

Real-time image enhancement in virtual reality applications for low vision people

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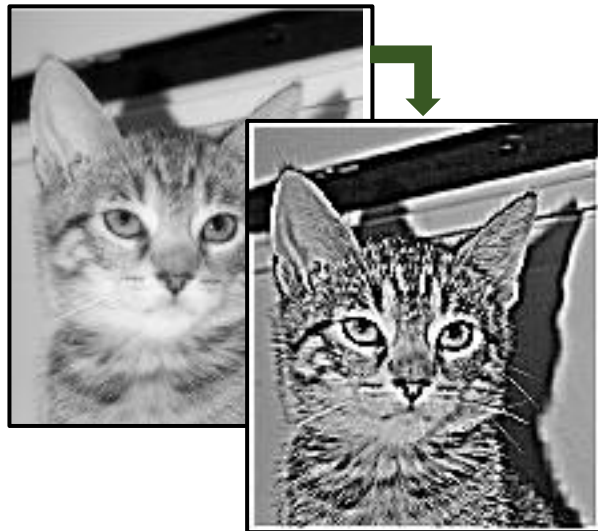
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Maximizing the residual vision of the visually impaired

Moshtael et al., High tech aids low vision: a review of image processing for the visually impaired. *Translational vision science & technology*, 2015

- Recent advances in **digital image processing provide promising methods**



Contrast enhancement



Scene retargeting



Gaze/Head direction contingent display

Maximizing the residual vision of the visually impaired

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- Recent advances in **digital image processing provide promising methods**
- **Improvements of perception** for the visually impaired
- Design efficient methods depends on:
 - The **task**: maximize interpretation of image, video, 3D, text?
 - The **pathology**: central field loss, periphery vision loss, degenerative myopia?
 - The **hardware**: computer screen, tablet or...

Head-mounted displays (HMDs)

- A **high potential** for low vision: Why?
 - Large **field of view**
 - **Easy and comfortable** to use
 - Low cost & high quality



Morton Heilig's Sensorama

1950s → 2017



Man Sitting On Sofa At Home Wearing Virtual Reality Headset

Head-mounted displays (HMDs)

- A **high potential** for low vision: Why?
 - Large **field of view**
 - **Easy and comfortable** to use
 - Low cost & high quality
- **Whole new contents!**
 - Virtual reality TV series and shows
 - Virtual reality games and movies
 - Applications for tourism, arts etc
- How to make them **accessible?**



Maximizing the residual vision of the visually impaired using HMDs

- **State-of-the-art** Ehrlich, Ojeda et al., Am J Ophthalmol, 2017
 - HMDs offer advantages wrt conventional displays, e.g. useful for patients with peripheral vision loss
 - Optical and human-factors considerations are important when selecting HMDs for specific applications and patient groups
- **Problems**
 - Big images, e.g., 2048x2048 pixels
 - Limited computational power in phone-based platforms
- **Today's focus: image enhancement** *Peli and Lim, Optical Engineering (1982)*
 - Evaluated with visually impaired
 - Can we implement it to run in realtime in HMDs?

Peli and Lim (1982) transform

$f(x, y)$



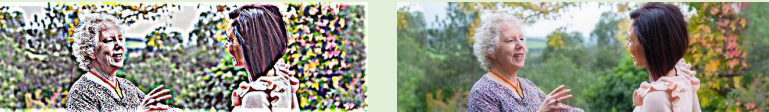
$g(x, y)$



Peli and Lim (1982) transform

- **Equation:**

Output Input


$$g(x, y) = k * (f(x, y) - f_{\text{lowpass}}(x, y)) + \bar{f}_{\text{lowpass}} + n * (f_{\text{lowpass}}(x, y) - \bar{f}_{\text{lowpass}})$$

