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# Automated Glaucoma Screening using CDR from 2D Fundus Images

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## Abstract:

Glaucoma is a chronic eye disease that leads to blindness. This disease cannot be cured but we can detect the disease in time. Current tests using intraocular pressure (IOP) measurement are not sensitive enough for population based glaucoma screening. Optic nerve head assessment in retinal fundus images is more promising and superior than current methods. This paper proposes segmentation of optic disc and optic cup using superpixel classification for glaucoma screening. In optic disc segmentation, clustering algorithms are used to classify each superpixel as disc or non-disc. For optic cup segmentation, in addition to the clustering algorithms, the Gabor filter and thresholding is used. . The segmented optic disc and optic cup are then used to compute the cup to disc ratio for glaucoma screening. The Cup to Disc Ratio (CDR) of retinal fundus camera image is the primary identifier to confirm glaucoma for a given patient.

**Index terms:** Glaucoma Screening, Gabor Filter, Intraocular pressure, Optic cup segmentation, Optic disc segmentation, Thresholding, CDR.

## I. INTRODUCTION

Glaucoma is a chronic eye disease of the major nerve of vision, called the optic nerve which is progressively damaged. If glaucoma is not diagnosed and treated in time, it can progress to loss of vision and even blindness. Glaucoma usually causes no symptoms early, it can only be diagnosed by regular eye examinations. It is predicted to affect around 80 million people by 2020[1].

There are different methods to detect glaucoma: assessment of (1) raised intraocular pressure (IOP), (2) abnormal visual field,(3) damaged optic nerve head. The IOP measurement using non-contact tonometry is not sensitive enough for population based glaucoma screening. A functional test through vision loss requires special equipment only present in territory hospitals and therefore unsuitable for screening. Optic nerve head assessment can be done by a trained professional. However manual assessment is subjective, time consuming and expensive. Hence, automatic optic nerve head assessment would be very beneficial.

In the previous work on “Classifying glaucoma with image-based features from fundus photographs”[2], the features are normally computed at the image-level and we use image features for binary classification between glaucomatous and healthy subjects[3]. Many glaucoma risk factors are considered, such as vertical cup to disk ratio(CDR),disc diameter, peripapillary atrophy(PPA),etc.Among of these CDR is commonly used. A larger CDR indicates a higher risk of glaucoma. There has been some research into automatic CDR measurement from 3D images[4]. The 3D images are not easily available and high cost of obtaining 3D images makes it inappropriate for a large scale screening program. This paper proposes an automatic glaucoma screening using CDR from 2D fundus images.

## II. Literature Survey

### [1] Effects of Preprocessing Eye Fundus Images on Appearance Based Glaucoma Classification:

Early detection of glaucoma is essential for preventing one of the most common causes of blindness. Our research is focused on a novel automated classification system based on image features from fundus photographs[5] which does not depend on structure segmentation or prior expert knowledge. Our new data driven approach that needs no manual assistance achieves an accuracy of detecting glaucomatous retina fundus images comparable to human experts. In this paper, we study image preprocessing methods to provide better input for more reliable automated glaucoma detection. We reduce disease independent variations without removing information that discriminates between images of healthy and glaucomatous eyes. In particular,

nonuniform illumination is corrected, blood vessels are inpainted and the region of interest is normalized before feature extraction and subsequent classification.

#### **[2] Locating the Optic Nerve in a Retinal Image Using the Fuzzy Convergence of the Blood Vessels**

We describe an automated method to locate the optic nerve in images of the ocular fundus. Our method uses a novel algorithm we call fuzzy convergence to determine the origination of the blood vessel network[6]. We evaluate our method many images of healthy retinas and diseased retinas, containing such diverse symptoms as tortuous vessels, choroid revascularization, and hemorrhages that completely obscure the actual nerve. We also compare our method against three simpler methods, demonstrating the performance improvement. All our images and data are freely available for other researchers to use in evaluating related methods.

#### **[3] Detection of Optic Disc in Retinal Images by Means of a Geometrical Model of Vessel Structure**

We present here a new method to identify the position of the optic disc (OD) in retinal fundus images. The method is based on the preliminary detection of the main retinal vessels[7]. All retinal vessels originate from the OD and their path follows a similar directional pattern (parabolic course) in all images. To describe the general direction of retinal vessels at any given position in the image, a geometrical parametric model was proposed, where two of the model parameters are the coordinates of the OD center. Using as experimental data samples of vessel centerline points and corresponding vessel directions, provided by any vessel identification procedure, model parameters were identified by means of a simulated annealing optimization technique. These estimated values provide the coordinates of the center of OD.

#### **[4] Detecting the Optic Disc Boundary in Digital Fundus Images Using Morphological, Edge Detection, and Feature Extraction Techniques.**

Optic disc (OD) detection is an important step in developing systems for automated diagnosis of various serious ophthalmic pathologies. This paper presents a new template-based methodology for segmenting the OD from digital retinal images. This methodology uses morphological and edge detection techniques followed by the Circular Hough Transform to obtain a circular OD boundary approximation. It requires a pixel located within the OD as initial information. For this purpose, a location methodology based on a voting-type algorithm is also proposed. The algorithms were evaluated on many images and the results were fairly good.

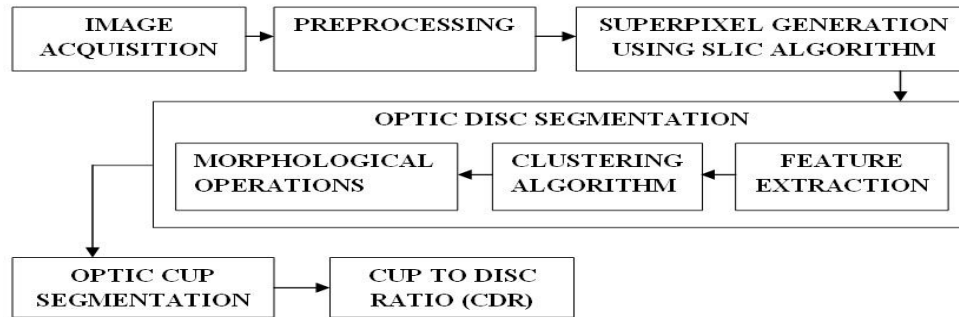
#### **[5] Optic Nerve Head Segmentation**

Reliable and efficient optic disk localization and segmentation are important tasks in automated retinal screening. General-purpose edge detection algorithms often fail to segment the optic disk due to fuzzy boundaries, inconsistent image contrast or missing edge features. This paper presents an algorithm for the localization and segmentation of the optic nerve head boundary in low-resolution images (about 20 /pixel). Optic disk localization is achieved using specialized template matching and segmentation by a deformable contour model. The latter uses a global elliptical model and a local deformable model with variable edge-strength dependent stiffness. The algorithm is evaluated against randomly selected images from a diabetic screening program. Ten images were classified as unusable; the others were of variable quality. The localization algorithm succeeded on all but one usable image.

### **III. PROPOSED SYSTEM**

This paper focuses on automatic glaucoma screening using CDR from 2D fundus images. This paper proposes superpixel classification based disc and cup segmentations for glaucoma screening. In this proposed approach, preprocessing such as image filtration, color contrast enhancement are performed which is followed by a combined approach for image segmentation and classification using texture, thresholding and morphological operation. Multimodalities including K-Means clustering, Gabor wavelet transformations are also used to obtain accurate boundary delineation. We incorporate prior knowledge of the cup by including location information for cup segmentation. Based on the segmented disc and cup, CDR is computed for glaucoma screening.

