Multi-Frame Super Resolution for Ocular Biometrics

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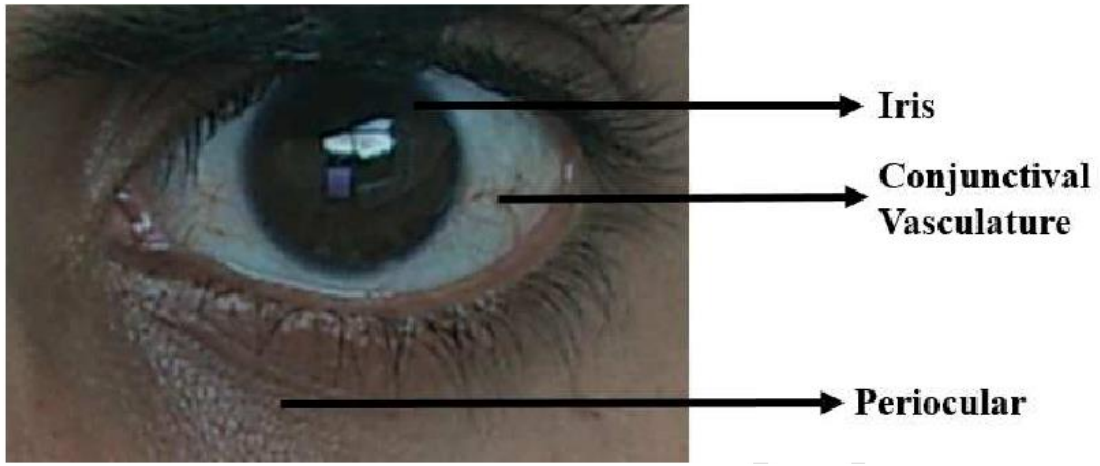
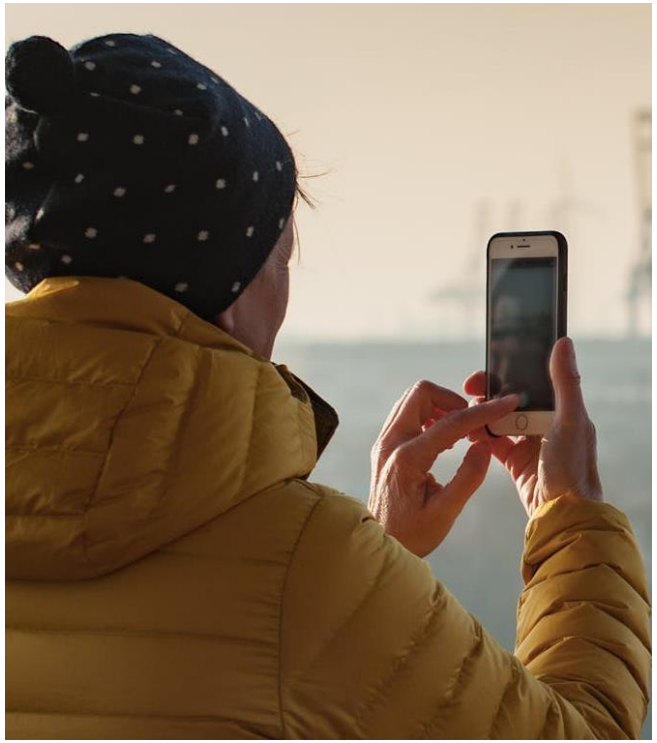
Mobile Ocular Biometrics:

Authenticating a person using traits such as iris, periocular patterns, and conjunctival vasculature.

Visible spectrum mobile ocular biometrics can be captured by taking **selfie** of one's ocular region. Such biometric can be used by itself or in conjunction with other ocular biometrics. However, resolving finer features could be difficul.





