AUTOMATIC DETECTION OF TUBERCULOSIS IN CHEST RADIOGRAPHY USING FUZZY CLASSIFIER

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***ABSTRACT*: Tuberculosis is one of the major health concerns which an infectious disease is caused by the bacterium Mycobacterium tuberculosis (MTB). Tuberculosis generally affects the lungs, but can also affect other parts of the body. Most infections do not have symptoms, known as latent tuberculosis. In 2014, there were 9.6 million cases of active TB which resulted in 1.5 million deaths. More than 95% of deaths occurred in developing countries. Automatic systems to detect TB on chest radiographs (CXRs) can improve the efficiency of diagnostic algorithms for pulmonary TB.A computer aided detection (CAD) system was developed which combines several sub scores of supervised subsystems detecting textural, shape, and focal abnormalities into one TB score. A typical thin curvilinear shape of fissure profiles inside 2D cross-sections, the dos filter is presented by first defining nonlinear derivatives along a triple stick kernel in varying directions. To accommodate pathological abnormality and orientation deviation, a max-min cascading and multiple plane integration scheme is adopted to form a shape-tuned likelihood for 3D surface patches discrimination. Our main contribution is to isolate the fissure patches from adhering clutters by introducing a branch-point removal algorithm, and a multi-threshold merging framework is employed to compensate for local intensity inhomogeneity.**

***Keywords*: Tuberculosis, X-rays , MATLAB**

I. INTRODUCTION

Image processing is a subset of the electronic domain where in the image is converted to an array of small integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory and processed by computer or other digital hardware. A digital image differs from a photo in that the x, y, and f(x, y) values are all discrete. Usually they take on only integer values, so the image shown in figure 1 will have x and y ranging from 1to 256 each, and the brightness values also ranging from 0 (black) to 255 (white). A digital image can be considered as a large array of discrete dots, each of which has a brightness associated with it. These dots are called picture elements, or more simply pixels. The pixels surrounding a given pixel constitute its neighborhood. A neighborhood can be characterized by its shape in the same way as a matrix: we can speak of a 3*3 neighborhood, or of a 5*7 neighborhood. Except in very special circumstances, neighborhood has odd numbers of rows and columns; this ensures that the current pixel is in the center of the neighborhood. An example of a neighborhood is given in figure 1.1 If a neighborhood has an even number of rows or columns (or both), it may be necessary to specify which pixel in the neighborhood is the "current pixel"

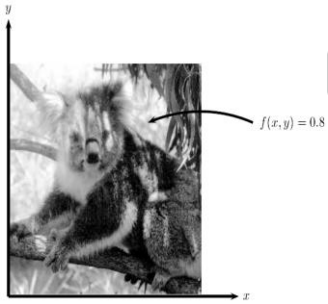


Figure 1.1 Grey scale image

1.1 IMAGE ENHANCEMENT

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. If the source of degradation is known, one calls the process image restoration. Both are conical processes, viz. input and outputs are images. We discuss a few recipes that have shown to be useful both for the human observer and/or for machine recognition. These methods are very problem-oriented: a method that works fine in one case may be completely inadequate for another problem. Apart from geometrical transformations some preliminary grey level adjustments may be indicated, to take into account imperfections in the acquisition system. This can be done pixel by pixel, calibrating with the output of an image with constant brightness. Frequently space-invariant grey value transformations are also done for contrast stretching, range compression, etc. The critical distribution is the relative frequency of each grey value, the grey value histogram.

Examples of simple grey level transformations in this domain are:

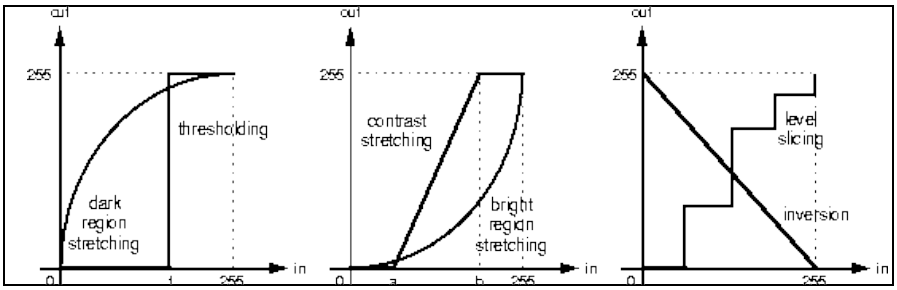
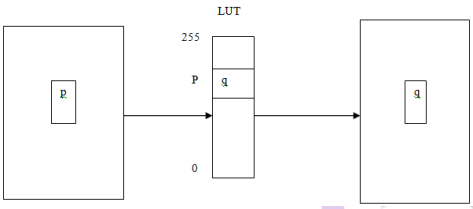


