Matthias Hillenbrand, Beate Mitschunas, Sarah Homberg, Stefan Sinzinger*:*

Novel vision aids for people suffering from Age-Related Macular Degeneration

Zuerst erschienen in:
DGaO-Proceedings. - Erlangen-Nürnberg: Dt. Gesellschaft für angewandte Optik, ISSN 1614-8436. - Bd. 113.2012, B28, insg. 2 S.

URN: urn:nbn:de:0287-2012-B028-0

Novel vision aids for people suffering from Age-Related Macular Degeneration

Matthias Hillenbrand, Beate Mitschunas, Sarah Homberg, Stefan Sinzinger

Fachgebiet Technische Optik, IMN MacroNano®, Technische Universität Ilmenau

mailto:matthias.hillenbrand@tu-ilmenau.de

Age-Related Macular Degeneration is one of the most common causes of partial blindness. It mainly affects the macula including the centre of sharpest vision. We present different optical principles for the redirection of the central part of the field of view while the loss of information at the boarders is kept to a minimum.

1 Introduction

Worldwide, about 30 million people suffer from Age-Related Macular Degeneration (AMD), a disease that causes progressive damage to the macula, the central part of the retina. People suffering from AMD usually experience growing dark or blurred spots in the centre of their vision which render them unable to read texts, to drive cars, or to recognise faces (Fig. 1). Current vision aids for AMD patients are mainly based on the magnification and/or the redirection of the full field of view which result in a loss of information at the outer parts of the retina.

Our multidisciplinary research project is aimed at the development of passive vision aids for all-day use as well as the evaluation of their influence on human perception. A key concept is the redirection of the most important central information onto the unimpaired parts of the retina. At the same time the loss of information at the outer parts of the retina has to be minimized in order to retain peripheral vision. Our focus is on highly integrated, nonelectric, spectacle-like systems.

2 Concepts for redirection of the central information

Humans are used to automatically reorienting their eyes in order to focus the most important information onto the macula. As AMD mainly affects this area including the centre of sharpest vision, patients have to adapt to a new way of perception. Owing to the reduced number of light sensitive cells outside of macula, the central information has to be magnified in order to e.g. restore the ability to read texts or to recognize faces.

Fig. 2 shows two concepts for redirection of the central information. The first principle is based on the magnification and distortion of the full field of view. An early design concept is presented in Fig. 3. The magnification of the image reduces the information density on the damaged areas of the retina. To retain peripheral vision, the information at the outer parts of the retina is condensed through deliberately induced barrel distortion. The

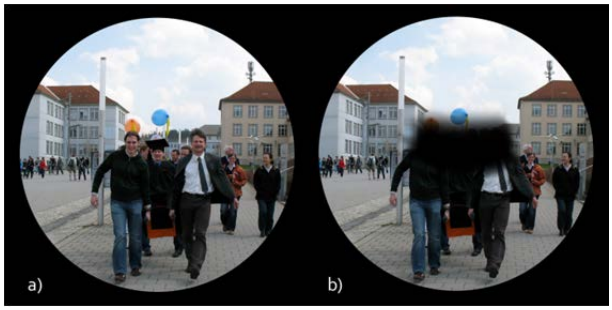

Fig. 1 *Comparison between a) normal vision and b) vision with Age-Related Macular Degeneration*

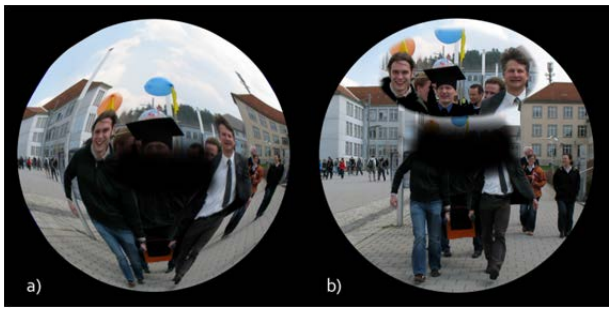

Fig. 2 *Concepts for the redirection of the central information through distortion or field segmentation*

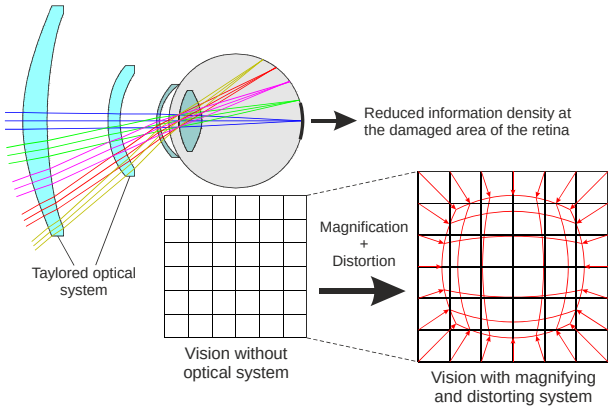

Fig. 3 *Early design concept for information redirection through magnification and distortion*

second principle shown in Fig 2b) combines the magnification and redirection of the central information to an unimpaired part of the retina. In this case the image is segmented and the redirected

information is not linked to the surrounding field of view. Fig. 4 shows how the image segmentation can be realised with image deflecting elements. The next step will be the combination of the deflecting elements with magnifying systems e.g. miniaturised Galilean telescopes. As both methods change the principles of human vision, the evaluation of their influence on human perception is a central part of our research project. Studies with image inversion goggles have shown that the human brain is able to adapt to inverted or reversed vision [1, 2].