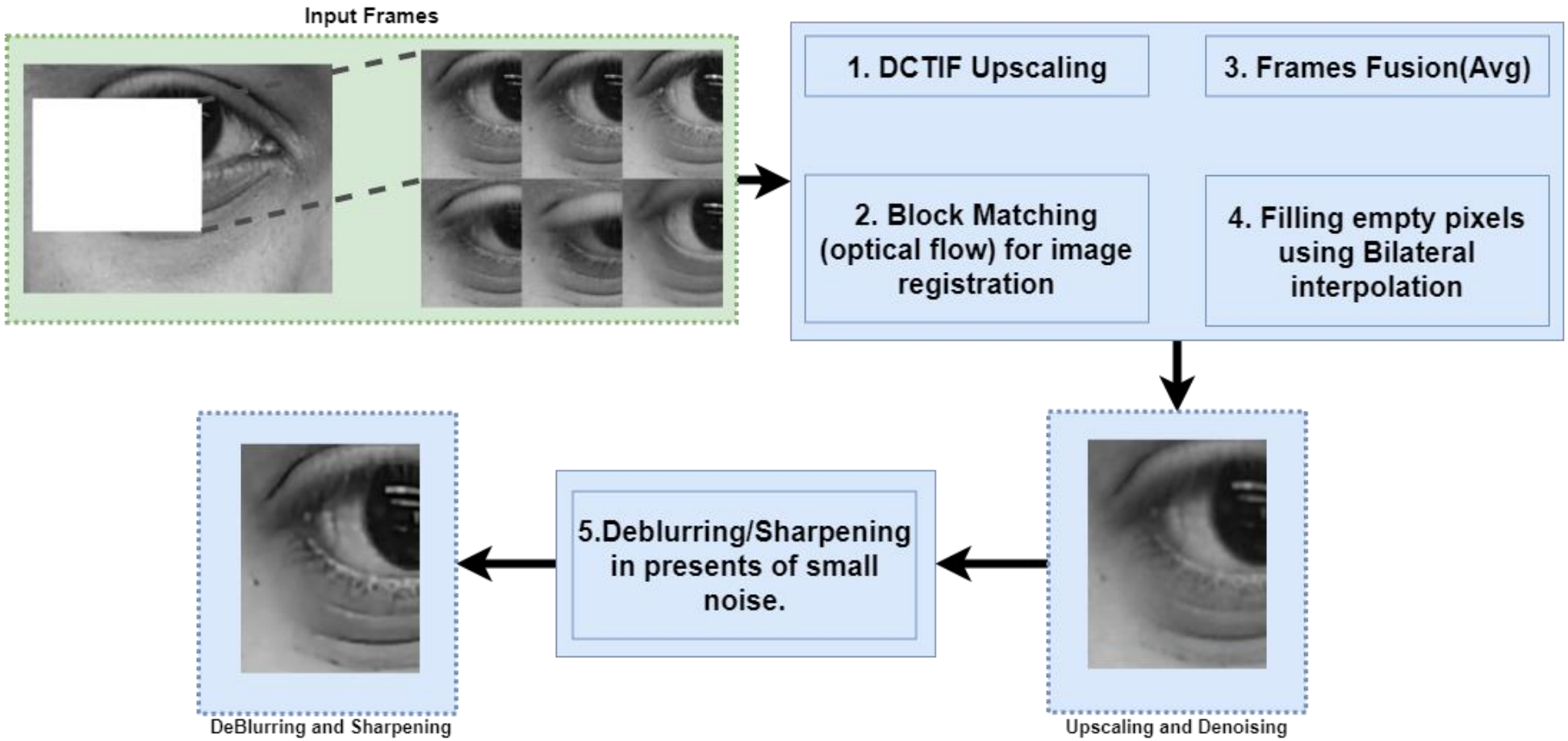
Uncontrolled Environment

Issues: motion and defocus blur, low light/noise, fine vascular and periocular features; combined with subpar front facing cameras.

One solution: Multi-Frame Super Resolution (MFSR).

