Enhancing Facial Recognition in Visual Prostheses using Region of Interest Magnification and Caricaturing

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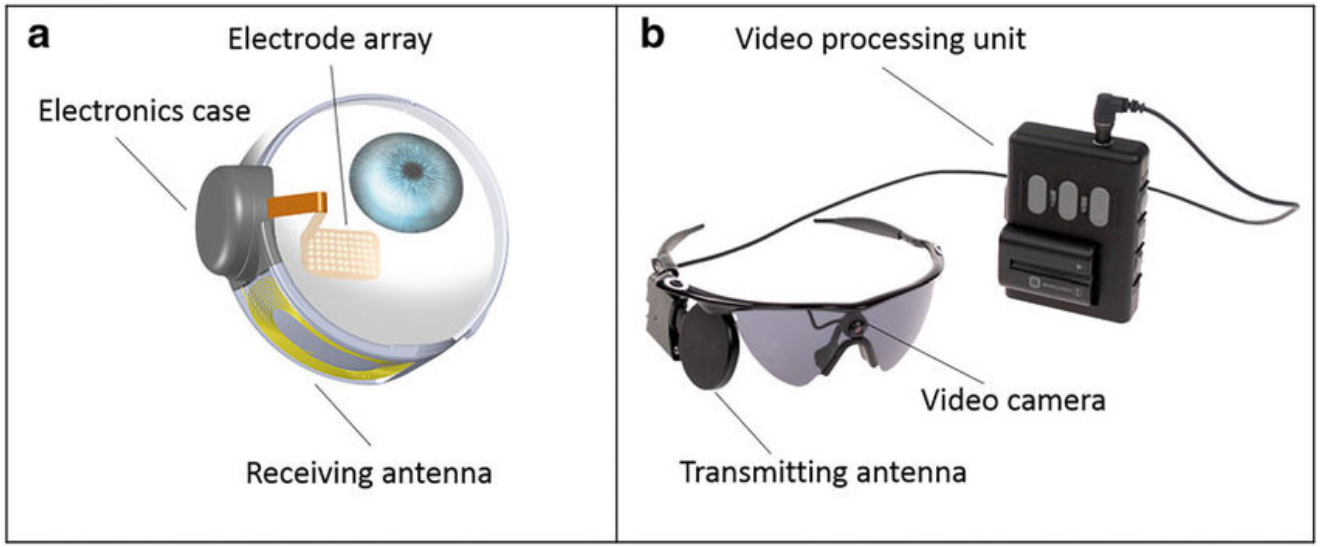
Introduction

Acquired Blindness (e.g., Retinitis Pigmentosa [peripheral vision loss])



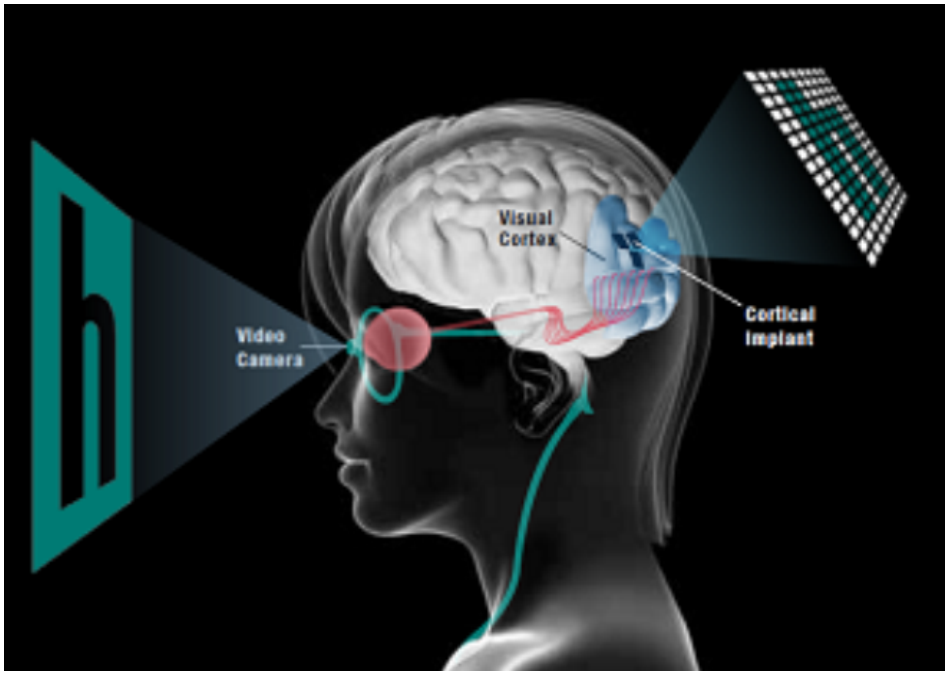

Introduction

Visual Prostheses system (e.g., Argus II)