3 Analytical vignetting model and experimental results

Since the deflecting elements for the image segmentation principle are not positioned at an intermediate image or pupil plane, the image plane intensities of the individual segments are subjected to vignetting (see Fig. 4). Thus, a clear understanding of the vignetting effects is essential for the effective development of AMD vision aids. We have developed an analytical model based on collinear theory that enables the fast calculation of the image plane intensity profile for a given set of apertures in front of the optical system or human eye. Fig. 6 shows that the experimental results with the demonstrator system presented in Fig. 5 are in good agreement with the analytical predictions.

The demonstrator system shown in Fig. 7 has been built as a proof of concept for the image segmentation principle. The experimental results presented in Fig. 8 clearly indicate the feasibility of this approach.

4 Conclusion and outlook

We have presented two principles for the redirection and magnification of the central part of the field of view. Those principles are the basis for the development of novel vision aids for people suffering from Age-related Macular Degeneration. Further work within our project includes the integration of magnifying optical elements, the design and fabrication of the vision aids as well as a study on their influence on human perception.

5 Acknowledgement

This work has been supported by the European Social Fund, the Thüringer Ministerium für Technologie, Wirtschaft und Arbeit, and by the Thüringer Ministerium für Bildung Wissenschaft und Kultur within the projects "Erforschung der optoneurologischen Rahabilitation für AMD-Patienten (ONERA)" (FKZ: 2012 FGR 0014) and "Graduate Research School on Optical Microsystems Technology (OMITEC)" (FKZ: PE 104-1-1).

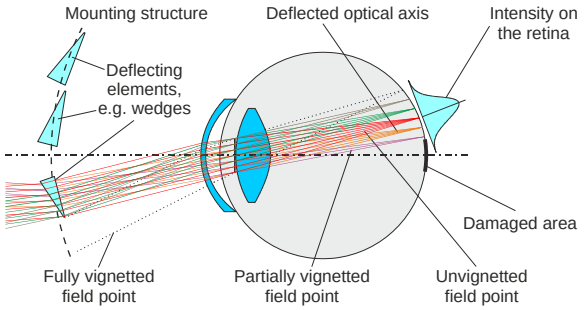

Fig. 4 *Image segmentation using deflecting elements*

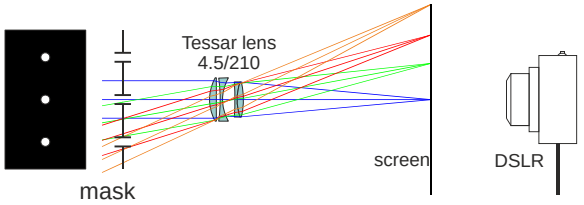

Fig. 5 *Experimental setup used for the vignetting analysis*

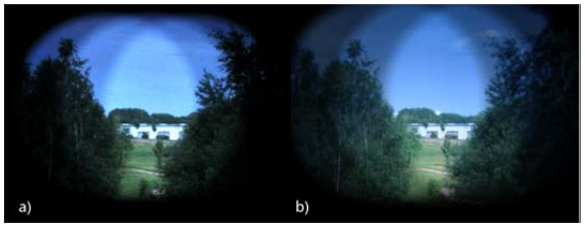

Fig. 6 *Comparison between a) analytical model and b) experimental results for the setup shown in Fig. 5*

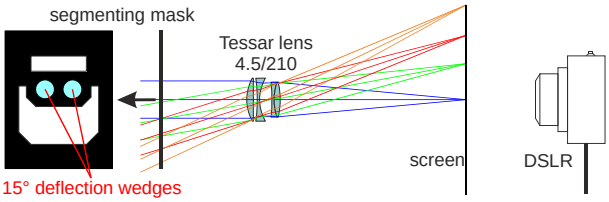

Fig. 7 *Experimental setup based on the image segmentation principle*

Fig. 8 *Proof of principle for the image segmentation approach*

Literature

[1] D. G. Myers, "*Psychology*", 9th Ed. (Worth Publishers, 2009)

[2] Harris, "Perceptual Adaption to Inverted, Reversed, and Displaced Vision," in Psychological Review **72:** 419 (1965)