Research on the Image Identification Quality Assessment with Triangular Fuzzy Information

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Abstract

In this paper, we investigate the assessment problems for evaluating the image identification quality with triangular fuzzy information. We utilize the triangular fuzzy weighted average (TFWA) operator to aggregate the triangular fuzzy information corresponding to each alternative and get the overall value of alternatives, then rank the alternatives and select the most desirable one(s) by using the formula of the degree of possibility for comparison between two triangular fuzzy variables. Finally an illustrative example for evaluating the image identification quality has been given to show the developed approach.

Keywords

Image identification quality, Triangular Fuzzy Information, Triangular Fuzzy Weighted Average (TFWA) Operator, Triangular Fuzzy Information.

1. Introduction

With the rapid technology development and cost reduction of the remote surveillance system, more and more surveillance systems are used to meet the requirement of security in all aspects of human life. A number of potential problems emerge with the promotion of the surveillance system, among which the surveillance video quality assessment is the most important one. In surveillance system, out-of-focus blur and blocking effects obviously affect the image quality. If the problems of image quality can't be detected, the performance of surveillance system is affected. Today, the scale of surveillance system is very large. Normally, surveillance system includes hundreds of surveillance videos. It is impractical to hire huge amount of people to assess the quality of surveillance videos. Therefore, Objective evaluation of the quality of the surveillance video has become a new research direction of surveillance system. Objective image quality measurement can be classified into threecategories,full-reference、reduce-reference、no-reference,bythedegreeofthe availability of an reference image. Based on the actual situation of the application, we choose no-reference objective assessment algorithm to evaluate the image quality.

The assessment problems for evaluating the image identification quality with triangular fuzzy information is a classical multiple attribute decision making problem[1-17]. The aim of this paper is to develop the appraisal model of the image identification quality with triangular fuzzy information. The remainder of this paper is set out as follows. In the next section, we introduce some basic concepts related to triangular fuzzy variables. In Section 3 we introduce the problem deal with appraisal model of the image identification quality with triangular fuzzy information, in which the information about attribute weights is completely known, and the attribute values take the form of triangular fuzzy information. Then, we utilize the triangular fuzzy weighted average (TFWA) operator to aggregate the triangular fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) by using the formula of the degree of possibility for the comparison between two triangular fuzzy variables. In Section 4, an illustrative example is pointed out. In Section 5 we conclude the paper and give some remarks.

2. Preliminaries

In this section, we briefly describe some basic concepts and basic operational laws related to triangular fuzzy numbers.

Definition 1[16]. A triangular fuzzy numbers $\tilde{a}$ can be defined by a triplet $\left(a^L, a^M, a^U\right)$.The membership function $\mu_{\tilde{a}}\left(x\right)$ is defined as:

$$\mu_{\tilde{a}}\left(x\right)=\begin{cases}0, & x<a^L, \\ \dfrac{x-a^L}{a^M-a^L}, & a^L \le x \le a^M, \\ \dfrac{x-a^U}{a^M-a^U}, & a^M \le x \le a^U, \\ 0, & x \ge a^U.\end{cases} \tag{1}$$

where $0<a^L \le a^M \le a^U$, a^L and a^U stand for the lower and upper values of the support of $\tilde{a}$,respectively, and a^M for the modal value.

Definition 2[16]. Basic operational laws related to triangular fuzzy numbers:

$$\tilde{a}\oplus\tilde{b}=\left[a^L, a^M, a^U\right]\oplus\left[b^L, b^M, b^U\right]=\left[a^L+b^L, a^M+b^M, a^U+b^U\right]$$

$$\tilde{a}\otimes\tilde{b}=\left[a^L, a^M, a^U\right]\otimes\left[b^L, b^M, b^U\right]=\left[a^Lb^L, a^Mb^M, a^Ub^U\right]$$

