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IMAGE & SIGNAL PROCESSING

Distance-Based Method used to Localize the Eyeball Effectively for Cerebral Palsy Rehabilitation

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Abstract

Iris plays a vital role in human life for object identification. Many models and techniques were proposed and suggested for detecting the Iris, but the accuracy was not achieved up to the level and its frequently used for biometric application. The Proposed Work divided into two steps, at first, we detect the entire eye region outer layer by using mathematics first order derivatives by applying combinations of canny edge detection and circular hough transform. The next, we detect the inner portion of eye region that is Iris region is detected by combination of sobel edge detector and circular hough transform, As the results thereby reducing the error rate, marking the edges closest to the actual edges for maximizing the localization, indicating edges and also detect the inner and outer layer of the eye portions accurately. Finally this process is applied for cerebral palsy Children to detect the misalignment of eye and obtain the deviation position and results are compared with normal children eyes. In this context, image processing techniques are being recommended as a performance evaluation tool in cerebral palsy kids.

Keywords Canny edge detection algorithm · Circular Hough Transform · Eye · Iris · Cerebral PalsyKids

Introduction

Nowadays, continuous detection and eye tracking is the most important functioning zone of research in computer vision society. Eye movements are essential to get the accurate and precise vision of sensory perception. The most common techniques used to detect iris position are, Video Oculography (VOG) and Electro-Oculography (EOG) [1, 2]. Iris Recognition (IR)- based techniques require additional equipment and particularly optimal resolution cameras. Eye tracker for recording the movement of the eye allowed fast and quick acquisition of records from the clinical patient [3, 4]. An iris description strategy is based upon area of identification and limbus area estimation were utilized with promising outcomes in real situations. Algorithms utilized for segmentation incorporate a versatile canny algorithm, the hybrid operation of the Fuzzy Logic and Particle Swam Optimization algorithms, Morphology, RGB decay to Lab Color Space [5, 6]. After discovering the pupil, the diameter of the pupil is estimated and utilizing many of them. For example, the midpoint of the pupil and diameter of the pupil are measured using the Least-Square method, geometric feature fitting algorithm or the ellipse's condition, followed by a technique called Hough transform. Through precise segmentation, the important data of iris examples can be accomplished and will expand the exactness of the framework the irregular pupil area separation which triggered by eye diseases. The Hough Transforms is utilized for doing accurate pupil segmentation [4, 7]. Iris segmentation process has to contract with the eyelids, and reflections that may cause serious segmentation errors. Incorrect iris segmentation due to segmentation errors deteriorates the recognition accuracy of an iris biometric system [8, 9]. Iris segmentation method has three phases; image enhancement, inner boundary recognition, and outer boundary recognition [10, 11]. Iris Localization process is used to locate the pupils accurately in the unconstrained NIR iris images [12, 13]. These methods utilized the iris segmentation process for achieving high accuracy, speed and for reducing noise in the images [14, 15].

This article is part of the Topical Collection on *Image & Signal Processing*

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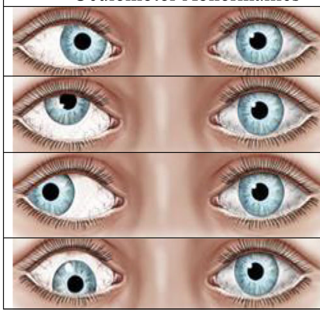
Fig. 1 The Oculomotor Abnormalities Eyes of CP kids



Oculomotor Abnormaliies	Visual Dysfunction
	Esotropia condition - Eyeball moves inner direction.
	Hypertropia condition - Eyeball moves upper direction.
	Exotropia condition - Eyeball moves outer direction.
	Hypotropia condition - Eyeball moves down direction.

The Importance of the proposed research in the context of current status, According to World Health Organization estimation, In India, is around 3 per1000 live births suffer from CP kids. For World, the estimated incidence is around 7.5 per 1000 live births. Currently 17 million people in the world diagnosed with CP. Majority of CP Kids are affected by Visual Dysfunction [16, 17]. Visual therapy is non surgical method to improve the specific visual dysfunction useful in treatment of strabismus and nystagmus in CP kids. This research approach assesses the improvement in CP kids by using the Eye Image which overcomes the burden of VEP test. The Proposed image processing techniques have proven good performance in terms of robustness and accuracy and very easy to implementation. This Approach shows the considerable potential of this method to become an easy to use, modern tool with widespread application in basic and clinical research or in diagnostic testing.

This approach is which is alternate and cost-effective to detect the abnormal deviation position.

The Fig. 1 Demonstrate the strabismus issues for CP kids.

Many methods are available to distinguish the vision. However, while predicting the normal and anomalous condition of the eye, the accuracy of that existing methods are very less and where there prediction error is also very high [2, 18]. So, to improve the prediction process, this paper familiarizes an detection process of edges and iris. This approach calculates the distance between eye centre to the iris center position. This distance identifies the normal and anomalous condition of the eye [19, 20]. For this purpose, a newly proposed Globular Canny Edge Transform algorithm for detection of inner and outer region of eye portion.

Materials and methodology

Subject selection and data collection

This study was done in Sai ram school for differently disable children, Madurai, and Rejoice special school mentally challenged children, Kanyakumari District, Tamilnadu, supported to collect the statistics information to continue procedure of analysis. For this particular study, 30 cerebral palsy affected students were considered as participants. The input eye image is taken from the 30 cerebral palsy vision affected participants. To find the Anomalous eye, the distance of the eye edges and the centroid of the pupil measurements are done. This technique is carried out in MATLAB.