Introduction

Phosphenes (similar to pixels in a raster image)



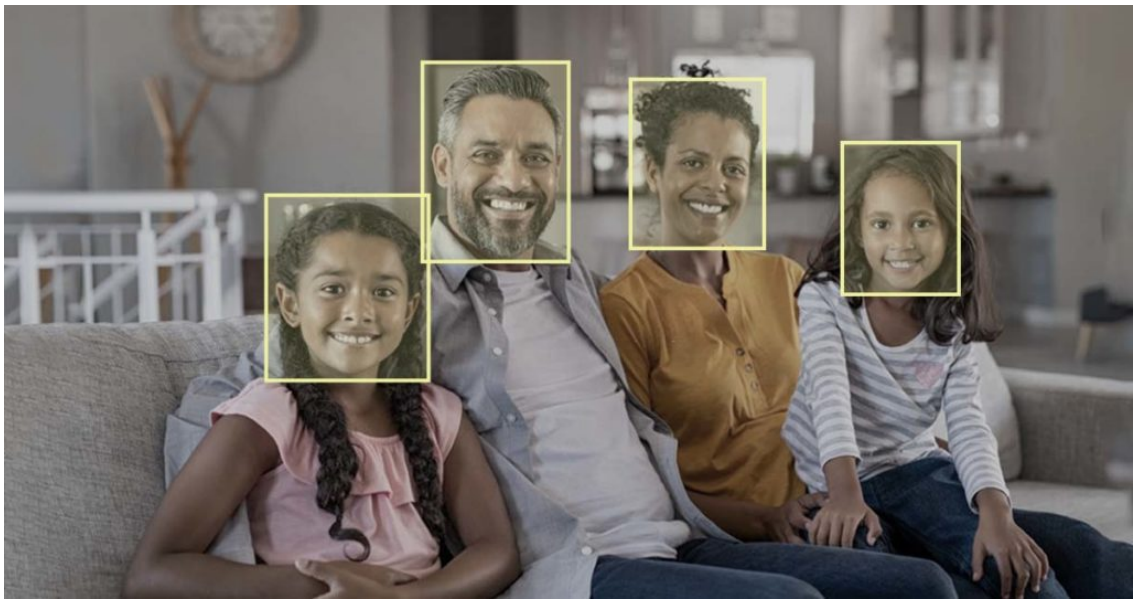
Introduction

Normal sight VS Prosthetic Vision sight
(N.B., faces details are invisible due to low resolution)

Introduction

The objective of this study is to improve the implantees efficiency in

- recognizing familiar faces,
- distinguishing similar faces, and
- identifying facial expressions.