$$\lambda\otimes\tilde{a}=\lambda\otimes\left[a^L, a^M, a^U\right]=\left[\lambda a^L, \lambda a^M, \lambda a^U\right], \ \lambda>0.$$

$$\frac{1}{\tilde{a}}=\left[1/a^U, 1/a^M, 1/a^L\right]$$

Zétényi [17] pointed out that psychologists generally consider a good representation of a fuzzy set its expected value. The expected value of a fuzzy set A is equal to (Matarazzo & Munda, 2001)

$$E\left(A\right)=\frac{\int_{-\infty}^{+\infty} x\mu_A\left(x\right)dx}{\int_{-\infty}^{+\infty} \mu_A\left(x\right)dx} \tag{2}$$

where the integral converges absolutely, that is $\int_{-\infty}^{+\infty}\left|x\mu_A\left(x\right)\right|dx<+\infty$. Otherwise, A has no finite expected value.

Definition **3**[18-19]. Let $\tilde{a}_j=\left[a_j^L, a_j^M, a_j^U\right]\left(j=1,2,\cdots,n\right)$ be a collection of triangular fuzzy numbers,

$$\begin{aligned}\text{TFWA}_w\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)&=\overset{n}{\underset{j=1}{\oplus}} w_j\tilde{a}_j \\ &=\left[\sum_{j=1}^n w_j a_j^L, \sum_{j=1}^n w_j a_j^M, \sum_{j=1}^n w_j a_j^U\right]\end{aligned} \tag{3}$$

where $\omega=\left(\omega_1,\omega_2,\cdots,\omega_n\right)$ is the weighting vector of triangular fuzzy numbers $\tilde{a}_j$ $\left(\tilde{a}_j=\left[a_j^L, a_j^M, a_j^U\right]\right)$ $\left(j=1,2,\cdots,n\right)$ with $\omega_j\in\left[0,1\right]$, $\sum_{j=1}^n\omega_j=1$, then function TFWA is called the triangular fuzzy weighted average (TFWA) operator of dimension n.

Definition **4**[20]. Let $\tilde{b}=\left[b^L,b^M,b^U\right]$ and $\tilde{a}=\left[a^L,a^M,a^U\right]$ be two triangular fuzzy numbers, then the degree of possibility of $a \ge b$ is defined as

$$\begin{aligned} p(a\ge b)=\lambda \max\left\{1-\max\left[\frac{b^M-a^L}{a^M-a^L+b^M-b^L},0\right],0\right\}+ \\ (1-\lambda)\max\left\{1-\max\left[\frac{b^U-a^M}{a^U-a^M+b^U-b^M},0\right],0\right\} \end{aligned} \tag{4}$$

where the value λ is an index of rating attitude. It reflects the decision maker's risk-bearing attitude. If $\lambda>0.5$, the decision maker is risk lover. If $\lambda=0.5$, the decision maker is neutral to risk. If $\lambda<0.5$, the decision maker is risk avertor.

From Definition 4, we can easily get the following results easily:

(1) $0\le p(a\ge b)\le 1, 0\le p(b\ge a)\le 1$;

(2) $p(a\ge b)+p(b\ge a)=1$. Especially, $p(a\ge a)=p(b\ge b)=0.5$.