Figure 1.2: The grey value histogram

Grey values can also be modified such that their histogram has any desired shape, e.g. flat (every grey value has the same probability). All examples assume point processing, viz. each output pixel is the function of one input pixel; usually, the transformation is implemented with a look-up table. Physiological experiments have shown that very small changes in luminance are recognized by the human visual system in regions of continuous grey value, and not at all seen in regions of some discontinuities. Therefore, a design goal for image enhancement often is to smooth images in more uniform regions, but to preserve edges. On the other hand, it has alsobeen shown that somehow degraded images with enhancement of certain features, e.g. edges,



Simplify image interpretation both for a human observer and for machine recognition. A second design goal, therefore, is image sharpening. All these operations need neighbourhood processing, viz. the output pixel is a function of some neighbourhood of the input pixels: These operations could be performed using linear operations in either the frequency or the spatial domain. We could, e.g. design, in the frequency domain, one-dimensional low or high pass filters (Filtering), and transform them according to the two-dimensional case. Unfortunately, linear filter operations do not really satisfy the above two design goals; in this book, we limit ourselves to discussing separately only (and superficially) Smoothing and Sharpening. Here is a trick that can speed up operations substantially, and serves as an example for both point and neighbourhood processing in a binary image: we number the pixels in a 3x3 neighbourhood like: and denote the binary values (0,1) by b_i (i = 0,8); we then concatenate the bits into a 9-bit word, like $b_8b_7b_6b_5b_4b_3b_2b_1b_0$. This leaves us with a 9-bit grey value for each pixel, hence a new image (an 8-bit image with b_8 taken from the original binary image will also do).

5	6	7
4	8	0
3	2	1

The new image corresponds to the result of a convolution of the binary image, with a 3 x 3 matrix containing as coefficients the powers of two. This neighbour image can then be passed through a look-up table to perform erosions, dilations, noise cleaning, skeletonization, etc.

Apart from point and neighbourhood processing, there are also global processing techniques, i.e. methods where every pixel depends on all pixels of the whole image. Histogram methods are usually global, but they can also be used in a neighbourhood.

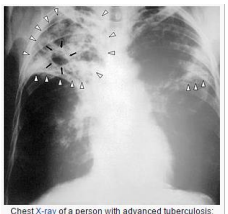
1.2 TUBERCULOSIS

Tuberculosis (TB) is an infectious disease caused by the bacterium Mycobacterium tuberculosis (MTB). Tuberculosis generally affects the lungs, but can also affect other parts of the body. Most infections do not have symptoms, known as latent tuberculosis. About 10% of latent infections progress to active disease which, if left untreated, kills about half of those infected. The classic symptoms of active TB are a chronic cough with blood-containing sputum, fever, night sweats, and weight loss. The historical term "consumption" came about due to the weight loss. Infection of other organs can cause a wide range of symptoms. Tuberculosis is spread through the air when people who have active TB in their lungs cough, spit, speak, or sneeze. People with latent TB do not spread the disease. Active infection occurs more often in people with HIV/AIDS and in those who smoke. Diagnosis of active TB is based on chest X-rays, as well as microscopic examination and culture of body fluids. Diagnosis of latent TB relies on the tuberculin skin test (TST) or blood tests. Prevention of TB involves screening those at high risk, early detection and treatment of cases, and vaccination with the bacillus Calmette-Guérin vaccine. Those at high risk include household, workplace, and social contacts of people with active TB. Treatment requires the use of multiple antibiotics over a long period of time. Antibiotic resistance is a growing problem with increasing rates of multiple drug-resistant tuberculosis (MDR-TB). One-third of the world's population is thought to be infected with TB. New infections occur in about 1% of the population each year. In 2014, there were 9.6 million cases of active TB which resulted in 1.5 million deaths. More than 95% of deaths occurred in developing countries. The number of new cases each year has decreased since 2000. About 80% of people in many

Asian and African countries test positive while 5–10% of people in the United States population tests positive by the tuberculin test. Tuberculosis has been present in humans since ancient times.

