Color Image Contrast Enhancement Using Modified Firefly Algorithm

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ABSTRACT

The image enhancement process is used for improving the standard of the image. It’s inspired by the development of human perception pictorial information. Increasing the contrast of the image and removing the unwanted noise from the images is the picture enhancement process. A histogram of the low contrast images and depth image is employed to enhance image contrast. In the work, a color image is used as input and the authors extract the red, green, and blue pixel matrixes from it, then obtain the optimized histogram using the modified firefly algorithm, and then compare the performance matrices like PSNR and Entropy, etc. with other optimization techniques.

KEYWORDS

Firefly Algorithm, Image Enhancement, Image Processing, PSNR

1. INTRODUCTION

Image enhancement aims to contrast improvement of the original images. When the image display appropriately, a computer system or human can extract the required information. The image enhancement methods can be classified into four main parts: Pseudo coloring, transformation, unique domain, and point domain. The transformation of the histogram is used to improve the contrast of gray-level images. The histogram equalization method is popular, but the disadvantages are that output images have unnatural contrast and lighting. Image enhancement can be used in different applications for image processing, such as contrast enhancement, noise reduction, edge restoration, and edge enhancement (Singh, Kohli, and Diwakar 2013)(Maini and Aggarwal 2010).

Global histogram equalization is the most common way of enhancing contrast in a picture. During the previous few decades, many approaches are used to enhance the contrast of image like Range Limited Bi-Histogram equalization (RLBHE), Brightness Preserving Bi-Histogram Equalization (BBHE), Brightness Error Bi-Histogram Equalization (MMBEBHE), Equal Area DSIHE(Dualistic Sub-Image Histogram Equalization) andrightness Preserving Bi-Histogram Equalization (BBHE) (Singh, Kohli, and Diwakar 2013).

The firefly algorithm is a simulated evolutionary algorithm used for parallel searching on local and global extremum. The firefly algorithm-based local enhancement algorithm has been used to optimize parameters search for better enhancement. The firefly algorithm is a modern heuristic algorithm applied to the non-continuous and non-linear optimization problem. The characteristics
of the firefly algorithm are like minimum computation rate and higher converging to optimization problem solution. The greedy heuristic method is used to contrast enhancement of images (Majumder and Irani 2006). Hassanzadeh et al. (Hassanzadeh, Vojodi, and Mahmoudi 2011) developed a firefly algorithm-based adaptive local enhancement algorithm to improve the detail and grayscale of source images. Gopal et al. (Dhal et al. 2015) developed two algorithms to improve the contrast between low-contrast images using chaotic sequence and levy flight. All algorithms were applied to optimized Boost Filter parameters. Ye et al. (Ye, Zhao, and Ma 2015) developed an adaptive firefly algorithm to find optimal parameters and produce a gray level curve transformation to enhance images. This algorithm achieved the effective optimal parameters in an adaptive manner, which results better. Samanta et al. (Samanta et al. 2018) proposed the Mini Unmanned Aerial Vehicle (MUAV) system for capturing the low contrast/quality image. The firefly algorithm-based image enhancement method for gray level is used to enhance the image contrast. Xie et al. (Xie et al. 2019) developed two Types of Firefly algorithms like inward intensified exploration Firefly Algorithm and compound intensified exploration Firefly Algorithm. The first variant was found by the replacement of the attractiveness coefficient with a randomized control matrix. In the compound intensified exploration, firefly employs a dispensing mechanism. The Bat algorithm, firefly algorithm, and particle swarm optimization algorithm are used to solve the optimization problem.

Various image removal techniques are also used filters. Narendra et al. (Narendra Kumar, Dahiya, and Kumar 2020b), (Narendra Kumar et al. 2019), (N. Kumar, Dahiya, and Kumar 2020), (Narendra Kumar, Dahiya, and Kumar 2020a) Experimental results show that these more efficient for removing multilevel noise.

Here, we have modified the firefly optimization techniques to improve the image’s contrast and compare the existing optimization techniques. The rest of the paper is organized as a section that discusses methodology, section 3 results, and discussion and rests above the paper’s conclusion.

2. METHODOLOGY

2.1 Firefly Algorithm

The metaheuristic algorithm firefly is predicated on the behavior of fireflies and flashing patterns. Fireflies attract no matter their sex, thanks to the unisex nature of fireflies. The attractiveness of fireflies is proportional to fireflies’ brightness, and attractiveness and brightness decrease, then distance increases. The less bright firefly move towards, the brighter firefly. If there’s no brighter firefly, then a specific firefly moves randomly. The landscape of objective function is employed to work out the brightness of the firefly. Use the inverse square law when the sunshine intensity is out there at a specific distance \( r \) from the sunshine source. So, the sunshine intensity \( I \) decreases because the increasing the range \( r \) in terms of \( I \propto 1/ r^2 \).

