FPGA IMPLEMENTATION OF CMF FOR EMBEDDED PALM BIOMETRIC SYSTEM

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Introduction

In this work we demonstrate how to implement Complex Matched Filter (CMF) in FPGA based systems for real-time palmprint and palm vein image processing. CMF first was introduced in [1] and intended for palm vein extraction from noisy images. This filtering approach is based on matched filtering with rotated line extraction kernels and CMF requires less computational resources and it obtains additional angular information about the extracted biometric features. This information is valuable in the feature description and recognition process.

However, this filtering approach can also be used in applications where lines, edges and other features has to be extracted.

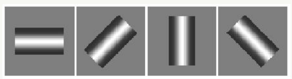
Complex Matched Filtering

CMF is one complex kernel from a larger, generalized complex matched filter (GCMF) bank that can be used for line-like object extraction [2]. **CMF** kernel can be described in polar coordinates by:

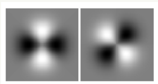
$$M(\rho,\theta) = e^{j2\theta} r(\rho)$$

The right part of equation consists of two multipliers:

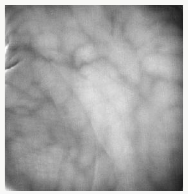
$e^{j2\theta}$ is the angular component (0-360°) of the complex mask; and $r(\rho)$ is the radial component of the complex mask.



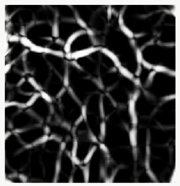
4 rotated Matched filter masks



CMF complex mask



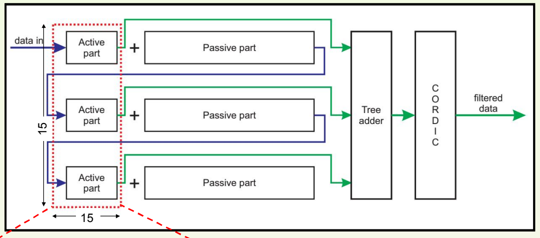
Palm image acquired in infrared light spectrum

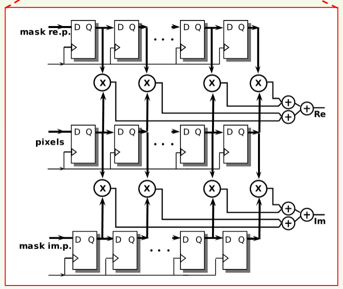


Palm vein image processed with CMF

Implementation

The proposed implementation of CMF consists of modified active parts for pixel multiplication with kernel coefficients and passive parts for pixel storage.



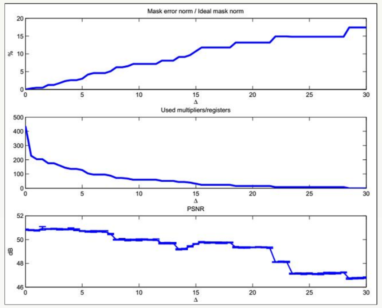


Further, multipliers can be saved by checking the both kernel coefficients for:

- equal values;
- inverse values;
- Zeros;
- 2^n values, which can be substituted by shift operation.

Precision of the filter is defined by the round off interval $\pm\Delta$ and mask parameters (σ *and* r_0).

Δ was changed from 0 (perfect representation of CMF mask) to 28 (most distortion – no multipliers used).



Three different parameters were estimated for each of the Δ value. 1. Mask error in terms of mask error L^2 norm divided to ideal mask L^2 norm; 2. amount of used multipliers; 3. image filtration error in terms of peak signal-to-noise ration (PSNR) for absolute values of matching intensity vectors.

Conclusions

There is a tradeoff between filter precision and the amount of used resources. By using automated mask coefficient round off procedure the amount of used multipliers might be decreased to zero by introducing only 17% of mask error.

The CMF implemented in FPGA system can process images at 30 fps, which is suitable for biometric system development.

This filter can also be used in other applications where line like object extraction is needed. Below is our work-in-progress biometric system with CMF implemented for palm vein and palm print image processing.

References

[1] M.Greitans, M.Pudzs, R.Fuksis. „Object Analysis in Images Using Complex 2d Matched Filters", Proceedings of the IEEE Region 8 Conference EUROCON 2009. Saint–Petersburg, Russia, May, 2009., pp. 1392-1397.

[2] M.Pudzs, M.Greitans, R.Fuksis. "Generalized Complex 2D Matched Filtering for Local Regular Line-Like Feature Detection". 19th European Signal Processing Conference (EUSIPCO 2011), Barcelona, Spain, August 29 - September 2, 2011.

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