“ARTIFICIAL INTELLIGENCE TECHNIQUES FOR DETECTION OF DRY EYE DISEASE”

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I HAVE NO FINANCIAL INTEREST TO DISCLOSE

Artificial intelligence (AI) refers to the science that seeks to create machines, such that they are capable of performing functions that require human intelligence [1] .

Machine learning (ML) is a subfield of AI and deals with development algorithms that allow machines to "learn" through the provided data [1].

The sub-field of ML, deep learning uses deep artificial neural networks used especially for image and text recognition.

Dry Eye Disease [2]

- Dry Eye Disease (DED) is one of the most common eye diseases worldwide, with a prevalence of between 5 and 50%, depending on the diagnostic criteria used and study population
- It is considered as one of the most underdiagnosed condition in ophthalmology
- Women affected more than men and increases with the age

2 types of DED :

- Aqueous deficient DED, where tear production from the lacrimal gland is insufficient .
- evaporative DED (the most common form), which is typically caused by dysfunctional meibomian glands in the eyelids.

Symptoms [3]

- ✓ Eye irritation
- ✓ Photophobia
- ✓ Fluctuating vision

The main clinical signs of DED [4]:

- decreased tear volume
- more rapid break-up of the tear film (fluorescein tear break-up time (TBUT))
- microwounds of the ocular surface

Tests for DED diagnosis

- Tests for determining the physical parameters of tears (TBUT, the Schirmer's test, tear osmolarity and tear meniscus height).
- ocular surface staining
- corneal sensibility,
- interblink frequency
- corneal surface topography
- interferometry
- aberrometry
- imaging techniques such as meibography and in vivo confocal microscopy (IVCM), as well as visual function tests.

1. Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
2. doi:http://dx.doi.org/10.1167/iovs.10-6997g.
3. 3. C. Matossian, M. McDonald, K. E. Donaldson, K. K. Nichols, S. MacIver, P. K. Gupta, Dry eye disease: consideration for women's health, Journal of Women's Health 28 (4) (2019) 502–514.
4. M. D. Willcox, P. Argüeso, G. A. Georgiev, J. M. Holopainen, G. W. Laurie, T. J. Millar, E. B. Papas,J. P. Rolland, T. A. Schmidt, U. Stahl, et al., TFOS DEWS II tear film report, The ocular surface 15 (3)(2017) 366–403

Most studies about AI in DED employed machine learning for interpretation of interferometry, slit-lamp and meibography images [5]. Here, we refer some AI algorithms which have better results.

Fluorescein tear break-up time

- Levenberg-Marquardt algorithm detect dry areas achieved an accuracy of 91% compared to assessments by an optometrist

Meibography

- A combination of Otsu's method and the skeletonization and watershed algorithms was useful in automatically quantifying meibomian glands. Method was faster than an ophthalmologist and achieved a sensitivity and specificity of 0.993 and 0.975 [6].
- Wang et al. used 4 different CNNs to determine meibomian gland atrophy [7]. The CNNs were trained to identify meibomian gland drop-out areas and estimate the percentage atrophy in a set of images. Comparison of model predictions with experienced clinicians indicated that the best CNN (ResNet50 architecture) was superior.

Interferometry and slit-lamp images

for lipid layer classification based on morphological properties, *estimation of* the lipid layer thickness, diagnosis of DED, determination of ocular redness and estimation of tear meniscus height. Diagnosis of DED can be based on the following morphological properties: open meshwork, closed meshwork, wave, amorphous and color fringe.

- Garcia et al. used a K-nearest neighbors model trained to classify images resulting in an accuracy of 86,2%.
- Hwang et al. investigated whether tear film lipid layer thickness can be used to distinguish Meibomian gland dysfunction (MGD) severity groups. Machine learning was used to estimate the thickness from Lipiscanner and slit-lamp videos with promising results.
- Ocular redness from slit lamp exam. multiple linear regression model was trained to predict ocular redness based on the extracted features. The system achieved an accuracy of 100%.
- The tear meniscus height could be estimated by keratography images using CNN. Machine learning system achieved an accuracy of 82.5% and was found to be more effective and consistent than a well-trained clinician working with limited time.

OCT

- Images from clinical examinations with AS-OCT were used to diagnose DED. A pretrained VGG19 CNN [8] was fine-tuned using separate images for training and validation. Two similar CNN models were developed, and evaluation was performed on an external test set. The AUC values were 0.99 and 0.98.

Proteomic analysis

- The most important proteins were selected to train an artificial neural network to classify tear samples as aqueous-deficient DED, MGD or healthy. The model gave an overall accuracy of 89.3% [9]

5. https://doi.org/10.1101/2021.09.02.21263021
6. URL https://www.sciencedirect.com/science/article/pii/S0010482516301391
7. doi:https://doi.org/10.1167/tvst.8.6.37.
8. doi:https://doi.org/10.1145/3065386.
9. https://www.sciencedirect.com/science/article/pii/S221296851400021X