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Detection and Classification Strabismus Using Convolutional Neural Network and Spatial Image Processing

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Abstract : Strabismus refers to a misalignment of the eyes. Early detection and treatment of strabismus in childhood can prevent the development of permanent vision loss due to abnormal development of visual brain areas. We developed a two-stage method for strabismus detection and classification based on photographs of the face. The first stage detects the presence or absence of strabismus, and the second stage classifies the type of strabismus. The first stage comprises face detection using Haar cascade, facial landmark estimation, face alignment, aligned face landmark detection, segmentation of the eye region, and detection of strabismus using VGG 16 convolution neural networks. Face alignment transforms the face to a canonical pose to ensure consistency in subsequent analysis. Using facial landmarks, the eye region is segmented from the aligned face and fed into a VGG 16 CNN model, which has been trained to classify strabismus. The CNN determines whether strabismus is present and classifies the type of strabismus (exotropia, esotropia, and vertical deviation). If stage 1 detects strabismus, the eye region image is fed into stage 2, which starts with the estimation of pupil center coordinates using mask R-CNN deep neural networks. Then, the distance between the pupil coordinates and eye landmarks is calculated along with the angle that the pupil coordinates make with the horizontal and vertical axis. The distance and angle information is used to characterize the degree and direction of the strabismic eye misalignment. This model was tested on 100 clinically labeled images of children with (n = 50) and without (n = 50) strabismus. The True Positive Rate (TPR) and False Positive Rate (FPR) of the first stage were 94% and 6% respectively. The classification stage has produced a TPR of 94.73%, 94.44%, and 100% for esotropia, exotropia, and vertical deviations, respectively. This method also had an FPR of 5.26%, 5.55%, and 0% for esotropia, exotropia, and vertical deviation, respectively. The addition of one more feature related to the location of corneal light reflections may reduce the FPR, which was primarily due to children with pseudo-strabismus (the appearance of strabismus due to a wide nasal bridge or skin folds on the nasal side of the eyes).

Keywords : strabismus, deep neural networks, face detection, facial landmarks, face alignment, segmentation, VGG 16, mask R-CNN, pupil coordinates, angle deviation, horizontal and vertical deviation
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