In the algorithm of a firefly, there are three critical formulas, which are:

\[ B(r) = B_0 e^{-\gamma r} \text{ (m}^3\text{l)} \]  \hspace{1cm} (1)

Here \( \gamma \) is light retention coefficient, \( r \) is the distance of two fireflies, \( B_0 \) is the attractiveness at \( r = 0 \) and is a fixed light coefficient.

The function of attractiveness can be any decreasing monotonically functions such as following generalized form.
b) Distance:
The distance between any two fireflies i, j at \( x_i \) and \( x_j \) is the Cartesian distance

\[
r_{ij} = x_i - x_j = \sum_{k=1}^{d} (x_{i,k} - x_{j,k})^2
\]

(2)

Here \( x_{i,k} \) is the \((k)\)th spatial coordinate component \( x_i \) of \((i)\)th firefly and \( d \) is the number of dimensions.

c) Movement:
The firefly movement ‘i’ is attracted to the next brighter firefly ‘j’ is obtained by the following equation:

\[
x_{i} = x_{i} + B_0 e^{-\gamma r_{ij}} (x_{j} - x_{i}) + \pm (rand - 0.5)
\]

(3)

The second term of the equation is due to the attraction; the third term is randomization with \( \alpha \) is a parameter for randomization, random number generator \( rand \) uniformly distributed in \([0, 1]\). For the many cases in the implementation \( B_0 = 1 \) and \( \alpha \in [0, 1] \)

Pseudocode of the firefly algorithm:

Begin
\( f(x) \), \( x = (x_1, ..., x_j)^T \) is the objective function
Produce starting populace \( x_i \) \((i = 1, 2, ..., n)\) of fireflies
\( I_i \) is light intensity at \( x_i \) which is determined by \( f(x_i) \)
Characterize light retention coefficient \( \gamma \)
while \((t < \text{maxgeneration})\)
for \( i = 1: n \)
    for \( j = 1: i \) all n fireflies (inner loop)
        if \((I_j > I_i)\)
            Move firefly \( i \) towards \( j \);
        end if
        Varies attractiveness with range \( r \) via \( e^{-\gamma r} \)
        Assess new arrangements and update with new light intensity
    end for \( j \)
end for \( i \)
fireflies rank and locate the current best
end while
Post-process results and perception
end

2.2 Proposed Modified Firefly Algorithm:

1. Take a Colour input image and extract the red, green, and blue pixel matrixes.
2. Obtain the histograms $h_i[n]$, mass function (un-normalized discrete probability) of pixel intensities for each matrix.

3. Set the parameters, lambda, the quantity for positioning the amount of contrast on a scale of 0-20, and gamma, the amount of detail in the image to be retained, on a scale from $1 - 10^9$. Usually, lambda is around 4, and gamma is 50000.

4. Construct a Difference matrix, $D$, with backward-difference of histogram, i.e $h[i]-h[i-1]$, required for histogram smoothening. The Difference matrix $D \in \mathbb{R}^{255*256}$ is bi-diagonal.

5. For each pixel matrix, obtain the optimized histogram, $h_o[n]$, from the firefly optimization algorithm.

6. Obtain the normalized histograms, $p[n]$, from the optimized histograms. It gives an approximate probability distribution function of the pixel intensities.

$$p[i] = \frac{h_o[i]}{\text{number of pixels}}$$  \hspace{1cm} (4)

7. Then, $c[n]$, the Approximate CDF (Cumulative distribution Function), is obtained from $p[n]$.

$$c[i] = \text{sum}(p[1 : i])$$  \hspace{1cm} (5)

8. After the CDF is obtained, a modified discrete mapping function $T[n]$ is used to map back to the spatial domain (pixels).

$$T(n) = (\lambda + 1) \cdot x(2^\beta - 1) \cdot x(\text{sum}(p[1 : n]) + 0.5)$$  \hspace{1cm} (6)

Where $\beta$ is the number of bits used for representing pixel values and $n \in [0, 2^\beta-1]$ and $p[n]$ is the probability density function.