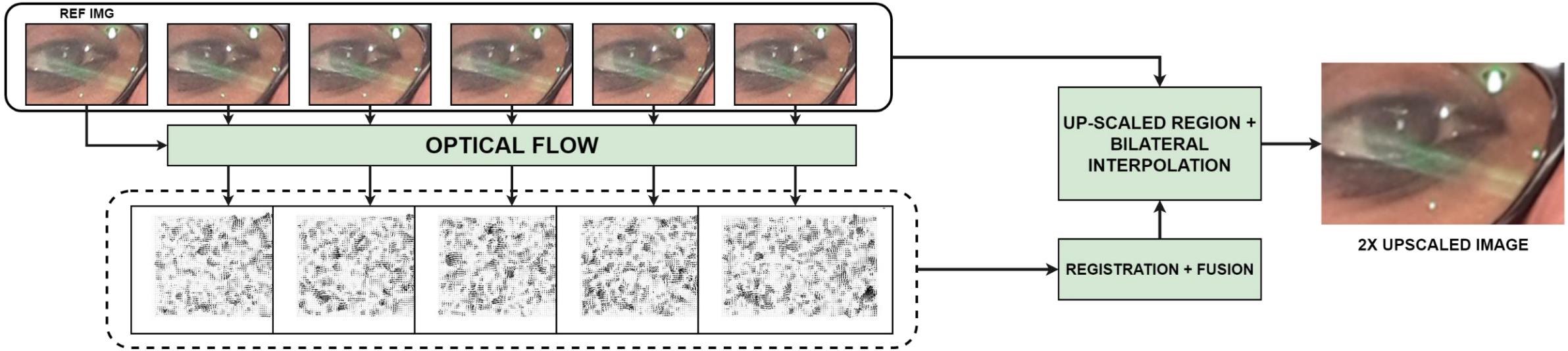
Capturing multiple eye images consecutively using **burst mode** in mobile phones.

Proposed MFSR pipeline



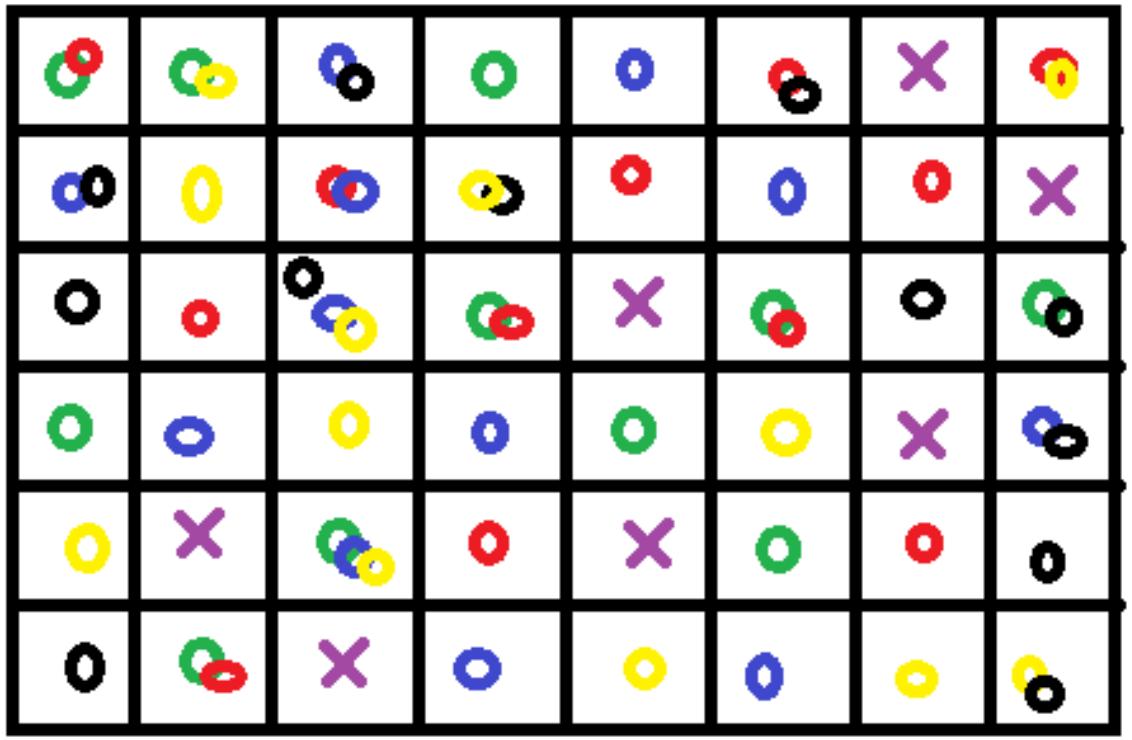
Proposed MFSR Method (cont.)

1. Upscaling:
   - We use discrete cosine transformation interpolation filter(DCTIF) to perform 2X upscaling.
2. Image Registration:
   - Considering first frame as reference, we apply motion block estimation optical flow to predict the reference frame from the next consecutive frames.



