

A Hybrid Top-Down Approach to Diabetic Retinopathy Screening

June 2011

Carla Agurto / Staff Engineer
505-508-1994 / cagurto@visionquest-bio.com



A Hybrid Top-Down Approach to Diabetic Retinopathy Screening

SIGNIFICANCE

Cases of diabetes have been increasing at alarming rates in the U.S. and throughout the world. According to the International Diabetes Federation, as of 2010 there are 285 million people with diabetes in the world. Factors such as lack of exercise, consumption of fast foods with high fat content contribute to the increase in obesity, a risk factor for type II diabetes. For that reason, the number of diabetes cases is expected to increase to 438 million people around the world. One of the consequences of diabetes is diabetic retinopathy (DR), the second leading cause of blindness in the western world and the leading cause of blindness among people of working age.

As the number of DR cases increases each year, the capacity of the U.S. health care system does not increase correspondingly. In order to help mitigate this problem, VisionQuest Biomedical has developed an automatic DR screening algorithm. We have adopted a hybrid approach of combining a binary screening algorithm and a human reading center. Our hybrid approach consists of two parts: 1) A top-down DR screening algorithm developed by our staff to detect if an image is outside of the normative range, and 2) A reading center where all the suspect cases found by the algorithm are derived to a certified retinal grader for proper diagnosis. This type of system increases the throughput of diabetics seen by the reading center by 300%, thus making it possible to increase the number of people being screened for DR every year, as recommended by the American Academy of Ophthalmology and the American Diabetes Association.

OUR PRODUCT

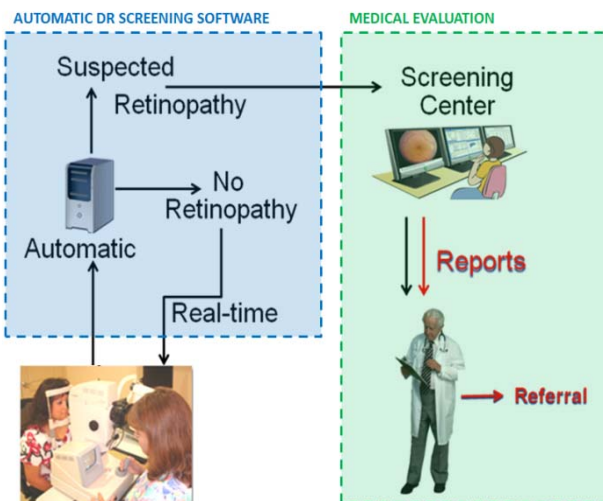


Figure 1 Hybrid DR screening system.

Our hybrid top-down approach works in three steps, as shown in the Fig. 1. First, retinal images of the patient are captured with a non-mydratric fundus camera. Next, the images are analyzed with our automatic DR screening software. The software has the following steps. First, an algorithm¹ to evaluate the image quality of the fundus images is applied to the images. Then, the optic disc and the fovea are located using the algorithm described in Yu 2011. Using this information, optic disc diseases such as neovascularization as well as risk of macular edema can be found in the retinal images. The retinal images are then processed with a technique called amplitude modulation-frequency modulation (AM-FM)² in order to obtain 39 different representations of the retinal images with information of different range of frequencies. Using the information of the location of the optic disc, the image is subdivided in regions and statistical information is

extracted from each of them.

Then the images are classified using the process shown in Fig. 2. A combination of k-means clustering and partial least squares (PLS) is applied to obtain the final classification. If the algorithm does not classify the subject as a suspect for DR, the results are provided to the patient in real time. On the other hand, if any abnormality is detected by the algorithm, the case is referred to a certified retinal grader for further evaluation.

Top-down approaches, such as the implemented by VisionQuest, do not depend on the segmentation of specific pathologies. Therefore, top-down methods can potentially detect abnormalities not explicitly used in our set of cases in the training stage. In addition to that, top-down approaches are flexible, so they can be implemented to detect pathologies in any part of the fundus image such as the optic disc⁵.