### **IV. PROPOSED SYSTEM BLOCK DIAGRAM**



#### 4.1. Image acquisition:

The retina can be observed and recorded using several methods including Fluorescein Angiograms (FA), Transient Visual Evoked Potential (TVEP) or fundus camera. FA is a medical estimation tool that injects fluorescein into the body before image capture so vessel features (arteries, capillaries and veins) can stand out and be photographed

#### 4.1. Image Preprocessing:

First, we need to enhance the image that we are going to use. We can either apply basic filter techniques or we can use histogram equalization techniques for the process of histogram equalization. We also found some techniques to generate too noisy images for glaucoma detection (histogram equalization adaptive histogram equalization or color normalization). Thus, we have selected methods which are well-known in medical image processing and preserve image characteristics. Naturally, the proposed system can be improved in the future with adding new methods. In detecting abnormalities associated with fundus image, the images have to be preprocessed in order to correct the problems of uneven illumination problem, nonsufficient contrast between exudates and image background pixels and presence of noise in the input fundus image. Aside from aforementioned problems, this section is also responsible for color space conversion and image size standardization for the system.

One of the problems associated with fundus images is uneven illumination. Some areas of the fundus images appear to be brighter than the other. Areas at the centre of the image are always well illuminated, hence appears very bright while the sides at the edges or far away are poorly illuminated and appears to be very dark. In fact the illumination decreases as distance from the centre of the image increase. Many methods were tried in resolving this problem of un-even illumination, among which are the use of Naka Rushton method and Adaptive Histogram Equalization Method (AHM). AHM gives better performance, higher processing speed and work well for all images of different sizes, hence the reason for it being used as method of correcting un-even illumination.

#### 4.2. Superpixel Generation:

They have been proved to be useful in image segmentations in various images of scene, animal, human etc.

#### Slc Algorithm:

This paper uses the simple linear iterative clustering algorithm (SLIC) to aggregate nearby pixels into superpixels in retinal fundus images[8]. Compared with other superpixel methods, SLIC is fast, memory efficient and has excellent boundary adherence. SLIC is also simple to use with only one parameter, i.e., the number of desired superpixels. We introduce a new superpixel algorithm, simple linear iterative clustering (SLIC), which adapts a k-means clustering approach to efficiently generate superpixels. Despite its simplicity, SLIC adheres to boundaries as well as or better than previous methods. At the same time, it is faster and more memory efficient, improves segmentation performance, and is straightforward to extend to superpixel generation. SLIC is simple to use and understand.

By default, the only parameter of the algorithm is  $k$ , the desired number of approximately equally-sized superpixels. For color images in the CIELAB color space, the clustering procedure begins with an initialization step where  $k$  initial cluster centers  $= l_i, a_i, b_i, x_i, y_i$  are sampled on a regular grid spaced  $S$  pixels apart. To produce roughly equally sized superpixels, the grid interval is  $S = N/k$ . The centers are moved to seed locations corresponding to the lowest gradient position in a  $3 \times 3$  neighborhood. This is done to avoid centering a superpixel on an edge, and to reduce the chance of seeding a superpixel with a noisy pixel.

Next, in the assignment step, each pixel  $i$  is associated with the nearest cluster center whose search region overlaps its location. This is the key to speeding up our algorithm because limiting the size of the search

region significantly reduces the number of distance calculations, and results in a significant speed advantage over conventional  $k$ -means clustering where each pixel must be compared with all cluster centers. This is only possible through the introduction of a distance measure  $D$ , which determines the nearest cluster center for each pixel.

### 4.3. Optic Disc Segmentation:

#### 4.3.1. Background:

The segmentation estimates the disc boundary, which is a challenging task due to blood vessel occlusions, pathological changes around disc, variable imaging conditions, etc. Feature Extraction techniques like clustering algorithm and morphological operations are used for optic disc segmentation[9]. Circular Hough transform is also used to model the disc boundary because of its computational efficiency.

#### K-means clustering algorithm:

K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them.

K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them. The points are clustered around centroids  $\mu_i$ ,  $i = 1 \dots k$  which are obtained by minimizing the objective

$$\sum_{j=1}^K \sum_{i=1}^X \|X_i^{(j)} - c_j\|^2$$

where  $\|x_i - c_j\|^2$  is a chosen distance measure between a data point  $x_i$  and the cluster centre  $c_j$ , is an indicator of the distance of the  $n$  data points from their respective cluster centres.

- Compute the intensity distribution (also called the histogram) of the intensities.
- Initialize the centroids with  $k$  random intensities
- Repeat the following steps until the cluster labels of the image do not change anymore.
- Cluster the points based on distance of their intensities from centroid intensities replicated with the mean value within each of the array and then the distance matrix is calculated.

$$c^{(i)} := \arg \min_j \|x^{(i)} - \mu_j\|^2$$

- Compute the new centroid for each of the clusters.

$$\mu_i := \frac{\sum_{i=1}^m 1\{c^{(i)} = j\} x^{(i)}}{\sum_{i=1}^m 1\{c^{(i)} = j\}}$$

Where  $k$  is a parameter of the algorithm (the number of clusters to be found),  $i$  iterates over the all the intensities,  $j$  iterates over all the centroids and  $\mu_i$  are the centroid intensities.

#### 4.3.2. Feature extraction:

##### Gabor Filter:

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. The Gabor filters are self-similar: all filters can be generated from one mother wavelet by dilation and rotation.

Gabor filters are directly related to Gabor wavelets, since they can be designed for a number of dilations and rotations. However, in general, expansion is not applied for Gabor wavelets, since this requires computation of bi-orthogonal wavelets, which may be very time-consuming. Therefore, usually, a filter bank consisting of Gabor filters with various scales and rotations is created. The filters are convolved with the signal, resulting in a so-called Gabor space. This process is closely related to processes in the primary visual cortex. Jones and Palmer showed that the real part of the complex Gabor function is a good fit to the receptive field

weight functions found in simple cells in a cat's striate cortex. The Gabor space is very useful in [image processing](#) applications such as [optical character recognition](#), [iris recognition](#) and [fingerprint recognition](#). Relations between activations for a specific spatial location are very distinctive between objects in an image. Furthermore, important activations can be extracted from the Gabor space in order to create a sparse object representation. Among various wavelet bases, Gabor functions provide the optimal resolution in both the time (spatial) and frequency domains, and the Gabor wavelet transform seems to be the optimal basis to extract local features for several reasons. The problem with cup and disc segmentation is that the visibility of boundary is usually not good especially due to blood vessels. Gabor wavelets can be tuned for specific frequencies and orientations which is useful for blood vessels. They act as low level oriented edge discriminators and also filter out the background noise of the image. Since vessels have directional pattern so 2-D Gabor wavelet is best option due to its directional selectiveness capability of detecting oriented features and fine tuning to specific frequencies

#### 4.4 Optic Cup Segmentation:

We can use thresholding or binarization for Optic Cup segmentation Process. This process will convert the given image into a thresholded or binarized image where we can easily get our Optic Cup. Binary images are produced from color images by segmentation. Segmentation is the process of assigning each pixel in the source image to two or more classes. If there are more than two classes then the usual result is several binary images.

The simplest form of segmentation is probably [Otsu thresholding](#) which assigns pixels to foreground or background based on grayscale intensity. Another method is the [watershed algorithm](#). [Edge detection](#) also often creates a binary image with some pixels assigned to edge pixels, and is also a first step in further segmentation.