Thirty children with CP age range of (3–15 years) are subjected in this study though they are several categories of CP children. These studies include the participant of potential visual symptoms and performance deficit frequently reported in CP children. The CP children visual ability includes Seventeen children with strabismus, two children with visual field loss, one visual acuity due to dry eyes. The CP children characteristics are represented in Table 1. In this present study, obtained the abnormal deviation position in CP children. The CP children eye image captured by high resolution camera and also performed the implementation by using these high resolution camera images.

Proposed image processing methodology

Image acquisition

The algorithm has been implemented in real-time using Canon Camera resolution of 640 × 480 pixels.

Table 1 Detailed Characteristics of children with CP (Subject Selection)

Cerebral palsy children	Total CP children	Age range between
Vision affected CP Children	30	3 years to 11 years
Boys	20	3-10 years.
Girls	10	4-11 years.
Strabismus	17	3-10 years.
Visual field loss	2	9-11 years.
Visual Acuity	1	6-9 years.

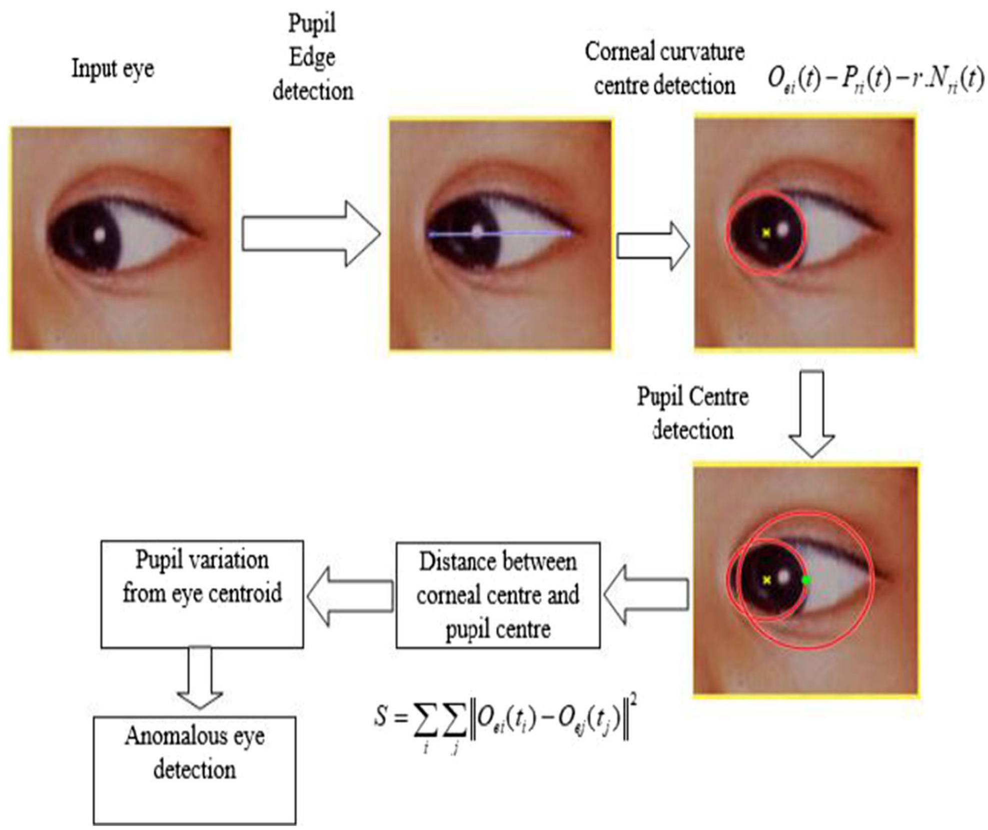


Fig. 2 Abnormalities eye detection system block diagram

Pre-processing step

The Pre-processing step achieved by converting the input image into gray scale and resize the input image.

Segmentation

Image segmentation dissects an eye image to numerous parts. It is applied in object identification and other appropriate information in digital images. Recognition and delineation were the two important factor for image subdivision [21, 22]. Segmentation is use to transfer information. By understanding the image and extract information to do some works, major work in the digital image technology. Using some images in where algorithm is used to segmentation process and it gives some useful information.

The proposed Globular Canny Transform is formulated for the segmentation process. This canny edge detection algorithm is employed to detect the edges. It could be smoothened with the Gaussian filter. Using the zero-crossing method gradient of the image was calculated by the above formula as shown in eq. (1). The direction of the gradient was calculated in the next step. If gradient orientation range in between 22.5 to 67.5 degrees means the point of the edge lies from the upper right corner to the base left eye. The same magnitude was used to compare for the upper left pixel of the eye. The edges are detected by thresholding operation and hysteresis were calculated. If the intensity gradient value is greater compared to the maximum value, then the edge is a positive edge and vice-versa. After completion of the edge detection, Circle detection in the image was done using CHT based algorithm technique. Collector cluster was used for the circle recognition.

