

Design of Fuzzy Inference System for Contrast Enhancement of Color Images

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Abstract

This paper presents the design of the technique using fuzzy inference system for contrast enhancement of color images. The quality of the raw image is improved by filtering of the noise components. For this reason, there is a need for noise filtering. The contrast of the image is enhanced with fuzzy if then rules. Hence the fuzzy inference system is applied by taking a movable window of 3x3 sizes over the image. A comparison is made in one direction to the other adjacent pixels to find their intensity level and then a new value is assigned according to the fuzzy rules and function.

Keywords

Fuzzy filtering, Defuzzification, Fuzzification, Fuzzy Inference system, Membership function.

1. Introduction

Fuzzy image enhancement is based on gray level mapping into a fuzzy plane, using a membership transformation function. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image than to those that are farther from the mean. An image I of size $M \times N$ and L gray level scan be considered as an array of fuzzy singletons, each having a value of membership denoting its degree of brightness relative to some brightness levels [1].

Fuzzy Image Processing

The fuzzy systems are knowledge based systems and their performance can be optimized by an adaptive learning. The image enhancement is obtained by using fuzzy Technique which mainly contains four steps.

1. Image Fuzzification
2. Removing noise present in the image by fuzzy filtering
3. Enhancing Intensity component
4. Image Defuzzification.

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fuzzy image processing is in the middle step (membership modification) Fuzzy systems are made of a knowledge base and reasoning mechanism called fuzzy inference system. Fuzzy inference maps the given input to the desired output using fuzzy logic by using membership functions, logical operations and if-then rules. Mamdani fuzzy inference system is used here.

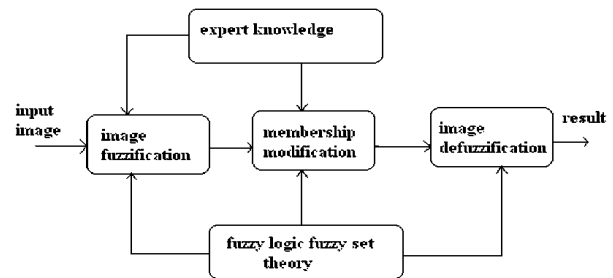


Figure 1.1: Fuzzy Image processing [1]

After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, and a fuzzy integration approach and so on.

Fuzzy inference system is applied by taking a movable window over the image of 3×3 sizes, where the pixels around the center pixel are named according to the direction to identify them [2].

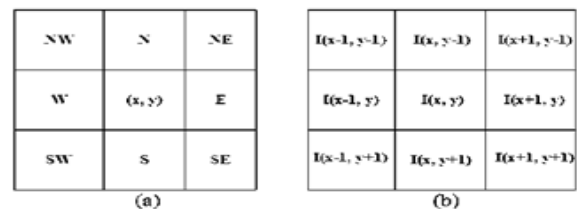


Figure 1.2: (a) Neighborhood of a central pixel (x,y) ,
 (b) Pixel value [2]

In the filtering window W each pixel corresponds to the adjacent pixel by the given direction. The basic assumption in this technique is that the new pixel must be taken from the window W . After fuzzification, the fuzzy rules applied are[3]

If fdata between 0 and 0.5
Then fdata = $2*(fdata)^2$;
Else if fdata between 0.5 and 1
Then fdata = $1-2*(1-fdata)^2$;

The process is repeated for pixels in all the neighborhood pixels of the center pixel $I(i,j)$ by sliding the 3×3 window. This way the whole image is enhanced. Finally, after applying these IF-THEN rules, the fuzzy enhanced image is obtained [2].

This paper is organized as follows. Section 2 presents the algorithm to enhance image using Fuzzy technique. Section 3 presents the design of the fuzzy inference system with GUI tools. Before concluding in Section 5, Section 4 gives the experimental result.

2. Algorithm to enhance image using fuzzy technique

Step1: i) Read the image.

ii) The image $I = I(i,j) \in \{1,2,\dots,255\}$ is considered to be of size $m \times n$, where $i=1,2,\dots,m$ and $j=1,2,\dots,n$.

iii) Assign L is equal to 255, maximum intensity value in the image

iv) Initialize, no. of iterations=no. of rows

v) Read the fuzzy inference system with readfis

Step2: To find 3×3 matrix in the image as a movable window over the image.