3. Research on the Image Identification Quality Assessment with Triangular Fuzzy Information

With the speedy development of the Internet technology, digital image is widely used in many fields of human life. The image quality is good or bad will directly affect accuracy of acquired information. So, the image quality assessment has become a basic problem. Since 1980's, the research about image quality assessment has never been interrupted. From the full reference assessment to reduced reference assessment, and then to no-reference process of research, has countless image quality evaluation algorithm came into being. The full reference assessment which is need to have complete information about the original image as a reference, reduced reference assessment which is need only part of the original image information as a reference, and no-reference which is not need original image information as a reference. Each algorithm has its own unique way of thinking, as well as feature extraction methods. Therefore, how to find the optimal image quality assessment algorithm suitable for a certain kind of distorted image quickly and intuitively from numerous image quality assessment algorithm is very valuable. MATLAB has a powerful matrix computing capabilities, rich library, convenient toolbox, as well as visual GUI interface platform, etc. It is more convenient to deal with images, and is very popular among researchers. Therefore, in order to comparative analysis of advantages and disadvantages of numerous image quality evaluation algorithm and its applicable range of distortion types, the article designs an image quality assessment system based on the visual GUI interface platform provided by MATLAB. Consider a MADM problems for evaluating the image identification quality with triangular fuzzy information: let $A=\{A_1,A_2,\cdots,A_m\}$ be a discrete set of alternatives, and $G=\{G_1,G_2,\cdots,G_n\}$ be the set of attributes, $\omega=(\omega_1,\omega_2,\cdots,\omega_n)$ is the exponential weighting vector of the attributes $G_j\ (j=1,2,\cdots,n)$, where $\omega_j\in[0,1]$, $\sum_{j=1}^{n}\omega_j=1$. Suppose that $\tilde{R}=\left(\tilde{r}_{ij}\right)_{m\times n}=\left[r_{ij}^L,r_{ij}^M,r_{ij}^U\right]_{m\times n}$ is the decision matrix, where $\tilde{r}_{ij}$ is a preference value, which takes the form of triangular fuzzy numbers, given by the decision maker for the alternative $A_i\in A$ with respect to the attribute $G_j\in G$.

In the following, we apply the TFWA operator for evaluating the image identification quality with triangular fuzzy information.

Step 1. Utilize the decision information given in matrix $\tilde{R}$, and the TFWA operator

$$\tilde{r}_i = \text{TFWA}_\omega\left(\tilde{r}_{i1}, \tilde{r}_{i2}, \cdots, \tilde{r}_{in}\right),\ i = 1, 2, \cdots, m. \tag{5}$$

to derive the collective overall preference values $\tilde{r}_i\left(i = 1, 2, \cdots, m\right)$ of the alternative A_i ,where $\omega = \left(\omega_1, \omega_2, \cdots, \omega_n\right)^T$ is the weighting vector of the attributes.

Step 2. To rank these collective overall preference values $\tilde{r}_i\left(i = 1, 2, \cdots, m\right)$, we first compare each $\tilde{r}_i$ with all the $\tilde{r}_j\left(j = 1, 2, \cdots, m\right)$ by using (5). For simplicity, we let $p_{ij} = p\left(\tilde{r}_i \geq \tilde{r}_j\right)$, then we develop a complementary matrix as $P = \left(p_{ij}\right)_{m \times m}$ and sum all the elements in each line of matrix P , we have $p_i = \sum_{j=1}^{m} p_{ij}, i = 1, 2, \cdots, m$.

Step 3. Rank all the alternatives $A_i\left(i = 1, 2, \cdots, m\right)$ and select the best one(s) in accordance with $p_i\left(i = 1, 2, \cdots, m\right)$.

4. Illustrative Example

With the development of information technology, iris recognition has become a hot research topic in the cross-subject of Applied Mathematics, pattern recognition, image processing and information security. Recently, more and more researchers devote themselves to iris recognition, but the research of recognition on low-quality iris image (for example, covered by the eyelashes and eyelids, at-a-distance, motion-blurred, focusing-blurred, rotation, glasses, poor lighting etc.) is lacking. Most practical application systems require user's strict cooperation to obtain high-quality iris image in the process of iris image collection, and most algorithms have certain requirements for the quality of iris image. Nevertheless, it is hard to ensure the quality of iris image in the practical application. To solve the problem of low-quality iris image recognition, through analyzing and researching low-quality iris image, this section presents a numerical example to illustrate the method proposed in this paper. Suppose a company plans to evaluate the image identification quality. The experts selects four attribute to evaluate the five possible cities: ①G1 is the road traffic safety management facilities; ② G2 is the road police management; ③G3 is the road traffic accident management; ④G4 is the road traffic safety science and technology equipment. The five possible cities $A_i\left(i = 1, 2, 3, 4, 5\right)$ are to be evaluated by using the triangular fuzzy numbers by the three decision makers under the above five attributes, and construct, respectively, the decision matrices as listed in the following matrices $\tilde{R}_k = \left(\tilde{r}_{ij}^{(k)}\right)_{5 \times 4}\left(k = 1, 2, 3\right)$ is shown in Table 1.

