False Position based Auto Exposure Algorithm for Properly Exposing the Leather Samples in the Leather Industries

B.Ravi Kiran[1], K.Murali Krishna, Ph.D [1], S.A. Shajahan Basha[1], G.V.N.A.Harsha Vardhan[1],Dr.K.V.S.V.N.Raju[1], V.Valli Kumari[2]
1 Anil Neerukonda Institute of Technology and Sciences
Visakhapatnam,Andhra pradesh,India.
[2]Andhra University, Visakhapatnam,Andhra pradesh,India

ABSTRACT
In order to detect the defects in the leather sample in an automated way, the image of the leather sample has to be captured properly. To properly capture the images of the leather sample, we have implemented an auto exposure algorithm based on false position method which is discussed in this paper. This algorithm can also be used to properly expose the natural scenes

Keywords
Auto Exposure algorithm, Bisection method, False Position Method

1. INTRODUCTION
To detect the defects in the leather samples, the proper image of the sample has to be captured, on which the image processing techniques has to be performed. But the lighting changes in the industrial environment will affect the image that has to be captured. The solution for this problem is the usage of the Auto exposure algorithm, to properly capture the images according the varying lighting conditions. In the auto exposure algorithm, the properties of the camera such as the Shutter speed, ISO (gain), Aperture size etc are varied depending on the lighting conditions to capture the properly exposed image for that particular lighting condition only. To obtain the proper exposure for the under exposed scene the shutter speed and gain are increased to obtain the optimal exposure for the low lighting regions, similarly we decrease the shutter speed and gain for over exposed scene to obtain the optimal exposure for the high lighting regions. This process of adjustment is performed in the auto exposure algorithm until proper exposure of the particular scene is obtained, this adjustment can be done in several ways as in [1][2][3] to obtain the proper exposure. We have implemented the auto exposure algorithm by using the false position method, which will be discussed in the later sections..

2. RELATED WORK
According to Tetsuya Kuno and Narihiro Matoba [4] for a scene a sampling area has taken and given as input to the camera processor, which calculates an integrated value for the imaging signal. This integrated value is divided by the ISO and shutter speed to obtain the brightness of the scene. The optimum brightness is obtained by varying these shutter speed and ISO and these values are maintained in the lookup table. The drawback of this method is the storage and maintenance of this look up tables.

According to Simon Schulz et al [5] initially the image of the scene is captured and that image is processed by using the luminance histograms. The under exposed and over exposed regions are clipped by using the histogram, the drawback of this method is that the proper exposure of the scene is obtained by processing the already captured image but it is not capturing at the real time image with proper exposure. To overcome these drawbacks the appropriate way is to use the iteration methods such as the numerical analysis methods etc. We found that there is not much usage of numerical analysis methods to the auto exposure algorithm. To our knowledge the bisection and secant methods have been implemented to find the exposure values as the roots.

2.1 Bisection Method
According to B.Ravi Kiran et al [6][7], the bisection method is used to find the exposure values as the root. The bisection method is the basic numerical analysis method, which is used to find the roots for the continuous functions. In the bisection method, the method starts by identifying the initial roots. The initial roots are considered in such a way that the function value of the initial roots has contain the opposite signs. These initial roots are bisected to find the new approximation value. if the function value at the new approximation is negative then the root with negative function value is replaced else if the function value is positive then the root with positive function value is replaced else if the function value is zero then the new approximation is the root value. This is repeatedly performed until the root of the continuous function is obtained. This method is applied to auto exposure algorithm in such a way that the initial roots are considered one with under exposure and the other with over exposure and these values are bisected to find the new approximation and the scene at this new approximate value will decide which initial root is to be replaced with the approximation. The below figure 1.1 represents the diagrammatic approach of the bisection method. The advantage of this method is it reliably converges to the proper exposure values. The drawback of this method is that the algorithm takes more number of iteration to converge to the root as the interval to bisect decreases. So by using this auto exposure algorithm will lead to slow result and in the leather industry there is a chance of missing some leather samples to capture for defect detection.

2.2 Secant Method
According to Myung Hee Cho, et al [8] the initial exposure values are considered randomly and the formula of the secant method is applied to find the next approximation. This process of finding the next approximation is repeated until the proper exposure is obtained. The secant method has the problem of

divergence to the root. The following figures 1.2 and 1.3 diagrammatically explain the reasons of why not to use the secant method and also why we use the false position method. The figures 1.2 and 1.3 represents the comparison between secant method and false position method as the next approximation in false position will always be with in the boundary limit of the curve but where as in the secant method there is boundaries so there is a chance of divergence of the root in some cases so the secant method is not reliable. So in our algorithm we implemented the false position method.

