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Development of Adaptive Fuzzy based Image Filtering Techniques to Enhance Lung Lobe Images

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ABSTRACT

A new fuzzy filter is presented for the noise reduction of images corrupted with additive noise. The filter consists of two stages. The first stage computes a fuzzy derivative for eight different directions. The second stage uses these fuzzy derivatives to perform fuzzy smoothing by weighting the contributions of neighboring pixel values. Both stages are based on fuzzy rules which make use of membership functions. The filter can be applied iteratively to effectively reduce heavy noise. In particular, the shape of the membership functions is adapted according to the remaining noise level after each iteration, making use of the distribution of the homogeneity in the image. A statistical model for the noise distribution can be incorporated to relate the homogeneity to the adaptation scheme of the membership functions. Experimental results are obtained to show the feasibility of the proposed approach. These results are also compared to other filters by numerical measures and visual inspection.

1. INTRODUCTION

Medical imaging is the technique that is used to create images of the human body (or parts and function thereof) for clinical purposes (medical procedures seeking to reveal, diagnose or examine disease) or medical science (including the study of normal anatomy and physiology)[3]. The CT images offer detailed information of lung cavities, which could be used for better surgical planning of treating Lung Cancer. Preprocessing is done to remove the noise from the isotropic CT image. Many existing methods are there for preprocessing. Filtering is the most fundamental operation in image processing and computer vision. The filtered image at a given location is a function of values of the input image in a small neighborhood of the same location. Assuming that images vary slowly over space, near pixels is likely to have similar values. But this assumption fails at regions that contain edges and image details (e.g. corners, lines, end of lines etc.) Most of the classical linear filters like the averaging low pass filters tend to blur and destroythe lines, edges and other fine image details. Wiener filter [2] is an optimization filter aimed to minimize the mean square error between the original image and the filtered counterpart. Since noise in CT images follows the Poisson distribution, which can be approximated using a Gaussian distribution for large number of occurrences. Fuzzy image processing [4] is the collection of all approaches that understand, represent and process the images, their segments and feature as fuzzy sets.
The structure of the human lungs is shown here.

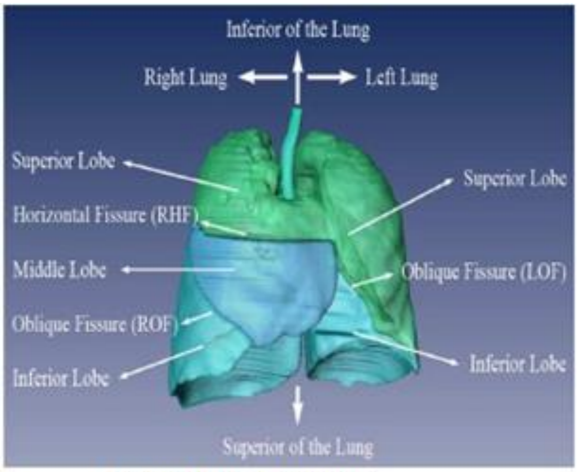


Fig 1: Structure of human lungs

The representation and processing depend on the selected fuzzy technique and on the problem to be solved. Fuzzy
image processing involves three main stages. Image fuzzification, Membership modification, Image defuzzification.Fuzzy image processing using fuzzy techniques plays a very important role in image processing. Fuzzy techniques are important and powerful tools for knowledge representation and processing, and also managing the subjectivity and uncertainty very efficiently. The three important areas that are not perfect are Greyness ambiguity, Geometrical fuzziness, vague knowledge. Fuzzy Geometry, measures of Fuzziness and image information, fuzzy inference systems, fuzzy clustering, Fuzzy mathematical morphology, fuzzy measure theory, Fuzzy Grammars, neural fuzzy are some of important theoretical components of fuzzy image processing scheme. A fuzzy filter [7] to remove impulse noise in an image with the combined ability of the RCM filter and fuzzy thresholding technique to preserve edges and fine details. The pixels lying outside the trimming range after ranking in the RCM filter are further tested for being noisy by the process of fuzzy thresholding. On CT, a fissure can have a variety of appearances[8], which makes its detection and segmentation challenging.Due to respiratory and cardiac motion, as well as partial volume effect, a fissure often appears as a ribbon-like structure several pixels wide, rather than the more typical configuration of a thin curvilinear opacity with sharp edges. For segmenting lung lobes depicted on 3-D CT examinations. The unique characteristic of this scheme is the representation of fissures in the form of implicit functions using Radial Basis Functions (RBFs)[9], capable of seamlessly interpolating "holes" in the detected fissures and smoothly extrapolating the fissure surfaces to the lung

