Artificial intelligence technology for myopia challenge

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diabetic retinopathy (DR)
age-related macular degeneration (AMD)
cataracts

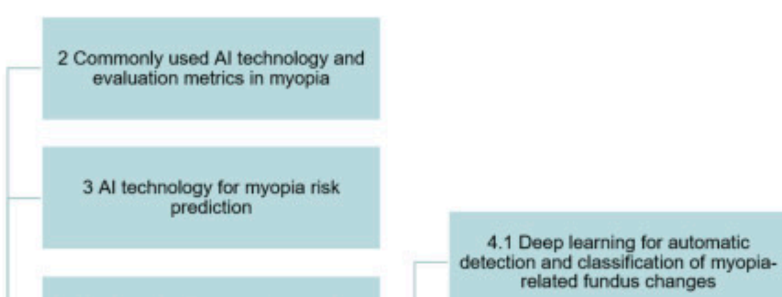
Introduction:
Myopia: blurred vision at a distance / refractive error / the high corneal curvature and long eye axis cause distant objects to be imaged in front of the retina
As myopia progresses further, the axial length (AL) increases,
Optic disc tilts and twists
28.3%, and this number will grow to 49.8% by 2050

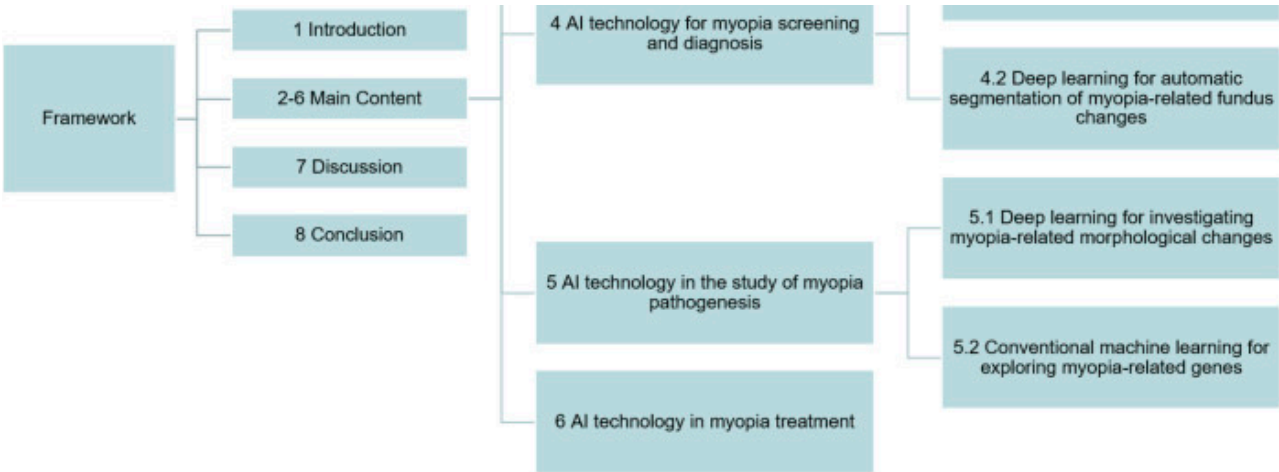
Challenges:
A) Unclear pathogenesis: genetics, environment, and lifestyle
B) Large screening workload: Myopia can only be prevented but not cured
C) Difficulties in risk prediction.
D) Uncertain efficacy: how to choose the most appropriate

myopia risk prediction, myopia screening and diagnosis, myopia pathogenesis, and myopia treatment

Understand Strenghts and limitations of AI helps to choose better

automated analysis automated screening, diagnosis, or risk assessment based on clinical and imaging data





2. Commonly used AI technology and evaluation metrics in myopia
Several AI methods and select best performin
ML train computers to learn relationships between inputs and outputs / large data
Linear regression / svm / random forest
XGBoost and Gradient Boosting
deep learning : ResNet, DenseNet, Inception V3, MobileNet, UNet, and VGGNet
data privacy issues

Evaluating performance:
Classification: confussion matrix AUROC , AUPRC give a more general idea of the classifier performance
Segmentation - prediction region - fungus : Intersection of union (IoU) and Dice similarity coefficient (DSC)
Classification: disease detection and prognosis prediction: accuracy, sensitivity, specifity, F1 score
regression tasks (MAE MSE RMSE) such as refraction prediction and axial length prediction

(A) The confusion matrix. **(B)** Evaluation metrics for segmentation tasks in the field of myopia. **(C)** Evaluation metrics for classification tasks in the field of myopia. **(D)** Evaluation metrics for regression tasks in the field of myopia. yi is the ground-truth value of sample i and $\hat{yi}$ is the predicted value of sample i .

