Implementation of Algorithm to Detect the Diseases in Fruit Using Image Processing Technique

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Abstract:

In ancient time, the method of detecting and studying of any fruit infections or diseases were done by naked eyes, which is always not suitable for eyes to detect them accurately. The fruits show the gesticulation by changing their color .it can be from the natural, showing the different spots on the fruit like black spots or dark brown spots. The recognition of the infection is finished physically by observing and detecting the pathogens, are which is generally take more time and is also much costly with lower accuracy. So, in order to overcome that there is best choice which is very speedy and errorless diagnosis by using some techniques in MATLAB which are more dependable than some other old techniques. We can see the symptoms of infections or diseases on the different parts of the fruits in the plant, leaf, lesions. The aim of this article is to detect and identify the disease accurately from the image. The things need in the process is image segmentation, pre-processing, feature extraction and identification. The infection considered is viral fungal, bacterial or disease by insects and by climate. Here we are going to detect the disease on the fruits. For identification of particular disease we are going to use features of fruit such as their axis including major axis, minor axis etcetera is extracted from fruit image and by classification techniques we can identify the infection.

INTRODUCTION:

India is developing nation. In this advancement contribution of agricultural field is major. Keen cultivating is tied in with engaging the present ranchers with the choice instruments and automation advances that consistently coordinates items, learning and administration for better efficiency, quality and benefit. In this cutting edge age another ideas of shrewd cultivating has been presented Where the field condition are controlled and checked utilizing oneself working frameworks as opposed to utilizing the customary strategies, for example ,traditional methods such as different image processing methods. Indeed, even in the wake of paying a singular amount sum clients are disappointed with the items they purchase. One of such items is the fruits and vegetables. To a human eye may seem healthy and fresh yet simply in the wake of cutting or eating it, the clients know its quality. This likewise influences the benefit for the makers. Along these lines, there is need applications which distinguish the quality, deformities of fruits and vegetables so that the clients get just the best quality item for the cash they pay. The quality, imperfections of fruits are checked utilizing innovations like MRI, x-ray imaging etc which are exorbitant for farmers to bear, consume extensive space, clients need to scientific knowledge to utilize and analyze the outcomes, and have harmful affect on the specimen used for research and the established methodology for detection and identification of fruit diseases depends on the stripped eye perception by the specialists. In some developing nation, consulting specialists are costly and tedious because of the far areas of their accessibility. In this way, they cannot be utilized by everybody and on every single item. Some disease likewise taints different zones of the tree causing disease of twigs, leaves, and branches. Every disease happening in fruits makes a specific surface or explicit shaded spot. We can utilize these highlights for identification of disease in the fruit. Fruit disease detection requires enormous measure of work, knowledge in the fruit disease.

For instance some common disease of apple fruits is apple scab, apple rot and apple blotch. Presently multi day is in all fields innovation assumes fundamental job yet till today we are utilizing some old strategies in farming. In the event that infection is wrongly recognized it will prompts lost yield, time, creation and money. Programmed recognition of fruit diseases is fundamental to consequently distinguish the indication of diseases as right on time as they show up on the developing fruits. This framework recognizes the disease of fruits easily. By utilizing this framework we can dodge the economical loss of farmers. For identification of disease we can utilize image processing techniques for more accuracy, less time prerequisite and better execution. A few systems have secured apple, mango and grapes and so forth. There are such a significant number of fruits as yet remaining that are traded from India and give more benefit to the farmers should be secured under automatic fruits disease identification system.

MATLAB SUMMARY:

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

MATLAB is a commercial "Matrix Laboratory" package which operates as an interactive programming environment. It is a mainstay of the Mathematics Department software lineup and is also available for PC's and Macintoshes and may be

found on the CIRCA VAX's. Mat lab is well adapted to numerical experiments since the underlying algorithms for Mat lab's built-in functions and supplied m-files are based on the standard libraries LINPACK and EISPACK .MATLAB program and script files always have filenames ending with ".m"; the programming language is exceptionally straightforward since almost every data object is assumed to be an array. Graphical output is available to supplement numerical results.

RELATED WORK:

In farming the main and hard area is cultivation of fruits and vegetables. Work already done toward masterly optimality in terms of manufacture and standard, Image processing in MATLAB is one of the things which are widely used in order to find diseases present in the image of fruit. In most of the case, image processing techniques is unite with machine learning process to increase the performance of detection. Also we can see the work has been already developed to include rice crop. The identification of problem in rice crop is achieved for this we use pre-processing, segmentation, extraction etc. [11]

The main hard thing is to monitor condition of fruit by physically. So using artificial neural network we can construct the techniques to detect diseases in the fruit.

If we can detect the disease in early stages then we can cure the affected fruit. Detection of diseases in fruit data mining capability is used.

Image processing techniques also need, Automatic approach which is going to help to boost up the work by finding the problems existing within the fruit. With the help of optimization tool we can detect the infection at early stage and it will help in fix the fruit.

Diseases spread in human body from the fruit which after contain the infection so, infection in fruit is main thing of diseases in human body through fruit, which is grow extremely very fast. Apple fruit is common for cause the diseases. Large amount of work is already done in this area. To filter out the information generated, we going to use k means clustering technique and then distortion is detected. Local binary pattern mechanism is available in image processing toolbox which is utilized for this purpose. [12]

FRUIT DISEASES:

(a) Apple Scab:

This apple infection causes most devastating from all infections. Apple-growing areas are affected by this type infection. Apple scab is more severe when its bloom time in cool and wet weather but in significant dry or warm climates it is not reasonably. Leaves, petals, flowers, husk, fruit, young shoots and bud scales of apple tree shows the symptom of apple scab. The common and obvious infection is on fruit and leaves. Appropriate temperatures and moisture increase the release of v.Inaequalisascospores in fruit. This rotation of

secondary disease continues throughout the summer, until the leaves and fruit fall from the tree at the onset of winter. [10]

Fig.1 apple scab [26]

(b) Bitter Rot:

Botryosphaeriaobtusa named fungus causes the bitter rot in fruit. The leaves, bark and fruits of apple tree are main part where its affect. After the 1 to 3 weeks the first symptoms of apple rot appears on outer surfaces of leaves, petiole fall as small, purple blotch after which center turn brown tan and yellowish brown. After that second stage of apple rot occurs after few weeks. In this stage secondary enlargement of leaf spots occurs. Leaf fall from the tree which are highly affected by this diseases.[10]