Formulation

- Detection of upper and lower eyelids with parabolic arcs by Hough Transform

$$\left(\left(-X-h_j\right)\mathrm{SinQj} + (Y-Kj)\mathrm{CosQ}_j\right)^2 = a_j\left(\left(x-h_j\right)\mathrm{cosQ}_j\right)^2$$
$$= a_i\left(\left(_{x-h}j\right)\mathrm{cosQ}_j + \left(y-k_{j\sin}Qj\right)\right. \quad (1)$$

Where aj is for curvature control, (hj, Kj) is the height of the parabola and θj is the angle of rotation comparative to the x-axis. This method yields best results in sensing of eyelids in horizontal direction, and also in vertical directions for noticing the external part of the iris.

- The K Gaussian probability density distributions give the pixel in an image. The history of a certain pixel {×0,y0} is be defined as a time series,

Table 2 Image of normal eye measurement

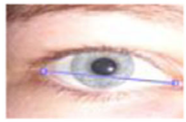
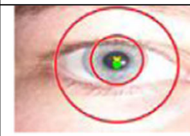
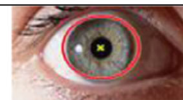
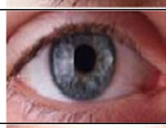
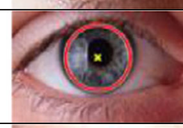
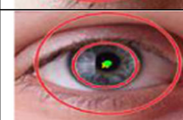
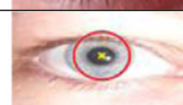
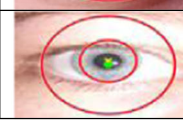
Image No	Input image	Edge distance	Pupil centre	Variation
I_1				
I_2				
I_3				
I_4				
I_5				

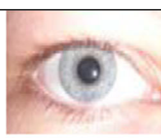
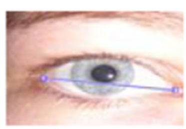
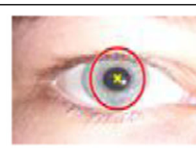
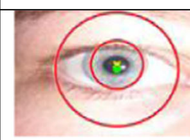
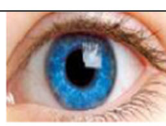
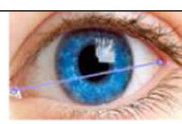
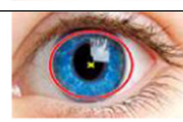
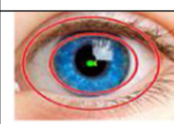
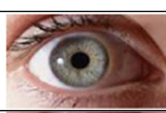
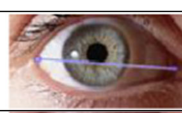
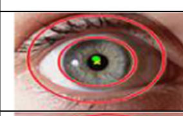
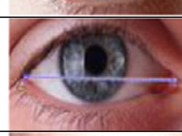
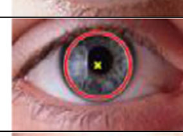
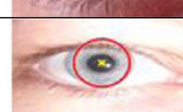
Image No	Input image	Edge distance	Pupil centre	Variation
I_1				
I_2				
I_3				
I_4				
I_5				

Table 3 Performance Results of Normal Eye

Image No	Edge distance	Pupil centroid	Outer Centroid	Variation	Results
I_1	54.129	42.4403	42.4403	0	Normal
I_2	76.335	49.071	47.7454	1.32626	Normal
I_3	70.2666	53.5809	53.0504	0.530504	Normal
I_4	54.2671	51.7245	53.0504	1.32625	Normal
I_5	70.7096	61.005	61.005	0	Normal

$$\{X_1, \ldots\ldots\ldots X_t\} = \{I(x_0, y_{0,} i) : 1 <= i <= t\} \quad (2)$$

Where i is the image sequence & x_i is the intensity value of pixel $\{x_{0,}\ y_0\}$ at a time constant.

Globular canny transform algorithm

Step 1: Initiate the canny edge detection technique to identify the straight edges of the eye.
Step 2: Initiate Pre-processing based on smoothening with a Gaussian filter.
Step 3: Evaluate the zero-crossing method using Laplacian of Gaussian methods.
Step 4: Calculate the gradient magnitude of the Sobel operator using the equation,

$$m = \sqrt{G_x^2 + G_y^2} \quad (3)$$

Step 5: Calculate the direction of the gradient using $\theta = \arctan\left(\frac{G_y}{G_x}\right)$, where G_x and G_y are the gradient of X and Y derivatives at the point.
Step 6: In Non-maximum suppression, if the gradient orientation is between the level from 22.5 to 67.5 degrees, at that point the edge lies from the upper right corner to the base left eye.
Step 7: Compare its magnitude to the upper left pixel with the base right pixel.
Step 8: If it is most extreme and its magnitude is more prominent than the upper limit, stamp this pixel as an edge.

Table 4 The average eye range values

Unit	Particulars	Condition	Range	values
mm	Eye distance	Normal	55–65	58.9
mm	Pupil center	Normal	20–39	28.6
mm	Eye centre point	Normal	27–32	28.9
mm	Variation	Normal	−7 to +7	6

Step 9: Apply threshold with hysteresis to identify the strong edges using two threshold values, min value, and max value. If intensity gradient > max value, then it is a positive edge and it's vice-versa to find the non-edges.
Step 10: After detecting the edges, imfindcircles CHT based algorithm to detect the images in a circle.
Step 11: An accumulator array is computed to detect foreground pixels having high gradient.
Step 12: Measure votes centre of contender pixels having a place with an image circle will result in general aggregate at the gatherer array receptacle relating to the circle's inside.
Step 13: Recognize the circle focuses by distinguishing the peaks in the collector cluster.
Step 14: Estimate the span of the circle if a similar collector exhibit is utilized for radius value more than one.