##### 4.4.1. Binarization:

Binarization is a process where each pixel in an image is converted into one bit and you assign the value as '1' or '0' depending upon the mean value of all the pixel. If greater than mean value then its '1' otherwise its '0'.

##### 4.4.2 Thresholding:

Thresholding is the simplest method of image [segmentation](#). From a [grayscale](#) image, thresholding can be used to create [binary images](#).

During the thresholding process, individual [pixels](#) in an image are marked as "object" pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) and as "background" pixels otherwise. This convention is known as threshold above. Variants include threshold below, which is opposite of threshold above; threshold inside, where a pixel is labeled "object" if its value is between two thresholds; and threshold outside, which is the opposite of threshold inside. Typically, an object pixel is given a value of "1" while a background pixel is given a value of "0." Finally, a binary image is created by coloring each pixel white or black, depending on a pixel's labels.

##### Threshold selection:

The key parameter in the thresholding process is the choice of the threshold value (or values, as mentioned earlier). Several different methods for choosing a threshold exist; users can manually choose a threshold value, or a thresholding algorithm can compute a value automatically, which is known as automatic thresholding

A simple method would be to choose the [mean](#) or [median](#) value, the rationale being that if the object pixels are brighter than the background, they should also be brighter than the average. In a noiseless image with uniform background and object values, the mean or median will work well as the threshold, however, this will generally not be the case. A more sophisticated approach might be to create a [histogram](#) of the image pixel intensities and use the valley point as the threshold.

The histogram approach assumes that there is some average values for both the background and object pixels, but that the actual pixel values have some variation around these average values. However, this may be computationally expensive, and image histograms may not have clearly defined valley points, often making the selection of an accurate threshold difficult. In such cases a [unimodal threshold selection algorithm](#) may be more appropriate.

**Morphological operation:**

The disc and cup boundary detected from the segmentation methods may not represent the actual shape of the disc and cup since the boundaries can be affected by a large number of blood vessels entering the disc. Therefore the morphological operations are employed to reshape the obtained disc and cup boundary. Then CDR is calculated by taking the ratio of the area of cup to OD.

**4.5. CDR Calculation and Diagnosis:**

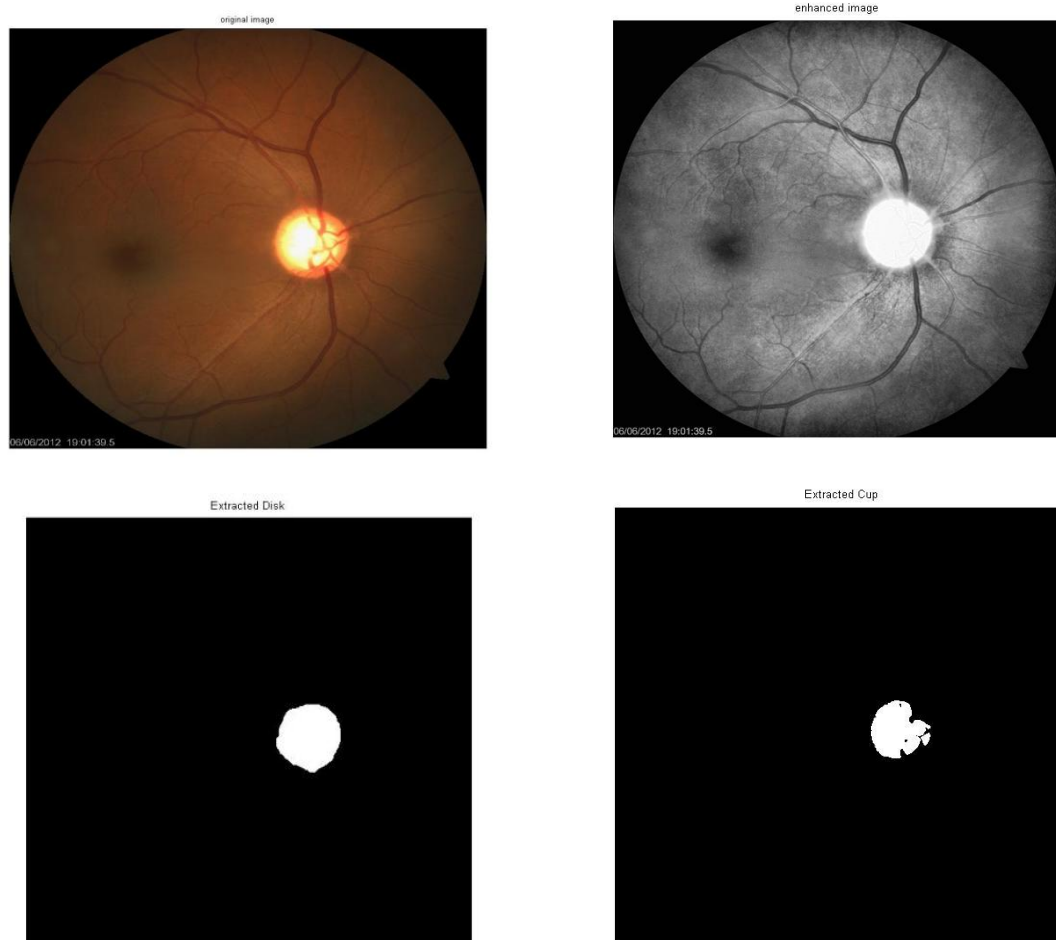
After obtaining the disc and cup, various features can be computed. We follow the clinical convention to compute the CDR. As mentioned in the introduction, CDR is an important indicator for glaucoma screening computed as

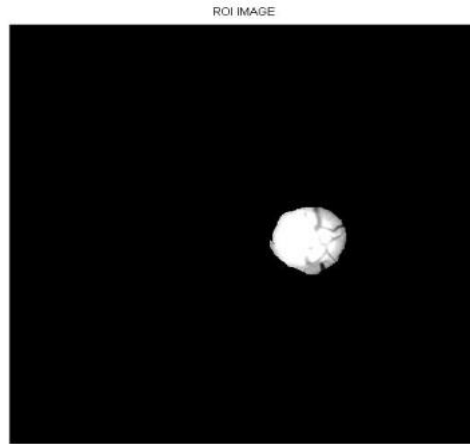
$$\text{CDR} = \text{Area of Cup} / \text{Area of Disc}$$

The computed CDR is used for glaucoma screening. When CDR is greater than a threshold, it is glaucomatous, otherwise it will be considered as a healthy one.

**V. EXPERIMENTAL RESULT**

Our experiments uses 2326 images from 2326 different subject eyes including 650 from the Singapore Malay Eye study (SiMES) and 1676 from Singapore Chinese Eye Study (SCES). We evaluate the proposed disc segmentation and cup segmentation method using the manual boundary as “ground truth” Among the 2326 eyes, 168 SiMES and 46 SCES eyes are diagnosed as glaucomatous by ophthalmologists.





## VI. CONCLUSIONS

In this paper, I present superpixel classification based methods for disc and cup segmentation for glaucoma screening. It has been demonstrated that CSS is beneficial for both disc and cup segmentation. In disc segmentation, HIST and CSS complement each other as CSS responds to blobs and provides better differentiation between PPA and discs compared with histograms. Reliability score is an important indicator of the automated results. I have demonstrated that, by replacing circular Hough transform based initialization with the proposed one for active shape model, I am able to improve the disc segmentation. In future work, multiple kernel learning [65] will be used for enhancement. The accuracy of the proposed method is much better than the airpuff IOP measurement and previous CDR based methods.

