# Survey of Strabismus Detection Techniques

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***Abstract*— Strabismus, or "crossed-eyes," is one of the most common ocular diseases. Strabismus has a serious impact on human life. Patients with strabismus not only have visual but also psychological and social effects from their condition. In adults, one study showed that large-angle horizontal strabismus could affect one's ability to gain employment. This appeared to be more important for women's employability than men. These psychosocial effects may be influenced by whether the degree of ocular misalignment is detectable by those with whom they have contact. If the strabismus is not detectable, presumably the observers' negative feelings for strabismus would not be invoked. As a result, a timely strabismus screening becomes important and essential for preventing strabismus. So far, there are multiple ways to complete strabismus screening. Traditional strabismus screening is conducted manually by ophthalmologists through many tests, such as the cover and uncover test, prism cover test and the Hirschberg test. The proposed method uses a frontal facial image from a patient, and it measures the deviation of the positional similarity of two eyes within the image, which aims to provide ophthalmologists with interpretable information for the diagnosis of strabismus.**

***Index Terms*—Strabismus Detection, Convolutional Neural Network, K-Nearest Neighbors, Support Vector Machine**

## I. Introduction

Strabismus, often referred to as "crossed-eyes," is a prevalent eye condition affecting approximately 4-8% of the Indian population, with children being the primary demographic. Beyond its impact on vision, strabismus carries significant psychological and social consequences, including challenges in interpersonal relationships, academic performance, and self-esteem. Moreover, the risk of amblyopia, leading to irreversible vision loss, is a major concern associated with strabismus. Early detection is paramount, as timely screening can prevent complications related to strabismus. However, negative societal perceptions, particularly towards children with strabismus, can exacerbate the impact on their overall well-being. Diagnosis typically involves a range of exams, including visual acuity assessments, eye background examinations, and eye movement tests like the Cover and Hirschberg tests. The latter involves projecting light into the eyes to assess the symmetry of corneal reflections. While technological advancements in ophthalmology have been remarkable, the subspecialty of strabismus often receives less attention. In remote areas where access to expert professionals is limited, digital tools have emerged as invaluable resources for streamlining and simplifying the screening process. However, some high-tech solutions, such as eye trackers and virtual reality headsets, may be impractical due to cost constraints in resource-limited settings. In response to this challenge, low-cost and efficient digital tools like photo screeners and automatic strabismus screening using digital images have gained traction. Although deep learning methods hold promise in this regard, their complex internal learning processes can pose challenges in result interpretation. The overarching goal remains to make strabismus screening accessible and cost-effective, particularly in regions with limited medical resources.



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## II. RELATED WORKS

### *A. A Detection of Amblyopia using Image Processing and Machine Learning Techniques*

It consists of two main steps: feature extraction and image processing. In order to successfully classify images, textures are extracted in image processing and used as input for neural networks. In order to extract important details from the photos, feature extraction is crucial and uses methods like thresholding and clever edge detection. Additionally, supervised learning is quite important and involves utilizing Python to construct algorithms such as KNN (K-Nearest Neighbour) and Logistic Regression. Handling data, calculating distances, locating nearest points, predicting classes, and evaluating accuracy are all part of the process. Through the integration of these elements, the methodology guarantees a thorough approach to picture classification, utilizing cutting-edge methods in3 machine learning and image processing to produce reliable and accurate outcomes. Several methods are used [1] to manage data, compute distances, locate nearby spots, forecast classifications, and evaluate accuracy. The Random Forests Classifier algorithm is highly valued for its adaptability and ease of usage among them. The main objective of the study is to efficiently diagnose amblyopia using methodical techniques and to attain high diagnostic accuracy rates. The employed algorithms exhibit potential in the timely identification of amblyopia, providing possible treatments for those who are impacted.

### *B. A Novel Method for Measuring Subtle Alterations in Pupil Size in Children With Congenital Strabismus*

Anisocoria, a condition where pupils differ by more than 0.4 mm, is a key consideration in neurological assessments. Common methods involve infrared photography, often focusing on perimeter or diameter rather than pupil area. Baseline pupil measurements serve as a foundational step before introducing age-appropriate stimuli to elicit dynamic responses. This methodological approach is crucial for understanding the intricate dynamics of pupil behavior. The deliberate choice of stimuli tailored to different age groups ensures a nuanced exploration of how individuals respond to varying visual or auditory inputs. The multifaceted nature of this research design, encompassing both baseline measurements and dynamic response analysis, enhances the robustness and comprehensiveness of the findings. By systematically examining pupil reactions across different age groups and stimuli scenarios, researchers can uncover patterns, trends, or anomalies that contribute to a deeper understanding of the factors influencing pupillary responses. The Pattern Pupil (PP) concept improves analysis by allowing independent scrutiny of each pupil, presenting a more comprehensive understanding of shape and size alterations [2]. Notably, this approach is particularly valuable in congenital strabismus, where cortical disorders are subtle and challenging to capture using conventional neuroimaging techniques. This approach not only provides valuable insights into the complex interplay between age, stimuli, and individual reactions but also contributes to the broader understanding of pupillometry as a research tool in various fields and compares the group as anisocoria as shown in Fig. 1.

