#1342

AUTOMATIC SCREENING OF EYE DISEASES USING 3-FIELD FUNDUS PHOTOGRAPHS

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Purpose

Objective

- To present an automatic computer system that screens retinal photographs for the presence of diabetic retinopathy (DR), age-related macular degeneration (AMD), and glaucoma.
- To evaluate the performance of the system in the detection of different pathologies.
- To validate our system by testing it on two different databases.

Background

- DR, AMD and glaucoma are the main causes of blindness. In the US there are 12, 4.3, and 4.1 million people with AMD, glaucoma and DR, respectively.
- Automatic screening systems are important because they meet the high volume of people who are at risk.
- This approach reduces the economic burden by triaging cases that do not require attention by eye care specialists.

Dataset

- Digital retinal photographs were collected at two sites: Retina Institute of South Texas (RIST) and University of Texas Health Science Center at San Antonio (UTHSC-SA).

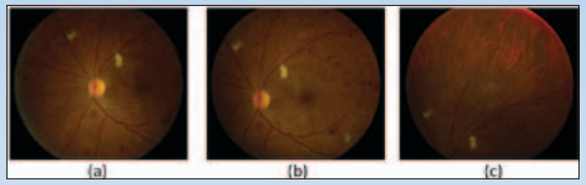

Figure 1 UTHSC-SA database. Each retina was captured using 3 different Fields of View (FOV): (a)Disc-centered, (b) Macula-centered, (c) Superior temporal.

- Images were graded as normal, non-proliferative DR (NPDR), sight-threatening DR (STDR), and maculopathy by 3 readers. Substantial agreement with kappa values in the range of [0.6 0.8] were obtained among the readers.

Table 1 Distribution of the RIST and the UTHSC-SA databases.

Database	# of Patients	Normal eyes	NPDR eyes	STDR eyes	Maculopathy
RIST	378 eyes	64	486	158	174
UTHSCSA	444 eyes	116	418	292	207

- Pathologies on each image were identified (Table2).

Table 2 Distribution of DR and AMD pathologies for the RIST and the UTHSC-SA databases.

Presence of Pathologies	Exudates Fovea	IRMA	NVE	NVD	Drusen	Pigmen-tation	Geographic Atrophy
# images (RIST)	174	80	30	58	343	345	154
# images (UTHSCSA)	207	70	59	118	188	86	54

[1]M. S. Pattichis and A. C. Bovik, "Analyzing image structure by multidimensional frecuency modulation", IEEE Trans. Pattern Anal. Mach. Intell., 2007; no. 5, pp. 753-766.

Methods

Classification Algorithm

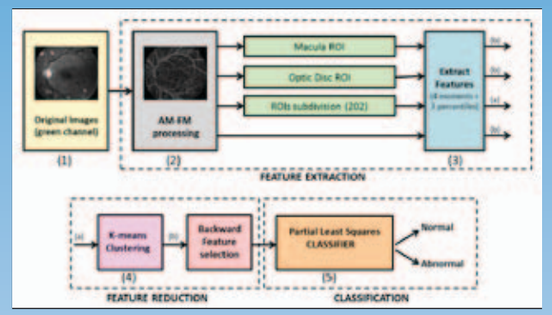

Figure 2 DR, AMD and glaucoma classification system.

1) The green channel of the images is selected.
2) Images are decomposed in their Amplitude modulation-Frequency modulation (AM-FM) estimates [1].
3) Features are obtained for each image.
4) Features are clustered using k-means.
5) A PLS classifier is applied to obtain the estimated class for each image.

- The following images show the characterization of AM-FM for two types of pathologies: drusen and neovascularization in the optic disc. The AM-FM characterization of other retinal pathologies has been described in [2].

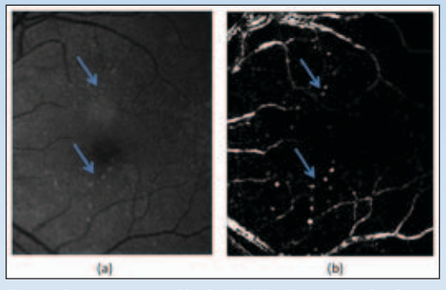

Figure 3 Structures captured by the AM-FM estimates using low frequencies of a retinal region with drusen.

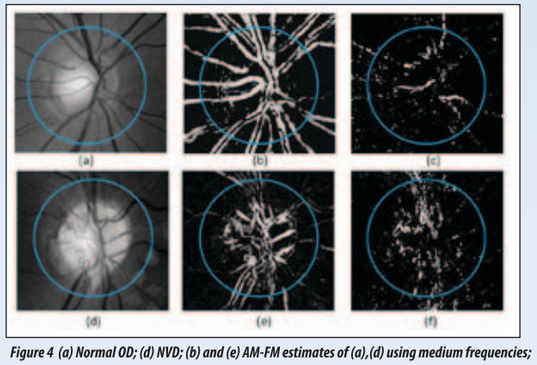

Figure 4 (a) Normal OD; (d) NVD; (b) and (e) AM-FM estimates of (a),(d) using medium frequencies; (c) and (f) AM-FM estimates of (a),(d) using high frequencies which capture NVD with higher intensity than other structures such as normal vessels.