Fig.2 bitter rot[27]

(c) Black Rot:

This problem is caused by an infection that spread on many woody plants and trees and its bacteria are spread by wind. Leaves may have many big brown marks that start round and become patches as they grow together. The spots are dry and like paper. Spots on fruit may appear any time during the season and infected fruit rot and hang on the tree. The fungus also causes cankers on branches.[10]

Fig.3 black rot[28]

(d) Apple Blotch:

It is most common "summer disease" of apples in the northwest. Apple blotch is caused due to two different organisms. The cruel result of this infection is economical failure and commercial quality harm. Dark greenish-blue spots on the surface of infected fruit are signs of disease. One to many nearly circular colonies are developed individually. These signs occur three to four weeks after once leaflet falls. [10]

Fig.4 apple blotch [29]

(e) Scooty Blotch:

On surface of the fruit brown to dull black color, sooty blotches with an indefinite outline are singing of this infection. Blotches are ¼ inch in diameter or may be larger. The hole fruit is cover by the blotches practically. Thepycnidia on host plants build many numbers of spores that come out of disease and collect in a sticky mass. [10]

Fig.5 scooty blotch[30]

(f) Bacterial Blight:

In the year 1952, it was first recorded in Delhi .till 1998 bacterial blight was take as a low economic threat. But now-a-days this infection record widely and has been seen everywhere. This infection arises in all pomegranate-growing states like maharashtra, karnataka, and andhra pradesh. Sepals, twigs and pomegranate are infected by bacterial blight. Mainly signs for the infection can be black colored spots covered by bacterial slime. 90% yield of pomegranate depletes because of bacterial blight. Due to this type of disease fruit crack.[6]

Fig.6 bacterial blight[31]

(g) Aspergillus Fruit Rot:

Alias of alternaria fruit rot. Infection spared in internal part of fruit when it's open in rainy season. Small change in color of skin and low weight due to internal decay are some of the signs of disease. But this infection usually is not appeared until harvesting or during fruit sorting. Without any external signs of fungus may be growing inside the fruit. Most of the time, infected fruit show small yellowish to brownish-red discoloration and are small off-color such as a pale red.[6]

Fig.7 aspergillus fruit rot [32]

(h) Gray Mold:

Gray mold is also known as botrytis cinetea. During the time of post-harvest wash and spread and kept in room temperature this infection is more effective and frequently seen. Flower part of fruit take damage in gray mold infection and affects the crop until its ripening. When the fruit is washed or stored in high humidity, condensation or water on the blossom tissues activates the fungal mycelium to begin growing. The typical grayish coating of spores and pathogen sporulats on the flower parts are developed. Eventually the fungus will spread out inside fruit tissue the crown tissue will be occupied. We have to store defected fruit in high moisture.[6]

Fig.8 gray mold[33]

STUDY OF TECHNIQUES USED TO ANALYZE DISEASES IN FRUITS :

Techniques of image processing are utilized in order to detect the diseases at early stage. These techniques are described as under

(a) Image Pre-Processing:

In MATLAB, image pre processing means to prepared the image for the upcoming operation, for example if we want to do some specified task like tracking targets, recognition, detection than we have to do image pre processing .its contain adjust the size of image, filtration of noise in image etc .in our case the detection of diseases in fruit is we have to look each fruit for that image is capture and analyze by image pre processing toolbox. For the analyzing of real time problem we use image pre processing technique. [12]

(b) Feature Extraction:

Feature extraction use when the image size is too large and we want to focus on particular part of that image. Its extract the details only of that part. How this will help in our case?

If we want to differentiation fruit feature extraction used, It will detect the common parts of the fruit and extract the feature of that part and then using clusters we can remove unwanted part to reduce the complexity of the process.[14]

(c) Image Denoising:

Every image has its own noise there is no image without small amount of noise because of noise image is corrupt and cannot use of processing ,we can use but the result is not accurate. Noise in image is due to medium in which its transmitted and other one is unauthorized access. Noise are divided in three types.[16]

Salt and pepper

This type of noise is occurred suddenly in image signal .its contain group of black and white pixels. The value of pixels are go up to 255 or 0, it will give a spikes in our result so analyze the image is very difficult with salt and pepper noise.

(d) Gaussian Noise:

We can lose the detail information of the image because of the Gaussian noise. Image lost its celerity because of this type of noise. The results of this noise is images become blurry, transmission medium cause this noise.[17]

(e) Shot Noise:

Shot noise is upgraded version of salt and pepper noise, in this the spike is within image. To resolve this problem we use filtering process. The certain level is decided by the median filter for pixels, shot noise produce the problem related to

information of the image, there is also some mechanisms like diverse filtering system for smoothing the image. [18]

(f) Median Filter:

This type of filter is mainly use for salt and pepper type of noise. The certain level is decided by the median filter for pixels its control the value of pixel not exceeds from threshold value. The modified version of median filter is use for salt and pepper noise. This filter is mainly and widely use because it's in no linear type filter and its complexity level is also low because of that characteristics we can control sap noise at its starting level and there is also one different version for hardware implementation. [19]

(g) Mean Filter:

The parameter form we can tell that this image is fine or acceptable for processing is the quality, if the quality is not proper than we cannot process that image. To solve the poor quality of image, Image enhancement strategy is used and it's from mean filter if we have high spike noise than we can use mean filter to resolve this.

The total sum of the neighbour pixel is used to remove the noise of that pixel and enhance. Nonlinear filter is for this process and mean filter help with that. We cannot say that mean filter is resolve our noise problem for that we can use fuzzy techniques with mean filter that one know as fuzzy mean filter. [20]

(h) Contrast Enhancement Schemes:

When we consider the image processing with medical images quality of that image is main parameter consider is quality of image if quality is poor than results maybe danger. Main reason for degrade the quality is medium and temperature. We all know that image is in binary format is computer system than at the time of transmission bit are corrupted, so to solve this problem this techniques is used.

With the help of equalization of histogram we can enhance the contrast of input image; if we can improve the contrast of the input image then information can be easily read. [21-23]

(i) Particle Filter:

Partial filter can handle the unusual blur of the image .segment of image have the noise so we have to remove that noise using novel approach. Image is smoothening by partial filter. Image of compression and complexity reduce by partial filter. To transfer the image less bandwidth is used.