Scaled high-pass Contrast-adjusted low-pass

- **Parameters:** k , n and *blur spread* for $f_{\text{lowpass}}(x, y)$

Real-time implementation on mobile

- **Goal:**



Samsung Gear VR
Samsung Galaxy S6 smartphone

External controller



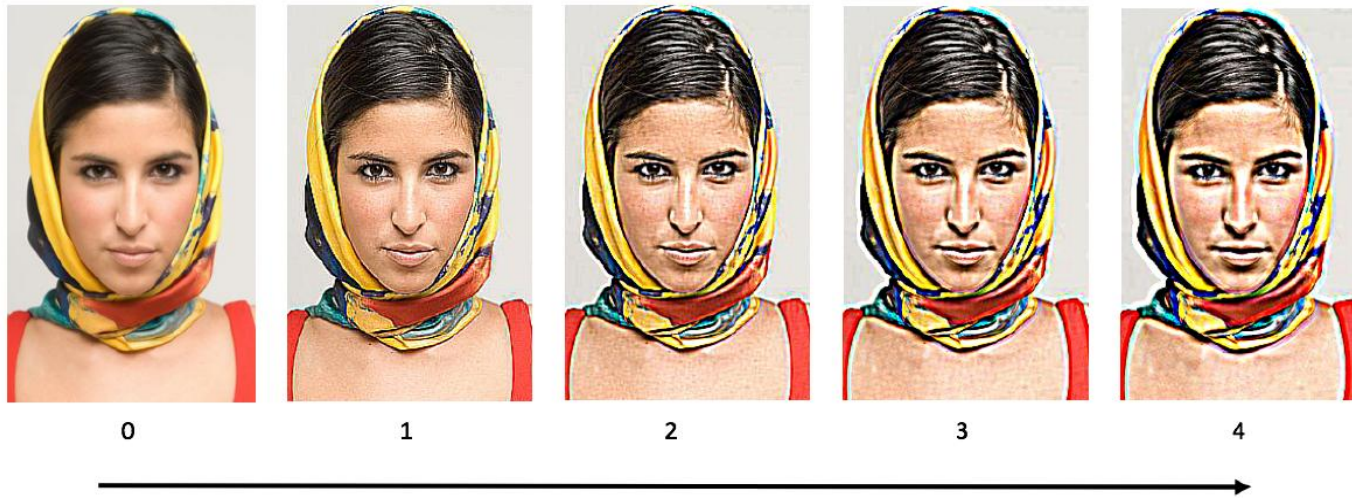
Change blur spread

- **Difficulty:** Cost of estimating $f_{\text{lowpass}}(x, y)$
- Approximation of $f_{\text{lowpass}}(x, y)$ using Unity **shaders**
 - A shader is a set of instructions that perform calculations on the GPU in order to render graphics.

Approximation of $f_{\text{lowpass}}(x, y)$

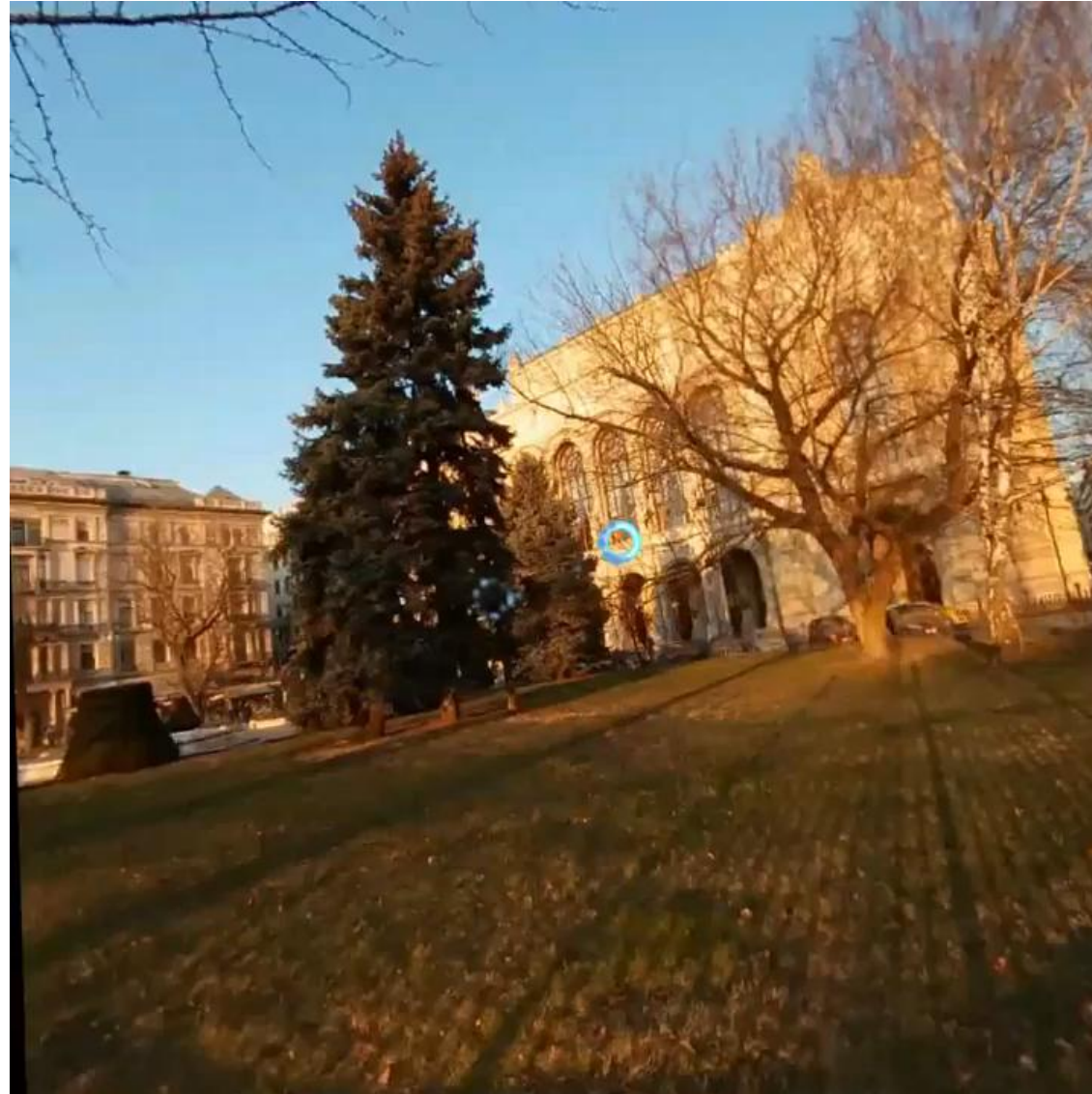
- To approximate $f_{\text{lowpass}}(x, y)$ we use the "N-tap filter" algorithm.
 - It samples N texels in the texel neighborhood, sums them and divides the result by N to get the output.
- It is possible to control the **blur spread** parameter:
 - Blur spread adds an offset between the samples

