Performance Analysis of Machine Learning Algorithms for Strabismus Detection – A Systematic Review

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Abstract— In recent days statistical reports focus those 8 to 10 conditions in kids whenever analysed early can forestall youth visual impairment which incorporates youth Strabismus (Squint Eye), Amblyopia (Lazy Eye) and so on, metropolitan regions have 1 ophthalmologist for 10,000 individuals yet in country zones, it is 1 for every 2,50,000 individuals. This paper provides a systematic study based mainly on strabismus detection surveys using Machine Learning techniques. Among all Machine Learning Algorithms Convolution Neural Network - CNN produces more accuracy of 95.83%. than Support vector machine -SVM.

Indexed Terms-- Strabismus (Squint Eye or Crossed Eye), Machine Learning, Accuracy, Sensitivity, Specificity, Convolution Neural Network - CNN, Support vector machine -SVM.

I. INTRODUCTION

India in 2020, stated in a report named 'Status of Child Eye Health in India' distributed by Orbis, an NGO that works in the counteraction and treatment of visual impairment [1]. The report features the metropolitan provincial difference, some eye issues are available upon entering the world, and others create as the youngster develops between the age of 0 years to 10 years. A major part of them are recognizable and treatable and the leftover is not.

Early identification of 35% of preventable reasons for visual deficiency in youngsters can massively decrease the monetary weight of visual deficiency in India, it added. This paper presents a comparative analysis of different techniques for detecting Strabismus we analyzed few papers which can detect Strabismus using Machine Learning based algorithms.

We mainly focused on papers that are related to Machine Learning techniques for detecting the Strabismus analysis and listed some key points. Section 1 describes an introduction of survival rates published by AIIMS and Orbis, India. Section 2 briefs different Machine Learning (ML) techniques. Section 3 brings out a literature survey based on ML techniques based on the strabismus dataset. Section 4 focuses on dataset and evaluation metrics used for specification comparison. Section 5 lists the performance parameters which highlights key points that help us for the completion of this survey.

II. MACHINE LEARNING TECHNIQUES

Machine learning (ML) and artificial intelligence (AI) imitate the way humans gain certain types of knowledge. Machine learning is a significant component of information science, which incorporates measurements and predictive modeling. The field of AI (ML) [2], which crosses these orders, examines the computational cycles that underlie learning in the two people and machines. The field's main objects of study are the artifacts, specifically algorithms that improve their performance at some task with experience. Classification is among the most common methods that go under supervised learning. It utilizes verifiable labeled [3] information to build up a model that is then utilized for future forecasts. In the clinical field, facilities and clinics keep up huge data sets that contain records of patients with their manifestations and conclusion. Therefore, researchers make use of this knowledge to develop classification models that can make inferences based on historical cases. Clinical surmising has thusly become a lot less difficult assignment with machine-based help utilizing the sheer measure of clinical information that is accessible today. It is useful to note that the entirety of the strategies used in this paper fall under classification models.

I. Convolutional neural network - CNN

The convolutional neural network is a class of machine learning techniques [5] that has gotten predominant in different PC vision undertakings, including ophthalmology. The convolutional neural network is made out of numerous structure blocks, for example, convolution layers, pooling layers, and complete associated layers, and is intended to consequently and adaptively learn spatial orders of highlights through a backpropagation calculation.

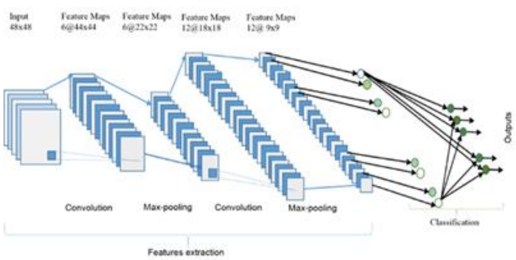

Fig 1 . Architecture of Convolutional neural network – CNN [22]

II. Random forest- RF

How a jury in the court is assembled for deciding in the court, this algorithm gathers numerous decision trees to form a forest of trees. RF uses a collection of trees rather than having a single decision tree as it gives either a very simple model or a specific one [6]. Compared to individual decision trees RF has better stability. This calls attention to that RF is unaffected by the commotion present in the information. RF has the element of dealing with information minorities as is utilized for disease identification. It additionally identification of outliers. It likewise incorporates developing and consolidating trees, self-testing, and post-preparing.