When we work on partial filter process SVD approach is used. We can exactly detect the disease in the fruit using the filtering process and enhancement techniques in image processing.[25]
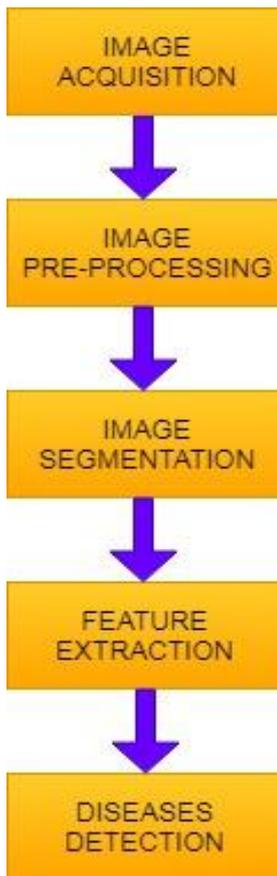
METHODOLOGY:

Fig.9 block diagram

Digital camera image:

We can get input image using digital camera. Digital camera can get colour RGB image and every image is of same size. In this algorithm we obtain four colour image of infected fruit.

Image pre-processing:

The image restoring process is also known as image pre processing. It's done before the main processing is starting to prepare the image for testing. Image threshold technique is also including in this process .in that back ground and for ground is separate from image.

Image pre processing also include below process,

Filtering image:

To remove noise in image filtration is used such as high pass and low pass filter or median filter.

Crop image:

To remove unwanted background and make image more clean and free.

Resize image:

To define size of image as we need in process. We can make image as small as we need to reduce the process speed, we can also make image fit to screen also.

Segmentation:

We can see that image segmentation is also useful in medical image processing not alone in satellite image processing and also in computer vision. And segmentation is very wide, open and active region. The use of image segmentation is that we can divide image into multiple parts and use particular region for specific work. We can use different method to do segmentation there is many types to do; methods can be used depends on the problem, which type of result we want that type of methods can be used. In image processing the first step of image detection, explanation and categorization is segmentation.

There are two major approaches region based methods in which similarities are detected and other is boundary based methods in which discontinuities are detected and linked to from boundaries around regions

Mainly image contain multiple parts. With the help of segmentation we can differ that parts and its help to study in detail. We can divide image in multiple parts until we get desire part, but when we add all the segmented part we should get the original input image .here we use colour based segmentation in this we divide the image based on colour. After this gray scale and black and white conversion is applied.

Morphological Image Processing:

In image processing morphology is a tool to differentiate or improve image information .for examination of binary image we can use morphological operator like erosion and dilation, not just for binary image also it can be useful for gray scale image. Morphological operators are non linear. Its have common usages includes filtering, edge detection ,feature detection ,counting objects in an image ,image segmentation ,noise reduction and finding the mid-line of an object.

The field of mathematical contributes a wide range of operates to image processing all based around a few simple mathematical concepts from set theory and in the case of binary image logic operations such as "and" ,"or" ,"xor" and "not".

K mean segmentation:

K means cluster is use for colour based image segmentation. When we done k means clustering we get number of different types of cluster and from that we have to choose only one cluster which contain affected part , in our case affected part is also known as ROI(region of interest).

We can get affected part using k means clustering method.

The input image is converted in to l*a*b colour space from RGB. In l*a*b colour space l layer is known as luminosity layer, a, b layer is known as chromaticity-layer. 'A*' and 'b*' layer contain all of the colour information.

Feature extraction:

To understand the whole image we have to extract the feature than we can understand the true meaning of image.

Many researchers say that texture is most important thing to detect the fruit area. With the help of boundary based segmentation the shape of fruit is defined. For brightness and intensity we can go for colour of fruit. In region our case have different cluster from them we choose the part which contain brown, black colour affected parts. Using edge detection we can differentiate affected parts from non affected parts of fruit. The edge detection is done by many methods such as sobel, canny, prewitt, roberts and log. Here, in this algorithm we use the sobel .

Disease detection:

With the help of total area and affected area we can find the total affected area in percentage and divide in three parts slight ,moderate, highly affected. For that equation we us is:

$$\text{Total affected area} = \frac{\text{area of disease detected in image}}{\text{area of the leaf image}} \times 100$$

TEST RESULT AND DISCUSSION:

Below image is apple fruit take as input image.

Fig.10 input image

Then the image of fruit which we take as an input image is segmented and resized by some function. After that using the function the contrast of image is enhanced and display as contrast enhanced image.
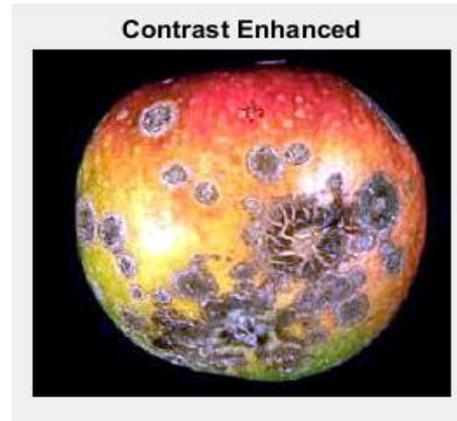
Fig.11 contrast enhanced

After that k mean clustering is applied on enhanced image. K-means cluster technique is used to divide the image in number of parts and after that we have to choose the appropriate part from that with the help of this technique we can detect exact part from whole image.
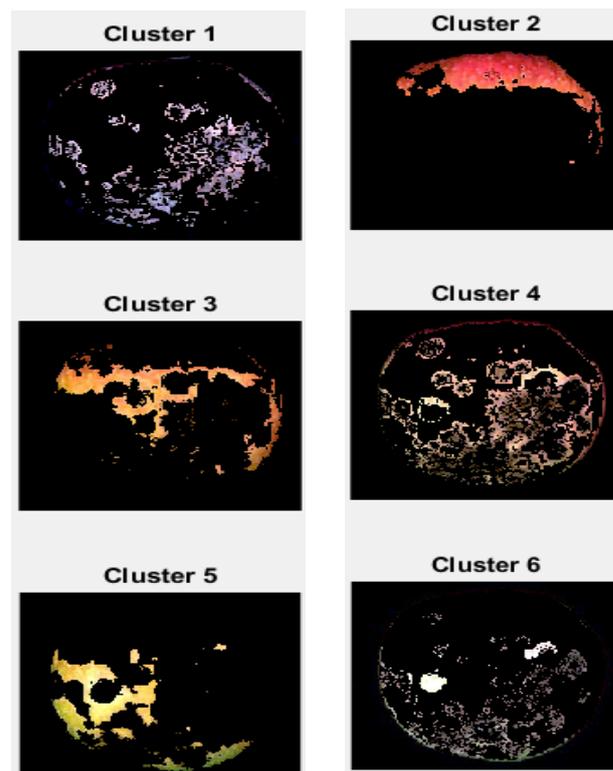
Fig.12 clusters

From the number of cluster we select the cluster which contain region of interest (ROI) .ROI means area which contain disease.

