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 difficult.
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

1. DCTIF Upscaling
2. Block Matching (optical flow) for image registration
3. Frames Fusion(Avg)
4. Filling empty pixels using Bilateral interpolation
5. Deblurring/Sharpening in present of small noise.

Input Frames

Upscaling and Denoising
Deblurring and Sharpening
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.
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.
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)

Testing dataset + methods

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

<table>
<thead>
<tr>
<th>Lighting</th>
<th>Enrollment</th>
<th>Verification</th>
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<tbody>
<tr>
<td>Daylight</td>
<td>1461</td>
<td>1323</td>
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<tr>
<td>Dim lighting</td>
<td>1407</td>
<td>1423</td>
</tr>
<tr>
<td>Office</td>
<td>1237</td>
<td>1881</td>
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</tbody>
</table>

Number of samples per lighting condition in test dataset.

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.
## Numerical results

<table>
<thead>
<tr>
<th>Methods</th>
<th>MFSR/SISR</th>
<th>Dim Light (EER%)</th>
<th>Daylight (EER%)</th>
<th>Office (EER%)</th>
<th>Time (Sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRWSR</td>
<td>MFSR</td>
<td>17.84</td>
<td>17.45</td>
<td>26.03</td>
<td>11.5</td>
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<td><strong>Proposed</strong></td>
<td>MFSR</td>
<td><strong>20.79</strong></td>
<td><strong>19.54</strong></td>
<td><strong>28.06</strong></td>
<td><strong>1.34</strong></td>
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<tr>
<td>MAP</td>
<td>MFSR</td>
<td>21.61</td>
<td>20.20</td>
<td>28.99</td>
<td>1.28</td>
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<tr>
<td>VDSR</td>
<td>SISR</td>
<td>22.13</td>
<td>21.16</td>
<td>31.38</td>
<td>1.56</td>
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<td>SRCNN</td>
<td>SISR</td>
<td>22.46</td>
<td>21.59</td>
<td>31.22</td>
<td>0.33</td>
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<tr>
<td>Bicubic + Averaging</td>
<td>MFSR</td>
<td>26.32</td>
<td>23.45</td>
<td>32.02</td>
<td>0.0068</td>
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<tr>
<td>Bicubic</td>
<td>SISR</td>
<td>32.08</td>
<td>29.39</td>
<td>38.83</td>
<td>0.0025</td>
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</tbody>
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Visual Comparison
Thank You