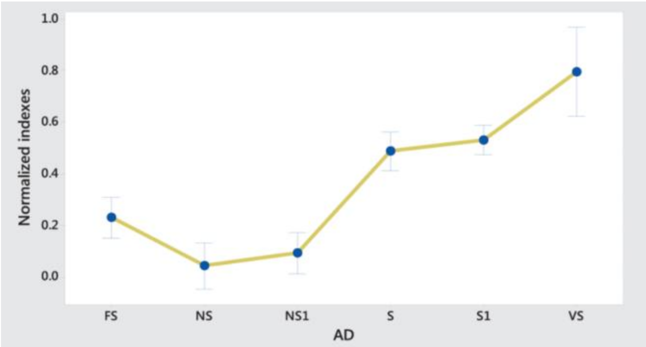


Fig. 1. Comparison among the groups of anisocoria

### *A. An automatic screening method for strabismus detection based on image processing*

The condition known as strabismus, or squint, is caused by improper eye alignment. Lazy eyes and double vision are two visual issues that may result from this. First step is taking the eye picture of the patient. Extraction of features from the eye image is the second step. The distance between the pupil centre and canthus landmarks are obtained as shown in Fig. 2. The trained CNN will allocate a probability to each class (strabismic or non-strabismic) based on a comparison between the features extracted from the eye image and the features from the training dataset [3]. These characteristics may be determined by the gaze angle, iris shape, and eye position. The trained CNN will allocate a probability to each class (strabismic or non-strabismic) based on a comparison between the features extracted from the eye image and the features from the training dataset. Since it is non-invasive, there is no need to make physical contact with the patient. It doesn't require any specialized equipment and can be completed quickly and easily.

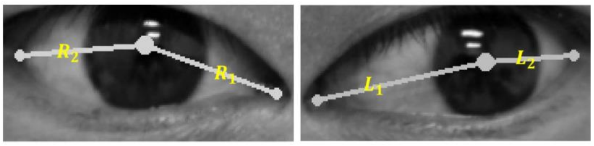


Fig. 2. Distance estimation between the pupil centre and canthus landmarks

*B. Eye Computer Based Eye Tracker for the detection of Manifest Strabismus*

The visual impairment known as strabismus, or squint, is typified by misaligned eyes. The brain receives different images from misaligned eyes, which can cause amblyopia (lazy eye), double vision, or blurred vision. Using a combination of machine learning techniques and eye-tracking data analysis, the proposed eye-tracking aided system for strabismus diagnosis classifies eye alignment patterns as either normal alignment or strabismus.

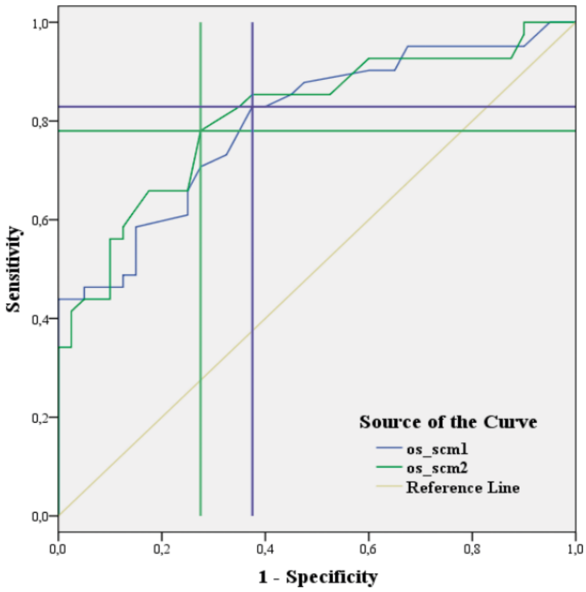


Fig. 3. The relation between sensitivity and specificity

The four main steps of this system are as follows: (1) gathering data at a high sampling rate using a computer-based eye tracker; (2) analysing eye position data to identify saccades, smooth pursuit eye movements, and fixations; (3) extracting features from the analysed eye position data to characterize eye alignment; and (4) classifying the data using a machine learning algorithm to differentiate between strabismus and normal alignment. The method can help with early detection and intervention for strabismus, potentially preventing vision loss. This promising performance can be attributed to the system's use of a machine learning algorithm that was able to understand the intricate relationships between eye movements and alignment patterns, as well as its thorough feature extraction process, which successfully extracted pertinent information from eye tracking data [4]. This high accuracy indicates that the suggested method has the potential to detect strabismus objectively and reliably. Fig. 3 shows the relation between sensitivity and specificity.

*C. An intelligent strabismus detection method based on Convolution Neural Network*

A convolutional neural network (CNN) is used in the proposed model in this work to create a detailed features vector for automatic strabismus identification. The model is divided into two stages: first, the eye region is separated from the face using the viola-jones method. Second, map the segmented eye areas into one of two output classes (strabismus: 1 or normal: 0) based on the iris location of each eye. Identifying eye areas from the face is the main technique for detecting strabismus in humans [5]. After acquiring the eye region, the following step is to divide the left and right eye segments. The spatial arrangement of neurons in CNNs is a basic feature that renders them valuable for an extensive array of applications and evaluation metrics will be used to assess the model's performance. Furthermore, a CNN model-based deep learning approach was used to automatically detect strabismus. The study approach segments the eye region using the viola-jones algorithm first, and then employs CNN to categorize the segmented regions as strabismus. Fig. 4. shows the accuracy obtained which was 95.62%.