Proposed MFSR Method (cont.)

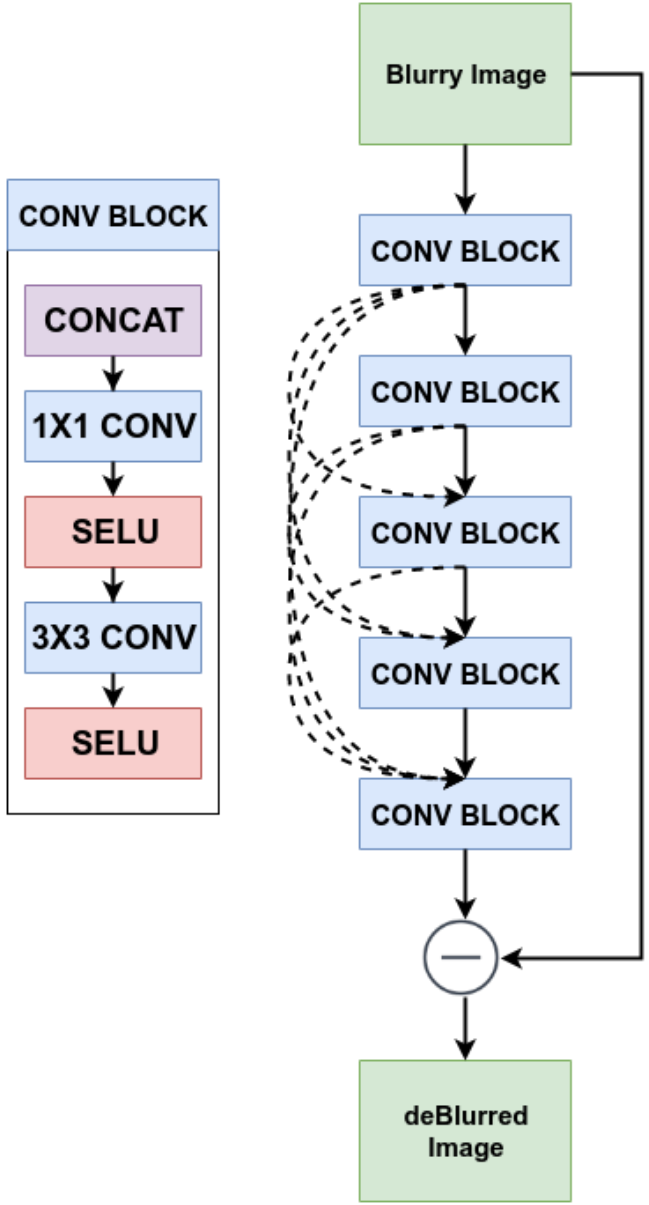
3. Frame Fusion:
   - A simple average is done to fuse the frames.
   - Helps reduce the noise.
4. Bilateral Interpolation:
   - To fill empty pixels after fusion.



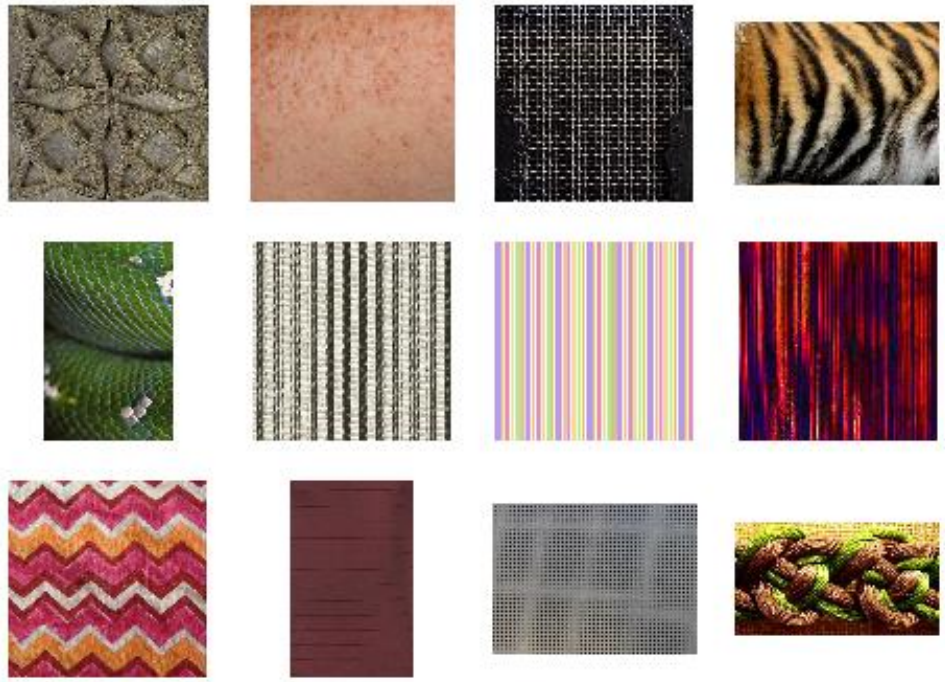
0 – Filled pixels.
0,0… – Overlapped Pixels.
X – Missing Pixels.

