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Convolutional neural network performances in detecting keratoconus using color and grayscale corneal curvature maps in different architectures

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Footnotes

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Abstract

Purpose : To create and test convolutional neural networks for the diagnosis of keratoconus and evaluate the importance of color information on their performances.

Methods : A total of 36,008 unique Scheimpflug corneal exams were used to evaluate different architectures of convolutional neural networks built from scratch in Python using Tensorflow. After defining the best network architecture, two networks were trained to analyze the axial map of the anterior corneal surface in both, colored and grayscale maps. The Topographic Keratoconus Classification index (TKC) provided by Pentacam was used as a label and the KC2-labeled maps were defined as keratoconus. Each model was trained using 3,000 images of normal and 3,000 keratoconic eyes, and then validated and tested on 1,000 images of each label.

Results : The evaluated network architectures varied in image size (32x32, 64x64, and 128x128 pixels), number of neurons per layer (width), number of layers (depth), and batch sizes (1, 8, 16, and 32 images) (figure 1). After multiple iterations, the optimal network was defined with images of 64x64 pixels in three convolutional layers, consisting of 128, 256, and 512 neurons, respectively. The first two layers were followed by a pooling layer, and the network structure was completed with five fully connected layers containing 1024, 512, 256, 128, and 64 neurons, respectively. The model trained with color images exhibited a sensitivity of 99.6% and specificity of 99.4%, with an Area Under the Curve (AUC) of 0.999890. The grayscale model showed sensitivity of 99.5%, specificity of 99.5%, and AUC = 0.999778 (figure 1). While there was no statistically significant difference in performance between the color and grayscale models, the feature maps indicate that they have distinct patterns of neural activation (figure 2).

Conclusions : The optimal architecture for the neural network was determined. The results support the hypothesis that it is possible to distinguish between normal and keratoconus-affected eyes using the axial map of the anterior corneal surface. The use of color did not impact significantly the network's performance, suggesting that this feature is not relevant to neuron activation.

This abstract was presented at the 2023 ARVO Annual Meeting, held in New Orleans, LA, April 23-27, 2023.

Format	Image size	Batch size	Sensitivity	Specificity	AUC
Color	32x32	1	0.9940	0.9960	0.999928
		8	0.9950	0.9970	0.999914
		16	0.9960	0.9960	0.999927
		32	0.9960	0.9960	0.999910
	64x64	1	0.9920	0.9920	0.999851
		8	0.9960	0.9970	0.999885
		16	0.9960	0.9960	0.999822
		32	0.9970	0.9960	0.999887
	128x128	1	0.9830	0.9920	0.999561
		8	0.9940	0.9970	0.999903
		16	0.9970	0.9940	0.999909
		32	0.9970	0.9950	0.999742
Grayscale	32x32	1	0.9930	0.9930	0.999856
		8	0.9950	0.9950	0.999840
		16	0.9950	0.9940	0.999867
		32	0.9950	0.9940	0.999867
	64x64	1	0.9950	0.9880	0.999795
		8	0.9940	0.9950	0.999807
		16	0.9940	0.9960	0.999823
		32	0.9950	0.9930	0.999814
	128x128	1	0.9970	0.9970	0.999517
		8	0.9955	0.9960	0.999849
		16	0.9960	0.9930	0.999669
		32	0.9960	0.9940	0.999766

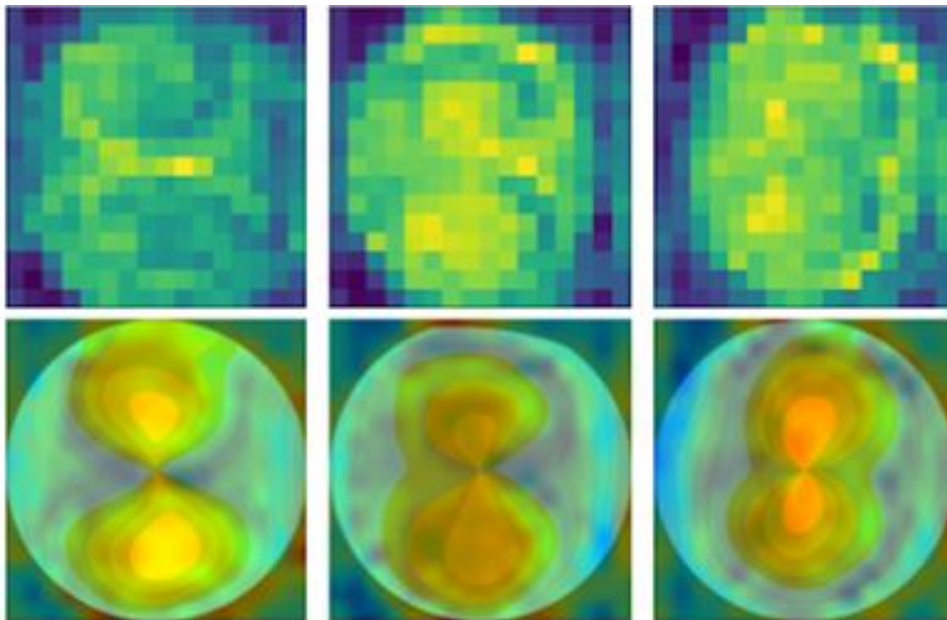
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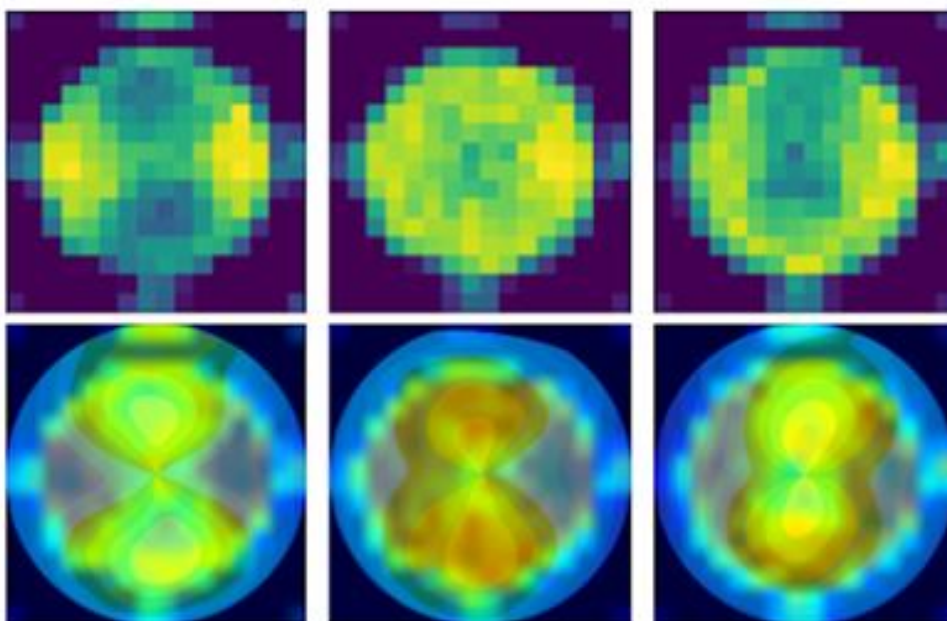
Comparison of sensitivity, specificity and AUC between different training parameters.



(a)



(b)

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Resulting feature maps for (a) color-maps model; and (b) grayscale-maps model.

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