Final output as a function of blur spread



Demo

REAL TIME IMAGE ENHANCEMENT IN HMD

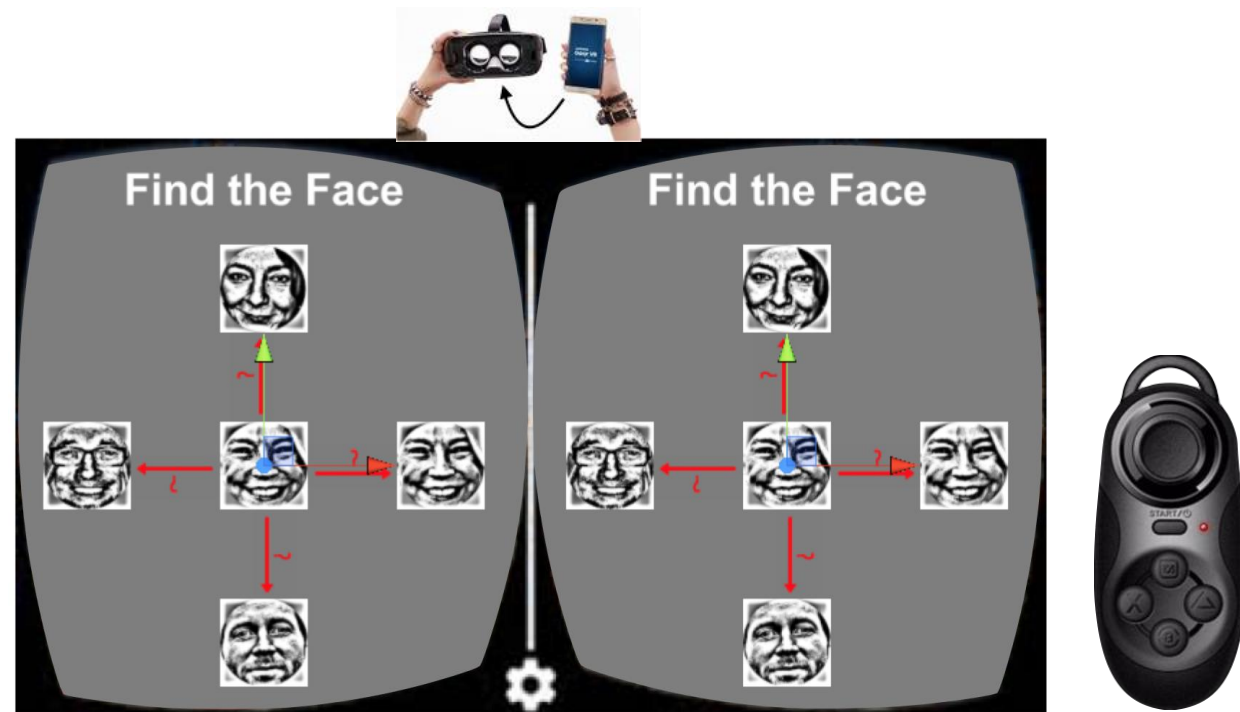


Conclusion and perspective

- Low-cost VR devices can support real-time image enhancements
 - Focus on Peli and Lim (1982) enhancement
 - Approximation and implementation using shader programming
- This work will be extended by:
 - Exploiting other digital processing techniques to improve accessibility
 - Proposing task specific strategies adapted to VR scenario
 - Evaluating the impact of these techniques depending on pathologies
 - e.g., recognition task

Recognition task

- Find the face in the “periphery” matching central target
 - How does performance depends on the level of enhancement?
 - Are there optimal enhancements depending on pathologies?
 - How patients adjust enhancements during experiments to fulfill the task?