The edge of an image is a curve which pursues short way to change the intensity of the picture. Usually appended to an object and distinguishes all the edges in that image [23]. An edge work comprises two criteria, for example,

- The primary derivative of the intensity is bigger in scale than some threshold.
- The secondary derivative of the intensity is zero intersection.

Through the Kernel Gaussian channel, noise in the image is filtered and smoothened. To find the edge quality by registering the inclination magnitude and point of slope vector for edge direction utilizing the Sobel filters cover. Apply non-maxima concealment to the gradient magnitude to follow along with the edge course and smother any pixel esteem that is not viewed as an edge and give a thin line to the input image [24]. Use two fold thresholding or hysteresis and network examination to identify and associate the potential edges. If the single limit point for edge identification is set too low or too high, there will be either false positives or false negatives edges, separately. Globular Canny Transform algorithm used to enhance the circumstance of false edge point discovery by utilizing a

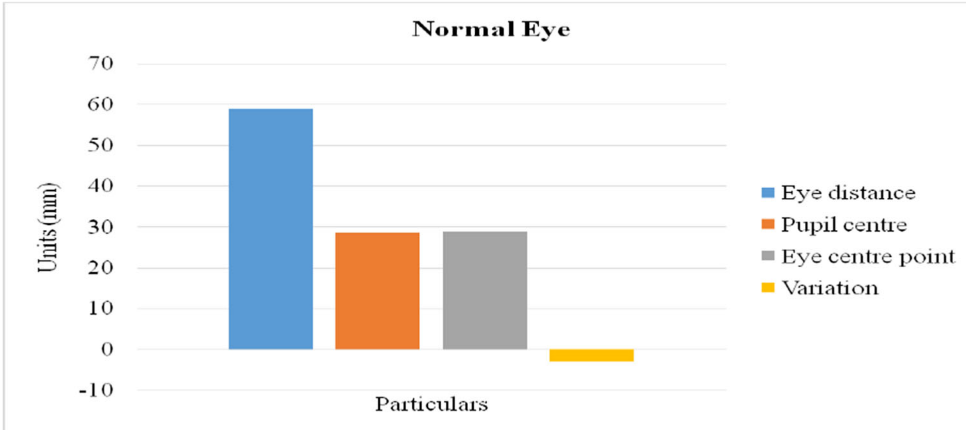


Fig. 3 Shows the Graphical representation of the normal eye

hysteresis limit, by two edges: a low edge and a high edge. At last, the focal point of the iris position and its distance is determined. Figure 2 signifies the anomalous eye detection system based upon the distance between the pupil and centroid of eye. This technique also opts for normal eye detection. The anomalous eye detection variation is greater than 7.

Mathematical model

First order edge detection or gradient based operator

If I(x, y) is the input image then the image function is given by

$$\Delta I(x,y) = \hat{x}\frac{\partial I(x,y)}{\partial x} + \hat{y}\frac{\partial I(x,y)}{\partial y} \quad (4)$$

Table 5 Images of anomalous both left and right cerebral pupil eye measurements

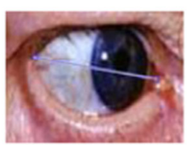
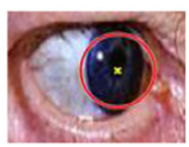
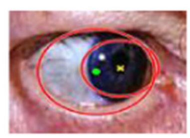
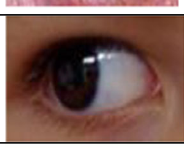
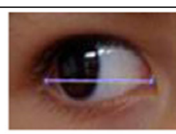
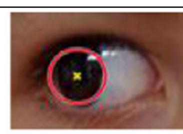
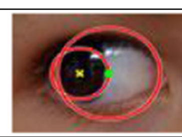
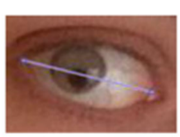
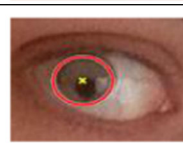
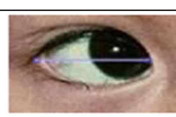
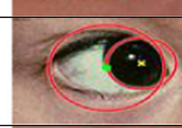
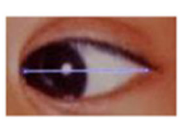
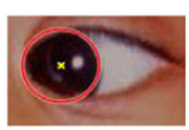
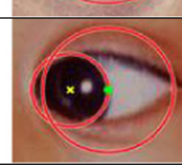
Image No	Input image	Edge distance	Pupil center	Variation	Cerebral pupil (Left / Right)
I_6					Left
I_7					Right
I_8					Right
I_9					Left
I_{10}					Right

Table 6 Performance Results of Normal Eye

Image No	Edge distance	Pupil centroid	Outer Centroid	Variation	Results
I_6	64.576	67.6393	55.7029	11.9363	Abnormal
I_7	53.9435	47.7454	61.005	13.2626	Abnormal
I_8	70.7969	42.4463	53.0504	10.6101	Abnormal

Where $\frac{\partial \mathrm{I(x,y)}}{\partial \mathrm{x}}$ $\frac{\partial I(x,y)}{\partial x}$ is the gradient along x direction and $\frac{\partial I(x,y)}{\partial y}$ is the gradient along y direction.