boundaries resulting in a “natural” segmentation of lung lobes. Takahiro [10] estimates the boundary surface between lung lobes by fitting curved surface. The fitting is performed with fuzzy control, and it searches the boundary where the density of tubular tissues is low. Image segmentation based contour models are also there in this paper fuzzy filter is used for the removal of noise from CT image of the lungs. The preprocessed image can be used for the lobe segmentation and for the extraction of the fissures.A fuzzy filter [7] to remove impulse noise in an image with the combined ability of the RCM filter and fuzzy thresholding technique to preserve edges and fine details. The pixels lying outside the trimming range after ranking in the RCM filter are further tested for being noisy by the process of fuzzy thresholding. On CT, a fissure can have a variety of appearances [8], which makes its detection and segmentation challenging. Due to respiratory and cardiac motion, as well as partial volume effect, a fissure often appears as a ribbon-like structure several pixels wide, rather than the more typical configuration of a thin curvilinear opacity with sharp edges. For segmenting lung lobes depicted on 3-D CT examinations. The unique characteristic of this scheme is the representation of fissures in the form of implicit functions using Radial Basis Functions (RBFs)[9], capable of seamlessly interpolating “holes” in the detected fissures and smoothly extrapolating the fissure surfaces to the lung boundaries resulting in a “natural” segmentation of lung lobes. Takahiro [10] estimates the boundary surface between lung lobes by fitting curved surface. The fitting is performed with fuzzy control, and it searches the boundary where the density of tubular tissues is low. Image segmentation based contour models are also there in this paper fuzzy filter is used for the removal of noise from CT image of the lungs. The preprocessed image can be used for the lobe segmentation and for the extraction of the fissures.

2. TECHINQUES

2.1 Fuzzy Derivative Estimation

In this part we want to determine whether a pixel is corrupted or not. For this, the following criteria are considered:

1) if a pixel is severely noisy, there aren’t any similar gray level value in its neighborhood pixels, so the minimum gray value difference of that pixel and its 8-neighborhood pixels is large. Reversely, if minimum gray level difference of a pixel and its neighborhood pixels is small, one assumes that the pixel is not categorized as a noisy pixel. Hence we use minimum gray level differences as the first parameter of our fuzzy rule based system:

$dif = \min f(x, y) - f(x', y')$

,where (x', y') is an 8-neighborhood pixel of (x,y).

2) if a pixel has many similar pixels in its neighborhood, one assumes that it is uncorrupted, so we can use number of similar pixels to an assumed pixel in its 8-neighborhood as an important parameter to realize whether the pixel is corrupted or not. For this, we determine the number of pixels in the 8-neighborhood of a given pixel that their gray level differences with central pixel is less than a predefined threshold. We exploit this number as the second parameter of our fuzzy rule based system:

Number Of Similar = {Number of (x', y') |
$(x', y') \in N_8(x,y)$ & $|f(x, y) - f(x', y')| <$ Threshold }

In this the threshold statically equal to 5, but it may determined dynamically for each image to gain better results. The output of the fuzzy system is a degree associated to each pixel that is a real number between 0 and 1. It denotes the degree which a pixel is considered as an uncorrupted pixel. The rule of the fuzzy system are as follows:

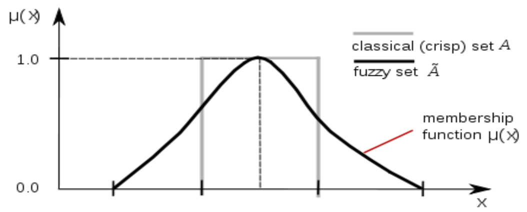
1. If (dif is low) and (num is none) then (deg is moderate)
2. If (dif is low) and (num is few) then (deg is big)
3. If (dif is low) and (num is many) then (deg is very big)
4. If (dif is med) and (num is none) then (deg is small)
5. If (dif is med) and (num is few) then (deg is moderate)
6. If (dif is med) and (num is many) then (deg is big)
7. If (dif is high) and (num is none) then (deg is small)
8. If (dif is high) and (num is few) then (deg is moderate)
9. If (dif is high) and (num is many) then (deg is moderate)

2.2 Membership Function

The **membership function** of a fuzzy set is a generalization of the indicator function in classical sets. In fuzzy logic, it represents the degree of truth as an extension of valuation. Degrees of truth are often confused with probabilities, although they are conceptually distinct, because fuzzy truth represents membership in vaguely defined sets, not likelihood of some event or condition.