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# Glaucoma Screening Based On Super pixel Classification

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## Abstract:

Glaucoma is a chronic eye disease in which the optic nerve head is progressively damaged which leads to loss of vision. Early diagnosis and treatment is the key to preserving sight in people with glaucoma. Current tests using intraocular pressure (IOP) are not sensitive enough for population based glaucoma screening. Assessment of the damaged optic nerve head is both more promising, and superior to IOP measurement or visual field testing. This paper presents superpixel classification based optic disc and optic cup segmentation for glaucoma screening. In optic disc segmentation, histograms and centre surround statistics are used to classify each superpixel as disc or non-disc. For optic cup segmentation, in addition to the histograms and centre surround statistics, the location information is also included into the feature space to boost the performance. The segmented optic disc and optic cup are used to compute the CDR for glaucoma screening. The Cup to Disc Ratio (CDR) of the color retinal fundus camera image is the primary identifier to confirm Glaucoma given patient.

**Keywords — IOP measurement, optic cup segmentation, optic disc segmentation, CDR.**

## I. INTRODUCTION

Glaucoma is a chronic eye disease of the major nerve of vision, called the optic nerve which is progressively damaged. Glaucoma is characterized by a particular pattern of progressive damage to the optic nerve that generally begins with a subtle loss of side vision. If glaucoma is not diagnosed and treated, it can progress to loss of central vision and blindness. Glaucoma usually causes no symptoms early in its course, at which time it can only be diagnosed by regular eye examinations (screenings with the frequency of examination based on age and the presence of other risk factors).It is predicted to affect around 80 million people by 2020[1].

There are three methods to detect glaucoma: (1) assessment Of raised intraocular pressure (IOP), (2) assessment of abnormal visual field, (3) assessment of damaged optic nerve head. The IOP measurement using non-contact tonometry (also known as the “air puff test”) is neither specific nor sensitive enough to be an effective screening tool

because glaucoma can be present with or without increased IOP.

measurement using non-contact tonometry (also known as the “air puff test”) is neither specific nor sensitive enough to be an effective screening tool because glaucoma can be present with or without increased IOP. A functional test through vision loss requires special equipments Only present in territory hospitals and therefore unsuitable for Screening. Assessment of the damaged optic nerve head is both more promising, and superior to IOP measurement or visual field testing for glaucoma screening. Optic nerve head assessment can be done by a trained professional. However, manual assessment is subjective, time consuming and expensive. Therefore, automatic optic nerve head assessment would be beneficial.

One strategy for automatic optic nerve head assessments to use image features for a binary classification between glaucomatous and healthy subjects [2] which are normally computed at the image-level. In these methods, selection of features and classification strategy is difficult and challenging There are many glaucoma risk factors

such as the vertical cup to disc ratio (CDR), peripapillary atrophy (PPA), notching etc. . Although different ophthalmologists have different opinions on the usefulness of these factors, CDR is well accepted and commonly used. A larger CDR indicates a higher risk of glaucoma. There has been some research into automatic CDR measurement from 3D images [3]. However, because 3D images are not easily available, 2D color fundus images are still referred to by most clinicians.

## II. PROPOSED SYSTEM

This paper focuses on automatic glaucoma screening using CDR from 2D fundus images. This paper proposes superpixel classification based disc and cup segmentations for glaucoma screening. We compute centre surround statistics from super pixels and unify them with histograms for disc and cup segmentation. In this proposed approach, preprocessing such as image filtration, color contrast enhancement are performed which is followed by a combined approach for image segmentation and classification using texture, thresholding and morphological operation. Multimodalities including K-Means clustering, Gabor wavelet transformations are also used to obtain accurate boundary delineation. We incorporate prior knowledge of the cup by including location information for cup segmentation. Based on the segmented disc and cup, CDR is computed for glaucoma screening.

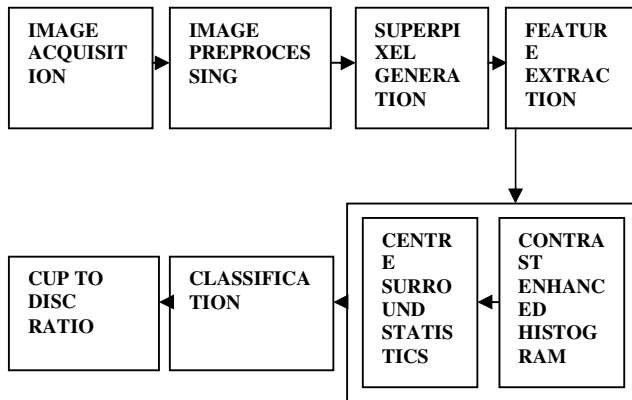


Fig. 1 Block diagram of proposed system

## Optic Disc Segmentation

Optic disc detection is an important step in developing systems for automated diagnosis of various serious ophthalmic pathologies. Optic disc segmentation is not an easy matter. Besides the variations in OD shape, size, and color pointed out, there are some additional complications to take into account. Some approaches have been proposed for disc segmentation but we use Circular Hough Transform [4] to model the disc boundary because of its computational efficiency.

In addition, we also present a superpixel classification based approach using histogram [5] to improve the initialization of the disc for deformable methods. The flow chart of the proposed disc segmentation method is summarized in figure 1. The segmentation comprises: a superpixel generation step to divide the image into super pixels; a feature extraction step to compute features from each superpixel; a classification step to determine each superpixel as a disc or non-disc superpixel to estimate the boundary; a deformation step using deformable models to fine tune the disc boundary.

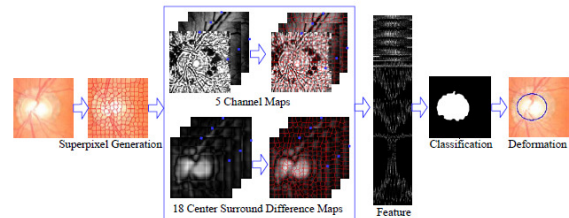


Fig.2 Superpixel based optic disc segmentation

### A. Superpixel generation

This paper uses the simple linear iterative clustering algorithm [6] (SLIC) to aggregate nearby pixels into super pixels in retinal fundus images. Compared with other methods, SLIC is fast, memory efficient and has excellent boundary adherence.

### B. Feature Extraction

#### 1) Contrast Enhanced Histogram:

Many features such as color, appearance, gist, location and texture can be extracted from super pixels for classification [7]. Since color is one of the main differences between disc and non-disc region, color histogram from super pixels is an

intuitive choice [5]. Histogram equalization is applied to red  $r$ , green  $g$ , and blue  $b$  channels from RGB color spaces individually to enhance the contrast for easier analysis. However, histogram equalization on  $r$ ,  $g$ ,  $b$  may yield dramatic changes in the image's color balance. Thus, hue  $h$  and saturation  $s$  from HSV color space are also included to form five channel maps. The histogram of each superpixel is computed from all the five channels: the histogram equalized  $r$ ,  $g$ ,  $b$  as well as the original  $h$ ,  $s$ . The histogram computation uses 256 bins and  $256 \times 5 = 1280$  dimensional feature  $HIST_j = [_j(HE(r)) \ _j(HE(g)) \ _j(HE(b)) \ _j(h) \ _j(s)]$  is computed for the  $j$ th superpixel  $SP_j$ , where  $HE(\cdot)$  denotes the function of histogram equalization and  $_j(\cdot)$  the function compute histogram from  $SP_j$ .