Next part is to convert the image in gray scale form RGB. And display as gray scale image.

Fig.13 gray scale image
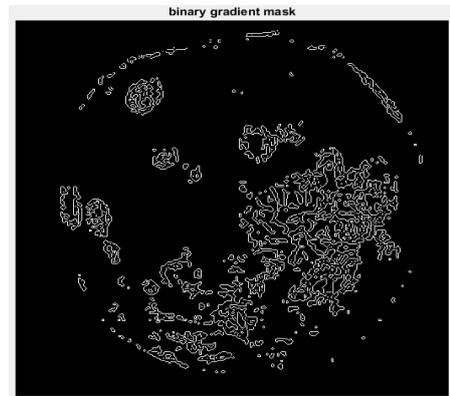
After the conversion of rgb image into gray ,image converted in black and white image and display as below.
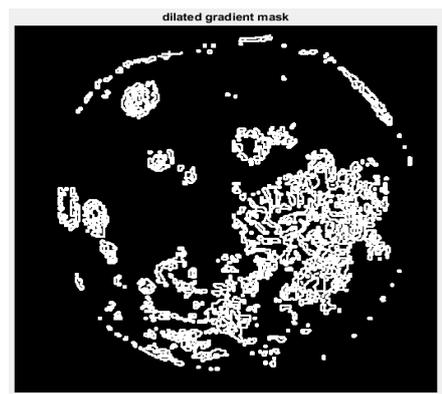

Fig.14 black and white image

Below figure show us the detected part of diseases from black and white image.

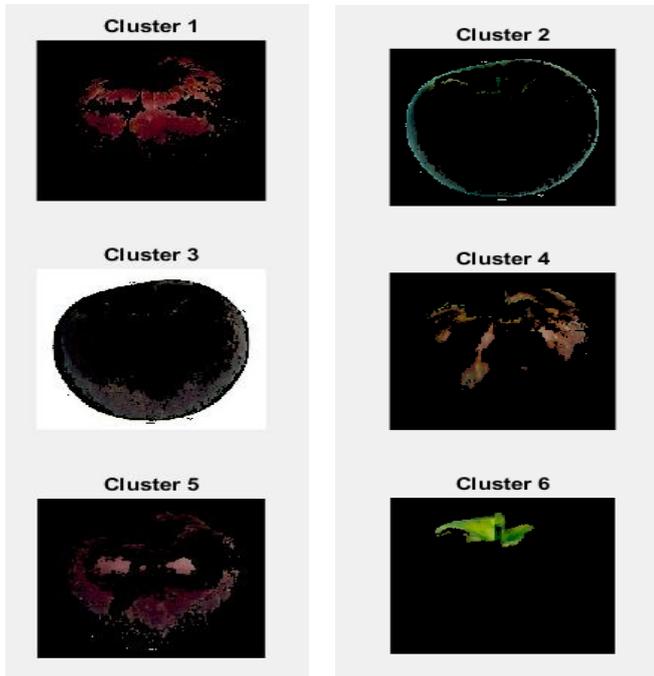**Fig.15** diseases extracted image

To study the image more comfortably we use different different mask ,first we apply gradient mask and after that delighted gradient mask .

Here the nexfigure show us binary gradient mask.

Fig.16 binary gradient mask

Here the next figure show us dilated gradient mask.

Fig.17 dilated gradient mask
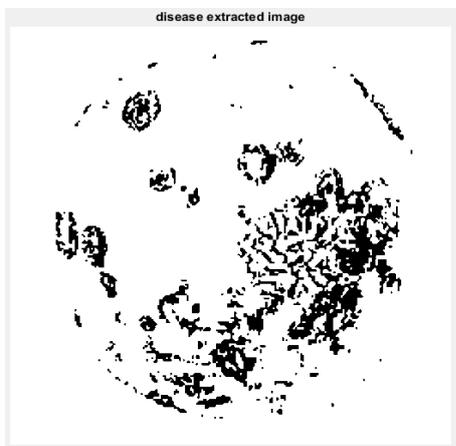
After that we use morphological function first step is erosion which is followed by dilation and after that reverse dilation.

The next figure shows us morphological opening performed on the diseases extracted image.
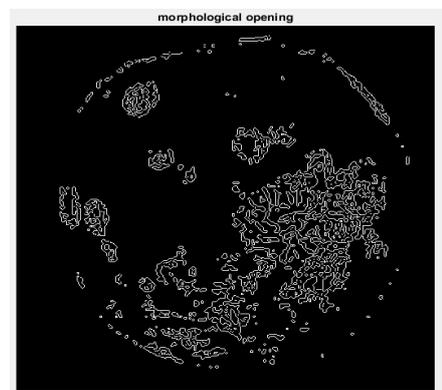
Fig.18 morphological opening

The next figure shows us morphological closing performed on morphological opening image.
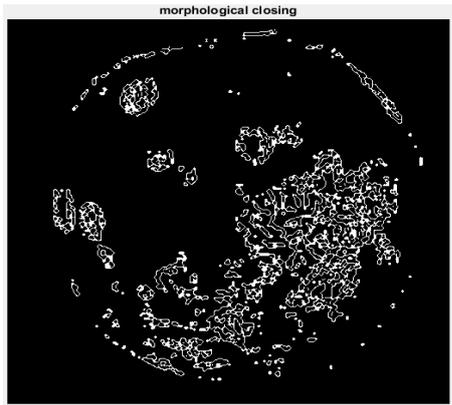
Fig.19 morphological closing

Below figure show red and green lines in which green line show the boundry of region and red line show defected part of the fruit.
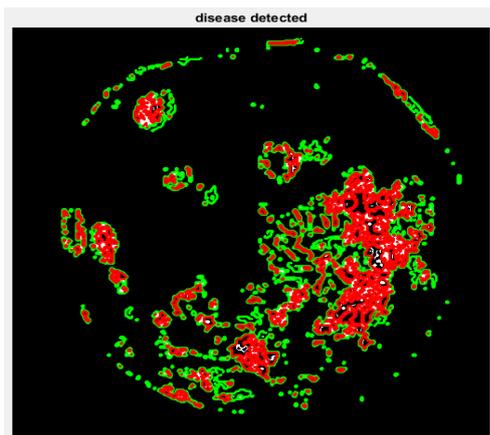
Fig.20 diseases detected

We divided diseases in three part slightly ,moderat,highly afftected .with the help of percentages we find , we can easly assign the part.