Definition

For any set *X*, a membership function on *X* is any function from *X* to the real unit interval [0,1].Membership functions on *X* represent fuzzy subsets of *X*. The membership function which represents a fuzzy set $\tilde{A}$ is usually denoted by μ_A. For an element x of X, the value $\mu_{\tilde{A}}(x)$ is called the membership degree of x in the fuzzy set $\tilde{A}$.The membership degree $\mu_A(x)$ quantifies the grade of membership of the element x to the fuzzy set $\tilde{A}$.The value 0 means that x is not a member of the fuzzy set; the value 1 means that x is fully a member of the fuzzy set. The values between 0 and 1 characterize fuzzy members, which belong to the fuzzy set only partially.



The usual membership functions with values in [0, 1] are then called [0, 1]-valued membership functions**.**

2.3 Smoothing

Smoothing is a noise reduction technique that derives its name from the fact that it employs a simple, fast filtering algorithm that sacrifices noise suppression power in order to preserve the high spatial frequency detail (*e.g.* sharp edges) in an image. It is explicitly designed to remove noise spikes --- *i.e.* isolated pixels of exceptionally low or high pixel intensity (e.g. salt and pepper noise) and is, therefore, less effective at removing additive noise (e.g. Gaussian noise) from an image.Smoothing, which is just a type of blurring is based on a concept called convolution.How this works is that you take a square section of pixels, often 3×3 but can be any size, although the larger you make the grid, the less pixels that will get affected by the effect around the edges.The centre pixel of the grid is the main pixel we are interested in. To use convolution, what we do is assign weightings to each pixel in the grid, depending on what effect we are trying to achieve, and then assign the result to the centre pixel.The basic data structure we use for the convolution is a class which contains the 2D array, as well as a weighting factor, and an offset.

2.4 Fuzzification

Fuzzification is the process of changing a real scalar value into a fuzzy value. This is achieved with the different types of fuzzifiers. There are generally three types of fuzzifiers, which are used for the fuzzification process; they are

1. singleton fuzzifier,
2. Gaussian fuzzifier, and
3. trapezoidal or triangular fuzzifier.

2.5 Defuzzification

Defuzzification is the process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. It is typically needed in fuzzy control systems. These will have a number of rules that transform a number of variables into a fuzzy result, that is, the result is described in terms of membership in fuzzy sets.Fuzzy logic is a rule-based system written in the form of horn clauses (*i.e.*, if-then rules). These rules are stored in the knowledge base of the system. The input to the fuzzy system is a scalar value that is fuzzified. The set of rules is applied to the fuzzified input. The output of each rule is fuzzy. These fuzzy outputs need to be converted into a scalar output quantity so that the nature of the action to be performed can be determined by the system. The process of converting the fuzzy output is called defuzzification. Before an output is defuzzified all the fuzzy outputs of the system are aggregated with an union operator. The union is the *max* of the set of given membership functions and can be expressed as

$$\mu_A = \bigcup_i \left(\mu_i(x) \right)$$

3. CONCLUSION :

The fuzzy filter can be used for preprocessing the CT image of lungs. The preprocessed CT image is subjected to sutaible algorithm for lung lobe segmentation and fissure extraction which provides a preplanning for surgery. While performing the filtering originality of the image have to be. preserved. The fuzzy filtering performs the noise removal by preserving the edges.

4. FUTURE ENHANCEMENT :

The future enhancement of this project can be that it can be integrated with the downloading systems that download the images from the internet and apply the filters with the consent of the user and provide a better image to the user.This project can also be updated and made a little more accurate with use of other complex technologies and methodologies and implemented for use of analyzing the satellite imagerys.

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