2) Centre surround statistics:

It is important to include features that reflect the difference between the PPA region and the disc region. The super pixels from the two regions often appear similar except for the texture: the PPA region contains blob-like structures while the disc region is relatively more homogeneous. The histogram of each superpixel does not work well as the texture variation in the PPA region is often from a larger area than the superpixel because the superpixel often consists of a group of pixels with similar colors. Inspired by these observations, we propose centre surround statistics (CSS) from super pixels as a texture feature.

C. Initialization and Deformation:

The LIBSVM with linear kernel is used as the classifier in our experiments. The output value for each superpixel is used as the decision values for all pixels in the superpixel. In our implementation, the mean filter is used as a smoothing filter to achieve the smoothed values. The smoothed decision values are then used to obtain the binary decisions for all pixels with a threshold. In our project, we assign +1 and -1 to positive (disc) and negative (non-disc) samples and the threshold is the average of them is 0. Now we have a matrix with binary values with 1 as object and 0 as background. The largest connected object, i.e., the connected component with largest number of pixels, is obtained through morphological operation and its boundary is used as

the raw estimation of the disc boundary. The best fitted ellipse using elliptical Hough transform [8] is computed as the fitted estimation. The active shape model employed in is used to fine tune the disc boundary. Compared with [9], the proposed method can also be treated as an active shape model based approach with initial contour obtained by superpixel classification.

Optic cup segmentation

The main challenge in cup segmentation is to determine the cup boundary when the pallor is non-obvious or weak. We present a superpixel classification based method for cup segmentation. The procedure for the cup segmentation is similar to that for disc segmentation with some minor modifications

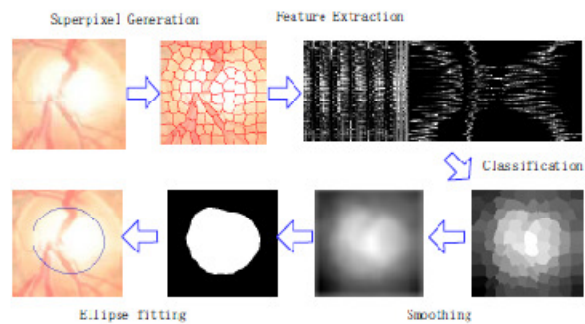


Fig.3. Superpixel based optic cup segmentation

A. Feature Extraction

After obtaining the disc, the minimum bounding box of the disc is used for the cup segmentation. The histogram feature is computed similarly to that for disc segmentation, except that the histogram from red channel is no longer is used. We denote it as  $HIST_{c_j}$  to be differentiated from that for disc segmentation. Similarly, the centre surround statistics  $_CSS_{c_j}$  can be computed

B. Superpixel Classification for Optic Cup Estimation

We randomly obtain the same number of super pixels from the cup and non-cup regions from a set of images with manual cup boundary. The LIBSVM with linear kernel is used again in our experiment for classification. The output value for each superpixel is used as the decision values for all pixels in the superpixel. A mean filter is applied on the decision values to compute smoothed decision

values. Then the smoothed decision values are used to obtain the binary decisions for all pixels. The largest connected object is obtained and its boundary is used as the raw estimation. The best fitted ellipse [10] is computed as the cup boundary.

### C. Cup to Disc Ratio

Based on the segmented disc and cup boundary, the cup to disc ratio (CDR) is computed as

$$\text{CDR}=\text{VCD}/\text{VDD}$$

The computed CDR is used for glaucoma screening. When it is greater than a threshold, it is glaucomatous, otherwise healthy.

## III. EXPERIMENTAL RESULTS

### A. Data sets

Our experiments uses 2326 images from 2326 different subject eyes including 650 from the Singapore Malay Eye study (SiMES) and 1676 from Singapore Chinese Eye Study (SCES). We evaluate the proposed disc segmentation and cup segmentation method using the manual boundary as “ground truth” Among the 2326 eyes, 168 SiMES and 46 SCES eyes are diagnosed as glaucomatous by ophthalmologists.

### B. Optic Disc Segmentation

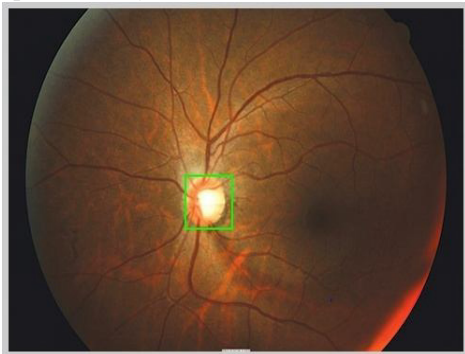


Fig.4. optic cup segmentation

From the fig, the disc boundary can be obtained by taking the decision values from the super pixel. The raw and fitted estimation is also performed for the initialization of disc boundary. The decision values from the support vector

machine are used for segmentation. Output of each super pixel is used as the decision values. Each image is divided into super pixels. The features are used to classify each super pixel as cup or non- cup. The decision values from the SVM output are smoothed to determine the cup boundary. The cup can be located at the centre section of the disc.

## IV. CONCLUSION

In this paper, I present superpixel classification based methods for disc and cup segmentation for glaucoma screening. It has been demonstrated that CSS is beneficial for both disc and cup segmentation. In disc segmentation, HIST and CSS complement each other as CSS responds to blobs and provides better differentiation between PPA and discs compared with histograms. Reliability score is an important indicator of the automated results. I have demonstrated that, by replacing circular Haugh transform based initialization with the proposed one for active shape model; I am able to improve the disc segmentation. In future work, multiple kernel learning will be used for enhancement. The accuracy of the proposed method is much better than the air puff IOP measurement and previous CDR based methods.

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Authored by

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## **DIGITALIZATION IN TEACHING AND LEARNING: A COMPREHENSIVE STUDY**

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### **Abstract:**

The educational system was severely impacted due to COVID-19 pandemic and teachers and students were both supposed to adapt digital environment. Rapid development of digitalization has affected in the development of teaching and learning. Digitalization is to provide digital platform and it is process of transformation of information in computerized format. Teaching is world's largest profession of transmission of knowledge where learning is ability to learn and understands the knowledge. Digital age has changed, how we communicate, inform ourselves, and even how we teach and learn. Main objective is to minimize manual work and physical documentation. Technologies and use of digital media will improve teaching and learning development. This paper provides a comprehensive review of the digitalization in teaching and learning, highlighting its impact on education system. Based on literature review author describes effect of digitalization on teaching and learning, author specify challenges and suggestions to overcome for the same. Finally, some recommendation and future directions for digitalization is highlighted in this research studies.

**Keywords:** Digitalization, Digital, Learning, Teaching, Challenges

### **Introduction:**

Digitization is related to the concept of digital transformation. Digitization is to provide a digital platform in every field all over the world. Digitization is the process of transformation of analog data into digital information, so it can be stored and understood by computer machine which include transfer of paper document to electronic or digital format that result as digital representation. Digitization refers to the conversion of existing hardcopy learning material and process to making them available through digital means. It can be easily stored, shared and backup the information of all kinds in all formats with consistent efficiency & managed. Digital and new technologies are used to send and receive information, deliver services and also impacted the way learning occurs. In the current situation people, society, businesses, and education have to matched and access the knowledge via Information and combination technology(ICT's) to be heart of digital world.

Education is a system with several components that interact with each other to achieve a particular goal. Some of the components include objectives of education; teaching materials, teaching tools/

media, teaching methods etc. If anyone component is missing then the result will not be very good. Learning is process which can be done through formal and non-formal education. In formal education teacher and student are communicate with each other where teacher is facilitator of social interaction education for student. Learning is an ability to learn, understand knowledge, behavior, skills, value and many more new things which is continuous and lifelong process, it doesn't end and play very crucial role in human development and modify existing knowledge, attitude towards current trends. It is active and adaptive to the current environment to learn and engage with information, and experience, and develop the necessary skills to function effectively in various areas.