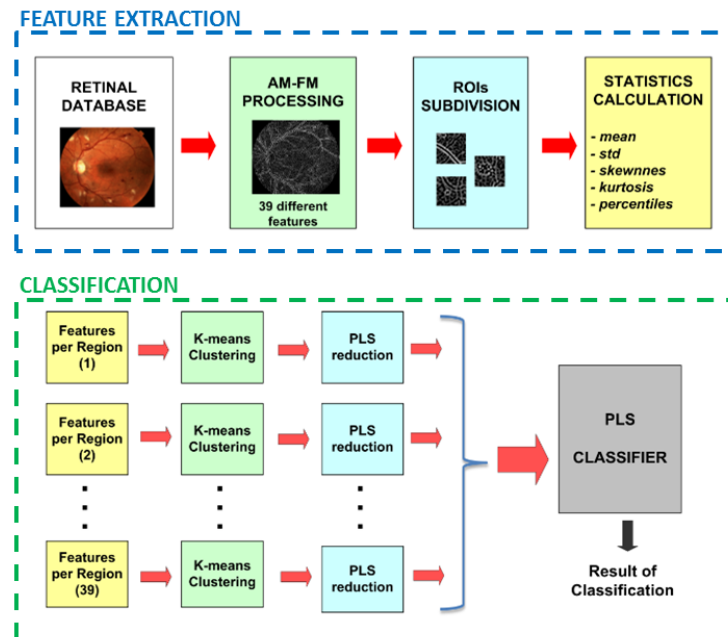


Figure 2 DR screening algorithm.

RESULTS

In order to test our algorithm we have used three databases. The first database, MESSIDOR, is freely available on-line. The other two were obtained in collaboration with the Retinal Institute of South Texas (RIST) and the University of Texas Health Science center (UTHSCSA). Results of the tests have been published in major per-reviewed journals^{3,4}. Results of sensitivity and specificity are shown in Table 1. Our results are comparable or better than the ones presented by other large studies. High sensitivity and specificity was obtained for STDR cases especially for the cases of Clinical Significant Macular edema (CSME). A complete summary of the results can be found in Agurto 2011.

THE FUTURE

Our staff is continuously working in order to increase the sensitivity and the specificity of our algorithm. More data have been collected from centers mentioned above and from health fairs in the U.S. in order to obtain more cases to make our algorithm more robust in facing the great variety of ethnicities around the country. In addition to that, new studies have been performed in order to incorporate the detection of other pathologies such as cardiovascular diseases and with age-related macular degeneration⁴.

Table 1 Results of the DR screening algorithm in different databases.

Databases	DR		Sight Threatening DR	
	Sens	Spec	Sens	Spec
MESSIDOR (1200 cases)	98%	70%	100%	85%
RIST (378 cases)	91%	60%	93%	75%
UTHSCSA (444 cases)	94%	60%	92%	80%

Contact: Simon Barriga, Ph.D. / Chief Research Scientist

Corporate Headquarters: VisionQuest Biomedical LLC 2501 Yale Blvd. SE Suite 301 Albuquerque, NM 87106

Phone: 505-508-1994 / Fax: 505-508-5308 / Web: <http://visionquest-bio.com> / E-mail: sbarriga@visionquest-bio.com

¹ [Davis H, Russell S, Barriga E, Abramoff M, Soliz P. "Vision-based, real-time retinal image quality assessment", *Computer-Based Medical Systems, 2009. CBMS 2009. 22nd IEEE International Symposium on*, pp.1-6, 2-5 Aug. 2009.](#)

² Murray, V, Rodriguez P, Pattichis MS. Multi-scale AM-FM Demodulation and Reconstruction Methods with Improved Accuracy. *IEEE Transactions on Image Processing*. 2010; 19(5): 1138-1152.

³ [Agurto C, Murray V, Barriga E, Murillo S, Pattichis MS, Davis H, Russell S, Abramoff MD and Soliz P. "Multiscale AM-FM Methods for Diabetic Retinopathy Lesion Detection", *IEEE Transactions on Medical Imaging*. 2010; 29\(2\): 502-512.](#)

⁴ [Agurto C, S Barriga, V Murray, S Nemeth, M Pattichis, W Bauman, G Zamora, and P Soliz, "Automatic algorithm for detection of diabetic retinopathy pathologies", *accepted for publication in IOVS journal*. May 2011.](#)