Table 1. Decision matrix $\tilde{R}$

	G_1	G_2	G_3	G_4
A_1	(0.91,0.93,0.96)	(0.80,0.85,0.90)	(0.62,0.65,0.68)	(0.72,0.76,0.80)
A_2	(0.60,0.67,0.70)	(0.88,0.90,0.93)	(0.69,0.72,0.75)	(0.67,0.77,0.83)
A_3	(0.77,0.79,0.82)	(0.95,0.97,0.98)	(0.93,0.95,0.96)	(0.90,0.93,0.95)
A_4	(0.98,0.99,1.00)	(0.82,0.85,0.88)	(0.97,0.99,1.00)	(0.97,0.98,1.00)
A_5	(0.83,0.85,0.88)	(0.78,0.79,0.81)	(0.94,0.97,0.99)	(0.78,0.79,0.81)

To get the most desirable city, the following steps are involved:

Step 1. We utilize the decision information given in matrix R, and the TFWA operator which has associated attribute weight vector $\omega = (0.25, 0.35, 0.10, 0.30)^T$ to obtain the overall preference values $\tilde{r}_i$ of the alternatives A_i $(i = 1, 2, 3, 4, 5)$. The results are shown in Table 2.

Table 2. The overall preference values of the alternatives

A1	**A2**	**A3**	**A4**	**A5**
(0.76,0.80,0.81)	(0.79,0.83,0.85)	(0.87,0.89,0.92)	(0.76,079,0.85)	(0.74,077,0.81)

Step 2. According to the aggregating results shown in Table 2 and the formula of degree of possibility (1), the ordering of the alternatives are shown in Table 3. Note that > means "preferred to". As we can see from Table 3, Thus the most desirable city is A_3.

Table 3. Ordering of the alternative by utilizing the TFWA operator

	Ordering
TFWA	$A_3 > A_5 > A_2 > A_4 > A_1$

5. Conclusion

Among all information received by a human being, visual information is the main and the most important one. And the image is an important kind of visual information carrier. From the acquisition, processing, compression, transmission, restoration to display of image or video, monitoring and controlling image quality are needed. Image quality assessment (IQA) can be categorized into two kinds: subjective ones and objective ones. The subjective one is the most reliable one (or the ground truth), but it is the most expensive, time-consuming, and can't be used in real-time system. Therefore, developing objective IQA metrics which can automatically, reliably and accurately predict the subjective image quality is meaningful. The traditional objective IQA metric such as PSNR is poor in predict-ing subjective image qualities. Although presently many alternative algorithms have been developed and also some achievements have been obtained, there is still no metric which has high prediction precision and reliability as well as linearly predicting subjective qualities at the same time. Considering the benefits and shortcomings of two main kinds of objective IQA metric (the human visual system based ones and the engineering based ones), in this paper, we investigate the multiple attribute decision making (MADM) problems for evaluating the image identification quality with triangular fuzzy information. We utilize the triangular fuzzy weighted average (TFWA) operator to aggregate the triangular fuzzy information corresponding to each alternative and get the overall value of alternatives, then rank the alternatives and select the most desirable one(s) by using the formula of the degree of possibility for the comparison between two triangular fuzzy variables. Finally an illustrative example for evaluating the image identification quality has been given to show the developed approach. In the future, we shall extend the proposed models to other domains[21-37].

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