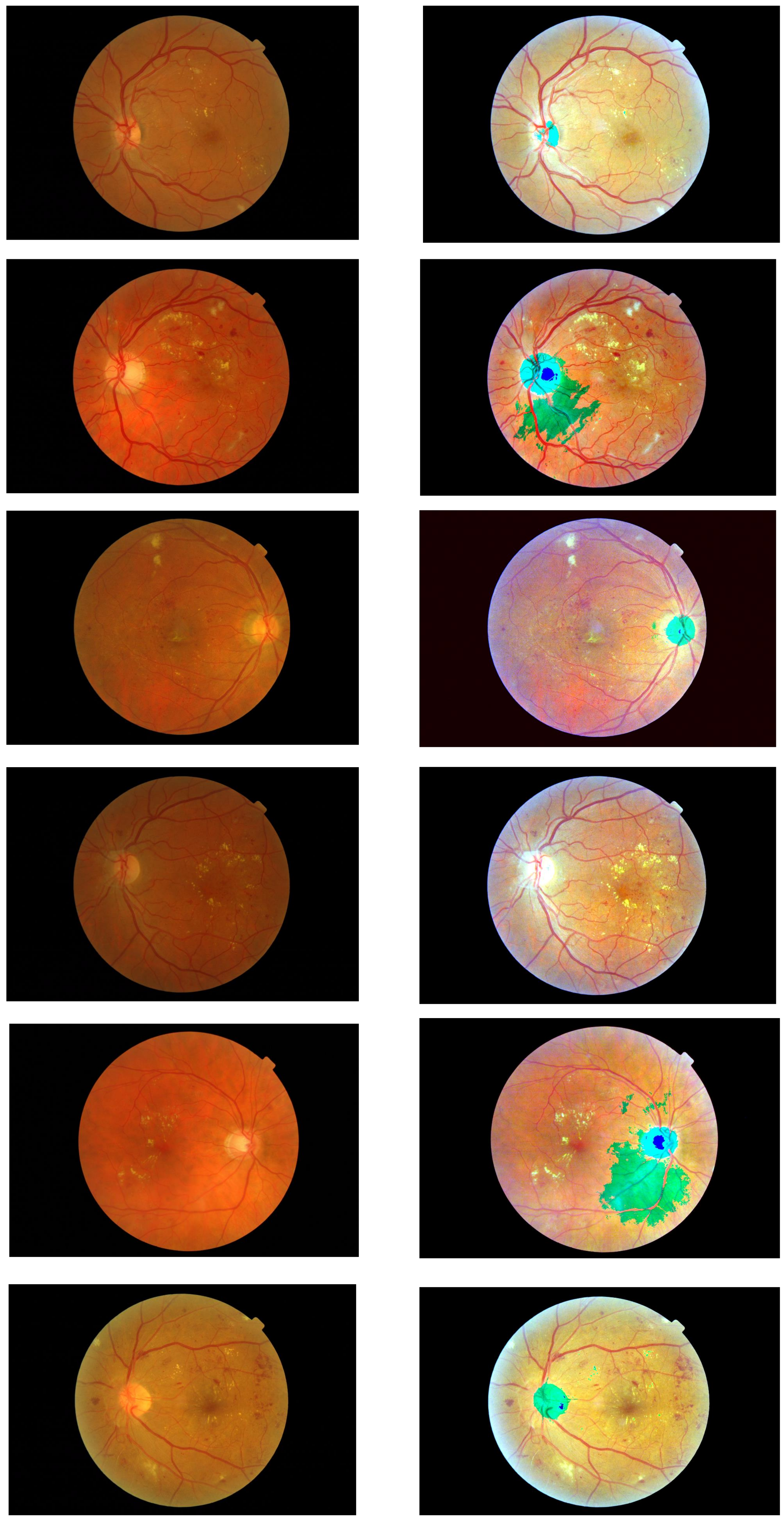
Implementation

I divided image to blocks. M. Forachio (et al) said they divided retina image to 200x200 pixels. For each block are calculated two values: average value and standard deviation of the distribution. Pixel (x,y) is pixel of background if its intensity is near the intensity of the average value of the distribution. Otherwise the pixel (x,y) belongs to foreground. This is mathematically defined by affirmation that the pixel belongs to background if its Mahalanobis distance defined in following equation is lower than threshold defined dynamically. Mentioned equation: $dm = abs((I(x,y) - \check{u}_n)/\check{o}_n)$ Where dm is mentioned Mahalanobis distance, $\check{o}_n$ is standard deviation of the distribution and $\check{u}_n$ is mean value of that distribution. We got two filters ($\check{u}_n$ and $\check{o}_n$). Due to the fact we have separated blocks forming the whole image, we just have sub-sampled filters, which need to be enlarged by applying bicubic interpolation. For the purpose of creation of mask we need to establish these filter only from pixels of background. The resulted image for the calculated layer is obtained by applying following formula using original image (just relevant layer) and enlarged filters: result(j, i) = (start(j, i)-luminosity(j, i))/contrast(j, i) In the next step I calculated two-dimensional matrices of pixels for another two layers. Finally I merged all three calculated layers into a final image.



Original retina image vs. Enhanced retina image

Results



Comparing: Bright pathogenic signs are more visible, but algorithm highlights neural filaments around the blood vessels, which are healthy diagnosis. Bright pathogenic signs are as bright as healthy ambient, which is confusing and harder to find only pathogenic signs. Red pathogenic signs are visibly better, algorithm highlights also the optical disc. This is not the objective, otherwise it does not matter. Unfortunately blue and green pools appear.

Conclusion

Pluses of the algorithm are: red pathogenic lesions are more visible, at some images are bright pathogenic lesions also better visible, macula is more contrastive. Minuses of the algorithm are: some images includes blue, green and turquoise pools, which could hide some relevant pathogenic signs. Also algorithm creates bright ambient over blood vessels. This is the biggest disability. Algorithm should be more elaborated. On the other side, if ophthalmologist has both images (original and recalculated), he/she will be able to make a more accurate diagnosis.