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IMPROVEMENT OF IMAGE APPLYING FUZZY LOGIC

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ABSTRACT

This paper presents an idea for improvement of image through super resoluting it, by using a set of Fuzzy Logic Rules. The logic is based upon Fiuzzyfication in which set of rules are applied on the fuzzy variables and Defuzzyfication, which is by using a generic Gaussian equation with its member function all rules fuzzy rules are combined, then a final super resolute image is obtained. In this paper, we have also discussed some learning based conventional methods for SR. Also we have discussed the methods with their advantages and disadvantages and compared the performance of every method including their PSNR and MSE values. Super-resolution technology has applications in many areas of image processing such as medical imaging, image sensing systems, satellite imaging, space technology and surveillance systems etc.

I. INTRODUCTION

Video surveillance is one of the most important applications in the security systems, it helps to detect intruders, identify and prevent crimes, and it is useful to deliver evidence of crimes. The necessity of a high definition image is must to get a precise result for evidences and also to prevent future crisis. However, the high resolution images are not always available; this is because it is often costly to obtain a high resolution image and sometimes may not be feasible due to the limitations of the sensor, among others. These drawbacks can be solved using mathematical image processing algorithms, which are relatively inexpensive, leading to the concept of super-resolution. This gives us an advantage because it can cost less and systems of existing low-resolution images are still used. The super resolution is also needed in applications like recognition, image analysis, medical imaging for a better diagnosis, and applications where a zoom is required, this for a specific area of interest and it is where the super resolution becomes essential, for example, video surveillance, satellite imagery and more.

Agree to the surveillance monitoring respect to a large open area using a camera, means losing important details to enable the people feature analysis or identification. The images are important in the analysis of crime as well as evidence of abuse. A possible solution to these problems is to enhance low resolution video surveillance systems with advanced algorithms that realize complex activities, such as increasing resolution in the images. Phenomena found every day are imprecise, i.e., have the ambiguity and vagueness implied in the scene captured. This imprecision can be associated in its shape, position, time, color, texture, or even semantic in the scene. This is the behavior of the images.

Fuzzy logic is conceptualized as a generalization of classical logic. It is a branch of artificial intelligence that allows specification vagueness to handle information. The first logic of vagueness was developed in 1920 by the philosopher Jan Lukasiewicz, visualized with possible joint membership degree values of 0 and 1, then the un-extended to an infinite number of values between 0 and 1.

In 1960, Lofti Zadeh creates a powerful tool, known as fuzzy logic to model imprecise data in which the inference rules are formulated in a very general way making use of fuzzy categories, Lukasiewicz combines the concepts of logic and sets defining by membership degrees.

The resolution in images is a perceptible detail measure. If the resolution increases, perception of fine details, edges, clearness of the objects and image quality increases too. Video surveillance cameras usually have a standard resolution for video surveillance applications, commonly in VGA resolution. This video image in most of the cases does not provide enough information to identify a person or an object; the cameras with low resolution deliver poor data information and poor information in detailed images to maximize its size. If an area needs more resolution, it is necessary an algorithm that achieve this without the loss of inherent characteristics. We selected the fuzzy logic theory to solve these problems. This technique is used to improve image resolution. It helps in processes where ambiguity and vagueness in the data interpolation are present; this is due to the non-linearity of image information (edges, fine details, textures, etc.).

In this paper we have also discussed some conventional methods of interpolation i.e. Nearest Neighbor Interpolation and Bilinear Interpolation techniques. We have discussed the methods with their advantages and disadvantages and compared the performance of every method including their PSNR and MSE values. By comparison, we have put forward the areas where we need to make improvements along with the future scope.

II. CONVENTIONAL INTERPOLATION METHODS

Common interpolation algorithms can be grouped into two categories as adaptive and non-adaptive. Adaptive methods change depending on what they are interpolating, whereas non-adaptive methods treat all pixels equally. Non-adaptive algorithms include: nearest neighbor, bilinear, bicubic, spline, sinc, and others, while Adaptive algorithms include many proprietary algorithms in licensed software such as: Qimage, PhotoZoom Pro and Genuine Fractals. In this project we will address with two of Non-adaptive algorithms for resolution purposes.