The RF calculation has a recursive methodology, the informational collection whose size is signified by N and is supplanted, another example is arbitrarily picked from the indicators and isn't supplanted. The above advance is done at each cycle after which the information that has been acquired is partitioned. The out-of-pack information is then dropped and relying upon the number of trees required. Ultimately, a count is made on the number of trees that fall under both classifications. At that point, the order is finished relying upon most of the decisions in favor of the choice trees [6].

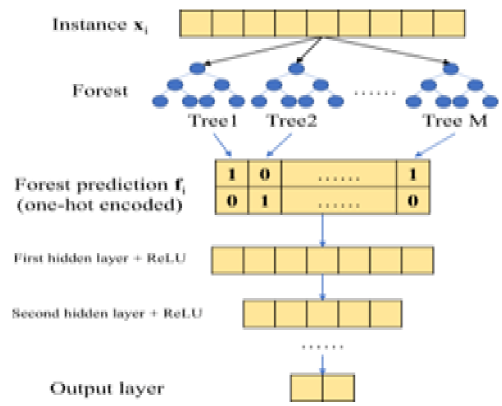

Fig 2. Hierarchy of Random Forest [6]

III. Support vector machine-SVM

It is the regulated AI arrangement procedure that partitions the dataset into classes utilizing an appropriate maximal edge hyperplane for example the improved choice limit [7]. This method is generally utilized in the field of medication for the determination of the sickness. As the dataset may have numerous such hyperplanes, SVM calculation performs edge amplification which implies that it attempts to make the greatest hole between various classes [7][8]. In this dataset, we notice the haziness in classes. A basic line can't isolate the strabismus dataset into wanted classes. The haziness is found in Fig 3

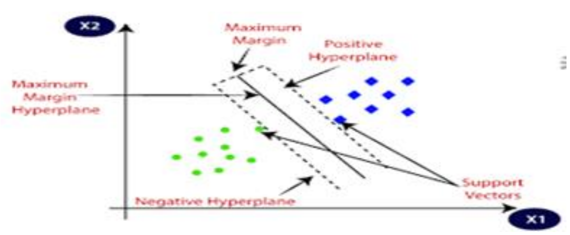

Fig 3. Classes of Support Vector Machine –SVM [23]

To overcome this complexity, we apply transformation and add one more dimension as we call it the z-axis. Presently if the dataset is plotted in Z-axis, the unmistakable qualification between the classes is obvious. This transformation is done using kernels. Polynomial and exponential kernels compute division lines in higher measurement [8]. In Fig 4 given below, we can see how kernels have played a major role in obtaining a distinction in the strabismus dataset.

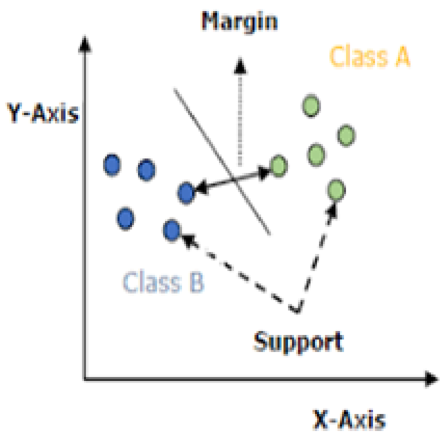

Fig 4. Graph representation of class transformation [23]

III. DATASET AND EVALUATING METRICS

I. Dataset

The training dataset collection that has been utilized in this paper is taken from the strabismus Dataset [18]. We have altogether 2400 examples, with 1000 ordinary examples and 1400 strabismic tests. That is, each time one example is utilized for testing, and the rest examples are for preparing. We would thus be able to have 1400 distinct outcomes. The 1400 outcomes arrive at the midpoint of getting the last presentation [18]. A linear kernel of an SVM is utilized for both the CNN strategy and standard technique, and the SVM classifiers are prepared to utilize a two-fold cross-validation scheme.

II. Evaluation Metrics

This section describes the parameters and sets forth the result of different machine learning techniques that are being explored in this paper Sensitivity, Specificity, Accuracy [3][4].