Methodology

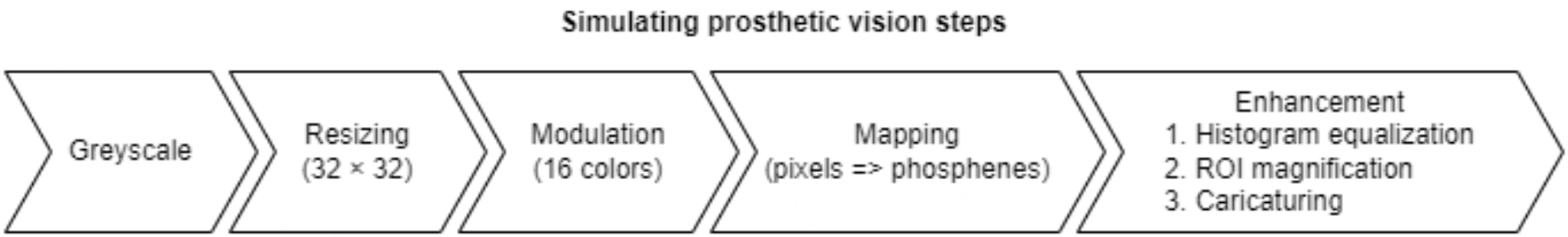
Processing of high resolution scene

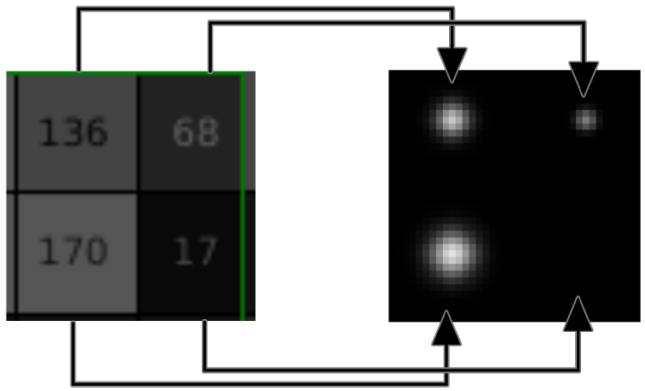
No access to actual implantees

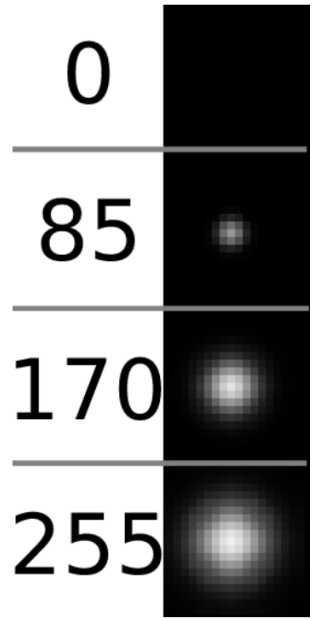
Simulations were applied to normally sighted subjects for testing

For an immersive experience for the subjects, the experiment was conducted using Virtual Reality.

Methodology







Methodology

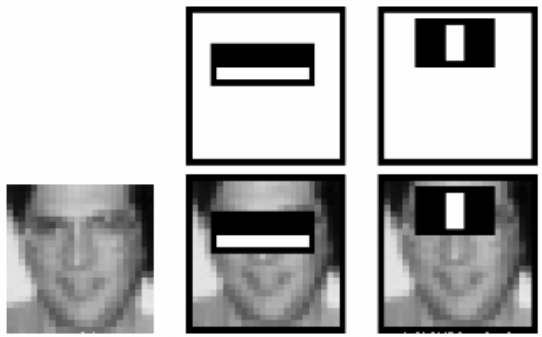
Histogram Equalization

- Transforms the pixel intensity distribution of an image to a more uniform distribution.
- Enhances the contrast and visibility of an image.
- Overcomes poor lighting conditions.

Methodology

Region of Interest (ROI) Magnification
First step is the detection of the ROI (i.e., face region)

- Simple rectangular features.
- Adaptive boosting (AdaBoost) to select and combine the most relevant features, creating a strong classifier.



Then the detected face could be magnified to fill the visual field to use the limited resolution to convey as much useful information as possible.

Methodology

Caricaturing

To exaggerate facial features enhancing their perceptibility for subjects.

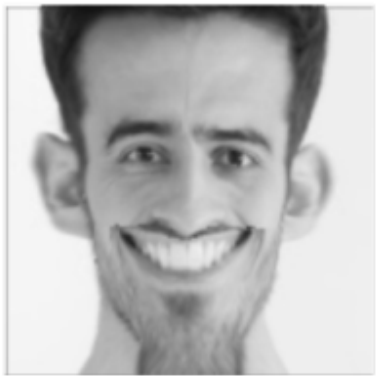
Average Face

Average Landmarks

Veridical Face

Face Detection
Face Landmarks
Delaunay Triangulation

Caricatured Face



Methodology

Experiment groups (5 subjects each)

Group name	Description
DLR	Direct lowering of resolution (without any enhancements)
VJm	Visual field histogram equalization Viola Jones (VJ) face region magnification
VJc	Visual field histogram equalization Viola Jones (VJ) face region magnification Caricaturing