Below figure show us result of input image.
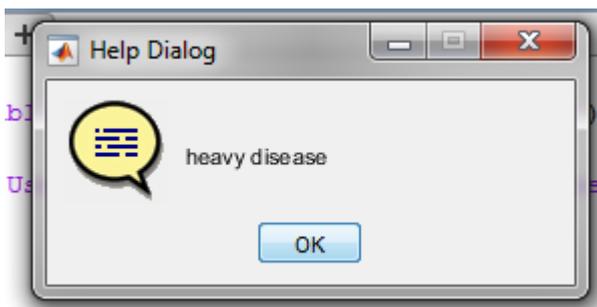
Fig.21 dialog box

In the command window we can see the percentages of the input image.
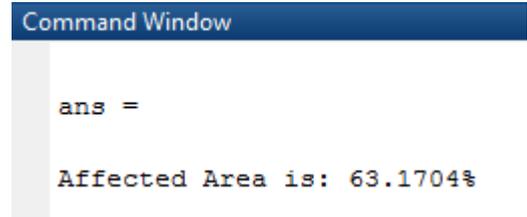
Fig.22 percentage of diseases

2)below image is apple fruit take as input image.
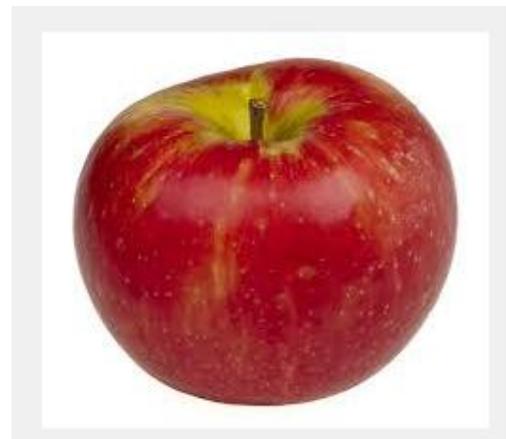
Fig.23 input image

Then the image of fruit which we take as an input image is segmented and resized by some function. After that using the function the contrast of image is enhanced and display as contrast enhanced image.
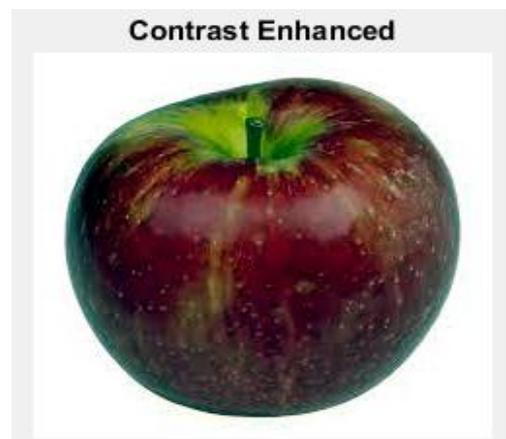
Fig.24 contrast enhanced image

After that k mean clustering is applied on enhanced image. K-means cluster technique is used to divided the image in number of parts and after that we have to choose the appropriate part from that with the help of this technique we can detect exact part from hole image.

Fig.25 clusters

From the number of cluster we select the cluster which contain region of interest (ROI). ROI means area which contains disease.

Next part is to convert the image in gray scale form RGB. And display as gray scale image.
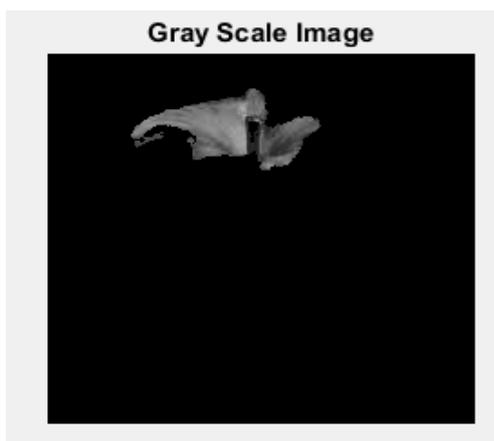
Fig.26 gray scale image

After the conversion of RGB image into gray, image converted in black and white image and display as below.
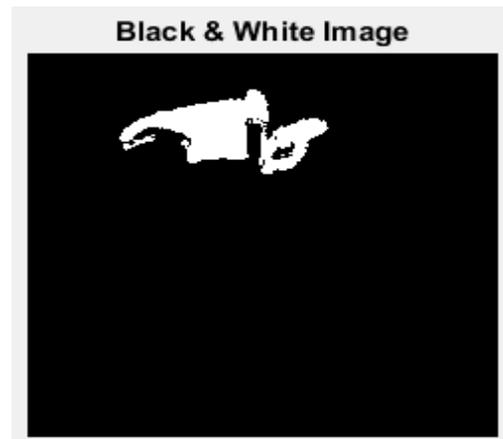
Fig.27 black and white image

Below figure show us the detected part of diseases from black and white image**.**

Fig.28 diseases extracted image

To study the image more comfortably we use different different mask ,first we apply gradient mask and after that delighted gradient mask here the nexfigure show us binary gradient mask.
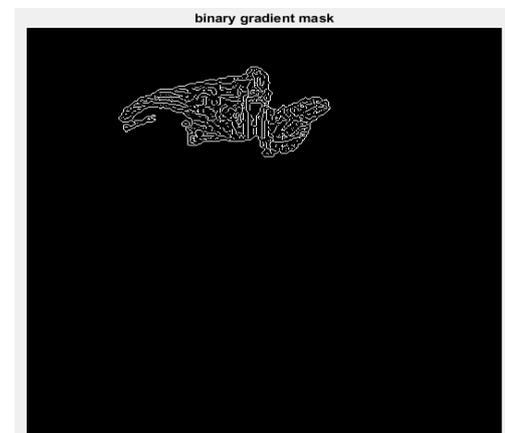