The gradient magnitude is computed as

$$|A| = \sqrt{\left(\frac{\partial I}{\partial x}\right)^2 + \left(\frac{\partial I}{\partial y}\right)^2} \tag{5}$$

$$|A| = \sqrt{A_x{}^2 + A_y{}^2} \tag{6}$$

The gradient magnitude is calculated using the formula

$$\theta = \arctan\left(\frac{A_x}{A_y}\right) \tag{7}$$

Sobel operator

The differentiation operator that is employed for computing the approximation of the gradient of the image for edge detection is Sobel Operator. It Convolves the Kernel with the input image and helps in computing the magnitude and the direction of the gradient. It uses a 3 × 3 Kernels.

$$A_x = \begin{matrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{matrix} \tag{8}$$

$$A_y = \begin{matrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{matrix} \tag{9}$$

It has a larger mask, therefore the error due to noise are removed by local averaging within the mask.

First order edge detection algorithm

For noise reduction For removing the noise in the image, the Gaussian filter performs convolution of the input image. Mathematically it can be expressed as

$$F(x,y) = A*I(x,y) \tag{10}$$

For finding gradients Edges are detected in the places of maximum grayscale intensity of the image. At each pixel, the gradient of the image is found by the use of the Sobel operator. Sobel operator along the directions x and y are as follows

$$V_x = \begin{matrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{matrix} \tag{11}$$

$$V_y = \begin{matrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix} \tag{12}$$

$$A_x = V_x*F(x,y) \text{ and } A_y = V_y*F(x,y) \tag{13}$$

Therefore, the edge strength and the magnitude of the gradient of a pixel is given by

$$|A| = \sqrt{A_x{}^2 + A_y{}^2} \tag{14}$$

The direction of the gradient is given by

$$\theta = \arctan\left(\frac{A_x}{A_y}\right) \tag{15}$$

A_x and A_y are the gradients in the x and y direction respectively.

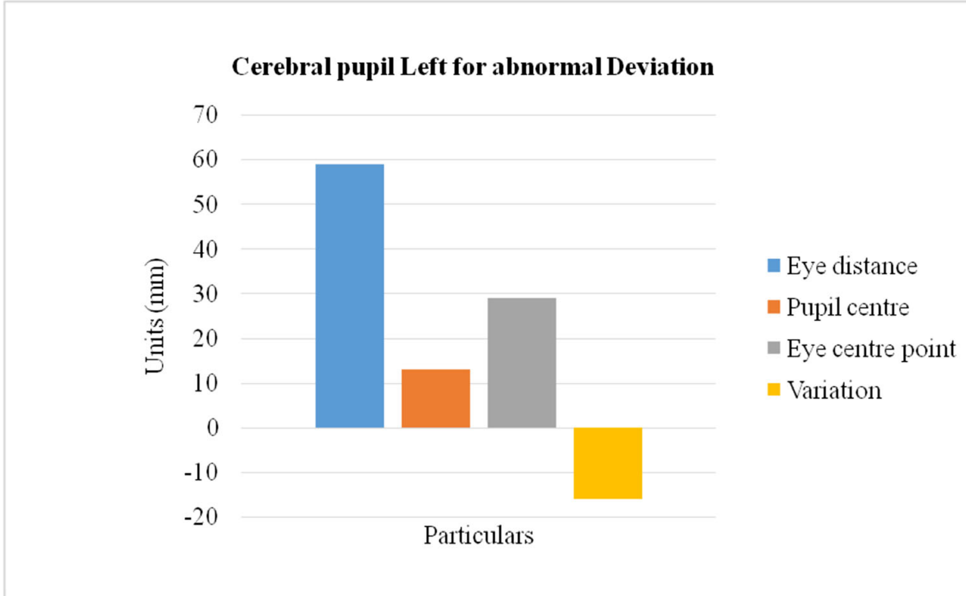
Table 7 Average ranges of the cerebral pupil left for an anomalous deviation

Unit	Particulars	Position	Range	Values
mm	Eye distance	Cerebral Pupil right	55–65	58.9
mm	Pupil centre	Cerebral Pupil right	40–65	46.3
mm	Eye centre point	Cerebral Pupil right	27–32	28.7
mm	Variation	Cerebral Pupil right	≥ 7	17.6

Table 8 Average ranges of the cerebral pupil right for the anomalous deviation

Unit	Particulars	Position	Range	Values
mm	Eye distance	Cerebral Pupil Left	55–65	58.9
mm	Pupil centre	Cerebral Pupil Left	119	12.9
mm	Eye centre point	Cerebral Pupil Left	27–32	28.9
mm	Variation	Cerebral Pupil Left	≤ −7	−16

Fig. 4 Anomalous Cerebral pupil left eye's graphical presentation



Second order edge detector

For a 2D image the Laplacian operator ∇2, The Laplacian operator function is given by

$$\nabla^2 = I(x,y) = \frac{\partial^2}{\partial x^2} I(x,y) + \frac{\partial^2}{\partial y^2} I(x,y) \tag{16}$$

Laplacian Gaussian operator

Noise reduction is done by the Gaussian operator and the sharp edge detection is done by Laplacian operator. The Laplacian Gaussian operator function is given by the formula

$$A(x,y) = \frac{1}{\sqrt{2\pi\sigma^2}} exp - \left(\frac{x^2 + y^2}{2\sigma^2} \right) \tag{17}$$

Where σ is the standard deviation.