1.2.1 Signs and symptoms

Tuberculosis may infect any part of the body, but most commonly occurs in the lungs (known as pulmonary tuberculosis). Extra pulmonary TB occurs when tuberculosis develops outside of the lungs, although extra pulmonary TB may coexist with pulmonary TB.General signs and symptoms include fever, chills, night sweats, loss of appetite, weight loss, and fatigue. Significant nail clubbing may also occur.



Chest X-ray of a person with advanced tuberculosis: Infection in both lungs is marked by white arrow-heads, and the formation of a cavity is marked by black arrows.

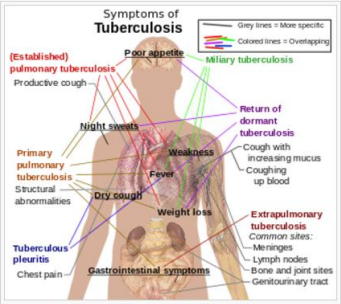
Fig 1.3 Chest X-Ray of person with advanced TB

1.2.2 Pulmonary

If a tuberculosis infection does become active, it most commonly involves the lungs (in about 90% of cases). Symptoms may include chest pain and a prolonged cough producing sputum. About 25% of people may not have any symptoms (i.e. they remain "asymptomatic"). Occasionally, people may cough up blood in small amounts, and in very rare cases, the infection may erode into the pulmonary artery or a Rasmussen's aneurysm, resulting in massive bleeding. Tuberculosis may become a chronic illness and cause extensive scarring in the upper lobes of the lungs. The upper lung lobes are more frequently affected by tuberculosis than the lower ones.

1.2.3 Extra pulmonary

In 15–20% of active cases, the infection spreads outside the lungs, causing other kinds of TB. These are collectively denoted as "extra pulmonary tuberculosis". Extra pulmonary TB occurs more commonly in immunosuppressed persons and young children. In those with HIV, this occurs in more than 50% of cases. Notable extra pulmonary infection sites include the pleura (in tuberculosis pleurisy), the central nervous system (in tuberculosis meningitis), the lymphatic system (in scrofula of the neck), the genitourinary system (in urogenital tuberculosis), and the bones and joints (in Pott disease of the spine), among others. When it spreads to the bones, it is also known as "osseous tuberculosis", a form of osteomyelitis. Sometimes, bursting of a tubercular abscess through skin results in tuberculosis ulcer. An ulcer originating from nearby infected lymph nodes is painless, slowly enlarging and has an appearance of "wash leather". A potentially more serious, widespread form of TB is called "disseminated tuberculosis", alsoknown as military tuberculosis. Military TB makes up about 10% of extra pulmonary cases.



The main symptoms of variants and stages of tuberculosis are given,[12] with many symptoms overlapping with other variants, while others are more (but not entirely) specific for certain variants. Multiple variants may be present simultaneously.

Fig 1.4 Symptoms of TB

1.3 CAUSES

1.3.1 Mycobacteria

The main cause of TB is Mycobacterium tuberculosis, a small, aerobic, nonmotile bacillus. The high lipid content of this pathogen accounts for many of its unique clinical characteristics. It divides every 16 to 20 hours, which is an extremely slow rate compared with other bacteria, which usually divide in less than an hour. Mycobacteria have an outer membrane lipid bilayer. If a Gram stain is performed, MTB either stains very weakly "Gram-positive" or does not retain dye as a result of the high lipid and mycolic acid content of its cell wall. MTB can withstand weak disinfectants and survive in a dry state for weeks. In nature, the bacterium can grow only within the cells of a host organism, but M. tuberculosis can be cultured in the laboratory.Using histological stains on expectorated samples from phlegm (also called "sputum"), scientists can identify MTB under a microscope. Since MTB retains certain stains even after being treated with acidic solution, it is classified as an acid-fast bacillus. The most common acid-fast staining techniques are the Ziehl–Neelsen stain and the Kinyoun stain, which dye acid-fastbacilli a bright red that stands out against a blue background. Auramine-rhodamine staining and fluorescence microscopy are also used.The M. tuberculosis complex (MTBC) includes four other TB-causing mycobacteria: M. bovis, M. Africanism, M. canetti, and M.

microti. M. africanum is not widespread, but it is a significant cause of tuberculosis in parts of Africa. M. bovis was once a common cause of tuberculosis, but the introduction of pasteurized milk has almost completely eliminated this as a public health problem in developed countries. M. canetti is rare and seems to be limited to the Horn of Africa, although a few cases have been seen in African emigrants. M. microti is also rare and is seen almost only in immune deficient people, although its prevalence may be significantly underestimated.Other known pathogenic mycobacteria include M. leprae, M. avium, and M. kansasii. The latter two species are classified as "non-tuberculosis mycobacteria" (NTM). NTM cause neither TB nor leprosy, but they do cause pulmonary diseases that resemble TB.

