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Guest Editorial

INFORMATION SETS AND INFORMATION PROCESSING

Information Sets in Image Processing

The area of image processing has made rapid strides because of enormous applications it has in different fields. This growth can also be attributed to the increasing use of fuzzy logic in all tasks of image processing as the fuzzy logic facilitates the representation of inherent uncertainty in the image information which can be local or global. For problems like enhancement global information is of interest whereas the local information is needed for the problems of edge detection, segmentation, and recognition. However we need both for the noise removal. The images are of varied types: Medical images (CT scans, MR, X-rays, ECG, etc.), satellite images, natural scenes, videos, games, multimedia, biometrics, industrial, astronomical so on and so forth. The approaches to tackle different images have to be different. For example skin texture can't represented by a colour model.

Whatever may be the type of image, there are a few basic properties called cues such as colour, texture, motion that are essential for solving the problems of image processing. As the properties are ambiguous they are better represented by fuzzy logic. Thus fuzzy image processing has come into the fore. But in the fuzzy domain the choice of membership is very crucial. We will now discuss a few problems associated with the fuzzy logic essentially in the context of time varying information.

Fuzzy Sets

All the elements satisfying a particular property form a fuzzy set and each element in the set has a degree of association called membership function.

The concept of fuzzy set as given by Zadeh has a limitation that it can't cope up with the property that changes with space or time or both. Moreover devising a membership function to an element in the fuzzy set is subjective unless the property has a well defined distribution. In case we are not bestowed with such a boon, we would be judging the property of an element subjectively. In that case, the membership degree may be decided objectively wrt a reference value, which could be the maximum, average or median to mention a few.

Let us open up to a more general situation where the fuzzy sets grow enormously as the number of properties describing an object increases. To visualise this situation, consider a person (an object) being authenticated (described) by several biometric modalities (properties) like face, iris, fingerprint, palmprint, hand geometry, hand veins, ears, etc., then a single modality or more than one modality may qualify a person. Some of these modalities like face change with time as a person gets older. Especially, faces shows up differently in response to the environmental changes, and physical changes like emotions taking place in the person of its possession while it is being acquired. These changes occurring over space are the space changes. We may witness significant changes in some modalities over a longtime. On the top of the possible time and space changes in the modalities, if the agents (membership functions) evaluating the modalities have their own perception (offering different membership grades) we would be entering into a dangerous situation where the existing fuzzy tools are not equipped to deal with. If the age of a person is not revealed, it is very difficult to assess his age from his face. Some onlookers might say he is young and others might say old. Actually each onlooker judges the age perhaps based on his own his age as the reference. This kind of differential assessment of property by an agents leads to rough sets of Pawlack.

Fuzzy Rough Sets

The agents evaluating a property on higher side (above a certain membership function value) make a lower approximation of the fuzzy set describing the property while agents evaluating the same property on lower side (below a certain membership function value) make a higher approximation of the fuzzy set thus making a rough set to a fuzzy rough set. We will now move to different agents emerging from using different reference parameters.

Reference Parameters

Let us consider the gray level of an image (be of face, iris or any) as the property. For simplicity we take a window in the image I with coordinates i and j. Let a pixel be noted by $I_k(i, j)$ in the k^{th} window of size W x W, The possible reference (ref) parameters could be the average I(ave), maximum I(max) or median I(med). So we have ref = {ave, max, med}. One can think of other parameters too. Any membership function can be devised with respect to a reference parameter. If the height is an attribute of a person, whether he is tall or short among a group of persons is generally judged from the maximum height in that group. To detect the noisy pixels from among all gray levels of pixels in a window, we generally prefer the median of the gray levels as the reference. But to point out a rich person or a poor person among some people belonging to different income groups, the average income is only a suitable measure of reference. The choice of a reference is a matter of domain of application.

Membership Functions

If an attribute or property follows a distribution it is easy to fit a function describing the very distribution or at least an approximating function. The exponential and Gaussian type function are such examples.

Information

Let us now enter the vast domain of multimedia where an

image, text, speech, videos, music, signs, and symbols are the sources of information the human beings engrossed, obsessed, and enamored with and these are not only the ones that rule the roost. The speech and music can be represented by time series approaches whereas images and videos can be dealt with soft computing techniques.