Proposed MFSR Method (cont.)

5. Deblurring:
   - DenseNet[*] architecture model with residual image generation.
   - Trained on Describable Textures Dataset(DTD) [*]
   - Augmentation: Gaussian noise 0-10dB, Blur 0-2σ
   - Loss: structural similarity index(SSIM)



Proposed deblurring model



Samples from DTD dataset

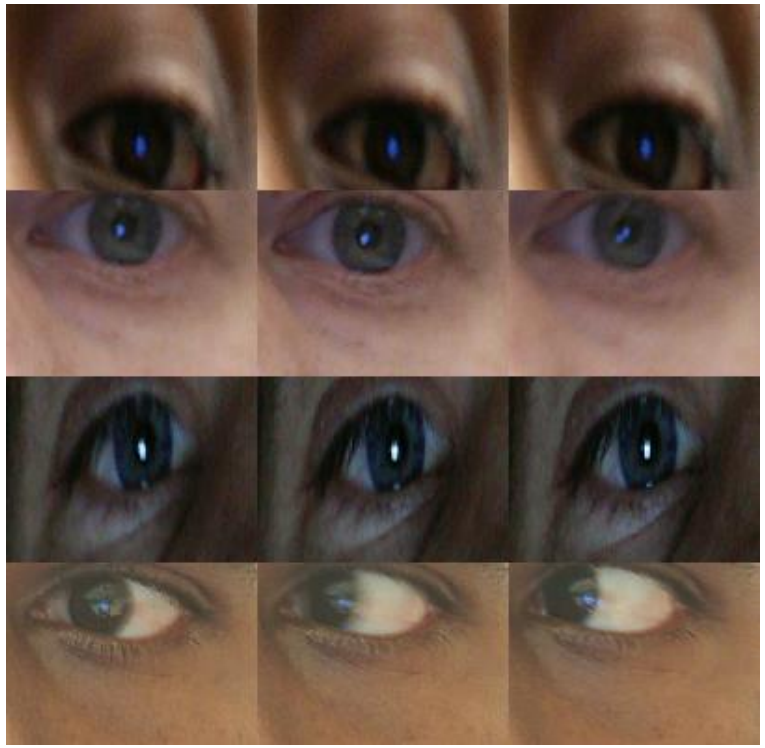
* Huang, Gao, et al. "Densely connected convolutional networks." *Proceedings of the IEEE conference on computer vision and pattern recognition*. Vol. 1. No. 2. 2017.

Testing dataset + methods

- 50 subjects, 6-frame burst (100x135 pixles) test dataset generated from VISOB dataset[*].

Lighting	Enrollment	Verification
Daylight	1461	1323
Dim lighting	1407	1423
Office	1237	1881

Number of samples per lighting condition in test dataset.



Samples from dataset showing the first thee frames.

* Rattani, Ajita, et al. "ICIP 2016 competition on mobile ocular biometric recognition." *Image Processing (ICIP), 2016 IEEE International Conference on*. IEEE, 2016.