The main steps of the proposed firefly method can be summarized as follow:

1) The firefly populations are initialized. The related parameters of firefly algorithm Initialize, such as initial attraction, medium absorption coefficient, phase factor, and the maximum number of iterations is 4000, randomly generate the initial location of firefly populations. To improve efficiency, $\alpha=\text{num}/\text{N\_iteration}$, $\beta_{\text{min}}=\alpha/\text{N\_iteration}$ and $\gamma=\beta_{\text{min}}/\text{N\_iteration}$ are modified to the constant value.

2) Get the luminosity of each firefly by measuring the objective function.

3) Recalculate the algorithm brightness of the modified position, then remove the first value and therefore the original position when the final value is increased, then retain the optimum value for the first value.

4) When the number of iterations exceeds the utmost value, populations sort of firefly by the brightness size and record the optimum location and, therefore, the maximum brightness returns to step 2 if the number of iterations fails to exceed the total value. They are taking the optimal solution for image enhancement into the simplified, incomplete beta function.

Finally, the image is obtained from this mapping. We have compared the results with existing optimization techniques, on various performance metrics are calculated like PSNR, entropy, MSE,
MAE, UQI, Average difference, Structural content, Normalized Absolute error, and Normalized cross-correlation.

3. RESULTS AND DISCUSSION

The measurement tests were carried out to evaluate the performance of the proposed technique in 256x256 pixel image resolutions in these input images. In this paper, 6 images (shown in figure 1) are tested compared to PSO (particle swarm optimization), WDO (Wind Driven Optimization), CST (Cuckoo Search Technique), and FA (Firefly Algorithm) performance of the proposed technique. These results reflect that the output image is more precise and smoother than the other conventional approaches, contrast-enhanced by the proposed technique. We used different measurement measures of image quality to determine the consistency of the contrast images.

Figure 1. Original Images

![Figure 1. Original Images](image)

After applying various contrast enhancement techniques and our proposed technique, the contrast-enhanced images are given below in Fig. 2.

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3.1 Image Quality Measurement:
Various image quality measurement metrics like PSNR (Peak Signal to Noise Ratio), Root Mean Square Error (RMSE), Universal Quality Index (UQI), Mean Absolute Error (MAE), and Mean Square Error (MSE) in Table-1. Table 1 showing that our proposed technique is better than other contrast enhancement techniques.
Table 1. Image quality measurement results PSNR, RMSE, UQI, MAE, and MSE

| Image quality measurement | Image | PSO | WDO | Cuckoo Search Techniques | Firefly | Proposed technique |
|---------------------------|-------|-----|-----|--------------------------|--------|--------------------|
| **PSNR**                  |       |     |     |                          |        |                    |
| a                         | 24.9881761 | 24.53175867 | 24.80980154 | 24.24383464 | 24.89998545 |
| b                         | 24.55564833 | 25.17236533 | 25.43784338 | 24.59737435 | 25.57194463 |
| c                         | 24.54760284 | 24.62581159 | 24.88675405 | 24.22740269 | 24.96250278 |
| d                         | 24.72240271 | 25.00915929 | 25.16096966 | 24.65195924 | 25.27898848 |
| e                         | 24.43203628 | 24.54858809 | 24.72570376 | 24.21416782 | 24.76497026 |
| f                         | 24.63273131 | 24.86306976 | 25.21129196 | 24.25358751 | 25.30224185 |
| **RMSE**                  |       |     |     |                          |        |                    |
| a                         | 26.6672 | 27.4831 | 27.2935 | 27.5155 | 27.0316 |
| b                         | 27.273 | 27.273 | 27.0446 | 26.9684 | 26.7114 |
| c                         | 26.0283 | 26.9021 | 26.6239 | 26.8219 | 26.416 |
| d                         | 27.2741 | 27.2996 | 27.1589 | 27.2783 | 26.9364 |
| e                         | 27.3329 | 27.346 | 26.9144 | 27.0048 | 27.0207 |
| f                         | 27.49 | 27.5936 | 27.11 | 27.623 | 26.8812 |
| **UQI**                   |       |     |     |                          |        |                    |
| a                         | 0.56318633 | 0.509336924 | 0.562463598 | 0.473588863 | 0.583581816 |
| b                         | 0.335784186 | 0.37699197 | 0.41843466 | 0.330452848 | 0.443520317 |
| c                         | 0.5922717173 | 0.578756355 | 0.624447373 | 0.527530098 | 0.636916247 |
| d                         | 0.446798221 | 0.502642426 | 0.543415395 | 0.438530634 | 0.561351492 |
| e                         | 0.531664655 | 0.516034577 | 0.548716884 | 0.491361407 | 0.555833375 |
| f                         | 0.39566567 | 0.4253437 | 0.478465999 | 0.3472727234 | 0.488856043 |
| **Mean absolute error**   |       |     |     |                          |        |                    |
| a                         | 327.2654572 | 347.204483 | 308.4660645 | 390.6735687 | 297.8182526 |
| b                         | 330.4471283 | 281.2168427 | 253.672827 | 331.190506 | 240.1844025 |
| c                         | 293.9021606 | 281.6362762 | 249.7732697 | 337.1946564 | 244.2194977 |
| d                         | 384.1290283 | 326.8092194 | 298.6529846 | 392.9012604 | 288.562439 |
| e                         | 270.9181671 | 283.8328705 | 261.2786865 | 298.6360931 | 259.0487518 |
| f                         | 406.4295959 | 372.4773865 | 332.4949341 | 463.6839142 | 322.3859558 |
| **MSE**                   |       |     |     |                          |        |                    |
| a                         | 711.1385 | 755.3223 | 744.9365 | 757.1035 | 730.7049 |
| b                         | 743.8176 | 743.8167 | 731.4117 | 727.2968 | 713.4972 |
| c                         | 677.4701 | 723.7205 | 708.831 | 719.4164 | 697.8034 |
| d                         | 743.8764 | 745.2704 | 737.6051 | 744.1058 | 725.5682 |
| e                         | 747.0884 | 747.8028 | 724.3863 | 729.2608 | 730.1204 |
| f                         | 755.6986 | 761.4049 | 734.9512 | 763.0314 | 722.5983 |
Figure 3. Performance (Noise removal) of our proposed technique and existing techniques for images a, b, c, d, e, and f.