3. FALSE POSITION METHOD

The false position method is a numerical analysis method, which is used to find the root for a non-linear equation(curve). The root of the equation is a

point where the curve cuts the x-axis when y equals 0. In the false position method, the next approximation value is the intersection point of the X-axis and the straight line formed by the initial values. By iteratively doing the same process we will end up with the final root values, as shown in the Figure2.

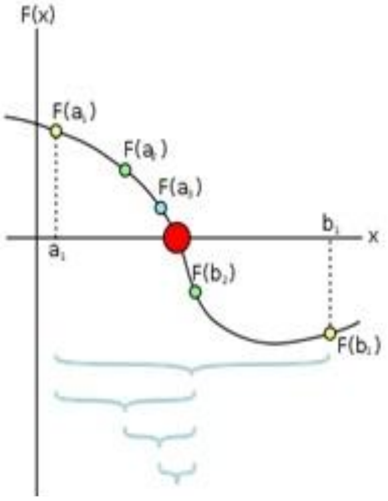

Figure 1.1: Diagrammatical representation of Bisection method

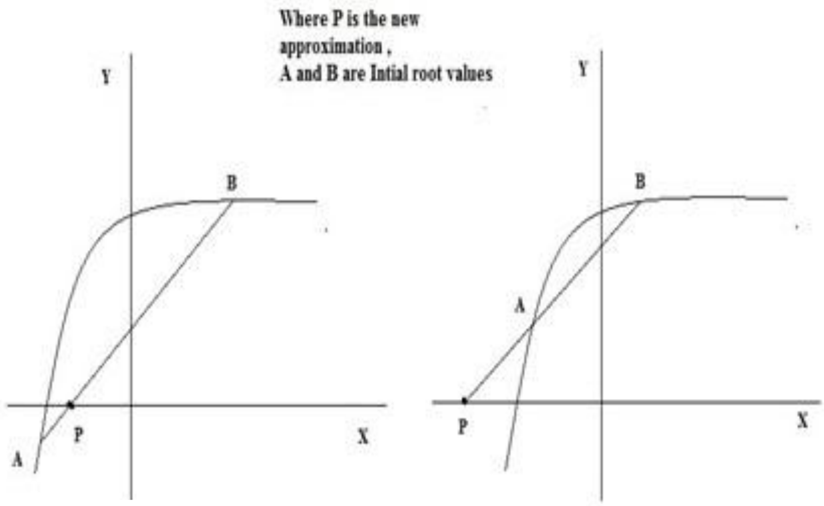

Figure 1.2: Approximations in false position method

Figure 1.3: Approximations in Secant method

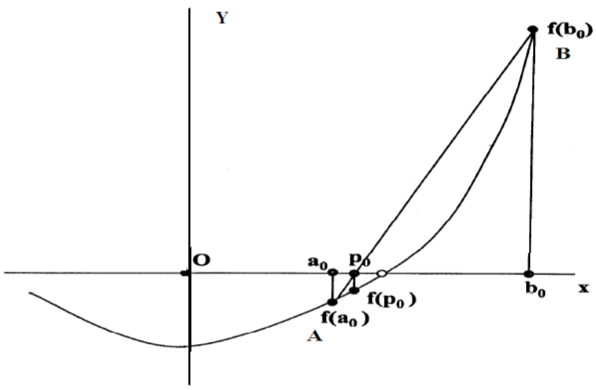

Figure 2: False position method diagrammatical approach

The false position method chooses the point p_0 to be the point where the straight line between $A(a_i, f(a_i))$ and $B(b_i, f(b_i))$ cuts the x axis.

The equation of the line AB is

$$Y = f(a_i) + ((x - a_i) * \frac{f(b_i) - f(a_i)}{(b_i - a_i)}) \quad (1)$$

So on solving (1) by substituting y=0 and x=$p_i$we get the root p_i and the formula of false position method which is as in (2)

$$p_i = a_i - \frac{f(a_i) * (b_i - a_i)}{(f(b_i) - f(a_i))} \quad (2)$$

So now this root finding formula can be used for the auto exposure algorithm to find the shutter speed and the gain (ISO) as in formula (3) and (4) respectively. In the false position method the initial roots has to contain the opposite signs, so in our method we first consider the initial exposures in such a way that one exposure value as the under exposure and the other as the over exposure of the scene, so that the proper exposure will converge between them.