Step3: The fuzzification of the image is done for each 3×3 matrix.

Step4: Evaluate the fuzzy inference system with evalfis.

Step5: To design a new image matrix with values between 0 to 1.

i) First make a new matrix with zeros of input image size

ii) Divide each value in the input image matrix by $L=255$.

Step6: fuzzy rules are applied to enhance the image.

i) If fdata between 0 and 0.5
Then fdata= $2*(fdata)^2$;

ii) Else if fdata between 0.5 and 1
Then fdata= $1-2*(1-fdata)^2$;

Step7: Conversion of image values in 0 to 255.

i) Multiply by $L=255$ to each value in the entire image

ii) Convert image in unit8 format

Step8: Display the enhanced images.

Step9: Finding the PSNR value of the image.

3. Design of the Fuzzy Inference System

After applying the fuzzy filtering algorithm, the fuzzy inference system tools are applied to the images for enhancement. The steps for image enhancement using fuzzy inference system are:

- Passing parameter to the FIS. The process of fuzzy inference involves membership functions, logical operations and if then rules.
- Building (Mamdani type) system with fuzzy logic toolbox software.

Fuzzy Inference System Tools for Image Enhancement: We can use five GUI tools for building, editing and observing fuzzy inference systems.

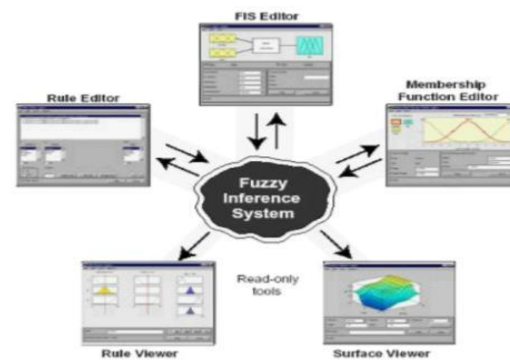


Figure 3.1: Fuzzy Inference System

1. Fuzzy Inference System Editor

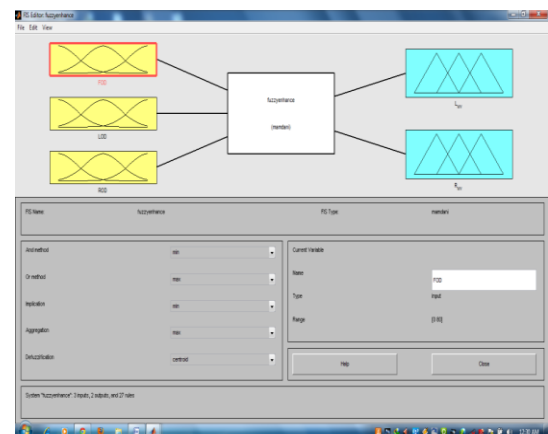


Figure 3.2: FIS editor window

- The FIS editor displays the general information about a fuzzy inference system.
- In the diagram shows the names of each input variable on the left, and those of each output variable on the right.

the input and output variables for the entire fuzzy inference system.