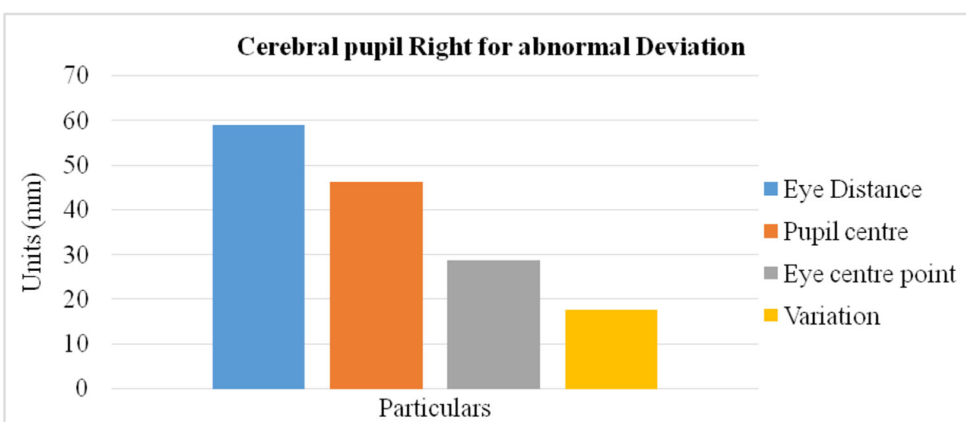
Hough transform

Hough transform algorithm is utilized for the detection of curve in the images. The Hough transform algorithm functions on the basis of voting. It chooses a simple approach using the equation of the circle as,

$$(x-a)^2-(y-b)^2-r^2 = 0 \tag{18}$$

Where (x, y) are the image points (a, b,r) are voting for each bins. The area is characterized by a, b and r. The next process is taking the circle with a radius R_i and locate the position of x_i and y_i the edges of the eye.

Fig. 5 Anomalous Cerebral Pupil Right eye's graphical presentation



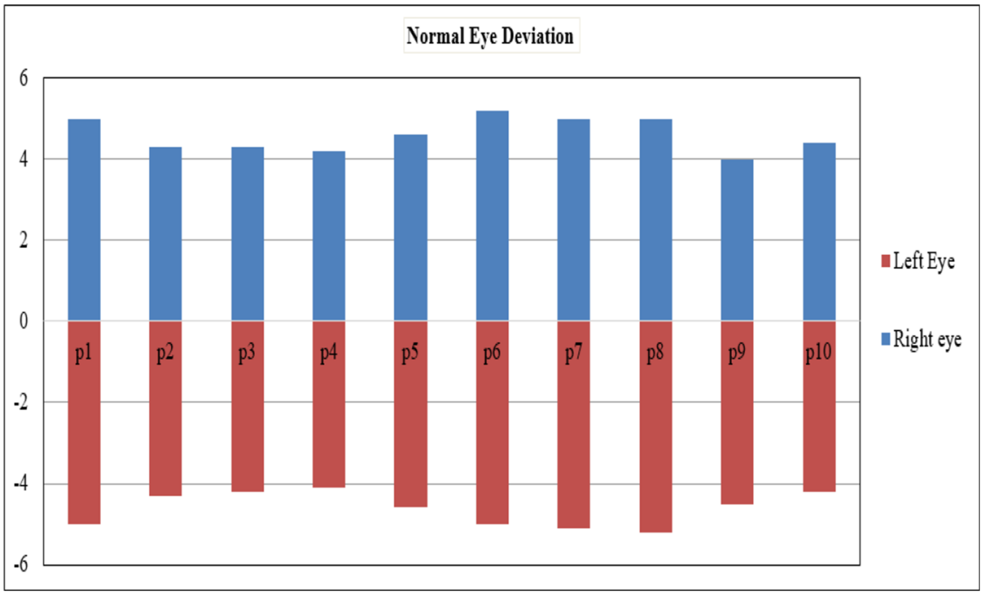


Fig. 6 Deviation of normal eye

Distance-based technique

The normal and anomalous condition of the eye is identifying by measuring the distance of the eye edges and also measuring the centroid of the pupil. The distance will calculate by the Hough Transform technique in MATLAB (GUI) [25]. The feature extraction method used here is the Hough transform. This is used in visual communication, processing of digital analysis of the image. The imperfect instance of an image within a definite class of position or shape by the process of voting. With the help of Hough Transform it is possible to form a line, circle or ellipse on the images. The different eye images have taken as a sample and then that images will be loaded. Before loading the picture should do some pre-process work to remove the noises in the image. The measuring procedure is done by following steps

- Load the filtered eye image
- Draw the line between two endpoints of the eye edges
- Calculate the distance automatically in a tool with the pixel values using the Euclidean formula.

$$\text{Pixel} \quad \text{distance} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (19)$$

Where,

x, y Directions

- Localize pupil position, which is in the loaded image
- Form a circle around the pupil.

$$\begin{aligned} X &= a + r\cos(\theta) \\ Y &= b + r\sin(\theta) \end{aligned} \qquad (20)$$