The digital revolution has brought about significant changes in various aspects of our lives, including education. With the proliferation of digital technologies and the internet, education has become more accessible and convenient than ever before. The impact of the digital revolution on education and how it has transformed the way is essential. Teaching is the world's largest and cutest profession, where we can transmit knowledge to learners, Students, or any other audience. During the teaching process, a teacher's job is to impart knowledge to students and inspire and motivate students to be more active. In higher education teaching are committed to developing as professional teachers not only as researchers, they should provide good quality learning material with the help of researchers. Teachers can broadly be defined as the confident, creative use of ICT tools, this is an essential skill for today's teachers. This helps the teacher to acquire and update skills needed in their work for teaching. To create a positive, respectful, curiosity, and punctuality learning attitude among the learner, teachers should be innovative, creative, motivational, caring, enthusiasm, adaptable, and research-oriented to lifelong learning.

The present paper is considering the view of digitalization in teaching learning process and its impact on education institutes. The present study based on mixed methods approach of secondary data with the following objectives -

- to understand the evolution of digitalization in education.
- to study the importance and relevance of digitalization in teaching and Learning.
- to know the benefits and challenges of digitalization in education.

**Review of Literature:** In 2015, Jessica Muetterties in her paper "Enhancing Education through Digitization" highlighted that teachers must learn to embrace the fact that computers and other aspects of technology are used by children every day the classroom needs to incorporate new and emerging technology. It also focuses on how to prepare online presentations with various methods. Dr. Raju Kumar (2020) emphasis that Artificial Intelligence will boost to digitalization and it can be used for making education systems online. It also highlights that computer tools and applications will help to conduct the examinations and evaluation of papers. Saiful Islam(2018) presented in his paper that today most of the learning styles have been converted into digital education system. Digital education also extends through social networks. He said the effect of social networking on our education site.

Dr. Anssi Mattila(2015) analyzed Teachers should be able to deepen students' understanding and knowledge, and develop skills like problems solving, interaction, self-correction, critical reflection,

competence improvement meaning making an experiential learning. In the future, we have to focus resources on teaching teachers, and not only at the beginning of their career, but teachers should have a possibility to develop professionally throughout their academic working life. M Tsarapkina(2021) concludes that the leading role in any pedagogical process belongs to the teacher, and in the application of digital technologies, his contribution is undeniable. He said the primary focus should be on innovations created by teachers which must associate with technology produced in the market and improved technological process while using in practice. Tarmo Tuis(2015) concluded this leads the researchers to believe that ICT does play a role in increasing and facilitating, interactions for students studying in an international context both with each other and with university staff.

Mei, X., Aas, E. & Medgard, M. (2019), stressed that teachers use of digital learning tools for teaching in higher education and exploring teaching practice and sharing culture as creating activity, variation and commitment are some of the main reasons for using digital learning tools in planning and conducting the teaching with positive impact which can improve by teaching practice through digital learning tool. Vasileios Dagdilelis (2018) concluded as the initial data analysis seems to indicate that the use of ICT in teaching has been generally accepted by the teachers.

Ulyawati (2022) describes digitalization is using media of digital form, the research illustrates that digitalization of effective elementary school natural science learning using E-learning, personalized learning, and continuous feedback mechanisms and student have their ownership towards learning. Issa I. Salame (2023) proposed there are significant differences between online learning and a traditional face-to-face format. Jens Riehemann & Regina Jucks (2017) highlighted that the digital age has changed how we communicate, inform ourselves, and even how we teach and learn. Sheila García-Martín (2019) concluded the ability to integrate and use of technologies for educational purposes requires generic and specific teaching skills, known as professional digital competence.

**Evolution of Digitalization in Education ;** As the effect of technology seen in every aspect of society, the results of digitalization in education have been unable to avoid. In educational field, digitalization has different applications like e-learning, online courses, online examinations, distant learning and administrative work. Along with these methods, mentality of students is also changing. They are not restricted with text books available in market. Their methods of learning are changing every day. They like to learn through social media such as YouTube, Online Apps, Facebook etc. The e-books provide an interactive media in which the students have access to multimedia contents such as videos, slide presentation and hyperlinks. Learning through animations like pictures, diagrams, and different color combinations is more effective.

Like traditional methods, nowadays people don't like to stand in long queue for admission process. Students can fill their applications online at their convenience. Payment of fees can be transferred online from anywhere and anytime using internet.

**Effect of Digitalization in Teaching and Learning:** Some benefits are not so obvious, but still worth noting. So, let us show you some of the critical areas where you can digitalize the learning process.

**Managing Admissions:** Uploading the enrollment application to institution offline is lengthy and time-consuming process but through the digital way submitting them is more convenient and a time-savvy.

**Minimizing Risks:** Whether lectures or classes were canceled due to unhealthy conditions, online learning can handle it all and convenience to maintain excellent attendance rates and not miss an important lesson through digital tools or just read through the material uploaded on the cloud.

**Improving Learning Outcomes:** With interactive lessons and implementing high-tech solutions can motivate students and, as a result, improve their learning skills. The more attention will give to what's going on, the more relevant information will be able to absorb at once.

**Evaluating Performance:** The process of digitalization in education offers a lot of benefits for students, such as faster access to tests and grades through online systems. E-learning systems allow to track students' performance levels that you can easily measure via a digital platform.

### **Benefits of Digitalization in Education:**

Today education is becoming digitized faster than expected the reason cited is that digital way of learning has a long-lasting impact on the memory of the learner and makes him smarter embodied with logical thinking and sharp reactions in a given situation that that being possessed when more reliance was on class room teaching and traditional methods of imparting education. Following are the important benefits of digital education over the traditional education system of education.

- Digital tools provide students with access to vast amounts of information, enabling them to explore diverse perspectives and resources beyond traditional textbooks.
- Digital platforms can be tailored to individual learning styles and paces, allowing students to engage with content at their own speed and receive personalized feedback.
- Interactive multimedia elements, gamified learning experiences, and virtual simulations can make learning more engaging and enjoyable, fostering active participation and motivation among students.
- Nowadays, E-learning, distant learning and online education have become very important of education system now days. Even several foreign universities have started online degree courses that students can join. There is no restriction to attend the class physically. Thus, digitization of education has crossed all boundaries for students who have thirst for knowledge.

### **Challenges of Digitalization in Education:**

While the benefits of digitalization in teaching and learning are clear, there are also significant challenges that must be addressed to realize its potential. According to review of various papers ,there are some challenges faced by people in various filed. It can be difficult to teachers to keep up with the latest trend in technology

- One of the key challenges is related to technology integration. Integrating technology effectively into teaching practices requires significant time, training, and support for teachers,

as well as access to reliable infrastructure and technical support. Without adequate support, teachers may not adopt digital technologies, or they may use them ineffectively which can negatively impact student learning outcomes.