1.3.2 Risk factors

A number of factors make people more susceptible to TB infections. The most important risk factor globally is HIV; 13% of all people with TB are infected by the virus. This is a particular problem in sub-Saharan Africa, where rates of HIV are high. Of people without HIV who are infected with tuberculosis, about 5–10% develops active disease during their lifetimes; in contrast, 30% of those confected with HIV develop the active disease.Tuberculosis is closely linked to both overcrowding and malnutrition, making it one of the principal diseases of poverty. Those at high risk thus include: people who inject illicit drugs, inhabitants and employees of locales where vulnerable people gather (e.g. prisons and homeless shelters), medically underprivileged and resource-poor communities, high-risk ethnic minorities, children in close contact with high-risk category patients, and health-care providers serving these patients. Chronic lung disease is another significant risk factor. Silicosis increases the risk about 30-fold. Those who smoke cigarettes have nearly twice the risk of TB compared to nonsmokers.Other disease states can also increase the risk of developing tuberculosis. These include alcoholism and diabetes mellitus (three-fold increase).

1.4 DIAGNOSIS

1.4.1 Active tuberculosis

Diagnosing active tuberculosis based only on signs and symptoms is difficult, as is diagnosing the disease in those who are immunosuppressed. A diagnosis of TB should, however, be considered in those with signs of lung disease or constitutional symptoms lasting longer than two weeks. A chest X-ray and multiple sputum cultures for acid-fast bacilli are typically part of the initial evaluation. Interferon-γ release assays and tuberculin skin tests are of little use in the, developing world. IGRA have similar limitations in those with HIV.A definitive diagnosis of TB is made by identifying M. tuberculosis in a clinical sample (e.g., sputum, pus, or a tissue biopsy). However, the difficult culture process for this slow-growing organism can take two to six weeks for blood or sputum culture. Thus, treatment is often begun before cultures are confirmed.Nucleic acid amplification tests and adenosine deaminize testing may allow rapid diagnosis of TB. These tests, however, are not routinely recommended, as they rarely alter how a person is treated. Blood tests to detect antibodies are not specific or sensitive, so they are not recommended.

1.4.2 Latent tuberculosis

The Mantoux tuberculin skin test is often used to screen people at high risk for TB. Those who have been previously immunized may have a false-positive test result. The test may be falsely negative in those with sarcoidosis, Hodgkin's lymphoma, malnutrition, and most notably, active tuberculosis. Interferon gamma release assays (IGRAs), on a blood sample, are recommended in those who are positive to the Mantoux test. These are not affected by immunization or most environmental mycobacteria, so they generate fewer false-positive results. However, they are affected by M. szulgai, M. marinum, and M. kansasii. IGRAs may increase sensitivity when used in addition to the skin test, but may be less sensitive than the skin test when used alone.

II. SYSTEM DESIGN

The proposed system consists of a pre- processing stage, feature extraction, segmentation and classification. Fig 4.1 Architecture of the proposed system The image is first processed in order to extract the features, which describe its contents. Preprocessing involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. From the resulted image is give as input to feature extraction ,which is an important step in image processing. such as histogram of gradients, local binary patterns, lungs features are extracted Then the image is segmented using a k-neighbor algorithm for the extraction of lung regions from chest radiographs. Computer aidedDiagnosis is very much useful for detecting lung regions from chest X-rays. Finally, by feeding the segmented image to the input stage of the classifier. Fuzzy classifier was trained by using training datasets. The classifier predicted whether the image is normal or abnormal