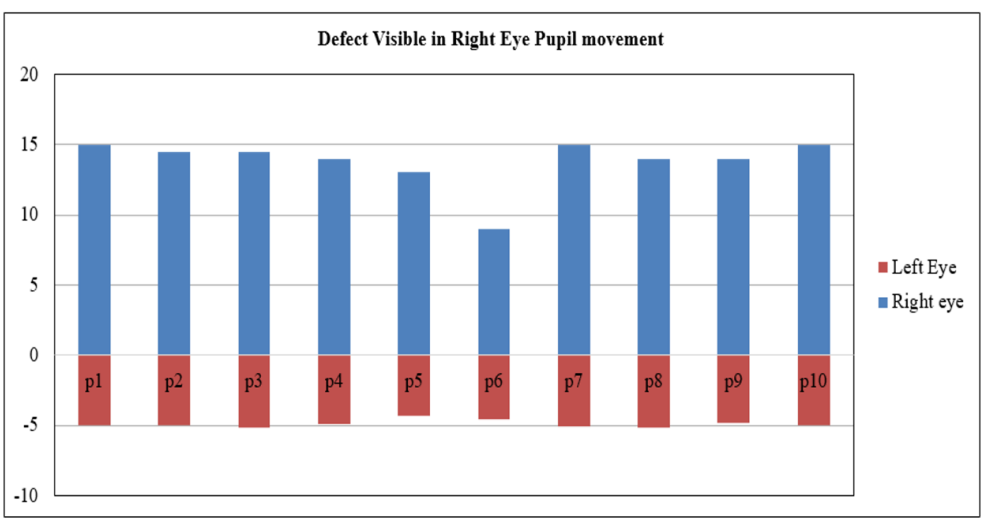
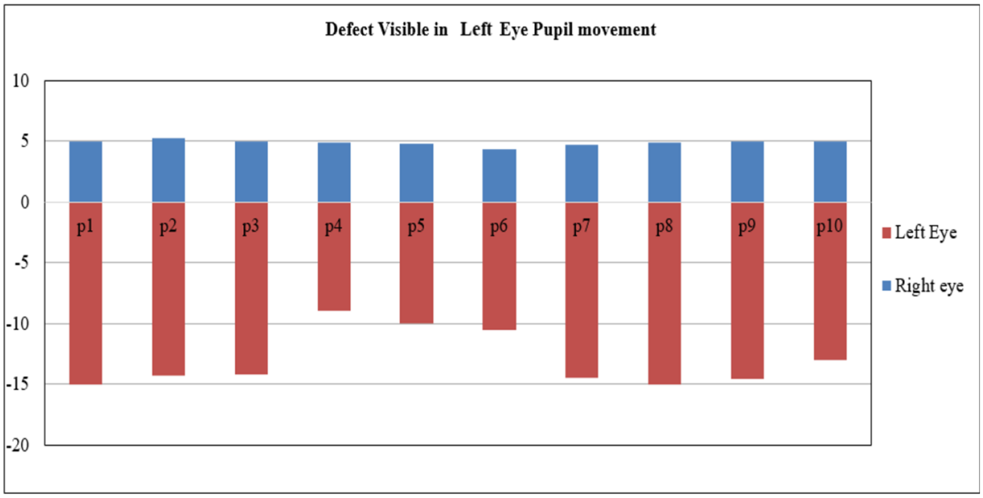


Fig. 7 Defect visible in Right Eye

Fig. 8 Defect visible in Left Eye



Where,

a and b - the center of the circle in the x and y-direction respectively r- radius

- Centre point of the circle is as the pupil midpoint, i.e., centroid.
- Visualize the circle by forming another circle around the whole eye
- The image shows the distance between the external and internal circle of the eye and pupil.

Obtain the conditions of the eye established on the binary values of the distance differences.

Result and discussion

At first, Our approach is applied to finding the condition of the eye, whether it is normal or anomalous by with the localization of the pupil. This technique is tested on the 30 different eye images by using MATLAB software, and the result of those eyes is given below (Table 2).

Table 9 Characteristics of 100 manually labeled images

Parameter	50 Pupil center images			
	Max	Min	Average	Std
Iris region (Pixels)	39,854	13,000	23,894	5693
Eye region (Pixels)	15,427	1154	4100	2520
Parameter	50 Pupil off-axis images			
	Max	Min	Average	Std
Iris region (Pixels)	43,524	23,387	33,584	4622
Eye region (Pixels)	10,983	1624	3846	1585

The above table shows that five different eye images and their conditions. In I_1, the distance between the edges is 54.129 mm, the pupil centroid is 42.4403 mm, the outer centroid is 42.4403, and it shows zero variation in the measurement, so it is in normal condition. In I_2, the edge distance is 76.335 mm, the centroid of the pupil is 49.0716 mm and centroid of the exact eye is 47.7454 mm. When comparing all the distance values with the centroid values, it gives 1.32626 mm variation, and it falls in the acceptable range, so the I_2 is in normal condition. The image I_3 gives the measured values of 70.2666 mm, 53.5809 mm and 53.0504 mm of edge distance, pupil centroid, and exact eye centroid. The variation of the image value is 0.530504 mm, so I_3 also in normal condition. In image I_4, the measured values are 54.2671 mm, 51.7245 mm and 53.0504 mm of the eye edge distance, pupil and exact eye center point. The variation of image I_4 (−1.32625 mm) is laid in acceptable rages, and it is in normal condition. While measuring the values of I_5, the edge distance, pupil and exact eye centroid are 70.7096 mm, 61.005 mm, and 61.005 mm. So in I_5 ultimately comes under the normal eye because zero variation in that measured values. It is represented in Table 3.