Sensitivity (Se) and Specificity (Sp) indicate the calculation's capacity for distinguishing normal images and strabismus images.

The Sensitivity can be calculated as:

Sensitivity = TP / TP+FN

The Specificity can be calculated as:

Specificity = TN / TN+FP

Accuracy is also known as the recognition rate. The formula of accuracy is given as the total number of cases identified as correct divided by the total number of cases in the dataset. AUC also gives the overall performance [3] [4]
The accuracy is determined as:

Accuracy = (TP+TN) / (TN+FP+FN)

where *TP* (genuine positive), *TN* (genuine negative), *FP* (bogus positive), and *FN* (bogus negative) are the quantities of effectively distinguished strabismus pictures, accurately recognized ordinary pictures, erroneously recognized strabismus image and inaccurately distinguished typical image, individually.

IV. LITERATURE SURVEY

In this section, we are discussing Strabismus statistics[1] provided by popular standards such as, New All India Institute of Medical Science Delhi(AIIMS). Along with statistics we are also discussing some previous work related to Strabismus detection using Deep Learning and Machine Learning Algorithms. The National Survey on Human Resources & Infrastructure for Paediatric Eye Care Services in India. As of fifteenth October 2020, there are almost 10303 eye establishments in the whole country, out of which 8125 (78.9%) foundations have been reached telephonically for investment in the HR overview. Out of them, finished reactions have been gotten from 7200 organizations (Response Rate 88.6%) and around 2000 foundations were found to have pediatric arranged administrations (characterized as pediatric OT offices under broad sedation).

National Blindness Survey[1] was finished in 30 regions and the National Trachoma Survey in 24 regions in the country with help from the National Program for Control Blindness (NPCB), Government of India. Under the NBS and in each locale, an example of 3000 members matured 50 years or more were listed and at any rate, 90% of them have inspected across 50 groups spread all through the area. More than 93,000 members were taken a crack at the National Blindness Survey and more than 25,00 kids and 55,000 grown-ups in the National Trachoma Survey.

Generally, the Community Ophthalmology division[1] has been occupied with different public level visual deficiency overviews, INDEYE and INDGEN concentrate on age-related eye illnesses and their hereditary part as a team with LSH&TM, labour, and the executives preparing with Lions Club International Foundation, operational examination concentrates with ORBIS, situational assessment of eye care infrastructure, Corneal Opacity Rural Epidemiological (CORE) study, North India Myopia Study (NIMS), training programs in primary eye care.

Aragawkegne Assaye, Melkamu Temeselew Tegegn, Natnael Lakachew Assefa [9], In their paper highlighted a study to assess information about strabismus and related elements among grown-ups in Gondar town, Northwest Ethiopia Strabismus/squint is a visual misalignment where the eyes are not appropriately lined up with one another. It is an avoidable reason for visual impairment and has a worldwide commonness that goes from 2% to 6%. Information on eye illnesses is significant in urging individuals to look for early treatment, which further aids in lessening the weight of visual impedance. Studies in Ethiopia showed that the degree of good information was 37%. Data are absent concerning information and related components of strabismus in the examination region and restricted in Ethiopia on the loose. Other than a sum of 553 grown-ups with a reaction pace of 93.25% took an interest in the investigation.

Yang Zhenga,b, Hong Fuc, Ruimin Li a,b, Tai-Chiu Hsung d, Zongxi Songa, Desheng Wena [10] proposed a deep neural network evolutionary parametric eye modeling to build a fine and accurate model of eyes and the fitness evaluation to measure the fitting effect of the parametric curves. The CNN works as the wellness function in the genetic algorithm, of which the input is the Contour-Eye picture, and the yield is the class label. The overall classification accuracy is 73%.

Kaushik Murali, Viswesh Krishna, Vrishab Krishna, B Kumari [11] applied algorithm an F-Score in detecting the ARF to obtain necessary features they conducted a clinical validation with a sample of 658 children (5% level of significance and 3% error limit of detection) with a mean age of 8.86 years (range 2 to 15 years). The algorithm had an overall accuracy of 81.00%, with a sensitivity of 89.55% and specificity of 78.81%.