- Socioeconomic disparities in access to technology and internet connectivity can exacerbate inequalities in educational opportunities, creating a digital divide among students from different socioeconomic backgrounds.
- Excessive use of digital devices and online platforms can lead to distractions, multitasking, and information overload, potentially hindering students' ability to focus, retain information, and develop critical thinking skills.
- Digitalization raises concerns about the privacy and security of student data, as well as the risk of cyber threats, data breaches, and unauthorized access to sensitive information stored on digital platforms.
- Implementing digital tools and online learning environments requires careful consideration of pedagogical approaches, instructional design principles, and assessment strategies to ensure meaningful learning experiences and academic integrity.
- Students and teachers need to develop digital literacy skills to navigate digital platforms effectively, evaluate online information critically, and use digital tools responsibly for learning and communication.
- Ensuring equitable access to digital resources and addressing barriers to participation for students with disabilities, English language learners, and other marginalized groups are critical challenges in digitalized learning environments.
- During online learning students complaining about of lack of motivation, it happens because every student is not accompanying by teacher face to face interaction of student teacher is not possible because more number of student are present in the session. Some students are not able to speak in front of all students due to fear as there is lack on one to one interaction between student and teacher.

### **Conclusion:**

Digitalization used to provide digital platform and it is process of converting hard paper in digital form. Teachers must realize that they are the main facilitators not replaced by new technology, but with the new technology, one can improve the efficiency of teaching by teachers. The use of digital learning media used by teachers for teaching as well as used by students for learning in beneficial in the current situation. Challenges faced by students are lack of motivation, infrastructure problem and faced by teacher as availability of learning media; innovative learning is an expensive part. In the following ways, the digitalization of education can be more fruitful results in terms of knowledge and learning

- Teachers must consistently update with the latest technologies by taking part in training and workshops, especially in the field of education sector which will help them not only to learn

how to use new technology but also how to provide meaningful instruction and activities using technology in the classroom.

- With the potentially powerful effect of media and the growing empirical evidence for the negative impact of technology on students, parents should take care to limit exposure to deleterious technology. They should know what content their wards are reading and viewing in the name of online education.
- There should be clear learning objectives and Institute should provide facilities to teachers and students as per the requirement of new digitization technology. So, be ensure about a technology planning team comprising administrators, teachers, technology coordinators to determine the educational goals for students and the types of technology that will be beneficial to meet the goals.

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**मध्य भारती**  
मानविकी एवं समाजविज्ञान की द्विभाषी शोध-पत्रिका



**MADHYA BHARTI**  
(UGC CARE Group-1, Multi disciplinary)

## CERTIFICATE OF PUBLICATION

This is to certify that the article entitled

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Authored By

**Mrs. Sushma Pingale**

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# मध्य भारती

मानविकी एवं समाजविज्ञान की द्विभाषी शोध-पत्रिका

**EFFECTIVE PROJECT MANAGEMENT WITH AN IOT**

Mrs. Sushma Pingale, Mrs. Gauri Shirude, Assistant Professor, SNBP College of Arts,  
Commerce, Science & Management Studies, Pune. [pingalesushma23@gmail.com](mailto:pingalesushma23@gmail.com),

**Abstract-**Internet of Things (IoT) is one of the main indications in project management for the technology enhancement. It is a great relationship between project management and IoT by mutual understanding of project team and implement the project with great accuracy and faster. Nowadays to develop project management, project managers are supposed to do careful planning, designing, management and use of IoT in projects. Researcher found that IoT can offer significant benefit in project management including cost reduction, increase efficiency and improve communication. With the analysis of the different articles from other researcher's works, the authors are enabled to acquire detailed information about the implementation of IoT in the project management. This paper represents the impact of IoT on project management in project based organizations. A qualitative method of research was adapted to structure interview of 18 selected participants and identifies benefits and challenges of using IoT in project management. Also some feature recommendation and solution for implementing and managing IoT system is highlighted in this research studies.

**Keywords:** Internet of Things (IoT), Project Management, Mutual Understanding, Technology.

## **I. INTRODUCTION**

### **A. Internet of Technology**

The term IoT or Internet of Things integrates everyday “things” with the internet. It is the collective network of connected devices and the technology which provides communication between devices and the cloud, as well as between the devices themselves to share data and automate tasks. Due to inexpensive computer technology and high bandwidth telecommunication, nowadays billions of devices are connected to the internet. This means everyday devices like smart home appliances, vacuums, cars, and machines can use sensors to collect data and respond intelligently to user. The base of IoT system is the real-time collection and analysis of data. The smart devices, IoT applications and Graphical User Interface (GUI) are three components of IoT system. To improve business efficiencies, IoT is used in several industries such as manufacturing, retail, healthcare, transportation and other enterprises etc. In industrial IoT, Industrial devices, from sensors to equipment give business owners detailed, real-time data that can be used to improve business processes. They also gives insights on supply chain management, logistics, human resources, and production which leads to decrease costs and increase business revenue. In future, IoT will become increasingly tremendously in our daily routine.

### **B. Project Based Organization**

A project specifically focuses on one task or outcome. It is vast becoming an important approach to organize work in many firms either in small scale or large scale. It could be for internal development of any organization or for a client or customer. To utilize these business opportunities, many companies make arrangement for projects to work according to client or customer needs. After deployment of project, the client or customer perform acceptance testing gave feedback and the team works according to it requirement. Historically, every team in project management, have team leader or project manager who can decide to work on project with his team members. The team leader or project manager is responsible for the overall qualitative outcome of the project. He ensures that team expertise members of projects have access of right functionality. The project manager's responsibilities are to choose team members, assign tasks to them, and monitor the performances. The team members further divided into groups executes all the plans and do all the work. Project will need to handle in different ways; it can be traditional, IT project, hardware or software. There are different phases of any project such as communication, planning, execution, monitoring &

controlling and closure. Project manager or team manager should be involved in all phases as shown in fig.1

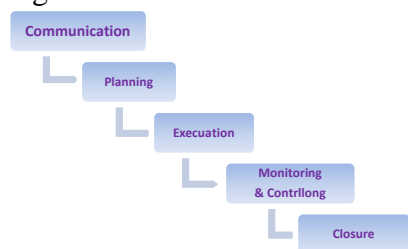


Figure 1: Phases of software development

Project manager use various ways to do planning and execution of projects and review should be taken time to time as project finalized on time, within budget and wider scope. This process of planning, monitoring and executing the progress of project is called project management. As IoT technology is rapidly growing, project manager must deeply understand this development. Initially, project management methodologies used different models in developing advanced projects such as Waterfall and Agile models. And now, we have IoT projects, where it provide real time data and help project manager to take better decisions, utilize resources, and improve project quality and it helps to automate project tasks.

## II. REVIEW OF LITERATURE

Different opinions from several authors help to provide the important concepts of Internet of Things, current trends in this project based organization and both the managerial as well as the technical challenges being faced in such projects.

For successful deployment of IoT-based products and services, the top five technologies that are essential such as radio frequency identification (RFID), wireless sensor networks (WSN), Internet of Things (IoT) and middleware, cloud computing and IoT application software. This study is highlighted by Vlad HurTOI (2020) in IOT project management

A literature review by M. Bakker(2017) focuses on five phases of an IoT project and analyses technical and managerial challenges occurs in these five phases. Also this study carries out some options to justify the investment in such projects. Additionally, this article introduces a conceptual model of IoT applications where challenges in implementing IoT in project management, especially in terms of information sharing and collaboration, monitoring and control, and business analytics aspects are highlighted.

Somayya Madakam,(2015) mentioned an introduction of Internet of Things, IoT architectures, different technologies and their socio-economic impacts, this study highlighted the requirements for implementation of IoT projects and their components This can help an enterprise in understanding the concept, search for the right tools and coming up with a solid business case, and a project management plan. This paper gives an idea about the technical and management areas, which need to be worked on from both organization and IoT projects.This review provides more insight into the IoT world and how stakeholders are receiving this technology interruption.

