A Rule-based Expert System for Image Processing

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Abstract. In this paper, we adopt a fuzzy rule-based inference system to improve format conversion algorithms. We explain three main issues of image enhancement, and they are system consideration, image quality assessment, and parameter adjustment. By using membership hedge, we can bring additional effects for membership function. Simulation results are obtained by using two format conversion methods: line average method and edge direction based method.

Keywords: Image enhancement approach, fuzzy method, Gaussian noise, hedge

1 Introduction

In general, there are two types of noise in image processing: impulse noise and random noise [1-3]. The impulse noise is also known as salt and pepper noise, while the random noise is known as Gaussian noise [4]. To generate Gaussian noise, the mean and the variance values are required. The noise can be occurred in the stages of image capture, transmission, and storage. Therefore, during the television broadcasting, information may be lost due to the noise [5,6].

The fuzzy logic is a procedure of multi-valued logic where the truth values of variables can be any value between [0,1]. The opposite word of fuzzy is crisp, which is known as Boolean logic where only two values exist: [0,1]. In particular, when linguistic variables are employed, the degree of fuzziness is calculated by membership functions [7].

The rest of the manuscript is arranged as follows. In Section 2, we explain the proposed method. A block diagram of the proposed method is introduced in this section. Section 3 shows performance analysis. Finally, summary and conclusion remarks are presented in Section 4.
2 Proposed method

There are three main issues in image enhancement. The first issue is there is no systematic consideration of subjectivity. The second issue is how to assess concurred image qualities. The third issue is how adjust parameters for algorithms. This idea is shown in Fig. 1.

Fig. 1. Three issues in image enhancement.

Fig. 2. Examples of fuzzy operations: (a) SMALL, (a) original LARGE, (c) prodor operation, (d) max operation, (e) product operation, and (f) min operation.

Figures 2(a) and 2(b) show two membership functions, SMALL ($\mu_{\text{SMALL}}$) and LARGE ($\mu_{\text{LARGE}}$). Figures 2(c) and 2(d) show prodor and max operations results, while Figs. 2(e) and 2(f) show product and min operations results.

We also can apply hedge such as very, extremely, very very, more or less, and indeed. The equations of above hedges are,

\[ \mu_A^{\text{very}}(x) = \left[ \mu_A(x) \right]^2 \]  \hspace{1cm} (1)

\[ \mu_A^{\text{extremely}}(x) = \left[ \mu_A(x) \right]^3 \]  \hspace{1cm} (2)
\[ \mu_A^{veryvery}(x) = \left[ \mu_A^{very}(x) \right]^2 \]  
(3)

\[ \mu_A^{moreorless}(x) = \left[ \mu_A(x) \right]^{1/2} \]  
(4)

\[ 2\left[ \mu_A(x) \right]^2 \text{ or } \mu_A^{indeed}(x) = 1 - 2\left[ 1 - \mu_A(x) \right]^2 \]  
(5)

3 Visual Quality Comparison

In this paper, we used two methods: line average method and edge direction based method. Figure 3(a) shows original Man image. We use line average method and edge direction based method in this test image and we could obtain Figs. 3(b) and (c). Figure 4 shows part of reconstructed and difference images.

![Figure 3](image)

Fig. 3. (a) Original Man image, (b) line average method result, and (c) edge direction based method.

![Figure 4](image)

Fig. 4. (a) Part of line average method result image, (b) difference between original and Fig. 4(a), (c) part of edge direction based method, and (d) difference between original and Fig. 4(c).
4 Conclusion

To improve image quality, we used fuzzy rule-based inference system. We described three main issues of image enhancement, and they were system consideration, image quality assessment, and parameter adjustment. By adopting hedge for membership function, we could yield several effects in image processing. Experimental results were obtained by two methods. In particular, subjective performance was compared in this section.

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References