From the observation of the MATLAB calculation, the range of the normal eye condition was shown in Table 4. It clearly shows the low and high ranges of edge distance, pupil center, exact eye center point, and the variation. The range was calculated from the average values of all the sample of eyes taken into account.

Above mentioned normal eye range values performance graph are represented in Fig. 3.

The Table 5 shows the comparison of equally left and right cerebral pupil position of the anomalous eye condition. The image I_6 shows that the cerebral pupil position of the left eye, it gives the values are 64.576 mm,

Table 10 Comparison of the proposed algorithm with existing algorithms

Parameter	Average error for pupil center/ Off axis and standard deviation (in pixels)					
	Our algorithm		Masek - Daugman's algorithm		Edge-based segmentation	
	Pupil center	Off axis	Pupil center	Off axis	Pupil center	Off axis
Iris Center (x)	2.4/0.8	2.1/2.6	10.1/15.2	7.1/14.2	5.8/12.5	4.5/10.2
Iris Radius (x)	2.7/3.4	3.3/3.4	6.1/7.2	5.1/6.0	6.0/13.5	6.7/14.6
Eye Center (x)	0.5/1.0	1.3/1.5	5.0/10.1	2.8/14.3	2.4/14.9	1.2/2.4
Eye Radius (x)	1.4/2.0	1.7/1.5	3.4/5.0	2.5/1.8	1.7/1.7	1.5/1.1

67.6393 mm, and 55.7029 mm of the edge distance, pupil center point and eye center point. The variation of I_6 is 11.9363 mm, so it shows that the high progress of the value and it was not considered as a normal eye. In image I_7, is the right side of the cerebral pupil position and the measured values are 53.9435 mm, 47.7454 mm, and 61.005 mm of distance, pupil center, an eye center. The variation of I_7 is in negative value as −13.2626 mm, and it comes under the anomalous eye condition. While Measuring the values of right side cerebral pupil position of the image I_8, the distance, pupil and eye center points are 70.7969 mm, 42.4463 mm and 53.0504 mm. While calculating the difference between all values and find the variation is −10.6101 mm. So it was considered as an anomalous eye. Similarly, I_9 and I_{10} of both left and right side of cerebral pupil eye position are measured, and the values are shown in the huge amount of variations. So it cannot be considered as a normal eye. The performance results represented in Table 6.

The Tables 7 and 8 represents the average value ranges of the different parameters for anomalous eye condition in both left and right, which is considered in this proposed work.

This minimum and the maximum value of the anomalous left and right side eye cerebral pupil is represented by the graph which is shown in above Figs. 4 and 5. The threshold value of 7 mm is fixed for selecting the normal right eye, and the threshold value of -7 mm is fixed for selecting the left eye. From the Fig. 6, it is understood that the left and right eyes are normal because the threshold value is within 7 mm and -7 mm.

From the Fig. 7, it is understood that the right eyes are anomalous because it exceeds the threshold value of 7 mm.

From the Fig. 8, it is understood that the left eyes are anomalous because it exceeds the threshold value of -7 mm.

Table 9 represents the parameters of the 100 images, and it labeled manually. They are the average, maximum, minimum and standard deviation of the Iris and eye region pixels. The standard deviations of both images are higher in Iris pixels.

The iris, accountable for supervisory measurement and the size of the pupil and the quantity of light on reaching the retina as well. Generally, the radius is 5.5 mm, and the diameter of the iris is 11–12 mm, the pupillary margin perimeter is about 38 mm and thickness is 0.6 mm and is collarette at the ciliary margin with the thickness 0.5 mm. The vertical measure lesser than the plane is 24 mm. The above tables represent the comparison of average error the proposed system with an existing system (Masek and Kovesi, 2003). Edge pixels recognize by the strong response when the threshold value is above low value. In our work parameter set as $\tau = 45$ (threshold on strong texture), $\kappa = 0.72$ (range for iris boundary) and $\sigma = 7$ (smoothing factor). An ellipse correctly fit corners of the eyes and iris. The results through the Table 10 witness that the pixel values of Iris and the Eye of the proposed system, were comparably better than that of the existing system.

Conclusion

This proposed methodology to recognize the anomalous eye by using an edge detection technique by image processing. A novel Globular Canny Edge Transform is developed, and the image conditions were identified with the aid of both algorithms. The outcome result of this process is compared with variables and identified whether the eyes are in normal or anomalous condition. To detect the cerebral palsy eye, VEP is generally used. However, the cost for the VEP is very high and the time duration also high. By using the proposed edge detection method, the cerebral palsy eye can be detected with low cost and minimum time duration. The prediction of the proposed method calculates the horizontal distance and doesn't consider about the angular movement of the eye. In the future, a model will be proposed to improve the prediction accuracy with the consideration of angular eye movement.

This research can be used in any rehabilitation centers to assess the improvement in CP kids by recording and analyzing the eye features over a period of time. The number of CP kids improved over a period of time can be assessed using this application to determine the effectiveness of therapy given in the rehabilitation center. This Experimental results show that investigation of eye features can be used to assess improvement of CP kids and hence this approach can be used to avoid VEP test to assess improvement.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of the paper.

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