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Automated and Integrated Analysis and Characterization System for Visual Field Defects in 3D

Program # 2335

Visual and Autonomous Exploration Systems Research Laboratory
Division of Physics, Mathematics and Astronomy
California Institute of Technology, Pasadena, CA 91125

Cindy You & Wolfgang Fink
Email: wfink@autonomy.caltech.edu Website: http://autonomy.caltech.edu

Visual and Autonomous Exploration Systems Research Laboratory
Electrical & Computer Engineering and Biomedical Engineering
University of Arizona, Tucson, AZ 85721

Purpose

To introduce an automated analysis and characterization system for visual field data in three dimensions (3D).

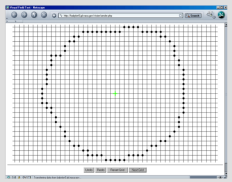
Methods

The 3D computer-automated threshold Amsler grid test (3D-CTAG) [1] allows for an unprecedented characterization of the structure of visual field defects in 3D. Results of the 3D-CTAG are recorded by the computer in form of a three-dimensional data array: (x, y, contrast sensitivity(x, y)). x and y mark the location of a tested grid point in the visual field with respect to the fovea (0, 0). Contrast sensitivity(x, y) is the measured contrast sensitivity of the particular visual field location (x, y). To analyze these three-dimensional visual field data sets and to characterize the occurring visual field defects within, we have developed numerical methods that characterize the entire visual field (*visual field data transforms*) and scotomas within (*scotoma data transforms*). Visual field data transforms comprise area and volume of visual field loss, lost and preserved area grades [2], and slope distribution. Scotoma data transforms comprise scotoma perimeter, perimeter scallopedness [3], and center location.

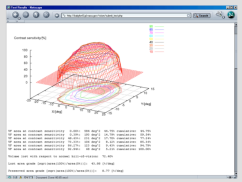
Results

We have created an automated and integrated analysis and characterization system, which, in the absence of clinical experts, analyzes 3D-CTAG visual field data and objectively characterizes visual field defects according to the above devised numerical methods. The output of these scotoma parameters occurs in the form of individual, appropriately documented ASCII files. Where appropriate, an automatic graphical representation, using the freely available Gnuplot graphics program, of the analysis data is generated via a Gnuplot script.

3D Computer-automated Threshold Amsler Grid Test (3D-CTAG)

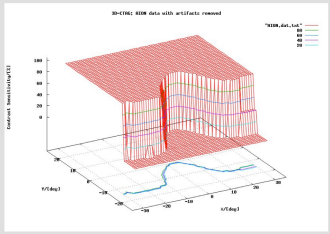
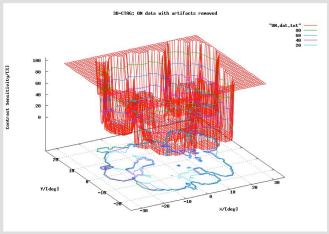
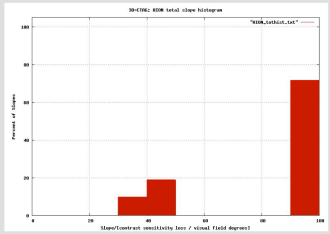
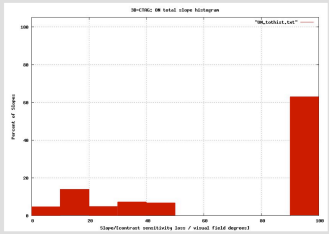
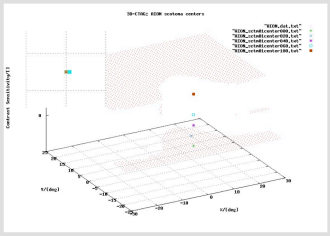
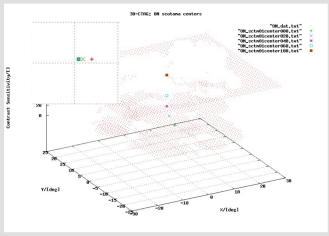
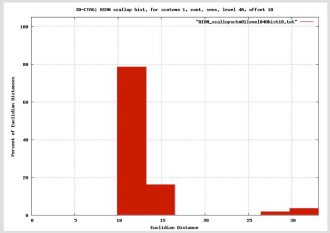
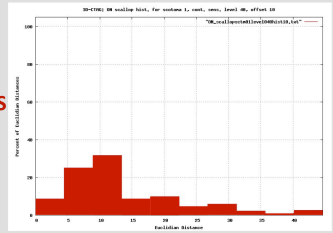


Amsler Grid with subject input



3D data structure

APPLICATION EXAMPLE

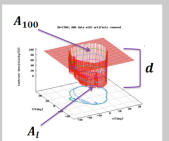
Anterior Ischemic Optic Neuropathy (AION)	TRANSFORMS	Optic Neuritis (ON)
	ORIGINAL DATA	
	TOTAL SLOPE HISTOGRAMS	
	SCOTOMA CENTERS	
	SCALLOPEDNESS	

MORE TRANSFORMS

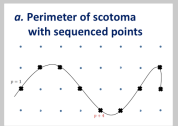
	AION	ON
VOLUME LOST	27.45%	54.27%
AREA LOST Contrast sensitivity level 0:	26.89%	44.15%
LOST AREA GRADE (LAG) [2] $LAG = \left(\frac{A_l}{A_{100}}\right) * \left(\frac{d}{100}\right)^2$	0.96	0.74
PRESERVED AREA GRADE (PAG) [2] $PAG = \left(\frac{A - A_{100}}{A - A_l}\right) * \left(\frac{d}{100}\right)^2$	0.99	0.72

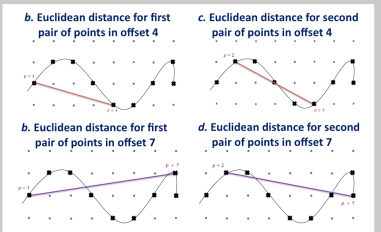
1. Fink W, Sadun A (2004) *3D Computer-automated Threshold Amsler Grid Test*, Journal for Biomedical Optics 2004 Jan; 9(1):149-53.

2. **Legend for LAG and PAG** *(image to the right)*:
   A_{100} is the area of the scotoma at the highest contrast sensitivity.
   A_l is the area of the scotoma at the lowest contrast sensitivity.
   d is the difference in contrast sensitivity between the highest and lowest tested levels.



3. **Scallopedness** *(image below and bottom right)*: Scallopedness is the measure of the fluctuation in curvature. The Euclidean distance between point intervals (i.e., offsets) are measured and compiled into histograms. This procedure was repeated for different offset values.





Conclusions

The introduced automated analysis and characterization system is generically applicable to all perimetry techniques that yield a three-dimensional description of the hill-of-vision or parts thereof. The objectively derived scotoma parameters can be stored in a database and may serve as the input for an automated classification system for visual field defects, currently under development, that will probabilistically predict the ailment using statistical methods and artificial neural networks. Equipped with the above analysis package, the 3D-CTAG will be a significant step towards screening and examining people worldwide, and may assist physicians with an independent second opinion or provide expertise where otherwise not readily available.