One of the methods used for increasing the size is nearest-neighbor interpolation, replacing every pixel with a number of pixels of the same color. The resulting image is larger than the original, and preserves all the original detail, but has possibly undesirable jaggedness. Nearest Neighbor Interpolation, the simplest method, determines the grey level value or color from the closest pixel to the specified input coordinates, and assigns that value to the output coordinates. Bilinear Interpolation another method determines the grey level value or color from the weighted average of the four closest pixels to the specified input coordinates, and assigns that value to the output coordinates. It considers the closest 2x2 neighborhood of known pixel values surrounding the unknown pixel's computed location. It then takes a weighted average of these 4 pixels to arrive at its final, interpolated value. The weight on each of the 4 pixel values is based on the computed pixel's distance in 2D plane from each of the known points.

III. PROPOSED METHOD

The main purpose to introduce FRI was to break down the computational complexity required in most classical fuzzy reasoning methods. Rule interpolation is efficient if the shape of the fuzzy set is simple, mostly piecewise linear. In such cases, fuzzy sets can be described by only a few characteristic points.

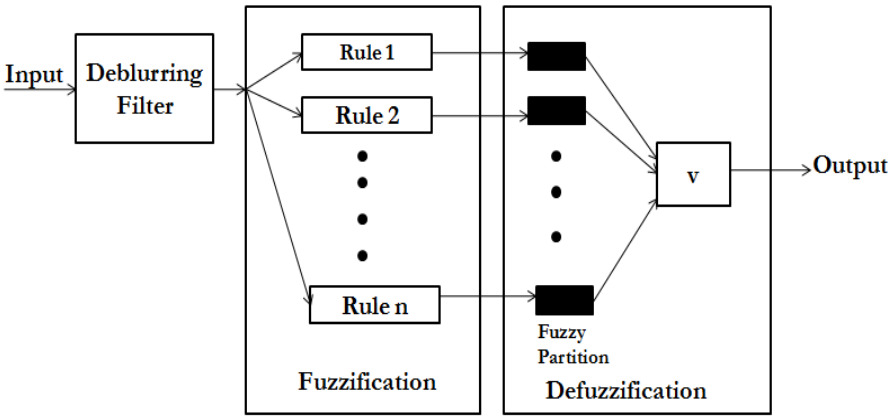

Figure 1. General Structure of Fuzzy Logic

A. Turning the pixels rule into Set of Fuzzy Variables

In this method a single frame is considered as the block of number of pixels upon which the set of fuzzy rule in the form of variables are applied. The algorithm is based on the pixel intensity and the fuzzy rule applied on the pixels is according to ELA algorithm. The edge-based line average ELA algorithm uses directional correlation among pixels to perform linear interpolation. There are three detection directions, which are vertical, and diagonal. In each direction, the difference is calculated.

The inputs of the algorithms are computed as the absolute difference values of the luminance differences in the three directions (a, b, c).

B. Fuzzification

Fuzzy rule are applied on this fuzzy variables in the following manner:

The fuzzy rules 1 and 2, delivers values near to 1 (≈ 1) when the correlation is big in one direction while deliver small values (≈ 0) in the opposite directions. In both cases, the result is obtained by interpolating the average value of the luminance (A+F)/2 or (C+D)/2. The fuzzy rule 3, estimates the fuzzy value of an edge because of the correlation, in this case, if big (≈ 1) for both directions. In this case, we get a result interpolating the four pixels (A+C+D+F)/4. Finally, in the fuzzy rule 4, the otherwise antecedent parameter is obtained interpolating in vertical direction agree to (B+E)/2. This method works using an amplification factor equal to 2.

C. Defuzzification

Because of the images do not have linear behavior, it is proposed nonlinear membership functions, so Gaussian membership functions to take into account the mean and the variance values of the sample processed in the image. This allows adaptability of the algorithm to texture changes, and produce good interpolation results. In this method a Gaussian equation is generated by using all the sets of fuzzy rule with their membership function as its degree. The equation is as follows:

$$f(x) = ae^{\frac{(x-b)^2}{2c^2}} \quad \text{.....(1)}$$

$$where \ \ a = \frac{1}{c\sqrt{2\pi}}, \ \ b = \mu, \ c = \sigma$$

where μ is Gaussian Mean, σ is Standard Deviation

By using these degree constants the defuzzyfication process could be taken through combining the weighted values and membership functions as defuzzyfication constant, D.