Internet of Things (IoT) and changing face of project management research by Prasher Vikram (2018) is an excellent article highlighting IoT technology in project based organization. In this article, author identified most important challenges being faced in IoT products development based on a mix of quantitative research, and then also suggests the solution to overcome this problem.

Percudani & Batrawi (2017) discussed that in any project based organization, IoT and project management are two close parameters, they also explained the challenges, obstacles, and advantages of IoT in PMO. The article also considered one of the most important elements of any organization or business, people, fixating on project managers and how the role of a project manager is affected in the innovative project oriented organizations.

The Internet of Things (IoT) provides many benefits for organizations but like other technology adoption, it may also introduce risks and opportunities. P. Brous, M. Janssen, and P. Herder (2020) analyze implementation in project management and insights into IoT advantages and disadvantages.

Also they highlighted necessary changes to the organization processes and system to overcome unexpected risks and ensures that IoT fits the organization puposes.

Jyotsna Gabhane, Shradha Thakare, and Monika Craig (2017) presented various problems and challenges in IoT as well as IoT-based smart home systems. They highlighted some solutions to overcome those problems and challenges.

According to Cisco survey, about 75% of IoT projects are this issue having a negative impact on several industries which are falling less confident in investing money in IoT business as is seen as a risky business.

Seamless connectivity is a key requirement of any IoT system. Means it requires anytime, anywhere by anyone and anything to provide intelligent services including identifying, sensing, networking, processing and execution capabilities. This concept is brought by Čolaković, A., & Hadžialić, M. (2018) in the article.

M. Elkhatib, A. A. Hosani, I. A. Hosani, and K. Albuflasa (2020), discusses improving Project Risk Management in agile projects in different sectors and analyzes if a hybrid approach adopted can deliver better results in project risk management in an agile environment. And it was concluded that agile projects will have a positive impact on project success.

### **III. RESEARCH METHODOLOGY**

The present study falls under research method which can be divided into two categories of qualitative and quantitative research. Qualitative research depends on studying and observing event before concluding it. Researchers can use several qualitative research methodologies include case study research, grounded theory, etc. whereas quantitative research methodologies collect and analyze the numerical data, which includes surveys, interviews, experiments, and observations.

In this research, quantitative research methodology is used. Structured interviews on questionnaires were used to collect qualitative data implementing the use of IoT in project management. This research paper focuses on establishing the impact of IoT in project management and this is determined by collecting the data from interviews. The participants selected for an interview based on various factors in terms of at least 4-5 years of experience and professional background in project management. In this structured interview, interviewers have a predetermined set of questions, and it allows a more in-depth exploration of the interviewee's thoughts and experiences on IoT implementation in project management.

### **IV. RESULT ANALYSIS**

The interviews were conducted among 25 people; only 70% cooperated throughout the interview and answered all questions. All eighteen participants agreed that any project is divided into five phases. In the project planning phase, 65% of respondents believed that IoT implementation in this phase helped and guided staff throughout the project. Also, manager gave a real time update on the progress of project to stakeholders during planning. In the execution phase, 60% of interviewees agreed that implementation of IoT improved effectiveness, efficiency, and productivity. Almost all respondents agreed that the benefits of IoT can be detected by the overcome at this stage. In the closing phase of the project, all respondents indicated that it is important to collect and store the data in this stage as it will acts as a reference in future.

TABLE 1  
PARTICIPANTS

Number of Participants	of	25
Participants responded	that	18
Participants that do not responded	that do	7

TABLE 2  
DETAILS OF PARTICIPANTS

Sr · N o.	Designation	Professio nal Experien ce	Mode of Intervi ew	Duratio n
1	Project Manager	Above 14	Phone	40 mins
2	CEO	Above 15	Physica l	45 mins
3	CEO	Above 16	Physica l	40 mins
4	Senior lecturer	Above 2	Skype	25 mins
5	Project Manager	Above 18	Phone	15 mins
6	Senior lecturer	Above 19	Zoom	45 mins
7	Senior lecturer	Above 6	Zoom	20 mins
8	Senior lecturer	Above 21	Zoom	30 mins
9	Senior lecturer	Less than 3	Physica l	70 mins
10	Professor	Above 23	Phone	45 mins
11	Professor	Above 9	Ms Team	50 mins
12	CEO	Above 35	Google Meet	60 mins
13	Project Manager	Above 14	Phone	35 mins
14	Project Manager	Above 17	Zoom	40 mins
15	Project Manager	Above 20	Skype and Phone	35 mins
16	Senior lecturer	Above 8	Physica l	55 mins
17	Senior lecturer	Above 12	Phone	20 mins
18	CEO	Above 29	Google Meet	30 mins

## V. BENIFITS OF IOT IN PROJECT MANAGEMENT

With an advanced technology, IoT will fundamentally change the speed of project implementation. Previously, an old data is stored in a traditional way which takes a lot of time to store. But by using Internet of Things, this data is stored in a centralized location and can be easily available and is useful for current and future projects. The Internet of Things helps project managers and stakeholders to monitor and manage project activities in real time. This monitoring is done through display showing all the steps which will be useful to manage project quickly. There is much equipment that uses different sensors to monitor the needs for maintenance throughout the project implementation

process that will help to reduce the risk to project. IoT ensures continuous flow of data which automates business system and execute the project with IoT. Project manager can prepare smart devices which will assist him to prepare the reports quickly that help to communicate the data fast.

## VI. CHALLENGES OF IOT IN PROJECT MANAGEMENT

The adoption and implementation of new technology is always difficult. However it is reasonable to consider the impact of IoT technology in corporate world is transforming change in which a company makes significant changes or innovation is a faster. But these new updates will influence all the activities such as products, policies and practices. In IoT based project management organization, standardization is

also a key problem which represents the first technical issue related with IoT implementation. Since IoT is a series of interconnected devices and networks, any software or hardware (devices) failure will leads to failure opportunities and inconveniences. Since many IoT devices are mostly focused on connectivity not on the security. So they are easily hacked by attackers. Therefore, accessibility, secrecy, authenticity and authorization are major requirements of IoT based project management. The implementation of IoT requires a high technology and services from any organizations point of view, mostly a huge storage place to store the data and uninterrupted flow of data. The cost of implementing such storage systems is high and ability to handle such quantity of data should be organized on a cloud.

## VII. FUTURE RECOMMENDATION

The following are some research recommendations to implement IoT in effective project management:

- To introduce and implement IoT in project management, the regulatory authority plays an important role. To establish regulation and framework in project management, all project team members and stakeholders must follow the regulatory authority. Accordingly, the regulatory authority should facilitate to protect the big data of project by setting security policies for collected data during the different project stages through the Internet of Things, and to protect it from unauthorized access. So, it is recommended that the regulatory authority to prepare the guidelines for security and privacy of data or information for the project and show positive impact of an IoT on project management in terms of reduced cost, resources to monitor and execute the project.
- It is essential to have a clear understanding of the goals and objectives of the project before implementation starts. As per project requirement, research and select the most appropriate IoT technology.
- Considering the data security and privacy manage the data collected by IoT devices carefully.

## VIII. CONCLUSION

The result of research methodology showed that IoT impacts project management in project-based organizations in every project stage. Since IoT implementation have a positive impact on project management by increasing project quality and reducing risks. This study also presented an overview of the challenges that the project manager and stakeholder may be facing in implementation of IoT in projects. Hence we emphasis the e-future recommendation to implement IoT in effective project management.

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