Comprehensive Visual Field Test and Diagnosis System for Visual Performance Assessment in Military Settings

Caltech Patents issued
Support: ARO Grant
W81XWH-09-1-0266

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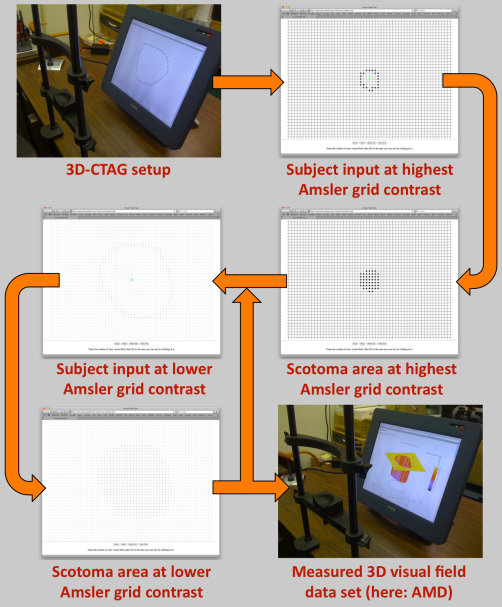
System Overview

We have developed an Internet-based, integrated, and comprehensive visual field test and diagnosis system to assess the visual performance of warfighters, veterans, and civilians. The system is based on the *3D Computer-automated Threshold Amsler Grid (3D-CTAG)* test (Fink & Sadun, JBO 2004). In multiple clinical studies 3D-CTAG has proven to be innovative and successful for fast, easy, accurate, non-invasive, and comprehensive visual field testing. We have created an automated and integrated analysis and characterization system, which analyzes 3D-CTAG visual field data and objectively identifies and characterizes the occurring visual field defects (scotomas) within. Following each test, a topographical contour map, a 3D depiction of the central hill-of-vision, and the comprehensive visual field and scotoma characterization are automatically generated and displayed onscreen, using the freely available Gnuplot© plotting package.

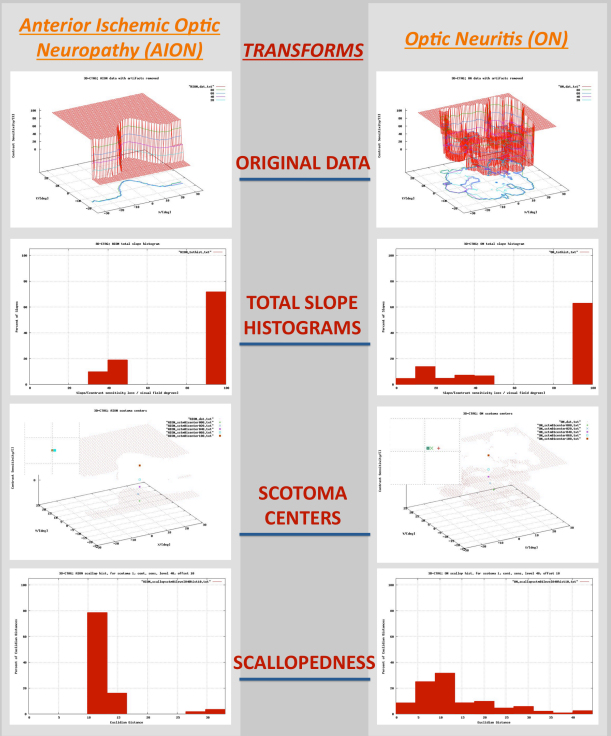
3D Computer-automated Threshold Amsler Grid Test (3D-CTAG)



Visual Field Testing and Analysis Methods

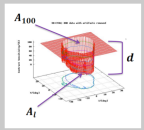
With one eye covered, the subject is positioned in front of a computer touch screen on a head-chin rest and finger-traces the areas of an Amsler grid that are missing from his field of vision. Various degrees of contrast of the Amsler grid are presented by repeating the test at different grayscale levels. Results of the 3D-CTAG are recorded in form of a 3D data array. The resulting 3D data represent the measured contrast sensitivity across the tested visual field locations (x, y) with respect to the fovea (0, 0) and are stored in a relational MySQL database. We have developed numerical methods that automatically 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, and slope distribution. Scotoma data transforms comprise scotoma perimeter, perimeter scallopedness, and center location.

Auto-Characterization of 3D-CTAG Data (Example)



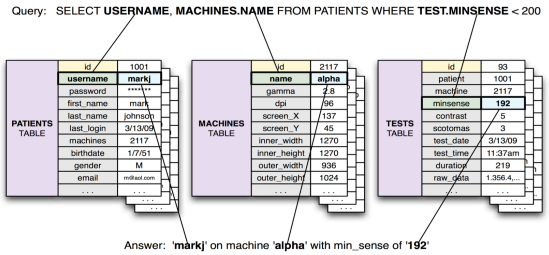
MORE TRANSFORMS	*AION*	*ON*
VOLUME LOST	27.45%	54.27%
AREA LOST Contrast sensitivity level 0:	26.89%	44.15%
LOST AREA GRADE (LAG) $LAG = \left(\frac{A_l}{A_{100}}\right) * \left(\frac{d}{100}\right)^2$	0.96	0.74
PRESERVED AREA GRADE (PAG) $PAG = \left(\frac{A - A_{100}}{A - A_l}\right) * \left(\frac{d}{100}\right)^2$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

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.



MySQL Database for Examination Data

The database for the visual field test and diagnosis system is logically divided into three main elements: PATIENTS, MACHINES, and TESTS. Each element is represented in the database as its own table. The MACHINES table records information concerning each computer system upon which a test may be run. The PATIENTS database table represents user information, such as first and last name, password, usage history, test history, etc. The last major table in the database is the TESTS table, which records the results of each test session, cross-referenced by patient, machine, date, etc.



Conclusions & Outlook

The newly developed integrated visual field test and diagnosis system provides medical support personnel both in hospitals and in the field with a non-invasive, accurate, sensitive, and fast visual field test, a relational MySQL database for patient data, and a software package of sophisticated analysis and characterization algorithms to help classify and diagnose visual field defects. The objectively derived visual field and scotoma characterization data will serve as the input for an *automated classification system* for visual field defects, currently under development, that will probabilistically predict ailments using statistical methods and artificial neural networks. The system is capable of detecting and diagnosing conditions affecting the visual performance of warfighters in the field, allowing for the timely application of therapeutic countermeasures. The visual field test and diagnosis system can be hosted locally on a computer (Intranet/standalone application). Moreover, thanks to the global accessibility of the World Wide Web, it also permits screening and examining patients (e.g., veterans and civilians) on a regional to global scale. As such, the automated visual field test and diagnosis system may assist physicians with an independent second opinion and provide expertise where otherwise not readily available, offering a promising perspective towards modern computer-assisted diagnosis in medicine and telemedicine in military settings and beyond.

Scallopedness
(image below and 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 is repeated for different offset values.