Figure 4. The RMSE performance of our proposed technique and existing techniques for images a, b, c, d, e, and f.

Figure 5. UQI performance of our proposed technique and existing techniques for images a, b, c, d, e, and f.
3.2 Image Error Measurement

We have evaluated the Average Difference, Structural Content, Normalized Absolute Error, Normalized Cross-Correlation of our proposed and existing techniques for the images a, b, c, d, e, and f.
Table 2. Image error measurement of our proposed technique and existing techniques for images a, b, c, d, e, and f.

| Image error measurement | Image | Contrast enhancement techniques | Firefly | Proposed technique |
|-------------------------|-------|---------------------------------|--------|--------------------|
|                         |       | PSO  | WDO  | Cuckoo Search Techniques |        |
| Average Difference      | a     | 92.06652832 | 107.4785767 | 98.08900452 | 120.6197357 | 95.21647644 |
|                        | b     | 102.5136719 | 85.9833374 | 79.32380676 | 101.8190308 | 75.90180969 |
|                        | c     | 107.2675934 | 103.5390472 | 96.79129028 | 119.7168579 | 95.19555664 |
|                        | d     | 112.0076599 | 99.61355591 | 92.44923401 | 114.5398102 | 89.55895996 |
|                        | e     | 111.8907623 | 111.2514648 | 106.7682037 | 117.1077423 | 105.9883118 |
|                        | f     | 101.1876068 | 94.88568115 | 85.51078796 | 118.6170654 | 83.31756592 |
| Structural Content      | a     | 1.031439001 | 1.031439001 | 1.031439001 | 1.031439001 | 1.031439001 |
|                        | b     | 1.031439001 | 1.031439001 | 1.031439001 | 1.031439001 | 1.031415609 |
|                        | c     | 1.031408018 | 1.03143536  | 1.030825508 | 1.031426287 | 1.027927955 |
|                        | d     | 1.030686885 | 1.029745167 | 1.026911803 | 1.031207491 | 1.017822474 |
|                        | e     | 1.031043872 | 1.031303588 | 1.030729102 | 1.031437149 | 1.030049507 |
|                        | f     | 1.031439001 | 1.031439001 | 1.031490162 | 1.031439001 | 1.030015499 |
| Normalized Absolute Error| a    | 0.454773059 | 0.482044125 | 0.46561967  | 0.505960235 | 0.460796321 |
|                         | b    | 0.468092696 | 0.444333981 | 0.434972416 | 0.466202933 | 0.430903249 |
|                         | c    | 0.481349896 | 0.47791435  | 0.469060336 | 0.505107495 | 0.467826441 |
|                         | d    | 0.507093263 | 0.490751253 | 0.478140233 | 0.510356979 | 0.473522881 |
|                         | e    | 0.491348979 | 0.495685698 | 0.494363384 | 0.498870407 | 0.49478827 |
|                         | f    | 0.469708265 | 0.460302153 | 0.44532045  | 0.502353739 | 0.441904237 |
| Normalized Cross-Correlation | a    | 0.9999927  | 0.994996799 | 0.999980852 | 1         | 0.999930767 |
|                        | b    | 0.999999102 | 0.999997307 | 0.999995811 | 0.99999982 | 1.000016815 |
|                        | c    | 0.999864821 | 0.999793018 | 0.999855464 | 0.999929031 | 1.001870453 |
|                        | d    | 1.000412408 | 1.001166311 | 1.003749836 | 1.000038305 | 1.01236385 |
|                        | e    | 1.000382753 | 1.000131303 | 1.000688735 | 1.000001795 | 1.001348959 |
|                        | f    | 0.999996051 | 0.999980912 | 1.000236023 | 0.99999994 | 1.00119213 |
Figure 8. Average Differences of our proposed technique and existing techniques for images a, b, c, d, e, and f.