Julia E. Reida,b and Eric Eatonc [12] Summarised machine learning–based techniques for pediatric ophthalmic sickness strabismus identification and characterized different methods to discover the exactness of each utilized different procedure for discovering best precision of different CNN calculations utilizing strabismus datasets. This framework is the first to distinguish strabismus distantly from advanced facial pictures. As a telemedical application, this could help figure out which youngsters require an ophthalmology reference for strabismus. Strabismus RF-CNN Strabismus utilized Two-stage CNN: eye districts sectioned from face pictures through R-FCNN-layer CNN to SVM/VGG-S Strabismus presence. Eye-following look maps CNN (VGG-S pre-trained on Image Net) highlights SVM Pediatric vision Screener. At last, demonstrated that CNN gives the best exactness when contrasted and other calculation.

Sadie Malic, Nadia Kanwal, Maroona Navaid Asher, Mohammad Ali A. Sadiq, Irfan Karamat, and Martin Fleury [13] Attributable to an organized information course of action, the arbitrary woods, and choice tree calculations' forecast rate is over 90% when contrasted with more intricate strategies, for example, neural organizations and the innocent Bayes calculation.

K. Praveen, S.Lalitha, S.Gopinath [14] in their paper proposed implementation on strabismus dataset which was applied in different ML algorithms CNN, Random forest methodology classified in two steps, one is Image Processing feature Extraction, second is Supervised learning and proved that CNN algorithm accuracy is 0.70% which is high when compared with Random Forest.

Gramatikov BI [15] Depending on the direction of gaze and the instrument plan, the screener creates a few sign frequencies that can be utilized in the identification of focal obsession. In his examination contrasted fake neural organizations and old-style factual strategies, concerning their capacity to distinguish focal obsession dependably. A traditional feedforward, design acknowledgment, two-layer neural organization engineering was utilized, comprising of one concealed layer and one yield layer. The yield proposes the presence or nonappearance of focal obsession. Backpropagation was utilized to prepare the network. The network was prepared, approved, and tried on a bunch of controlled adjustment information got from 600 estimations from ten eyes in a past report[15], and was furthermore tried on a clinical arrangement of 78 eyes, freely analyzed by an ophthalmologist. In the initial segment of this examination, a neural organization was planned around the adjustment set. With legitimate engineering and preparing, the organization gave execution that was practically identical to traditional measurable strategies, permitting ideal division between the focal and paracentral obsession information, with both the affectability and the particularity of the instrument being 100%. In the second piece of the examination, the neural organization was applied to the clinical information. It permitted solid partition between ordinary subjects and influenced subjects, its precision again coordinating that of the factual strategies.

JieweiLua, Zhun Fana, Ce Zhengb, Jingan Fenga, Longtao Huanga, Wenji Lia, Erik D. Goodmanc [16] focused on the RF-CNN algorithm which detects Strabismus because it's a widely used best algorithm Deep Learning method. The methodology uses RF-CNN as a two-stage strabismus detection method. For pre-handling tele strabismus, a dataset contains 5685 pictures were applied to actualize the RF-CNN calculation which first uses R-FCN to perform eye area division, and afterward groups the divided eye districts as strabismus or typical with a profound convolutional neural organization. The discovery results showed high scores of Accuracy=0.9389 and AUC=0.9865, which implies that RF-CNN can accomplish generally great recognition results on the setup strabismus dataset.

Ce Zheng, Qian Yao, Jiewei Lu [17] purposed in their study to develop and evaluate deep learning algorithms that screen referable horizontal strabismus in children's primary gaze photographs. The test was finished utilizing 5-fold cross-approval during preparation, the normal AUCs of the DL models were around 0.99. In utilizing the outer approval informational index, the DL calculation accomplished an AUC of 0.99 with an affectability of 94.0% and explicitness of 99.3%. The DL calculation's exhibition (with an exactness of 0.95) in diagnosing referable flat strabismus was superior to that of the inhabitant ophthalmologists (with precision going from 0.81 to 0.85). In the future, they need to execute with more highlights for getting the best outcomes to analyze strabismus precisely.