Experiments

Comparison:

- Single Image Super Resolution (SISR) methods:
  1. Bicubic Upscaling
  2. SRCNN
  3. VDSR
- Multi-Frame Super Resolution (MFSR) methods:
  1. Bicubic + Averaging
  2. Maximum a Posteriori (MAP)
  3. Iteratively Re-Weighted Maximization Super Resolution (IRWSR)

Biometrics Matcher:

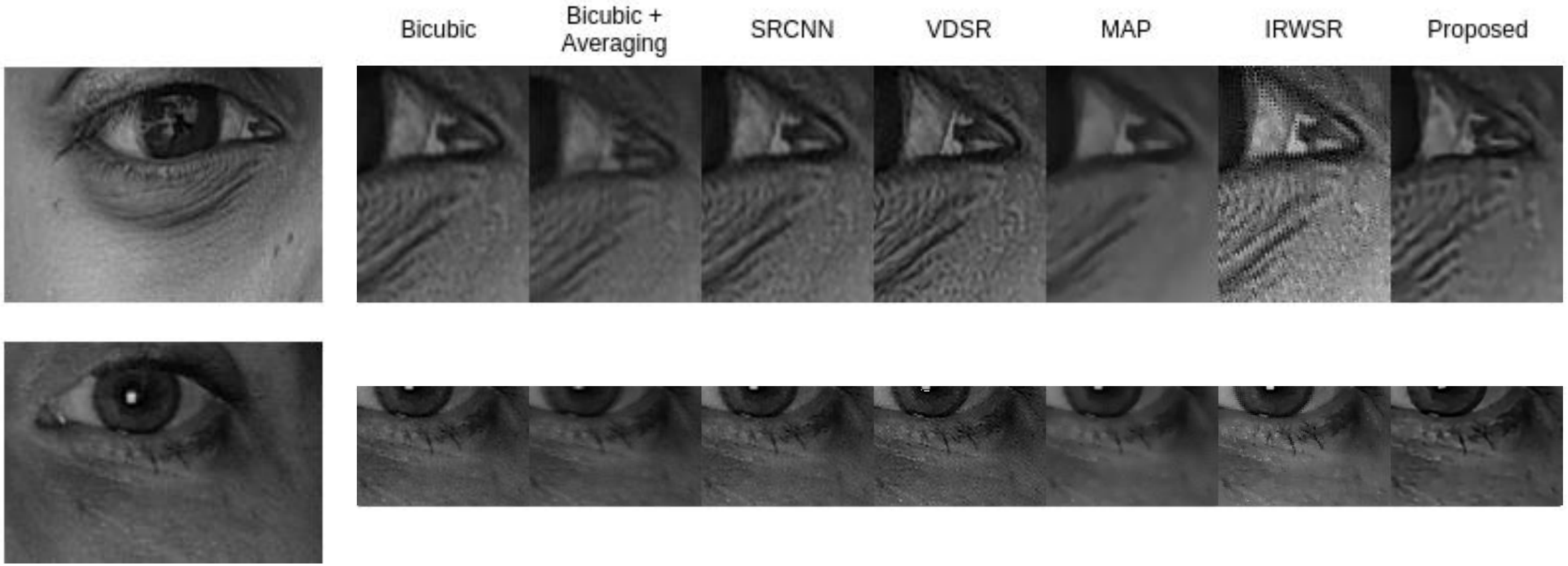
- SURF feature descriptor and point detector.
- Matching pairs using nearest neighbor symmetric match (NNS) criteria.
- RANSAC to remove outliers.
- Single eye match results reported using EER

Hardware:

- CPU: Intel i7 6700K 4.00GHz
- RAM: 32GB
- GPU: GTX 1080Ti
- ALL the experiments are conducted on **CPU only (single threaded)** for better comparison.

Methods	MFSR/SISR	Dim Light (EER%)	Daylight (EER%)	Office (EER%)	Time(Sec.)
IRWSR	MFSR	17.84	17.45	26.03	11.5
Proposed	**MFSR**	**20.79**	**19.54**	**28.06**	**1.34**
MAP	MFSR	21.61	20.20	28.99	1.28
VDSR	SISR	22.13	21.16	31.38	1.56
SRCNN	SISR	22.46	21.59	31.22	0.33
Bicubic + Averaging	MFSR	26.32	23.45	32.02	0.0068
Bicubic	SISR	32.08	29.39	38.83	0.0025

Numerical results



Visual Comparison

Thank You