Abstract: The number of premature babies affected by ROP disease (Retinopathy of Prematurity), a foremost cause of childhood blindness, is continually increasing. ROP can be effectively and successfully cured if diagnosis is given at an early stage. The collaboration between physicians and ophthalmologists is therefore important to reduce and prevent this eye loss phenomenon. The RetCam is a recently developed instrument, which can be used to view the retina of a preterm baby. Nevertheless, pictures taken by RetCam are still not clear and vessels cannot be clearly seen, which causes a delay in diagnosis and treatment. This research is aimed at improving the pictures from RetCam camera using image processing techniques. Edge detection techniques are tested and further developed to detect the edge of eye vessels automatically. The resulting improved pictures will help doctors to instantly diagnose the patient and then provide proper treatment in due course.

Introduction: Retinopathy disease is a blind eye condition of premature babies. In Thailand 16 out of 120 premature babies lose their vision compared with 300 out of 1,000,000 in the United States of America. Digital camera technology is adopted in photographing the eye but a problem is that the image is not clear enough and not able to be used in diagnosing the disease. Researchers have realized the issue, and set up...
research on methods of improving the image for specialist physicians to adopt in diagnosing and treating the disease in time.

**Methodology:** To find blood vessels automatically, image processing techniques are applied. The researcher has developed a testing procedure. First, image is converted to gray scale image, and then pre-processed using a procedure of Local Contrast Enhancement (as in equation 1).

\[ f(i, j) \rightarrow g(i, j) = 255 \left[ \frac{\Psi_w(f) - \Psi_w(f_{\min})}{\Psi_w(f_{\max}) - \Psi_w(f_{\min})} \right] \quad \ldots \quad (1) \]

where the sigmoid function is

\[ \Psi_w(f) = \left[ 1 + \exp \left( \frac{f - f_{\min}}{\sigma_w} \right) \right]^{-1} \quad \ldots \quad (2) \]

while \( f_{\max} \) and \( f_{\min} \) are the maximum and minimum value of intensity within the whole image with \( \langle f \rangle_{w(i,j)} = \frac{1}{M^2} \sum_{(k,l)w(i,j)} f(k,l) \), and \( \sigma^2_w(f) = \frac{1}{M^2} \sum_{(k,l)w(i,j)} (f(k,l) - \langle f \rangle_w)^2 \).

With local contrast enhancement, intensity is adjusted more clearly while the colour remains original. A clearer image will be produced. The image is then put into Edge Model with an application of image gradients, in which edge of eye vessel can be detected by Gradient derived from calculation of “mask” values of Roberts cross operator, Prewitt operator, and Sobel operator. The gradient images are derived by calculation of convolution in x and y axis, multiplication between the total of mask values in x and y axis and the image, and then calculate on Gradient value from following equation,

\[ |G| = \sqrt{G_x^2 + G_y^2} \]

In second order differential method of edge detection, theory of LOG, Laplacian of Gaussian, has been applied. The procedure applies Gaussian smoothing first, and then a Laplacian process, and finally a Zero-Crossing. A mask value can then be derived from the following formula.

\[ \text{LoG}(x, y) = \frac{1}{\pi\sigma^4} \left[ 1 - \frac{x^2 + y^2}{2\sigma^2} \right] e^{-\frac{x^2 + y^2}{2\sigma^2}} \]

Canny edge detection has also been experimented with a mask size of 11x3, 15x3, and 15x5 and calculating from Pascal triangular and Gaussian value. Mask size 5x5 is adopted suitable for our set of images by deriving Gaussian value. A mask value taken from first order differential methods of edge will again be applied in this edge detection process.

**Result, Discussion and Conclusion:**

The modified algorithms are applied to the original images shown in figures A and B. The results after application are shown in figures 2 and 3.
Fig1. Original retinal vessels in infant images.

Fig2. Resulting edge image of A and B use Sobel operators.

Fig3. Resulting edge image of A and B use canny operator with Mask 15x3

After getting results of image’s edge detection from several methods, the researcher has distributed the images to specialist physicians to evaluate. The method or theory that is the most practical in detecting eye’s image edge of ROP premature babies will be identified by clinician. The result, from the specialist physicians, is in the following.

<table>
<thead>
<tr>
<th>Method</th>
<th>Average Value Evaluated by Specialist Physicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sobel</td>
<td>84.75</td>
</tr>
<tr>
<td>Robert Prewitt</td>
<td>46.25</td>
</tr>
<tr>
<td>Canny Mask 11x3</td>
<td>82.5</td>
</tr>
<tr>
<td>Canny Mask 15x3</td>
<td>78.5</td>
</tr>
<tr>
<td>Canny Mask 15x5</td>
<td>79</td>
</tr>
<tr>
<td>Canny Use Sobel Mask</td>
<td>46</td>
</tr>
<tr>
<td>LoG</td>
<td>46.2</td>
</tr>
</tbody>
</table>

After the evaluation by specialist physicians, Sobel operator approach using Image Gradient theory is found most suitable at 84.75 correctness.

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**Keyword:** ROP, Edge Detection, Convolution, Laplacian, Gaussian, gradient and mask.