Results

- The data was randomly divided into training (70%) and testing (30%) sets.

Table 3 Results of performance evaluation for DR detection.

PATHOLOGIES	RIST DATABASE				UTHSCSA DATABASE			
	Number of cases + controls	AUC	Sens for Spec=0.60	Sens for Spec = 0.50	Number of cases + controls	AUC	Sens for Spec=0.60	Sens for Spec = 0.50
DR	583	0.81	0.92	0.92	573	0.89	0.94	0.97
NPDR only	370	0.77	0.83	0.88	260	0.85	0.90	0.95
STDR only	337	0.92	0.95	0.98	449	0.92	0.96	0.96
CSME	112	0.98	1	1	240	0.97	0.98	0.99
IRMA + NVE	239	0.85	0.92	0.93	273	0.92	0.97	0.98
NVD	78	0.88	0.90	0.92	168	0.91	0.95	0.95

Table 4 Results of performance evaluation for AMD detection.

PATHOLOGIES	RIST DATABASE				UTHSCSA DATABASE			
	Number of cases + controls	AUC	Sens for Spec=0.60	Sens for Spec = 0.50	Number of cases + controls	AUC	Sens for Spec=0.60	Sens for Spec = 0.50
AMD only	392	0.84	0.90	0.94	395	0.77	0.90	0.90
Drusen	189	0.77	0.88	0.95	279	0.73	0.80	0.85
Pigmentation	153	0.80	0.90	0.90	197	0.81	0.87	0.90
Geographic Atrophy	198	0.92	0.97	1	212	0.92	0.90	1

- In addition to those pathologies, we assessed the performance of the algorithm in images of glaucoma suspects.
  - An AUC of 0.88 were obtained for both databases with best sens/spec of 0.90/0.88 and 0.90/0.75 for RIST (57 cases) and UTHSC-SA (91 cases) respectively.
  - AM-FM can capture features in the optic disc such as shape, color information and notching in the vessels which are some of the signatures of glaucoma suspects.
- RIST database (Figure 5)
  In the detection of STDR, the algorithm achieved sens/spec = 0.92/0.80. For NPDR and DR detection, sensitivities in the range of [0.88 0.92] for 0.50 specificity were obtained.

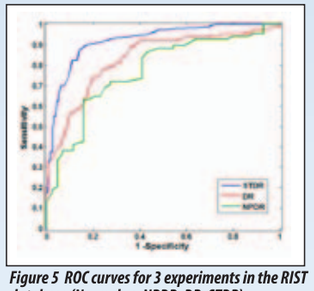

Figure 5 ROC curves for 3 experiments in the RIST database (Normal vs. NPDR, DR, STDR).

- UTHSC-SA database (Figure 6)
  The performance of the algorithm for the detection of STDR was sens/spec = 0.93/0.75. For NPDR and DR, sensitivities in the range of [0.90 0.94] for 0.50 specificity

[2]Agurto C, Murray V, Barriga S, et al. Multiscale AM-FM Methods for Diabetic Retinopathy Lesion Detection. IEEE Transactions on Medical Imaging. 2010; 29(2): 502-512.

Results

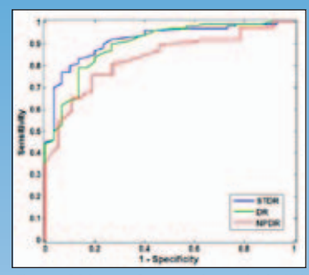

Figure 6 ROC curves for 3 experiments in the UTHSC-SA database (Normal vs. NPDR, DR, STDR).

Validation

- 34 new patients from RIST were analyzed using the model created in the previous experiment for the detection of DR. The distribution of the images was: 109 normal images, 57 images with NPDR and 31 images with STDR.
- To produce the patient classification, we used the "sum rule" which consists in averaging the individual results for each FOV of the two retinas in each patient.
- Sens/spec of 0.86/0.85 was obtained in the detection of DR for the 34 patients. All the STDR cases were detected by the algorithm.

Conclusions

- A computer-aided detection algorithm based on AM-FM and PLS was trained to detect different kinds of retinal pathologies.
- Of the DR pathologies studied, mild non-proliferative DR was the most challenging to detect, whereas the cases of STDR were detected with high accuracy.
- This work presents a viable and efficient means to characterize different retinal abnormalities and build binary classifiers for screening purposes.

Acknowledgements

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