Fig.29 binary gradient mask

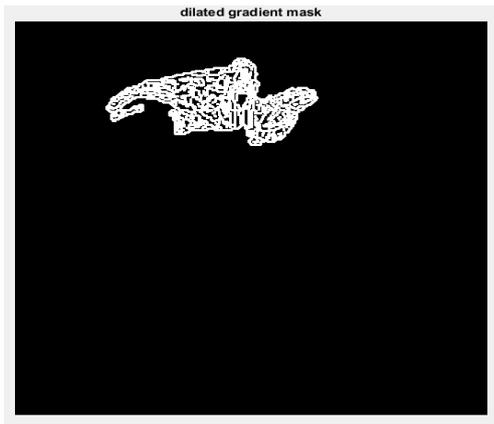Here the next figure show us dilated gradient mask.

Fig.30 dilated gradient mask

After that we use morphological function first step is erosion which is followed by dilation and after that reverse dilation.

The next figure shows us morphological opening performed on the diseases extracted image.
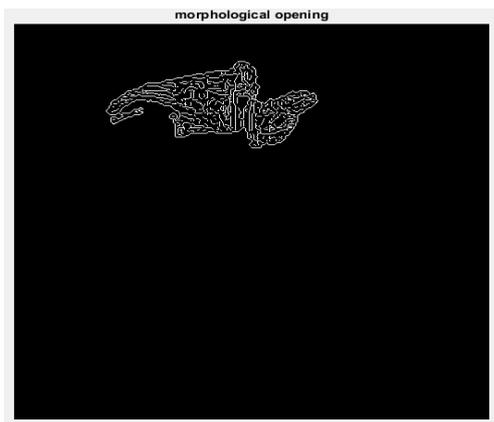

Fig.31 morphological opening

The next figure shows us morphological closing performed on morphological opening image.

Fig.32 morphological closing

Below figure show red and green lines in which green line show the boundary of region and red line show defected part of the fruit.

Fig.33 diseases detected image

We divided diseases in three parts slightly, moderate, highly affected .with the help of percentages we find, we can easily assign the part.
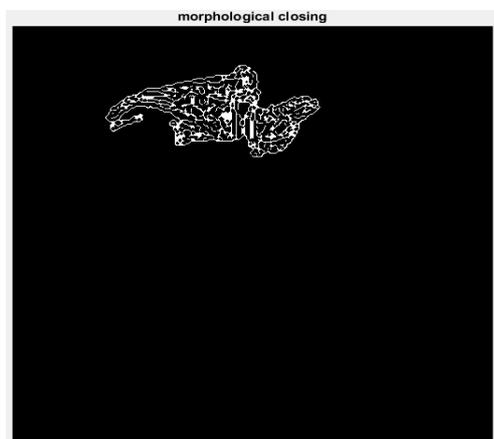
Below figure show us result of input image.

Fig.34 dialog box

In the command window we can see the percentages of the input image.
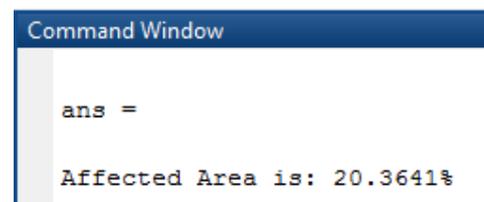

Fig.35 percentage of diseases

3) below image is apple fruit take as input image.

Figure.36 input image

Then the image of fruit which we take as an input image is segmented and resized by some function. After that using the function the contrast of image is enhanced and display as contrast enhanced image.

Fig.37 contrast enhanced
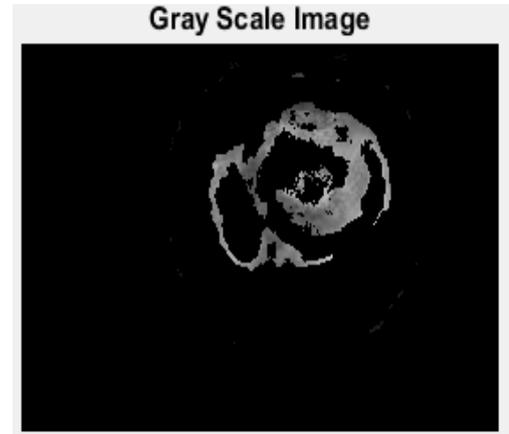
After that k mean clustering is applied on enhanced image. K-means cluster technique is used to divide the image in number of parts and after that we have to choose the appropriate part from that with the help of this technique we can detect exact part from whole image**.**
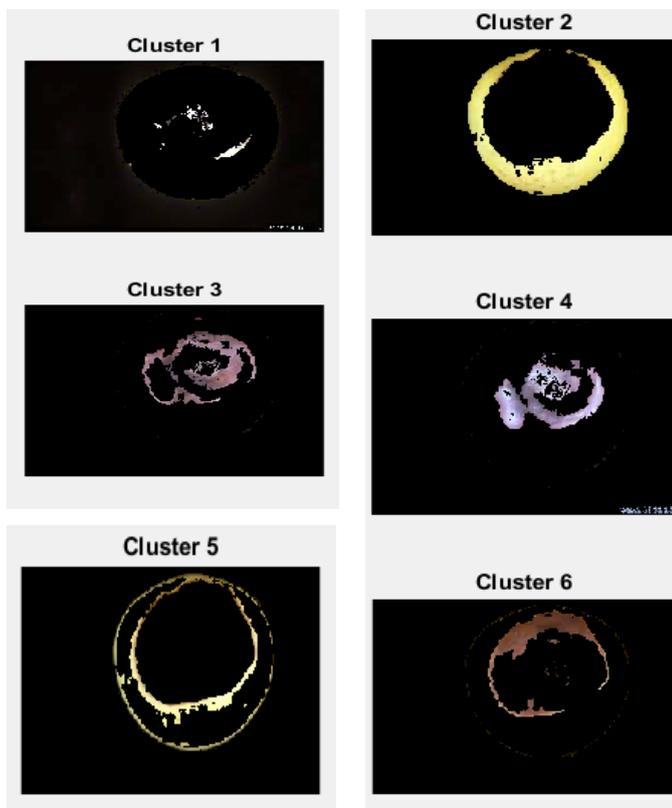

Fig.38 clusters

From the number of cluster we select the cluster which contain region of interest (ROI) .ROI means area which contain disease.