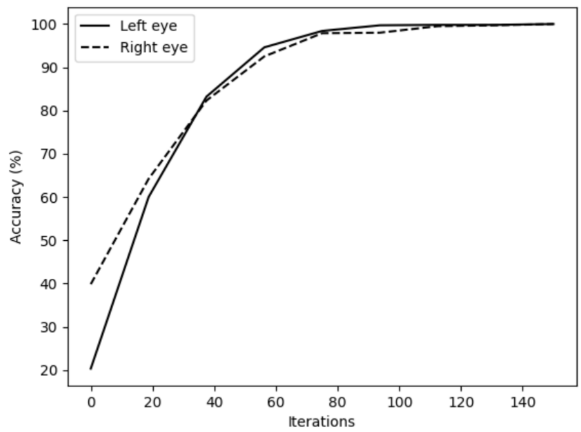


Fig. 4. The accuracy of training state of CNN model of left and right eyes

*C. An Detection of Referable Horizontal Strabimus in Children's Primary Gaze Photographs using Deep Learning*

The study [9] used the TensorFlow framework to develop deep learning algorithms. On an Ubuntu 16.04 operating system with hardware setups, models were trained. The algorithm's performance was assessed using diagnostic metrics such area under the receiver operating curve (AUC), sensitivity, specificity, and accuracy. A dataset for external validation was gathered to evaluate the deep learning model. A two-phase deep learning technique was used, with Inception-V3 networks used for classification and Faster R-CNN for ROI identification. The deep learning technique produced an AUC of 0.99 with a sensitivity of 94.0% and a specificity of 99.3% in the external validation dataset. With a 95% accuracy rate, the deep learning algorithm diagnosed referable horizontal strabismus more accurately than resident ophthalmologists. A deep learning model for automatically detecting referable horizontal strabismus in images of children's main gaze was effectively built and assessed by the study. A deep learning model for automatically detecting referable horizontal strabismus in images of children's main gaze was effectively built and assessed by the study. The clinical evaluation and screening process for children at risk of strabismus can be improved by automating the identification of strabismus using deep learning techniques.

## III. DISCUSSION AND ANALYSIS OF STRABISMUS DETECTION TECHNIQUES

Many methods, including CNN, SIFT, SVM and KNN, are widely used in the diagnosis of strabismus. Although tree algorithms are used, their complexity frequently prevents industry adoption on a large scale. CNNs are particularly good at interpreting complex patterns from eye pictures are good at identifying and distinguishing characteristics, which helps with diagnosis. Despite their usefulness, tree algorithms are not as widely used as they may be due to their processing requirements and interpretational difficulties. In general, the accuracy and suitability of CNNs, SVM and CNN/5 fold cross validation stand out as especially remarkable for diagnosing strabismus as seen in Table 1. Nevertheless, continuous work is necessary to improve and validate these methods even more, guaranteeing their applicability to a wide range of demographic groups. To further improve accessibility and scalability, machine learning and image processing techniques must be incorporated into current healthcare systems. The field of strabismus diagnostics can make great advancements in early detection and better patient outcomes by utilizing the capabilities of these cutting-edge technology, which will ultimately enhance the standard of treatment for those who are afflicted.

TABLE I. Comparison of different algorithms

| ALGORITHM | YEAR | DATASET | ACCURACY (%) |
|---|---|---|---|
| CNN | 2022 | UCI | 95.62 |
| SVM | 2021 | Sestre Milosrdnice University Hospital, Croatia | 92.4 |
| CNN/5 fold cross validation | 2018 | Clinical dataset | 95 |
| KNN | 2019 | Clinical dataset | 70 |

## IV. CONCLUSION

To lessen the negative impacts of this common ocular disorder, early and accurate screening methods are crucial, as demonstrated by the study of strabismus detection techniques. Even though they are effective, traditional screening procedures frequently rely significantly on ophthalmologists' manual assessments, which limits their accessibility and effectiveness—especially in areas with limited resources. But new developments in digital technologies have created opportunities for creative and automatic strabismus detection methods. To diagnose strabismus, techniques like eye tracking, convolutional neural networks (CNNs), and image processing algorithms like SIFT and Canny edge detection have shown encouraging results. These methods combine accessibility, efficiency, and precision to create a powerful tool for early identification and intervention. Additionally, incorporating machine learning algorithms improves the diagnostic results' interpretability and accuracy. Even with these developments, there are still issues to be resolved, such as the requirement for additional testing and improvement of digital screening techniques, especially in populations with a variety of demographics. For broad adoption and impact, it is also essential to work toward affordable solutions and integration with the current healthcare infrastructure. Overall, the poll highlights how digital technologies can have the ability to revolutionize strabismus screening, increasing outcomes and augmenting the quality of life for those who are affected.

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