Figure 9. Normalized Absolute Error value of our proposed technique and existing techniques for images a, b, c, d, e, and f.
3.3 Image Entropy Measurement

The average information of images is a measure of the degree of randomness is also called entropy. We have used entropy to evaluate the entropy of original images as well as contrast images. Conditional entropy, joint entropy Normalized mutual information, Mutual information is used for evaluating the contrast images, that is, the output images of various existing techniques and the proposed technique.

Table 3. Image entropy measurement of our proposed technique and existing techniques for images a, b, c, d, e, and f.

| Image | The entropy of the original image | The entropy of the contrast image | PSO | WDO | Cuckoo Search | Firefly | Proposed Technique |
|-------|----------------------------------|----------------------------------|-----|-----|---------------|--------|-------------------|
| (a)   | 7.800219894                     | 2.909818813                     | 3.199495802 | 3.738809325 | 2.046679556 | 3.908575114 |
| (b)   | 7.248845875                     | 3.603027097                     | 4.583274236 | 4.91876065  | 3.68981472  | 5.012412094 |
| (c)   | 7.902213008                     | 3.086097633                     | 3.680402539 | 4.0301438  | 2.466449336 | 4.157944443 |
| (d)   | 7.711000601                     | 2.479520008                     | 3.975540335 | 4.316623336 | 2.536013181 | 4.536387278 |
| (e)   | 7.588589584                     | 2.780000569                     | 3.128772188 | 3.42958601  | 2.299688264 | 3.519495885 |
| (f)   | 7.362636835                     | 3.430574406                     | 4.08128896  | 4.602275552 | 2.377511337 | 4.78073566  |

Figure 10. The entropy of our proposed technique and existing techniques for contrast images of original images a, b, c, d, e, and f.
Table 4. Entropy values of our proposed technique and existing techniques for contrast images of original images a, b, c, d, e, and f.