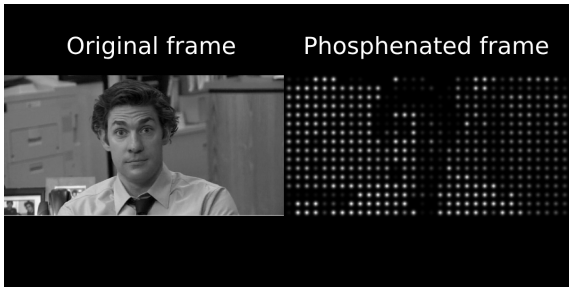
Methodology

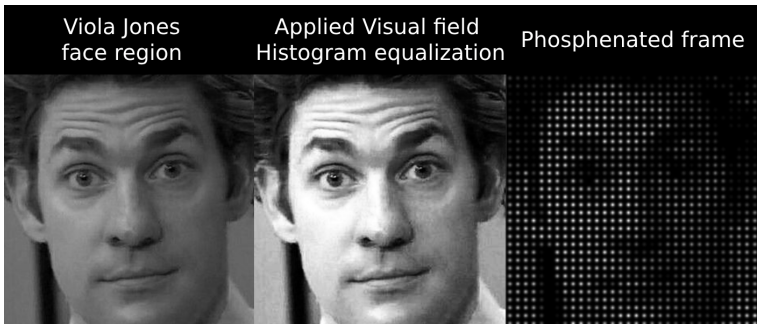
Experiment tests

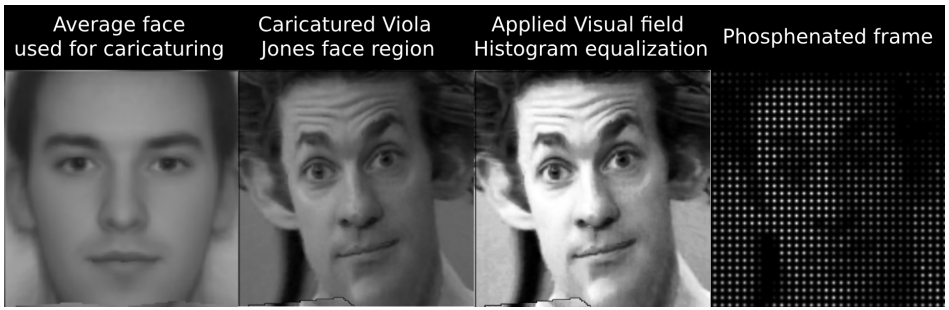
1. Recognition test
   - 6 images of celebrities for 10 seconds each
   - Recorded accuracy, response time, and confidence level
2. Expressions test
   - 4 facial expressions for 10 seconds each
   - Frowning, surprised, happy, or sad
   - Recorded accuracy
3. Distinction test
   - 4 images for 10 seconds each
   - Recorded accuracy

Results

Simulation outputs (DLR / VJm / VJc)

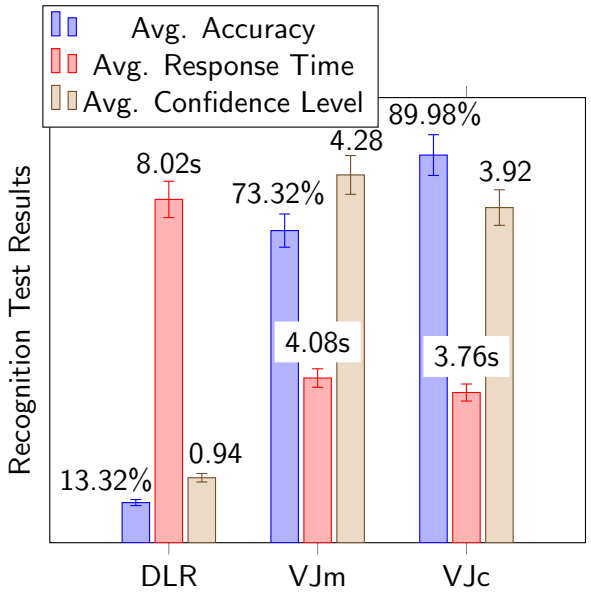


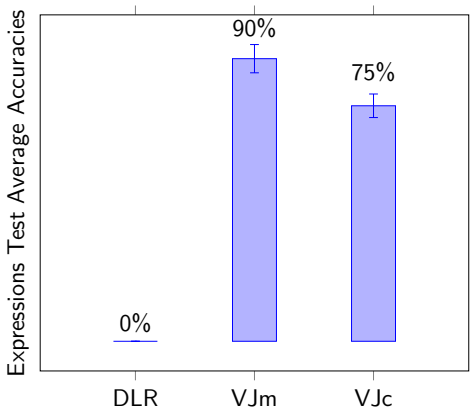


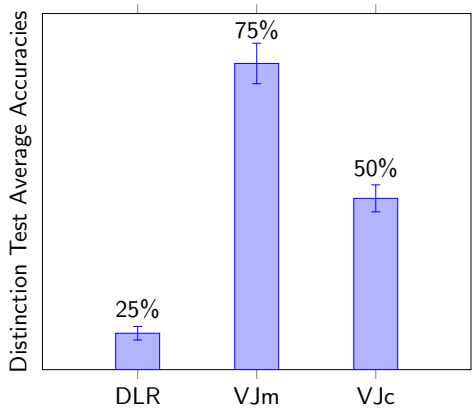


Results

The results show that enhancements work!!







Results

ROI magnification	??	recognize faces
Caricaturing	??	Distinguish similar faces

Results

ROI magnification	$=>$	recognize faces
Caricaturing	$\approx>$	Distinguish similar faces

Conclusion

The best option for enhancing faces (without violating real-time requirements) comprised:

- Visual field histogram equalization
- Region of interest magnification
- Optional Caricaturing (up to the implantee to activate it or not)

Conclusion

Future improvements

- More participants and more questions
- Actual implantees experiment
- Higher quality Caricaturing algorithm (e.g. CariGAN)

The End

Thank You!
Any questions?