Zenghai Chen, Hong Fu [18] introduced convolutional neural networks to recognize strabismus using eye-tracking data. A gaze deviation (GaDe) image is then proposed to describe the subject's eye-following information based on the correctness of look focuses. A dataset containing eye-following information of both strabismic subjects and ordinary subjects is set up for tests. Test results exhibit strabismus can be viably perceived by the proposed Baseline Method by utilizing complete 42 examples, with 25 typical examples and 17 strabismic tests. The exactness of the standard technique is 69.1. The standard strategy has a high particularity (84%) yet an extremely low affectability (47.1%). This implies that the benchmark technique is harsh toward strabismic information.

Tyson N. Kim[19] employed, Convolutional Neural Networks (CNN) for higher classification accuracy on the strabismus dataset The performance scores obtained with accuracy were 95.83 %, sensitivity (0.93), and specificity (0.97).

Seira Tak, Prof. K. J. Satao [20] using SVM deep learning algorithm efficiency of detection of squint eye has been kept Obtained inception range of 80% and 85% the training set data used is clinical strabismus dataset
Almeida JD, Silva AC, Paiva AC, Teixeira JA.[21] described a paper for the calculation of the alignment between the eyes on digital images obtained from the Hirschberg test using the SVM algorithm The methodology has produced results on the range of 100% sensibility, 91.3% specificity, and 94% for the correct identification of strabismus.

V. PERFORMANCE ANALYSIS OF DIFFERENT MACHINE LEARNING ALGORITHMS ON STRABISMUS DETECTION

Based on the survey performed on many papers related to Machine Learning techniques which detects Strabismus we found some key points Table-1 that are shown below

Table-1 Key points in our survey

Paper Published Year	Corresponding Author Name	Algorithm	Dataset	Specification Parameters (%)
2020	Yang Zhenga ,b	CNN/ Parametric modeling	Clinical dataset	Accuracy =73
2020	Kaushik Murali	CNN	Clinical dataset	Accuracy =81.00 Sensitivity =89.55 Specificity= 78.81
2019	Julia E. Reida,b and Eric Eatonc	RF-CNN /Two-stage CNN	Strabismus dataset	Sensitivity=93.30 Specificity =96.17 Accuracy =93.89
2019	Julia E. Reida,b and Eric Eatonc	CNN /SVM /VGG-S	Strabismus dataset	Sensitivity=94.1 Specificity=96.0 Accuracy =95.2
2019	Julia E. Reida,b and Eric Eatonc	Signals from retinal birefringence scanning two-layer feed-forward neural net	Clinical dataset	Sensitivity= 100.0 Specificity =100.00
2019	Sadie Malic	Random Forest	Clinical dataset	Accuracy = 93.5
2019	K. Praveen , S.Lalitha , S.Gopinath	CNN	Strabismus dataset	Accuracy =0.70
2019	Gramatikov BI	CNN Backpropagation	Callibaration dataset	Sensibility=100 Specificity =100
2018	JieweiLua , Zhun Fana, Ce Zhengb , Jingan Fenga , Longtao Huanga , Wenji Lia , Erik D. Goodmanc	RF-CNN	Strabismus dataset	Accuracy =0.9389, Sensitivity=0.9330 Specificity=0.9617
2018	Ce Zheng, Qian Yao, Jiewei Lu	CNN/5-fold cross-validation	External validation strabismus dataset.	Sensitivity =94.0 Specificity =99.3
2018	Zenghai Chen, Hong Fu	CNN/ Baseline Method	Strabismus dataset	Accuracy =69.1 Specificity= 84 Sensitivity = 47.1

2018	Tyson N. Kim	CNN	Strabismus dataset	Accuracy =95.83 Sensitivity=0.93 Specificity= 0.97
2013	Seira Tak, Prof. K. J. Satao	SVM	Clinical dataset	Accuracy =85
2011	Joao Dallyson Sousa de Almeida JD	SVM/ Hirschberg test	Strabismus dataset	Sensibility=100 Specificity=91.3 Accuracy =94

VI. CONCLUSION

Machine Learning based strabismus Detection-A systematic review analysis was completed. In this study, we assessed different types of Machine Learning Algorithm as per the analysis CNN produces more accuracy of 95.83%. than SVM. So we conclude that by evaluating accuracy metrics we can detect strabismus earlier in patients, thereby reducing the early blindness percentage rate in children.

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