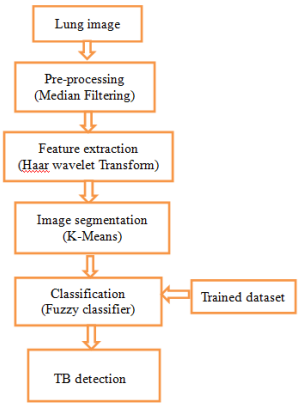


Fig 2.1 System Architecture

2.1 USECASE DIAGRAM

Use case diagrams overview the usage requirement for system. they are useful for presentations to management and/or project stakeholders, but for actual development you will find that use cases provide significantly more value because they describe "the meant" of the actual requirements. A use case describes a sequence of action that provides something of measurable value to an action and is drawn as a horizontal ellipse

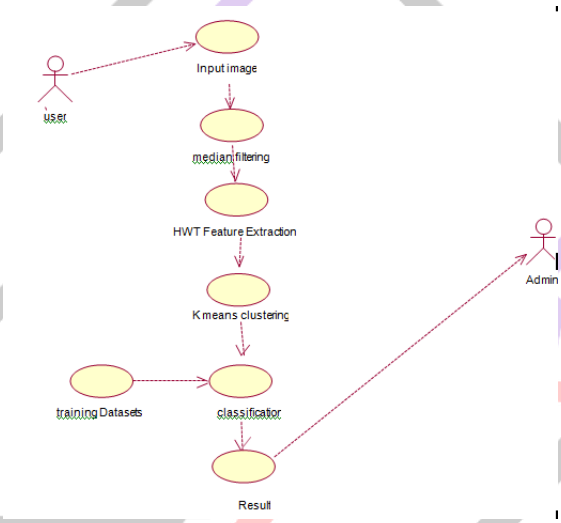


Fig 2.2 Use case diagram

2.2 ACTIVITY DIAGRAM:

Activity diagram is basically a flow chart to represent the flow form one activity to another activity. The activity can be described as an operation of the system. So the control flow is drawn from one operation to another. This flow can be sequential, branched or concurrent. It captures the dynamic behavior of the system. Other four diagrams are used to show the message flow from one object to another but activity diagram is used to show message flow from one activity to another. Activity is a particular operation of the system. Activity diagrams are not only used for visualizing dynamic nature of a system but they are also used to construct the executable system by using forward and reverse engineering techniques. So the purposes can be described as: (i) Draw the activity flow of a system.(ii) Describe the sequence from one activity to another. (iii) Describe the parallel, branched and concurrent flow of the system.So before drawing an activity diagram we should identify the following elements:Activities, Association, Conditions, Constraints

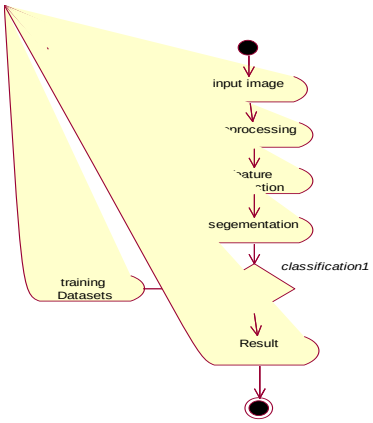


Fig 2.3 Activity diagram

2.3 COLLABORATION DIAGRAM

Another type of interaction diagram is the collaboration diagram. A collaboration diagram represents a collaboration, which is a set of objects related in a particular context, and interaction, which is a set of messages exchange among the objects within the collaboration to achieve a desired outcome.

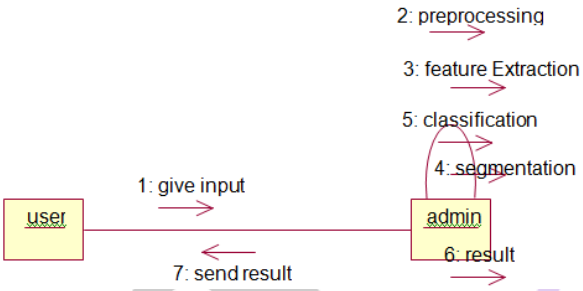


Fig 2.4 collaboration diagram

2.4 SEQUENCE DIAGRAM

Sequence diagram model the flow of logic within your system in a visual manner, enabling you both to document and validate your logic, and commonly used for both analysis and design purpose. Sequence diagram are the most popular UML artifact for dynamic modeling, which focuses on identifying the behavior within your system. All process of concern elements are done in single line with sequence on execution. A Sequence diagram is an interaction diagram that shows how objects operate with one another and in what order. It is a construct of a message sequence chart.A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios

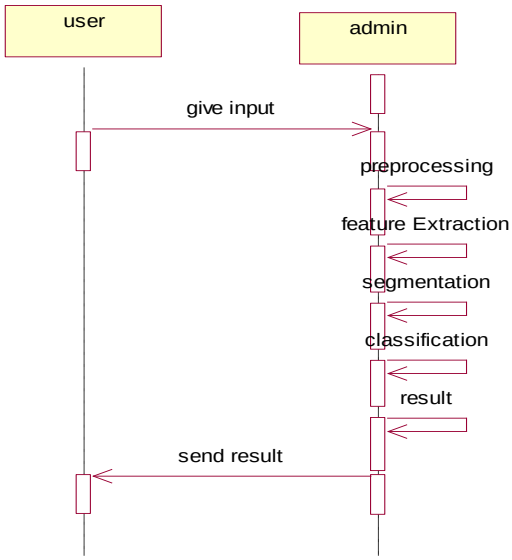


Fig 2.5 sequence diagram

III. IMPLEMENTATION AND TESTING

3.1 PRE-PROCESSSING

Pre-processing is a common name for operations with images at the lowest level of abstraction both input and output are intensity images. These iconic images are of the same kind as the original data captured by the sensor, with an intensity image usually represented by a matrix of image function values (brightness's). The aim of pre-processing is an improvement of the image data that suppresses unwilling distortions or enhances some image features important for further processing, although geometric transformations of images (e.g. rotation, scaling, and translation) are classified among pre-processing methods here since similar techniques are used.

3.2MEDIAN FILTER

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise (but see discussion below).

3.3ALGORITHM DESCRIPTION

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signals, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as "box" or "cross" patterns). Note that if the window has an odd number of entries, then the median is simple to define: it is just the middle value after all the entries in the window are sorted numerically. For an even number of entries, there is more than one possible median

3.4WORKED 1D EXAMPLE

To demonstrate, using a window size of three with one entry immediately preceding and following each entry, a median filter will be applied to the following simple 1D signal:

x = [2 80 6 3]
So, the median filtered output signal y will be:
y[1] = Median[2 2 80] = 2
y[2] = Median[2 80 6] = Median[2 6 80] = 6
y[3] = Median[80 6 3] = Median[3 6 80] = 6
y[4] = Median[6 3 3] = Median[3 3 6] = 3
i.e. y = [2 6 6 3].

3.5Boundary issues

Note that, in the example above, because there is no entry preceding the first value, the first value is repeated, as with the last value, to obtain enough entries to fill the window. This is one way of handling missing window entries at the boundaries of the signal, but there are other schemes that have different properties that might be preferred in particular circumstances: (i) Avoid processing the boundaries, with or without cropping the signal or image boundary afterwards, (ii)Fetching entries from other places in the signal. With images for example, entries from the far horizontal or vertical boundary might be selected, (iii)Shrinking the window near the boundaries, so that every window is full.

3.62D MEDIAN FILTER PSEUDO CODE

Code for a simple 2D median filter algorithm might look like this:

```
allocateoutputPixelValue[image width][image height
allocate window[window width * window height]
edgex := (window width / 2) rounded down
edgey := (window height / 2) rounded down
for x from edgex to image width - edgex
for y from edgey to image height - edgey
  i = 0
forfx from 0 to window width
forfy from 0 to window height
window[i] := inputPixelValue[x + fx - edgex][y + fy - edgey]
i := i + 1 sort entries in window[]
outputPixelValue[x][y] := window[window width * window height / 2]
```

Note that this algorithm:

Processes one color channel only,

Takes the "not processing boundaries" approach (see above discussion about boundary issues).

3.7Algorithm implementation issues

Typically, by far the majority of the computational effort and time is spent on calculating the median of each window. Because the filter must process every entry in the signal, for large signals such as images, the efficiency of this median calculation is a critical factor in determining how fast the algorithm can run. The "vanilla" implementation described above sorts every entry in the window to find the median; however, since only the middle value in a list of numbers is required, selection algorithms can be much more efficient. Furthermore, some types of signals (very often the case for images) use whole number representations: in these cases, histogram medians can be far more efficient because it is simple to update the histogram from window to window, and finding the median of a histogram is not particularly onerous.