Next part is to convert the image in gray scale form RGB. And display as gray scale image.

Fig.39 gray scale image

After the conversion of RGB image into gray, image converted in black and white image and display as below.
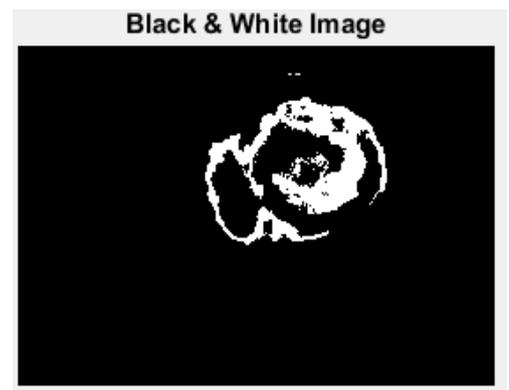

Fig.40 black and white image

Below figure show us the detected part of diseases from black and white image.

Fig,41 diseases extracted image

To study the image more comfortably we use different different mask, first we apply gradient mask and after that delighted gradient mask here the next figure show us binary gradient mask.
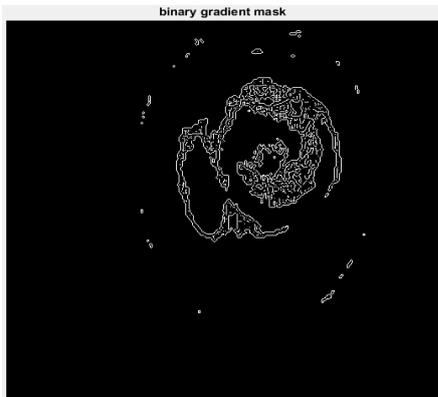

Fig.42 binary gradient mask
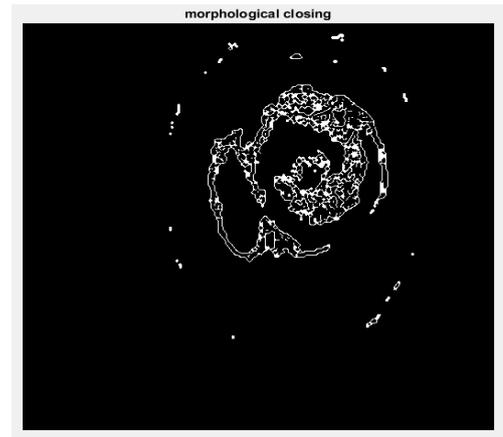
Here the next figure show us dilated gradient mask.

Fig.43 dilated gradient mask

After that we use morphological function first step is erosion which is followed by dilation and after that reverse dilation. the next figure shows us morphological opening performed on the diseases extracted image**.**

Fig.44 morphological opening

The next figure shows us morphological closing performed on morphological opening image.

Fig.45 morphological closing

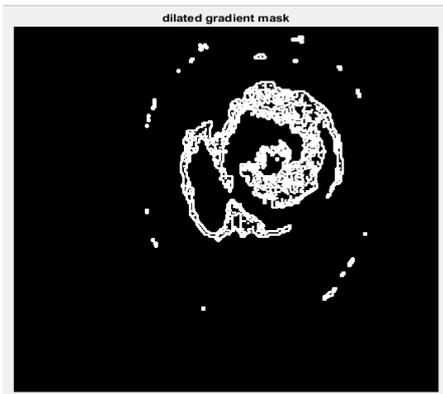Below figure show red and green lines in which green line show the boundary of region and red line show defected part of the fruit**.**
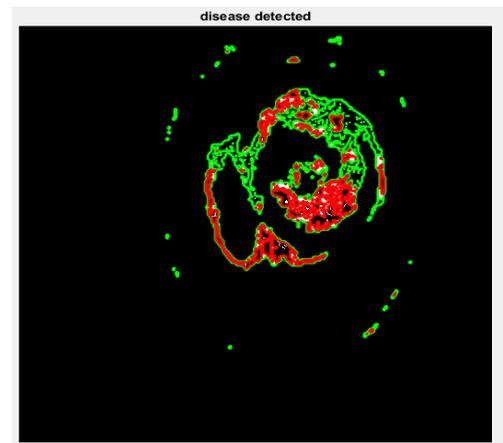

Fig.46 diseases detected image
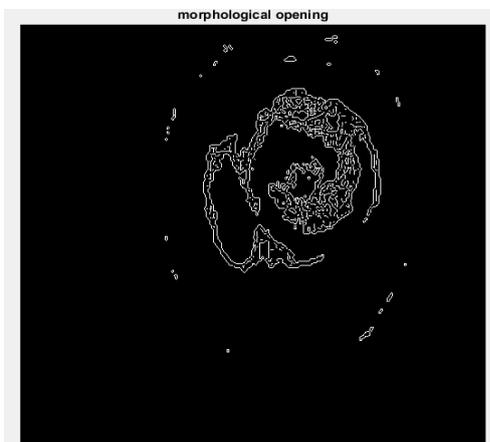
We divided diseases in three parts slightly, moderate, highly affected .with the help of percentages we find, we can easily assign the part.

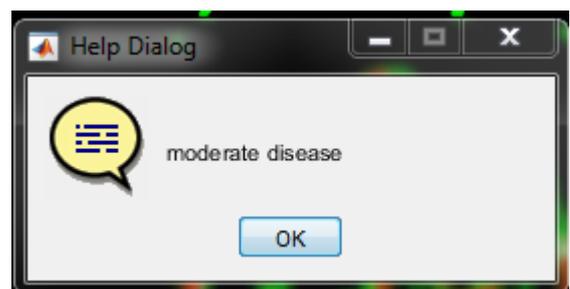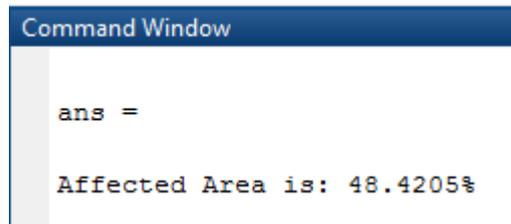Below figure show us result of input image.

Fig.46 dialog box

In the command window we can see the percentages of the input image.