Our concern is to process the information to achieve different tasks such as recognition, information retrieval and modification, decision making etc. In the context of information, the member functions serve as agents that judge the information like any image, speech signals, text to name a few.

Origin of Information Concept

The original definition of information is credited to Shannon in the form of entropy

$$H = \sum p(-\log p)$$

Here p is the probability and bracketed term is the logarithmic gain. Pal and Pal entropy uses the exponential gain in place of the bracketed term as $H = \sum pe^{(1-p)}$

A suitable definition to the information comes from the Hanman –Anirban entropy function, which is an offshoot of Pal and Pal entropy function. It is given by

$$H = \sum pe^{-(ap^3+bp^2+cp+d)}$$

Where a, b, c and d are real valued parameters. This entropy is in the probabilistic domain. But by an appropriate choice of the parameters, the exponential term gets converted into the exponential or the Gaussian membership function when we relax the assumption that the sum of probabilities is equal to 1. Then H becomes $H=\{p\mu(p)\}$. Here p is treated as information sources comprising any multimedia component.

Information Set

Any fuzzy set defined over a Universe of Discourse can be thought of information set with its elements as product of information source values (p) and their membership grades $\mu(p)$.

The Salient features of Information sets are :

(a) Information sets allow the information to be modified.
(b) The probability and possibility can be treated very easily through information sets.
(c) The weighted information source facilitates the capture of the desired components from the information.
(d) The spatial and time variation of 1-D (signals) and 2-D (images) can be characterized by the information sets.
(e) The information sets make the fuzzy modeling easier even when the output is not available.
(f) They allow the application of agent theory.
(g) The information sets easily incarnate into information rough and rough information sets.

We have two types. The information resulting from the product of gray level and its membership value is called the auto information whereas that obtained from the product of a membership value but another gray level is called the cross information.

Let us consider a single information source p. If an agent $\mu(p)$ derived from an information source judges the same information then the information content is called auto automation as given by

$$H_{auto}(p) = \{p\mu(p)\}$$

On the other hand, if the information source p is judged by another agent derived from a different source q then the information content is called cross information:

$$H_{auto}(p) = \{p\mu(q)\}$$

Summing the above two gives the total information:

$$H = H_{auto} + H_{cross}$$

This concept of information set opens up a host of possibilities for changing the information contained in an image so that the desirable tasks can be performed on the image thus ushering an era of information sets and information processing.

In this special issue, the following problems of image processing are presented through eight papers written by eminent research scholars of the field.

- Protecting the input information by way of digital watermarking.
- Image retrieval using the new entropy function called Hanman-Anirban entropy. In this the texture as the region concept is represented as the sum of the information values in the neighbourhood of the pixel of interest.
- Face recognition using segmental Euclidean distance as the classifier and principal component analysis (PCA) as the features. Here fuzzy features are also introduced where the concept of information is used.
- Selection of seed points in the extraction of vessel features from fluoroscopic images.
- Enhancement and restoration of fluoroscopic microscopy corrupted with Poisson noise using non-partial difference equation based filter. The filter can be thought modifying the image information so as to obtain a desirable image.
- Enhancing the under and over exposed images and also mixed images. Here two operators are used that transform the original image information into the form such that the resulting images appear pleasing.
- A family of Pearson distributions is employed to characterize the speckle in echocardiographic images. The distributions tell us how the information exists in an image. If we have the PDF of a distribution, it is possible to know the information content in an image.
- Fusion of images of different resolutions using the singular value decomposition method.

Rough Information Sets and Information Rough Sets

During the admission of a candidate for a programme, each expert of the interview committee x gives only the relative marks $H(p) = p\mu(p)$ wrt his ability. If $\{H(p) \geq M\}$ is satisfied than it leads to the lower rough information set. Here M stands

for a positive value. On the other hand, if $\{H(p) = p\mu(p); \mu(p) \geq alpha\}$ is satisfied then it leads to the lower information rough set. Thus, a whole of theory can be developed around the rough sets under the framework of information sets.

We have presented the information sets as the future direction in the advancement of image processing. It is hoped that information sets simplify the solutions to methods for different tasks the problems of image processing.

Before closing, Guest Editor wishes to thanks Prof Biswas, Dr Shankar Prakriya, and Dr Sumantra Dutta Roy for spending their valuable time in reviewing the papers. He is also grateful to all the authors for their valuable contributions.

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