2. The membership function editor

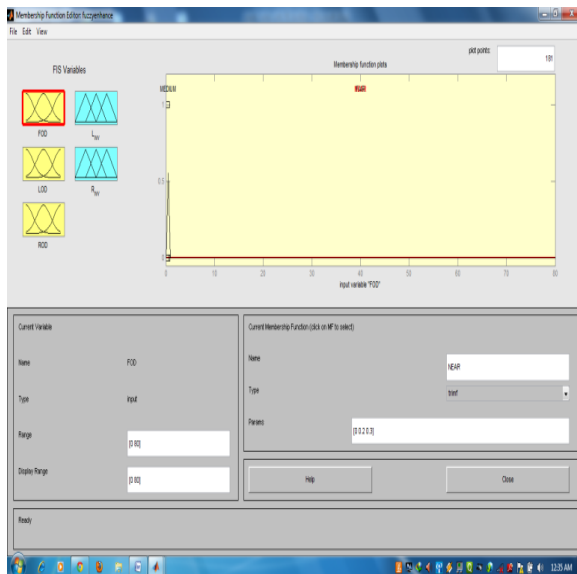


Figure 3.3: Input membership function editor window

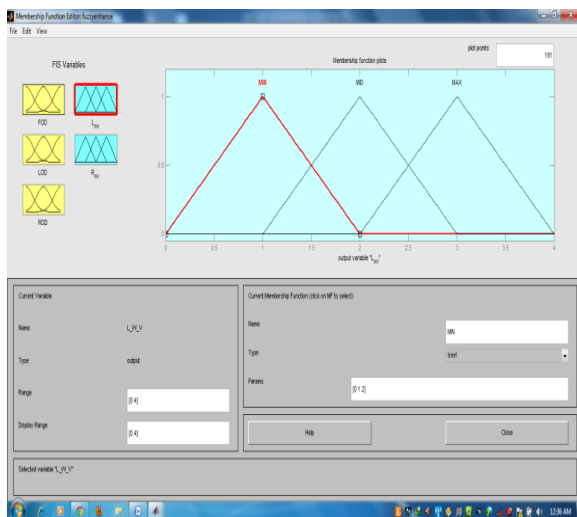


Figure 3.4: output membership function editor window

- The membership function editor is the tool that lets you display and edits all of the membership functions associated with all of

3. The Rule Editor

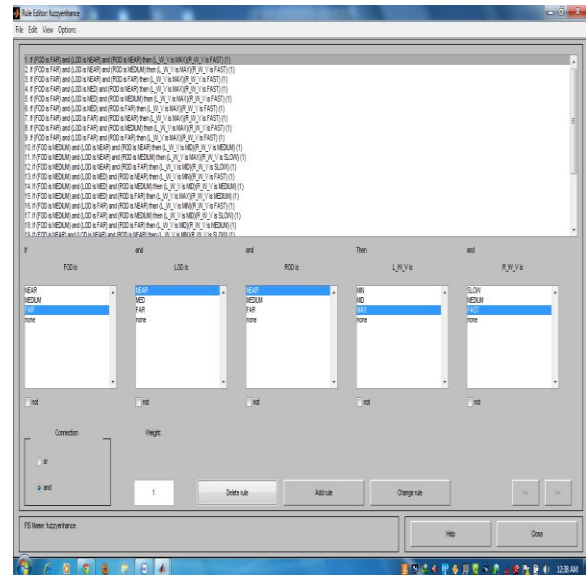


Figure 3.5: Rule editor window

The Rule Editor allows us to construct the rule statements automatically by selecting one item in each input variable box, one item in each output box and one connection item.

4. The Rule Viewer

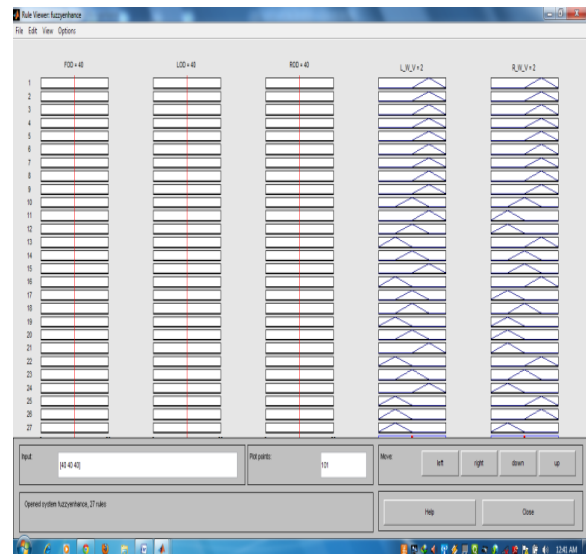


Figure 3.6: Rule viewer window

The Rule viewer displays a road map of the whole fuzzy inference system.