Fig.47 percentage of diseases

CONCLUSION AND FUTUREWORK:

Overall, the paper justifies the study of the diseases which are present in the fruits. The software approach consumes less time as compared to the manual approach. Due to distortion of the image, it can be blurted out so here the de-noising process is used to remove this. Fruit plants are mostly infected by the disease named "bacterial blight". To tackle these kind of diseases the image of the blur image is taken and it is fed to the further system. For the early stage detection, the image processing techniques like pre-processing, extraction, single valued analysis etc. For the cost effective steps, in the future, we will work on the SVD approach to analyze the disease in fruits in the prior stage.

REFERENCES:

[1] zhang, yan-cheng, han-ping mao, bo hu, and ming-xi li. "features selection of cotton disease leaves image based on fuzzy feature selection techniques." in 2007 international conference on wavelet analysis and pattern recognition, Ieee, 2007 vol. 1, pp. 124-129.

[2] husin, zulkifli bin, ali yeon bin md shakaff, abdul hallis bin abdul aziz, and rohani binti s. Mohamed farook. "feasibility study on plant chilli disease detection using image processing techniques." in 2012 third international conference on intelligent systems modelling and simulation, Ieee, 2012 pp. 291-296.

[3] dubey, shiv ram, and anand singh jalal. "detection and classification of apple fruit diseases using complete local binary   patterns." in 2012 third international conference on computer and communication technology, Ieee, 2012 pp. 346-351..

[4] patil, sagar, and anjali chandavale. "a survey on methods of plant disease detection." international journal of science and research (ijsr) 4 (2015): 1392-1396.

[5] sannakki, s. S., and v. S. Rajpurohit. "classification of pomegranate diseases based on back propagation neural network." international research journal of engineering and technology (irjet), (2015). vol2 02

[6] manisha a. Bhange, prof. H. A. Hingoliwala"a review of image processing for pomegranate disease detection" ijcsit] international journal of computer science and information technologies, 2015 vol. 6 [1],

[7] barot, zalak r., and narendrasinh limbad. "an approach for detection and classification of fruit disease: a survey." international journal of science and research (ijsr) issn (online) (2015): 2319-7064.

[8] dubey, shiv ram, and anand singh jalal. "apple disease classification using color, texture and shape features from images." signal, image and video processing 10, no. 5 (2016): 819-826.

[9] feng, pan, gu weikang, jin renjie, and yao qindong. "one-pass preprocessing algorithm for real-time image processing system." in [1988 proceedings] 9th international conference on pattern recognition, Ieee, 1988 pp. 851-853.

[10] gavhale, kiran r., ujwalla gawande, and kamal o. Hajari. "unhealthy region of citrus leaf detection using image processing techniques." in international conference for convergence for technology-2014, Ieee, 2014 pp. 1-6.

[11] kumar, a., and g. S. Gill. "automatic fruit grading and classification system using computer vision: a review." in 2015 second international conference on advances in computing and communication engineering, Ieee, 2015 pp. 598-603.

[12] sadek, rowayda a. "svd based image processing applications: state of the art, contributions and research challenges." arxiv preprint arxiv: (2012) 1211.7102.

[13] dubey, shiv ram, and anand singh jalal. "apple disease classification using color, texture and shape features from images." signal, image and video processing 10, no. 5 (2016): 819-826.

[14] wang, yi, jiangyun wang, xiao song, and liang han. "an efficient adaptive fuzzy switching weighted mean filter for salt-and-pepper noise removal." ieee signal processing letters 23, no. 11 (2016): 1582-1586.

[15] abramovich, yuri i., olivier besson, and ben a. Johnson. "conditional expected likelihood technique for compound gaussian and gaussian distributed noise mixtures." ieee transactions on signal processing 64, no. 24 (2016): 6640-6649.

[16] djidjou, thaddee kamdem, dieter alexander bevans, sergey li, and andrey rogachev. "observation of shot noise in phosphorescent organic light-emitting diodes." ieee transactions on electron devices 61, no. 9 (2014): 3252-3257.

[17] nikahd, eesa, payman behnam, and reza sameni. "high-speed hardware implementation of fixed and runtime variable window length 1-d median filters." ieee transactions on circuits and systems ii: express briefs 63, no. 5 (2016): 478-482.

[18] chithirala, neela, b. Natasha, n. Rubini, and anisha radhakrishnan. "weighted mean filter for removal of high density salt and pepper noise." in 2016 3rd international conference on advanced computing and

communication systems (icaccs), vol. 1, pp. 1-4. Ieee, 2016.

[19] mehta, palak, and bhumika shah. "review on techniques and steps of computer aided skin cancer diagnosis." procedia computer science 85 (2016): 309-316.

[20] situ, ning, xiaojing yuan, george zouridakis, and nizar mullani. "automatic segmentation of skin lesion images using evolutionary strategy." in 2007 ieee international conference on image processing, Ieee, 2007 vol. 6, pp. Vi-277..

[21] parekh, ranjan. "using texture analysis for medical diagnosis." ieee multimedia 19, no. 2 (2012): 28-37.

[22] prasanna, j. K., and a. N. Rajagopalan. "image restoration using the particle filter: handling non-causality." iee proceedings-vision, image and signal processing 153, no. 5 (2006): 650-656.

[23] wolke, andreas, martin bichler, and thomas setzer. "planning vs. Dynamic control: resource allocation in corporate clouds." ieee transactions on cloud computing 4, no. 3 (2016): 322-335.

[24] Hardik Modi, Niyati Trivedi, Prachi Soni and Himanshu Patel "Design and Implementation of Image Processing Techniques for Plant Disease Detection" International Journal of Applied Engineering Research pp. 7724-7758

[25] image of "apple scab" available at https://goo.gl/images/7gvtsc   .

[26] image of "bitter rot" available at https://goo.gl/images/pmmmpk .

[27] image of "black rot" available at https://goo.gl/images/iapgbq.

[28] image of "apple blotch" available at https://goo.gl/images/vlnbdq.

[29] image of "scooty blotch" available at https://goo.gl/images/9vc8pl.

[30] image of "bacterial blight" available at https://goo.gl/images/ukzaru.

[31] image of "aspergillus fruit rot available at " https://ucanr.edu/sites/pomegranates/files/134012.pdf .

[32] image of "gray mold" available at https://goo.gl/images/r7sjdm.

[33] baxes, gregory a. Digital image processing: principles and applications. New york: wiley, 1994.