3.8Edge preservation properties

Median filtering is one kind of smoothing technique, as is linear Gaussian filtering. All smoothing techniques are effective at removing noise in smooth patches or smooth regions of a signal, but adversely affect edges. Often though, at the same time as reducing the noise in a signal, it is important to preserve the edges. Edges are of critical importance to the visual appearance of images. For example, small to moderate levels of (Gaussian) noise, the median filter is demonstrably better than Gaussian blur at removing noise which preserving edges for a given, fixed window size.

However, its performance is not that much better than Gaussian blur for high levels of noise, whereas, for speckle noise and salt and pepper noise (impulsive noise), it is particularly effective. Because of this, median filtering is very widely used in digital image processing.

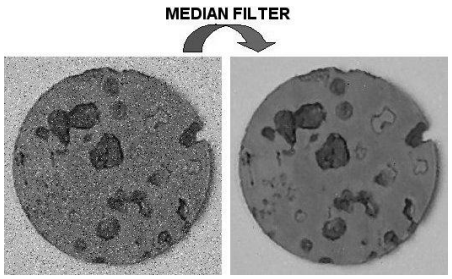


Figure : 3.1 Noise removal-median filter

3.9Analysis of the Two-Dimensional HWT

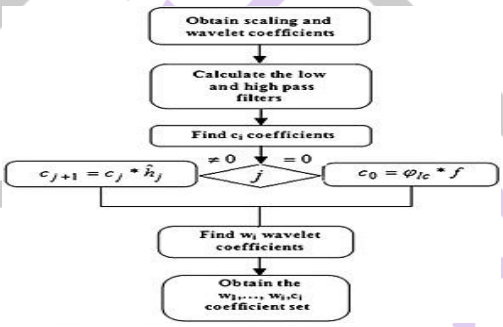
You can see why the wavelet transformation is well-suited for image compression. The two-dimensional HWT of the image has most of the energy conserved in the upper left-hand corner of the transform - the remaining three-quarters of

the HWT consists primarily of values that are zero or near zero. The transformation is local as well - it turns out any element of the HWT is constructed from only four elements of the original input image.
Suppose that the input image is square so we will drop the subscripts that indicate the dimension of the HWT matrix. If we use H to denote the top block of the HWT matrix and G to denote the bottom block of the HWT, we can express the transformation as:

$$B = WAW^T = \begin{bmatrix} H \\ G \end{bmatrix} A \begin{bmatrix} H \\ G \end{bmatrix}^T = \begin{bmatrix} H \\ G \end{bmatrix} A \begin{bmatrix} H^T \\ G^T \end{bmatrix} = \begin{bmatrix} HA \\ GA \end{bmatrix} \begin{bmatrix} H^T \\ G^T \end{bmatrix} = \begin{bmatrix} HAH^T & HAG^T \\ GAH^T & GAG^T \end{bmatrix}$$

We now see why there are four blocks in the wavelet transform.Let's look at each block individually. Note that the matrix H is constructed from the low pass Haar filter and computes weighted averages while G computes weighted differences. The upper left-hand block is HAHT - HA averages columns of A and the rows of this product are averaged by multiplication with HT. Thus the upper left-hand corner is an approximation of the entire image. In fact, it can be shown that elements in the upper left-hand corner of the HWT can be constructed by computing weighted averages of each 2 x 2 block of the inputmatrix.

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \rightarrow 2 \cdot (a + b + c + d)/4$$



Algorithm
Step1. Read image.
Step2. Image resize to all image in database.
Step3. Decompose color image using Haar DWT at 1st level to get app. coefficient and culpa detail coefficients.
Step4. Assign the weights 0.003 to approximate coefficients.
Step5. Convert the approximate coefficient image in to HSV plane.
Step6. Color quantization is carried out using color histogram by assigning 18 bins to hue, and 3 bins to saturation and 4 bins to value to give a quantized HSV space with 18+3+4=25 histogram bins.S
Step7. Repeat step1 to step6 on an image in the database.
Step8. Calculate the similarity matrix of query image and the image present in the database.
Step9. Repeat the steps from 7 to 8 for all the images in the database.
Step10. Retrieve the images.

IV. CONCLUSION

We have developed an automated system that screens CXRs for manifestations of TB in individuals. We present an input image from which features are extracted and lung region are segmented the X-ray and then using fuzzy classifier we get TB positive or negative case. We have applied our algorithm on many images and found that it successfully detect the TB with performance closer to human performance Therefore the proposed system ic very much useful for medical experts to diagnose tuberculosis with much accuracy of 95% using the chest X-rays.

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