5. The Surface Viewer

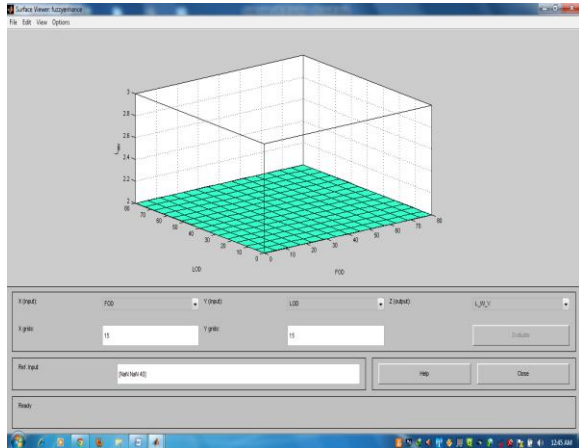


Figure 3.7: Surface viewer window

The Surface Viewer presents curves that represent the mapping from input to output.

4. Results

The above steps are applied to the image 1 (fig.4.1) and image 2 (fig.4.2) as shown below.

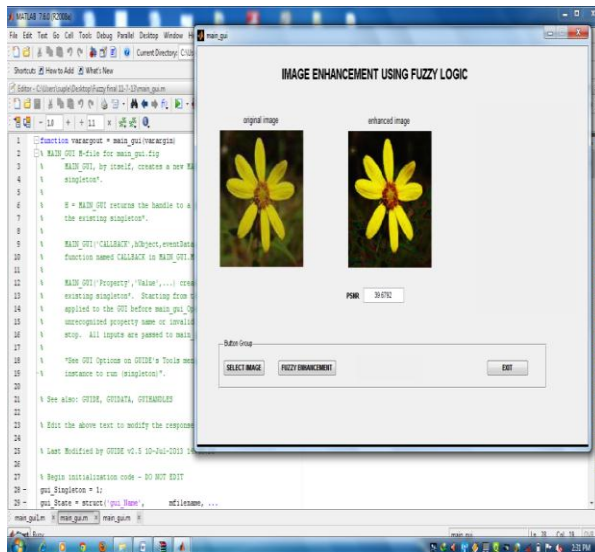


Figure 4.1: output of the fuzzy technique (image1)

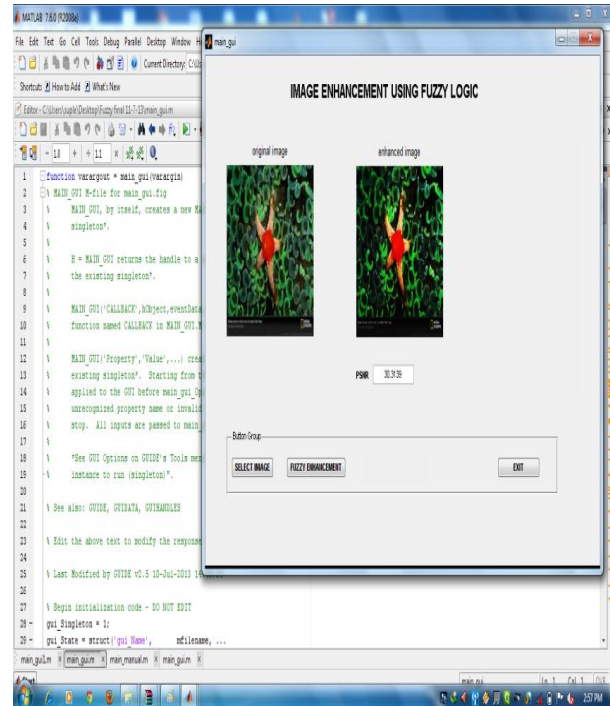


Figure 4.2: output of the fuzzy technique (image 2)

The figures above shows the input images applied to the fuzzy technique and the obtained output images called the enhanced images. The output images show the result of enhancement of the fuzzy method. Here visualization is the basis of comparison to compare the two images.

5. Conclusion and future work

Conclusion

The fuzzy technique is able to get good contrasted image which increases the brightness and improves the contrast of the low contrasted images. This algorithm is tested on different type of images. This method achieves good noise discrimination and enhances the quality of the image to a great extent. This has been demonstrated by a MATLAB implementation of the fuzzy technique which was applied to several images. Thus, it is possible to conclude that the theory of fuzzy sets is a powerful tool in the construction of an image enhancement system.

Future Scope

In the future the existing systems can be modified by fuzzy set theory application. Modification of fuzzy

rules can produce better results. Neuro-Fuzzy techniques can be used to enhance the images.

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