| Image entropy measurement | Image | Joint entropy | Conditional entropy | Mutual information | Normalized mutual information |
|---------------------------|-------|---------------|---------------------|-------------------|------------------------------|
|                           |       | PSO           | WDO                 | Cuckoo Search Techniques | Firefly                      | Proposed technique  |
|                           | a     | 8.424693039   | 8.289470607        | 8.386772005        | 8.029729548                | 8.416742755        |
|                           | b     | 7.698202737   | 7.74169932         | 7.779818301        | 7.643614671                | 7.803094462        |
|                           | c     | 8.416916553   | 8.432784503        | 8.467181793        | 8.198599061                | 8.505117943        |
|                           | d     | 8.141175149   | 8.348183444        | 8.413352226        | 8.101437619                | 8.46002838         |
|                           | e     | 7.978364841   | 7.882072423        | 7.930470203        | 7.725315158                | 7.934191194        |
|                           | f     | 8.018980726   | 8.06048665         | 8.160548944        | 7.723440515                | 8.183551087        |
|                           |       |               |                     |                   |                              |                 |
|                           | a     | 5.514874226   | 5.089974805        | 4.647962679        | 5.983049991                | 4.508167641        |
|                           | b     | 4.09589364    | 3.158425085        | 2.861057651        | 3.953799951                | 2.790682368        |
|                           | c     | 5.330818919   | 4.752381965        | 4.437037994        | 5.732149725                | 4.3471735          |
|                           | d     | 5.661655141   | 4.372643109        | 4.096728889        | 5.565424438                | 3.923641101        |
|                           | e     | 5.198364272   | 4.753300235        | 4.500884194        | 5.425626894                | 4.414695309        |
|                           | f     | 4.58840632    | 3.979199705        | 3.558273392        | 5.345929177                | 3.402815427        |
|                           |       |               |                     |                   |                              |                 |
|                           | a     | 2.285345668   | 2.71024509         | 3.152257215        | 1.817169903                | 3.292052253        |
|                           | b     | 3.152952234   | 4.09042079         | 4.387788224        | 3.295045924                | 4.458163507        |
|                           | c     | 2.571394089   | 3.149831043        | 3.465175015        | 2.170063283                | 3.555039509        |
|                           | d     | 2.049345459   | 3.338357491        | 3.614271711        | 2.145576163                | 3.787359499        |
|                           | e     | 2.390225311   | 2.835289349        | 3.08770539         | 2.16296269                 | 3.173894275        |
|                           | f     | 2.774230516   | 3.38343713         | 3.804364343        | 2.016707658                | 3.959821408        |
|                           |       |               |                     |                   |                              |                 |
|                           | a     | 0.479695342   | 0.542518273        | 0.583715957        | 0.454796576                | 0.596216603        |
|                           | b     | 0.6169489     | 0.709652329        | 0.734824081        | 0.637125165                | 0.739602167        |
|                           | c     | 0.520702238   | 0.584070447        | 0.614031339        | 0.491543473                | 0.620198518        |
|                           | d     | 0.468679542   | 0.602947351        | 0.62646001         | 0.485191087                | 0.640362808        |
|                           | e     | 0.520398296   | 0.581875247        | 0.605249548        | 0.517766575                | 0.61446092         |
|                           | f     | 0.552004265   | 0.617223921        | 0.653550274        | 0.48201989                 | 0.667438945        |
3.4 Mean and Standard Deviation (std) Measurement:
We have compared the mean and standard deviation(std) of our proposed technique and existing techniques for contrast images of original images a, b, c, d, e, and f.
3.5 Discussion:

We have taken six images for result analysis and compared the results with the existing optimization techniques; it is found that our proposed techniques' results and image quality are giving better than existing optimization techniques. We are not able to implement the result in video signals. This paper has not also calculated the time complexity because we have given more priority to enhancement.

4. CONCLUSION:

This article introduces the modified firefly algorithm; the histogram method is used from image enhancement and compared the proposed model (i.e., modified firefly algorithm) with existing optimization algorithms. The test is performed on 6 images. From the comparison tables, we can conclude that our proposed model gives better image enhancement quality than others, as the PSNR

Table 5. Mean and standard deviation (std) of our proposed technique and existing techniques for contrast images of original images a, b, c, d, e, and f.

| image | PSO Mean | PSO std | WDO Mean | WDO std | Cuckoo Search Mean | Cuckoo Search std | Firefly Mean | Firefly std | Proposed techniques Mean | Proposed Techniques std |
|-------|---------|--------|----------|--------|-------------------|------------------|--------------|-----------|-------------------------|------------------------|
| (a)   | 211.872 | 75.006 | 218.794 | 65.639 | 205.881           | 75.456           | 233.283      | 53.929    | 202.32                  | 78.084                 |
| (b)   | 182.419 | 91.106 | 166.009 | 92.128 | 156.828           | 92.922           | 182.667      | 93.806    | 152.30                   | 93.482                 |
| (c)   | 210.269 | 75.304 | 206.389 | 74.578 | 195.767           | 81.419           | 222.908      | 63.697    | 193.906                  | 82.562                 |
| (d)   | 220.831 | 69.151 | 201.724 | 79.323 | 192.339           | 83.835           | 233.755      | 65.590    | 188.97                   | 85.595                 |
| (e)   | 194.651 | 88.161 | 198.956 | 85.175 | 191.438           | 89.174           | 203.890      | 90.660    | 190.674                  | 88.811                 |
| (f)   | 214.302 | 67.009 | 202.984 | 71.712 | 189.657           | 80.359           | 233.386      | 49.150    | 186.266                  | 82.231                 |

Figure 13. The mean and Std of our proposed technique and existing techniques for contrast images of original images a, b, c, d, e, and f.

![Figure 13](image-url)
of our proposed algorithm is better than other existing techniques. In the future, we will use various modified optimization techniques and implement the video and compare the time taken.

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