		Truth	
		Positive	Negative
Predict	Positive	True positive (TP)	False Positive (FP)
	Negative	False negative (FN)	True negative (TN)

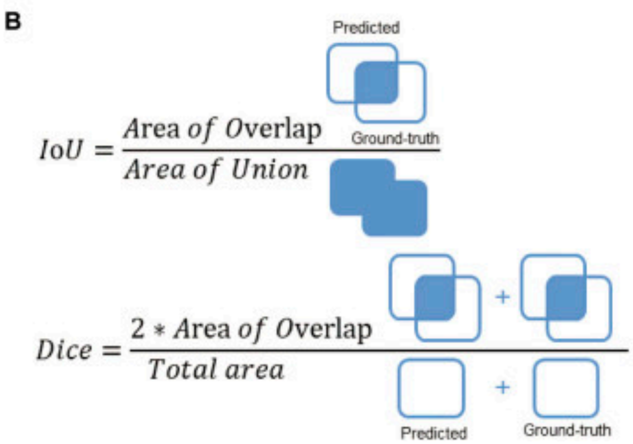
$$Sensitivity = \frac{}{TP + FN}$$

$$Specificity = \frac{TN}{TN + FP}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$F1\ Score = \frac{2 * \left(\frac{TP}{TP + FP}\right) * \frac{TP}{TP + FN}}{\frac{TP}{TP + FP} + \frac{TP}{TP + FN}}$$

B



D

$$MAE = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)$$

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2}$$

3. AI technology for myopia risk prediction
   myopia-related risk factors (e.g., near work time, outdoor activity time, genetics, race, gender, etc.), best-corrected visual acuity, refraction, axial length, and some ocular metrics (e.g., intraocular pressure, ocular surface conditions)
   Large data is hard to analyse
   showed that robust regression model was able to achieve an accurate prediction of axial length growth
   With more information that can be mined, not only can the model performance be improved, but also more application scenarios will emerge.
   myopia-related fundus lesions are not obvious in their early stages and are difficult to describe or quantify.

4. AI technology for myopia screenning and diagnosis
   manual interpretation of these images is laborious and even unfeasible.
   myopia-related fundus lesions are not obvious in their early stages and are difficult to describe or quantify

   4.1 Deep learning for automatic detection and classification of myopia-related fundus changes
   The detection of fundus lesions and myopia-related complications in high myopia is an important need
   CNNs already have high accuracy

CNNs already have high accuracy

The structure of CNNs

- Preprocessing: noise reduction, enhancement of FP, OCT (images) or other pictures, unifying resolution, focusing on regions of interest (ROIs)
- feature extraction (backbone network or core) Convolutional kernels are selected to extract image features by convolutional operation on the original input image.
- classification: fully connected layers, which convert the output feature map of the last convolutional layer into a one-dimensional vector. probability : Sigmoid or Softmax
- special modules representing various novel ideas

Commonly used modules in ophthalmic image processing include attention mechanisms, residual connectivity, and bottleneck structures.
The fact that in fundus image analysis, the number of pixels in target structures such as lesions, optic cups optic discs and blood vessels is much less than the background and the curved structure of blood vessels (especially capillaries) is often complicated.

Proposing customized backbone networks or special modules based on the characteristics of myopia-related tasks could be a way to further improve the model performance.

Detection and differentiation of diverse classes of myopia related fundus
More difficult? Increase deph of backbone network

traditional convolutional neural networks such as AlexNet and VGG16 may suffer from gradient explosion or disappearance when the depth is increased

New methods represented by ResNet, InceptionNet, DenseNet

4.2 Deep learning for automatic segmentation of myopia-related fundus changes
better comprehend the morphological changes
aid in the training of physicians to interpret images

UNet is one of the most commonly used models for semantic segmentation of medical images
Decoder-Encoder

Accurate segmentation results were obtained even for the thin choroid of highly myopic

patients. By using the upgraded version of UNet, namely UNet++, the segmentation of optic disc, retinal atrophy lesions, and retinal detachment lesions was also satisfactory

Feature Pyramid Networks (FPNs)

5. AI technology in the study of myopia pathogenesis

   5.1 deep learning for investigating myopia-related morphological changes

   Artificial intelligence (AI) can help identify changes in myopic eyes.
   predict eye conditions
   Deep learning , analyze images, predict with low error rates
   gradient-weighted class activation mapping Grad-CAM identifies the important areas in the image
   heatmap for the prediction, area of interest optic disc and macula
   AI techniques can analyze fundus images to predict ChT accurately

   5.2 conventional machine learning for exploring myopia-related genes
   identify genes associated with myopia
   analyzing genetic links, studying specific genes, and conducting large-scale genetic studies.

   Conclusion:
   AI research should be just applying models, more attention to technical problems
   more technical approaches need to be proposed according to the characteristics of each task.