The defuzzification processes of algorithms ELA 3+3 is illustrated in equation:

$$D = \alpha 1^{\frac{A+F}{2}} + \alpha 2^{\frac{C+D}{2}} + \alpha 3^{\frac{A+F+C+D}{2}} + \alpha 4^{\frac{B+E}{2}} \quad \text{.....(2)}$$

IV. EXPERIMENTAL RESULTS

When interpolation on the three methods i.e. nearest neighbor, bilinear interpolation and fuzzy interpolation is performed, the following results of image resolution are obtained. A comparison is drawn from the simulation of these interpolation methods on the certain factors.

Nearest neighbor interpolation method takes nearest value of pixel. Bilinear interpolation method takes neighborhood of four pixels and creates jaggy picture. The fuzzy rules 1 and 2, delivers values near to 1 when the correlation is big in one direction while deliver small values (≈0) in the opposite directions. In both cases, the result is obtained by interpolating the average value of the luminance. The fuzzy rule 3, estimates the fuzzy value of an edge because of the correlation, in this case, if big (≈1) for both directions, a result interpolating the four pixels is obtained. Finally, in the fuzzy rule 4, the otherwise antecedent parameter is obtained interpolating in vertical direction

Table 1 Comparison of Interpolation Methods

Comparison of Interpolation Methods	
Nearest Neighbor Interpolation	
PSNR (db)	29.68
MSE	69.87
RESOLUTION	121x166
Bilinear Interpolation	
PSNR (db)	21.59
MSE	450.09
RESOLUTION	121x166
FUZZY RULE INTERPOLATION	
PSNR (db)	30.45
MSE	68.50
RESOLUTION	121x166

The algorithms described for all three methods were applied to different images because different images emulate different environments like colors changes, textures etc.

The images show a significant improvement results in a qualitative and quantitative way, due to the fuzzy algorithm. It delivers better results compared with other methods because of nonlinear membership functions applied to identify edges and details in interpolation algorithm to preserve them. Different interpolation methods were analyzed, where the method of nearest neighbor interpolation is a basic method, has loss of the image details such as preserving edges. Contrary to this, the bilinear algorithm, a window of 2x2 pixels is used, the result is an image with soft edges, but it requires more processing time compared to the nearest neighbor interpolation.

Algorithms that use fuzzy logic techniques waste more processing time, due to the steps that must be performed to fuzzify and defuzzify the values to interpolate pixels, the main advantage presented is to have an image with more edges delineated and defined.All three methods are compared on different parameters such as MSE, PSNR, and Resolution.

V. APPLICATION

A. Intelligent Transportation

Intelligent Transport System concept is used to handle traffic condition, road patterns, number of accidents and continuing threats to security. But Intelligent Transport System are design keep in mind the ideal traffic conditions. But Fuzzy Logic is capable of dealing uncertainty can be implemented here.

Remote Sensing

In remote sensing, sensors collect data about object distance from aircraft or satellite. The Fuzzy Logic has implication in improving quality of the classification of airborne images and object recognition.

B. Defense surveillance

Aerial surveillance methods are used to continuously keep an eye on the land and oceans. This application is also used to locate the types and formation of naval vessels of the ocean surface. We can interpret the entire oceanic scenario from the spatial distribution of these objects.

C. Automatic surface inspection systems

In metal industries it is essential to detect the flaws on the surfaces. For instance, it is essential to detect any kind of aberration on the rolled metal surface in the hot or cold rolling mills in a steel plant. Image processing techniques such as texture identification, edge detection, fractal analysis etc are used for the detection.

D. Faulty component identification

This application identifies the faulty components in electronic or electromechanical systems. Higher amount of thermal energy is generated by these faulty components. The Infra-red images are produced from the distribution of thermal energies in the assembly. The faulty components can be identified by analyzing the Infra-red images

E. Biomedical

Many biological systems and objects are intrinsically fuzzy as their properties and behavior contains randomness or uncertainty. Fuzzy can be used in neurobiology for brain tumor extraction, CT scan, MRI and surgeries.

VI. CONCLUSION

In this paper, we have proposed Fuzzy Logic based approach for interpolation of a single image to obtain super resolution image. We have compared it with two conventional adaptive interpolation techniques. Nearest Neighbor Interpolation has a low processing time where Fuzzy Logic Interpolation has high processing time because of fuzzification and defuzzification of inputs. Bilinear Interpolation has a processing time between Nearest Neighbor Interpolation and Fuzzy Logic Interpolation. The experimental results show that the Fuzzy Logic method is much better than the other two techniques. The result of this method provides soft edges, more detailed image, less blurring. Recently this method is applied on single frame. Furthermore, more work can be performed on this method to provide super resolution image for multiple image or video.

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