The formula (2) is adapted to the shutter speed and gain as in formula (3) and (4) by making some modifications to it. The shutter and gain values will not be negative, so to avoid the negative values the basic false position method formula is slightly modified as in the equations (3) and (4).

The next approximation of shutter speed $\mathbf{Shutter_{k+1}}$ is obtained by using the formula (3) where $\mathbf{Shutter_k}$ is the approximation of the present iteration and $\mathbf{mean_k}$ is the mean luminance value of the scene for $\mathbf{Shutter_k}$.The $\mathbf{Shutter_{k-1}}$ is the previous iteration value of shutter speed, where $\mathbf{mean_{k-1}}$ is the mean luminance of the scene for $\mathbf{Shutter_{k-1}}$ .For the first iteration the initial exposure values are considered for $\mathbf{Shutter_k}$ and $\mathbf{Shutter_{k-1}}$.The values of the $\mathbf{Shutter_k}$ and $\mathbf{Shutter_{k-1}}$ are further modified in every iteration .

$$\mathbf{Shutter}_{k+1} = \frac{(shutter_k \times mean_{k-1}) + (shutter_{k-1} \times mean_k)}{(mean_{k-1} + mean_k)} \quad (3)$$

The next approximation of gain $\mathbf{Gain_{k+1}}$ is obtained by using the formula (4) where $\mathbf{Gain_k}$ is the approximation of the present iteration, $\mathbf{mean_k}$ is the mean luminance value of the scene for $\mathbf{Gain_k}$.The $\mathbf{Gain_{k-1}}$ is the previous iteration value of gain, where $\mathbf{mean_{k-1}}$ is the mean luminance of the scene for $\mathbf{Gain_{k-1}}$. For the first iteration the initial exposure values are considered for $\mathbf{Gain_k}$ and $\mathbf{Gain_{k-1}}$. Similarly as in shutter speed the values of $\mathbf{Gain_k}$ and $\mathbf{Gain_{k-1}}$ are also modified.

$$Gain_{k+1} = \frac{(Gain_k \times mean_{k-1}) + (Gain_{k-1} \times mean_k)}{(mean_{k-1} + mean_k)} \quad (4)$$

The classification of the lighting condition in the algorithm is performed as ,if the scene contains the mean luminance value in the limit [100-140] is considered as the proper exposure and the scenes with mean luminance value below 100 is considered as under exposure .similarly the scenes with above 140 mean luminance value is considered as the overexposure [2][3].

4. EXPERIMENTAL RESULTS

In this section we are comparing the false position based auto exposure algorithm with the bisection based auto exposure algorithm. The bisection method iteration wise results are in the Table 1 and the results of the false position method are in Table 2.

The Bisection method took 6 iterations, whereas the false position took only 2 iterations to find the proper exposure of the same leather sample under the same lighting conditions. The usage of the false position for the auto exposure algorithm than the bisection method reduces 3-6 iterations to converge to the proper exposure value.

Table 1: Iteration wise results of the algorithm based on bisection method

Iterations	Shutter speed (in ms)	Gain (in db)	Type of Exposure (mean luminance)
Iteration1	2000.5 ms	8.5 db	Over (255.0)
Iteration2	1000.8 ms	4.3 db	Over (254.8)
Iteration3	500.9 ms	2.1 db	Over (184.5)
Iteration4	250.9 ms	1.1 db	Under (85.0)
Iteration5	260.9 ms	2.1 db	Under (98.3)
Iteration6	270.9 ms	3.1 db	Proper (113.4)

Table 2: Iteration wise results of the algorithm based on false position method

Iterations	Shutter speed (in ms)	Gain (in db)	Type of Exposure (mean luminance)
Iteration1	90.2 ms	0.4db	Under (27.9)
Iteration2	389.9 ms	1.7db	Proper (126.3)

5. CONCLUSION

A Fast and Reliable auto exposure algorithm has been implemented using the false position method. Our method is simple and can be easily implemented, so this method can be easily implemented on the devices like cell phones, surveillance cameras etc.

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