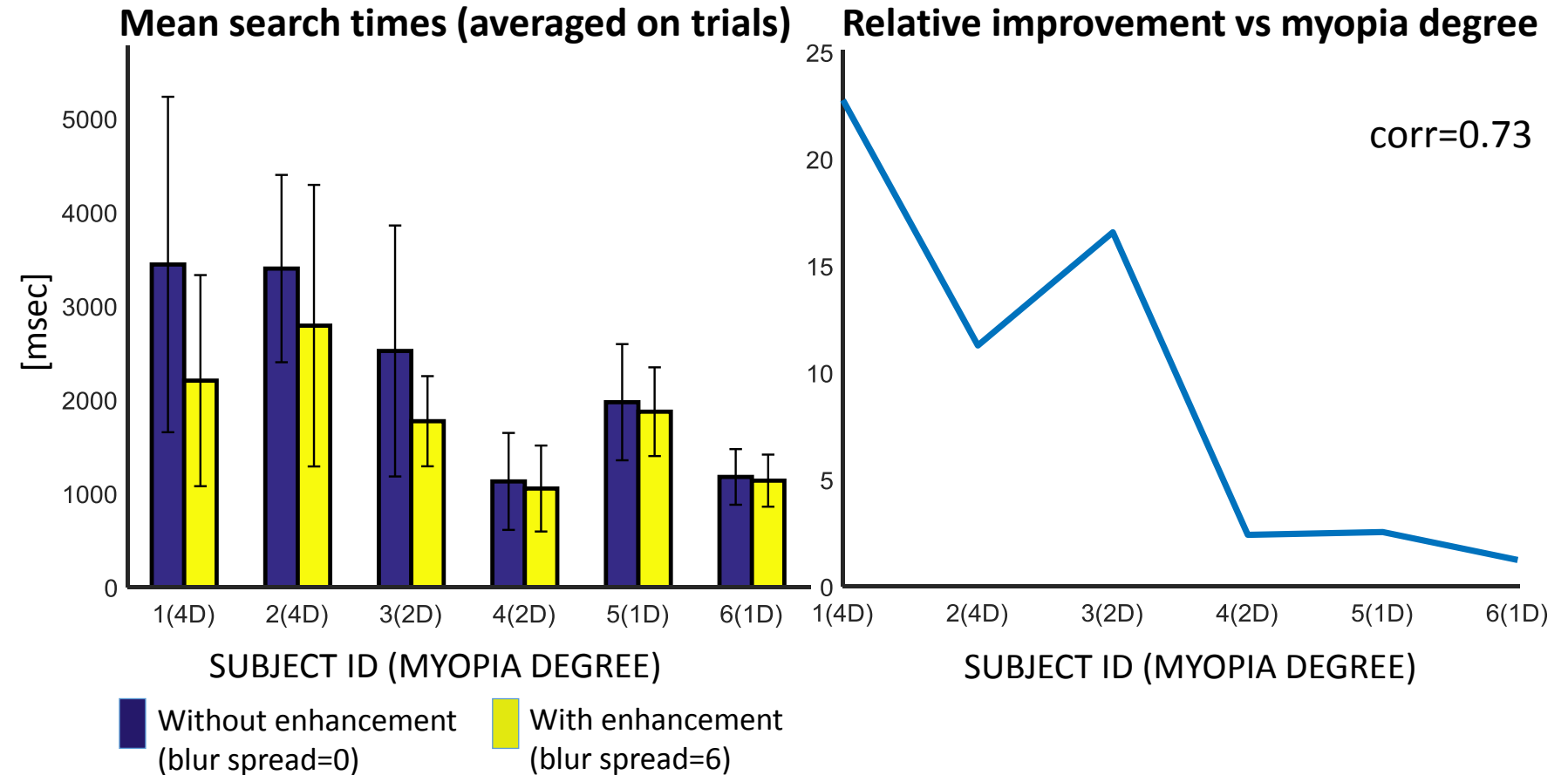


Preliminary result

- Performance is increased thanks to enhancement and even more when people have myopia

Experimental protocol:

- Training session before
- 4 possible faces randomly chosen among 8, 1 target face chosen among 8
- **2 values of blur spread**
- 50 trials per session
- 6 participants with myopia (4 females, 2 males)
- All not corrected



Thank for your attention

Questions?

Feedback?

Interested to participate to our project?

Please contact us!

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Or meet us at the conference:



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Eric Castet
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Pierre Kornprobst
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Experimental Session

Experimental protocol:

- Training session before
- 4 possible faces randomly chosen among 8, 1 target face chosen among 8
- **5 values of blur spread**
- 50 trials per session
- 11 participants (8 females, 3 males)
- 8 Normal or corrected-to-normal vision
- 3 not corrected (myopia)

