

# Certainty Measurement with Fuzzy Entropy for Video Up-Sampling

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**Abstract.** In this paper, we propose a new upsampling algorithm based on certainty measurement concept of fuzzy entropy. The conventional entropy was introduced by C.E. Shannon. We study the vagueness and ambiguous uncertainties of fuzzy entropy. Simulation results show that our presented upsampling algorithm is better than famous ELA method.

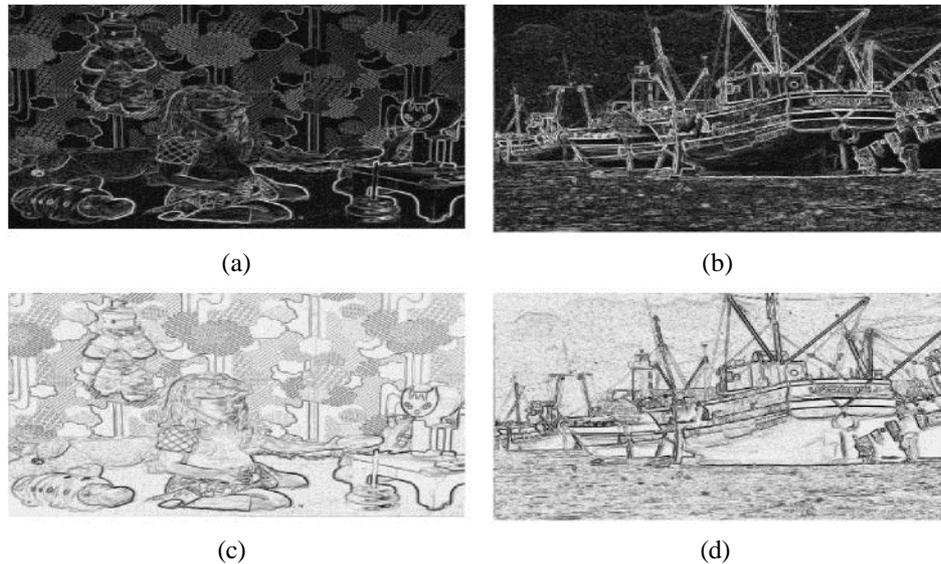
**Keywords:** fuzzy entropy, upsampling, image upscaling.

## 1 Introduction

Traditional television display does not yield full-frame at once and only can display odd and even lines in every 1/60 (in North America and Korea) and 1/50 (European countries) second [1]. This issue was brought by insufficient bandwidth. However, current television displays full video images at once, therefore interlace scanning format videos must be changed to progressive one [2,3].

There have been different upsampling methods to enhance video format conversion. Those methods can be classified into two categories. One category is motion based method [4-6], and the other is non-motion based method [7-10]. Generally motion based method is called temporal domain approach and non-motion based method is called spatial domain method. The edge-based line average (ELA) method is one of non-motion based methods, which is widely used in video deinterlacing application.

Information theory was introduced by C.E. Shannon. According to information theory, entropy is an uncertainty measure in a random variable. We assume Shannon entropy is a conventional one, which is average unpredictability in a random variable. Shannon entropy gives an absolute limit on the possible lossless coding or compression of any communication and video. In this paper, we use fuzzy entropy concept to improve video upsampling. The fuzzy sets were studied by Zadeh with a purpose to solving issues where indefiniteness resulting from a inherent vagueness plays a fundamental function. In this paper, we research fuzzy information computation with fuzzy entropy that is employed to choose the applicant method [7-10]. It is known that the principal difference between Shannon entropy of information theory and fuzzy entropy is that the former one deals with stochastic uncertainties and the later one deals with unclarity and ambiguous uncertainties.



**Fig. 1.** Fuzzy entropy map for Girl and Boat images: (a,b) original entropy map, (c,d) reversed images.

This paper is organized as follows. In Section 2, we compare conventional Shannon entropy with the proposed fuzzy entropy. Moreover, the fuzzy entropy-based upsampling method is introduced. Section 3 gives the visual results with traditional methods. Section 4 finalizes the paper with the concluding remarks.

## 2 Shannon Entropy vs. Fuzzy Entropy

The Shannon's entropy is calculated as Eq. (1).

$$H_{Shannon} = - \sum_{i=1}^n p_i \log_2(p_i), \quad (1)$$

where  $\Delta_n = \{L=l_1, \dots, l_n\}$ :  $l_i \geq 0$ , and  $n \geq 2$  be a set of  $n$ -complete likelihood distributions. De Luca and Termini [11,12] defined fuzzy entropy for a fuzzy set  $A$  as,

$$H_{DeLuca} = \text{fuzzyentropy} \\ = - \sum_{x \in A} \mu_{A_i}(x) \log_2(\mu_{A_i}(x)) + (1 - \mu_{A_i}(x)) \log_2(1 - \mu_{A_i}(x)) \quad (2)$$

Our algorithm is Based on fuzzy entropy of  $H_{DeLuca}$ .

Figures 1(a,b) show fuzzy entropy map of  $H_{DeLuca}$  for Girl and Boat images. Figures 1(c,d) show reversed images.

### 3 Experimental Results

We employed 24 image/video sequences to assess the visual performance comparison. The threshold value was determined empirically, which is chosen as 0.3 [13]. Equation (3) shows structural similarity (SSIM) formula, which takes into account image degradation as noticed alter in structural information.

$$SSIM(a, b) = \frac{(2\mu_a\mu_b + c)}{(\mu_a^2 + \mu_b^2 + c)} \frac{(2\sigma_{ab} + c)}{(\sigma_a^2 + \sigma_b^2 + c)} \quad (3)$$

Figure 2 shows subjective performance comparison on Baboon and Man images. As we can see, our proposed entropy based method gives better results than conventional ELA method.



**Fig. 2.** Subjective performance comparison: (a) original Baboon image, (b) ELA method, and (c) proposed fuzzy entropy-based method.



**Fig. 3.** Subjective performance comparison: (a) original Man image, (b) ELA method, and (c) proposed fuzzy entropy-based method.

## 4 Conclusions

A new image/video upsampling method was proposed in this paper. The presented method is based on De Luca and Termini's fuzzy entropy. When it compared to conventional ELA method, the proposed entropy-based method gives better performance.

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